TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

17.2

The Wetlands Diversity

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

Sibiu – Romania
2015

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Faculty of Sciences,
Department of Ecology and Environment Protection

Published based mainly on some of the scientific materials presented at the fourth "Aquatic Biodiversity International Conference" – Sibiu/Romania 2015

ESENIAS East and South European network for Invasive Alien Species	Ecotur Sibiu N.G.O.	"*Lucian Blaga*" University of Sibiu	International Association for Danube Research

Sibiu – Romania
2015

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IN MEMORIAM
Edward Forbes
(1815 – 1854)

Edward Forbes was born in 1815 at Douglas, Isle of Man, Great Britain. In his childhood he collected insects, shells, fossils, plants and many other natural history objects.

The beginning of his education was as a day scholar at Athole House Academy in Douglas. In 1832, he pursued studies in the natural history of the Isle of Man.

In 1833 he made a journey in Norway, the botanical results of which were published in London's Magazine of Natural History for 1835–1836. In 1834 he dedicated time to dredging in the Irish Sea, and in the next year he journeyed in Switzerland, France and Germany.

A born naturalist, in 1836 he abandoned the idea of taking a medical degree, devoting himself to science. In 1836–1837 found him at Paris, where he was present at the lectures at the Jardin des Plantes on natural history, mineralogy, geology, and comparative anatomy.

In 1837, he went to Algiers, and there acquired materials for a study on freshwater and land Mollusca, printed in the Annals of Natural History. In 1838 arose his first volume, Malacologia Monensis, a synopsis of the Manx species of Mollusca. During 1838 he visited Carniola and Styria in SE Austria and Slovenia, and made botanical collections. His Azoic hypothesis was disproved after a quarter of a century when starfish and worms were found on the deep bottom of the sea.

In 1838 he read before the British Association at Newcastle a report on the distribution of Pulmonata in Europe, and was nominee to produce a similar publication for the British Isles. In 1841 appeared his History of British star-fishes and, in the same year, he joined at Malta H.M. survey ship "Beacon" to which he had been appointed naturalist. Between 1841 and 1842 he was employed in studying the botany, zoology and geology of the Mediterranean area. The results of these studies were made known in his Report on the Mollusca and Radiata of the Aegean Sea, presented to the British Association in 1843, and in Travels in Lycia, in 1847. In the previous treatise he deliberated the influence of climate and of the nature and depth of the sea bottom upon marine organisms, and split the Aegean into eight biological areas.

Towards the end of 1842 Forbes gain the curatorship of the museum of the Geological Society of London. To the charges of that post he added in 1843 those of the professorship of botany at King's College London. In November 1844 he became palaeontologist to the Geological Survey of Great Britain.

In 1846, he wrote in the Memoirs of the Geological Survey, i. 336, his great essay On the Connection between the distribution of the existing Fauna and Flora of the British Isles, and the Geological Changes which have affected their Area, especially during the epoch of the Northern Drift. It is therein pointed out that, in accordance with the theory of their origin from various centres, the plants of Great Britain may be divided into five well-marked groups.

In 1852 was published the fourth volume of Forbes and S. Hanley's History of British Mollusca; also his Monograph of the Echinodermata of the British Tertiaries.

In 1853 Forbes held the presidency of the Geological Society of London, and in 1854 he was appointed to the professorship of natural history at the University of Edinburgh. He lectured at Edinburgh that year. But he was sick just after he had started his winter course of lectures, and after some days he died at Wardie, near Edinburgh, on 18 November 1854.

In 1859, a previous student of Forbes dedicated Mount Forbes, Alberta, Canada to his greatly appreciated memory. He is commemorated too in the lily Fritillaria forbesii, the type specimen of which he collected in Lycia 1842.

Some works were published after his death: On the Tertiary Fluviomarine Formation of the Isle of Wight in 1856; and The Natural History of the European Seas, in 1859.

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.

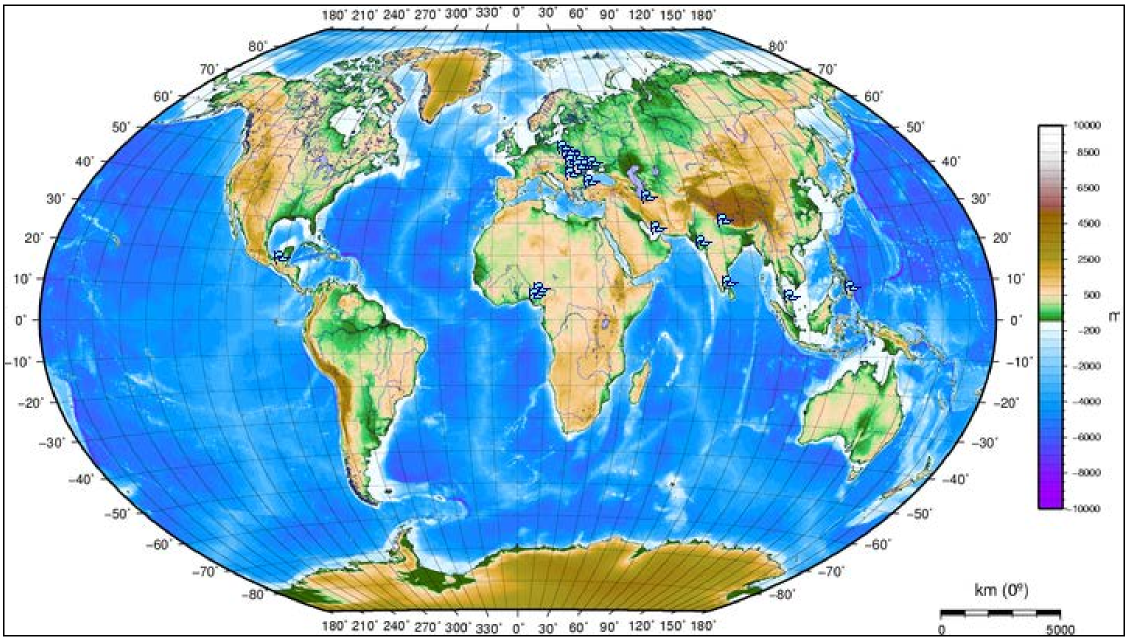
The causes, effects, trends and possibilities of human society to positively intervene to slow down this process or to adapt to it involve a huge variety of aproacess and efforts.

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, 2007-2011.

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 22th volume included variated researches from diverse wetlands around the world.



The subject areas (flag symbol) 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.

Acknowledgements

The editors would like to express their sincere gratitude to the authors and the scientific reviewers whose work made the appearance of this volume possible.

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(ISSN-L 1841 – 7051; online ISSN 2344 – 3219)

PROFILING SUSPENSIONS IN NATURAL WATER BY A SIMPLIFIED DYNAMIC LIGHT SCATTERING PROCEDURE AND SEDIMENTATION

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DOI: 10.1515/trser-2015-0059

KEYWORDS: coherent light scattering, suspensions, dynamic light scattering (DLS), natural water.

ABSTRACT
A coherent light scattering experiment was carried out. The samples were aqueous natural water suspensions picked from the same river. While sedimentation occurred in the samples, they were subjected to a dynamic light scattering (DLS) experiment and the time series was recorded at certain time intervals. For each recording, a program written for this purpose, performing at least square minimisation, computed the average diameter of the particles in suspension. The variation of the average diameter in time indicates the dominant type of suspensions in water.

ZUSAMMENFASSUNG: Bestimmung der Suspensionenprofile in natürlichem Wasser durch ein vereinfachtes Analyseverfahren der Dynamik des kohärenten gestreuten Lichts und der Sedimentation.

Vorliegende Arbeit befasst sich mit einem Experiment der kohärenten Lichtstreuung. Bei den Proben handelt es sich um natürliche Wassersuspensionen, die zu unterschiedlichen Zeiten alle aus demselben Fluss entnommen wurden. Während der Sedimentierungsphase der Proben wurden sie einem Experiment dynamischer Lichtzerstreuung (DLS) ausgesetzt, während dessen Zeitreihen unterschiedlicher Intervalle aufgezeichnet wurden. Für jede Aufzeichnung wurde ein für diesen Zweck geschriebenes Programm eingesetzt, mit Hilfe dessen der mittlere Durchmesser der Suspensionspartikel bestimmt wurde. Die zeitliche Variation des Durchmessers liefert Informationen zum Typus der Suspensionspartikel.

REZUMAT: Determinarea profilului suspensiilor în apa naturală folosind un procedeu simplificat de analiză a dinamicii luminii coerente împrăștiate și de sedimentare.

A fost efectuat un experiment de împrăştiere a luminii coerente. Probele au fost apă naturală cu suspensii, prelevate din acelaşi râu. În timpul în care suspensiile se sedimentau, acestea au constituit ținta unui fascicul într-un experiment de împrăştiere a luminii coerente, în cadrul căruia s-au înregistrat serii de timp de diferite intervale. Pentru fiecare înregistrare, un program scris în acest scop, a determinat diametrul mediu al particulelor în suspensie. Variația în timp a diametrului oferă informații despre tipul particulelor din suspensie.

INTRODUCTION

Natural water is less than 100% transparent, because light is in part scattered and absorbed by the particles suspended in it. This physical property that describes this partial opacity to water is called turbidity (Waterwatch Australia, 2002). Suspended particles consist of sand, clay, silt, plankton, algae, micro-organisms and other substances in small amounts (National Soil Survey Handbook, 2006). Suspended particles can undergo elastic scattering, which causes changes in water. On the other hand, particles can absorb light and this causes a temperature increase in turbid water. Under the same light exposure turbid water is warmer than less turbid (more transparent) water. Water temperature is a tremendously important parameter in an ecosystem. Gumpinger et al. (2010) stated that “water temperature is considered one of the most essential regulating parameters in aquatic ecosystems”. Moreover, because of the intensive interrelations with other physical and chemical parameters, water temperature has a high indicative value when considering the general condition of a river ecosystem (Gumpinger et al., 2010).

This frequently used parameter, turbidity, is related to the total amount of suspended material in water. As previously stated (Chicea, 2013a, b, c) turbidity is not a measure of the concentration or the size of the particles. Moreover, measuring and knowing turbidity does not provide adequate knowledge of the size and the type of particles. As previously stated (Chicea, 2013c), an understanding of the size and the type of the suspended particles is important.

The work presented here is a continuation of previous work (Chicea, 2013a, b, c) aiming to assess the type of suspension in natural water (organic or inorganic) using a combination of two physical procedures, sedimentation and Dynamic Light Scattering, details and results are presented in the next sections.

MATERIALS AND METHODS

Particles sedimentation

When a particle is placed inside a carrier fluid, such as a suspension particle in natural water, it is subject to the action of three forces: gravity, buoyant force and the Stokes drag, if the motion of the particle takes place in laminar regime (Chicea, 2008).

For a particle of radius R the three forces, gravity, buoyant and Stokes drag are expressed as:

$$G = \frac{4\pi}{3} R^3 \rho g \tag{1}$$

$$F_b = \frac{4\pi}{3} R^3 \rho_0 g \tag{2}$$

$$F_s = 6\pi\eta R v \tag{3}$$

where ρ is the density of the particle, ρ_0 is the density of the fluid (water), g is the gravitational acceleration, v is the velocity of the particle in fluid, and μ is the dynamic viscosity.

If the density of the particle, ρ, is bigger than the density of the fluid, ρ_0, the particle will start the sedimentation motion and velocity v will increase. As the velocity increases, so does the Stokes drag, up to the point that makes the sum of the three forces null, as illustrated in figure 1 and equation (4). When the limit velocity of falling is reached and kept constant thereafter. The limit velocity v_l is given by equation (5).

$$\overrightarrow{F_b} + \overrightarrow{F_S} + \vec{G} = 0 \tag{4}$$

$$v_l = \frac{2(\rho - \rho_0)R^2 g}{9\eta} \tag{5}$$

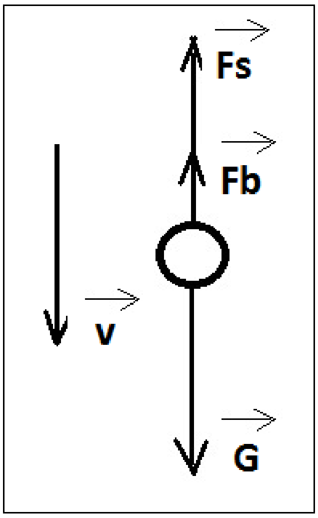

Figure 1: The forces that act upon a particle in a fluid, as water.

The limit velocity can be used in more ways, either to assess the viscosity of the fluid, like in falling sphere viscometers, or to assess the diameter of the particles that are still suspended in the fluid after a certain time from the beginning of the experiment, as presented below. For this purpose we can consider a cuvette with the suspension, as in figure 2.

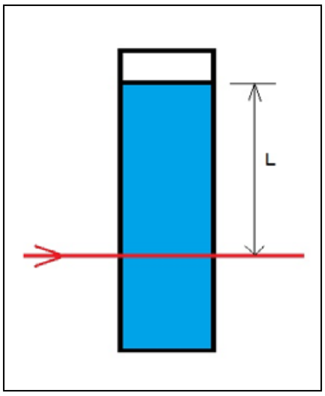

Figure 2: A cuvette with a suspension and a laser beam.

Equation (5) shows that bigger particles have bigger velocity, therefore they fall faster from the part of the cuvette above a certain mark, like the laser beam. All the particles that were located above the mark at the beginning of the experiment, (hereafter at time 0) will fall below the laser beam level in time t if they have a velocity bigger than $v_m(t)$, given by equation (6):

$$v_m(t) = \frac{L}{t} \tag{6}$$

This dictates that at time t, only the particles having a velocity smaller than $v_m(t)$ in equation (6), are still remaining in suspension, above the line and hence a diameter smaller than d_{max} found by reverting equation (5):

$$d_{max} = 2 \cdot R_{max} = \sqrt{\frac{9\eta v_m}{2(\rho - \rho_0)g}} \tag{7}$$

A plot of the d_{max} versus time, considering L = 1 cm, as was used in the work described here, and the suspensions whether it was silt or sand, with a density ρ = 2,600 kg/m^3, is presented in figure 3.

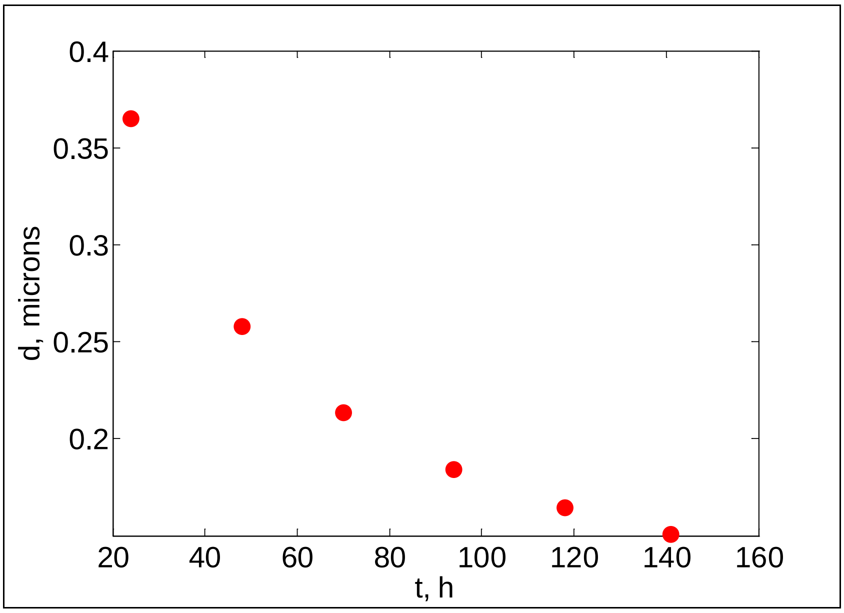

Figure 3: The maximum diameter, in microns,
of the particles still being in suspension above the line, after time t, in hours.

These considerations allow us to assess the type of suspensions in water, together with another complimentary procedure to measure the diameter of the particles at time t. This complimentary procedure is a modified Dynamic Light Scattering procedure and is described in the following subsection.

Dynamic Light Scattering

Dynamic Light Scattering (DLS hereafter) is an optical procedure used for assessing the size of the particles in suspension (Chicea, 2010). When coherent light crosses a medium having scattering centers (SC) an un-uniformly illuminated image is obtained, currently named speckled image, as explained in a report of previous work on this subject (Chicea, 2013a, b). The image is not static, but changes in time giving the aspect of “boiling speckles” (Goodman, 1984; Briers, 2001).

The speckled image can be observed either in free space and is named objective speckle (Goodman, 1984) or far field speckle (Briers, 2001) or on the image plane of a diffuse object and it is named subjective speckle (Goodman, 1984) or image speckle (Briers, 2001). The dynamics of the speckle field was analyzed by correlometric methods (Boas and Yodh, 1997; Aizu and Asakura, 1991; Fedosov and Tuchin, 2001) or by laser speckle contrast analysis (Briers et al., 1999; Zimnyakov et al., 2002). The far field statistics, as speckle size, can be used to measure the roughness of a surface (Lehmann, 1999; da Costa and Ferrari, 1997; Berlasso et al., 2000) or to assess the thickness of a semi-transparent thin slab (Sadhwani et al., 1996). Other papers (Giglio et al., 2001) report on using the near-field speckle dependence of the particles size. The work reported by Piederrière et al. (2004a, b) and Chicea, (2010) used a transmission optical set-up to analyze the far field, and this type of experimental setup was used in the work reported here, which is a continuation of the previous experimental work (Chicea, 2013a, b, c), but using a different procedure for data recording and processing, called DLS.

As the SCs are moving, the image presents fluctuations, hence variations of the intensity in each locations. An image of the far interference field covering an area of 0.5 x 0.5 cm is presented in figure 4.

If we place a detector in a location, the time variations of the intensity are recorded and a time series is the result. The schematic of the experimental setup is presented in figure 5.

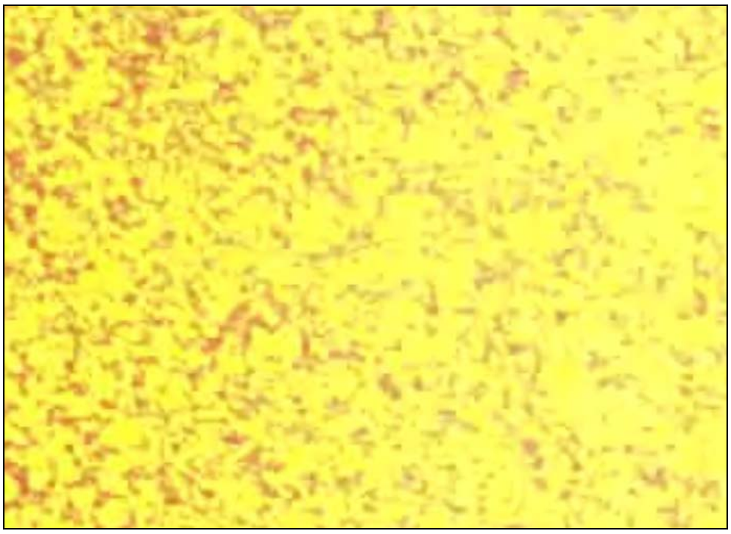

Figure 4: An image of the far interference field covering an area of 0.5 x 0.5.

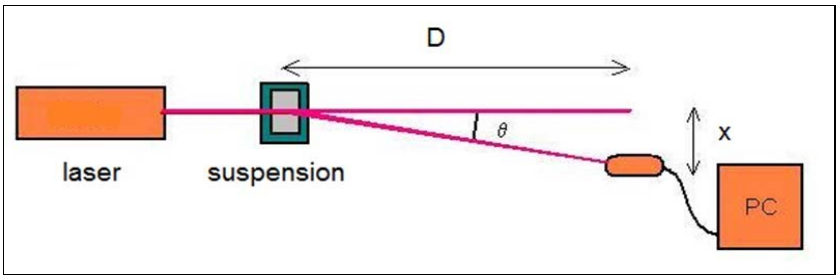

Figure 5: The schematic of the experimental setup.

The power spectrum of the intensity of the light scattered by particles in suspension can be linked to the probability density function (here after PDF) (Clark, 1970; Tscharnuter, 2000). This link between the PDF and the power spectrum is a consequence of the translation of the relative motion of the scattering particles into phase differences of the scattered light. Thus spatial correlations are translated into phase correlations. As already proved (Clark, 1970; Tscharnuter, 2000) the width of the autocorrelation function of the time series is proportional to the diffusion coefficient, which, on its turn, depends of the particle diameter. The power spectrum of the intensity of the light scattered by particles in suspension can be linked to the probability density function. This link between the PDF and the power spectrum is a consequence of the translation of the relative motion of the scattering particles into phase differences of the scattered light. Thus spatial correlations are translated into phase correlations, relating the power spectrum to the autocorrelation function of a process.

By subtracting the average intensity from the recorded time series and calculating the square of the intensity we obtain the power time series. The Fourier transform of the power time series is the power spectrum. We can compare the spectrum calculated from the experimental data with the theoretically expected spectrum, namely the functional form of the Lorentzian line S(f) (8):

$$S(f) = a_0 \frac{a_1}{(2\pi f)^2 + a1^2} \tag{8}$$

The Lorentzian line S(f) has two free parameters a_0 and a_1 and is fit to the power spectrum using a non-linear minimization procedure to minimize the distance between the data-set and the line. We notice that a_0 performs a scaling of the function in the range, which translates into a shift in the logarithmic representation.

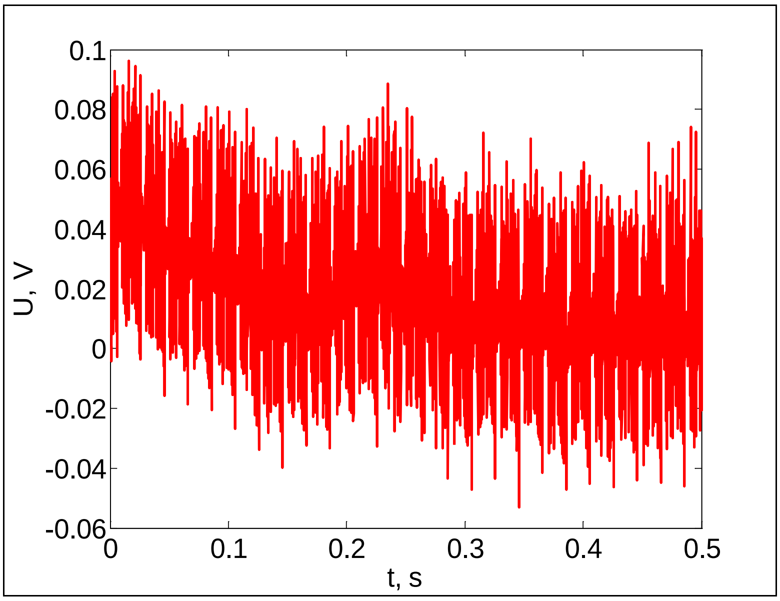

Figure 6: The first second of a time series.

The a_1 parameter enters nonlinearly into the function. Once the fit is completed and the parameters are found, the diameter of the SCs can be assessed as the double of the radius R. The radius can be derived as a function of the fitted parameter a_1 and other known quantities using (9):

$$R = \frac{2k_B T K^2}{6\pi\eta a_1} \tag{9}$$

where

$$K = \frac{4\pi n}{\lambda} \cdot \sin\left(\frac{\theta}{2}\right) \tag{10}$$

In (9) k_B is Boltzman's constant, T is the absolute temperature of the sample, η is the dynamic viscosity of the solvent. In (10), θ is the scattering angle, n is the refractive index of the scattering particles and λ is the wavelength of the laser radiation in vacuum.

The scattering angle θ is equal to $4^o58'11''$. This is not typical for DLS where a bigger angle is chosen, usually 90°. This setup shifts the rollover point in the Lorentzian line towards smaller a_1 values, hence smaller frequencies, where the noise is considerably smaller (Chicea, 2012a, b). For this reason, and for fitting the Lorentzian line rather than the autocorrelation function, the above mentioned DLS procedure is called a modified DLS. The wavelength was 633 nm, the light source was a laser diode and the power was 18 mW. The data acquisition rate was 8,000 Hz and the DLS experiment was carried on at 20^oC. Figure 7 presents the power spectrum and the fitted Lorentzian line.

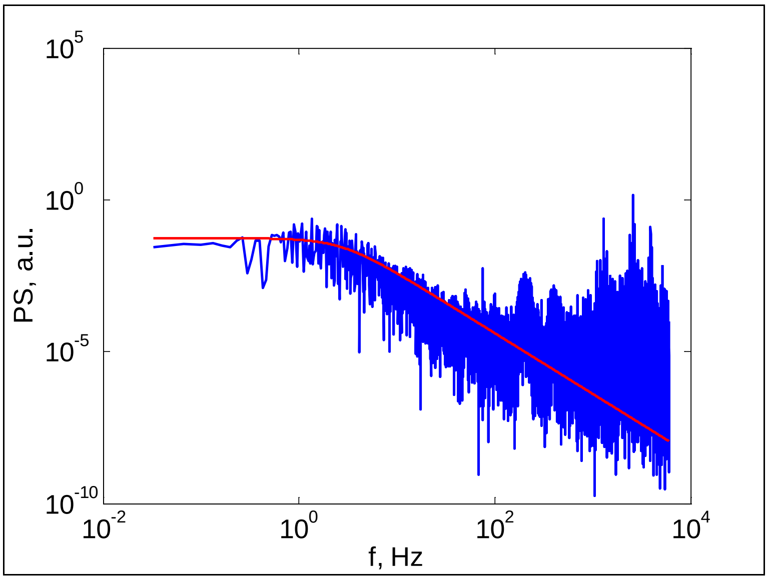

Figure 7: The power spectrum (shattered line) and the fitted Lorentzian line (continuous).

Experimental procedure and data processing

River water samples from the Trinkbach River were taken and each one was placed in the 1 x 1 cm cuvette. The DLS experiment was started and time series were recorded with a time interval of 24 hours for each sample. The time series were processed using the modified DLS procedure and the average diameter of the suspended particles was computed using the least squares procedure, as described above. The diameter considering sedimentation was computed as well, and compared with the measured DLS diameter. The results are presented in the next section.

RESULTS AND DISCUSSION

Figure 8 presents the variation of the diameter calculated using the sedimentation assumption, considering the particles to be sand and silt, and the variation of the measured DLS diameter, with the time elapsed from the beginning of the experiment.

If the particles are sand or silt, the sedimentation and the diameter variation is described by the red circles. If the particles are organic suspension, their density is comparable with the density of water and they remain in suspension. In this case the diameter is described by a constant set of data.

The variation of the average diameter, as results from the DLS sizing over five days, described by the blue squares, indicates that the initial sediment consisted of both organic and mineral particles. During the first 24 hours the mineral suspension, most probably sand or silt became sediment and the remaining particles were organic, which is proved by the constant diameter over the next days.

Moreover, the diameter of the sand and silt particles is smaller, which is proved by the increase of the average diameter after sedimentation.

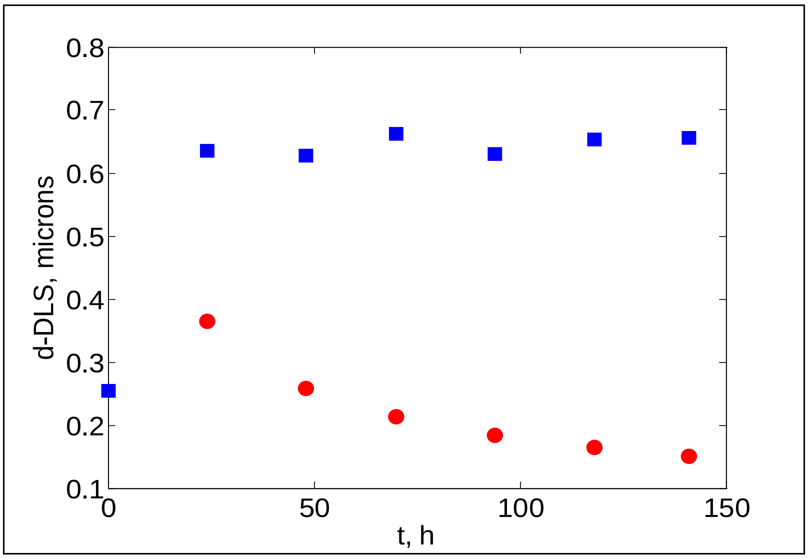

Figure 8: The variation of the sedimentation diameter (circles) and of the measured DLS diameter (squares) with the time elapsed from the beginning of the experiment.

CONCLUSIONS

Using the combination of DLS with sedimentation can be a simple, but useful tool in describing the type of suspension in natural water. The combined procedure does not provide the amount of particle suspended, hence turbidity, but the type and the average diameter of the particles. The combined procedure is relative insensitive to the concentration of particles and works well even for extremely diluted samples, completely transparent. If the concentration of particles is too big and the sample becomes opaque, the sample can be diluted to achieve transparency, without altering the results.

The DLS procedure is an absolute procedure, which means that a calibration is not required. This procedure can be used in combination with other optical techniques, like average speckle size and intensity to assess the amount of particles in suspension, these procedures require calibration though.

ACKNOWLEDGEMENTS

We are especially indebted to the editors of Transylvanian Review of Systematical and Ecological Research, Curtean-Bănăduc A. and Bănăduc D. for fruitful discussions, for providing laboratory equipment and for encouragement in dealing with this paper approach and subject.

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MICROHABITAT PREFERENCES OF PHAEOPHYTA ON SHORE PLATFORM OF DWARKA, GUJARAT COAST, INDIA

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DOI: 10.1515/trser-2015-0060

KEYWORDS: Marine algae, Phaeophyta, microhabitats, shore platform, Dwarka.

ABSTRACT

This paper reports microhabitat preferences of Phaeophyta from the shore platform, Dwarka, Gujarat coast, India. Macroalgae distribution was tagged with shore platform's zonal morphology. Macroalgae (Phaeophyta) were surveyed based on systematic random sampling for two years (April, 2013 to March, 2015). Total 21 species of Phaeophyta were identified through intensive fieldwork/in situ survey based on Line Intercept Transect and Quadrate based methods. Five groups of Phaeophyta were identified as per their zonal preference on the shore platform. On family level, most of the Sargassaceae showed a ubiquitous distribution on the shore platform while Dictyotaceae showed preference towards the subtidal and intertidal mixed zone of the shore platform.

RESUMEN: Preferencias de microhabitat de algas pardas en la plataforma costera de Dwarka, costa de Gujarat, India.

En este artículo se reportan las preferencias de microhábitat de las Phaeophytas de la plataforma continental de Dwarka, en la costa de Gujarat, India. Se mapeó la distribución de las macrofítas mediante la morfología zonal de la plataforma costera. Las macroalgas (Phaoeophyta) se colectaron mediante un muestreo sistemático al azar durante dos años (abril de 2013 a marzo de 2015). Tras un muestreo intensivo en campo, basado en trayectos lineales y cuadrantes, se identificó un total de 21 especies de algas pardas. Se identificaron cinco grupos con preferencia a la plataforma costera. A nivel familia, Sargasseaceae mostró ubiquidad en la plataforma, mientras que en Dictyotaceae se evidenció preferencia a la zona mareal e intermareal.

REZUMAT: Preferințe de microhabitat ale Phaeophyta pe platforma costieră Dwarka, Coasta Gujarat, India.

Prezentul articol indică preferințele de microhabitat ale Phaeophyta de pe platforma costieră Dwarka, în largul provinciei Gujarat, India. Distribuția macroalgelor a fost identificată în funcție de morfologia zonală a platformei costiere. Macroalgele (Phaeophyta) au fost studiate pe baza unei eșantionări aleatorii timp de doi ani (aprilie 2013 – martie 2015). În total 21 specii au fost identificate prin campanii intensive de teren/studiere in situ pe baza metodei de transect cu intersectare de linii și a metodei pătratelor. Au fost identificate cinci grupuri de Phaeophyta în funcție de preferințele zonale de pe platforma continentală. La nivel de familii, majoritatea Sargassaceelor au prezentat o distribuție ubicvistă pe platforma costieră, în timp ce Dictyoceele au prezentat preferințe pentru zona de amestec subtidală și intertidală a platformei costiere.

INTRODUCTION

Marine macroalgae are commonally known as seaweeds in the world. They grow in the intertidal and subtidal zones, in the estuaries and backwaters on solid substrates such as rocks, corals, pebbles, shells and even on plant materials (Sanghvi et al., 2014). Conventionally seaweeds include any large marine benthic algae that are multicellular, macrothallic and thus differentiated from most algae that are of microscopic size (Subba Rao and Mantri, 2006). In the marine ecosystem, marine algae are ecologically important as they provide nutrition and accommodation to other living organisms on an ecological base. These plants form an important renewable resource in the marine environment. They have been part of human civilization from ancient times (Subba Rao and Mantri, 2006). Seaweeds are one of the most important marine living resources for food, feed and raw materials for medicines, cosmetics and industries.

Shore platform is stable compared to other soft substratum environments like beach. It supports many different kinds of plants and animals, some underwater, while other parts are dry stable substratum to the marine algae. There can be distinct patterns of spatial distribution of different species of macroalgae on the shore platform even at minute scale.

Three major groups of seaweeds Chlorophyta, Phaeophyta and Rhodophyta are recognized according to their pigments that absorb light of particular wavelength and give them their characteristic colour of green, brown and red (Thahira, 2011). Out of these three, the brown algae (Phaeophyta) are multi-cellular and are found in a variety of physical forms including crusts and filaments. It contains green pigments chlorophyll and gold and brown pigments: fucoxanthin. Phaeophyta is the most complex algae. Brown algae are almost exclusively marine. They exit either in a uniaxial branched filaments or in a large elaborately parencymatous thalloid organization; usually of the defined form. In majority generally a holdfast, a long or short stipe and an expanded blade work as a photosynthetic and a reproductive structure are present. They are found all over the world.

Phaeophyta play the ecological roles of a decomposer, producer and a food source for aquatic life, very important for the aquatic biodiversity form important habitats for marine life. For instance macrocystis, a kelp of the order Laminariales may reach 60 m in length and form prominent underwater forests. *Sargassum* sp. creates unique habitats in the tropical waters of the Sargasso Sea. Phaeophyta like *Sargassum* sp. and other rockweed such as *Fucus* sp. float in a thick tangled mass through the Sargasso Sea, which supports a variety of marine organisms. Phaeophyta are commonly used as food thickeners, stabilizers and fillers. Phaeophyta hold high carbon dioxide levels used in photosynthesis. Kelp, which is the general name for large Phaeophyta constitutes an important source of iodine, mineral salts, bromine and potash. Some are used as fertilizers because of their high content of nitrogen, potassium and other minerals. The fertilizers contain all the micronutrients required for plants. From the cell wall of Phaeophyta, a gel forming substance is obtained. Algin is used to manufacture chemicals. Alginates are used in production of food and drugs in industries such as food, paper, pharmaceutical, textile and welding.

Phaeophyta species have seasonal nature, species level preference to habitat. This study was carried out to certain species specific microhabitat preferences of the Phaeophyta group on the shore platform of Dwarka, Gujarat coast, India. Following are the objectives of the present work: to study spatial variation of Phaeophyta; to study the microhabitat preference of Phaeophyta in Dwarka.

MATERIALS AND METHODS

Study Area. For seaweeds' growth, geographical, geological, topographical and physical nature of the shore is important. Rocky coasts have vertical zonation (Woodward, 2003). Shore platform provides stable coastal environment as compared to soft sediment coasts like beaches and spits. It represents a case environment where majority of macroalgae species grow with a firm substratum attachment. India has 7,516.6 km of coastline including the island territories with diverse coastal habitats and rich biota (Singh et al., 2012). Out of this, the coastline of Gujarat state is 1,600 km. It represents the north-western most part of peninsular India. This coastline occurs within the geographical limits of 20˚00' to 24˚45' N and 68˚00' to 78˚30' E. Gujarat coast extends in the form of four major coastal ecological components from North to South: I) Kori creek; II) Gulf of Kachchh; III) Saurashtra coast from Okha to Porbandar, and IV) Gulf of Khambhat. Gujarat coastline is reportedly rich with diversity of seaweeds (Chakraborty and Bhattacharya, 2012). The substratum of Gujarat coast is rocky in many parts, which provides suitable environment for macroalgae growth (Chakraborty and Bhattacharya, 2012). The Saurashtra coast, which runs for an approximate length of 985 km, is characterized by rocky, sandy and muddy intertidal zones, harbouring rich and varied flora and fauna (Gohil and Kundu, 2012). The present study was carried out on the shore platform of Dwarka, located on the Saurashtra coast, Gujarat, India (22˚14'22" – 22˚14'38" N and 68˚57'15" – 68˚57'25" E) (Figs. 1A and 1B). Total length of the study area is 572.28 m, maximum width of the shore platform sampled is 143.8 m and it covers a surface area of 82,293.86 m^2. Previous surveys of marine algal resources along the Gujarat coast, performed at the intertidal zones, have revealed great diversity of marine algae in this region (Dhargalkar and Deshmukhe, 1996). In this area three groups of seaweeds: Chlorophyta, Phaeophyta and Rhodophyta were found. Sanghvi et al. (2014) has reported 16 Chlorophyta, 11 Phaeophyta and nine Rhodophyta species of algae under each group. For the present study, Phaeophyta group was selected.

Field Data Collection. The study area was divided into three sections in North-South directions: I) Northern; II) Central; III) Southern sections for systematic field sampling. Field sampling of seaweeds was done from April, 2013 to March, 2015 considering annual cycles of each year. Field surveys/samplings were performed during low tides. For qualitative and quantitative assessment, GPS (Spheroid and Datum: WGS 84) tagged Line Intercept Transect (LIT) were carried out. The length of the transect lines depended on the tidal exposure of the shore platform during the surveys. Maximum depth of the subtidal zone sampled for seaweeds in the present study is 0.5 m. For quantitative assessment of the seaweeds in the given area, line transect was laid perpendicular to the coast in a seaward direction with the help of a long rope of 50 m (Dhargalkar and Kavlekar, 2004). A sampling point along the rope is marked depending on the gradient and exposure of intertidal and subtidal areas. In Saurashtra coast, the tidal amplitude is quite high as compared to other parts of the Indian coast and the west coast in particular. Growth of seaweeds in intertidal and shallow subtidal regions can be easily observed in this area as the spring tides expose the intertidal area up to a maximum length of one km (Jha et al., 2009). Each of the three sections on the shore platform was represented by one transect line: thus resulting 33 transect lines over two years' sampling. Quadrates of one m^2 were positioned on the transect lines wherever the algae growth, density and diversity were high. Total 258 quadrates were performed on the thirty three transect lines. GPS tagged photos of quadrates were taken for further analysis. Seaweed species present within the quadrates were sampled.

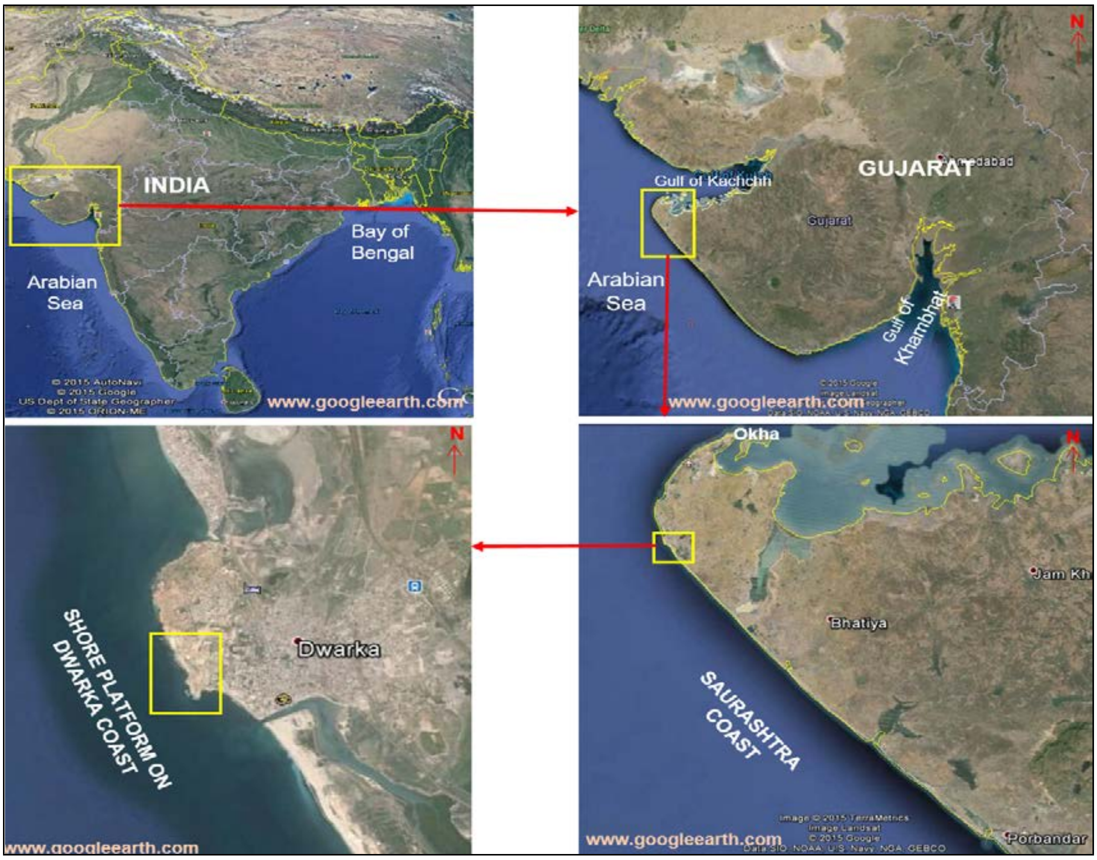

Figure 1A: Location of Shore Platform on Dwarka Coast, Gujarat, India.

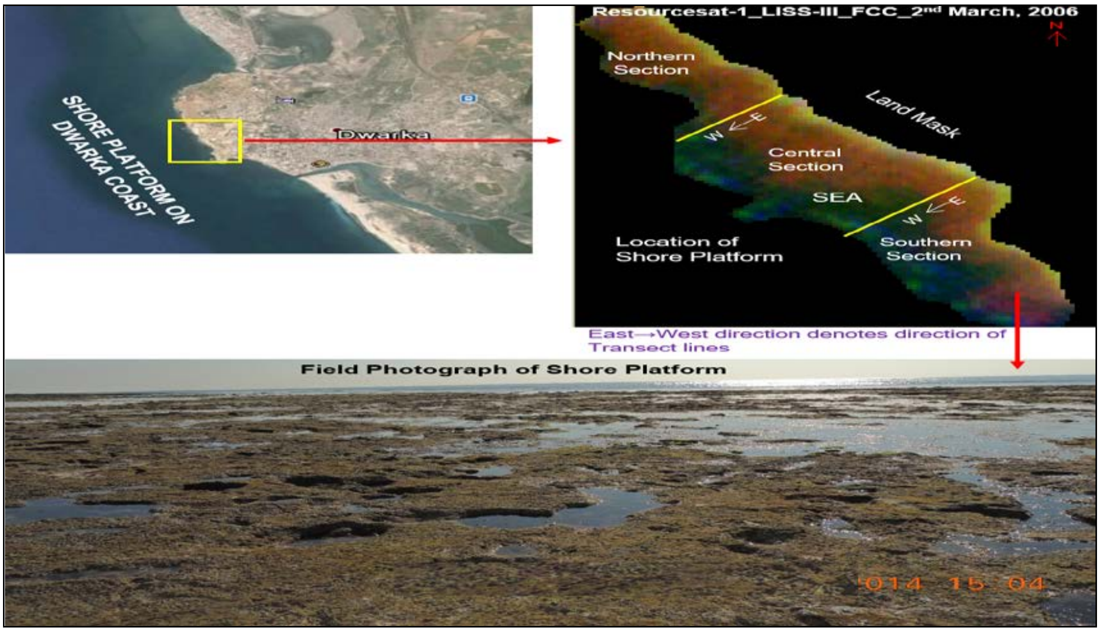

Figure 1B: Study Site: Shore Platform of Dwarka.

Field Data Analysis

Seaweed samples were collected from field and taken to laboratory for preparation of herbarium sheets and specimen identification. Morphological criteria and reproductive structure were analyzed for taxa identification. A cladogram was prepared for identifying algae species in order to generate classification statistics of Phaeophyta i.e. number of genera and species pertaining to different classes as shown in figure 2.

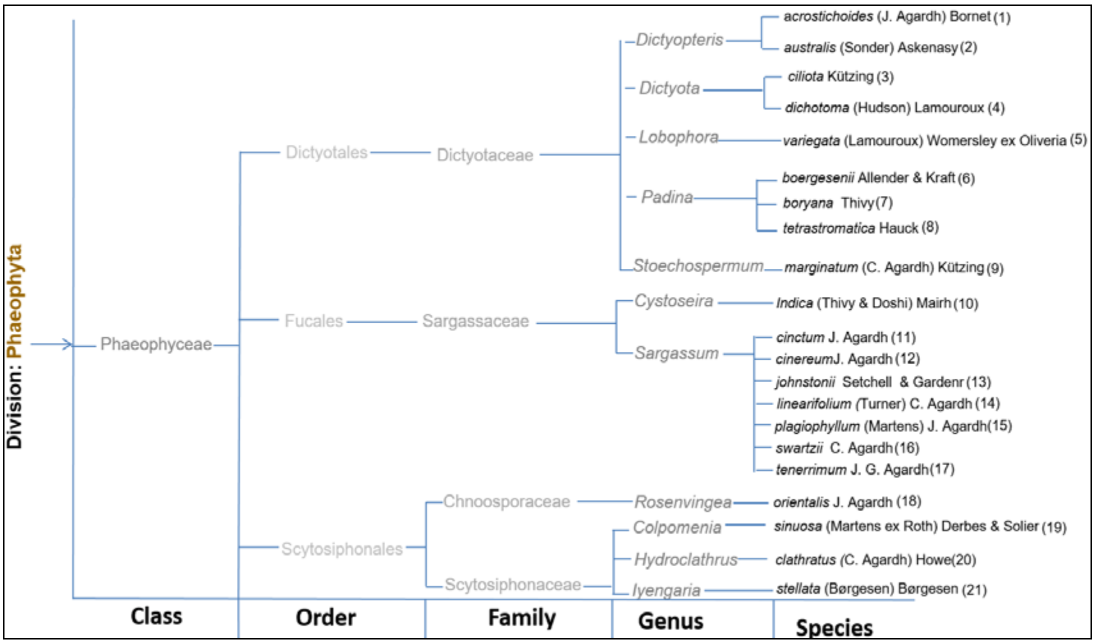

Figure 2: Cladogram of Phaeophyta species sampled from shore platform, Dwarka.

RESULTS AND DISCUSSION

The shore platform of Dwarka was further divided into three microzones in East-West direction representing sectional cross-profiles. These micro-zones are: a) Cliff-base; b) Mixed zone; c) Subtidal zone. These zones are based on the general geomorphological and topographical characteristics of the shore platform, level of tidal inundation and dominance of seaweeds. Seaweeds' distribution was tagged with shore platform's zonal morphology as part of this study. The cliff base zone has many rock shore pools as compared to other zones. Mixed zone also has rock pools, but in less frequency. The subtidal zone is almost submerged in water; exposed only during spring tide.

Seaweeds on the shore platform were studied based on systematic random sampling for two years (April, 2013 – March, 2015). 21 taxa of Phaeophyta (Tab. 1) were identified from this site through intensive fieldwork based on Line Intercept Transect (LIT) and Quadrate based sampling methods. Phaeophyta belongs to three orders, four families, 11 genus and 21 species as shown in the cladogram. Each species was studied with respect to their occurrences and frequencies observed through quadrate survey within the three zones.

A detailed analysis of the field data shows that the 21 taxa of Phaeophyta can be classified into five major groups as per their zonal preferences on the shore platform. These five groups include: I) indicator species of subtidal zone; II) common species of cliff base and mixed zone; III) common species of mixed zone and subtidal zone; IV) chance factor species; V) ubiquitous found species.

1. Indicator species of subtidal zone

In this group, only one species *Dictyota dichotoma* (Hudson) Lamouroux (Fig. 3A) was found. This species occurred in the subtidal zone of all the sections of the shore platform and was absent in either the mixed zone or the cliff-base region. Therefore, it is tagged as an indicator species of the subtidal zone.

2. Common species of cliff base and mixed zone

Three species: *Padina boergesenii* Allender and Kraft (Fig. 3B), *Cystoseira indica* (Thivy and Doshi) Mairh (Fig. 3C) and *Sargassum swartzii* Agardh C. were found. These were recorded in the cliff base and mixed zones of the northern, central and southern sections. The first one belongs to the Dictyotaceae while the last two to Sargassaceae.

3. Common species of mixed zone and subtidal zone

Lobophora variegata (Lamouroux) Womersley ex Oliveria (Fig. 3D), *Padina boryana* Thivy, *Stoechospermum marginatum* (Agardh C.) Kützing (Fig. 3E) and *Hydroclathrus clathratus* (Agardh C.) Howe (Fig. 3F). *H. clathratus* and *L. variegata* were found in mixed and subtidal zones of central and southern sections. *P. boryana* and *S. marginatum* in mixed and subtidal zones of northern, central and southern sections. The first three species belong to Dictyotaceae while the fourth one to Scytosiphonaceae.

4. Chance Factor Species

The fourth group represents the chance factor species as they were encountered only for once during the field surveys. Three species are included in this group: *Dictyopteris acrostichoides* (Agardh J.) Bornet (Fig. 3G), *Dictyopteris australis* (Sonder) Askenasy (Fig. 3H) and *Rosenvingea orientalis* Agardh J. *D. acrostichoides* was recorded once only in the mixed zone of southern section in the month of November while *D. australis* was also found in the mixed zone of the northern section in April. *R. orientalis* was recorded in the cliff base of the central section during October. The first two species belong to Dictyotaceae family while the last one belongs to Chnoosporaceae family.

5. Ubiquitous found species

Ten out of 21 species were found ubiquitously present on the shore platform. These species include *Dictyota ciliolata* Kützing, *Padina tetrastromatica* Hauck (Fig. 4A), *Sargassum cinctum* Agardh J. (Fig. 4B), *Sargassum cinereum* Agardh J. (Fig. 4C), *Sargassum johnstonii* Setchell and Gardner (Fig. 4D), *Sargassum linearifolium* (Turner) Agardh C. (Fig. 4E), *Sargassum plagiophyllum* (Martens) Agardh J. and *Sargassum tenerrimum* Agardh J. G. (Fig. 4F), *Colpomenia sinuosa* (Martens ex Roth) Derbes and Solier (Fig. 4G), *Iyengaria stellata* (Børgesen) Børgesen (Fig. 4H). These species do not show microhabitat preference. These were found in all three zones of all three sections. The first two species belong to Dictyotaceae family and the last two belongs to Scytosiphonaceae. The remaining six species belong to Sargassaceae family and *Sargassum* genus.

Globally, very few reports are available on Phaeophyta and their habitat preferences. Monterio and Engelen (2012) have studied habitat related difference in recruitment and early survival of the invasive seaweed *Sargassum muticum* (Yendo) Fensholt in relation to the lunar phase and meso-grazing between mid-intertidal and low-intertidal pools in site name northern Portugal. In this study, in-situ experiments were performed to determine recruitment and to test the effect of mid-intertidal and low-intertidal pools, grazing and lunar phases (full, new and each quarter moon) on recruit survival reproduction seasons in two consecutive years. They have found recruitment and survival of *Sargassum muticum* higher in the mid-intertidal pools than in low-intertidal environments in both the study periods.

Table 1: Spatial variation of Phaeophyta species observed at shore platform, Dwarka (P – Presence, A – Absence).

Northern Section				
Sr. no.	Name of species	Cliff base	Mixed zone	Subtidal zone
1.	*Dictyopteris acrostichoides* (J. Agardh) Bornet	A	A	A
2.	*Dictyopteris australis* (Sonder) Askenasy	A	P	A
3.	*Dictyota ciliolata* Kützing	P	A	A
4.	*Dictyota dichotoma* (Hudson) Lamouroux	A	A	P
5.	*Lobophora variegata* (Lamouroux) Womersley ex Oliveria	A	A	A
6.	*Padina boergesenii* Allender and Kraft (Juvenile)	A	P	A
7.	*Padina boryana* Thivy	A	P	A
8.	*Padina tetrastromatica* Hauck	P	P	P
9.	*Stoechospermum marginatum* (Agardh C.) Kützing	A	P	P
10.	*Cystoseira indica* (Thivy and Doshi) Mairh	P	P	A
11.	*Sargassum cinctum* Agardh J.	A	A	A
12.	*Sargassum cinereum* Agardh J.	P	P	P
13.	*Sargassum johnstonii* Setchell and Gardner	A	P	A
14.	*Sargassum linearifolium* (Turner) Agardh C.	P	A	P
15.	*Sargassum plagiophyllum* (Martens) Agardh J.	A	P	
16.	*Sargassum swartzii* Agardh C.	A	A	A
17.	*Sargassum tenerrimum* Agardh J. G.	A	A	A
18.	*Rosenvingea orientalis* Agardh J.	A	A	A
19.	*Colpomenia sinuosa* (Martens ex Roth) Derbes and Solier	P	P	P
20.	*Hydroclathrus clathratus* (Agardh C.) Howe	A	A	A
21.	*Iyengaria stellata* (Børgesen) Børgesen	A	P	A
Central Section				
1.	*Dictyopteris acrostichoides* (Agardh J.) Bornet	A	A	A
2.	*Dictyopteris australis* (Sonder) Askenasy	A	A	A
3.	*Dictyota ciliolata* Kützing	A	P	A
4.	*Dictyota dichotoma* (Hudson) Lamouroux	A	A	P
5.	*Lobophora variegata* (Lamouroux) Womersley ex Oliveria	A	P	P
6.	*Padina boergesenii* Allender and Kraft (Juvenile)	A	A	A
7.	*Padina boryana* Thivy	A	P	A
8.	*Padina tetrastromatica* Hauck	A	P	A
9.	*Stoechospermum marginatum* (Agardh C.) Kützing	A	P	P
10.	*Cystoseira indica* (Thivy and Doshi) Mairh	P	P	A
11.	*Sargassum cinctum* Agardh J.	A	P	P
12.	*Sargassum cinereum* Agardh J.	A	P	P
13.	*Sargassum johnstonii* Setchell and Gardner	P	P	P

Table 1 (continued): Spatial variation of Phaeophyta species observed at shore platform, Dwarka (P – Presence, A – Absence).

Sr. no.	Name of species	Cliff base	Mixed zone	Subtidal zone
14.	*Sargassum linearifolium* (Turner) Agardh C.	P	A	A
15.	*Sargassum plagiophyllum* (Martens) Agardh J.	A	P	A
16.	*Sargassum swartzii* Agardh C.	P	A	A
17.	*Sargassum tenerrimum* Agardh J. G.	A	P	A
18.	*Rosenvingea orientalis* Agardh J.	P	A	A
19.	*Colpomenia sinuosa* (Martens ex Roth) Derbes and Solier	A	P	P
20.	*Hydroclathrus clathratus* (Agardh C.) Howe	A	A	P
21.	*Iyengaria stellata* (Børgesen) Børgesen	P	P	A
	Southern Section			
1.	*Dictyopteris acrostichoides* (Agardh J.) Bornet	A	P	A
2.	*Dictyopteris australis* (Sonder) Askenasy	A	A	A
3.	*Dictyota ciliolata* Kützing	P	A	P
4.	*Dictyota dichotoma* (Hudson) Lamouroux	A	A	P
5.	*Lobophora variegata* (Lamouroux) Womersley ex Oliveria	A	P	P
6.	*Padina boergesenii* Allender and Kraft (Juvenile)	P	P	A
7.	*Padina boryana* Thivy	A	P	P
8.	*Padina tetrastromatica* Hauck	P	P	A
9.	*Stoechospermum marginatum* (Agardh C.) Kützing	A	P	A
10.	*Cystoseira indica* (Thivy and Doshi) Mairh	P	P	A
11.	*Sargassum cinctum* Agardh J.	P	P	P
12.	*Sargassum cinereum* Agardh J.	A	P	P
13.	*Sargassum johnstonii* Setchell and Gardner	A	P	A
14.	*Sargassum linearifolium* (Turner) Agardh C.	P	P	P
15.	*Sargassum plagiophyllum* (Martens) Agardh J.	P	P	A
16.	*Sargassum swartzii* Agardh C.	P	P	A
17.	*Sargassum tenerrimum* Agardh J. G.	P	P	P
18.	*Rosenvingea orientalis* Agardh J.	A	A	A
19.	*Colpomenia sinuosa* (Martens ex Roth) Derbes and Solier	A	P	P
20.	*Hydroclathrus clathratus* (Agardh C.) Howe	A	P	P
21.	*Iyengaria stellata* (Børgesen) Børgesen	P	P	P

Santelices and Ojeda (1984) studied recruitment, growth and survival of the low-intertidal, shallow-subtidal *Lessonia nigrescens* Bory de-Saint-Vincent at four tidal levels in rocky habitats in Chile. They have found the effect of the abiotic environment, small grazers and mid-littoral algae on the survival of the juvenile of *L. nigrescens* recruited in the upper part of it vertical range. Disturbance effects of adult plants, grazing effects of large-sized subtidal herbivores on juvenile recruitment and effects of interspecific interference on the survival of newly settled juveniles were also evaluated. The studies focus on recruitment, growth and survival factors of the phaeophyceae species in rock shore platform, India.

Many of phycologists and researchers have studied the seaweeds of Gujarat and India. Iyengar (1927) was the first phycologist to report marine flora of the Indian coast.

Many researchers studied the seasonal variation (Jayasankar and Paliwal, 2002; Dhargalkar et al., 2001; Dhargalkar and Deshmukhe, 1996; Kesava Rao and Singbal, 1995), frequency and biomass (Satheesh and Wesley, 2012), growth cycle (Kotiya et al., 2011), etc. of seaweeds of India, but so far no one has studied microhabitat preference of Phaeophyta in such species level detail from the India coast.

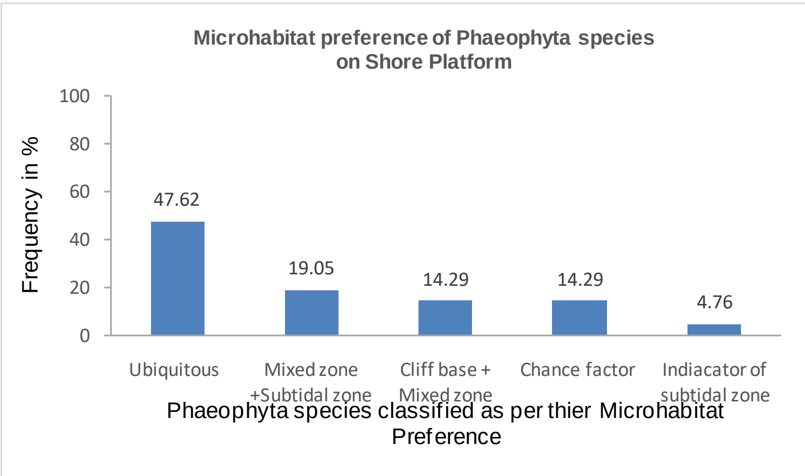

Figure 5: Microhabitat Preference of Phaeophyta on Shore Platform, Dwarka, Guajrat.

Were found 21 Phaeophyta species of four families i.e. Dictyotaceae, Sargassaceae, Chnoosporaceae and Scytosiphonaceae. Eight species have been found in Sargassaceae family, eight in Dictyotaceae, one in Chnoosporaceae and three in Scytosiphonaceae. From eight species of Sargassaceae family, six are showing ubiquitous distribution in the shore platform, while the other two show cliff base and mixed zone distribution. From eight species of Dictyotaceae family two species are showing ubiquitous distribution, two show mixed zone and subtidal zone, one species shows cliff base and mixed zone, two species are chance factor and one species showing subtidal zone distribution in the shore platform. It shows that Sargassaceae dominates on all the zones and can colonize intertidal as well the subtidal zones, while Dictyotaceae mostly prefers subtidal and parts of intertidal zone (i.e. in the mixed zone) and does not occur in the cliff base part which is the most dry part of study area with respect to tidal inundation. 47.62% is ubiquitous, 14.29% cliff base and mixed zone, 19.05% mixed zone and subtidal zone, 14.29% chance factor and 4.76% indicator species of subtidal zone in the shore platform (Fig. 5).

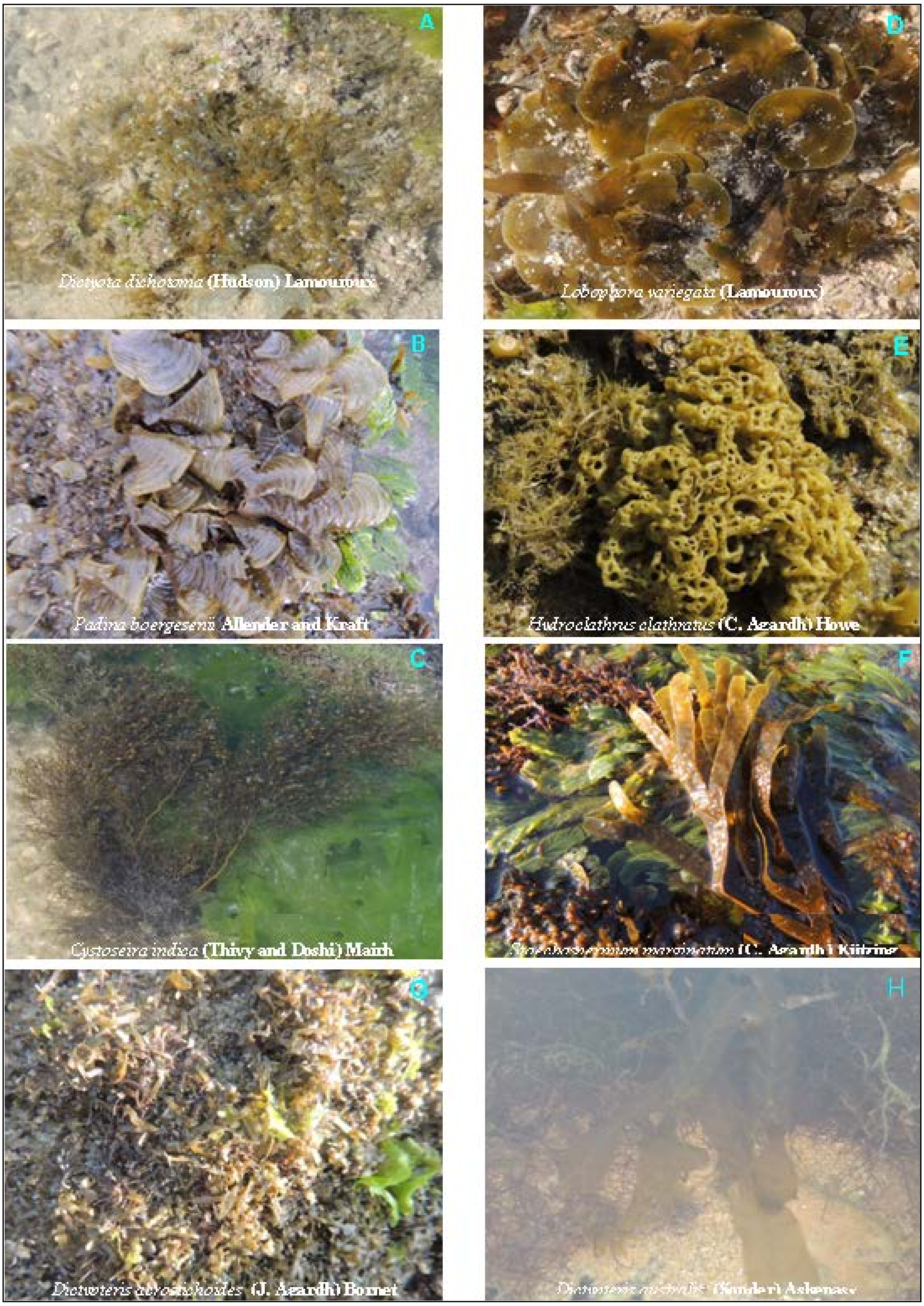

Figure 3: indicator species on shore Platform: A) ind. of subtidal Zone; B-C) ind. of cliff base and mixed zone; D-F) ind. of mixed and subtidal zones; G-H) chance factor.

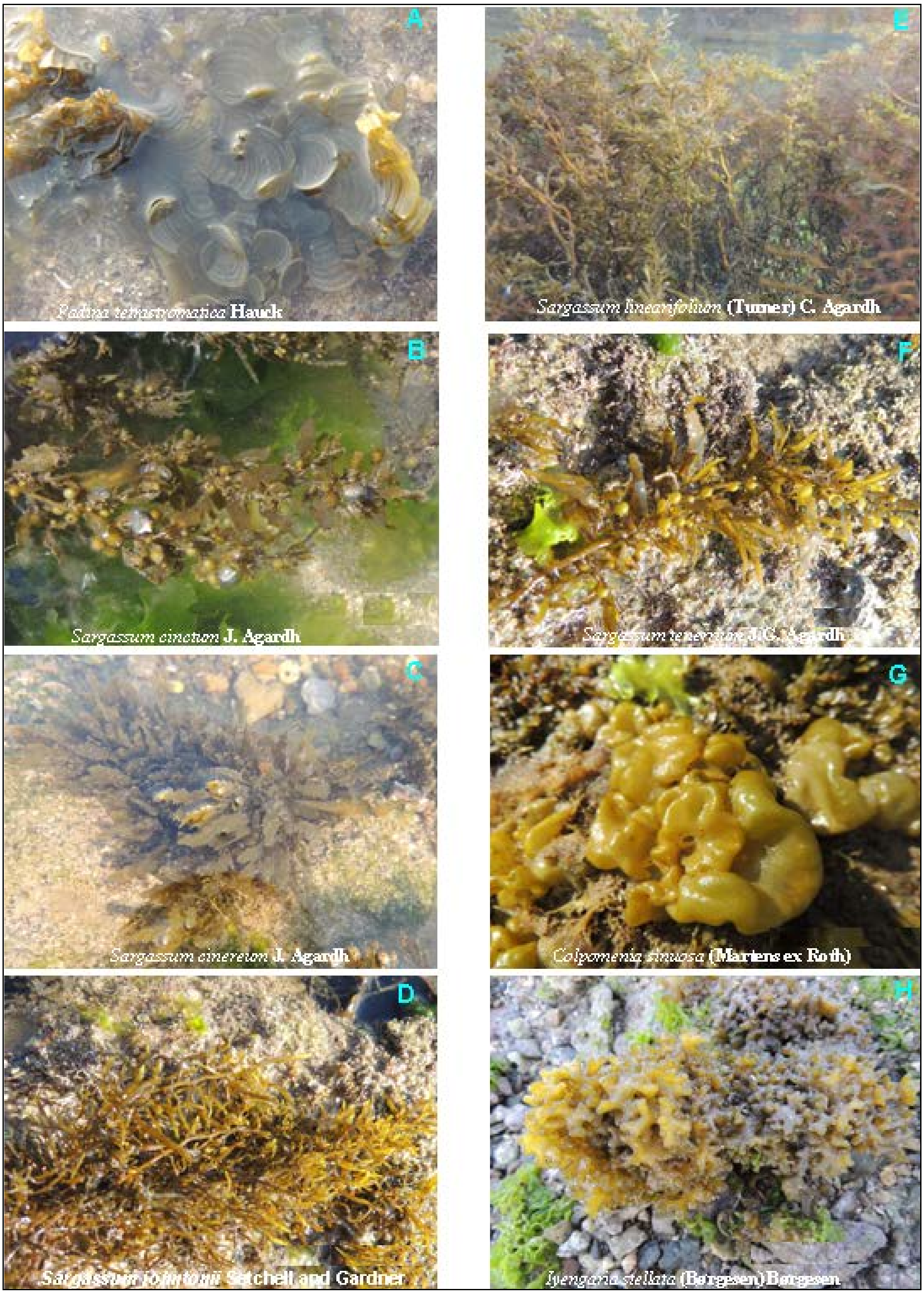

Figure 4: A-H) Photograph of ubiquitous species on shore platform.

CONCLUSIONS

This study reports microhabitat preferences of Phaeophyta from the shore platform of Dwarka in an additional dimension for future field-based macroalgae monitoring. 47.62% of phaeophyta were found to have ubiquitous distribution. Sargassaceae members are most ubiquitous on shore platform. Five out of eight species of Sargassaceae found ubiquitous. Dictyotaceae members still show microhabitat preference on the shore platform. It was mostly found in mixed zone and subtidal zone. *Dictyota dichotoma* (Hudson) Lamouroux is a species of Pheaophyta in subtidal zone of shore platform, Dwarka. This work can serve as a baseline data for designing field sampling strategies exclusively for monitoring Phaeophyta and related biodiversity in the shore platform of Dwarka. Microhabitat preference of the Pheaophyta species thus can become an additional dimension for future field-based macroalgae inventory and monitoring. The methodology adopted can be applied for other groups of seaweeds or for other shore platforms with case specific refinement.

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WETLAND ALGAL COMMUNITIES FROM BALTA MICĂ A BRĂILEI NATURE PARK (ROMANIA)

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DOI: 10.1515/trser-2015-0061

KEYWORDS: floodplain lakes, phytoplankton, phytobenthos, similarity, species richness, water quality.

ABSTRACT

The present paper aims to characterize the algal communities from Balta Mică a Brăilei Nature Park in terms of their species richness and their ability to reflect the water quality of the aquatic ecosystems they live in. Thirteen shallow floodplain lakes, both permanent and temporary, were considered for the present study, with 16 sampling occasions in 2012 and 2013. More than 300 algal taxa were identified, with the green algae (Chlorophyta) being the dominant phyla in almost all the sampling sites. The trophicity and the organic pollution reached high values in 2012, probably due to low water levels caused by drought. Spring floods from 2013 led to lower trophicity and saprobity levels in all sampled water pools.

RÉSUMÉ: Les communautés d'algues du Parc Naturel Balta Mică à Brăilei (Roumanie).

Le présent article vise à caractériser les communautés d'algues du Parc Naturel Balta Mică à Brăilei, en fonction de leur richesse en espèces et de leur capacité à refléter la qualité des écosystèmes aquatiques. Treize lacs peu profonds, permanents ou temporaires, ont été considérés pour la présente étude, avec 16 occasions d'échantillonnage en 2012 et 2013. Plus de 300 taxons d'algues ont été identifiés; les algues vertes (Chlorophyta) ont été dominantes dans presque tous les sites d'échantillonnage. La trophicité et la pollution organique ont enregistré des valeurs élevées en 2012, probablement en raison de faibles niveaux d'eau causés par la sécheresse. Les inondations du printemps 2013 ont conduit aux niveaux inférieurs de trophicité et de pollution organique dans les tous les lacs échantillonnés.

REZUMAT: Comunitățile algale din Parcul Natural Balta Mică a Brăilei (România).

Lucrarea de față are ca scop caracterizarea comunităților algale din Parcul Natural Balta Mică a Brăilei din punctul de vedere al bogăției specifice, luând în considerare şi informațiile valoroase pe care aceste comunități le pot aduce în ceea ce privește calitatea apei în ecosistemele acvatice în care trăiesc. Treisprezece lacuri, atât permanente cât și temporare, au fost luate în considerare pentru prezentul studiu, cu 16 prelevări în 2012 și 2013. Peste 300 de taxoni algali au fost identificați, algele verzi (Chlorophyta) fiind grupul dominant la majoritatea stațiilor de prelevare. Troficitatea și saprobitatea lacurilor considerate, calculate pe baza a trei indici specifici comunităților algale, au avut niveluri ridicate în lunile de prelevare din 2012, datorită secetei prelungite care a dus la scăderi drastice ale nivelului apei în lacuri, dar mai reduse în aprilie și iunie 2013, datorită inundațiilor care au condus la creșteri semnificative a volumului de apă din zona inundabilă.

INTRODUCTION

Algae inhabit most freshwater environments, playing a core role in aquatic food webs, being one of the three major groups of photosynthetic organisms, along with macrophytes and bacteria. Algae are also important in relation to human use of natural resources, because they respond quickly to any changes in the status of their environment, whether natural or human-induced (Suthers and Rissik, 2009). Thus, algal bioindicators of water quality are particularly important in terms of eutrophication and saprobity (the amount of decomposing organic matter existing in the system) (Bellinger and Sigee, 2010). In fact, the current European legislation in the field of water policy, the Water Framework Directive (2000/60/EC), aims to maintain and improve the water quality of EU water bodies, and indicates phytoplankton, macrophytes and phytobenthos as quality elements for the classification of ecological status in lakes.

Wetlands comprise a range of aquatic habitats, from peat lands to shallow lakes, not exceeding six m in depth, according to the Ramsar Convention on Wetlands of International Importance (1971). Due to their shallow depth, wetlands are not usually stratified, with the photic zone extending to the sediments (Moore, 2008). Thus, wetland algal communities are both planktonic and benthic, because the free-floating and rooted macrophytes that usually dominate wetlands provide a rich substratum for epiphytic algae (Bellinger and Sigee, 2010).

Balta Mică a Brăilei Nature Park (“Small Island of Brăila” in the annotated Ramsar list of wetlands of international importance, www.ramsar.org) represents a group of wetlands located on the Lower Danube, South-East Romania, stretching between kilometers 176 and 238 of the river Danube, just upstream of Brăila, at an altitude ranging between three and nine m a.s.l. (Dimitriu et al., 2009). The area includes temporary or permanent floodplain lakes, marshes, connecting canals, islands, the Danube arms and the river itself, covering a total area of 17,586 ha. The natural hydrological conditions are maintained by human activity in Balta Mică a Brăilei area. In fact, the region represents a mixture of inter-connected terrestrial and aquatic ecosystems, with no strict boundaries between them, but strongly dependent on seasonal floods (Stănescu et al., 2009). The Nature Park is an important conservation area: in 2001, the area was declared a Wetland of International Importance (Ramsar site no. 1074) and since 2008 it has been included in Natura 2000 networks, both as a Site of Community Importance (SCI) and as a Special Area for Bird Protection (SPA) (Brînzan, 2013).

Despite the major ecological value of Balta Mică a Brăilei, few scientific works regarding algal communities have been published from the region. We focused on articles from the wetland itself, and not from the Danube River, since the present paper deals solely with the floodplain lakes within the Nature Park. However, the previous literature is either old (Antonescu et al., 1952, from Cărăuș, 2012), or dealing with macroscopic algae like Characeae (Ionescu – Țeculescu, 1966/1967, from Cărăuș 2012), or unpublished (Adamescu, personal communication). A total number of 176 planktonic algal species are mentioned on the official website of the Nature Park (www.bmb.ro).

That is why the present paper represents an important update on the algal flora from the Balta Mică a Brăilei area, aiming to: 1) characterize the algal communities from the region; 2) describe the algal species richness from 13 floodplain lakes; and 3) assess the water quality from the sampling sites based on ecological indices.

MATERIALS AND METHODS

The samples were collected in 2012 (June, July and September) and in 2013 (April and June), from 13 sampling sites on 16 occasions, with Lakes Lupoiu, Curcubeu and Bordeiele being sampled twice (Tab. 1). L1 is the sampling site; DD is the day, MM the month and YY the year of the samplings. Thus, L1_14.06.12 represents lake Japșa, sampled in 14th of June 2012, for the example L1_DD.MM.YY.

The characteristics of the sampled lakes depend mainly on the regional climatic variations. Thus, extended drought periods were recorded in 2012, which clearly influenced the water volume from the floodplain lakes: for example, the mean July temperature in 2012 was 26-28°C, with 4-6°C deviation against the multiannual mean from 1961 to 1990, with precipitation volumes not exceeding 10-20 mm in the Balta Mică a Brăilei area (data source: National Meteorological Administration, www.meteoromania.ro). These factors led to drastic drops of the water levels in all water bodies from the region. On the other hand, catastrophic floods took place in the upper and middle stretches of the Danube in spring 2013, with consequences on the water discharge of the river in the Balta Mică a Brăilei region (data source: National Institute of Hydrology and Water Management, www.inhga.ro). In fact, if we consider the mean Danube discharge values at Vadu Oii, Constanța County, just upstream of the Nature Park, we can divide the sampling periods into two categories: 1) months with low discharge values (June, July and September 2012, with discharges of 6,870, 4,340 and 3,040 m^3/sec., respectively); and 2) months with high discharge values (April and June 2013, with 12,220 and 8,900 m^3/sec., respectively) (data source: National Institute of Hydrology and Water Management, www.inhga.ro).

Seven sampling sites were located in the southern region of the Nature Park: lakes Japșa, Sbenghiosu, Lupoiu, Jigara, Curcubeu, Gâsca and Cortele (L1-L7); one site was located in the central area: lake Cucova (L8); while five sites were situated in the northern area: Lakes Lupu, Bordeiele, Stan, Iezerul Morilor and Chiriloaia (L9-L13) (Tab. 1; Fig. 1).

Most of the water bodies included for sampling were permanent shallow lakes, rich in submerged, emerged and floating vegetation; often connected with each other and with the Danube River or its arms. In a study conducted in the summer of 2008, Stănescu et al. (2009) characterized these permanent water pools as shallow, with a maximum water depth of 150 cm and an average depth of 85 cm; with smooth, indefinite shorelines created from alluvia transported inwards and outwards during floods. The largest lakes in terms of their surface were the following: lake Curcubeu (296 ha), lake Lupoiu (272 ha), lake Jigara (244 ha), lake Gâsca (203 ha) and lake Cucova (236 ha) (Stănescu et al., 2009).

Lake Japșa (L1) was the only temporary water pool from the 13 sites included in the present study. These temporary water bodies from the Balta Mică a Brăilei area usually become marshes in drought periods, having a shallower depth compared to permanent pools, not exceeding 100 cm, with a mean depth of 55 cm (Stănescu et al., 2009).

The altitude differences between the floodplain lakes included in this study were minimal. In fact, the mean slope of the water surface was about 0.02‰ in the 83 km long Danube sector between Hârşova and Brăila (which includes our study area), meaning a drop of two cm in the water level for each river kilometer, when going downstream (Dimitriu et al., 2009). More importantly, the reference value of the Danube low water level was deeper compared to its floodplain lakes, so the general tendency of the waters in this area was to flow towards the stream beds of the Danube and its arms (Stănescu et al., 2009).

The samples were collected using a 30 µm mesh size phytoplankton net, and preserved in 4% formaldehyde. Several physical and chemical parameters were also measured at each site, using portable meters (Consort P902 for pH and YSI 52 for dissolved oxygen and water temperature). Identifications were made to the species level (Ettl and Gärtner, 1988; Komárek and Anagnostidis, 2005; Krammer and Lange, 1986; Popovsky and Pfiester, 1990; Wolowski, 2005).

Table 1: The sampling sites located in the Balta Mică a Brăilei Nature Park.

Sampling site code	Lake name	Sampling date	GPS coordinates	Maximum depth (m)
L1_14.06.12	Lake Japşa	14.06.2012	N 44°48’06.5” E 27°50’17.5”	0.60
L2_19.07.12	Lake Sbenghiosu	19.07.2012	N 44°49’30.3” E 27°54’38.7”	1.50
L3_18.07.12	Lake Lupoiu	18.07.2012	N 44°50’43.8” E 27°56’07.1”	0.70
L3_22.06.13		22.06.2013		2.00
L4_21.07.12	Lake Jigara	21.07.2012	N 44°50’03.3” E 27°52’18.8”	1.50
L5_13.06.12	Lake Curcubeu	13.06.2012	N 44°51’09.5” E 27°54’21.4”	0.65
L5_22.06.13		22.06.2013		2.00
L6_13.06.12	Lake Gâsca	13.06.2012	N 44°51’17.6” E 27°53’33.6”	0.70
L7_20.07.12	Lake Cortele	20.07.2012	N 44°52’09.2” E 27°54’45.2”	1.30
L8_15.06.12	Lake Cucova	15.06.2012	N 45°00’42” E 27°54’40.7”	1.00
L9_29.04.13	Lake Lupu	29.04.2013	N 45°07’38.5” E 27°57’12”	3.50
L10_26.09.12	Lake Bordeiele	26.09.2012	N 45°10’13.2” E 27°58’04.1”	0.30
L10_28.04.13		28.04.2013		3.80
L11_27.04.13	Lake Stan	27.04.2013	N 45°10’40.6” E 27°58’19.5”	3.00
L12_28.04.13	Lake Iezerul Morilor	28.04.2013	N 45°10’04.3” E 27°57’14.6”	2.50
L13_27.04.13	Lake Chiriloaia	27.04.2013	N 45°11’45.1” E 27°58’21.5”	3.00

Principal Component Analysis (PCA), one of the most frequently used multivariate data analysis methods (Jolliffe, 2002), was performed in order to visualize the sampling sites depending on several variables: water temperature, dissolved oxygen, pH, maximum depth and the Danube River discharge values.

The non-parametric Mann-Whitney test (Lehmann, 1975) was used to determine if the algal species richness differed in the lakes sampled in 2012 compared to those sampled in 2013. The similarity between the algal communities from the sampling sites was calculated using the Jaccard index (Washington, 1984), which only uses qualitative data (presence/absence of the taxon).

Several trophicity and organic pollution indices based on phytoplankton community were considered (Willén, 2000). The first one, the trophic index according to Heinonen (1980) is calculated as the ratio between the number of species indicating eutrophic conditions and the number of species indicating oligotrophic conditions. Values lower than eight indicate oligotrophic waters. The second trophicity index, the compound index, represents the number of species of Cyanoprokaryota, Chlorococcales, Centrales and Euglenophyta divided by the number of species belonging to Order Desmidiales (Nygaard, 1949). Values below one indicate oligotrophic conditions, values between one and three mesotrophic conditions and values exceeding three eutrophic conditions. The organic pollution index calculated at the genus level (Palmer, 1969) represents the sum of the indicator values of the genera tolerant to organic load. Values not exceeding 15 indicate low organic pollution; values between 15 and 19 indicate moderate pollution and values greater than 20 represent high organic pollution.

Statistical analyses were performed using PAST software version 2.14-2012 and XLSTAT software – evaluation version 2013.5.

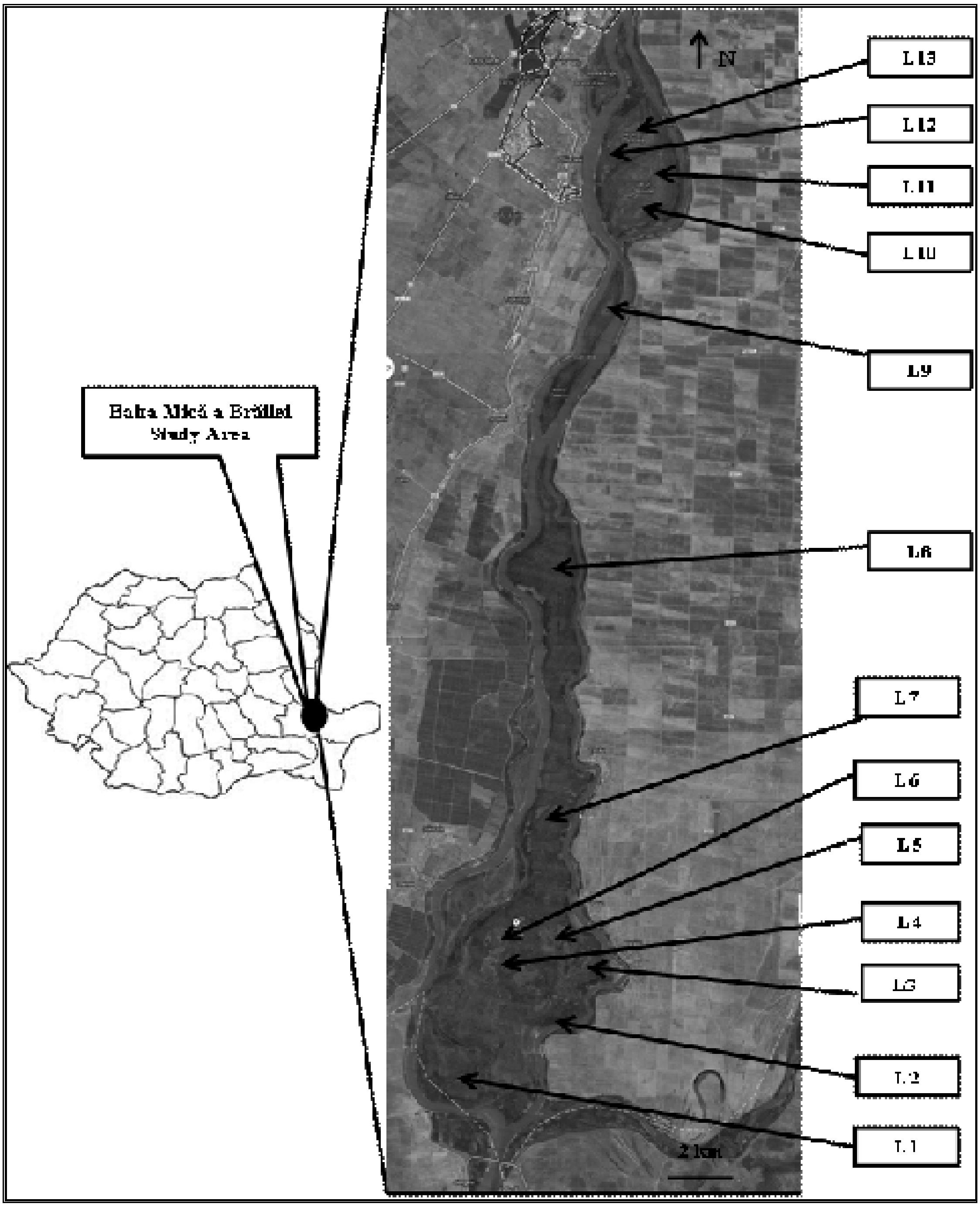

Figure 1: Location of the 13 floodplain lakes from the Balta Mică a Brăilei Nature Park, considered for this study (abbreviation of the sampling sites and occasions as in table 1) (Google Earth, 2013).

RESULTS AND DISCUSSIONS

Physico-chemical factors

The main physical and chemical parameters were recorded at each site (Tab. 2). pH values were circum-neutral, typical for most surface freshwater systems. Water temperatures recorded normal variations, higher in summer and lower in spring. The quantity of oxygen dissolved in water, on the other hand, was more variable, ranging from minimum values of three or four mg/L in small, shaded lakes (L7 – lake Cortele and L1 – lake Japșa), to maximum values of 10 or 11 mg/L caused by lower temperatures and spring mixing, in the sites sampled in April 2013.

The sampling lakes from Balta Mică a Brăilei Nature Park were aggregated in the Principal Component Analysis (PCA) biplot based on five physical and chemical parameters: the water temperature, maximum depth measured in situ, the Danube mean water discharge recorded in the sampling months at Vadu Oii (Constanța County), dissolved oxygen and the pH (Fig. 2). Three groups were distinguished on axis F1, based on the first three parameters: 1) one including the lakes with maximum depth, high discharge, but low water temperatures, sampled in April 2013 (left in Fig. 2); 2) the second one including the lakes with minimum depth, low discharge, but high water temperatures, sampled in June, July and September 2012 (right in Fig. 2); and 3) the third one (middle in Fig. 2) with intermediate values.

Species richness

The algal communities recorded a heterogeneous structure, with planktonic and benthic taxa, which represented a typical situation for shallow floodplain lakes (Bellinger and Sigee, 2010). A total number of 315 algal taxa from seven phyla were identified in the sampling sites. Chlorophyta (green algae) was the dominant phylum, with 42% of all taxa, followed by Bacillariophyta (28%), Euglenophyta (20%), Cyanophyta (6%) and Xanthophyta, Chrysophyta and Dinophyta, each with less than 2% (Tab. 3).

In fact, most freshwater shallow lakes are dominated by green algae and diatoms, with the first usually peaking in summer and the latter in spring and autumn (Bellinger and Sigee, 2010). However, in the Danube Delta, similar floodplain lakes located less than 150 km away from Balta Mică a Brăilei Nature Park in straight line show a slightly different hierarchy of the dominant algal phyla in terms of species number: Bacillariophyta was the most numerous group, followed by Chlorophyta and Cyanophyta (Török, 2011). This difference was caused by the fact that no running waters, usually dominated by diatoms, were sampled in the present paper.

Most of the sampled Chlorophyta taxa were planktonic, since only 17 out of the total number of 135 were true benthic species. However, in the lakes sampled in April and June 2013, during the river floods, green algae recorded a minimum number of species, ranging between one and six, because of their incapacity to remain in the water column during floods.

Diatoms dominated the algal communities from the lakes sampled during the spring floods, in April 2013, as number of taxa. The presence and composition of epiphytic diatom communities are used to detect floods in sediment records (Wiklund et al., 2010). The majority of diatom species from Balta Mică a Brăilei Nature Park was represented by forms attached to substratum, since only 20 out of the total number of 87 diatom species were true planktonic. For example, in lake Chiriloaia (L13_27.04.13), 23 out of 29 diatom taxa were benthic, so they could be either brought by the Danube, or taken from the lake sediment due to the flood.

In contrast, Euglenoids were absent from the lakes sampled in April 2013, due to the high water volume and high water current that made their survival in the water column impossible. This absence could be also explained by the lower levels of organic matter present in the water, caused by the spring floods.

Similarly, a low number of Cyanophyta species was in April 2013, caused also by increases in water level, a similar situation to that cited in Mihaljević and Stević (2011).

Eleven algal taxa were listed for the first time in Romania: *Coccomonas elliptica*, *Coccomonas platyformis*, *Euglena obtusa*, *Goniochloris spinosa*, *Phacus agilis* var. *inversa*, *Phacus asymmetricus*, *Phacus sesquitortus*, *Scenedesmus lefevre* var. *manguinii*, *Staurastrum paradoxum* var. *reductum*, *Trachelomonas wislouchii* and *Trachelomonas woycickii*. Most of these species were identified in lake Sbenghiosu (L2_19.07.12), probably because of the diversity of sampled microhabitats: both open water and shallow regions with macrophytes.

Table 2: Physical and chemical parameters measured in Balta Mică a Brăilei Nature Park (abbreviation of the sampling sites and occasions as in table 1).

Sampling site code	Water temperature (°C)	Dissolved oxygen (mg/L)	pH
L1_14.06.12	24.60	4.44	–
L2_19.07.12	25.30	6.20	7.50
L3_18.07.12	25.80	7.35	7.50
L3_22.06.13	23.20	6.00	7.30
L4_21.07.12	29.30	7.67	7.50
L5_13.06.12	29.00	7.50	8.00
L5_22.06.13	23.70	6.00	7.90
L6_13.06.12	30.60	7.15	8.00
L7_20.07.12	26.20	3.10	7.50
L8_15.06.12	27.60	6.30	7.00
L9_29.04.13	16.60	8.00	–
L10_26.09.12	30.10	6.48	7.00
L10_28.04.13	18.00	10.50	–
L11_27.04.13	16.30	8.00	–
L12_28.04.13	17.30	7.25	–
L13_27.04.13	16.70	11.25	6.50

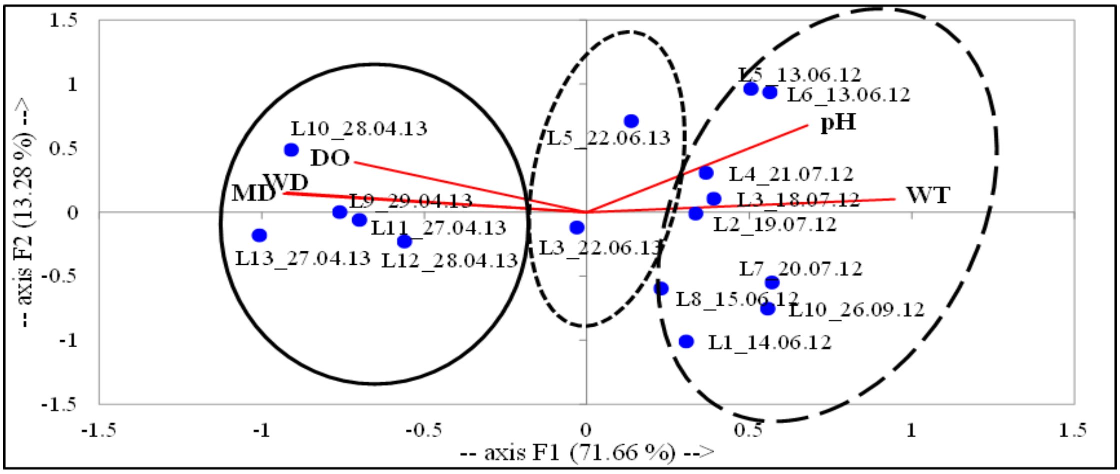

Figure 2: Principal Component Analysis (PCA) biplot of the sampling sites and their aggregation based on: dissolved oxygen – DO (mg/L); maximum depth measured in situ – MD (m); the pH; the Danube mean water discharge recorded in the sampling months at Vadu Oii, Constanța County – WD (m^3/sec.) and the water temperature – WT (°C) (abbreviation of the sampling sites and occasions as in table 1) (axes F1 and F2: 84.94%).

Table 3: List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of sampling sites and occasions as in table 1).

SAMPLING SITES (→)/ALGAL TAXA (↓)	1	2	3	4	5	6	7	8	9	10	11	12	13
Phyllum Cyanophyta (Cyanoprokaryota)													
Anabaena elliptica Lemmermann, 1898			+		+								
Anabaena flos-quae rébisson ex Bornet and Flauhault, 1886						+							
Anabaena variabilis Kützing, 1843	+	+	+	+	+	+	+	+		+			
Arthrospira jenneri Stizenberger ex Gomont, 1892		+					+						
Lyngbya kuetzingii Schmidle, 1897								+					
Merismopedia glauca (Ehrenberg) Kützing, 1845		+			+								
Merismopedia tenuissima Lemmermann, 1898		+											
Oscillatoria agardhii Gomont, 1892							+						
Oscillatoria amphibia Agardh C., 1827		+		+						+			
Oscillatoria formosa Bory de Saint-Vincent ex Gomont, 1892												+	
Oscillatoria limnetica Lemmermann, 1900					+				+	+			
Oscillatoria limosa Agardh C., 1812					+					+			
Oscillatoria planctonica Woloszynska 1912				+									
Oscillatoria tenuis Agardh C., 1892	+	+	+		+						+	+	
Oscillatoria utermoehliana Elenkin, 1949										+			
Phormidium molle Gomont, 1892								+					
Snowella lacustris (Chodat) Komárek and Hindák, 1988					+	+							
Phyllum Euglenophyta													
Euglena acus (Müller O. F.) Ehrenberg, 1830	+	+	+	+	+	+	+	+	+				
Euglena agilis Carter H. J., 1856								+		+			
Euglena caudata Hübner, 1886								+					
Euglena charkowiensis Svirenko D. O., 1913							+	+					
Euglena contabrica Pringsheim E. G., 1956								+					
Euglena cuneata Pringsheim E. G., 1956				+	+			+					
Euglena deses Ehrenberg, 1834							+			+			
Euglena deses f. *intermedia* Klebs G. A., 1883		+											
Euglena ehrenbergii Klebs G. A., 1883		+				+	+			+			
Euglena gracilis Klebs G. A., 1883								+					
Euglena limnophila Lemmermann, 1898							+	+					
Euglena oblonga Schmitz F., 1884								+		+			
Euglena obtusa Van Goor, 1925								+					
Euglena oxyuris Schmarda, 1846		+	+		+								
Euglena proxima Dangeard P. A., 1901	+				+				+				
Euglena repulsans Schiller J., 1952	+												
Euglena spathirhyncha Skuja, 1948		+											

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Euglena spirogyra Ehrenberg, 1832	+	+			+								
Euglena texta (Dujardin) Hübner, 1886	+	+	+		+	+							
Euglena tripteris (Dujardin) Klebs G. A., 1883		+			+								
Euglena variabilis Klebs G. A., 1883								+		+			
Euglena velata Klebs G. A., 1883							+						
Euglena viridis (Müller O. F.) Ehrenberg, 1830		+		+									
Lepocinclis marssonii Lemmermann, 1904		+											
Lepocinclis ovum Lemmermann, 1901		+	+	+						+			
Phacus acuminatus Stokes, 1885				+			+	+					
Phacus agilis Skuja, 1926			+	+			+						
Phacus agilis var. *inversa* Bourrelly P., 1947		+											
Phacus alatus Klebs G. A., 1886	+												
Phacus anomalus Fritsch F. E. and Rich M. F., 1929				+						+			
Phacus asymmetricus Prescott, 1944			+										
Phacus cochleatus Pochmann, 1942	+												
Phacus glaber (Deflandre) Pochmann, 1931		+								+			
Phacus helicoides Pochmann, 1948		+											
Phacus hispidulus (Eichwald) Lemmermann, 1910		+		+									
Phacus longicauda Dujardin, 1841		+	+				+					+	
Phacus monilatus Stokes, 1910		+											
Phacus nordstedtii Lemmermann, 1904		+											
Phacus orbicularis Hübner K., 1886	+		+		+								
Phacus parvulus Klebs G. A., 1883							+						
Phacus pleuronectes (Müller O. F.) Nitzsch ex Dujardin, 1841			+		+								
Phacus pyrum (Ehrenberg) Archer W., 1871				+									
Phacus sesquitortus Pochmann, 1942			+										
Phacus suecicus Lemmermann, 1904							+						
Phacus tortus (Lemmermann) Skvortzov, 1928	+	+			+								+
Phacus trypanon Pochmann, 1942		+											
Strombomonas acuminata (Schmarda) Deflandre, 1930		+		+	+			+					
Strombomonas deflandrei (Roll Y. V.) Deflandre, 1930					+								
Trachelomonas abrupta Svirenko, 1914	+												
Trachelomonas armata Stein F., 1878	+	+	+		+	+		+		+			
Trachelomonas bacillifera Playfair, 1915					+								
Trachelomonas caudata Stein, 1878								+					
Trachelomonas hexangulata Svirenko, 1914		+											
Trachelomonas hispida (Perty) Stein F. 1878		+	+	+	+	+		+		+			

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Trachelomonas intermedia Dangeard P. A., 1902	+												
Trachelomonas oblonga Lemmermann, 1899							+	+					
Trachelomonas planctonica Svirenko, 1914							+						
Trachelomonas pulcherrima Playfair, 1915										+			
Trachelomonas scabra Playfair, 1915				+									
Trachelomonas verrucosa Stokes A., 1887		+											
Trachelomonas volvocina (Ehrenberg) Ehrenberg, 1834				+			+	+		+			
Trachelomonas volvocinopsis Svirenko, 1914		+	+		+	+							
Trachelomonas wislouchii Skvortzov, 1917		+	+										
Trachelomonas woycickii Koczwara, 1914		+											
Phyllum Dinophyta													
Gymnodinium paradoxum Schilling A. J., 1891								+		+			
Peridinium aciculiferum Lemmermann, 1900						+							
Peridinium cinctum (Müller O. F.) Ehrenberg, 1832								+					
Phyllum Chrysophyta													
Chrysococcus rufescens Klebs, 1893							+	+					
Dinobryon bavaricum Imhof, 1890						+							
Dinobryon cylindricum Imhof O. E., 1887								+					
Dinobryon sertularia Ehrenberg, 1834			+		+	+				+	+	+	
Phyllum Bacillariophyta													
Achnanthes bioretii Germain, 1957	+												
Achnanthes helvetica (Hustedt) Lange-Bertalot, 1989										+			
Achnanthes hungarica (Grunow) Grunow in Cleve and Grunow, 1880		+	+										
Achnanthes lanceolata van Heurck H., 1880		+	+										+
Achnanthes minutissima Kützing, 1833			+							+			
Amphora libyca Ehrenberg, 1840			+							+			+
Amphora ovalis (Kützing) Kützing, 1844												+	
Amphora pediculus (Kützing) Grunow ex Schmidt A., 1875	+	+	+		+		+	+		+			
Amphora veneta Kützing, 1844	+	+			+	+	+			+			+
Anomoeoneis sphaerophora Pfitzer E., 1871				+				+					
Asterionella formosa Hassall, 1850									+	+	+		+
Aulacoseira granulata (Ehrenberg) Simonsen, 1979		+		+		+			+				
Caloneis silicula (Ehrenberg) Cleve, 1894		+	+	+		+		+		+			
Cocconeis pediculus Ehrenberg, 1838		+											
Cocconeis placentula Ehrenberg, 1838										+			
Cyclotella atomus Hustedt, 1937												+	

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Trachelomonas intermedia Dangeard P. A., 1902	+				+								
Trachelomonas oblonga Lemmermann, 1899	+	+						+		+			
Trachelomonas planctonica Svirenko, 1914									+	+		+	+
Trachelomonas pulcherrima Playfair, 1915	+												
Trachelomonas scabra Playfair, 1915	+	+	+			+			+	+			
Trachelomonas verrucosa Stokes A., 1887													+
Trachelomonas volvocina (Ehrenberg) Ehrenberg, 1834													+
Trachelomonas volvocinopsis Svirenko, 1914									+			+	
Trachelomonas wislouchii Skvortzov, 1917		+			+	+					+		+
Trachelomonas woycickii Koczwara, 1914										+			
Phyllum Dinophyta										+			
Gymnodinium paradoxum Schilling A. J., 1891										+		+	+
Peridinium aciculiferum Lemmermann, 1900										+			
Peridinium cinctum (Müller O. F.) Ehrenberg, 1832					+	+						+	+
Phyllum Chrysophyta	+			+			+			+			
Chrysococcus rufescens Klebs, 1893		+			+	+							
Dinobryon bavaricum Imhof, 1890					+			+		+			
Dinobryon cylindricum Imhof O. E., 1887							+	+					
Dinobryon sertularia Ehrenberg, 1834											+		+
Phyllum Bacillariophyta	+						+						+
Achnanthes bioretii Germain, 1957			+										
Achnanthes Helvetica (Hustedt) Lange-Bertalot, 1989												+	
Achnanthes hungarica (Grunow) Grunow in Cleve and Grunow, 1880			+		+				+		+	+	+
Achnanthes lanceolata van Heurck H. (1880)	+	+	+				+		+	+	+		+
Achnanthes minutissima Kützing, 1833	+												
Amphora libyca Ehrenberg, 1840										+			+
Amphora ovalis (Kützing) Kützing 1844			+		+				+	+			
Amphora pediculus (Kützing) Grunow ex Schmidt A., 1875			+										
Amphora veneta Kützing, 1844										+			+
Anomoeoneis sphaerophora Pfitzer E., 1871	+	+		+	+	+	+			+	+		+
Asterionella formosa Hassall, 1850			+										
Cyclotella atomus Hustedt, 1937										+			

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Cyclotella cyclopunctata Håkansson and Carter J. R., 1990									+	+	+	+	+
Cyclotella distinguenda Hustedt, 1928										+			
Cyclotella meneghiniana Kützing, 1844	+					+				+		+	+
Cyclotella pseudostelligera Hustedt, 1939	+		+			+				+			+
Cymatopleura solea (Brébisson) Smith, 1851		+											
Cymbella affinis Kützing, 1844	+	+					+						
Cymbella aspera (Ehrenberg) Cleve, 1894		+						+					
Cymbella helvetica Kützing, 1844	+	+	+										
Cymbella minuta Hilse in Rabenhorst, 1862		+								+			
Cymbella simonsenii Krammer in Krammer and Lange, 1985									+				
Cymbella tumida van Heurck, 1880		+					+	+					+
Diatoma monoliformis (Kützing) Williams D. M., 2012	+												
Diatoma tenuis Agardh C., 1812					+								
Diatoma vulgaris Bory de Saint-Vincent, 1824	+												
Didymosphenia geminata (Lyngbye) Schmidt M. in Schmidt A., 1899							+			+			+
Diploneis eliptica (Kützing) Cleve, 1894		+											
Epithemia adnata (Kützing) Brébisson, 1838										+			
Fragilaria capucina Desmazières, 1830		+											
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot, 1980	+												+
Fragilaria crotonensis Kitton, 1869						+				+			
Fragilaria pulchella (Ralfs ex Kützing) Lange-Bertalot, 1980							+						+
Fragilaria tenera (Smith W.) Lange-Bertalot, 1980		+											
Fragilaria ulna (Nitzsch) Lange, 1980		+	+	+	+	+		+					
Fragilaria ulna var. *acus* (Kützing) Lange-Bertalot, 1980					+				+				
Fragilaria bidens Heiberg, 1863	+	+			+	+						+	+
Gomphonema acuminatum Ehrenberg, 1832									+				
Gomphonema augur Ehrenberg, 1840	+	+								+			
Gomphonema clavatum Ehrenberg, 1832		+					+						
Gomphonema olivaceum (Hornemann) Brébisson, 1838						+							
Gomphonema parvulum (Kützing) Kützing, 1849											+		
Gyrosigma acuminatum (Kützing) Rabenhorst, 1853	+	+	+		+	+		+	+		+	+	+

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; 7: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Melosira varians Agardh C., 1827										+			
Navicula capitata Ehrenberg, 1838												+	+
Navicula capitatoradiata Germain, 1981	+												
Navicula cincta (Ehrenberg) Ralfs in Pritchard, 1861							+						+
Navicula cryptotenella Lange-Bertalot in Krammer and Lange-Bertalot, 1985								+			+	+	+
Navicula cuspidata (Kutzing) Kutzing, 1844	+	+	+	+	+	+	+	+		+			
Navicula cuspidata var. *ambigua* (Ehrenberg) Cleve, 1894											+		
Navicula decusis Østrup, 1910												+	
Navicula gregaria Donkin, 1861													
Navicula kotschyi Grunow, 1860											+		
Navicula placentula Kützing, 1844		+	+	+			+						
Navicula pupula Kützing, 1844							+						
Navicula pygmaea Kützing, 1849							+						
Navicula tripunctata (Müller O. F.) Bory de Saint-Vincent in Bory de Saint-Vincent, 1822										+			
Navicula veneta Kützing, 1844													
Navicula viridula (Kützing) Ehrenberg, 1838	+	+	+	+	+	+				+	+		+
Neidium ampliatum (Ehrenberg) Krammer							+						
Nitzschia acicularis (Kützing) Smith W., 1853		+	+				+			+			
Nitzschia amphibia Grunow, 1862		+	+			+							
Nitzschia calida Grunow, 1880			+	+		+							
Nitzschia disipata (Kützing) Grunow, 1862								+					
Nitzschia hungarica Grunow, 1862				+									
Nitzschia levidensis Grunow in Heurck, 1881					+								
Nitzschia linearis Smith W., 1853			+										
Nitzschia palea (Kützing) Smith W., 1856		+	+							+			
Nitzschia reversa Smith W., 1853						+							
Nitzschia subacicularis Hustedt in Schmidt et al., 1922													+
Pinnularia microstauron (Ehrenberg) Cleve, 1891					+								
Pinnularia rupestris Hantzsch in Rabenhorst, 1861			+										
Pinnularia viridiformes Krammer Gaiser and Johansen, 2000				+									
Melosira varians Agardh C., 1827		+											
Rhoicosphaenia abbreviata (Agardh C.) Lange-Bertalot, 1980											+		

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Coccomonas elliptica Conrad		+											
Coccomonas platyformis Jane, 1944		+											
Coelastrum astroideum De Notaris, 1867			+		+	+	+			+			
Coelastrum pseudomicroporum Korshikov, 1953							+						
Coelastrum sphaericum Nägeli, 1849							+						
Coenococcus planctonicus Korshikov, 1953					+						+	+	
Coenocystis planctonica Korshikov, 1953					+								
Cosmarium botrytis Meneghini ex Ralfs, 1848					+			+					
Cosmarium botrytis var. *tumidum* Wolle, 1884			+										
Cosmarium formosulum Hoff, 1888	+												
Cosmarium granatum Brébisson ex Ralfs, 1848					+								
Cosmarium moniliforme Ralfs, 1848			+										
Cosmarium punctulatum Brébisson, 1856	+							+					
Cosmarium punctulatum var. *subpunctulatum* (Nordstedt) Børgesen, 1894						+							
Cosmarium subprotumidum Nordstedt, 1876						+							
Crucigenia pulchra (West) Komárek							+						
Crucigenia quadrata Morren, 1830							+						
Crucigenia tetrapedia Kuntze, 1898							+						
Crucigeniella apiculata (Lemmermann) Komárek, 1974						+	+			+			
Crucigeniella rectangularis (Nägeli) Komárek, 1974					+								
Dictyosphaerium chlorelloides (Nauman) Komárek and Perman, 1978					+								
Dictyosphaerium pulchellun Wood H. C., 1873		+	+	+		+							
Dictyosphaerium tetrachotomum Printz, 1914						+							
Didymocystis fina Komárek, 1975							+						
Elakatothrix gelatinosa Wille, 1898		+											
Eudorina elegans Ehrenberg, 1832	+				+			+				+	
Eutetramorus tetrasporus Komarek, 1983					+								
Golenkinia radiata Chodat, 1894				+		+							
Golenkiniopsis longispina (Korshikov) Korshikov, 1953		+	+										
Gonatozygon brebisonii Bary, 1858			+										
Gonium pectorale Müller O. F., 1773	+	+	+			+		+		+			
Granulocystis chlamydomonadoides Hindak, 1980			+										
Kirchneriella aperta Teiling, 1912				+									
Kirchneriella contorta (Schmidle) Bohlin, 1897							+						

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Kirchneriella irregularis (Smith G. M.) Korshikov, 1953							+			+			
Kirchneriella lunaris Möbius K., 1894								+					
Kirchneriella obesa (West) West and West G. S., 1894						+		+					
Kirchneriella subcapitata Korshikov, 1953							+						
Lagerheimia genevensis Chodat, 1895						+							
Lagerheimia longiseta (Lemmermann) Printz, 1914		+											
Lagerheimia subsalsa Lemmermann, 1898						+	+						
Lagerheimia wratislaviensis Schröder, 1897		+		+			+						
Micractinium pusillum Fresenius, 1858			+	+			+						
Micractinium quadrisetum Smith G. M., 1916		+	+			+							+
Monoraphidium arcuatum (Korshikov) Hindák, 1970		+				+	+			+			
Monoraphidium contortum (Thuret) Komárková-Legnerová in Fott, 1969		+		+	+	+	+	+		+			
Monoraphidium convolutum (Corda) Komárková-Legnerová, 1969							+						
Monoraphidium griffithii (Berkeley) Komárková-Legnerová, 1969		+	+	+	+	+				+			
Monoraphidium irregulare (Smith G. M.) Komárková-Legnerová, 1969		+					+						
Monoraphidium pusillum (Printz) Komárková-Legnorová, 1969							+						
Mougeotia sp. Agardh C. A., 1824								+					
Nephrocytium agardhianum Nägeli, 1849						+							
Oocystis borgei Snow J. W., 1903					+								
Oocystis lacustris Chodat, 1897			+		+	+	+						
Oocystis marssonii Lemmermann, 1898						+							
Oocystis parva West and West G. S., 1898						+							
Pandorina charkoviensis Korsch, 1923			+							+			
Pandorina morum (Müller O. F.) Bory de Saint-Vincent in Lamouroux, Bory de Saint-Vincent and Deslongschamps, 1824	+	+	+	+	+	+		+	+	+	+	+	+
Pediastrum boryanum Meneghini, 1840					+		+				+	+	+
Pediastrum boryanum var. *cornutum* (Raciborski) Sulek in Fott, 1969	+				+								
Pediastrum boryanum var. *longicorne* Reinsch, 1867						+				+			
Pediastrum duplex Meyen, 1829	+	+	+	+	+	+	+			+			
Pediastrum simplex Meyen, 1829						+	+						
Pediastrum tetras Ralfs, 1845		+	+		+		+						

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Polyedriopsis spinulosa (Schmidle) Schmidle, 1899		+		+									
Pseudotetrastrum punctatum (Schmidle) Hindák, 1977		+											
Pteromonas pseudoangulosa L. Péterfi, 1965		+											
Scenedesmus aculeolatus Reinsch, 1877							+						
Scenedesmus acuminatus (Lagerheim) Chodat, 1902		+	+	+		+	+			+			
Scenedesmus acutus Meyen, 1829				+			+						
Scenedesmus apiculatus (West and West G. S.) Chodat, 1926		+											
Scenedesmus arcuatus Lemmermann, 1899		+				+		+		+			
Scenedesmus bicaudatus Dedusenko, 1925							+						
Scenedesmus communis Hegewald E., 1977							+			+		+	+
Scenedesmus dimorphus (Turpin) Kützing, 1834					+								
Scenedesmus gutwinskii var. *heterospina* Bodrogsközy										+			
Scenedesmus intermedius Chodat, 1926		+								+			
Scenedesmus lefevrei var. *manguinii* Lefèvre and Bourrelly, 1941		+											
Scenedesmus longispina Chodat R., 1913								+					
Scenedesmus obtusus Meyen, 1829				+	+		+						
Scenedesmus opoliensis Richter P. G., 1897		+	+	+		+	+			+			
Scenedesmus quadricauda (Turpin) Brébisson in Brébisson and Godey, 1835	+	+	+	+	+	+	+						
Scenedesmus regularis Svirenko, 1924						+	+						
Scenedesmus sempervires Chodat, 1913		+	+										
Scenedesmus spinosus Chodat, 1913							+						
Scenedesmus subspicatus Chodat, 1926							+						
Schizochlamys gelatinosa Braun A. in Kützing, 1849								+					
Schroederia setigera (Schröder) Lemmermann, 1898		+					+						
Schroederia spiralis (Printz) Korshikov, 1953							+			+			
Selenastrum bibraianum Reinsch, 1866		+	+			+							
Selenastrum gracile Reinsch, 1866			+			+							
Siderocelis ornata (Fott) Fott, 1934		+					+						
Sphaerellopsis ordinata Skuja H., 1964		+											
Spirogyra sp. Link, 1820								+					
Staurastrum inflexum Brébisson, 1856					+	+							
Staurastrum manfeldtii Delponte, 1878					+	+							
Staurastrum paradoxum Meyen ex Ralfs, 1848								+					

Table 3 (continued): List of algal taxa identified in the 13 floodplain lakes from Balta Mică a Brăilei area in 2012-2013 (**1**: L1_14.06.12; **2**: L2_19.07.12; **3**: L3_18.07.12 and L3_22.06.13; **4**: L4_21.07.12; **5**: L5_13.06.12 and L5_22.06.13; **6**: L6_13.06.12; **7**: L7_20.07.12; **8**: L8_15.06.12; **9**: L9_29.04.13; **10**: L10_26.09.12 and L10_28.04.13; **11**: L11_27.04.13; **12**: L12_28.04.13; **13**: L13_27.04.13; abbreviation of the sampling sites and occasions as in table 1).

Staurastrum paradoxum var. *reductum* Coesel, 1996						+							
Stigeoclonium lubricum Kützing, 1845												+	
Temnogametum sinense Jao C. C. and Hu H. J., 1978	+												
Tetraedron caudatum (Corda) Hansgirg, 1888		+	+				+						
Tetraedron acutum Playfair					+								
Tetraedron enorme (Ralfs) Hansgirg, 1888		+											
Tetraedron limneticum Borge, 1900		+											
Tetraedron longispinum (Perty) Playfair		+	+										
Tetraedron minimum (Braun A.) Hansgirg, 1888		+	+	+			+			+			
Tetraedron muticum (Braun A.) Hansgirg, 1888					+								
Tetraedron regulare Kützing, 1845		+											
Tetraedron triangulare Korshikov, 1953										+			
Tetraedron trigonum (Nägeli) Hansgirg, 1888		+											
Tetrastrum elegans Playfair, 1917							+						
Tetrastrum heteracanthum (Nordstedt) Chodat, 1895		+											
Tetrastrum peterfii Hortobagyi, 1967		+		+									
Tetrastrum staurogeniiforme (Schröder) Lemmermann, 1900										+			
Tetrastrum triangulare Komárek, 1974		+				+							
Treubaria setigera (Archer) Smith G. M., 1933			+										
Treubaria triappendiculata Bernard C., 1908						+							
Westella botryoides (West) De Wildeman, 1897					+	+		+					

Lake Sbenghiosu recorded the highest species richness, with a total of 109 taxa (Fig. 3). A higher number of taxa were identified in June, July and September 2012, compared to April and June 2013 (Mann-Whitney test U = 0; p = 0.00017; n_1 = 9; n_2 = 7). This is probably due to the differences in the Danube River discharge from one year to another: in 2013, drastic discharge increases led to a high volume of water entering the floodplain lakes, washing and reducing the algal species number, thus influencing the species richness.

A low similarity was recorded between the algal communities from the 13 sampling sites from Balta Mică a Brăilei Nature Park, even if most of the sampling lakes were located not far away from each other and some were even inter-connected through canals (Fig. 4). The Jaccard similarity percentage did not exceed 30%, probably due to the high diversity of microhabitats characteristic to the 13 sampling lakes, mainly depending on the characteristic macrophytes (submerged, emerged or natant).

Three clusters were clearly separated, similar to those distinguished in the PCA biplot (Fig. 2): lakes sampled in June 2013, the ones sampled in April 2013 and those sampled in 2012. The only sampling site that did not fit into one of these was lake Japşa – L1 (Fig. 4), due to its temporary character (lake Japşa was a shallow flooded area inside the Vărsătura Island).

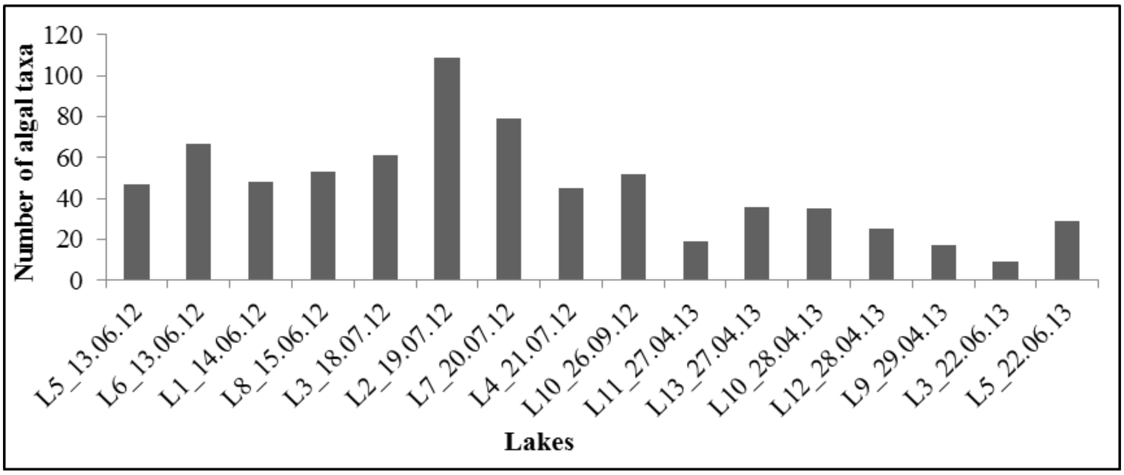

Figure 3: Number of algal taxa from the 13 lakes (16 sampling occasions) from Balta Mică a Brăilei Nature Park, arranged in chronological order (abbreviation of the sampling sites and occasions as in table 1).

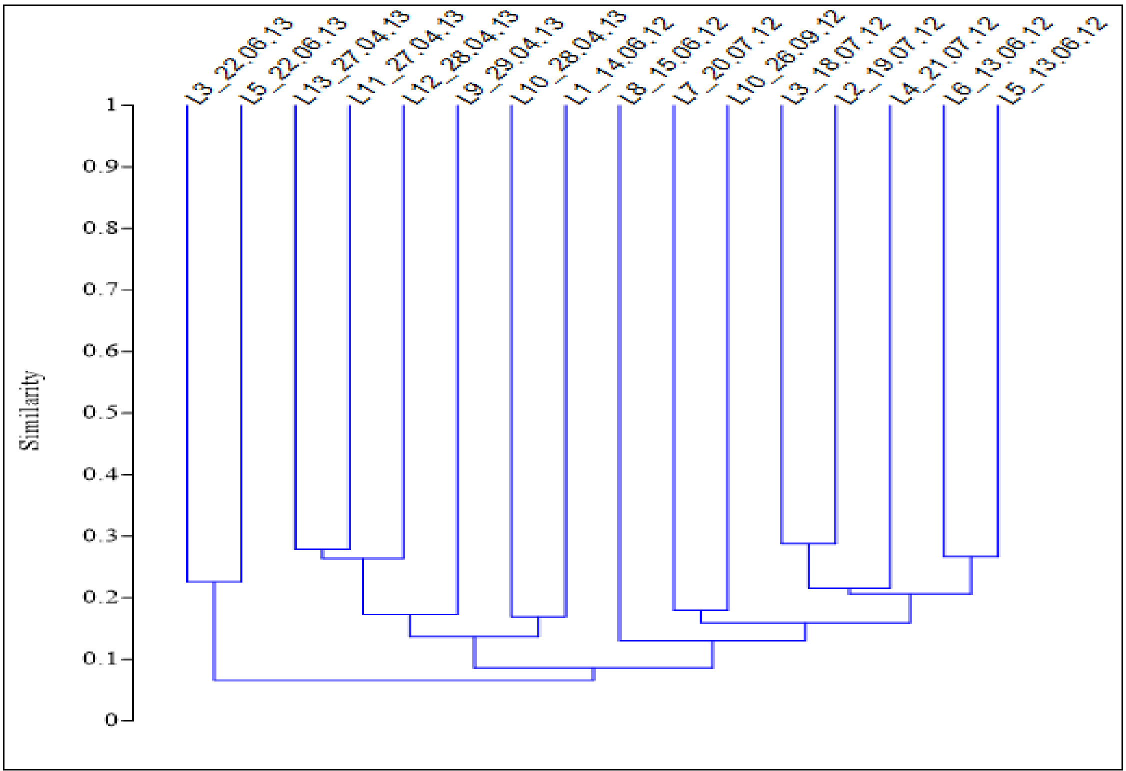

Figure 4: Jaccard similarity between the algal communities of the considered lakes from Balta Mică a Brăilei Nature Park (abbreviation of the sampling sites and occasions as in table 1).

The distinctive separation between these clusters indicates the importance of the flood pulses, meaning that the structure of algal communities from Balta Mică a Brăilei Nature Park was highly dependent on the water-level fluctuations of the Danube, ranging from extreme low flows to maximum ones. In fact, pelagic food chains in river floodplain systems are primarily under hydrological control (Schiemer et al., 2006). Thus, in order to maintain the biodiversity of the wetland, the connectivity between the river and its floodplain lakes must be preserved, together with a variable flow regime and a sufficient spatial scale (Opperman et al., 2010).

Water quality

Water quality of the 13 sampling lakes from Balta Mică a Brăilei Nature Park area was assessed in terms of trophicity and organic pollution (saprobity), using three main indices.

Water trophicity was evaluated by the trophic index Heinonen (1980) and the compound index (Nygaard, 1949). The first one was impossible to calculate in lakes Jigara and Bordeiele (L4_21.07.12 and L10_26.09.12), because no oligotrophic species were found. The compound index was not estimated in lake Cortele (L7_20.07.12), due to the absence of species belonging to the Order Desmidiales.

In the other lakes, both indices indicated eutrophic waters in summer and autumn 2012, probably due to the nutrient concentration in the floodplain lakes, caused by the extended drought period from 2012, characterized by a lack of precipitation and high temperatures, which led to increased water evaporation (Fig. 5). On the other hand, the trophicity level dropped in 2013, probably due to changes in hydrological conditions: the high water levels from April and June 2013 washed out some of the nutrients from the lakes.

The organic pollution index showed a similar status, with strong organic pollution in 2012, due to high quantities of decomposing organic matter accumulated during summer and autumn in the water pools. In 2013 however, organic pollution was relatively low, because of the spring flush, which washed away the organic matter, facilitating its mineralization (Fig. 5).

Water bloom caused by Euglenophyta was detected in lake Sbenghiosu in July 2012. Indeed, euglenoids are known to be dominant in eutrophic lakes, where organic pollution is high (Tas and Gonulol, 2007; Bellinger and Sigee, 2010).

The lower trophic and saprobic levels shown by the lakes from Balta Mică a Brăilei Nature Park in the period of high water levels from April and June 2013 are in accordance with other findings from the middle Danube River stretch. For example, Mihaljević et al. (2010) showed that the extreme flooding of the Danube from 2006 represented a stressor that led to the transition from turbid, eutrophic-hypertrophic conditions to a clear water state in the floodplain lake Sakadaš (Kopački Rit Nature Park, Croatia).

CONCLUSIONS

A total number of 315 algal taxa were identified through sampling 13 lakes from the Balta Mică a Brăilei Nature Park in 2012 and 2013, with 11 taxa cited for the first time in Romania. The algae identified were both planktonic and benthic forms, due to the shallow depth of the sampled water pools. During high water level periods (mostly April 2013), diatom species were numerous while green algae, euglenoids and blue-greens recorded drastic decreases in species number.

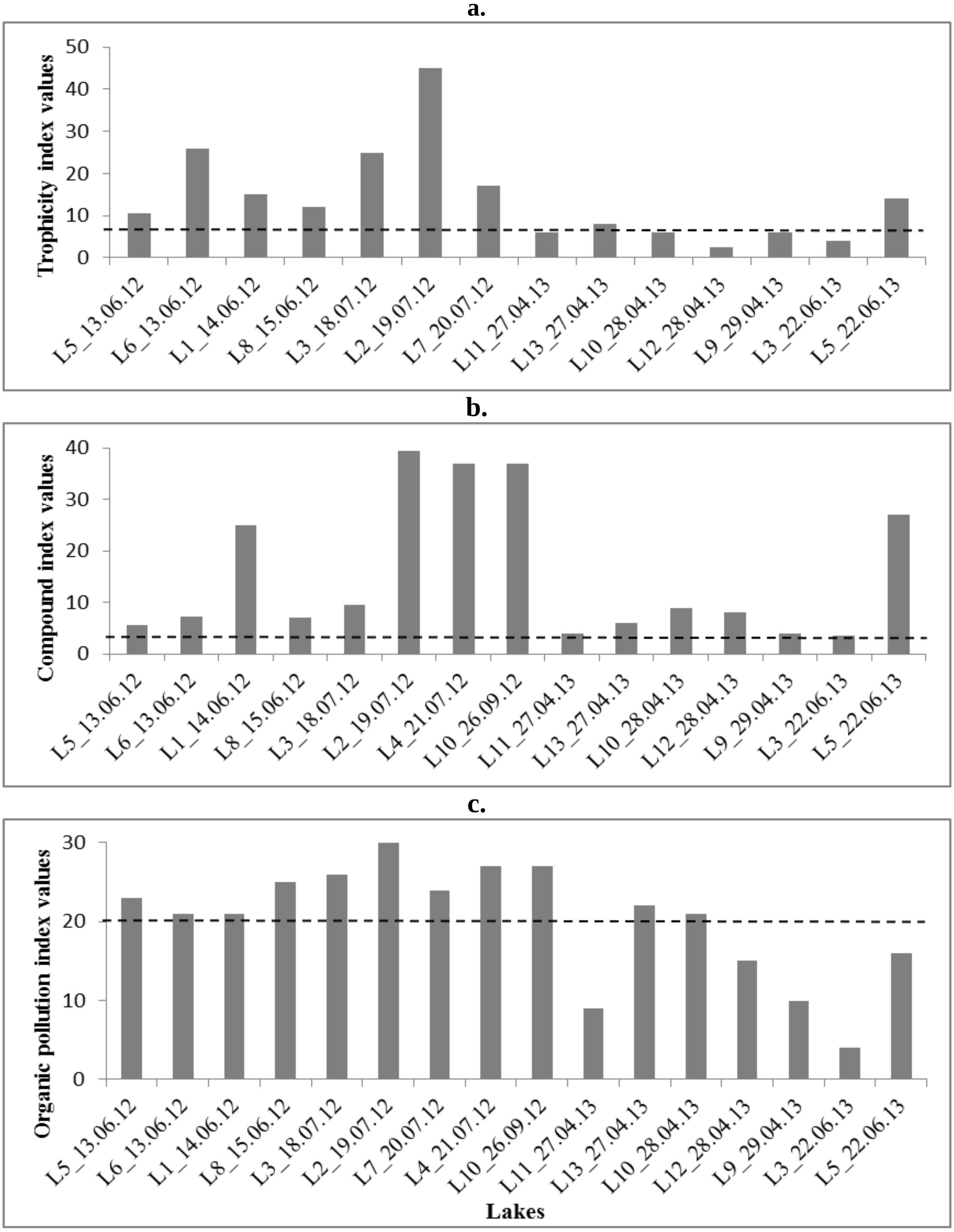

Figure 5a, b, c: Values of the trophicity and organic pollution indices (a, b, c), calculated for the sampling lakes from Balta Mică a Brăilei Nature Park, arranged in chronological order (dashed line: threshold values of the indices; abbreviation of the sampling sites and occasions as in table 1).

The sampled lakes demonstrated great diversity in terms of microhabitats, with a corresponding diversity in algal community composition, even for lakes located quite close together.

Algal communities are dependent on the flood pulse events, and so is the trophicity and organic pollution of all the lakes from the Balta Mică a Brăilei Nature Park. The Danube brings nutrients during the spring floods; they concentrate in summer, when the lakes are isolated from the river and its arms, leading to increases in trophicity. Spring floods also wash out the decomposing organic matter accumulated in the water pools from the area, leading to accelerated mineralization and lower organic pollution. In fact, trophicity and saprobity of the sampling lakes were higher in 2012 compared to 2013, due to this flood pulse cycle.

AKNOWLEDGEMENTS

The sampling took place as part of the project "Revizuirea Ediției a II-a a Planului de Management al Parcului Natural Balta Mică a Brăilei, în contextul atribuirii statutului de SCI și SPA (Balta Mică a Brăilei Nature Park management plan: review of the second edition for the assignment of SCI and SPA status)". We recognize with gratitude the support provided to us by the administration team of Balta Mică a Brăilei Nature Park. Thanks are also given to the National Institute of Hydrology and Water Management (INHGA) and to the National Meteorological Administration, who provided the hydrologic and climatic data.

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HABITATS WITH SEA GRAPE (*EPHEDRA DISTACHYA*) ON THE DUNES OF LETEA (DANUBE DELTA, ROMANIA)

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DOI: 10.1515/trser-2015-0062

KEYWORDS: grey dunes, pioneer colonisation, adaption to extreme dryness, xerothermophilous vegetation, ecological gradients, groundwater table.

ABSTRACT

The Danube Delta is known for its unique, biogeographical-important ecosystem complex that includes a large range of habitats from the permanently water-covered to the extremely dry area. These ecosystems are well represented in the area nearest to the Black Sea in the dune area of Letea, Caraorman and Sărăturile. Sea grape (*Ephedra distachya*) communities taking part of the habitat type 2130* fixed coastal dunes with herbaceous vegetation (grey dunes), Subtype 16.22 B Pontic fixed dunes and their classification in the European habitat system are discussed and a proposal is made for their appropriate integration in a corresponding category of habitat types in the frame of the Pontic bioregion.

ZUSAMMENFASSUNG: Lebensräume mit Meerträubchen (*Ephedra distachya*) auf den Dünen von Letea (Donau-Delta, Rumänien).

Das Donau-Delta ist bekannt für seinen einzigartigen Ökosystemkomplex von großer biogeographischer Bedeutung, der von ständig wasserbedeckten bis hin zu extrem trockenen Bereichen eine weite Spanne von Lebensräumen umfasst. Die ausgeprägt trockenen Bereiche konzentrieren sich auf den Meer nahen Bereich des Deltas und zwar auf die Dünengebiete von Letea, Caraorman und Sărăturile. Die Bestände des Meerträubchens (*Ephedra distachya*), die dem Habitatyp 2130* Festliegende Küstendünen mit krautiger Vegetation (Graudünen), Subtypus 16.22 B Pontische festliegende Dünen zugeordent sind, werden diskutiert und eine entsprechende Einordnung der Meerträubchenbestände im System der Habitattypen der pontischen Bioregion vorgeschlagen.

REZUMAT: Habitatele cu *Ephedra distachya* de pe dunele de la Letea (Delta Dunării, România).

Delta Dunării e cunoscută pentru unicul său complex de ecosisteme de importanţă biogeografică, cuprinzând o largă amplitudine de habitate, de la zone permanent acoperite cu apă până la locuri extrem de uscate. Ariile cele mai uscate se concentrează în delta maritimă şi anume pe dunele de la Letea, Caraorman şi Sărăturile. Fitocenoze edificate de cârcel (*Ephedra distachya*) făcând parte din tipul de habitat 2130* – Dune de coastă cu vegetaţie erbacee (dune gri), Subtipul 16.22 B Dune fixate pontice – dune fixate de pe Coastele Mării sunt discutate şi analizate din punct de vedere ecologic şi al integrării în sistemul de habitate europene de dune, făcându-se propunerea pentru o mai adecvată integrare în cadrul bioregiunii pontice.

INTRODUCTION

The Danube Delta is 4,180 km² (Gâştescu and Ştiucă, 2008), of which 84% is situated in Romania. It is one of the largest wetlands of Europe, and known worldwide for its unique, biogeographical important ecosystems, including a large range of habitats from the permanently water covered to the extremely dry. The diversity of the habitats is reflected through the remarkable diversity of plant and animal species and their coenoses. The delta shelter, with 1,560 km², is one of the worldwide largest, compact reed areas edified by *Phragmites australis*, with large floating reeds. The so-called "Plaur", gallery-like white willow softwood, stands along the Delta branches. Sheltering species adapt to extreme conditions, such as large water bodies covered by floating, emerged and submerged macrophytes as well the maritime part dune area, partly with extremely dry sites. The largest dune complexes are those of "Grindul Letea", north of the Sulina branch, "Grindul Caraorman", and "Grindul Sărăturile", between Sulina and Sfântu Gheorghe Branch.

The so-called "Grind" area of the Danube Delta is also represented, according to Antipa (1911), by high elevations of various genesis. On the one hand, there are natural river bank levees named in Romanian "grinduri de mal", emerged by the continuous dynamics of the Danube deposits during high floods fine sized sediments on the river banks. On the other hand, in the Delta high elevations of continental origin – the Grindul or "Plain" of Chilia (Câmpul Chiliei) and Grindul Stipoc, rests the Bugeac Plain with loess depositions of quaternary age rising up to one to 13 m. The third category, the above mentioned Grinds of Letea, Caraorman and Sărăturile are marine levees, old beach barrier complexes, composed by Sea mussels and sand (Gâştescu and Ştiucă, 2008). These dunes are almost fixed, but there are also some areas on the coast near Sfântu Gheorghe Branch which are in a less fixed state. The fan-like dunes of Letea (Fig. 1) and Caraorman with their dune ridges and dune depressions offer a rich structured and multifaceted complex of habitats sheltering a very specific and unique vegetation and fauna in a range of habitats. These habitats vary depending on the dunes exposure to sun and the related level of dryness, as well as the alternation between dunes and depressions between them. These dune depressions are occupied locally by shrubs of *Salix rosmarinifolia* at the initial stage, and by a type of floodplain forest with changing ground water table, being edified by oaks (*Quercus robur*, *Quercus pedunculiflora*) and ash (*Fraxinus pallisae*, *Fraxinus angustifolia*), as well as lianes such as Silke wine (*Periploca graeca*) and Wild wine (*Vitis sylvestris*), singular in its structure and biodiversity (Borza, 1931; Hanganu et al., 2015; Schneider, 2015). Dominate steppe vegetation with pontic and continental-Eurasian xero- and thermophilous species are on the top of the dunes with elevations of + 12.00 m (Caraorman) and + 14.00 m in the Letea area (Cioacă et al., 2005; Gâştescu and Ştiucă, 2008).

These more or less open dunes, entering in the majority of the category of grey dunes, are colonised by characteristic species of mostly dry sands and are included in the priority habitat type 2130* – Fixed coastal dunes with herbaceous vegetation (grey dunes), subtype 16.22 B − Pontic fixed dunes – of the coasts of the Black Sea (EUR 28, 2013; Gafta and Mountford, 2008; Fig. 2). One of the edifying species typical for the dune habitats on the Black Sea coasts, including the Danube Delta, is the Sea grape (*Ephedra distychya*), known in particular from the Letea dune area and "holding on with success on the higher levels of the dunes" (Borza, 1931). But these grey dunes have so many colonizers: edifying different phytocoenoses in different microhabitats; depending on the dunes altitude, exposition and related dryness; that it has to be clarified; if it is justified to include them all in the above mentioned habitat type of grey dunes; or each in separate habitat type. This consideration is related to the fact that there are also more detailed delineated habitat types for dune areas, edified each by characteristic species and not included in the habitat type of grey dunes.

Part of our considerations is as well the fact, that the grey dunes of the Black Sea coast and the Danube Delta are included in the category of habitat types of “Sea dunes of the Atlantic, North Sea and Baltic coasts” as the “subtype 16.22 B − Pontic fixed dunes – fixed dunes of the coasts of the Black Sea” although they occur in the Black Sea/Pontic Bioregion. This Bioregion is strongly related in its Southern part to the Mediterranean Bioregion and as well interlocked with the Steppic Bioregion. The Black Sea Pontic Bioregion − including the marine part of the Danube Delta − shelter some habitat types between others, the habitat type 1410 Mediterranean salt meadows (Juncetalia maritimi), characteristic for the Mediterranean Bioregion, occurring in the area of the Southern Sfântu Gheorghe Branch and the Popina area situated on the lower part of the Chilia Branch.

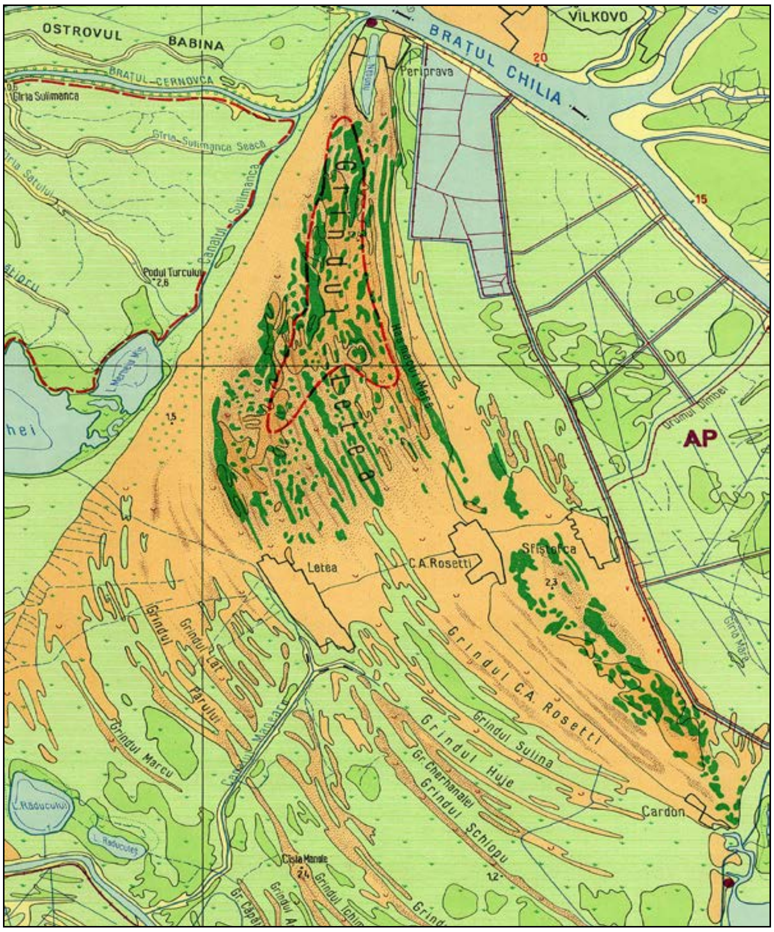

Figure 1: The Letea dune area showing the Letea Forest patches, the three villages Letea, C. A. Rosetti and Sfiştofca and surrounding area (Gâştescu, 1992 – detail of Touristic map of the Danube Delta). With red border is the strictly protected dune area.

Taking into account these facts, the objective of this paper is to analyse the habitat with *Ephedra distachya* in strong relation with other habitats of the area which are characteristic for the Steppic and the Pontic/Black Sea Bioregion, as well as the Mediterranean Bioregion, and to propose the appropriate type of habitat, subhabitat or category of habitat types of the above mentioned two bioregions in which it can be included.

Figure 2: Dune area of Letea with different type of dune vegetation:
Ephedra distachya and *Carex colchica* in the foreground,
dune slacks with *Salix rosmarinifolia* and forests in the background.

MATERIAL AND METHODS

The pioneer vegetation of the Letea dune area has been studied during field researches in the Danube Delta in September 2011. Some earlier data from the year 2003 from Letea dune Omer, the highest elevation, has been included. Samples were taken according to the method of Braun-Blanquet with the seven degree abundance-dominance scale (Braun-Blanquet, 1964; Borza and Boşcaiu, 1965). The taken samples are included in a phyto-coenological table where it is mentioned the distribution area of each species according to the data from Romanian Flora works (Ciocârlan, 1994, 2009; Oprea, 2005; Sârbu et al., 2013) and compared with data of other mentioned phytocoenoses and habitats edified by *Ephedra distachya* (Sanda et al., 2008; Doniţă et al., 2005; Horvat et al., 1974; Krausch, 1965; Simon, 1960). The nomenclature of species is used according to Sârbu et al. (2013), Ciocârlan (2009), and partly Oberdorfer (2001).

RESULTS AND DISCUSSIONS

Dunes with phytocoenoses edified by Sea grape (*Ephedra distachya*) are mentioned from the Black Sea coast in the dune area of Agigea near Constanța, the Caraorman and the Letea dune complexes, near Sulina, Gura Portiţei (Borza, 1931; Grinţescu, 1952; Simon, 1960; Krausch, 1965; Sanda and Popescu, 1973; Făgăraş, 2002; Sanda et al., 2008; Hanganu et al., 2015; Schneider, 2015), Grindul Chituc (Sârbu et al., 1995; Făgăraş, 2002), Mamaia, Eforie, Techirghiol, Grindul Saele (Făgăraş, 2002). *Ephedra distachya* is part of the Gymnospermae, Order Gnetales and Ephedraceae family, being a dioic scrub (Figs. 3 and 4), growing erectly, or prostrate, ramified on the base, with flexible nodose branches, being well adapted through its morphological structure to the dry conditions on the Southern, South-Eastern and South-Western exposed slopes of the dunes. It occurs more on the upper part of the slopes and on the top of the dunes, as it can be observed at the dune with the highest elevation, the Omer-dune in the fan-like dune complex of Letea.

Figure 3: *Ephedra distachya* male plant on the dune Omer/Letea dune complex (photo Schneider E., 2011).

Figure 4: *Ephedra distachya*, female plant with fruits on the dune Omer, Letea dune area in 2011.

On the dunes the Sea grape forms mostly open pioneer stands together with other species well adapted to the dry conditions of the top of the dunes. It edifies characteristic phytocoenoses in particular with *Carex colchica*, *Polygonum arenarium*, *Euphorbia seguieriana* and other arenophilous and xero-thermophilous species (Tab. 1).

Following the disposition of vegetation on the dune slopes, a clear ecological gradient can be remarked. On the foot of the dunes with existing influence of the changing groundwater table, phytocoenoses of *Scirpoides holoschoenus* (*Holoschoenus vulgaris*) occurs. In their lower part, they are locally in contact with dune slacks edified by *Salix rosmarinifolia.* On the upper part of the slopes are interlocking with phytocoenoses of *Carex colchica* with frequent facies of *Ephedra distachya* to the top of the dunes and accompanied by other xero-theromophilous species (Simon, 1960). This is the site where the Sea grape is growing in abundance. On the top of the dunes, it occurs also together with *Festuca beckeri* ssp. *arenicola* and *Stipa borysthenica*.

According to Sanda et al. (2008) *Ephedra distachya* occurs in phytocoenoses of the association Scabioso argenteae-Caricetum colchicae (Simon, 1960) Krausch 1965 (Syn. Caricetum colchicae Simon, 1960; Carici colchicae-Holoschoenetum vulgaris Ștefan and Sârbu, 1995) subass. ephedretosum Sanda et al., 1999 (Syn. Ephedro-Caricetum colchicae (Prodan n.n., Morariu, 1959) Sanda and Popescu, 1973). In these phytocoenoses, the Sea grape develops abundantly and it seems to be − according to our own observations − in continuous expansion. Similar observation where made also at Grindul Chituc (Sârbu et al., 1995).

Table 1: Scabioso argenteae-Caricetum colchicae (Simon 1960) Krausch, 1965, subass. ephedretosum Sanda et al., 1999; 1. Dune Omer/Letea 5.06.2003; 2-14 Dune Omer and proximity 08.09.2012.

	Sampling number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Covering degree %	45	20	20	25	35	10	20	25	45	20	55	25	40	30
Flor.-elem.															
	Scabiosion argenteae Festucetalia vaginatae														
Ct-Eua	*Ephedra distachya*	3	2	2	1	3	1	1	2	3	+	3	2	3	2
P	*Carex colchica*	1	+	.	.	.	.	.	.	.	+	.	.	+	1
P-Balc	*Scabiosa argentea*	+	.	.	.	.	.	.	.	.	.	.	+	+	.
P-Pan-Md	*Polygonum arenarium*	+	+	.	.	.	+	+	+	1	2	+	+	+	+
P-Med.	*Cynanchum acutum*	.	.	.	.	.	.	.	.	.	.	.	.	.	+
P	*Stipa borysthenica*	+	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 1 (continued): Scabioso argenteae-Caricetum colchicae (Simon 1960) Krausch, 1965, subass. ephedretosum Sanda et al., 1999; 1. Dune Omer/Letea 5.06.2003; 2-14 Dune Omer and proximity 08.09.2012.

P	*Dianthus bessarabicus*	.	.	.	+	+	.	.	.	.	.	.	.	.	.
	Elymion gigantei	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P	*Leymus sabulosus*	.	.	.	+	.	+	+	.	.	.	+	.	+	1
.	Festucion, Festucetalia														
Eua	*Linum austriacum*	.	+	+	.	.	.	.	.	.	.	.	.	.	.
Ct-Eua	*Linaria genistifolia*	+	.	.	.	.	.	.	.	.	.	.	.	+	.
Ct-Eua	*Euphorbia seguieriana*	.	+	+	+	+	+	+	.	.	+	.	+	+	.
Ct-Eua	*Silene otites*	+	.	.	+	.	.	.	.	.	.	.	.	.	.
Eua-Ct	*Alyssum desertorum*	+	.	.	.	.	.	.	.	.	.	.	.	.	.
	Acompainying species														
Eua-smed	*Scirpoides holoschoenus*	.	+	+	.	.	+	+	.	.	+	.	+	.	.
Eua-Ct	*Erysimum cuspidatum*	.	+	+	.	+	+	+	+	.	.	+	.	.	+
Ct-Eua	*Artemisia santonicum*	.	.	+	2	+	+	1	.	+	+	.	.	.	.
Ct-Eua	*Kochia prostrata*	.	+	.	.	.	.	.	.	+	.	.	+	.	+
Eur	*Berberis vulgaris*	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Euras	*Salix rosmarinifolia*	.	.	.	.	.	.	.	.	.	.	.	1	.	.
	Cladonia furcata	1	.	.	.	.	.	1	1	.	.	2	.	+	.

Near *Ephedra distachya* and *Carex colchica*, *Polygonum arenarium* with high constancy and *Euphorbia seguieriana* have to be mentioned accompanied by other xero-thermophilous species of Festuco-Brometea (Tab. 1).

The Sea grape (*Ephedra distachya*) is mentioned as edifying species in phytocoenoses of the association Koelerio glaucae-Stipetum borysthenicae (Popescu and Sanda, 1987) with species of the alliance Festucion vaginatae such are *Euphorbia seguieriana* (transgressive species of the Festuco-Brometea), *Helichrysum arenarium, Dianthus bessarabicus* and others.

As the abundance-dominance and the frequency of Sea grape (*Ephedra distachya*) are in some area relatively high and with a clear ecological differentiation, vis-à-vis – the typical association of Scabioso argenteae-Caricetum colchicae – it is also justified to consider the subassociation ephedretosum as it is given by Sanda et al., 2008, again as an independent association Ephedro-Caricetum colchicae (Prodan 1939 n.n. Morariu, 1959) Sanda and Popescu, 1973. This opinion is documented also by Doniţă et al. (2005) for the habitat type R1603 including communities of Sea grape of the Ephedro-Caricetum colchicae.

Due to changes of the Danube hydrological regime and the dropping down of the groundwater table in the dune area Letea (Cioacă et al., 2005), the xerophilous steppe species increased and became dominant lately. This observation fits together with the observation of continuous expansion of the species mentioned by Sanda et al. (2008). According to field observation, a strong interlocking exists between the phytocoenoses of the different phytocoenological units, thanks to the micromosaic of the dunes morphological structure.

The above presented association Scabioso argenteae-Caricetum colchicae (Simon 1960; Krausch 1965), subass. ephedretosum Sanda et al., 1999 takes part of an entire vegetation complex, colonising the dune area and forming the characteristic habitat type 2130* fixed coastal dunes with herbaceous vegetation (grey dunes), subtype 16.22 B Pontic fixed dunes – fixed dunes of the coasts of the Black Sea. But the site conditions of the dunes are various in dependence of localisation on the slope (foot of the slope or upper part and top of the dunes), the inclination and exposition, making it difficult to include all the different phytocoenoses in the broad considered habitat type of grey dunes. In this context, it can be stated that the habitat with Sea grape (*Ephedra distachya*) is very good contoured and can be considered together with the structure of its schrubs as an independent habitat type.

Phytocoenoses with *Ephedra distachya* as characteristic and edifying species are described also from grey dunes in the North-Eastern part of Greece as association *Ephedra distachya-Silene subconica* Oberd. 1952 (Oberdorfer, 1952; Horvat et al., 1974). The phytcoenoses of this association are characterized besides *Ephedra distachya* and *Silene subconica* through the species *Silene dichotoma, Centaurea cuneifolia, Fumana procumbens, Verbascum pinnatifidum, Jasione heldreichii, Corynephorus articulatus* and *Phleum arenarium.* The composition of this association − including many Eurasian continental species − indicates the relation with the arid steppe area north of the Black Sea and the semi-desert of Asia (Horvat et al., 1974). Both associations, *Ephedra distachya-Silene subconica* of North-Eastern Greece and Scabioso argenteae-Caricetum colchicae subass. ephedretosum of the Danube Delta, are strongly related; their species of continental, Pontic and Mediterranean origin and their habitat structure being near one to the other.

The grey dune habitats of North-Eastern Greece can be considered as a connector between Pontic associations and their habitats with those lying more in the Southern and Western Grey dunes of the Mediterranean Sea which are included in the habitat type 2220 Dunes with *Euphorbia terracina* (EUR28, 2013). These are characterized as coastal dune grassland communities among others like *Euphorbia terracina, Silene nicaeensis, Ephedra distachya* and *Silene subconica.* In each case, the grey dunes of the Black Sea coast − as a part of the Pontic bioregion − cannot be further included as a subtype of the habitat type 2130 in the Habitat category of Sea dunes of the Atlantic, North Sea and Baltic coasts as it is given in the Interpretation Manual of European Union Habitats (EUR28, 2013). It had to be included either in the category of Sea dunes of the Mediterranean coasts, as there are strong relations between the Dunes of the Mediterranean and the Black Sea coasts, or in an independent category of Sea dunes of the Black Sea/Pontic bioregion. This is justified by the transition character between the Mediterranean dunes and those of the Pontic and continental area. The

Black Sea particularity i.e. Pontic region is underlined as well by the Palaearctic classification, under the habitat number 1622B121, including North-Western Pontic *Ephedra-Carex* fixed dune and the EUNIS classification under B1.4B1 Western Pontic fixed dunes (Doniţă et al., 2005; Hanganu et al., 2015). The vegetation is a more or less open cover of *Ephedra distachya* and herbacous plants, as well in some places by lichens *Cladonia* ssp. The Western-Pontic character of the habitat is recognised also by Doniţă et al. (2005), where is mentioned as “Western Pontic communities with *Carex colchica* and *Ephedra distachya*”.

The communities of *Ephedra distachya* on sandy dunes with their small scrubs constitutes a habitat with a particular structure, given by the ramified branches. This is favourable for the rare Steppic Lizard (*Eremias arguta deserti*), a Pontic-Caspian species (Oţel, 2000) living on the dry dunes, which offer them a favourable habitat with appropriate hiding and nutrition places.

The Sea grape (*Ephedra distachya*) occurs also in another habitat existing on the Romanian coast i.e. the rocky slopes of the Razim Lake, a former lagoon of the Black Sea, where it occurs together with *Limonium* species, constituting a habitat near those mentioned from the coast of the Mediterranean Sea under the habitat number 1240 Vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* ssp. (EUR28, 2013) (Fig. 5). This is also a habitat type which is rare on the Black Sea coast and needs comparative studies with similar habitats of the Mediterranean region for the clarification of its distribution area and position in the system of habitats of the European Union.

Figure 5: Dune with Sea grape (*Ephedra distachya*) a characteristic habitat for the Steppe Lizard (*Eremias arguta*) (photo Schneider E., 2011).

Figure 6: Rocky slopes on the Razim Lake (Danube Delta Biosphere Reserve) with *Ephedra distachya*, *Kochia prostrata* and *Limonium meyeri* (photo Kuhlke F., 2011).

CONCLUSIONS

Considering the species composition of the habitat type with many species with Pontic, Pontic-Mediterranean and Eurasian-Continental distribution, it can be stated that the dune habitat with Sea grape (*Ephedra distachya*) is characteristic for the Pontic and Mediterranean bioregion. This is why the inclusion of such a habitat subtype in the habitat type category of "Sea dunes of the Atlantic, North Sea and Baltic coasts" is not appropriate and has to be changed.

The proposal is to include it in the category of Mediterranean dune habitats and to generalise this as a habitat type category under the name of "Sea dunes of the Mediterranean and the Black Sea coast", or to introduce in the Interpretation Manual a new, additional category of habitat types characteristic for the Pontic bioregion under the name "Sea dunes of the Pontic – Black Sea bioregion". This proposal is justified as in the Palaearctic classification of habitats is mentioned the habitat 16.22B 121 North-Western Pontic *Ephedra*-*Carex* fixed dunes and in the EUNIS classification the habitat B 1 4B1 Western Pontic fixed dunes.

In the frame of habitats of grey dunes, the Sea grape (*Ephedra distachya*) communities are different in their structure compared to the small schrub constituting a more independent habitat type in comparison with other components i.e. microhabitats included in the large habitat type of grey dunes.

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SOME MORPHOLOGICAL CHARACTERS OF FEMALE OF *MOTHOCYA EPIMERICA* COSTA, 1851 (FLABELLIFERA: CYMOTHOIDAE) FROM SEA OF MARMARA

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DOI: 10.1515/trser-2015-0063

KEYWORDS: Mothocya, mandible, maxilliped, maxilla, maxillae.

ABSTRACT

Mothocya epimerica Costa, 1851 (Flabellifera: Cymothoidae) is a cymothoid parasite of fishes belonging to Atherinidae (*Atherina hepsetus, Atherina boyeri*) from Mediterranean Sea, Black Sea and Atlantic Ocean. Öktener and Sezgin (2000) recorded this parasite for the first time in Turkey. The mentioned authors presented some morphological characters, although, some characters are not explained in the publication. Some morphological characters seen on the mandible, maxilliped, maxilla, maxillue and the spines on pleopods of the female of *M. epimerica* are shown. The characters presented in our study are based on the drawings made from collected specimens.

RESUMEN: Algunas características morfológicas de hembras de *Mothocya epimerica* Costa, 1851 (Flabellifera, Cymothoidae) del Mar de Mármara.

Mothocya epimerica Costa, 1851 (Flabellifera: Cymothoidae) es un parasito de peces perteneciente a Atherinidae (*Atherina hepsetus, Atherina boyeri*) del Mar Mediterráneo, Mar Negro y Océano Atlántico. Öktener y Sezgin (2000) presentaron este parasito por primera vez procedente de Turquía. Ellos mostraron algunas características morfológicas, no obstante algunas características no están explicadas en la publicación. Algunas de las características vistas en la mandíbula, maxilípedos, maxilares, maxílulas, y las espinas sobre los pleópodos de hembras de *M. epimerica* son mostradas en este estudio. Dichas características están basadas en dibujos hechos a partir de especímenes recogidos.

REZUMAT: Caractere morfologice la femelele de *Mothocya epimerica* Costa, 1851 (Flabellifera: Cymothoidae) din Marea Marmara.

Mothocya epimerica Costa, 1851 (Flabellifera: Cymothoidae) este un parazit al peștilor din familia Atherinidae (*Atherina hepsetus*, *Atherina boyeri*) din Marea Mediterană, Marea Neagră și Oceanul Atlantic. Öktener și Sezgin (2000) au fost primii care au înregistrat acest parazit în Turcia. Autorii menționați au prezentat câteva caractere morfologice, dar unele caractere nu sunt explicate în articolul lor. În această lucrare, sunt prezentate câteva din caracterele morfologice pentru femela de *M. epimerica* observate pe mandibulă, maxiliped, maxilă, maxilulă și pe spinii peopodelor. Caracterele prezentate în acest studiu sunt bazate pe desenele făcute pentru specimenele colectate.

INTRODUCTION

Crustacean ectoparasites on marine fish are diverse. Many species of fish are parasitized by cymothoids (Crustacea, Isopoda, and Cymothoidae). These parasitic isopods are blood-feeding. Several species settle in the buccal cavity of fish, others live in the gill chamber or on the body surface including the fins (Brusca, 1981; Trilles, 1994).

The cymothoid fauna of Turkey has received no attention until a *Ceratothoa* sp. was reported from *Boops boops* (Linnaeus, 1758) (Perciformes: Sparidae) (Monod, 1931). Several years later, a number of studies have given some systematic records about several cymothoids parasitizing Turkish wild and cultured fishes (Kırkım, 1998; Tokşen, 1999; Öktener and Trilles, 2004; İnnal et al., 2007; Öktener et al., 2009; Kayis and Er, 2012).

The aim of the present study is to give some morphological characteristics of female *Mothocya epimerica* from the gill chamber of *Atherina boyeri*, to add more information on the descriptions given by Montalenti (1948), Trilles (1968, 1976) and Bruce (1986).

MATERIAL AND METHODS

The fish samples were collected by trawl and local gears from Bandırma Bay in 2014. The body surface, oral cavity and branchial chamber of each fish were examined for isopod parasites. The parasites were dislodged from their host and preserved directly in labelled tubes with 70% ethanol. The identification, scientific names and synonyms of parasite and host classification, were presented in Trilles (1968, 1976, 1994), Bruce (1986), Montalenti (1948), WoRMS Editorial Board (2014), Fricke et al. (2007) and, Froese and Pauly (2014). Drawings were performed using a stereomicroscope (Wild M5) with a *camera lucida* and a compound microscope (Olympus CH20). Measurements were taken in micrometres with a micrometric programme (Pro-way). Bruce (1986) was a consultant for terminology. Parasites (MNHN-IU-2013-18750) were deposited in the collections of the Muséum National d'Histoire Naturelle (MNHN), Paris, France.

RESULTS

Mothocya epimerica was collected from the branchial chamber region of ten *Atherina boyeri* of among one hundred fifty specimens examined (prevalence = 6.6%).

Order Isopoda

Family Cymothoidae Leach, 1814

***Mothocya epimerica* Costa, 1851**

Syn. *Mothocya epimerica* Costa, in Hope, 1851

Ceratothoa atherinae Gourret, 1892

Livoneca sinuata Brian, 1912

Mothocya epiremica Brian, 1921

Description of female.

The body is slightly twisted to the right side, elongated, and about 2.8 times longer than wide (Figs. 1 and 2). The dorsum is weakly vaulted, the anterior margin of cephalon is slightly rounded, large eyes, 0.63 times width of cephalon, and the distance between them about 36% of head width. Pereon is about 0.65 as wide as long, pereonites one is longest and pereonite seven is shortest, posterolateral margins of pereonite seven is slightly rounded and produced in dorsal view. Pleon is about 0.4 as long as wide; all pleonites visible in dorsal view, but pleonite one is partially concealed by pereonite seven, pleonites two-five are entirely conspicuous in dorsal view, two-four subequal in length, and pleonite is five slightly longer and wider than the others. Pleotelson hemispherical is 0.66 times as long as wide and posterior margin rounded.

Maxilla medial and lateral lobes each with two curved spines, medial lobe is covered with small spines (Figs. 6, 7 and 10A); maxillule with four terminal spines (Figs. 8 and 10B); maxilliped article three with four recurved spines (Figs. 4, 5 and 10C); mandible palp article three (Figs. 9 and 10D); Antennule with eight articles, generally extending to the middle of eye (Figs. 2 and 10E), antenna with eight articles, slender than antennule, not extending to anterior of pereonite one (Figs. 3 and 10F).

Pereopods almost similar, pereopod one is the longest, pereopod six is the shortest, and pereopod one is much longer than pereopod seven (Figs. 11A-G).

Pleopods with all rami lamellar, peduncles of pleopods with four hooks (Figs. 12A-E); endopod five with proximomedial lobe moderately developed.

Coxae conspicuous in dorsal view and posterior margins rounded; coxae two-six not produced beyond posterior of respective segments, coxae of pereonites seven extending slightly beyond posterior of segment (Figs. 13A-B). Uropod short, not extending beyond posterior margin of pleotelson, exopod slightly longer than endopod (Fig. 13C).

White or brown in alcohol, densely covered by black chromatophores over dorsal surfaces, dactylus brown.

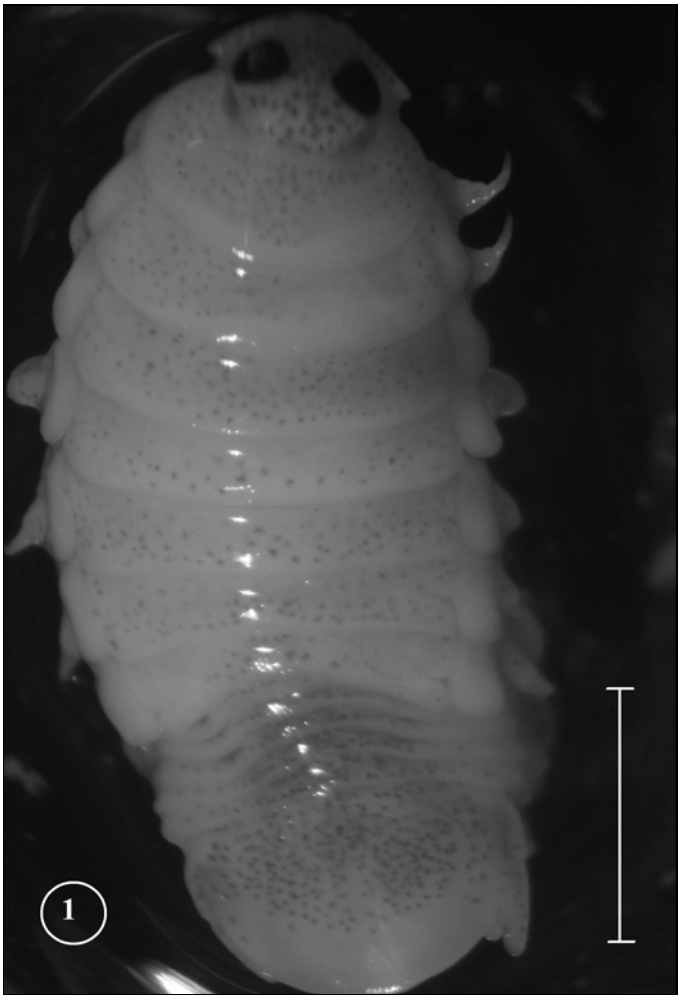
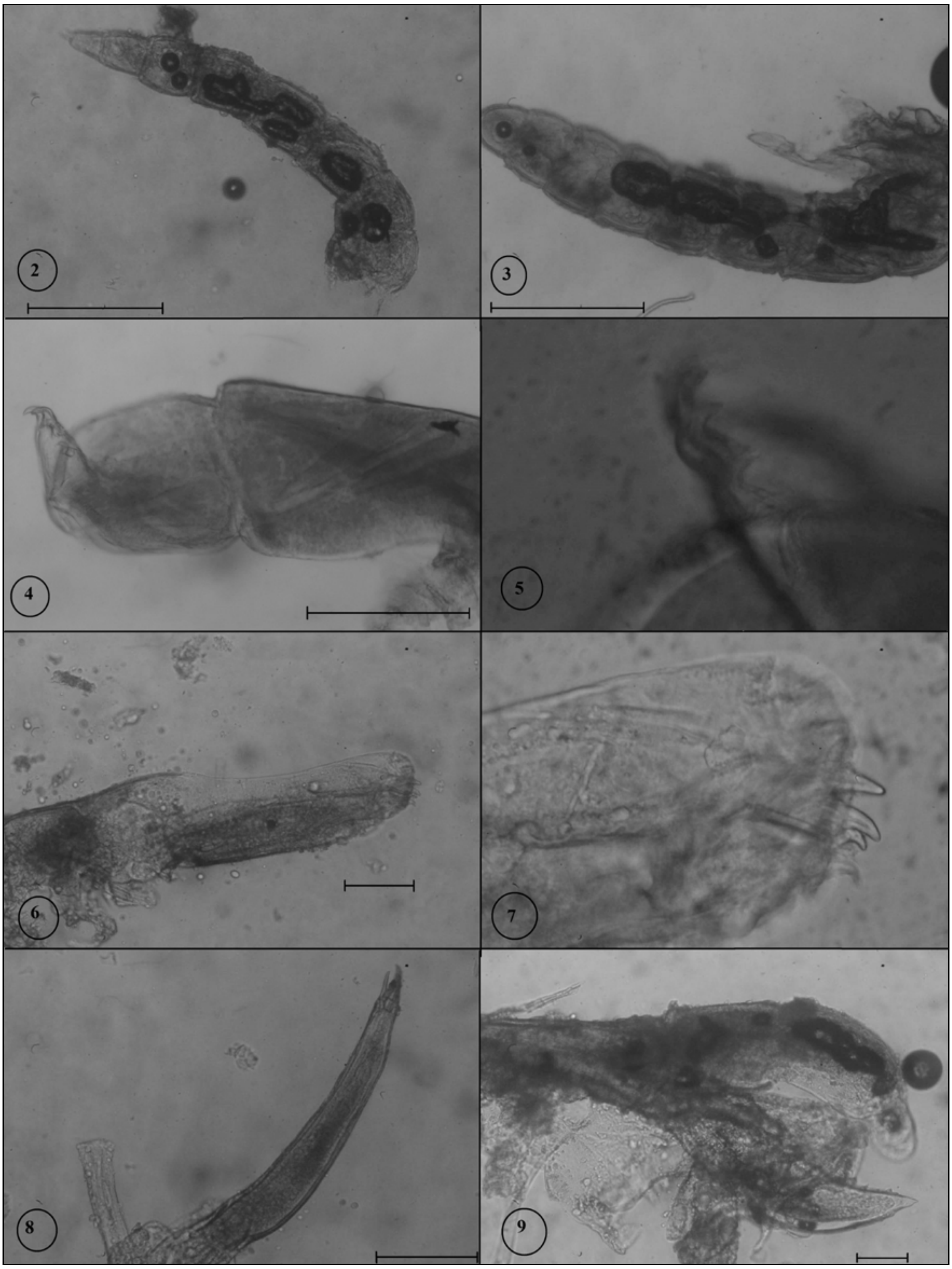


Figure 1: Female *Mothocya epimerica* (scale five mm).



Figures 2-9: 2. Antenna (0.23 mm); 3. Antenna (0.26 mm); 4. Maxilliped (0.32 mm);
5. Maxilliped spines; 6. Maxilla (0.15 mm); 7. Maxilla spines (two mm);
8. Maxillule (0.35 mm); 9. Mandible (0.11 mm).

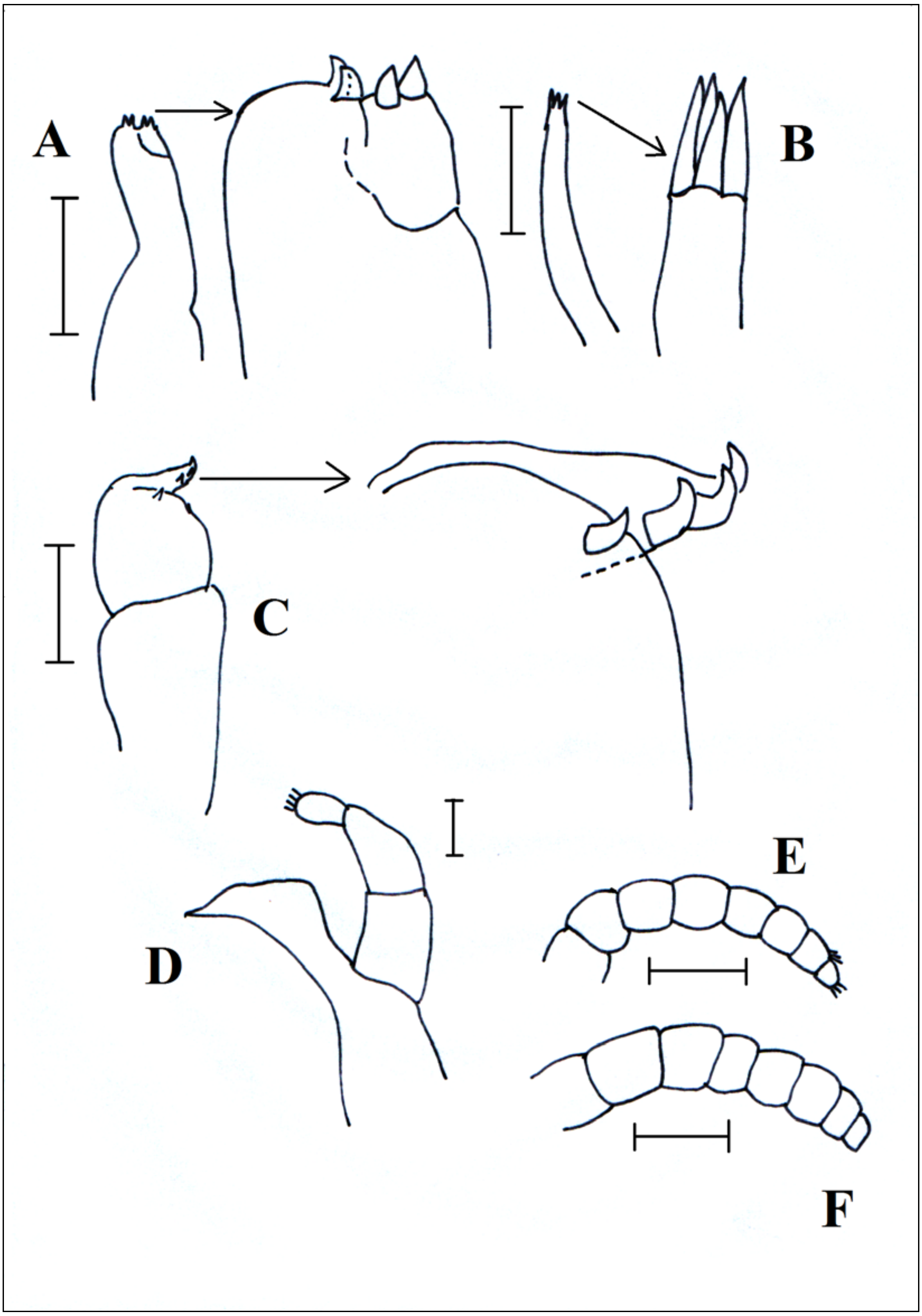


Figure 10: A: Maxilla (0.25 mm); B: Maxillule (0.35 mm); C: Maxilliped (0.40 mm); D: Mandible (0.11 mm); E: Antenna (0.26 mm); F: Antennule (0.23 mm).

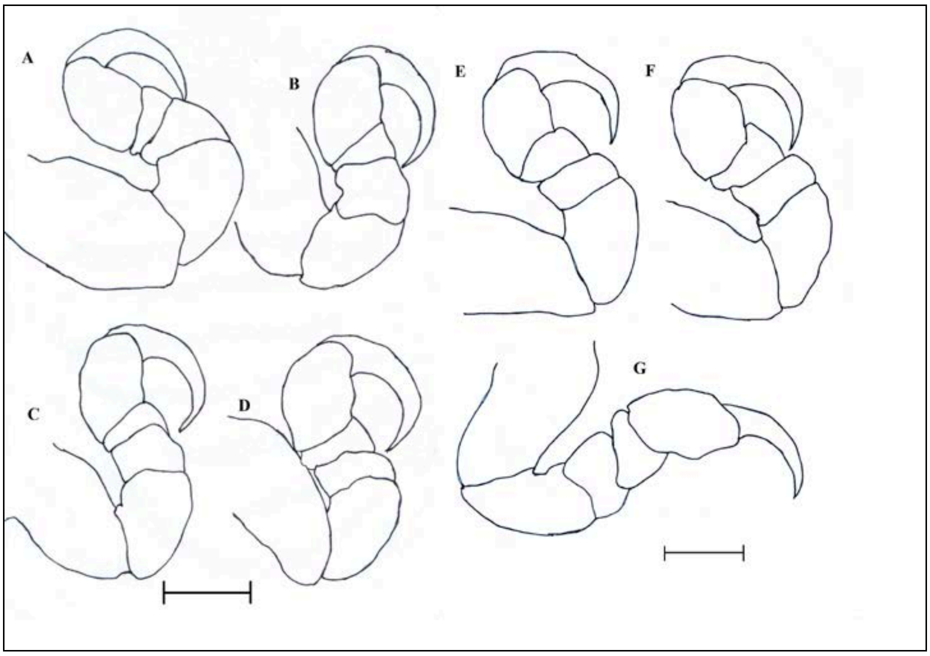


Figure 11: A. Pereopod I; B: II; C: III; D: IV; E: V; F: VI; G: VII (0.75 mm).

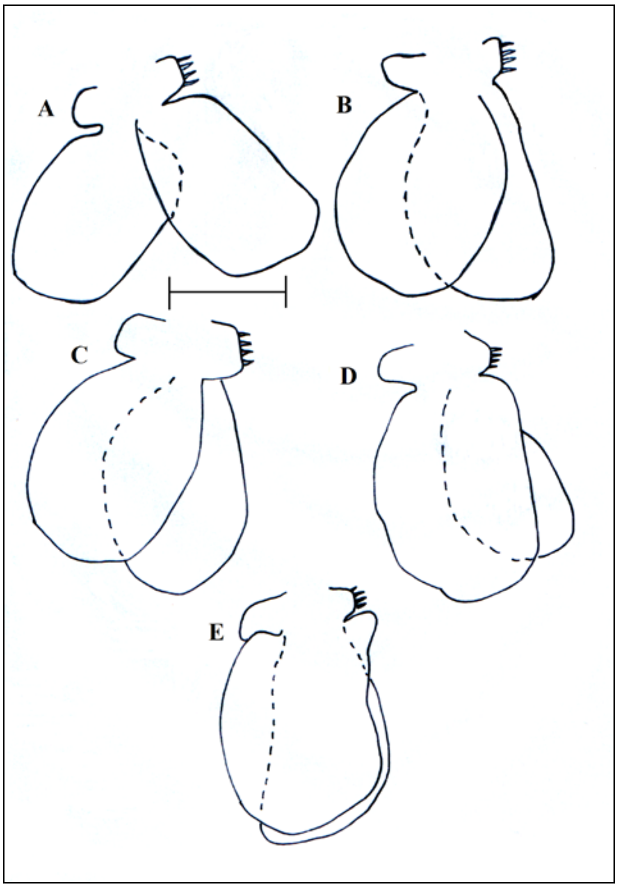


Figure 12: A: Pleopod I; B: II; C: III; D: IV; E: V. (one mm).

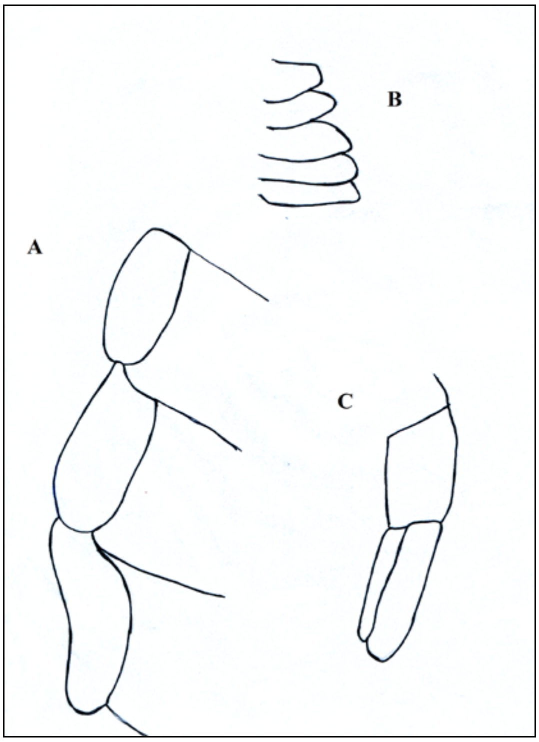


Figure 13: A: Coxae of left side; B: Pleonites, ventral view (left); C: Uropod.

DISCUSSION

Öktener and Sezgin (2000) recorded *Mothocya epimerica* for the first time in Turkey. They gave some morphological characters: antenna, antennule, pereopod and pleopod, but some characters were not explained in their publication.

After Trilles (1994) gave the distribution of *Mothocya epimerica* from the Mediterranean Sea, Black Sea, Adriatic, Atlantic, later, some records of it were published by Mariniello and Di Cave (1992), Bello et al. (1997), Charfi-Cheikhrouha et al. (2000), Öktener and Sezgin (2000), Leonardos and Trilles (2003), Ramdane et al. (2006), Trilles (2008), and Ramdane et al. (2009).

Mothocya epimerica is only associated with fishes belonging to the family Atherinidae. It was collected from *Atherina hepsetus, Atherina boyeri* (synonymies: *Atherina rissoi, Atherina mochon*) (Trilles, 1994).

Examination of the parasite specimens showed that they were *M. epimerica* according to the general drawings and descriptions given by Bruce (1986), Trilles (1968, 1976), Montalenti (1948). Their general body shapes, maxillule with four terminal spines, maxilla with two curved spines on medial and lateral lobes, mandible palp article three without setae, antennule and antenna with eight articles, maxilliped article three with four recurved spines, and pleopods two with four hooks agree with the drawings given by Bruce (1986), Trilles (1968, 1976), and Montalenti (1948).

ACKNOWLEDGEMENT

We would thank Ceregato A., Mascolo R. and Maffei G. for obtaining scanned literature.

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REPORT ON GREEN FROG (*EUPHLYCTIS HEXADACTYLUS*) FROM VENGAIVASAL LAKE (TAMILNADU, INDIA)

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DOI: 10.1515/trser-2015-0064

KEYWORDS: Anurans, *Euphlyctis hexadactylus*, Vengaivasal Lake, India.

ABSTRACT

Through the *Visual Encounter Survey* only one species of green frog (*Euphlyctis hexadactylus*) was encountered. As we lack previous data we cannot comment on the decline of the species. Frogs, known for specific habitats, are under threats if such habitats are lost. The physico-chemical parameters estimated along with the anuran survey reported that the quality of the lake is not congenial to support the tadpoles of the frogs. The adults can move away from water and survive on land. The habitat, as well as the surrounding wetland, plays a vital role to support a good quantum of anurans.

RESUMEN: Informe sobre la rana verde (*Euphlyctis hexadactylus*) del lago Vengaivasal (Tamilnadu, India).

Tras realizar un muestreo visual, se encontró solo una especie de rana (*Euphlyctis hexadactylus*). En virtud de que no existen estudios previos, no es posible saber si los números poblacionales de esta especie están declinando. Las ranas se encuentran relacionadas con hábitats muy particulares y por lo tanto éstas se verán amenazadas si dichos hábitats se perdieran. Los parámetros fisicoquímicos que fueron tomados en el lago a la par del muestreo visual, indican que la calidad del agua no es propicia para la sobrevivencia de los ajolotes de esta especie, sin embargo los adultos si pueden moverse a otros cuerpos de agua. La integridad de los estos hábitats y de sus alrededores juega un papel preponderante para sostener una cantidad razonable de anuros.

REZUMAT: Raport privind broasca verde (*Euphlyctis hexadactylus*) din Lacul Vengaivasal (Tamilnadu, India).

Cu ajutorul studiului Visual Encounter doar o specie de broască verde (*Euphlyctis hexadactylus*) a fost semnalată. Datorită absenței informațiilor din trecut nu putem comenta sau interpreta scăderea numărului de invidivizi sau fragmentarea habitatelor populate. Broaștele sunt recunoscute ca având habitate specifice, iar sub stres acestea pot fi degradate. Calitatea lacului nu este propice pentru existența mormolocilor de broască, fapt ce reiese din parametrii fizico-chimici identificați în acest studiu. Adulții se pot îndepărta de apă și trăi pe sol. Atât habitatul cât și zonele umede adiacente joacă un rol extrem de important în existența anurelor.

INTRODUCTION

In India, so far 347 species of amphibians were reported (Dines et al., 2012) out of which 77 species were reported from a variety of fresh water habitats of Chennai (Dinesh et al., 2012). Over 200 amphibian species have been reported to become extinct in the recent past, which gave an alarming signal to create awareness towards this.

Our regional problem is how to control mosquitoes. The Aedes mosquitoes spread Dengue and Chickenkunia to humans. Mosquitoes create a tremendous health hazard and need an indicator species to advocate and control their prevalence (Blaustein and Wake, 1990; Vitt et al., 1990; Wyman, 1990). Frogs are good predators and consume a large quantity of mosquitoes at their larval stage, thereby serving as a good biocontrol agent to control mosquito populations. Research has been initiated through integrated biocontrol methods which use frogs as a promising agent to control mosquito menace during early stages.

The main reason for the major decline in amphibian biodiversity is their sensitivity to a wide variety of environmental perturbations which has led them to be considered as bio-indicators of ecosystem health (Wake and Vredenburg, 2008), and often cited as the “ecological canaries in the coal mine” (Pechmann and Wilbur, 1994). Urbanization is one of the threats to anurans apart from land cover changes and loss of habitats (Stuart et al., 2004).

MATERIAL AND METHODS

E. hexadactylus is a large aquatic anuran found in all kinds of water bodies, mostly reported in brackish water. During 2014, from February 1st week onwards, the Visual Encounter Survey was carried out. Instead of collecting voucher samples, pictures were captured and kept as reference for identification of anurans. Collected at four locations and fixed based on our preliminary surveys (Fig. 1a, b).

Vengaivasal Lake is situated (12°54’20.15” N, 80°09’55.39” E, and 12°54’49.53” N 80°09’55.64” E) in Kanchipuram District of Tamilnadu (Fig. 1). Many small and medium size agricultural fields benefit out of this lake (Fig. 2). Vengaivasal Village housed nearly 10,000 residents living across its four square kilometres spread area around the lake.

Figure 1a: Vengaivasal study area.

Visual Encounter Survey (VES) is a simple method for identification. The Indian Pond Frog *Euphlyctis hexadactylus* is predominantly an aquatic species. Nearly 24 frogs basking on the leaves were recorded. It was quite unusual to notice this behaviour of frogs. The frogs were fully out on land exposing their entire body. Some frogs were floating still on the surface of the water. This floating surface basking and half or two-thirds of the body in water is commonly seen in amphibians. The frogs basking on land during the midday sun was an unusual sight. So the observation was continued from February 1st 2014 onwards. It is a regular phenomenon that pond frogs come out of the water bodies during night time and rest on land. Frogs are thought to be sensitive to acidic precipitation because they respire through their skin. It helps to sight and locate any individual current in the proposed study site. The frogs responded to the camera flash, and immediately hopped away to avoid the flash. Within that fraction of time available we captured their pictures. More green frogs were observed during the late evenings of the monsoon months, and with the help of photographs identified up to species level.

Figure 1b: Vengaivasal study area.

Experimental analysis. Physico-chemical parameters of these samples were determined by using standard procedures (APHA, 1992). The pH is determined by Eli co, digital pH meter which gives direct values of pH. Temperature: A mercury filled centigrade thermometer calibrated from 0 to 100ºC is used for temperature measurements.

Carbonate and bicarbonate: The water sample is determined by titrating it against standard acid solution using indicators like phenolphthalein and methyl orange.

Total dissolved solids: 100 ml of water sample is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. Further, it is heated and the water is totally evaporated. Whatever dissolved solid matter is present gets accumulated at the bottom of the evaporating dish. The evaporating dish is cooled and weighed. By weight, difference methods of the total dissolved solids are determined.

RESULTS AND DISCUSSION

Description of Green Frog

The body of the frog was elongated with a maximum jumping length of about 70 cm. The dorsal side was greenish and with a yellow straight line in the centre, and the ventral side was pale yellow in colour. The limbs are long and slender whereas the fore limbs are comparatively small. The prominent black eyes protrude on the front of the head (Fig. 3). Based on the key given by Seshadri et al. (2012), we identified mature individuals with the characters of the Green frog (*Euphlyctis hexadactylus*).

The size of the male frogs ranged between 85 and 90 mm and females from 125 and 130 mm. They were found actively swimming on the surface of the lake and at times inside the aquatic vegetation too. It has a flat broad snout pointed towards the end and almost looks like an inverted “V.” The dorsal side is a light green and light yellow mixture of colour and the ventral side is a pure lemon yellow colour. The eyes were prominent, projected and black in colour. The camthus rostalis and tympanum are distinct. The toes are fully webbed; the first finger is longer than the second one. Almost all of them are matured and bulky. They feed mostly on the insects and tadpoles. During monsoon season they breed and laid nearly 2000 eggs with in a diameter of one mm.

Vegetation of an area plays a vital role for supporting the survival strategy of any particular animal and is the main composition of a habitat. The vegetation of the study area has certain impacts on the amphibian populations. Many frogs are habitat specific. They will be under threat if their habitats come under deterioration. Habitats are one of the most important factors for amphibian existence, freshwater ecosystem along with thick tropical vegetation offer excellent habitats for anurans (Dey, 2004). Frogs specially prefer marshy areas. Indian five fingered frog was the most common in all types of wetlands. The amphibian abundance and diversity fluctuate directly with changes in the composition and amount of microhabitats. They may signal environmental stress earlier than most other organisms (Gardner et al., 2007). Habitat loss and modification is considered to be one of the reasons for amphibian declines (Gardner et al., 2007). *E. hexadactylus* was found only in water or in water logged cultivation areas (Seshadri et al., 2012). *E. hexadactylus* is commonly being hunted for consumption of frog legs in the local market.

Even though the species documented during this study are common and widely distributed across the peninsular India, many could be threatened and may face population decline due to uncontrolled hunting activities and increased urbanization which could negatively affect their diversity.

Figure 3: *Euphlyctis hexadactylus* in Vengaivasal Lake area.

According to the IUCN Red list, the current status of frogs come under the Least Concern. The only known herbivore frog exhibited a diet preference for plants. It was noted from the local residents that these frogs are caught for food. Habitat destruction and other climatic changes are considered to be the main reason for the decrease of amphibian population (Gardner et al., 2007). In India, due to the rapid urbanization and industrialization the amphibians decline occurs quickly (Padhye et al., 2002). A total of 16 species had been reported from Bangalore city (Karthikeyan, 1999). In Pune 31 species have been reported (Padhye et al., 2002).

It is estimated that freshwater wetlands support 20% of the range of biodiversity in India (Deepa and Ramachandra, 1999). Freshwater ecosystems are the most endangered ecosystems in the world. Biodiversity decline occurs far greater in fresh water habitats than in the most ecosystems (Sala et al., 2000; Dudgeon et al., 2006). The threats to global freshwater biodiversity can be grouped under five interacting categories: exploitation, water pollution, flow modification, destruction or degradation of habitat and invasion by exotic species (Allan and Flecker, 1993; Jackson et al., 2001; Rahel, 2002; Postel and Carpenter, 1997).

In the present study, a comparative analysis of physical and chemical characteristics of Vengaivasal Lake water along with four location sites selected were made during Feb 2014 – Mar 2015 and based on physical characteristics like pH, temperature, carbonate, bicarbonate and total dissolved solids the water quality has been assessed (Fig. 4).

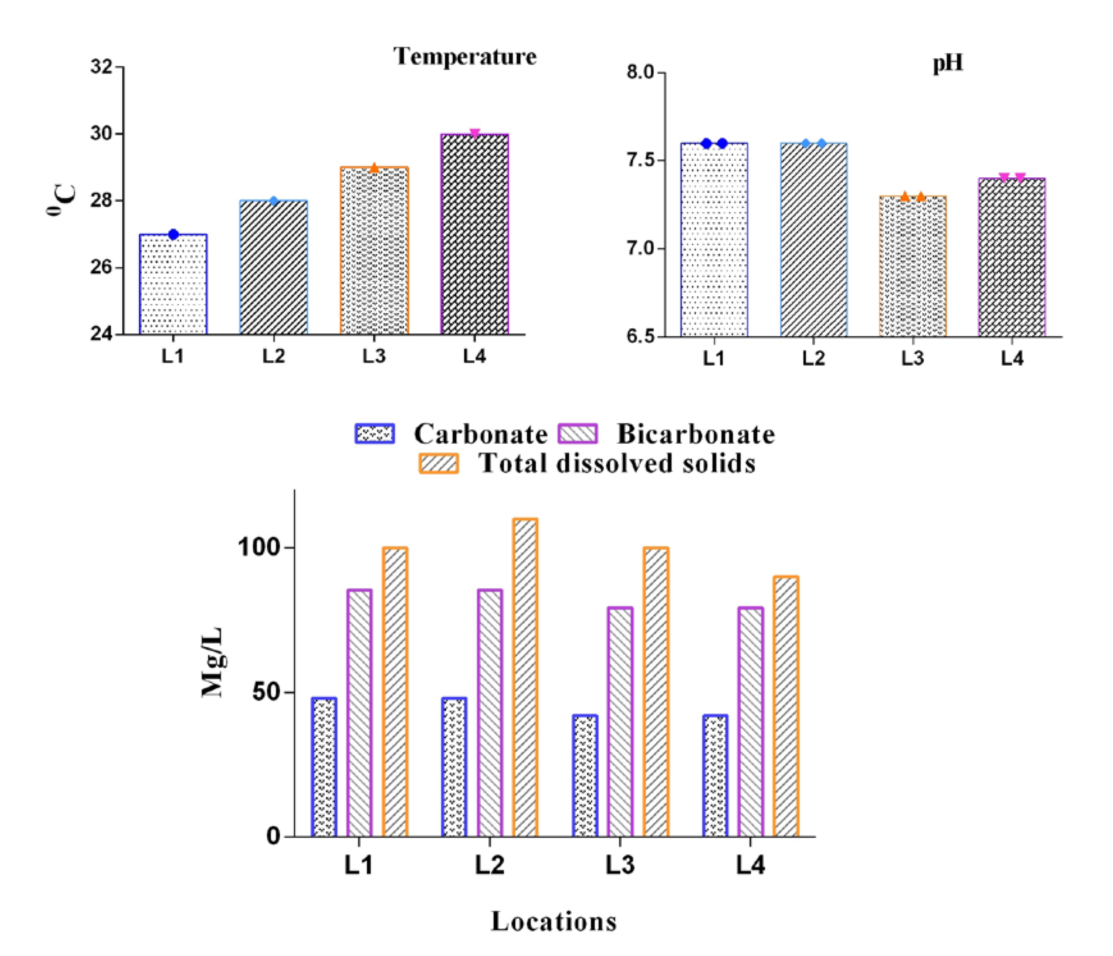

Figure 4: Physico-chemical parameters of Vengaivasal Lake.

CONCLUSIONS

Efforts to understand variations in richness and diversity in view of such disturbances need to be undertaken in the future for conserving anurans and the fragile wetland ecosystems in human dominated landscapes.

ACKNOWLEDGEMENTS

One of the authors (RR) acknowledge the funding support by DST (SERB) to carry out this work, Ref.: No SR/SO/AS-12/2012 dt:11.1.2013.

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LENGTH-WEIGHT RELATIONSHIP OF SOME FISH SPECIES IN A TROPICAL RAINFOREST RIVER IN SOUTH-EAST NIGERIA

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DOI: 10.1515/trser-2015-0065

KEYWORDS: Modelling ecosystem, condition Factor, morphometrics, climate.

ABSTRACT

The Length-Weight relationship of some fish species from Oramiri-Ukwa River, was studied from January to December, 2014. The slope (b) values obtained in the nine species ranged from 1.830 to 5.670 with most of the fishes indicating a negative allometric growth pattern except for *Papyrocranus afer*, with b value of 3.04, thus showing a positive isometric growth pattern. The following fish species showed a high degree of positive correlation at ($P > 0.05$); *Ctenopoma kingselyae, Alestes imberi, Channa obscura, Oreochromis niloticus, Tilapia mariae, Tilapia zillii, Synodontis omais*, and *Papyrocranus afer. Chrysichthys auratus* did not show this positive correlation. The condition factor (K) of the fish species ranged from 0.99 to 4.54, indicating that most of the fish were in good condition except for *Chrysichthys auratus* with 0.99.

ZUSAMMENFASSUNG: Die Länge-Gewicht-Beziehung einiger Fischarten in einem Regenwald Fluss in Südost Nigeria.

Das Länge-Gewicht-Verhältnis einiger Fischarten im Oramiri-Ukwa Fluss wurde von Januar bis Dezember 2014 untersucht. Die Gefälle (b)-Werte, die bei neun Arten festgestellt wurden, schwankten von 1.830 bis zu 5.670, wobei die meisten Fische ein negatives allometrisches Wachstumsmuster zeigten, mit Ausnahme von *Papyrocranus afer*, mit einem b-Wert von 3,04, somit ein positives isometrisches Wachstumsmuster aufwies. Die folgenden Fischarten zeigten einen hohen Grad einer positiven at-Korrelation ($P > 0,05$) und zwar *Ctenopoma kingselyae, Alestes imberi, Channa obscura, Oreochromis niloticus, Tilapia mariae, Tilapia zillii, Synodontis omais* und *Papyrocranus afer*, mit Ausnahme von *Chrysichthys auratus*. Der Zustandsfaktor (K) der Fischarten bewegte sich zwischen 0,99 und 4,54 und zeigte damit, dass die meisten Fische ein gutes Wohlbefinden aufwiesen, mit Ausnahme von *Chrysichthys auratus* mit einem Wert von 0,99.

REZUMAT: Relația dintre lungimea și greutatea unor specii de pești din pădurea tropicală, în sud-estul Nigeriei.

Relația lungime-greutate pentru unele specii de pești din râul Oramiri-Ukwa a fost studiată în intervalul ianuarie-decembrie 2014. Valorile pantei b în cazul a nouă specii au variat între 1,830 și 5,670, iar majoritatea peștilor au indicat un model de creștere alometrică negativ cu excepția specie *Papyrocranus afer* cu o valoare b de 3,04, deci un model de creștere isometrică pozitiv. Următoarele specii de pești au înregistrat un grad înalt de corelație pozitivă la ($P > 0,05$); *Ctenopoma kingselyae, Alestes imberi, Channa obscura, Oreochromis niloticus, Tilapia mariae, Tilapia zillii*, *Synodontis omais* și *Papyrocranus afer,* excepţie făcând *Chrysichthys auratus*. Factorul de condiție (K) al speciilor de pești a înregistrat valori cuprinse între 0,99 și 4,54, ceea ce arată că majoritatea peștilor se aflau în condiții de viață bune cu excepția specie *Chrysichthys auratus,* care a înregistrat valoarea 0,99.

INTRODUCTION

Fish play an important role in the development of a nation. Apart from being one of the cheapest sources of highly nutrient protein, they also contain other essential nutrients required by the body (Sikoki and Otobotekere, 1999). The degradation of aquatic life and ecosystems in many parts of the world can lead to low fish composition which gives rise to insufficient fish product supply in the commercial market, thereby causing an increase in price of the limited supply in the commercial market. The relationship between length and weight can be used to assess the well-being of individual and to determine possible differences between separate unit stocks of the same species (King, 2007). In addition, length-weight relationships are also important in fisheries management for growth comparative studies (Moutopoulos and Stergiou, 2002).

Pauly (1993) stated that length-weight relationship (LWR) provides valuable information on the habitat where the fish live, while Kulbicki et al. (2005) stressed the importance of LWR in modelling aquatic ecosystems. For proper exploitation and management of the population of fish species, the length-weight relationship is very important (Anene, 2005).

The condition factor, which is referred to as the wellbeing of fish, is also a useful index for monitoring the feeding intensity, age, and growth rates in fish (Oni et al., 1983). The study was designed to provide basic scientific information on the length-weight relationship of some fish species in a tropical rain forest river in Southeast Nigeria.

MATERIAL AND METHODS

The study area was the Orammiri-Ukwa River (Fig. 1) located at Azaraegbulu, Emekuku in Owerri North Local Government Area of Imo State, southeast Nigeria at approximately latitude 5º30’ N and longitude 7º19’ E. Oramiri-Ukwa is a typical rain forest river. On both sides of the main river channel are large fringes of heavily forested swamps dominated by the raffia palm. The river flows from a highland in Okigwe and joins the Mbaa River to flow through Okahia Ezihe in Isiala Mbano Local Government Area, through Opara-nadim in Mbaise to Onu-ngara Avuvu in Ikeduru Local Government Area of Imo-State, Nigeria.

Oramiri-Ukwa flows southward for about 5.8 km before discharging into Otamiri River and the Nworie River, both are tributaries of the larger Imo River which drains into the Atlantic Ocean, south-east Nigeria. The climate of the area is characterized by two distinct seasons; the dry (November-March), and rainy seasons (April to October). The River is the main source of water supply to the towns and villages through which it flows, especially during the dry season.

Three sampling stations (S_1 – Emekuku, S_2 – Avuvu, and S_3 – Amakohia) were established along the main course of the river. Fish species were collected bi-monthly for 12 consecutive months (January to December, 2014) from the three sampling stations with the assistance of local artisanal fishers using different types of nets namely gill nets, cast nets, hook and line, local traps, and bag nets. The sampling sites were also generally accessible throughout the year and shallow in depth, with surface to bottom transparency along sandy areas. Water lilly (*Nymphaea* ssp.) and floating filamentous plants were common.

The length-weight relationship of identified fish species were estimated using the equation:

$W = aL^b$ (Le Cren, 1951) ………………………………………………….. (1)

where

W = Weight of fish (g)

L = Standard Length of fish (cm)

a = Y – Intercept or the Initial growth index

b = Slope or the growth coefficient or an exponent

The values of constants "a" and "b" were estimated after logarithmic transformation of Equ. (1) Using Least square Linear regression (Zar, 1984).

The condition factor was calculated using the formula:

$K = \frac{100\,w}{L^3}$ (Pauly, 1993)……………………………………………………………… (2)

where

K = Condition factor

L = Standard Length (cm)

W = Weight (g)

Statistical evaluations of the variations observed in the different species were assessed using the SPSS (1999).

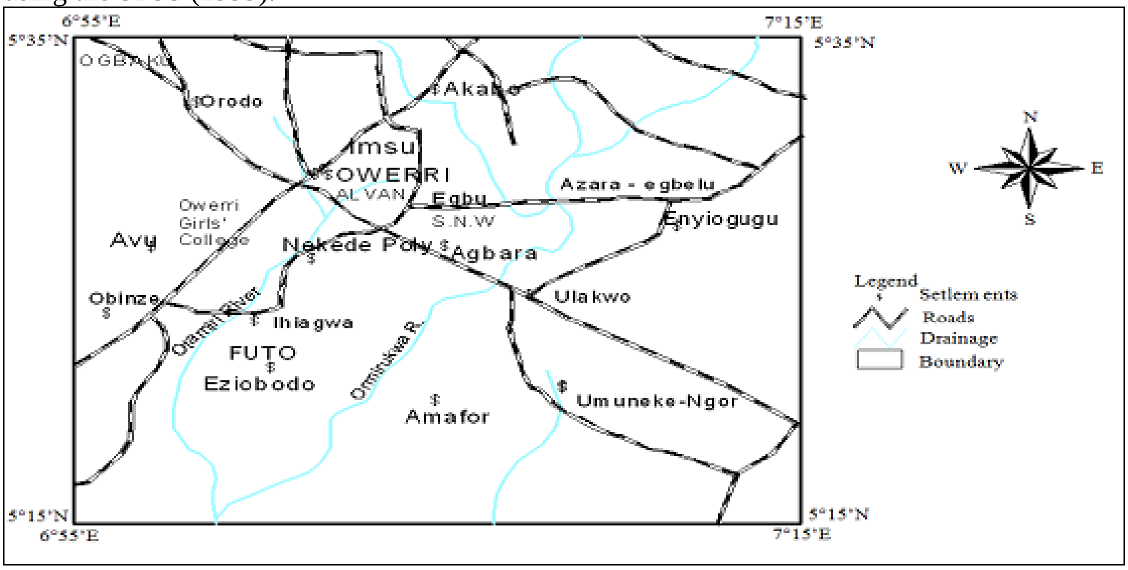

Figure 1: Map showing the location of Oramiri-Ukwa River in Imo State and sampling stations.

Fishes were collected from the different sample stations during the study period. Immediately after collection, photographs were taken prior to preservation since formalin decolorizes the fish on long preservation. Fishes were fixed in 4% formalin solution in separate bottles and brought to the laboratory. Fish identifications were carried out with the aid of Boulenger (1916), Talwar and Jhingran (1991), and Fishbase database (Froese and Pauly, 2010). The Total Length (TL) and Standard Length (SL) were measured in centimetre (cm), and the Body Weights (BW) were measured in grams (g). The Total Length (TL) of each fish was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a meter rule. The Standard Length (SL) was taken along the antero-posterior body axis, from mouth tip to the mid-point of caudal fin origin. The Body Weight (BW) was measured using a digital top-loading electronic weighing balance (Fafioye and Oluajo, 2005).

RESULTS AND DISCUSSION

The species, number of specimens, length-weight relationship parameters **a** and **b**, Correlation Coefficient (r), condition factor, mean length of fish species, mean weight of fish species and growth type (allometric or isometric) are presented in table 1.

Table 1: Length-weight relationship parameters and condition factor of some fishes from Oramiri-Ukwa River.

Species	No.	Standard Length (SL) (CM)		Body weight (BW) (g)		Regression Coefficient		Regression Coefficient	
		Range	Mean	Range	Mean	a	b	a	b
Anabantidae *Ctenopoma kingsleyae* (Gunther, 1896)	19	8.90-13.20	0.56 ± 0.27	17.05-66.00	33.2 ± 2.82	– 1.10	5.670	0.908	2.69
Bagridae *Chrysichthys auratus* (Ggeoffery St. Hilary, 1808)	4	13.50-20.00	16.89 ± 1.45	36.01-76.90	61.51 ± 8.37	– 0.40	2.538	0.188	0.99
Characidae *Alesters imberi* (Peters, 1852)	5	7.30-9.50	8.44 ± 0.34	13.00-16.10	14.6 ± 0.55	– 1.04	1.830	0.944	2.51
Channidae *Channa obscura* (Myers and Shaporador, 1932)	7	14.70-24.50	19.29 ± 1.25	98.10-135.04	121.54 ± 4.84	– 1.64	2.000	0.950	1.93
Cichlidae *Oreochromis niloticus* (Linne, 1758)	21	10.01-22.00	14.93 ± 0.76	40.21-182.30	82.57 ± 1159	– 1.30	4.615	0.939	2.37
Tilapia mariae (Boulenger, 1899)	60	10.00-15.80	11.76 ± 0.17	38.00-154.00	77.76 ± 3.34	– 3.47	5.026	6.600	4.54
Tilapia zillii (Gervais, 1848)	20	10.40-13.60	11.89 ± 0.19	23.00-49.08	30.93 ± 1.94	– 0.80	4.801	2.185	1.97
Mochokidae *Synodontis omais* (Gunter, 1852)	4	18.40-20.50	19.6 ± 0.39	109.20-122.0	118.18 ± 2.64	– 1.62	2.002		
Notopteridae *Papyrocranus afer* (Gunther, 1868)	28	9.80-26.00	13.61 ± 0.72	30.80-207.00	51.33 ± 6.52	– 1.24	3.040		
Total	168								

The study also showed that all the fish investigated exhibited negative allometric growth patterns with regression analyses exponents' **b** values less, or more than three, except for *Papyrocranus afer*, which exhibited a positive isometric growth pattern with exponent (**b**) value of 3.04. This is similar to the result of all fish species exhibiting negative allometric growth pattern reported by Obasohan et al. (2012). The following correlation coefficient (**r**) value 0.908, 0.950, 0.939, 0.9751, 2.185 and 6.600 at $P > 0.05$ indicated high degree of positive correlation between the standard lengths and body weights. Negative allometric was also reported for *Parachanna obsura* from Igwu and Itu Rivers wetlands, Nigeria (Bolaji et al., 2011). According to Adeyemi et al. (2009), negative allometric growth pattern in fish implied that the weight increased at a lesser rate than the cube of the body length. King (1996) reported similar negative allometric growth pattern in many fish in the Nigerian fresh waters. However, unlike the result in this study, isometric growth patterns were reported for *Mormyrus delicious* and *Gnathonemus tamandua* from Oramiri-Ukwa River (Nlewadim and Adaka, 2011). The differences in the results of these studies could be attributed to the age, sex, fecundity of the fishes, sampling methods, and sampling sizes as well as the prevailing ecological conditions in the water body at different times. The result of the study also shed light on the state of well-being of the fish examined. The value of the condition factor for *Chrysichythys auratus* was less than one; this implies a bad state or well-being, while the rest were more than one, implying a good state of well-being in the river. A different result was reported by Obasohan et al. (2012) where two out of five fish species condition factor were below one, and the remaining were above one. However, many factors such as sex, age, state of maturity, size state of stomach, illness, sampling methods, sample sizes and environmental condition affects fish condition and parameters of length-weight relationships in fish (Ama-Abasi, 2007; Yem et al., 2007; Adeyemi et al., 2009).

CONCLUSIONS

A comprehensive report on the species of fishes in this river should be carried out to know the actual population of fish species in the river.

Continuous evaluation should be constantly carried-out on the river and its resources to know its state at all time for proper management and control.

Fisheries activities should be encouraged in and around this river, especially on a commercial level, which will employ more local people living around the river.

ACKNOWLEDGEMENTS

The authors wish to thank the fishers in the study area for their immense contributions in collecting the samples during research work. Special thanks go to our employer; Federal University of Technology, Owerri, Imo State and Michael Okpara University of Agriculture, Umudike, Abia State for providing the financial platform for this research work.

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PRELIMINARY RESULTS REGARDING THE PRESENT MORPHOMETRIC CHARACTERS OF THERMAL RUDD, *SCARDINIUS RACOVITZAI* MÜLLER 1958 FROM PEȚEA SPRING NATURAL RESERVE

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DOI: 10.1515/trser-2015-0066

KEYWORDS: thermal rudd, Romania, endemic, shape, morphometry, variability.

ABSTRACT

The precarious temperature regime, associated with the negative influence of other environmental and biotic factors, represents a major risk for the survival of the thermal rudd from the lake Ochiul Mare, located in the Pârâul Peţea natural reserve. Therefore, a complex morphometric and body geometry analysis was conducted on specimens collected in 2013 in order to define the variability of the present population. The relatively small sample size is due to legislative restrictions on collecting endangered species, so statistical methods of analysis were applied to increase confidence in the assertions.

RÉSUMÉ: Les résultats préliminaires concernant la caractérisation morphométrique actuelle du rotengle thermale, *Scardinius racovitzai* Müller, 1958 de la Réserve Naturelle Pârâul Peţea.

Le régime précaire de température et en même temps l'influence négative des autres facteurs biotiques et de l'environnement est un risque majeur pour la survie et le potentiel reproductif du rotengle thermale, une espèce endémique de l'écosystème du lac thermal Ochiul Mare de la réserve naturelle Pârâul Peţea. C'est pourquoi l'analyse complexe de la morphométrie et la géométrie corporelle des spécimens capturés en 2013 a été effectuée pour caractériser la variabilité de la population courante. Les méthodes de traitement statistique ont été appliquées pour agrandir le degré de confiance des affirmations, en ce qui concerne les échantillons assez petits en raison des restrictions législatives pour la capture d'une espèce en péril.

REZUMAT: Rezultate preliminare privind caracterizarea morfometrică actuală a roşioarei termale, *Scardinius racovitzai* Müller 1958 din Rezervaţia Naturală Pârâul Peţea.

Regimul termic precar coroborat cu acţiunea negativă a altor factori de mediu şi biotici reprezintă un risc major pentru supravieţuirea şi potenţialul reproductiv al roşioarei termale *Scardinius racovitzai*, endemică în lacul termal Ochiul Mare din Rezervaţia Naturală Pârâul Peţea. De aceea, o analiză complexă din punct de vedere morfometric şi al geometriei corporale a specimenelor de roşioară termală, colectate în 2013 a fost realizată în vederea caracterizării variabilităţii populaţiei existente la momentul actual. Metode de prelucrare statistică au fost aplicate pentru a extinde gradul de confidenţă a afirmaţiilor, în condiţiile mărimii reduse a probelor impuse prin restricţiile legislative corespunzătoare gradului de periclitare a speciei.

INTRODUCTION

This study is a part of a larger research effort regarding the ex situ conservation of two critically endangered animal species from the thermal lake in "Peţea Spring" Natural Reserve, near Oradea, north-western Romania.

Ochiul Mare Lake was formed in the second half of the Holocene (Sümegi et al., 2012 in Sîrbu et al., 2013) and is a unique ecosystem where endemic species are living; the lake is the only location in Europe where the Egyptian white water-lily (*Nymphaea lotus* L. var. *thermalis*) grows naturally, along with the thermal rudd *Scardinius racovitzai* (Müller, 1958) and the thermal snail *Melanopsis parreyssii* (Philippi, 1847) which are both critically endangered species (Freyhof and Kottelat, 2008; Fehér, 2013).

Water temperature is a limiting factor that affects fish development, reproduction and survival. Annual and multi-annual statistical sesonaly temperature measurements in recent years have revealed frequent values below 20ºC during winter over significant surfaces of the thermal lake, a value previously considered the lowest tolerance limit (Bănărescu, 1964).

Telcean and Cupşa (2013) noted that the natural and ecological barriers between the "Ochiul Mare" thermal lake and related aquatic ecosystems have changed during the last few years, affecting fish population dynamics. Thermal conditions in "Ochiul Mare" lake have dramatically deteriorated as a result of overexploitation, consequently, there has been a drastic decrease of thermal spring flow, water temperature and level. The 42°C temperature according to Kováth (1977, in Telcean and Cupşa (2013) decreased in the '90s as shown in Crăciun (1997) in Telcean and Cupşa (2013), down to 34-35°C in summer and 26°C in winter. Our field measurements revealed water temperature values below references.

The drastic decrease of water level and temperature affected the entire ecosystem, so we proposed to test the morphological variability of the present thermal rudd population (*Scardinius racovitzai*) sampled during 2013, and compare it with a sample of its congener *S. erythrophthalmus* and to data from previous research (Müller, 1958; Bănărescu, 1964; Berinkey, 1960). There are several previous references regarding the morphology of this species; one considered this population as a species with a Miocene origin (Müller, 1958), another a subspecies with a more recent derivation from the Central European common rudd (Bănărescu, 2002). Telcean and Cupşa (2013) acknowledge the population as a valid species endemic in the thermal lake of the Peţea Creek. The present paper attempts to complete the data regarding the morphological features of the population that still persists in the thermal lake. Despite various references regarding the morphological, physiological and behavioural differences between the two species, application of molecular techniques are necessary for clarifying the taxonomic status of the thermal rudd population from the thermal lake (Bănărescu, 2002).

MATERIAL AND METHODS

A group of 19 thermal rudd specimens were approved for collection by Order no. 1231/2013 of the Environment and Climate Changes Ministry and were captured by use of scientific fishing net with 10-16 mm mesh sizes during sampling trips in August and October 2013.

The sampled fish were transported alive, in 50 l plastic bags with a 1:3 water/oxygen ratio to the Aquarium facilities at the Museum Complex of Natural Sciences "Răsvan Angheluţă", Galaţi, Romania.

Digital pictures were taken with a CANON A590 IS camera on the left side of each fish and 23 landmarks were defined and recorded as two-dimensional coordinates. Landmarks were selected to provide a homogeneous view of the whole shape. The operation was partially conducted on live specimens mindful of the project and legal demands (fish propagation and re-introduction of all adults and juveniles obtained by captive propagation back to their native environment).

A total of 14 morphometric characteristics of the fish were measured and the body weight of each individual was assessed to an accuracy of 0.1 g. A multivariate approach was applied for the morphometric method using Systat 10.2.

Geometric methods were also applied with MorfoJ 1.05f. The shape information was extracted by Procrustes superimposition, which removes variation in size, position and orientation from data on landmark coordinates. The coordinates of the superimposed landmarks were used in multivariate statistical analysis to address the main question: the current variability of the thermal rudd population strongly affected by ecosystem deterioration. There is a degree of similarity between this species and its congener *Scardinius erythrophtalmus* and the statistical approach helps to analyse the separation between specific groups (species/ecotypes).

RESULTS AND DISCUSSION

"Pârâul Peţea" Natural Reserve. The morphometric data were studied in order to assess the variability of the present critically endangered population. The main body measurements were made on 19 thermal rudd individuals (Fig. 1).

The standard body length of *S. racovitzai* individuals is between 83.34 – 108.89 mm (minimum – maximum values), individual weight is 9.99-20.27 g.

Equation 1 allows the computing of the Fulton Factor by using the weight/length relationship, one estimated the condition status of fish.

$$W = 0.0038 * L^{3.7688}, \; R^2 = 0.8408 \quad (1)$$

The allometric coefficient *b* assessed before spawning season that is 3.7688 reveals a positive allometric growth, with a high level of weight/length relationship (R^2 coefficient, of weight/length regression, was 0.84).

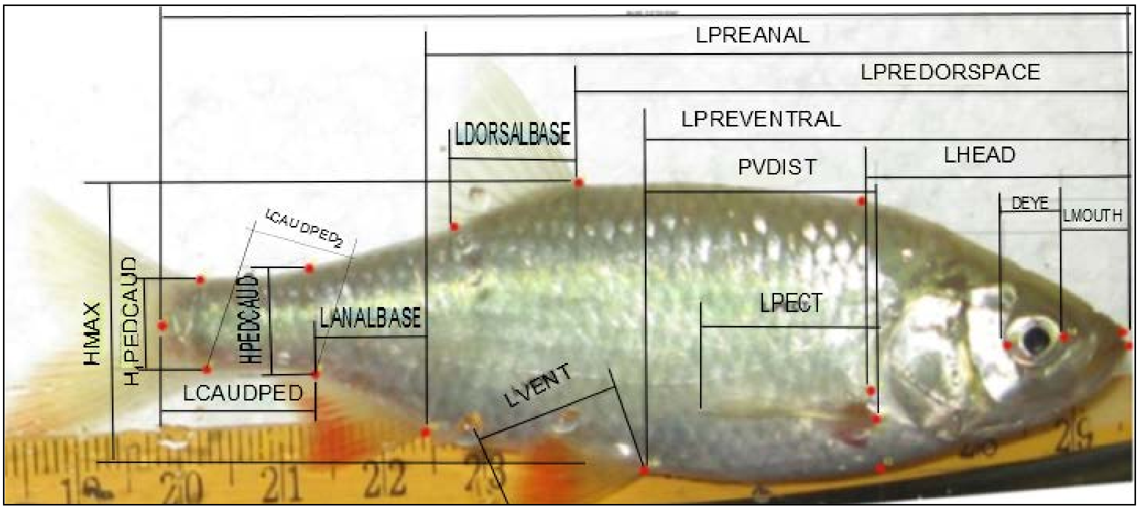

Figure 1: Determination of morphometric data of thermal rudd individuals sampled in 2013; explanations of morphometric characters are in table 1.

The data obtained through body measurements of thermal rudd are listed in table 1 (confidence intervals with 95% confidence level, n = 19 individuals). The values were expressed as percentage from standard length, with the exception of $LMOUTH_2$ (length of mouth as percentage from head length), $DEYE_2$ (eye diameter as percentage from head length), HPEDCAUD (maximum height of caudal peduncle as percentage from caudal peduncle length), $LPECT_2$ (length of pectoral fin as percentage of the distance between pectoral and ventral fins insertions).

The resulting data was compared to data published by Müller (1959), Bănărescu (1964), based on 69 individuals, and Berinkey (1960), based on five individuals, and data obtained by Kottelat and Freyhof (2007).

Table 1: Statistical parameters of the main morphological features of the thermal rudd (confidence intervals, $P < 0.05$). We noted the references of Kottelat and Freyhof (2007). The differences from references are bolded.

Crt. nr.	Morphometric character		Value of morphological feature (%)	Comparing results from references (%)		
				Bănărescu, 1964 *Kottelat and Freyhof, 2007	Müller, 1958	Berinkey, 1960
1.	L	Standard length (mm)	90.7-98.0	Max. 93	60-93	54.5-90.5
2.	HMAX	Maximum body height (% of standard length)	**27.1**-31.2	28.3-34.7	28.3-34.7	28.3-31.2
3.	LHEAD	Head length (% of standard length)	25.3-27.0	24.7-30.6 28.0-31.0*	24.7-30.6	26.7-29.9
4.	LMOUTH	Preorbital length (% of standard length)	**5.7**-6.9	6.7-7.6	No data	No data
5.	$LMOUTH_2$	Mouth length (% of head length)	22.5-25.5	22.5-25.0	No data	No data
6.	DEYE	Eye diameter (% of standard length)	6.2-6.7	5.5-8.2	No data	No data
7.	$DEYE_2$	Eye diameter (% of head length)	24.0-25.3	20.4-27.1	20.4-27.1	23.9-28.8
8.	LCAUDPED	Length of caudal peduncle (% of standard length)	15.9-16.9	14.7-21	15.1-21.0	13.7-17.0

9.	$LCAUDPED_2$	Length of caudal peduncle (% of standard length)	8.9-15.5	No data	No data	No data
10.	$H_1PEDCAUD$	Minimum height of caudal peduncle (% of standard length)	**9.7**-10.1	10.3-11.3	No data	10.9-14.5
11.	HPEDCAUD	Maximum height of caudal peduncle (% of caudal peduncle length)	0.7-**0.8**	No data	No data	No data
		Maximum height of caudal peduncle (% of $LCAUDPED_2$)	1.0-1.3	1.3-1.7*	No data	No data
12.	LPREDORSPACE	Predorsal distance (% of standard length)	57.3-59.0	57-62	No data	No data
13.	LPECT	Pectoral fin length (% of standard length)	**17.0**-19.3	18.5-21.3	No data	No data
14.	$LPECT_2$	Pectoral fin length (% of the distance between pectoral and ventral fins)	**67.9-76.2**	60.2-69.3	60.2-69.3	71.1-89.8
15.	LVENT	Ventral fin length (% of standard length)	**13.9**-15.5	15.4-18	No data	No data
16.	LPREANAL	Pre-anal distance (% of standard length)	71.9-73.1	70-76	No data	75.6-78.5
17.	LPREVENTRAL	Pre-ventral distance (% of standard length)	48.3-50.8	50-66	No data	52.6-55.3

18.	LDORSALBASE	Length of dorsal fin base (% of standard length)	11.4-12.5	10.6-14	No data	No data
19.	LANALBASE	Length of anal fin base (% of standard length)	10.7-11.7	10.5-12.7	No data	10.9-14.5
20.	PVDIST	Distance between pectoral and ventral fins insertions (% of standard length)	24.4-26.0	No data	No data	No data

It was observed that the lowering of ranges of some morphometric characteristics can be linked to the phenotypic plasticity of the fish which quickly adapt by modifying their physiology and behaviour to environmental changes (Bohlen et al., 2008). The dwarfism as a response to the thermal environment is noted by Bohlen et al., (2008) and shows the comparably small size in *Cobitis elongatoides* and *Sabanejewia balcanica* under the influence of warm water from the Băile Episcopeşti thermal spring.

The modification tendency of some of the morphological features of thermal rudd is consistent with the opinion expressed by Bănărescu (2002) regarding the recent derivation of species from the Central European common rudd, *Scardinius erythrophthalmus*.

The morphological variation in fish from the *S. racovitzai* sample was compared with data published by different authors (Müller, 1958; Berinkey, 1960; Bănărescu, 1964; Kottelat and Freyhof, 2007) and includes differences in magnitude to its congener, *S. erythrophthalmus*, and is assessed by the hierarchical clustering complete linkage method (Wilkinson, 2005). This procedure allows detection of natural groupings in data (Wilkinson, 2005). The data matrix used includes five morphological characteristics: body height, the lengths of head and caudal peduncle, minimum caudal peduncle height and eye diameter that can be found in all the next five cases:

- studies of Bănărescu (1964) and Berinkey (1960) regarding *S. racovitzai* (the results obtained by Müller, 1958 are similar to those published by Bănărescu, 1964);
- study of Bănărescu (1964) regarding *S. erythrophthalmus*;
- the results from this study regarding the morphological features in thermal rudd;
- for a better representation of data grouping, we added the measurements of these five characters in *S. erythrophthalmus* captured and measured within this research.

The output of hierarchical clustering is displayed in the dendrogram from figure 2 that represents the evidence of similarity and dissimilarity between results. The morphometric dendrogram revealed the clustering of our results and those obtained by the authors mentioned above, regarding the *S. racovitzai* morphometry.

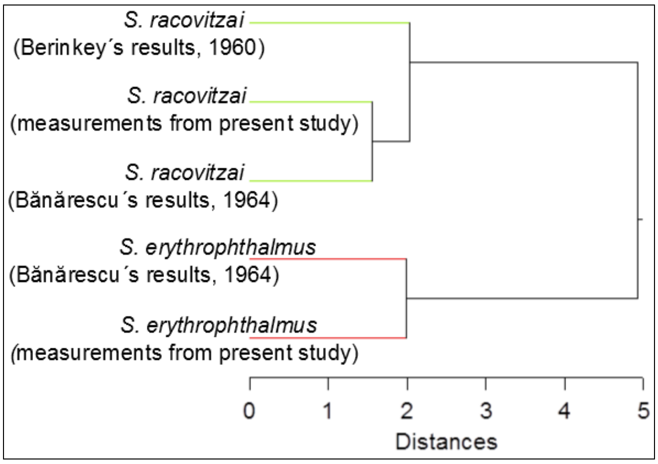

Figure 2: Hierachical clustering analysis based on morphometric data. The algorithm used was the complete linkage clustering (nearest neighbour) with the Euclidean distance as a similarity measure.

The distances between similar clusters and the remoteness from *S. erythrophthalmus* clusters is shown in table 2. The clusters containing the body measurements in *S. racovitzai* from different studies (the results from this research as well as those mentioned by Bănărescu, 1964 and Berinkey, 1960) were joined at the smallest Euclidean distances: 1.561 and 2.035.

Table 2: Euclidean distances between clusters.

Cluster containing:	and Cluster containing:	Were joined at distance	No. of members in new cluster
S. racovitzai (Bănărescu, 1964 results)	*S. racovitzai* (measurements from this study)	1.561	2
S. erythrophthalmus (measurements from this study)	*S. erythrophthalmus* (Bănărescu, 1964 results)	1.994	2
S. racovitzai (Berinkey, 1960 results)	*S. racovitzai* (Bănărescu, 1964 results)	2.035	3
S. erythrophthalmus (measurements from this study)	*S. racovitzai* (Berinkey, 1960 results)	4.919	5

Statistical analysis of morphometric data carried out during experiments. Principal component analysis allowed the identification of a combination of variables that influence the overall variability and the size of their impact (Prein et al., 1993; Stenson and Wilkinson, 2005). This approach to data analysis was applied in order to expand the degree of confidence in the conclusions, taking into account the small sample size which was limited by legal permit (1231 Order from 2013 of MMSC regarding the approval of exemption for scientific purposes capturing in some wildlife species).

The principal components analysis of morphometric values prove that the first two principal components sum up to 57.454% of the total variance (42.326% for PC1 and 15.128% for PC2), which means that more than 57% of the variance of all body variables is explained by the first two factors (Fig. 4). Looking for variables with high loadings, it is observed that the PC1 includes the significant, positive contribution of body height, caudal peduncle height and length, ventral, anal and dorsal fins length, and negative contribution of head length, mouth length, preanal, predorsal, preventral and preorbital distances (Fig. 4a). In the same way, PC2 indicates the positive contribution of characteristics like fin lengths (ventral and pectoral fins) (Fig. 4b).

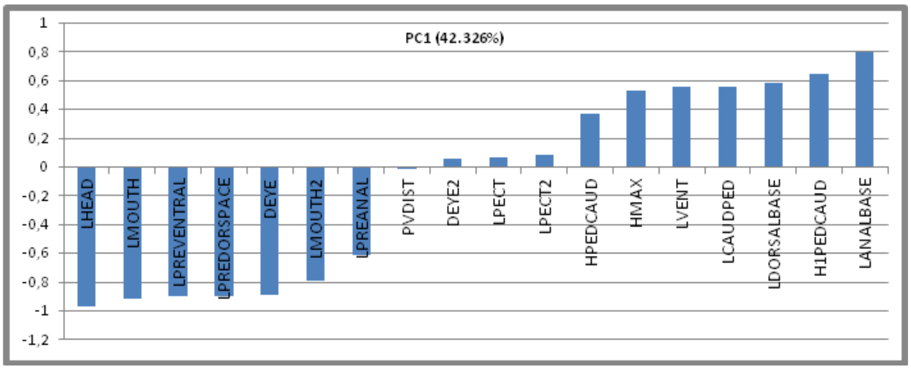

Figure 4a: Variables loaded in the principal component analysis (PCA) of morphometric measurement values of *Scardinius racovitzai* (n = 12). The full names of variables (Tab. 1).

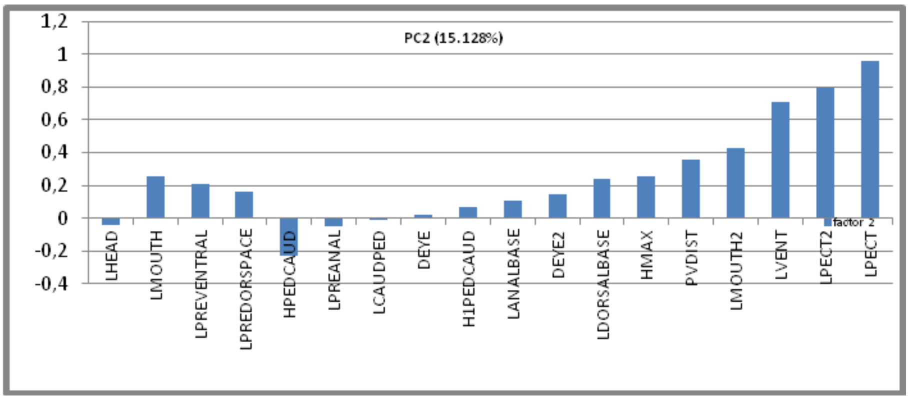

Figure 4b: Variables loaded in the principal component analysis (PCA) of morphometric measurement values of *Scardinius racovitzai* (n = 12). The full names of variables (Tab. 1).

Morphometric comparison between *S. racovitzai* and *S. erythrophthalmus*. A multivariate test was applied for a comparison between the thermal rudd sample captured in 2013 and a sample of its congener *S. erythrophthalmus* (eight individuals) collected from the Danube River population (Mm 80) in order to complete the data regarding the morphological variation in thermal rudd and to assess its plasticity.

The significant differences in the main characters of fish from the two samples by applying the T test ($P < 0.05$) were noted in table 3 as "*characteristic* ^{S}".

Table 3: Mean values of variables (%).

Morphometric feature	Non-thermal rudd (*Scardinius erythrophthalmus*)	Thermal rudd
HMAX^S	34.5	29.1
LHEAD^S	19.5	26.1
LMOUTH^S	3.8	6.3
$LMOUTH_2{}^S$	19.6	24.0
DEYE^S	4.8	6.5
$DEYE_2$	24.4	24.7
LCAUDPED^S	17.8	16.4
H1PEDCAUD^S	10.5	9.9
HPEDCAUD^S	0.8	0.8
LPREDORSPACE^S	54.3	58.1
LPECT	19.2	18.2
$LPECT_2$	75.1	72.0
LVENT^S	17.8	14.7
LPREANAL	67.2	72.5
LPREVENTRAL^S	44.5	49.6
LDORSALBASE^S	13.1	12.0
LANALBASE^S	13.4	11.2
PVDIST^S	25.8	25.2

The objective *discriminant analysis* (developed by Fisher, 1936, and quoted by Engelman, 2005) of morphometric measurements on samples from the two species was the identification/verification of the most relevant characteristics for discerning between two samples of the two species (Engelman, 2005). The sample frequencies are noted on table 4. The thermal rudd group is divided in three subsamples in relation with the time of capture (August, October and November 2013).

Table 4: Group frequencies used for discriminant analysis.

Sample	*S. racovizai* (1)	*S. racovizai* (2)	*S. racovizai* (3)	*S. erythrophthalmus* (4)
Number of individuals/sample	5	7	7	8

Between groups F-matrix shows the F parameter value for testing the differences between each pair of groups and all the variables. The F values are proportional to distances measured on morphospace. They are computed from Mahalanobis statistics (developed by the Indian statistician Prasanta C. Mahalanobis) (Engelman, 2005) and prove the correct classification of the thermal rudd groups with the farthest distance from the *S. erythropthalmus* group (5.736, 10.570 and 6.412 respectively) (Tab. 5).

The reliability of discriminant analysis of morphometric characters of fish from the two species is assessed by *Wilks' lambda statistical index*, which tests the dispersion among all the groups on all the variables (Engelman, 2005).

The computed value of Wilks' lambda statistical parameter (Wilks' lambda = 0.0152, prob = 0.0000) reveal discrimination with an advanced degree of confidence ($P < 0.05$).

The F-to-remove statistics (Engelman, 2005) determine the relative importance of variables/morphometric characters included in the model (Tab. 6). We noted that a number of six morphological characteristics are the most useful for discriminating between the species (head features, caudal peduncle, pectoral and ventral fins lengths).

Table 5: Between groups F-matrix and distances between *Scardinius racovitzai* groups (August, October and November samples) and *S. erythrophthalmus group* (June sample) (df = 17 and seven respectively).

Fish sample	Thermal rudd, 2013, August sample (1)	Thermal rudd, 2013, October sample (2)	Thermal rudd, 2013, November sample (3)	Non-thermal rudd (*S. erythropht.*), 2014, June sample (4)
Thermal rudd, 2013, August sample (1)	0.000			
Thermal rudd, 2013, October sample (2)	3.448	0.000	3.184	**10.570**
Thermal rudd, 2013, November (3)	2.030		0.000	**6.412**
Non-thermal rudd (*S. erythropht.*), 2014, June sample (4)	**5.736**			0.000

Table 6: F-to-remove statistics of main morphometric characters of two fish groups, *Scardinius racovitzai* and *S. erythrophthalmus*.

Variable		F-to-remove	Tolerance	Variable		F-to-enter	Tolerance
2	**HMAX**	3.17	0.20	19	PVDIST	2.90	0.0011
3	**LHEAD**	13.15	0.01				
4	LMOUTH	2.57	0.01				
5	LMOUTH2	2.22	0.02				
6	**DEYE**	145.79	0.01				
7	DEYE2	– 10.31	0.02				
8	**LCAUDPED**	5.88	0.23				
9	H1PEDCAUD	1.91	0.28				
10	HPEDCAUD	2.21	0.20				
11	LPREDORSPACE	1.30	0.16				
12	**LPECT**	6.88	0.07				
13	LPECT2	11.93	0.06				
14	**LVENT**	3.56	0.25				
15	LPREANAL	1.46	0.42				
16	LPREVENTRAL	– 2.40	0.04				
17	LDORSALBASE	0.95	0.45				
18	LANALBASE	– 2.38	0.22				

The classification matrix shows a high percentage of classification validation in all cases (100% correct classification).

The correct classification in thermal rudd was also confirmed by Jackknife matrix analysis that uses functions from all data except the case being classified (Engelman, 2005) (Tab. 7); the lower percent in the Jackknife panel could be assigned to the high number of predictors and small size of *S. erythrophthalmus* group.

Table 7: Jackknifed classification matrix.

Sample	Thermal rudd (*S. racovitzai*)	Non-thermal rudd (*S. erythrophthalmus*)	% correct
Thermal rudd (*Scardiunius racovitzai*)	19	0	100
Non-thermal rudd (*Scardinius erythrophthalmus*)	3	5	63
Total	22	5	89

The *Canonical scores plot* generates the graphic in which the axes are canonical variables and the points are the canonical variables scores (Engelman, 2005). The confidence ellipse ($P < 0.05$) of each group is centred on the centroid of each group (Fig. 5). Based on body measurement values, the groups are clearly distinct. The distance between the ellipses of groups from the same (thermal) ecosystem was explained by the different methods for taking pictures (live/dead specimen) and the small number of observations.

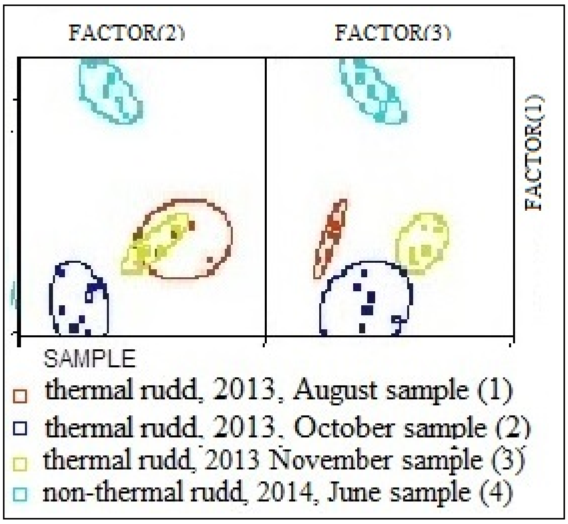

Figure 5: Diagram of canonical scores (95% confidence level) of the four samples on which discriminant analysis was applied: Peţea stage 1-3 and Danube.

The geometric statistical analysis. The *S. racovitzai* was considered a subspecies for a long time by some authors (Bănărescu, 1964), although the same author, in 2004, still considered that molecular techniques were necessary in order to clarify the taxonomic status of thermal rudd. A second approach of analysing of differences between *S. racovitzai* and its congener, *S. erythrophthalmus* was made by the body shape analysis. The 19 thermal rudd individuals randomly chosen from the fish population were used for a comparative, intraspecific and interspecific study with closely related *S. erythrophthalmus* (eight individuals).

The statistical test was made by use of the MorphoJ software through the analysis of the principal components analysis (PCA) (Klingenberg, 2011) and canonical variate analysis (CVA) (Klingenberg, 2011) of body shape.

The principal components analysis (PCA) allows for conclusions about shape variation between the samples, and was also used as an ordination analysis for examining the arrangement of specimens in morphospace and to discover patterns in the relations among observations (Klingenberg, 2011). The shape information was extracted by Procrustes superimposition (Goodall, 1991 quoted by Klingenberg, 2011) which removes variation in size, position and orientation from data on landmark coordinates (Polly, 2012; Zelditch et al., 2004 in Klingenberg, 2011). Each specimen is represented by the relative positions of morphological landmarks that can be located precisely and establish a one-to-one correspondence among all specimens included in the analysis (Klingeneberg, 2011). Information on the size of the landmark configuration is retained in the data set and available for subsequent analyses (Polly, 2012; Dryden and Mardia, 1998 in Klingenberg, 2011).

PCA was performed ing the co-variance matrix of the Procrustes coordinates of each sample and the first two components sum 62.494% of the total variance (Tab. 8).

The two scatter plots of PC scores from figures 6 and 7 display the patterns in the relations between observations, two ways of their grouping being applied for a higher confidence of results. PC1 separated the *S. racovizai* and *S. erythrophthalmus* (Fig. 6). Similarly, PC1 separated *S. racovitzai* individuals from 2013, August, October, November subsamples and *S. erythrophthalmus* (Fig. 7).

Table 8: Eigenvalues of each component expressed by unit of Procrustes variance (% percent of total variance).

Component	Eigenvalues	% Variance	Cumulative %
1	0.00109393	47.109	47.109
2	0.00035726	15.385	62.494
3	0.00018603	8.011	70.505

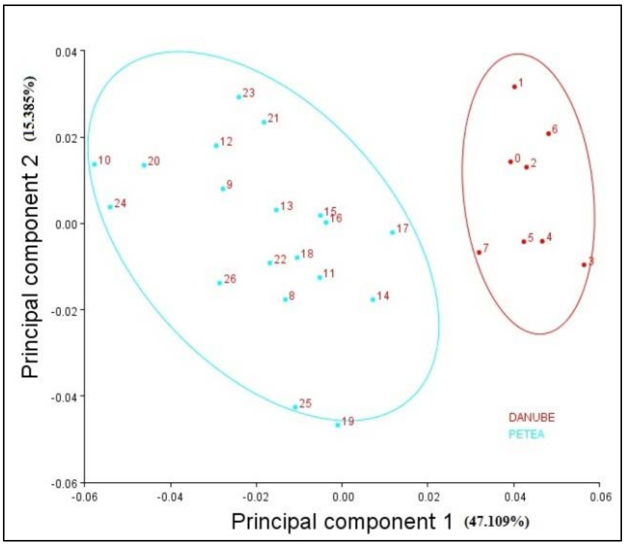

Figure 6: PC scores and the disposition of specimens in the morphospace of the multivariate analysis. Coordinates of PCA plot grouping by equal frequency confidence ellipses (P = 0.9); The specimens are grouped by species – *S. racovitzai*, – *S. erythrophthalmus*.

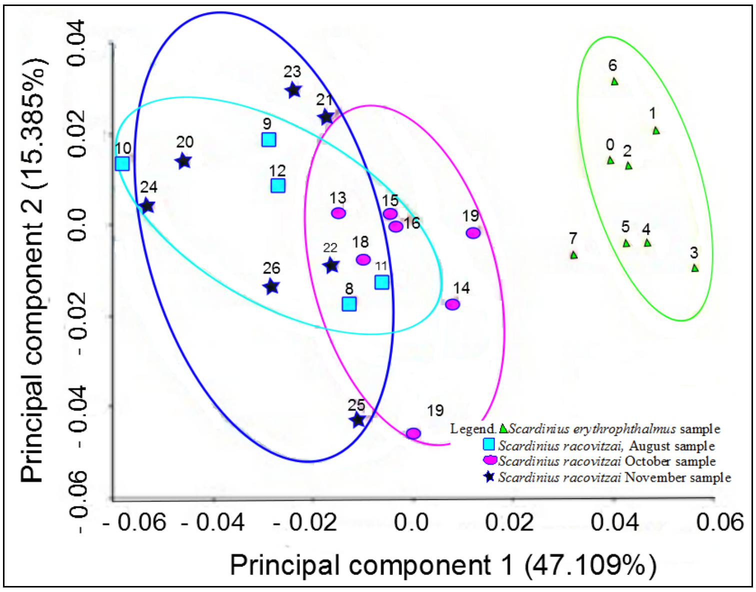

Figure 7: PC scores for the first two components and the disposition of specimens in the morphospace of the multivariate analysis (PC1 47.109%, PC2 15.385%). Coordinates of PCA plot grouping by equal frequency confidence ellipses (P = 0.9); The specimens are grouped by sampling stage (1 – thermal rudd, 2013 August sample, 2 – thermal rudd, 2013 October sample, 3 – thermal rudd, 2013 November sample, 4 – *Scardinius erythrophthalmus*, 2014 June sample).

Canonical variate analysis (CVA) allows a different type of ordination analysis, which maximizes the separation of specified groups (species/ecotypes, Klingenberg, 2011). The results provided the shape features that best distinguish among the fish groups from Peţea Lake and Danube River.

The scatter plot of the CV scores displays the species separation (Fig. 8).

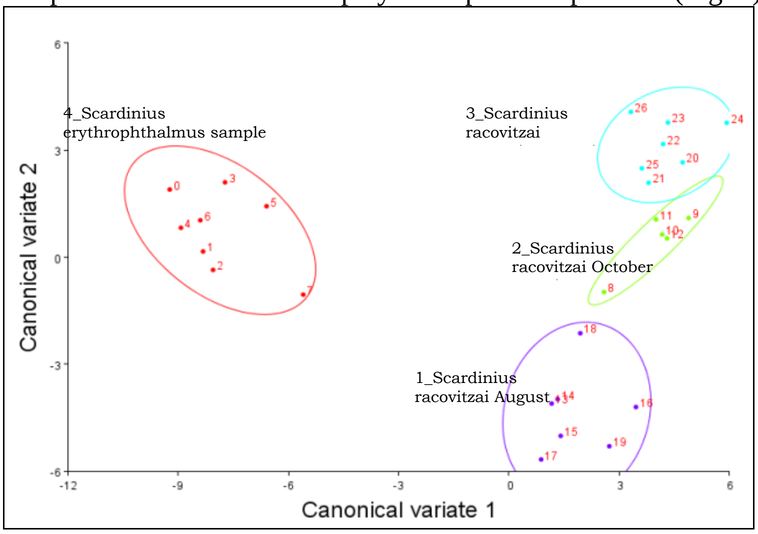

Figure 8: The scatter plot of the CV scores with equal frequency ellipses (P = 0.9) that group the coordinates by sampling stage.

CVA generated as a result the matrices of farthest Mahalanobis distances between group number four (*S. erythrophthalmus*) and the other three (representing the observations on Peţea lake fish) (Tab. 9). P-values from permutation tests (10.000 permutation rounds) for Mahalanobis distances among groups are statistically significant ($P < 0.05$).

The analysis of the geometry of individuals from the two species generated results in accordance with the morphometric discriminant analysis, yet a larger number of observations are needed for greater accuracy of results.

Table 9: Matrix with Mahalanobis distances among groups.

Sample	Sample no. 4
Sample no. 1	12.2975
Sample no. 3	12.4924
Sample no. 2	11.0096

CONCLUSIONS

Following the deterioration of the thermal ecosystem, one proposed the morphological variation in *S. racovitzai* and a detailed testing of morphometric features of individuals extracted from present thermal rudd population (*Scardinius racovitzai*) sampling during 2013, by comparing it to different references and also to its congener *S. erythrophthalmus*.

This study completes the data regarding the morphometric characters in *S. racovitzai*.

The statistical analysis of morphological characteristics of *S. racovitzai* revealed slightly decreased ranges of them when compared to other references. This can be linked to fish phenotypic plasticity in relation with thermal environments, but there are also several other factors that could influence their physiological and behavioural responses: drastic evolution of abiotic factors from the last years during first stages of fish development, availability/abundance of food resources, etc. That is why a detailed study of scale morphometry as a measure of habitat condition is needed to in order to expand on the conclusions regarding the fish plasticity findings.

The hierarchical clustering complete linkage analysis revealed the similarities between data resulting from this study and available data from literature regarding *S. racovitzai* morphology. The dissimilarity with its congener, *S. erythrophtalmus* is also evidenced by graphical dendrogram and the farthest distance between clusters of two species.

The PCA analysis of morphometric data in *S. racovitzai*examined the patterns in the relations among observations and identified the contribution of several body features on the overall variability of fish such as body height, caudal peduncle height and length, fins length, head and mouth length, preanal, predorsal, preventral and preorbital distances. The large number of variables with impact on this variability is connected to sample size.

The geometric and morphometric analyses revealed shape variations and statistically significant differences between the populations of thermal rudd and *S. erythrophthalmus.* A total number of six morphological characteristics are the most useful for discerning between the species (head features, caudal peduncle and pectoral and ventral fins lengths).

Despite a clear separation of specified groups in the morphospace of multivariate analysis, applying molecular techniques is necessary as the modern technique for distinction between species or ecotypes.

ACKNOWLEDGEMENTS

The results from this study are a part of the project regarding the captive breeding and ex situ maintaining of populations of *Scardinius racovitzai* and *Melanopsis parreyssii* funded by the Mohamed Bin Zayed Species Conservation Fund and the authors wish to thank the Fund for supporting the researches.

The authors also wish to thank to Mr. Telcean I., for his scientific suggestions and the personnel of the Aquarium Department of Museum Complex of Natural Sciences Galaţi for their contribution in the husbandry of the experimental stock.

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BIOTOPE DETERMINANTS OF EPT ASSAMBLAGES STRUCTURE – TÂRNAVA WATERSHED (TRANSYLVANIA, ROMANIA) CASE STUDY

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DOI: 10.1515/trser-2015-0067

KEYWORDS: mayfly communities, stonefly communities, caddisfly communities, Târnava Mare River, Târnava Mică River, Târnava River.

ABSTRACT

This study aims to analyze the biotopic factors affecting the EPT assemblage diversity in the rivers of the Târnava Watershed. Our research revealed that the high diversity of the Plecoptera communities is associated with river reaches with boulder and cobble lithological substrate, accentuated slope and natural bank dynamics, and also it is directly correlated with dissolved oxygen and inversely correlated with chemical and biochemical oxygen demand, total hardness, nitrates and total nitrogen in the water. The high diversity of the Trichoptera communities is associated with water which presents moderate quantities of nutrients (total phosphorus, phosphates) and with river reaches with heterogeneous structures (where runs and bends were present). The diversity of the Ephemeroptera communities is positively correlated with the multiannual average flow and riverbed width.

RÉSUMÉ: Déterminants du biotope sur les structures des communautés EPT – Etude de cas du bassin hydrographique de la Târnave (Transylvanie, Roumanie).

Cetta étude concerne l'analyse de l'influence des facteurs du biotope sur la diversité des communautés d'éphéméroptères, plécoptères et trichoptères des rivières des Târnava Bassin. Les résultats de l'étude relèvent que la grande diversité des associations de plécoptères est associée aux secteurs de rivière qui présentent les caractéristiques suivantes: fond dominant lithologique, pente accentuée et dynamique naturelle des berges, corrélation positive à la concentration d'oxygène dans l'eau et corrélation négative à la durite totale, à la concentration des nitrates, à la quantité d'azote total dans l'eau ainsi qu'aux valeurs CCO-Mn et CBO5. La grande diversité des trichoptères est associée aux eaux présentant des quantités modérées de nutriments (phosphore total et phosphates) ainsi qu'aux secteurs de rivière à structure hétérogène (présentant des rapides et des méandres). La diversité des communautés d'éphéméroptères est positivement corrélée aux débits liquides multi-annuels et à la largeur du lit mineur de la rivière.

REZUMAT: Determinanți de biotop asupra structurii comunităților EPT – Studiu de caz bazinul hidrografic Târnava (Transilvania, România).

Studiul analizează influența factorilor de biotop asupra diversității comunităților de efemeroptere, plecoptere și trihoptere în cazul râurilor din bazinul Târnava. Rezultatele studiului relevă faptul că diversitatea mare a comunităților de plecoptere este asociată sectoarelor de râu cu substrat dominant litologic, pantă accentuată și dinamică naturală a malurilor, de asemenea este corelată pozitiv cu gradul de oxigenare al apei și negativ cu duritatea totală, concentrația azotaților, cantitatea de azot total din apă și valorile CCO-Mn, CBO5. Diversitatea mare a trihopterelor este asociată cu apele care prezintă cantități moderate de nutrienți (fosfor total și fosfați) și cu sectoarele de râu cu structură heterogenă (în care sunt prezente repezișuri și meandre). Diversitatea comunităților de efemeroptere este corelată pozitiv cu debitele lichide multianuale și cu lățimea albiei minore.

INTRODUCTION

Ephemeroptera, Plecoptera and Trichoptera larvae communities are key components for matter cycling in the lotic systems (Allan, 1995; Wallace and Webster, 1996; Rawer-Jost et al., 2000; Abdul-Aziz et al., 2010; Yates and Bailey, 2010; Jiang et al., 2011), and are good indicators of ecological status (Staicu et al., 1998; Kreatzweiser et al., 2005; Bonada et al., 2006; Diggins, Newman, 2009; Aura et al., 2011; Sedeño-Díaz et al., 2012; Narangarvuu et al., 2014; Turkmen and Kazanci, 2015).

This study aims to analyze the biotopic factors influencing EPT assamblage diversity in the Târnava rivers. The Târnava River basin was selected for this analysis due to its dimensions, high variability of biotopes and also high variability of human impact (Curtean-Bănăduc et al., 2001; Curtean-Bănăduc, 2005a). The Târnava Watershed (Târnava Mare, Târnava Mică and Târnava main rivers) is situated in the central part of the Romanian Carpathians and drains the southern part of the Transylvanian Depression. With a total surface area of the catchment of 6,157 km^2, a length of 249 km and a height difference of approximately 1,250 m, the Târnava River is the second main tributary of the Mureş River, representing 21% of this hydrographic basin. The Târnava River is formed by the junction of Târnava Mare River (3,606 km^2 basin surface and a length of 221 km) and Târnava Mică River (2,049 km^2 basin surface and a length of 191 km) (Roşu, 1980).

MATERIAL AND METHODS

The results are based on the benthic macroinvertebrate quantitative samples of 24 stations in the reference area (Fig. 1, Tab. 1). The samples were taken from five different points, in each station (10 m length), in order to highlight the specific diversity of local microhabitats. The sampling was carried out with an 887 cm^2 surface Surber Sampler, with a 250 µm mesh net. The sampled biological material was fixed in 4% formaldehyde solution and was analyzed in the laboratory with an Olympus (150X) stereomicroscope. Ephemeroptera, Plecoptera and Trichoptera larvae were identified at the species level.

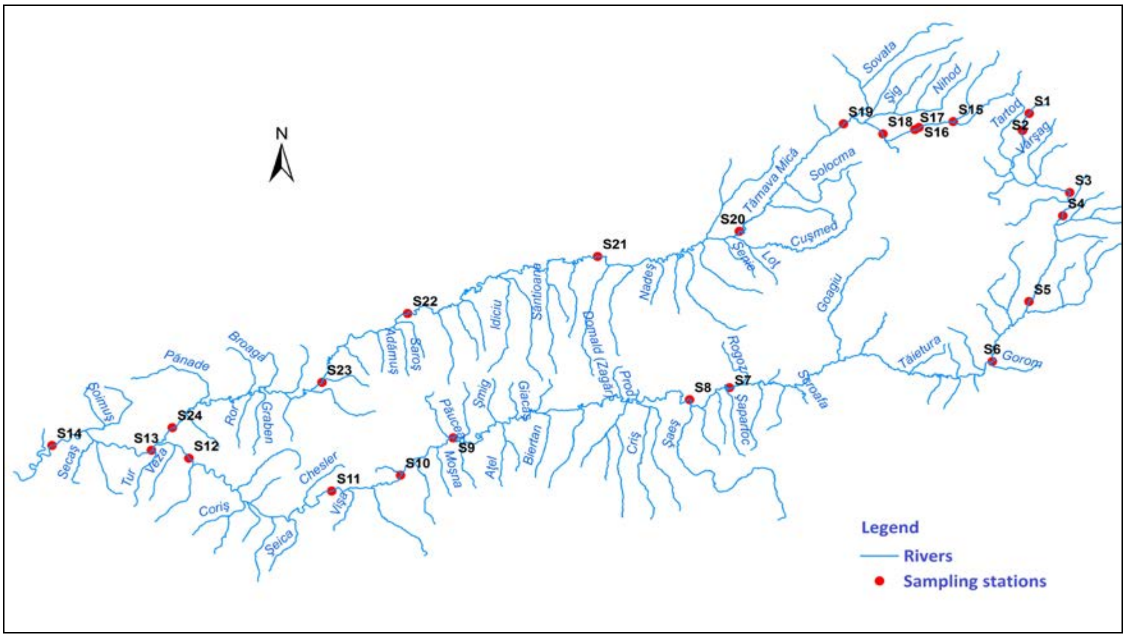

Figure 1: The sampling stations location on the studied rivers:
Târnava Mare (S1 – S12), Târnava (S13, S14), Târnava Mică (S15 – S24).

Table 1: The sampling stations location on the studied rivers.

Sampling stations	GIS Stereo 70 POINTS X, Y	Position
S1	527322,580905 564610,161545	Târnava Mare, five km upstream Vârşag locality
S2	526660,279367 562436,41699	Târnava Mare, one km upstream Vârşag locality
S3	532115,38254 554014,135054	Târnava Mare, one km upstream Zetea Dam lake
S4	531336,309742 550804,504496	Târnava Mare, one km downstream Zetea Dam lake
S5	527069,455486 539095,109498	Târnava Mare, between Zetea locality and Odorhei locality
S6	521937,932132 530838,859923	Târnava Mare, four km downstream Odorhei locality
S7	488134,519504 527886,824765	Târnava Mare, five km upstream Sighişoara locality
S8	482997,898116 526281,030128	Târnava Mare, one km downstream Sighişoara locality
S9	452726,517213 520268,736478	Târnava Mare, two km upstream Mediaş locality
S10	446241,702069 515269,513909	Târnava Mare, four km downstream Mediaş locality
S11	437195,876026 512952,91462	Târnava Mare three km downstream Copşa Mică locality
S12	414836,320828 519516,518406	Târnava Mare two km upstream Blaj locality
S13	414195,720599 518752,386123	Târnava, one km downstream confluence of Târnava Mare River and Târnava Mică River
S14	398239,794978 516402,326039	Târnava, three km upstream confluence with Mureş River
S16	511901,508551 561665,936165	Târnava Mică, one km upstream Praid locality
S17	510767,929206 561449,798245	Târnava Mică, one km upstream Praid locality
S18	508252,478901 562076,51088	Târnava Mică, one km downstream Praid locality
S19	503264,107128 563057,563364	Târnava Mică, one km downstream Sovata locality
S20	489173,69412 549014,554564	Târnava Mică, one km upstream Sângiorgiu de Pădure locality
S21	470935,991703 544743,681313	Târnava Mică, one km upstream Coroisânmartin locality
S22	447012,116361 537362,929148	Târnava Mică, one km upstream Târnăveni locality
S23	435624,085388 528247,747231	Târnava Mică at Cetatea de Baltă locality
S24	416824,63681 521604,529235	Târnava Mică, one km upstream Blaj locality

The assessed biotopic variables were: slope, multiannual average flow, riverbed width, depth, substratum type, presence of pools, riffles, runs and bends, channel modification (expressed in percentages of natural state of the riverbed) and chemical characteristics of the water (total hardness – DT, dissolved oxygen – DO, biochemical oxygen demand – BOD_5, chemical oxygen demand – COD-Mn, Cl^- SO_4^{2-}, NO_3^-, PO_4^{3-}, total nitrogen, total phosphorus). The substratum types (mud, sand, gravel, pebbles, cobbles, boulders, large boulders) were expressed as percentages of the transversal section surface (10 m length).

The community's diversity is expressed using the Menhinik (M) (Krebs, 1989) and Gini-Simpson (S) indices (Jost, 2007). Habitat factors – diversity of EPT assemblages conditionality were analyzed using Canonical Correspondence Analysis – CCA (ter Braak, 1986); ordinations were done using CANOCO v 4.5 (ter Braak, Smilauer, 2002). Were obtained regressions, which describe the variation of biodiversity indexes in relation with biotope conditions dynamic. For the statistical analysis and regressions the computer programme STATISTICA 7.0 was used. Statistical evaluations were performed using a level of significance probability (p) with 5% risk of error ($p \leq 0.05$).

RESULTS AND DISCUSSION

In the reference zone 12 mayfly species (belonging to seven genera and six families), (Bănăduc, 2013), eight stonefly species (belonging to five genera and five families) (Curtean-Bănăduc, 2005b) and 13 caddisfly species (belonging to nine genera and nine families) (Robert and Curtean-Bănăduc, 2005) were identified.

Ephemeropteran communities present a high specific diversity and heterogeneity in S1 (M = 0.802, S = 0.67), S3 (M = 0.718, S = 0.746), S7 (M = 1.336, S = 0.593), and S8 (M = 0.775, S = 0.705), in other sectors the Menhinik index values were between 0.4 (S11) and 0.77 (S5), and the Gini-Simpson index presented values between 0.153 (in S11) and 0.65 (in S5).

The plecopterans are present only in the upper courses of the Târnava Mare River (S1 – S4) and Târnava Mică Rivers (S15 – S17), in these sectors the communities of plecopterans present a relatively high specific diversity and heterogeneity (S2 M = 0.873, S = 0.76; S3 M = 1.376, S = 0.743; S4 M = 0.834, S = 0.641; S15 M = 0.804 S = 0.682; S16 M = 0.873, S = 0.705; S17 M = 0.87, S = 0.764) with the exception of the sector S1 (M = 0.767, S = 0.36) in which the heterogeneity is small.

The communities of trichopterans present a high heterogeneity in S3 (S = 0.8), S4 (S = 0.87), S6 (S = 0.762), S7 (S = 0.711), S16 (S = 0.8) and S17 (S = 0.868). In other lotic sectors the Gini-Simpson index values vary between 0 (in S11) and 0.605 (in S19); in all the analyzed sectors the Menhinik index values are small, ranging between 0.131 (S11) and 0.451 (S4).

The CCA which relates EPT biodiversity to the environmental variables, showed that the first two axes (eigenvalues $\lambda 1 = 0.402$, $\lambda 2 = 0.145$) explained 90% of the total variance (Fig. 2). The slope, presence of large boulders, boulders and cobbles were positively correlated with the first axis, whilst the presence of pools and pebbles were negatively correlated with the first axis. Menhinik and Gini-Simpson indices for Plecoptera were positively correlated with the first axis, which meant that the slope, presence of large boulders, boulders and cobbles are favorable for Plecoptera diversity. The presence of runs and bends were positively correlated with the second axis; maximum and average riverbed widths were negatively correlated with the second axis. Multiannual average flow, channel modification and the sand type of the substrate loaded equally on both axes, being negatively correlated with both of them. The diversity of Trichoptera communities expressed through Mehinik and Gini-Simpson indices were positively correlated with the presence of runs and bends; the Menhinik index for Ephemeroptera was positively correlated with the multiannual average flow and Gini-Simpson indices for Ephemeroptera were positively correlated with average and maximum riverbed width.

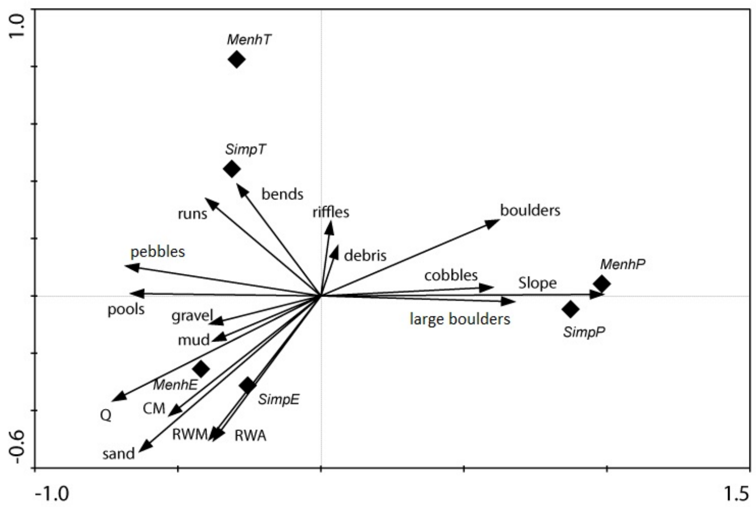

Figure 2: CCA biplot of EPT biodiversity and environmental variables. Abbreviations: MenhE – Menhinik index for Ephemeroptere, MenhP – Menhinik index for Plecoptera, MenhT – Menhinik index for Trichoptera, SimpE – Gini-Simpson index for Ephemeroptera, SimpP – Gini-Simpson index for Plecoptera, SimpT – Gini-Simpson index for Trichoptera, Q – multiannual average flow, CM – channel modification, RWM – maximum riverbed width, RWA – average riverbed width.

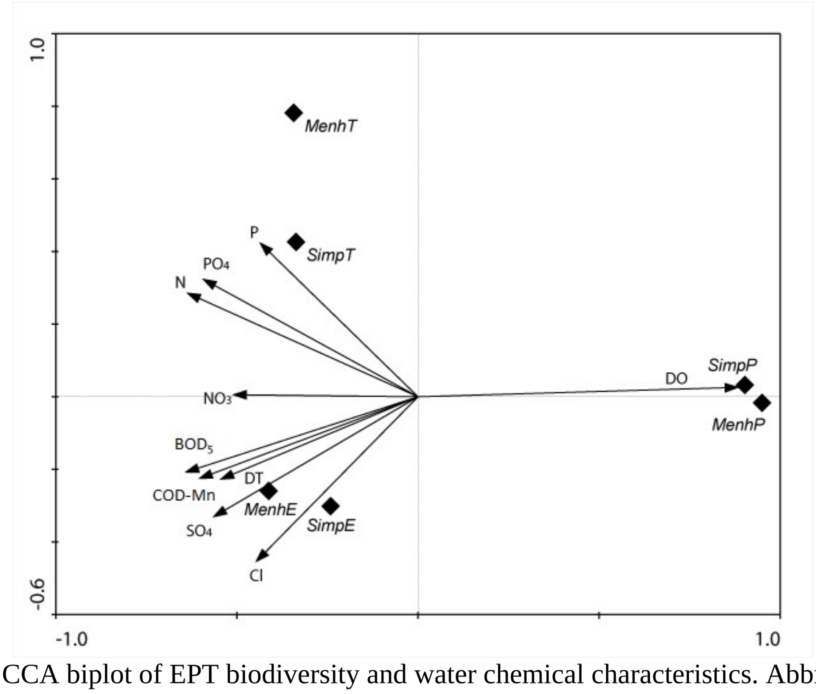

Figure 3: CCA biplot of EPT biodiversity and water chemical characteristics. Abbreviations: MenhE – Menhinik index for Ephemeroptera, MenhP – Menhinik index for Plecoptera, MenhT – Menhinik index for Trichoptera, SimpE – Gini-Simpson index for Ephemeroptera, SimpP – Gini-Simpson index for Plecoptera, SimpT – Gini-Simpson index for Trichoptera, DO – dissolved oxygen, COD – chemical oxygen demand, BOD_5 – biochemical oxygen demand, DT – total hardness.

The results of the CCA, which relates to EPT biodiversity values and water chemical characteristics, showed that the first two axes (eigenvalues λ1 = 0.406, λ2 = 0.162) cumulatively explained 89.3% of the total variance (Fig. 3). DO was strongly positively correlated with the first axis, while the nitrates concentration, total nitrogen, BOD_5, COD-Mn and total hardness were negatively correlated with this first axis. The biodiversity indices for Plecoptera were determined by the first axis, being positively correlated with dissolved oxygen and negatively correlated with nitrates concentration, total nitrogen, BOD_5, COD-Mn and total hardness. Total phosphorus was positively correlated with the second axis, while chloride concentration was negatively correlated with the second axis. The Gini-Simpson indices for Trichoptera were determined by the second axis, being positively correlated with moderate quantities of total phosphorus.

In the studied sectors, the concentration of nitrates ranged between 1.2 mg/l (S4) and 52.75 mg/l (S7), with an average of 9.268 mg/l. The concentration of phosphates was relatively low in all of the analyzed sectors and ranged between 0.0 mg/l and 0.167 mg/l. The concentration of sulphates varied between 5.71 mg/l (S4) and 291.12 mg/l (S11), with the highest values (> 165 mg/l) recorded in the lower part of the Târnava Mare River (S10 – S13) and the Târnava Mică River (S24) and in the Târnava River (S14). The chloride concentration varied between 7.1 mg/l (S4) and 415.35 mg/l (S21). The COD-Mn values, as an indicator of oxidable matter in the water, ranged between 4.1 mg/l (S16) and 31.04 mg/l (S8), with an average of 12.446 mg/l; BOD_5 values varied between 1.5 mg/l (S1) and 13.66 mg/l (S8) with an average of 4.971 mg/l. The total nitrogen shows moderate quantities, ranging between 0.317 mg/l (S3) and 3.280 mg/l (S6), with an average of 1.524 mg/l; the total phosphorus shows small amounts, ranging between 0 mg/l and 0.17 mg/l (S19), with an average of 0.029 mg/l (Tab. 2).

Analysis of correlations indicates that there exist significant correlations between diverse Ephemeroptera communities expressed by the Gini-Simpson and the following physico-chemical water parameters of the water: total hardness – DT (Fig. 4), dissolved oxygen – DO (Fig. 5), sulphates (Fig. 6), nitrates (Fig. 7), phosphates (Fig. 8), total nitrogen (Fig. 9) and total phosphorus (Fig. 10).

Table 2: Water chemical characteristics of the Târnave rivers.

Chemical variables	Minimum	Maximum	Median	Mean	Standard deviation
DO (%)	55.600	99.000	79.940	82.945	13.346
COD-Mn (mg/l)	4.100	31.040	10.290	12.446	7.819
BOD_5 (mg/l)	1.500	13.660	4.745	4.971	3.074
TH (german degrees)	3.080	20.940	7.840	9.626	5.834
NO_3^- (mg/l)	1.200	52.750	5.935	9.268	12.263
PO_4^{3-} (mg/l)	0.000	0.167	0.028	0.058	0.064
SO_4^{2-} (mg/l)	5.710	291.120	58.715	100.784	93.167
Cl^- (mg/l)	7.100	415.350	95.700	132.701	121.712
N total (mg/l)	0.317	3.280	1.113	1.524	1.041
P total (mg/l)	0.000	0.170	0.010	0.029	0.044

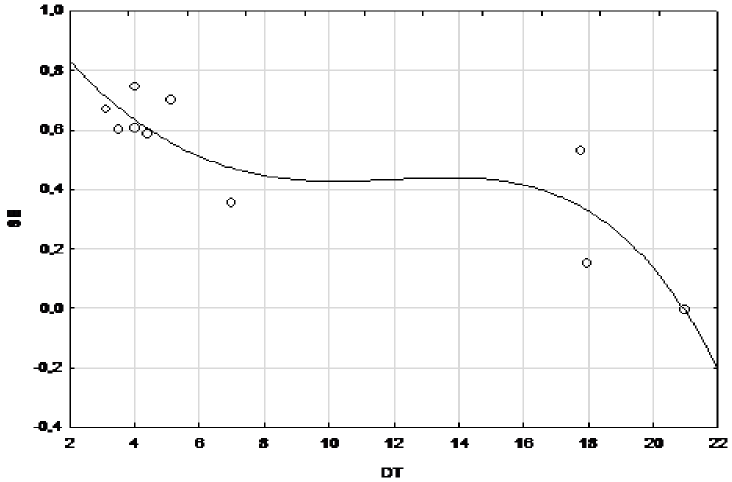

Figure 4: Ephemeroptera diversity variation, expresed by Gini-Simpson – SE index depending on the total water hardness – DT SE = 1.10738 – 0,15828*DT + 0.010215*DT^2 – 0.00001181*DT^4, r^2 = 0.881, p = 0

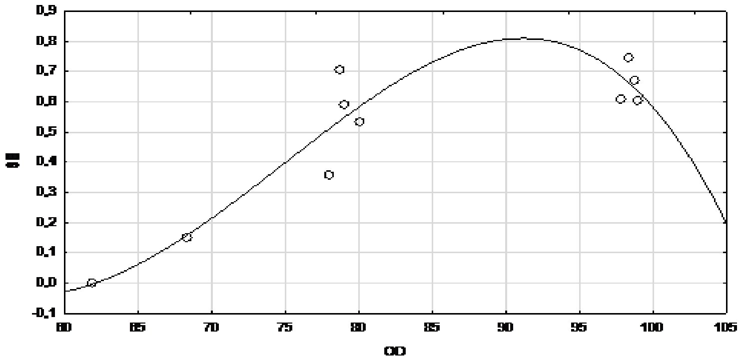

Figure 5: Ephemeroptera diversity, expressed by Gini-Simpson index – SE depending on the concentration of oxygen in water – DO.
SE = 11.7197 – 0.46603*DO + 0.005043*DO^2 – 0.000000149*DO^4, r^2 = 0.933, p = 0

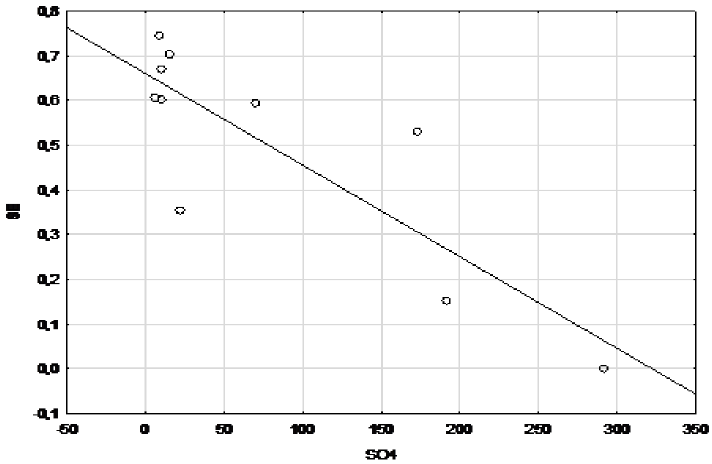

Figure 6: Ephemeroptera diversity variation, expressed by the Gini-Simpson index – SE depending on the concentration of sulphates in the water – SO4. SE = 0.660039 – 0.00205*SO4, r^2 = 0,841, p = 0

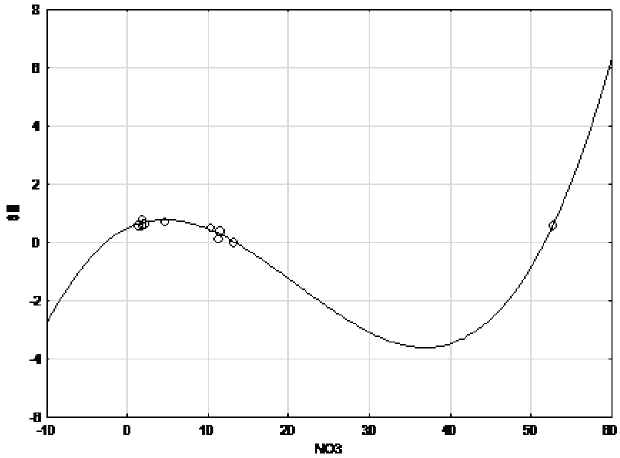

Figure 7: Ephemeroptera communities diversity variation, expressed by the Gini-Simpson index – SE depending on the concentration of nitrates in water – NO_3.
$SE = 0.467943 + 0.135536*NO_3 – 0,01635*NO_3^2 + 0.000262*NO_3^3$, $r^2 = 0,947$, $p < 0,05$

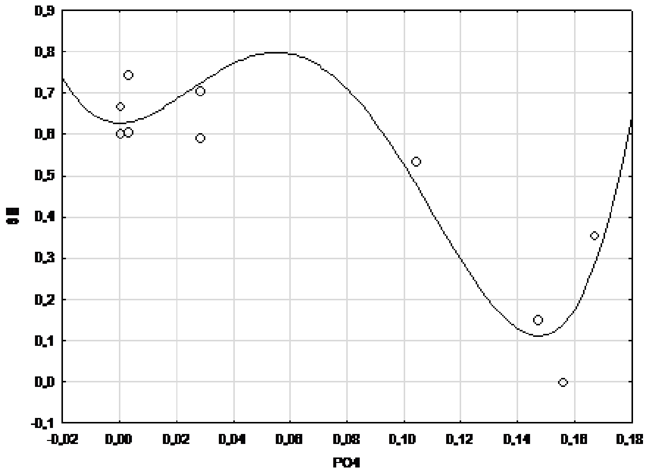

Figure 8: Ephemeroptera communities diversity variation, expressed by the Gini-Simpson index – SE depending on the concentration of phosphates in water – PO4.
$SE = 0.626602 + 208.757*PO_4^2 – 3478.7*PO_4^3 + 12901.2*PO_4^4$, $r^2 = 0,941$, $p < 0,01$

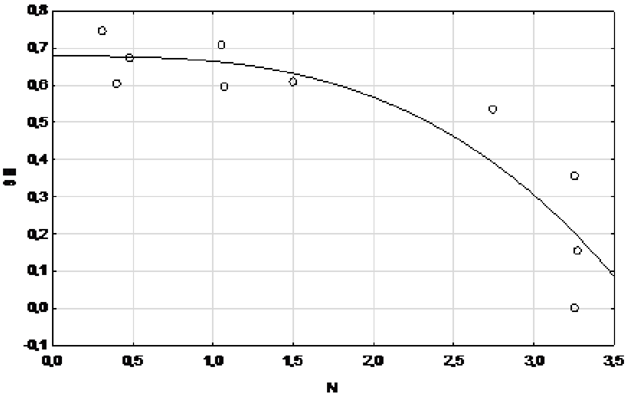

Figure 9: Ephemeroptera communities diversity variation, expressed by the Gini-Simpson index – SE depending on the concentration of total nitrogen in water – N.
$SE = 0.678297 – 0.01381*N^3$, $r^2 = 0.902$, $p = 0$

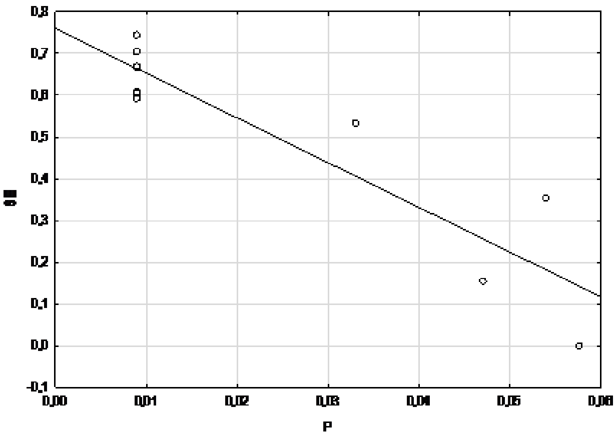

Figure 10: Ephemeroptera communities diversity variation, expressed by the Gini- Simpson index – SE depending on the total phosphorus concentration in water – P. SE = 0.759763 – 10.707*P, $r^2 = 0.908$, $p = 0$

CONCLUSIONS

High Plecoptera community diversity is associated with river sectors with a lithological substrate comprising boulders and cobbles, accentuated slope and with natural banks, and also is positively correlated with dissolved oxygen and negatively correlated with chemical and biochemical oxygen demand, total hardness, nitrates and total nitrogen in the water. The high diversity of the Trichoptera communities is associated with water which presents moderate quantities of nutrients (total phosphorus, phosphates) and with river sectors with heterogeneous structures (where runs and bends were present). The diversity of the Ephemeroptera communities is positively correlated with the multiannual average flow and riverbed width. Regression analysis can be used to forecast the biodiversity dynamic – as indicator of homeostasis of the analyzed lotic systems, in case of water physico-chemical parameters, in various management scenarios of the studied rivers.

ACKNOWLEDGEMENTS

The author thanks Mr. Olosutean H. for improved statistical analysis and to the students of "Lucian Blaga University", Faculty of Sciences, for some field activities. Some data were obtained in the project POSDRU/89/1.5/S/63258.

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WATER QUALITY AND HAEMATOLOGICAL INDICES OF *CLARIAS GARIEPINUS* FROM OGUN RIVER (NIGERIA)

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DOI: 10.1515/trser-2015-0068

KEYWORDS: hematological indices, water quality, *Clarias gariepinus*, Ogun River.

ABSTRACT

This study was conducted to assess the effect of water quality of the Ogun River on the haematological indices of the African catfish *Clarias gariepinus*. Samples of water and *Clarias gariepinus* were collected from Ogun River (Station I, Opeji and Station II, Lafenwa) to determine and compare effects of possible differences in water quality on haematological parameters of *Clarias gariepinus*. The results demonstrate that higher index values were recorded at station II than Station I for almost all the physicochemical parameters and only sulphate values from Stations I and II were statistically significant ($P < 0.05$).

RÉSUMÉ: La qualité de l’eau et les indices hématologiques pour *Clarias gariepinus* dans la rivière Ogun (Nigéria).

Le but de cette étude a été d’évaluer l’effet de la qualité de l’eau de la rivière d’Ogun sur les indicateurs hématologiques du poisson chat africain *Clarias gariepinus*. Des échantillons d’eau et des poissons de l’espèce *C. gariepinus* ont été collectés de la rivière d’Ogun (Station I, Opeji et Station II, Lafenwa) afin de mesurer de comparer les effets possibles des différences de la qualité de l’eau sur les paramètres hématologiques de *C. gariepinus*. Les résultats ont mis en évidence le fait que dans la station II ont été enregistrés des valeurs plus grandes que dans la station I pour presque tous les paramètres physiques et chimiques mais ils ont aussi montré le fait que seul l’indicateur sulfate a des valeurs statistiquement significatives ($P < 0,05$).

REZUMAT: Calitatea apei și indici hematologici la *Clarias gariepinus* din râul Ogun (Nigeria).

Prezentul studiu a fost efectuat pentru a evalua calitatea apei în râul Ogun, cu privire la indicii hematologici ai somnului african, *Clarias gariepinus*. Au fost colectate eșantioane de apă și pești din specia *Clarias gariepinus* din râul Ogun (stația I, Opeji și Stația II, Lanfewa) pentru a se determina și compara efectele posibilelor diferențe ale calității apei asupra parametrilor hematologici *Clarias gariepinus*. Rezultatele au arătat că în stația II s-au înregistrat valori mai mari decât în stația I, pentru aproape toți parametrii fizico-chimici și doar valorile pentru indicele sulfat din cele două stații au fost statistic semnificative ($P < 0,05$).

INTRODUCTION

Water is the most abundant of natural resources and is essential for the survival of living organisms. However, the availability of water in the appropriate quantity and quality remains a key challenge in most aquatic systems because of pollution. Pollution is caused by anthropogenic processes as a result of industrialization and urbanization because industries and cities have historically been located along freshwater ecosystem such as rivers.

Nigeria has several significant riverine systems: about two thirds of the country lies in the watershed of the Niger River, and other major river systems include the Benue River, Cross River, Anambra River, Imo River, Kwa Iboe River, Ogun River and Oshun River. The Ogun River is the largest water body in the south western part of Nigeria. This river serves as a source of livelihood for artisanal fishers and other economic activities for a number of communities. Due to a long history of use, the river has been subjected to environmental degradation.

Surface-water pollution is highly visible in the Ogun River and the major pollutants and damaging processes associated with the water body include erosion, siltation, domestic and industrial wastes, effluent from abattoir, motor garages, mechanical shops, excreta disposal, agricultural activities and bathing washing. These pollutants have reduced the river water quality and quantity particularly where the human activities are well pronounced and have also become threats to aquatic life in the river. This is because aquatic organisms, including fish, accumulate pollutants directly from contaminated water and indirectly *via* the food chain (Mohammed, 2009) and the pollutants enter the blood stream through the process of absorption where their potential harmful effects are distributed throughout the body.

Blood forms about 2-3% of the weight of fish. The blood composition of fish reflects its metabolic and physiological process and certain physiological dysfunctions in the body are reflected as alterations in blood. Blood parameters are important indicators of health status in animals and have been an indispensable tool in the diagnosis. The purpose of investigating blood composition of fish is to distinguish normal state from states of stress and health status.

This study was designed to investigate the water quality of Ogun River through analysis of some selected water quality parameters and examined haematological parameters of *Clarias gariepinus* caught from the study area.

MATERIAL AND METHODS

River Ogun is in the largest perennial river in South-Western part of Nigeria and it covers an area of 22.4 km^2. The river rises in Oyo State near Shaki at 8°41’0” N 3°28’0” E/ 8.68333° N 3.46667° E and flows through Ogun State into Lagos State (Ayoade et al., 2004).

Water sampling. The two stations (Opeji and Lafenwa) from Ogun River were chosen with consideration of the human activities in each area. Station I (Opeji) was thought to be less affected by pollution because of fewer human activities. Station II (Lafenwa) was thought to be highly polluted because of more intensive human uses in this section of the river. Samples were collected following the standard sampling guidelines and methods (WHO, 2004). The samples were taken into pre-sterilized bottles kept in ice-boxes and transported immediately to the laboratory for physicochemical analyses. Temperature, conductivity and pH were measured *in situ* using a temperature probe, conductivity meter and portable pH meter (model Hann HI 99300.HI 99301). Dissolved oxygen, hardness, nitrate, phosphate, sulphate, alkalinity and biological oxygen demand (BOD) were determined five days after sampling; samples were kept in a BOD bottle in a cool cupboard. The concentrations of sulphate and nitrate were determined in the laboratory using a Standard Colorimeter.

Collection and preservation of fish blood. Fish samples of *Clarias gariepinus* ranging in weight from 450-1,050 g with lengths between 42 to 54 cm were collected from the same spots where water samples were collected between 09.00-10.00 h in the morning, with the aid of fishermen using gill nets. The fish were carried to the laboratory in large plastic containers full of natural water to avoid stresses and injuries as far as possible.

Blood collection. Live fish were put on a table in the laboratory. A damp cloth was used to cover the fish's head. A small sample of whole blood was drawn from the caudal vein into a tube containing dipotassium EDTA following the process described by Hrubec et al. (2000). The haematological parameters were determined by using the standard techniques as described by Jain (1986).

Total Red Blood Cell (RBC) and White Blood Cell (WBC) counts were determined. The Packed Cell Volume (PCV) was determined by microhaematocrit method, Haemoglobin (Hb) values were estimated by the alkali haematin method by Schalm (1965). Values of RBC were determined by the microscopic method in a counting chamber after dilution with Hayens solution. Estimation of WBC was done in the improved Neubauer haemocytometer chamber using 2% acetic acid as diluent. Total leucocytes counts were carried out with a Haemocytometer method. Mean Corpuscular Value (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) were calculated values of PCV, Hb and RBC as described by Mitruka and Rawnsley (1977).

Analysis of data. Descriptive statistics was used to analyze the data collected, while means were separated using mean value and t-test at 5% confidence level.

RESULTS AND DISCUSSION

Physico-chemical characteristics

The results of the physico-chemical parameters and the descriptive statistics of the samples collected at the two locations are presented in table 1. Higher values were recorded at Station II than Station I for almost all physico-chemical parameters.

The pH values at Station I ranged from 7.05-8.81 with a mean value of 7.75 ± 0.48 while the pH value at Station II ranged from 7.31-8.45 with a mean value of 8.25 ± 0.48 which indicates that the river is slightly alkaline. The temperature ranged from 22-29.1°C with mean value of 26.00 ± 1.47 at Station I and the value ranged from 25-30°C at Station II with a mean value of 27.75 ± 1.25°C.

In the present study the observed dissolved oxygen ranged from 1.33-4.93 mg/l with mean value of 1.33 ± 4.9 at Station I and the value ranged from 1.22-4.40 mg/l with mean value of 2.75 ± 0.75 at Station II. BOD value of Ogun River water ranged from 1.20-1.47 mg/l at the station I and the values varied between 0.4-2.80 mg/l at Station II.

The mean value of the total dissolved solids (TDS) at Station I ranged from 46-108 ppm with a mean value of 73.50 ± 13.58 while that of Station II varied between 54 and 156 ppm with a mean value of 87.0 ± 23.87 and alkalinity at Station I ranged from 12-28 mg/l with a mean value of 20.00 ± 3.27 while that of Station II ranged from 16-38 mg/l with a mean value of 27.50 ± 5.12 respectively.

The total hardness concentration obtained in this study ranged from 72-118 mg/l with a mean value of 99.50 ± 9.88 and the value at Station II ranged from 16-38 mg/l with a mean value of 114.50 ± 13.00. The mean values of the conductivity at Station I varied between 92.00-281 us/cm with a mean value of 148.00 ± 27.54 while that of Station II ranged from 106-313 us/cm with a mean value of 172.25 ± 48.68.

The mean values of nitrate ranged from 0.00-12.52 mg/l with a mean value of 3.25 ± 3.25. At Station II, the values ranged from 0.03-27.94 mg/l with a mean value of 7.00 ± 7.00. Phosphate values ranged from 0.05-0.52 mg/l with a mean value of 0.25 ± 0.25 at Station I while that of Station II ranged from 0.77-0.24 mg/l with a mean value of 0.75 ± 0.25.

The sulphate values are 2.74-14.84 mg/l at Station I with a mean value of 7.75 ± 2.56 while that of Station II ranged from 10.00-39.84 mg/l with a mean value of 25.50 ± 6.19.

According to the results of physico-chemical characteristics of Ogun River, only sulphate values from Stations I and II were statistically significant ($P < 0.05$), indicating a significant difference in sulphate values between the two sampling locations.

Table 1: Range values of physicochemical parameters at Opeji and Lafenwa; [a] are significant at $p < 0.05$.

Parameters	Range	Station I mean	Range	Station II mean
Temperature (°C)	22.0-29.1	26.00 ± 1.47	25.0-30.6	27.75 ± 1.25
Conductivity (µcm)	92.0-218	148.00 ± 27.54	106-313	172.25 ± 48.68
DO (mg/l)	1.33-4.93	1.33 ± 4.93	1.22-4.40	2.75 ± 0.75
pH	7.05-8.81	8.25 ± 0.48	7.31-8.45	7.75 ± 0.48
Phosphate (mg/l)	0.05-0.52	0.25 ± 0.25	0.77-0.24	0.75 ± 0.25
Nitrate (mg/l)	0.00-12.52	3.25 ± 3.25	0.03-27.94	7.00 ± 7.00
TDS (mg/l)	46-108	73.50 ± 13.58	54-156	87.00 ± 23.87
Sulphate (mg/l)	2.74-14.84	7.75 ± 2.56[b]	10.00-39.84	25.50 ± 6.19[a]
BOD (mg/l)	1.20-1.47	0.00 ± 0.41	0.4-2.80	1.25 ± 0.63
Hardness (mg/l)	72-118	99.50 ± 9.88	92-152	114.50 ± 13.00
Alkalinity (mg/l)	12-28	20.00 ± 3.27	16-38	27.50 ± 5.12

The results of the mean values of the physicochemical parameters of the water samples from the two sampling points on the river segment are presented in table 1 while figure 1 shows the variations in pH, temperature and alkalinity values. The table showed that there were significant ($P < 0.05$) differences in the mean values of all the physicochemical parameters across the months.

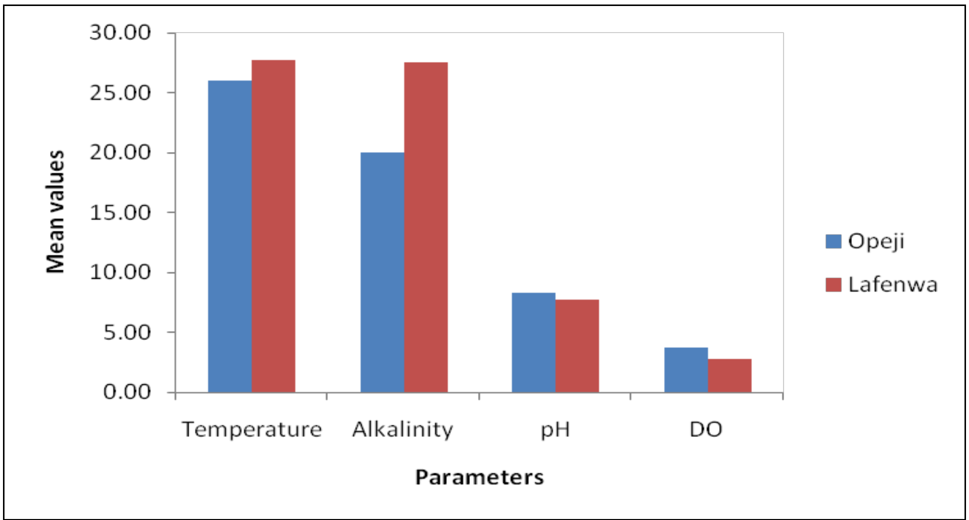

Figure 1: Water quality parameters in the two stations.

Haematological Indices of *Clarias gariepinus* from Ogun River

The haematological indices results shown in table 2, revealed the mean values of PCV, Hb, Rbc, Het and MCHC in Station I were higher than Station II while the mean values of Wbc, MCH were higher in Station I than Station II. The haematological parameters were not significantly ($P > 0.05$) different in the two stations.

Table 2: Haematological Indices of *Clarias gariepinus* from Ogun River.

Parameters	Station I	Station II
PCV (%)	34.00 ± 1.00	31.00 ± 2.00
Hb (g/dl)	11.30 ± 1.10	10.00 ± 1.00
RBC (x1012/L)	3.10 ± 0.30	2.60 ± 0.30
WBC (x1012/L)	15.00 ± 1.50	21.00 ± 1.00
Het (%)	37.00 ± 1.00	34.00 ± 2.00
Lym (%)	62.00 ± 2.00	66.00 ± 1.00
MCV (Fl)	110.40 ± 7.46	119.94 ± 6.15
MCH (Pg)	36.45 ± 0.02	38.53 ± 0.60
MCHC (g/dl)	33.17 ± 2.26	32.18 ± 1.15

Temperature influences the life of all biological organisms. During the period of study temperature recorded ranged from 26.00 ± 1.47 to 27.75 ± 1.25°C. Okayi et al. (2013) reported a lower surface water temperature (20.00-23.10°C) in river Benue which contrasts with the result of this study, indicating that river Ogue has a higher average temperature. The mean pH values in the two locations ranged from 7.75 ± 0.48 – 8.25 ± 0.48. The mean pH value obtained during this study falls within the EU acceptable limit for pH of six-nine for fisheries and aquatic life (Chapman, 1996).

Dissolved oxygen is crucial for aquatic organisms (Yakub and Ugwumba, 2009). Dissolved oxygen concentrations below five mg/l may adversely affect the functioning and survival of biological communities and below two mg/l may lead to the death of most fish. In the present study the observed dissolved oxygen mean values ranged from 2.75 ± 0.75 to 3.75 ± 0.95 mg/l. The low dissolved oxygen in the study area could be attributed to a high degree of pollution by waste discharges high in organic matter and nutrients particularly in Station II. Is there any indication of this pollution from the physico-chemical parameters? If so then bring it in here – e.g. the DO levels are low around Station II, reflecting the higher incidence of chemical pollutants such as Nitrogen and K (potassium) – or whatever the results indicate.

Biological oxygen demand (BOD) is an important parameter which is widely used to determine the pollution load of waste water. WHO recommends a general standard of one mg/l. The mean BOD values of Ogun River water ranged 0.01 ± 0.41 (Station I) to 1.25 ± 0.63 mg/l (Station II). The high value of BOD recorded at Station II was due to a higher rate of decomposition of organic matter at higher temperature, turbidity and in areas of lower water flow (Sanap et al., 2006).

The mean values of conductivity at Station I was 148.00 ± 27.54 µcm and at Station II was 172.25 ± 48.68 µcm. The average value of typical, unpolluted river is approximately 350 µcm (Koning and Ross, 1999). Therefore the parameter does not give cause for concern in Ogun River.

In the present study, the values of alkalinity ranged from 12-28 mg/l (Station I) to 16-38 mg/l which is below the permissible range. The range of alkalinity is 0.00-20.0 mg/l for low production, 20-40 mg/l for medium production and 40-90 mg/l for high production (Pandey and Shukla, 2005). However, the higher values recorded at Station II could be attributed to the quantity of waste in this section of the river. Nitrates are the final product of aerobic decomposition of organic nitrogenous compounds. The mean concentration of nitrate ranges from 3.25 ± 3.25 to 7.00 ± 7.00 mg/l. Nitrate levels exceeded optimum considering the global average of 0.1 mgl-1 in freshwater (Meybeck and Helmer, 1989). According to WHO (1994) levels in excess of 0.2 mg/l nitrate indicate eutrophic conditions in freshwater. The high mean nitrate values in this study may be due to the human activities which affect the river.

Swingle (1967) has suggested that a total hardness of 50 ppm $CaCO_3$ equivalent to be dividing line between hard and soft water. Hard water contains large concentrations of alkaline earths dissolved from the drainage of calcium deposits (Wetzel, 1975). The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature, high loads of inorganic substances, detergent, chlorides and other pollutants (Rajgopal et al., 2010) particularly at Station II.

During this investigation the mean TDS values ranged from 46-108 to 54-156 mg/l. This falls within the recommended value of 1,000.00 mg/l (WHO, 2004). TDS are comprised of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and small amount of organic matter that are dissolved in water.

Sulphate is found in almost all natural water, the values of sulphate recorded in station I (2.74-14.87 mg/l) were significantly lower than Station II (10.00-39.84 mg/l). Water sources with less than 10 mg/l indicate that the water sources is fresh and unpolluted (DWAF, 2001). High levels of sulphate in the study area particularly at Station II are indicative of some form of pollution.

In most natural waters, phosphorus usually ranges from 0.005-0.020 mg/l (Shinde et al., 2011). The phosphorus recorded in Station I (0.05-0.52 mg/l) and Station II (0.07-0.24 mg/l) was higher. According to Klein (1962) excess concentration of phosphorus of 0.015 mg/l and nitrogen concentration of about 0.3 mg/l are sufficient to cause algal bloom.

Haematological indices (RBC counts, concentration of haemoglobin and haematocrit) have been reported to indicate secondary responses of an organism to pollutants (O'Neal and Weirich, 2001). The mean values of PCV, Hb, Rbc, Het and MCHC in Station I were higher than Station II even though there were no significant changes in the haematological parameters of *C. gariepinus* in the two locations. A decrease in the concentration of haemoglobin in the blood, which is usually caused by the effect of toxic metals on blood, as well as decreases in oxygen also indicates anaemia or confirms negative changes occurring in fish (Ali et al., 2008). Decreases in RBC count, haematocrit and haemoglobin contents have also been reported by several workers after insecticide feeding (Mandal et al., 1986; Ali, 1989; Hamilton et al., 1978). These clearly indicate that the water pollution affects the haematological components of fish.

The higher values of WBC, Lym, MCH and MCV in Station II may be attributed to the higher level of pollutants in the station. Increase in MCV and normal MCH and MCHC were indication of Macrocytic-normochromic anaemia (Abubakar, 2013).

CONCLUSIONS

Aquatic pollution undoubtedly has direct effects on fish health and survival. It can be concluded from the study that the river Ogun is polluted especially at the Lafenwa area of the river thus affecting water quality and haematological parameters. The study revealed that parameters like conductivity, TDS, DO, temperature, hardness, nitrate, sulphate and phosphate had higher values beyond standard values which indicate a polluted environment particularly in Station II. Parameters like MCHC, MCV and MCH in Station II were higher than in Station I, reflecting the greater presence of potential pollution sources at Station II. The increase and decrease of various haematological and blood biochemical parameters in test fish samples explains the ailment caused by the ambient pollutants. Therefore, there is need to regulate human activities in and around the river for the benefit of diverse fish species and the livelihood of the local fishers.

ACKNOWLEDGEMENTS

The authors would thank to Curtean-Bănăduc A. and Bănăduc D. for their continuous editorial support.

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CLIMATE CHANGES AND ADAPTATION OF SOME MARINE ORGANISMS – PERSIAN GULF STUDY CASE

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DOI: 10.1515/trser-2015-0069

KEYWORDS: global warming, adaptation, effects, Persian Gulf.

ABSTRACT

Data records since from 2008 to 2012 show the occurrence of the coral reef bleaching, an increase in population of jellyfish and a decreasing presence of some migratory marine mammals in the Persian Gulf has increased. Results of our biometric methods on jellyfish of the Persian Gulf (*Aurelia aurata*), show a significant increase in size during the last four years ($p < 0.05$). Our studies in the area showed that in the sampling areas in close proximity to superhot wastewater of industries cooled in terrestrial pools and then emptied into the sea, the abundance of the *Aurelia aurata* was significantly lower than in regions where superhot water was directly emptied into the seawater. This paper will review the effects of global warming, especially in the Persian Gulf.

ZUSAMENNFASSUNG: Klimaveränderungen und die diesbezügliche Anpassung einiger Meeresorganismen – Fallstudie im Persischen Golf.

Datenaufzeichnungen von 2008-2012 zeigten, dass das Auftreten der Korallenriffbleiche, die wachsenden Populationen gallertartiger Fische und die Verringerung des Vorkommens einiger mariner, wandernder Säugetiere im Persischen Golf größere Ausmaße angenommen hat. Ergebnisse unserer biometrischen Methoden angewandt auf den gallertartigen Fisch *Aurelia aurata* des Persischen Golfs belegen ein signifikantes Größenwachstum während der letzten vier Jahre ($p < 0.05$). Unsere Untersuchungen zeigten, dass in den Probenahmegebieten, in denen sehr heißes Abwasser aus der Industrie in terrestrischen Becken gekühlt und dann in das Meer gelehrt wurden, die Abundanz von *Aurelia aurata* signifikant niedriger war als in den Gebieten, in denen sehr heißes Water direkt ins Meer eingeleitet wurde. In vorliegender Arbeit werden die Auswirkungen der globalen Erwärmung, insbesondere im Persischen Golf im Überblick dargestellt.

REZUMAT: Schimbările climatice și adaptarea unor organisme marine la acestea – studiu de caz Golful Persic.

Datele provenite din perioada 2008-2012 dezvăluie o manifestare crescută a fenomenului de albire a recifului de corali, creșterea populației de meduze și scăderea prezenței unora dintre mamiferele migratoare din Golful Persic. Rezultatele măsurătorilor biometrice asupra meduzelor din Golful Persic (*Aurelia aurata*) au arătat o creștere semnificativă în mărime în ultimii patru ani ($p < 0.05$). Studiile noastre au arătat că zonele unde a fost deversată apa fierbinte și poluată provenită de la diferite industrii în bazine de răcire și apoi în mare, sunt prezente un număr semnificativ mai mic de indivizi din specia *Aurelia aurata* decât zonele unde această apă fierbinte era deversată direct în mare. În lucrare abordăm aspecte legate de efectele încălzirii globale asupra cenozelor din în Golful Persic.

INTRODUCTION

Changing the environmental conditions in aquatic ecosystems is a major concern of many research projects all over the world. Climate change due to natural and anthropogenic activities are amongst the major reasons of such changes (Halpern et al., 2008).

IPCC reports that the atmosphere temperature has been rise during this century due to increasing the greenhouse gases (IPCC, 2007).

Different studies showed that changes in atmosphere temperature could lead to different changes in oceans and aquatic ecosystems in all aspects of biological, chemical or physical properties (Ji et al., 2007).

It has been shown that such changes could be different in case of different geographical sites; for example increasing in ocean temperature in some locations and decreasing the ocean temperature in some other ones (Scranton et al., 1987; Freeland, 1990; Bethoux et al., 1998; Read and Gould, 1992).

It has been previously declared that any alterations in abiotic aspects of marine environments (such as temperature, salinity, pH, currents, upwelling or down welling, UV radiation, etc.) could affects the biotic properties of that ecosystem and made some huge changes in food web and aquatic organisms life (IPCC, 1996, 2007; Ji et al., 2007).

In this paper we will review some effects of global warming, especially in the Persian Gulf and the activities for adaptation to its effects.

MATERIAL AND METHODS

The six sampling area on the northern coastline of the Persian Gulf (Fig. 1).

Figure 1: Sampling sites areas in Iranian coastal waters of the Persian Gulf.

Six sampling regions were selected as follow: Bushehr, Asaluyeh, Lengeh, Genaveh, Mahshahr, and Bandar Abbass. All sampling were performed during spring 2008 to winter 2012. Jellyfish species, sampled by zooplankton net (one m diameter, 500 µm mesh size, fitted with a flow meter), and samples of the jellyfish were immediately transferred to the laboratory after the collection for biometric measurements.

RESULTS AND DISCUSSION

Biometry, Abundance and Morphological Features

The focus of jellyfish sampling was on the species: *Aurelia aurita*, and the biggest diameter of the top of the bell was measured using biometry scale, the result of the mean body size of the samples in six sampling areas shown in figure 2. Results showed that the samples at the Asaluyeh sampling area were significantly bigger in size than the other sampling sites. Asaluyeh sampling site was the most significant site for the petrochemical industries.

Also results of the abundance of the jellyfish at the six sampling sites is shown in figure 3, results showed that abundance at Asaluyeh sampling site was significantly higher than the other sampling areas.

The jellyfish was translucent, and can be recognized by its four horseshoe-shaped gonads, easily seen through the top of the bell, and short tentacles beneath the bell (Fig. 4).

Coral Reef Bleaching

The coral reef bleaching is repeatedly reported by the marine environment protection agency of the Iran during past the decade. In the Persian Gulf the greatest abundance of coral reefs is in the northern part of the sea along the Iranian coastline and around the Iranian islands. Bleaching is reported in different species of corals but especially at the Kish Island coastal waters (Fig. 5).

There are many scenarios that show the resulting effects of the increase in Earth’s temperature, and there are also uncertainties about some of them, but the fact is that many of these scenarios were experienced in natural and laboratory conditions and their results were significant.

Global warming and the increase in Earth’s temperature can affect the marine ecosystem, directly and indirectly (Kosnik, 2008). As a direct effect, increasing the temperature of water in marginal seas can put the life of temperature-sensitive species (stenotherm) in danger, like salmon. Increasing water temperature can affect feeding, spawning, larval growth and many other physiological processes, and cause mortality. Extinction or elimination of some species from an ecosystem can affect the whole ecosystem through food chain; this can be counted as an indirect effect of global warming on marine life (Beardall and Raven, 2004).

Some other important effects of global warming on marine ecosystems are: changes in the ocean currents (because of misbalancing in heat conditions) that can have serious effects on both the ocean and terrestrial ecosystems (because oceanic currents affected the distribution of marine organisms, and also specific temperature and availability of nutrients in every region were mainly dependent to oceanic currents pattern).

Melting of polar caps, that means destroying of some special species habitat like the polar bears, melting of glaciers and increasing in freshwater input of the oceans, makes oceans less saline, and a decreasing in salinity can led to extinction of salinity-sensitive species (stenohaline) like valuable species of corals, also melting of glaciers increases the turbidity in near shore waters (because of their high load of sediments) and affect the photosynthesis in marine plants, decreases the productivity, and causes mortality in fishes, crustaceans, and other habitants mainly larvae (Hinga, 2002).

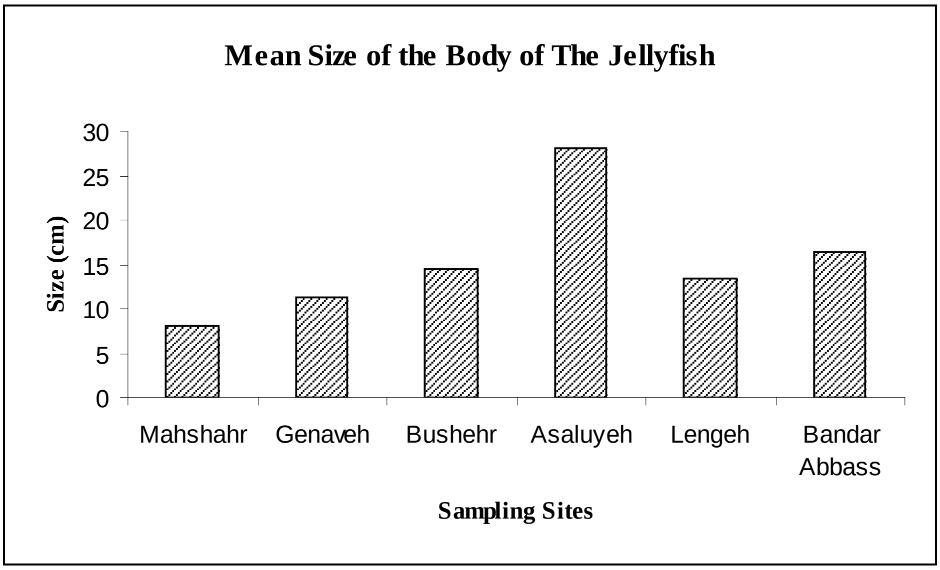

Figure 2: The mean body size of the *Aurelia aurita* at the six sampling sites along northern part of the Persian Gulf.

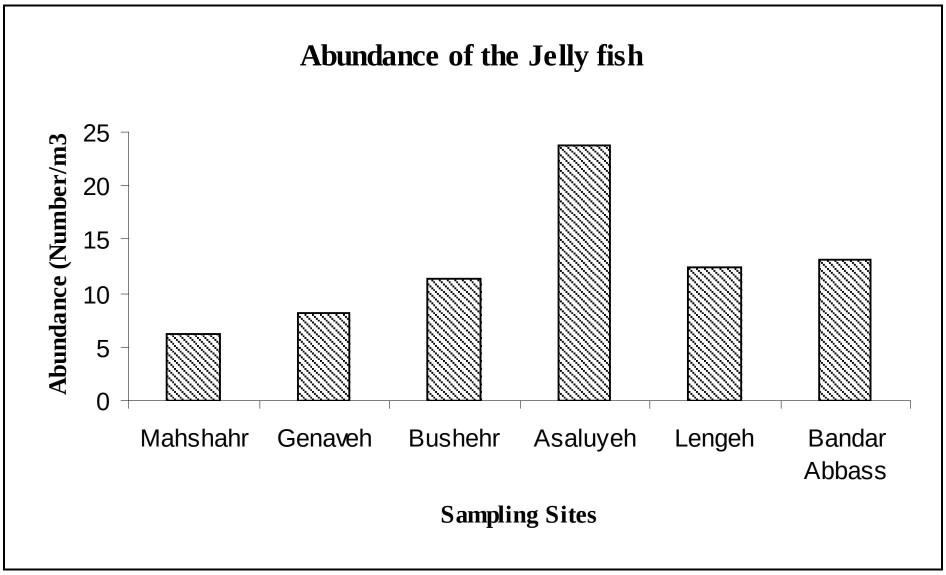

Figure 3: Abundance of the *Aurelia aurita* in six sampling sites along northern part of the Persian Gulf (mean values).

Increasing in sea level because of melting ice and heat-made water volume increase, will destroy the coastal habitats and their inhabitant species; increases in atmospheric CO_2 results in increases of the CO_2 concentration in the ocean, this increase causes the seas to be more acidic which can affect the life of shelled organisms (like corals, molluscs, foraminiferans, cocolithophores and others) because of changes in $CaCO_3$ availability, this acidification can also affect marine plants and physiological processes of marine organisms directly; and finally drought made by the increase in Earth temperature and changes in climate, destroying some of the lakes and habitats all over the world followed by extinction of its inhabitants (Florides and Christodoulides, 2008).

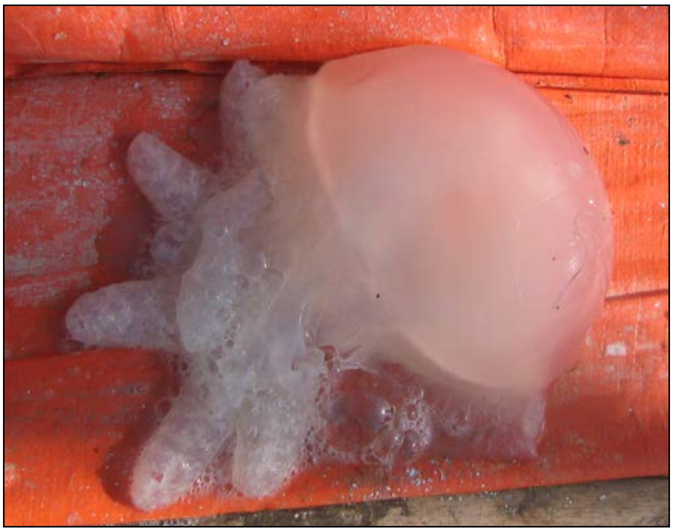

Figure 4: *Aurelia aurita* caught by the zooplankton net at the boat at the Persian Gulf.

Figure 5: Coral reef bleaching in the Persian Gulf.

CONCLUSIONS

Global warming is a very complicated phenomenon and its effects on different aspects of life on the earth are still unclear. Today many investigations predict these effects and the possible ways of prevention of the increases in global warming. It is clear that for controlling a global phenomenon we need a global will. For example although a high amount of CO_2 is released to the atmosphere by developed countries, but degradation of forests and uses of worn out machinery by developing and undeveloped countries have a great role in increasing the effects of global warming too. So for solving our global problem we need to prevent every harmful activity for the earth's ecosystem and try to improve our previous harmful activities.

We conclude that because of the Asaluyeh specific environment (petrochemical environment) the jellyfish were significantly bigger and in larger numbers which can be linked to differences in temperature between sites.

ACKNOWLEDGEMENTS

The authors wish to thank to Mr. Afkhami and Mrs. Ehsanpour for their great help during the experimental processes.

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IMPACT OF THE LOW HEAD DAM/BARRAGE ON FISHERIES – A CASE STUDY OF GIRI RIVER OF YAMUNA BASIN (INDIA)

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DOI: 10.1515/trser-2015-0070

KEYWORDS: India, Western Himalayas, habitat structure and fragmentation, water chemistry, biotic integrity, fish.

ABSTRACT

Shannon's diversity index H' = pi $\log_2$ pi was calculated for 16 fish species. The index was resolved into its components, species richness and relative abundance, to determine which components played a larger role in the determination of diversity pattern. Changes in diversity were correlated with species richness (r), habitat heterogeneity, and hydrological regimes in a longitudinal stretch of 35 km along the river Giri, a major tributary of the Yamuna River system, in Western Himalayas. Abundance differs with change in habitat structures, habitat preference of fish species and water regimes. The decrease in diversity in the lower stretch of about 3-4 km upstream of the barrage was found to be associated with habitat fragmentation and as well as d/s with loss of biotic integrity of aquatic ecosystem due to water scarcity. Species richness was found to be maximum at upper and middle reaches (elevation 650-800 m, msl) of the river, whereas it was low in lower reaches. Change in water chemistry was also noticed at Jatan barrage-low head dam due to impoundment of river water. It is inferred that the regulation of water has an impact on species richness and relative abundance, and on habitat heterogeneity which has decreased due to the change in environmental condition.

RÉSUMÉ: Impact des barrages de seuil sur les pêcheries – Etude de cas sur la rivière Giri du bassin de Yamuna, en Inde.

L'indice de diversité de Shannon H' = pi $\log_2$ pi a été calculé pour 16 espèces de poissons. L'indice a été résolu dans ses composantes, la richesse spécifique et l'abondance relative, afin de déterminer quelles composantes ont joué un rôle plus important dans la détermination du modèle de diversité. Les changements dans la diversité ont été corrélés avec la richesse spécifique(r), l'hétérogénéité de l'habitat et les régimes hydrologiques sur un secteur longitudinal de 35 km sur la rivière de Giri, un des tributaires majeurs du bassin hydrologique de Yamuna, dans le Ouest des Himalaya. L'abondance diffère selon les changements dans les structures des habitats, les préférences d'habitat des poissons et les régimes hydrologiques. La baisse en diversité dans le secteur inférieur à 3-4 km en amont du barrage a été associée avec la fragmentation de l'habitat et le rapport d/s a été associé avec la perte d'intégrité biotique de l'écosystème aquatique à cause du manque d'eau. La richesse spécifique a atteint la valeur maximale dans les secteurs supérieur et moyen de la rivière (altitude 650-800 m au-dessus du niveau de la mer) et elle est basse dans le secteur inférieur. De même un changement dans la chimie de l'eau a été détecté au barrage de seuil de Jatan, dû à la retenue d'eau de la rivière. On considère que la régularisation de la rivière porte atteinte à la richesse spécifique et à l'abondance relative ainsi qu'à la hétérogénéité de l'habitat, qui a baissé à cause des changements des conditions environnementales.

REZUMAT: Impactul stăvilarelor asupra resurselor piscicole – Studiu de caz pe râul Giri din bazinul Yamuna, India.

S-a calculat indicele de diversitate Shannon H' = pi $\log_2$ pi pentru 16 specii de pești. Indicele a fost calculat pe componente individuale, diversitatea specifică și abundența relativă, pentru a determina care sunt componentele determinante în tiparele de diversitate. Schimbările în biodiversitate au fost corelate cu diversitatea specifică (r), heterogenitatea habitatului și regimul hidrologic pe un sector longitudinal de 35 km în râul Giri, unul dintre afluenții majori din bazinul hidrografic al râului Yamuna din vestul lanțului himalayan. Abundența diferă în funcție de modificările în structura habitatelor, preferințele pentru anumite habitate ale diferitor specii de pești și dinamica regimului hidrologic. Diminuarea diversității în sectorul inferior la 3-4 km în amonte de baraj a fost asociată cu fragmentarea habitatului, iar raportul d/s a fost asociat cu pierderea integrității biotice a ecosistemului acvatic din pricina lipsei de apă. Diversitatea specifică a atins valori maxime în sectorul superior și mijlociu (altitudinea 650-800 m deasupra nivelului mării) și a fost scăzută în sectorul inferior. De asemenea, din pricina stagnării apei la stăvilarul din Jatan, s-a înregistrat și o modificare în chimismul apei. Se poate conchide că regularizarea cursului apei afectează diversitatea specifică și abundența relativă a peștilor, dar și heterogenitatea habitatului, care a scăzut din pricina modificării condițiilor de mediu.

INTRODUCTION

Rivers maintain ecological integrity through a river continuum process which is facing challenges worldwide due to instream barriers and other anthropological practices. The construction of dams and flow diversion are a matter of serious concern for ecologists (Covich, 1993; Dynesius and Nilson, 1994; Roserberg et al., 1995; Postel et al., 1996; Pringle and Scatena, 1998). Because their direct ecological effects include blocking the migration routes, the fragmentation of habitat with associated isolation of populations, the mortality of larva and juvenile at water intakes, alteration of natural hydrologic and geomorphic regimes. All these factors result in loss of biodiversity and alternation of natural food webs, disruption of riparian plant communities and shift in the water chemistry, whereas biological pattern is considered a vital foundation to sustain ecological integrity in aquatic ecosystems (Jonathan et al., 1999).

Due to an increasing demand of potable water and power supply, in the virgin area of Himalayas numerous river valley projects are executed. These projects either low head dams (barrages and weirs) or high head dams have had an impact on the habitat structure and endemic biodiversity. Such instream barriers have negative effects on the native ichthyofauna of streams by preventing the migration in the upstream areas, to spawning sites and wintering habitats (Irving and Modde, 2000). Similarly, these dams have had a negative impact on river fisheries in various systems throughout India. A sharp decline is noted in catches of *Hilsa ilisha* as a result of dams, barrage, weirs and Cauvery on the Hoogly, Godavari, Krishna and Cauvery rivers. A similar impact on *Tor putitora* and *T. tor* was inferred at Nangal and Talwara dams on river Sutlej and Byas. The impact has also restricted the migration of Indian major carps, in spite of fish ways (Sandhu and Toor, 1984). In recent studies it has been clearly inferred that mitigation measures with regards to providing fish ways for potamodramous as well as catadromous fishes, harms their migration (Pelicive and Agostinho, 2008).

These activities are factors of dying or shrinking rivers in India as well. This study assess the impact on biological diversity, habitat structures and water chemistry in river Giri, a major tributary of the Yamuna River system, west-central Himalayas. The study was focused on the evaluation of the fish diversity pattern and habitat structures and to highlight the stress posed from construction of a barrage – low head dam in Yamuna River basin (Figs. 1 and 2).

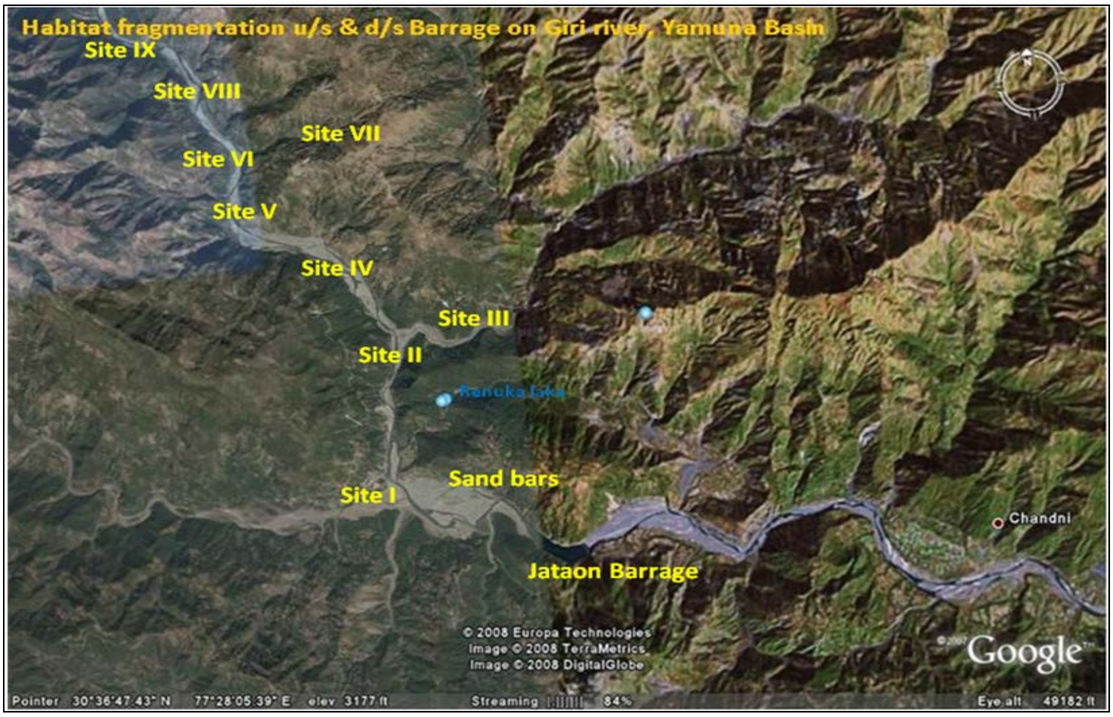

Figure 1: Study sites of Giri River, Yamuna Basin, western Himalayas.

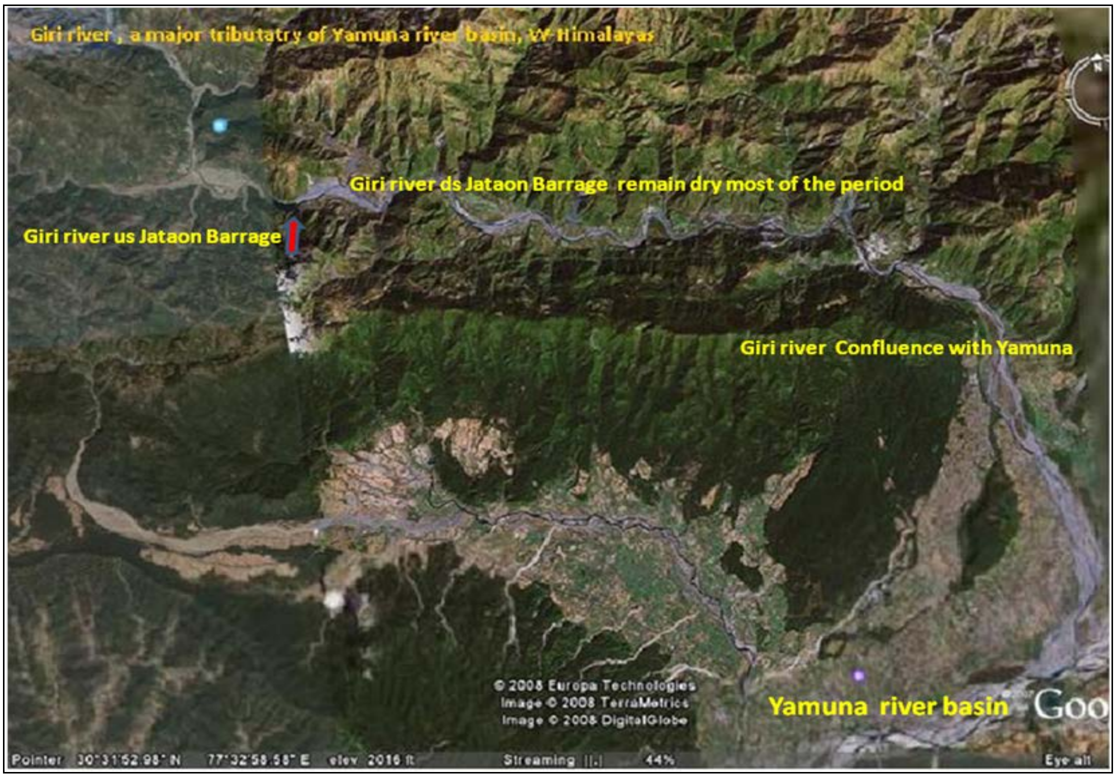

Figure 2: Giri River course and its confluence with Yamuna Basin, western Himalayas.

MATERIAL AND METHODS

Physiography. The study sites are located in Sirmour District of Himachal Pradesh falls under sub-Himalayas lower region in Siwalik Hills. The river Giri flows from NE to SW direction and near the study sites it takes a "U" turn (NE-SW-SE) at Dadahu, Sirmaur. The catchment ranges from 440 m to 3,600 m msl. The slope varies from 15-50%. The hill ranges of Churdhar and Haripurdhar are present on the left bank in northwest side of river Giri, whereas Saindhar range on the right bank in the S-SW direction of selected study sites. Both the bank spurs have very steep precipitous slopes right from the river bank is to hilltops, interspersed with partly rocky portions, having practically less habitation along the spurs. These slopes along the river bank contain khair and Sheesham Forest, i.e. mixed deciduous forest. Geologically the area lies in the major krol belt of Himachal Pradesh. The lithostratigraphy of the Blani formatting of the Krol belt is – boulder beds at the base, carbovavous shale, grey limestone, varved angillite, minor gray and pale quartezite in the middle and over lain by – flesh coloured and purple dolomite limestone, interbedded with red shale in the upper part. The area along the stretch of Joggar River is comprised of conglomerate (at base), shale, slate and limestone. Joger ka khala consists of famous Blaini boulders of considerable size. They are found randomly enclosed in a finely bedded silty matrix of slates. The size varies from a few centimetres to over half a meter in length. The krol formation forming the core of the Sain Dhar declines along the right bank of Giri and in the basins of Jalal River, which is comprised of thick bedded massive limestone and purple green calcareous shale/slates. The alkaline nature of water (pH) is clearly indicative of limestone in the river (above 8.0). There is a number of geo-environmental factors such as slope aspect, slope morphology, land use/land cover, rock mass, drainage, geology, ridge/crest line, road, and relative relief, which are playing a significant role in basin stability. The land is formed by the fluvial action of the river Giri and its tributaries. The mean run-off efficiency of the catchment came out to be 32.2% and the suspended sediment load 9.6 t/ha/yr (1.9-17.4 t/ha/yr) as observed from 1981-1992 by Chaudhary and Sharma (1999). The detail of the physiography of downstream and upstream sites of the study area is illustrated in table 1.

Table 1: Study Sites selected on the river Giri, part of Yamuna Basin.

Study site	Location	Longitude (E)	Latitude (N)	El (feet)	Distance from Giripul, Dadahu (km)
I	Satibag – Giri confluence with Jalal	077^{o}26'420"	30^{o}35'809"	2045'	1.0 km d/s
II	Dadahu – Giri confluences with Joggar	077^{o}27'907"	30^{o}37'327"	2160'	1.8 km u/p
III	Dhanoie Bridge – Joggar ka Khala	077^{o}27'908"	30^{o}37'327"	3192'	7.0 km u/p
IV	Jaincha Manjhai – Giri River Sunnan kund	NR	NR	NR	8.0 km u/p
V	Sieun – Giri confluences with Palar	077^{o}22'782"	30^{o}41'413"	2264'	13.0 km u/p
VI	Sieun Kandva – Palar Khad	077^{o}22'732"	30^{o}41'413"	2260'	14.5 km
VII	Balta – Giri confluences with Nait	077^{o}18'804"	30^{o}45'465"	250'	19.0 km u/p
VIII	Nait/baga khad (Anukoti)	077^{o}18'804"	30^{o}45'465"	2501'	20.0 km u/p
IX	Khairi (Lana marg) – Giri River	077^{o}17'872"	30^{o}46'486"	2523'	24.0 km u/p
–	Jatan Barrage	077^{o}26'420"	30^{o}35'809"	2010'	5.0 km d/s

Study Area Description. The river Giri, a major tributary of river Yamuna, has an approximate stretch of 150 km to its confluence with Yamuna at Paonta Sahib. The river flows from NE toward the SW direction. It's a spring river and also receives water from melting of snow during winters. The catchment area falls in the subtropical climate zone. The annual rainfall is about 1,675 mm. The climate is subtropical interspersed between cold weather, hot weather and southwest monsoon. During the monsoon period from June to September the weather remains humid. The relative humidity varies from 33 to 30%. The survey was carried out during monsoon (August-September 2007) and post-monsoon (October-November 2007) seasons. Nine sampling sites locations from I to IX were selected along the river reach length upto 35 km in the influence zone. This covers the upstream area of Khairi Village and downstream to the Jateon barrage of the Giri River basin, in Sirmour district, Himachal Pradesh. The studied area lies between $30^{o}33'5''$ N to $30^{o}38'277''$ N and $77^{o}23'48''$ E to $77^{o}30'$ E. The study area lies between elevations of 600-820 m mean sea level. The details of the selected study sites/locations are given in table 1 and in figure 1. The study sites include a three km stretch of the river Jalal, seven km stretch of Joggar, three km Palar, two km Nait and 30 km along river Giri from Jateon barrage to upstream. Its right bank, the Jalal, which joins it at Dadahu below Sati Bagh is present at the south-eastern extremity of the Sain Dhar Hills. On its left bank the perennial and cold water streams are the Joggar, Palar and Nait, which rises on the Kawal in Haripurdhar and Churdhar Hill range, which first flow westward and eventually falls into the Giri.

Sample collection procedure

For assessment of aquatic faunal diversity the biological parameters, fishes, plankton and zoo benthos were studied. To assess the fish diversity different fishing gears like cast net, scoop net, hand net, hook and line method and pot method were used. Random sampling in selected areas in the river was carried out at morning (6:00-8:00) hours. They were also visually observed in different habitats. Representative specimens were preserved in 10% formalin solution and brought to the laboratory for their identification. The sampled fishes were identified using the taxonomic keys.

Plankton samples were also collected using a tericot ring net of 20 µm net. For enumeration of phytoplankton and zooplankton population, 100 l composite water samples were collected from the river surface up to 60 cm depth and were filtered through a 20 µm net to make one l of bulk sample. The bulk samples collected in this way were preserved in 5% formalin solution or Lugol's solution and were brought to the laboratory for analysis. Ten replicate water samples each of 15 ml were made out of the preserved one l bulk sample and were centrifuged at 1,500 rpm for 10 minutes. After centrifuging, the volume of aliquot concentrate was measured. One ml of aliquot concentrate was used for enumeration of phytoplankton population in each replicate. A plankton chamber of one ml capacity was used for counting of plankton under a light microscope.

The total number of planktons present in a litre of water sample was calculated using the following formula:

$$N = (n \times v \times 100)/V$$

Where N = Number of phytoplankton per litre

n = average number of plankton cells in one ml of aliquot concentrate

v = volume of plankton concentrate (aliquot)

V = volume of water from bulk sample centrifuged

Zoobenthos invertebrates or Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. Their size spans six to seven orders of magnitude and they range from microscopic (e.g. micro-invertebrates, < 10 microns) to a few tens of centimetres or more in length (e.g. macro-invertebrates, > 50 cm). Benthic invertebrates live either on the surface of bed forms (e.g. rock, coral or sediment – epi benthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups e.g. deposit-feeders, filter-feeders, grazers and predators. The abundance, diversity, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. Construction of dams can impact the benthic invertebrates by alteration of the physical characteristics of the river which includes substratum, current velocity, food availability, water temperature, dissolved oxygen concentration, and water chemistry. In the present study, an enumeration of benthic invertebrates was done in order to know their composition, density and diversity in different reaches of the river.

Benthic invertebrates were collected from the pebbles, cobbles and gravels surface upto 15 cm sediment depth by stirring an area of one square meter at different elevations and dislodging the substrate to catch the dislodged organisms in a net (0.5 mm mesh) held downstream. Three replicates were collected at each site. Samples were also collected with the help of iron sieves of different mesh size, scrapers and forceps and were preserved in 5% formalin solution. The species were then brought to the laboratory and sorted order-wise and were later on identified and enumerated. The identification was done under stereomicroscope to the lowest possible taxonomic levels.

Sampling period. The sampling period was divided into monsoon (wet) and post monsoon (dry) season. The sampling was carried out twice during the months from September to November 2007. The samples of aquatic fauna and water quality which emphasize on fish communities were also collected. The monitoring of aquatic ecosystem at all selected locations was carried out once in a season. The samples were collected separately for fishes, plankton and zoo benthos from all selected sites. It was followed by the detail fish catch studies for establishing baseline data aiming to investigate the possible impacts and find the means of mitigating strategies.

Water sample collection. Representative water samples from different sites of the Giri River basin were collected twice. Three samples from running water upstream and one sample downstream from impounded water at Jatan barrage were collected and analysed for physical and chemical characterization of water quality. In the present context the water quality analysis was carried out at various places covering sections of river Giri u/s and d/s sites of river basin and Jataun barrage to have a holistic view of water quality (Tab. 6).

Data Analysis

The limnological parameters were recorded mainly following the standard methods described by Welch (1948), CSIR (1974), Mackereth et al. (1978), and APHA (1992, 1995, 1998). Attempts were made to identify all the samples up to generic level. For qualitative studies of biota, the references of Usinger (1950), Ward and Whipple (1959), Edmondson (1959), Pennak (1953), Needham and Needham (1962), Macan (1979), Tonapi (1980), Trivedy and Goel (1984), Welch (1948) and Edington and Hildrew (1995) and APHA (1992, 1998) were consulted. Fishes were identified upto the ssp. level with the help of keys given in Days (1958), Jayaram (1981, 1999), Menon (1987, 1999), Talwar and Jhingran (1991). The IUCN red data list was used for identification of threatened, endangered and vulnerable species in the Giri River a major tributary of the Yamuna River.

Habitat Inventory. Habitat features were quantified using transects within each stream reach. Variables measured at each point of the transect were water depth, water velocity and wetted width. Five transects each of 80 m length were laid down at interval of about 20 m distance and habitat were measure at 90^o across the river/stream. In each stream reach, habitat such as pools, riffles, cascades and runs were identified in 500 m thalweg length. Length and width of each habitat were measured based upon criteria outlined by Armontrout (1990, 1999) and Arunachalam (1999). In stream covers were small boulder edge, big boulder edge, bedrock edge, canopy, root undercut and snags/logs. The substratum observed was heterogeneous and represented by gravels, pebbles, cobbles, boulders, rocks and silt (Armantrout, 1999). The study sites were classified after Rosgen (1996). The classification was derived from 450 rivers throughout the U.S., Canada and New Zealand. Quantification of the availability of microhabitats (e.g. depth, water column velocity, cover type and substratum type) was carried out using the instream flow Incremental Methodology (Bovee et al., 1998). It was carefully done without disturbing the fish by the observer. Habitat diversity for each site was calculated using species diversity index (Pusey et al., 1993). Shields et al. (1995) classified the water area as pool habitat with depth > 30 cm and velocity < 10 cm s^{-1} which consists of 5-20% of the water area at base flow. Stream habitat is separated into different habitat types based on their hydraulic characteristics. To define habitat types, methods described by Bisson et al. (1982) were used with slight modifications (Tab. 1).

Table 1: Stream habitat types as modified from Bisson et al. (1982).

Habitat type	Characteristics
Riffle	A shallow reach of gradient < 4% with moderate current velocity and moderate turbulence.
Rapid	A shallow reach of gradient > 4% with high current velocity and considerable turbulence.
Cascade	A series of small steps of alternating small waterfalls and small pools.
Glide	A moderately shallow reach with an even flow and no pronounced turbulence.
Pools	
Trench pool	A long, usually deep slot in a stable substrate (often bedrock).
Plunge pool	A basin scoured by a vertical drop over a channel obstruction.
Lateral scour pool	A scoured basin near the channel margin caused by flow being directed to one side of the stream by a partial channel obstruction.
Mid-channel scour pool	A scoured basin near the centre of the channel usually caused by a channel constriction or high gradient rapid.
Dammed pool	A pool impounded upstream from a complete channel blockage.
Alcove	A slack water along the channel separated from the main current by stream banks or large channel obstructions such that it remains quiet even at high flows.
Beaver Pond	A pool impounded by a beaver dam.
Backwater pool	An eddy or slack water along the channel margin separated from the main current by a gravel bar or small channel obstruction.

Statistical Analysis. The Shannon and Wiener (1963) information function (1963) was used to describe species diversity in natural communities. The index (H') is

$$\bar{H} = \sum_{i=1}^{S} \left(\frac{Ni}{N}\right) log_{10} \left(\frac{Ni}{N}\right)$$

where, Ni is the total number of individuals of species i (from 1 to S) and N is the total number of all species in a stand.

Or H’ = – ∑ pi ln or log_2 pi, Where pi (Ni/N) is the proportion of individuals in the species (i = 1, 2, S). Lloyd and Ghelardi (1964) have pointed out that this measure has two separate components, “species richness and equitability or evenness” of species abundances. Species richness is simply S, the number of species in the sample. Several expressions have been employed to measure the relative abundance component; here we will use the index J’ = H’/H’ max in which H’max is log_2S. This index represents the ration of observed diversity to the maximum diversity possible for the same number of species. It has a maximum value of unity when all species are equally abundant are represented by only one individual; the more individual in the sample, the closer Jmin approach zero.

RESULTS

The results of habitat structures, biological diversity and water chemistry are described in tables 3-8 and figures 1-4. The biotic profiles of the aquatic ecosystem are characterized by periphyton and macrophytes at the primary trophic level, and zooplankton and aquatic benthic insects at a secondary trophic level and fishes at tertiary trophic level. These biotic components are food for the hill stream carps, perches, cat fishes, loaches etc. During the present investigation, a total of 16 taxa of fishes at the study sites were observed (Tab. 5). The percentage occurrence, species richness, seasonal variation and abundance of fishes at all selected sites are illustrated in tables 3-8. The water quality of river water and impounded river water is illustrated in table 6.

Table 3: Percentage (%) habitat distribution in the study area of Yamuna River basin.

Study sites*	Riffles	Pools*	Run	Rapids	Cascades
I	60.0	15.0	14.0	11.0	–
II	35.7	14.3	45.0	5.0	–
III	4.5	21.8	6.4	29.1	38.2
IV	35.0	21.0	37.0	7.0	–
V	20.0	7.0	38.0	35.0	–
VI	6.0	17.0	8.0	39.0	30.0
VII	25.0	12.0	18.0	45.0	–
VIII	15.0	21.0	11.0	23.0	30.0
IX	34.0	13.0	46.0	7.0	–

* Site – Jataon Barrage has pool habitat only.

Table 4: Fish species richness and Shannon diversity index in river Giri.

Monsoon season					Post monsoon season			
Index	N	H’	Hmax	J’	N	H’	Hmax	J’
Site I	4	0.56	0.6	0.94	6	0.63	0.78	0.81
Site II	6	0.7	0.78	0.89	6	0.64	0.78	0.83
Site III	4	0.51	0.6	0.84	5	0.63	0.7	0.9
Site IV	8	0.75	0.9	0.83	14	0.87	1.15	0.76
Site V	7	0.64	0.85	0.75	10	0.67	1	0.67
Site VI	4	0.57	0.6	0.94	4	0.49	0.6	0.81
Site VII	5	0.59	0.7	0.85	5	0.54	0.7	0.77
Site VIII	3	0.47	0.48	0.98	4	0.49	0.6	0.81
Site IX	7	0.725	0.845	0.858	13	0.843	1.114	0.757

*Site – Jataon Barrage has pool habitat and manmade structure only.

Table 5: Habit and habitat preference of fishes in the Study Area.

Fish Species*	Dwelling habits and habitat			
	Pools	Runs	Riffles	Rapids
Tor putitora (Ham.)	+++	++	+++	++
Schizothorax richardsoii (Gray)	++	++	+++	++ PH
Labeo dero (Ham.)	++ PH	++	++	–
Barilius bendelesis (Ham.)	++	++	++	+
B. barila (Ham.)	+	++	++	–
B. vagra vagra (Ham.)	+	++	++	–
P. ticto ticto (Ham.)	++	–	–	–
P. sarana (Ham.)	++	–	–	–
Bagarius bagarius	+	++	++	++ PH
Glyptothorax ssp.	+	++	++	++ PH
Channa orientalis (Bloch)	+++ PH	+	+	–
C. marulius	+++ PH	+	+	–
C. punctatus	+++ PH	+	+	–
Schistura ssp.		+	++	–
Brachiodenio rerio	++ PH	–	–	–
Mastecembelus armatus	++ PH	–	–	–

PH-Preferable habitat, +present, ++abundance, +++dominant, – Not recorded.

Table 6: Water Quality of the study area during monsoon and Post monsoon (2007).

S. no.	Parameters	Monsoon Season (August 2007)		Post monsoon season (November 2007)	
		Giri River n = 3	Jateon Barrage n = 1	Giri River n = 3	Jateon barrage n = 1
Physical Parameters					
1.	pH	7.88-7.90	8.0	8.04-8.20	8.2
2.	Temperature, ºC	20.0-22.0	23.0	16.0-17.0	18.0
3.	Dissolved Oxygen, mg/l	8.0-8.5	7.6	7.4-7.6	7.0
4.	Conductivity, mg/l	260-275	390	350-410	396
Chemical Parameters					
5.	Alkalinity, mg/l	90-98	110	156-178	120
6.	Total Hardness, mg/l	64-70	168	172-196	180
7.	Ca Hardness, mg/l	58-60	90	116-136	95
8.	Mg, mg/l	6-10	78	56-60	85
9.	Nitrate, mg/l	0.7-0.8	2.36	0.75-0.85	2.50
12.	Phosphate, mg/l	BDL	0.12	0.03-0.31	0.15
13.	Fluoride, mg/l	BDL	BDL	BDL	BDL
14.	Chloride, mg/l	6-10	20	4-10	24
15.	Sulphate, mg/l	4-5	50	32-40	66
16.	Sodium, mg/l	5-6	14	8-13	16
17.	Potassium, mg/l	BDL	5	2	7

BDL – Below Detection Limit.

Table 7: Detail Physiography of the Giri River and falling streams in the Impact zone of Renuka Dam Project; R = Bedrock/impregnated rocks, B = boulders, L = large boulders, B = small boulders, s = sand, C = cobbles, G = gravels Habitat; Rf = riffles, P = pools; Rp = Rapids; Rn = run. Cs = Cascade.

Geomorphology*	Jateon	D/s-Satibag	Dadahu	Upstream Sites						
	Barrage	I	II	III	IV	V	VI	VII	VIII	IX
Elevation (feet)	2010’	2045’	2160’	3192’	NR	2264’	2260’	250’	2501’	2523’
Gradient % (slope)	–	< 2%	< 2%	> 4%	< 2%	< 2%	> 4%	< 2%	> 4%	< 2%
Avg. channel width-m	–	6.3	35	7	32	40	10.75	32	8.9	40
Avg. channel depth-m	> 5 m	0.20	0.89	0.31	1.5	0.65	0.36	0.8	0.32	0.70
Bank full width	–	91	70	15	65	110	40	71	36	92
Maxim mepth -m	–	0.35	2.3	0.8	3.0	1.1	0.85	1.2	0.76	1.0
Width/ Depth ratio	> 10 m	32	48	23	20	62	30	40	28	67
Entrenchment ratio	–	14.4	2.12	2.14	2.13	2.8	3.7	2.2	4.1	2.3
Substratum	–	G, S	C, G, S, B	R, L, B, C, G, S	C, G, R, S	B, C, G, R, S	R, B, C, G, S	R, B, C, G, S	R, B, C, G	R, C, G, S
Habitat	P	Rf, P	Rp, Rf, P	Cs, Rp, Rf	Rf, P, R	Rp, Rf, P	Cs, P, Rp, Rf	Rf, Rp, P	Cs, Rp, Rf, P	Rn, Rf, P
Encroachment type	–	Bed material extraction	Bed material extraction	Agriculture practices	Agricultur practices					
Valley type	–	Wide valley	U shape valley	Confined stream	Confined valley	Confined stream	Confined valley	Confined stream	Confined valley	Confined stream
No. of fish species	4-6	4-6	6-6	4-5	8-14	7-10	4-4	5-5	3-4	7-13
Stream type	–	D	B	A	B	B	A	B	A	B

Table 8: Correlation of fish communities occurring during monsoon and post monsoon.

M	Site I	Site II	Site III	Site IV	Site V	Site VI	Site VII	Site VIII	Site IX
Site I	1	*	*	*	*	*	*	*	*
Site II	0.74	1	*	*	*	*	*	*	*
Site III	0.41	0.90	1	*	*	*	*	*	*
Site IV	0.31	0.81	0.92	1	*	*	*	*	*
Site V	0.22	0.77	0.93	0.92	1	*	*	*	*
Site VI	0.27	0.64	0.77	0.69	0.87	1	*	*	*
Site VII	0.49	0.88	0.94	0.89	0.95	0.91	1	*	*
Site VIII	0.27	0.66	0.79	0.70	0.86	0.97	0.90	1	*
Site IX	0.34	0.79	0.89	0.77	0.91	0.94	0.95	0.96	1
PM	Site I	Site II	Site III	Site IV	Site V	Site VI	Site VII	Site VIII	Site IX
Site I	1	*	*	*	*	*	*	*	*
Site II	0.70	1	*	*	*	*	*	*	*
Site III	0.45	0.8237	1	*	*	*	*	*	*
Site IV	0.46	0.9463	0.8194	1	*	*	*	*	*
Site V	0.41	0.9167	0.9292	0.96	1	*	*	*	*
Site VI	0.18	0.7184	0.9439	0.80	0.92	1	*	*	*
Site VII	0.27	0.8499	0.9275	0.93	0.99	0.95	1	*	*
Site VIII	0.10	0.4374	0.8443	0.47	0.67	0.89	0.72	1	*
Site IX	0.41	0.9109	0.9308	0.95	0.99	0.93	0.98	0.70	1

Habitat Inventory

a. Habitat structure and river morphology

The variables related to the channel morphology such as their width, depth, channel slope, substratum, habitats, and the source of water has been taken into account for the study of habitat inventory in the Giri River basin u/s and d/s sites and the details are depicted in tables 3-5 and figures 3-4. On the basis of stream morphology, the sites are classified into type A, B, C and D categories. The fish diversity is found maximum in the type B channel. The river Giri falls in this category and supports maximum aquatic life with the presence of maximum number of fish species (16). The type streams, which are present on the left bank of Giri, support 3-4 fish species only. A similar result was observed in D type channel present on its right bank, where only five fish species were reported.

Habitat essential for fish were pools, riffles, rapids, runs and cascades. Pools are the sites having minimum water flow with maximum depth (< 10 cm/s water current). Riffles are formed near the zone with gradient less than 4% and comparatively fast current and shallow water. Rapids are found in the areas having gradient > 4% with fast water current forming water waves. Cascades have step pools morphology and have been observed in side streams i.e. Joggar, Palar and Nait streams due to high gradient > 10%. The habitat structures observed at selected sites are illustrated in table 7. The results show that maximum habitat complexity in the river Giri upstream whereas minimum variation near the Jateon barrage area.

Results of habitat inventory showed an association with change in species richness as the change in habitat. During rains, the rapids were a common habitat and river was flooded. After the monsoon season natural restoration of habitat took places.

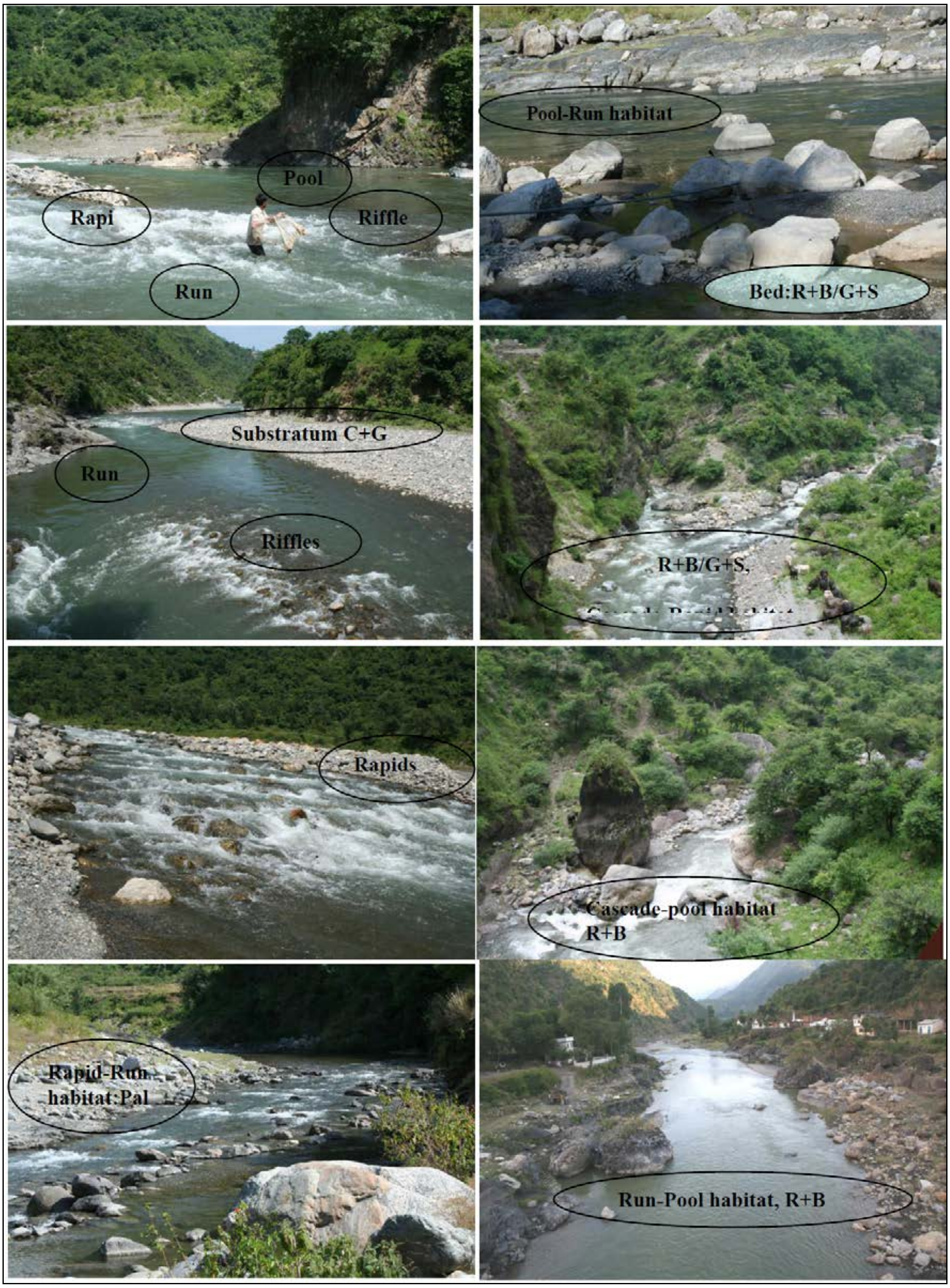

Figure 3: Habitats structure as Pool, Riffle, Run, Rapid and Cascade and substratum as rocks (R), boulders (B), cobbles (C), gravells (G) and sand (S) in the river course.

Figure 4: Habitats structure – heterogeneous habitat with formation of sand bars u/s barrage and homogenous habitat at barrage site.

b. Fish assemblages

The data collected for ichthyofauna also show an increasing trend from monsoon (eight sp.) to post monsoon months (16 sp.). Out of the 16 species, the order cypriniformes (carps, minnows and loaches) are the dominant group, five species of cyprinids, three species of chaniformes, one species each of siluriformes, sisroide and mastecemblide were found. The results of calculation of Shannon Weiner diversity index clearly indicate increasing trend of species richness and dominance from monsoon months to post monsoon months.

16 species represented by 11 genera, six families and four order were recorded in the study sites of Giri River basin, western – central Himalayan region. Of these, cyprinids were found to be the most dominant group represented by 10 species of seven genera. Of the order Cypriniformes, *Barchydanio rerio* was recorded from site IV. Out of the three, *Barilius* ssp., *B. bendelisis* (Ham.) is the most common at all sites. Other species like *B. barila* (Ham.) and *B. vagra* have been recorded at the sites but not regularly. *Tor putitora* (Ham.) was present at all sites. Species of *Puntus* i.e. *P. ticto ticto* (Ham.) and *P. sarana sarana* (Ham.) were observed at site IV. *Schizothorax richardsoinii* (Gray) is again typical hillstream forms with reduced scales and occur in II, V, VII, VIII and X sites. *Schistura* ssp. was recorded from site II. *Glyptothorax* ssp. is a true hillstream fish with well developed adhesive organs on the thorax. Mastembelus armatus (Lacepede) (Order Synbranchiformes) reported from all sites except site II and *Channa punctatus* (Bloch) (Order Perciformes) though are not true hill stream fishes but also harbour among hillstream fishes.

Most common and predominant fish were the endemic tiger fish-golden mahseer whereas the other fishes identified were *Channa* ssp., *Glyptothorax* ssp., *Bagarius* ssp., *Barilius* ssp., *Puntius* ssp. and *Mastecemblus* ssp. Among loaches *Noemacheilus* sp. was present and found in the crevices of cobbles, pebbles, and gravels in riffle habitat and slow flowing aquatic zones and prefer from deep to shallow water pools riffles, and rapid habitats.

During monsoon period fingerlings of the above mentioned species were observed. These young ones are present in the small ditches and shallow pools which are formed due to rains waters along the channel side during peak flow period or flood times. These are found rich in algal and detritus matter with insect larvae. The abundance of fingerlings was observed in post monsoon months in slow flowing water riffles. The present investigations in Giri River reveals that the population of the golden Mahseer contributes significantly to the fishery only in the main river where it comprises 37-40% of the total catch. The brooders, yearlings, fry and fingerlings of the golden mahseer were observed in the river Giri only.

The Giri ganga is a low gradient river, where the water runs all along the river except of some pools and riffles that are observed often along the course of the river. Many small pocket pools were noticed during the monsoon season alongside the river bank. These pools were predominantly found with fingerlings of variety of fishes, more particular the golden mahseer *Tor putitora*. In the upper reaches presence of Schizothoprax richardsonii was identified. The habitat distribution with feeding habits of the collected fish species are depicted in table 4.

C. Water Quality

Water quality was assessed during monsoon and post monsoon season (2007). The water quality analysis was carried in covered sections of the river Giri u/s and d/s of Giripul, Dadahu to have a holistic view. The physical and chemical characteristics of water quality are described in table number 6. The studied parameters clearly showed the difference between the running water in the river and impounded water at the barrage site. The temperature is higher in the impounded water along with higher concentration of migrate, phosphate, other cations and anions, BOD, COD and Ca and Mg hardness indicates accumulation of nutrients. These all variable were found in low concentration at all sites upstream. The difference was quite significant during monsoon season. Air temperature during monsoon months was recorded 19.5°-33.5°C in August and 18°C to 32.0°C in September, 2007. Average range was 26.0°C (August) to 24.5°C (September). The air temperature of the post monsoon months was 12.8°-30.2°C (average 23.5°C) in October and 8.0 to 27.5°C (average 21.0°C) in November months.

The change in water chemistry is due to impoundment of water at Jatoun barrage. The water is diverted through tunnels from the barrage for power production at Giri Nagar. Finally water flows into Bata River which joins river Yamuna near Pounta Sahib. The average flow since last ten years is illustrated in table 9. The monthly average surface discharge data i.e. hydrology series was based on the records available for a period of 10 years from 1991 to 2001 at Gauge and Discharge site Dadahu on river Giri as cleared by Hydrology (N), Directorate of Centre Water Commission (CWC, Delhi). The data shows in decline of water level after rainy season during lean period from November to May and minimum was during summers i.e. months of April and May. It can be inferred that the most quantity of available water was diverted for power generation. This resulted in the deficiency of water in downstream and river bed remains dry except during the wet season. It is necessary that a minimum of 10% flow of water is required throughout the year to maintain ecological integrity.

Table 9: Yearly and monthly average (Avg.) discharge (m^3/sec.) of Giri River.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Jan.	0.00	13.03	14.09	9.51	17.60	19.45	15.00	14.98	14.92	10.06	9.88
Feb.	0.00	25.14	13.76	13.62	20.15	34.01	13.67	21.07	12.22	12.21	8.56
March	0.00	15.19	22.38	10.09	19.48	39.20	12.03	50.88	9.43	9.47	7.50
April	0.00	10.32	15.29	11.59	16.34	18.79	18.04	21.22	7.16	8.33	6.30
May	11.60	7.21	8.81	10.03	9.31	10.22	15.20	15.78	11.07	7.65	6.21
June	10.24	6.19	10.42	9.52	7.34	18.12	14.19	35.22	8.62	46.12	9.76
July	11.13	30.47	175.56	107.46	66.76	40.06	17.40	64.74	102.17	113.29	60.55
Aug.	35.75	165.73	52.86	214.88	171.78	73.38	186.89	84.97	124.73	39.90	58.37
Sep.	41.96	147.91	134.85	89.44	159.28	141.42	102.59	98.80	71.43	29.94	20.22
Oct.	14.40	35.54	19.06	22.44	60.25	34.44	26.08	154.66	36.86	17.37	10.26
Nov.	11.05	17.44	12.45	18.18	24.46	19.91	17.77	28.87	13.65	12.35	6.62
Dec.	10.00	14.18	9.91	15.69	18.41	15.77	25.41	16.47	10.67	10.21	6.46
Avg.	18.27	40.70	40.79	44.37	49.26	38.73	38.69	50.64	35.25	26.41	17.56

Physical chemical characteristics show a low concentration of alkalinity, hardness, other cations and anions, which was likely due to the dilution factor of increased water level from rains. Other factors like high turbidity, heavy sedimentation rate and torrent flow were observed during monsoon season. Post monsoon months show higher concentration of alkalinity, hardness, dissolved oxygen, anions and cations were recorded but the water current, sedimentation rate and turbidity recede down. Almost the same trends were observed at Jateon barrage site, but higher level of physical and chemical variables as compared to the sites located on flowing watercourse were observed. This clearly indicates the difference between impounded water and stream/river water quality, though the results at all sites were found within the limit of drinking water standards. During rains, streams flow to their full capacity. In the post monsoon months rivulets in head water regions of these streams become dry and water is restricted to pools and shallow tanks along the course of the streams.

DISCUSSION

The rich fish diversity of the Giri River is due to spring fed river substratum that consists of bed rock, boulders, cobbles and gravels, which supports the survival, growth and reproduction of macro-benthic organisms. Observations further show a close relationship between the abundance of fish presence and population density of macro-zoobenthos in a particular area of the river. The richness of phytobenthos makes this riverine system supportive of many aquatic organisms such as macro invertebrates and fishes. The variables related to the channel morphology such as their width, depth, channel slope, substratum, habitats and the source of water were taken into account and shows a significant association of diversity with habitat structures (Tab. 7; Figs. 3-4). On the basis of morphology of the streams, the sites are classified into A, B, C and D-categories (Figs. 3 and 4). The fish diversity was found maximum in the type B channel. The river Giri falls under B category and supports maximum aquatic life with the presence of maximum number of fish species (16). A-type streams, which are present on the left bank of Giri supports only 3-4 fish species. Similar result was observed in D type channel present on its right bank where only five fish species were observed during present survey. Maximum species richness was observed in the Giri River as compared to the side tributaries and barrage side. This could be attributed to the physical and chemical characteristics of water and channel morphology (Tab. 6). Among physical factors, the most important factor is the habitat and channel geomorphology. It was observed that Joggar stream had a steep gradient (10%), than the Giri River (2%). The similar trend was observed in upstream at Palar and Nait stream as compared to river Giri. Changes in the gradient resulted in fast water current at Joggar stream (> two m/s) than the river Giri (< two m/s). Habitat in Joggar Stream is rapid and predominant near the confluence zone with Giri and cascades predominant with scour pools upstream. In Giri River upstream from the Giripul, Dadahu the frequent riffle pool habitat with lesser rapids and runs was observed whereas cascade was absent. Downstream from the Giripul (Dadahu), run predominates whereas at Jeaton barrage the channel completely changes into a small reservoir.

Downstream Dadahu River enters into wide open valley where it receives water from the Jalal channel located on its right bank. Four fish species were found in the downstream with fingerling of Mahseer near confluence of Jalal with Giri during Monsoon season and six species during post monsoon season were recorded. The influence zone of the Giri River recorded five to eight fish species during monsoon and 5-14 species in post monsoon season. The minimum species richness during monsoon may be attributed to the turbid and fast water current, fragmentation of habitat and flooded water channel whereas the maximum species richness during post monsoon could be due to favourable water current, temperature and dissolved oxygen, low sediment load or turbidity, habitat reappearance and availability of food matter. It was observed that the streams joining upstream on its left bank like Joggar, Palar and Nait in the influence zone of dam supported only three-five fish species i.e. low biodiversity which could be attributed to the high gradient, fast water current, rapid and cascade habitat and comparatively low water temperature (16-18^{o}C) than the rive Giri (21^{o}C) with suitable conditions sustaining rich biodiversity (14) due to low gradient, riffle pool habitat with rapids and runs, substratum with gravel and cobbles which support the maximum aquatic biodiversity. Thermal barrier plays an important role in distribution of fish population/fish communities in stream or rivers which change from headwaters to mouth (Shuter, 1992). Longitudinal environment gradients and fine-scale habitat patches are important in regulating fish assemblage structure during the dry season. Floods/rain water result in a dramatic reduction in habitat heterogeneity, which also lead to significant changes in assemblage structure from community dominated by *Tor putitora*, *Barilius bendelisis* and *Schizothorax* sp.

during post monsoon season to one dominated by *Tor* sp., *Barilius* sp. during wet season (monsoon). Torrent flow also results in the mobilization of bed sediments which are deposited near or at the tail region of Jateon barrage. Similar findings were also reported by Thomas et al. (2008). This process might be the major cause of habitat loss in a stretch of about three km where only run was found common due to impounded water at Jateon Barrage. It was evident from the literature also that low habitat heterogeneity correlated with poor species diversity. Increasing communities and habitat diversity after disturbances due to rains such as channelization, seasonal peak diversity attains levels typical of undisturbed stream due to rejuvenation of habitat heterogeneity (Gorman and Karr, 1978).

All three streams at the upstream of the dam site are cold water channels flowing through steep hills of Churdhar and Haripurdhar range whereas downward tributary flow through Saindhar range situated in warm climate zone. The Mahseer species need clean, stable, well oxygenated, gravel habitats to spawn in. After the eggs are laid in the gravel, well-oxygenated water must pass over the eggs (Chaudhary and Sharma, 1999). Adults and juveniles of species such as *Schizothorax* sp., *Tor* sp., and *Labeo* sp. move upstream and downstream respectively in Giri River including its streams Jogaar, Palar, Baga and Jalal. A majority of tributaries serve as the only routes through which the fish can have easy access to congenial environment to breed (breeding grounds) while juveniles move downstream (feeding grounds) during winter season (November-December). There are numerous sites with clean gravelled surface, riffle habitat followed by pools of favourable habitat that are suitable for spawning, breeding and feeding of endemic and migratory fishes which were inferred from the presence of large number of fingerling of migratory fish Mahseer (*Tor putitora*). The large number of fingerlings was observed near confluence or upstream in Giri River supporting the prevailing favourable conditions for fish.

It is important from the present survey that the spawning grounds (24 km) present in upstream of the Giri River will be submerged due to construction of dam. The total river basin area upstream of the proposed dam is 114 km. Thus a quite large area of the river will change into reservoir due to submergence of habitat of endemic fishes. The study carried out in upper reaches 900-1,100 m msl support seven – eight communities with maximum richness (Johal et al., 2002). It was inferred from the present study that the middle lower reaches of Himalayan hill streams are support maximum diversity (14 species) at elevation 650-800 m msl. The low diversity in lower reaches might be due to low habitat heterogeneity and fragmented habitat structures whereas upper reaches due to steep slope and turbulent water flow.

CONCLUSIONS

During monsoon season Hmax'varies between 0.48-0.85 and during post monsoon season from 0.6-1.15 at nine study sites (I-IX) made on river Giri of Yamuna River basin in the western-central Himalayan region. These fish species represented by 11 genera, six families and four orders which were recorded. Of these, cyprinids found most dominant group represented by 10 species of seven genera. Of the order Cypriniformes *Barchydanio rerio* was recorded from site IV. Of the three *Barilius* ssp., *B. bendelisis* (Ham.) is the most common at all sites. Other species like *B. barila* (Ham.) and *B. vagra* were recorded from sites but not regularly. *Tor putitora* (Ham.) was present at all sites. Species of *Puntus* i.e. *P. ticto ticto* (Ham.) and *P. sarana sarana* (Ham.) were observed at site IV. *Schizothorax richardsoinii* (Gray) is again typical hill stream forms with reduced scales and occur in II, V, VII, VIII and X sites. *Schistura* ssp. recorded from site II. *Glyptothorax* ssp. is a true hill stream fish with well developed adhesive organs on the thorax. *Mastembelus armatus* (Lacepede) (Order Synbranchiformes) reported from all sites except site II and *Channa punctatus* (Bloch) (Order Perciformes) though are not true hill stream fishes but also harbour among hill stream fishes. Change in diversity shows correlation with species richness(r), habitat heterogeneity, and hydrological regimes in a longitudinal stretch of 35 km along river Giri a major tributary of Yamuna River system, in Western Himalayas. The abundance differs with change in habitat structures, habitat preference of fishes and water regimes.

The decrease in diversity in the lower stretch of about 3-4 km upstream of barrage found associated with habitat fragmentation and as well as d/s with loss of biotic integrity of aquatic ecosystem due to water scarcity. The species richness was found maximum at upper and middle reaches (elevation 650-800 m, msl) of river whereas it was low in lower reaches. The change in water chemistry is also noticed at Jatan barrage-low head dam due to impoundment of river water. It is inferred that the regulation of water, impacts the species richness and relative abundance components and habitat heterogeneity, which has decreased due to the change in environmental condition.

Although, this is a small barrage-low head dam, but has resulted defragmentation of habitat as the water is being diverted through a tunnel of approximate six km long for hydropower generation at power house (2X30MW) near Majri Village, Girinagar. Water after tail race channel finally joins one of other tributary of Yamuna named Bata River and therefore, leaving downstream zone of about 25 km stretch of the Giri River till its confluence with Yamuna as water scare most of the period of the year except the monsoon season. For restoration of downstream habitat and maintaining wetted area downstream zone of barrage, a minimal of 10%, 20% or 30% of environmental flow (e-flow) of average of lean season shall be released as per Tennant (1976) approach-also known as Montana method (1976). The riparian flow or e-flow shall be sufficed with lower stream habitat enhancement programme (Rosgen, 1996). That will help to sustain biodiversity and maintain ecological balance as well as river continuum.

Fish ladders constructed on several weirs and barrages to facilitate migration of Tor putitora and other carps were reported ineffective (Sandhu and Toor, 1984). The drawbacks of these fish ladders are their steepness and then narrow and inconspicuous inlets. These ladders were found to function as fish traps and like the ones used by poachers. A high use on the river Sutlej at Bhakhra resulted in a sharp decline in catches of *Tor putitora* in Gobindsagar reservoir from 40% in 1966 to 0.5% in 1979 (Natranjan and Sehgal, 1982). But later an increase in catches of this mahseer has been reported, indicated that the Mahseer has found a way to produce new stocks under the new situation (Kumar, 1988).

Acknowledgements

The study was supported by EIA Division, ICFRE, Dehradun under the project Renuka Multipurpose Project as consultancy work awarded by the Himachal Pradesh Power Corporation Limited (HPPCL). All authors are thankful to DG, ICFRE and ADG, EIA Division, ICFRE, Dehradun for facilitation of regular field visits during the Impact Assessment Studies.

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EUDONTOMYZON DANFORDI (REGAN, 1911) SPECIES POPULATIONS ECOLOGICAL STATUS IN MARAMUREŞ MOUNTAINS NATURE PARK (ROMANIA)

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DOI: 10.1515/trser-2015-0071

KEYWORDS: Carpathian lamprey, habitats, human impact, assessment.

ABSTRACT

The *Eudontomyzon danfordi* characteristic habitats state of Maramureş Mountains Nature Park varies greatly, 19.05% are in excellent conservation status, 47.62% are in good/average status and 33.33% are in a partially degraded condition.

The identified human impact categories which induced the decreasing of *Eudontomyzon danfordi* species habitat state in the studied area are: poaching, minor riverbeds morphodynamic changings, liquid and solid natural flow disruption, destruction of riparian trees and bush vegetation, habitat fragmentation-fish populations isolation, and organic/mining pollution activities.

RESUMEN: Estado ecológico de las poblaciones de Eudontomyzon danfordi (Regan, 1911) en el Parque Natural Montañas Maramureș (Rumania).

El estado de las características del hábitat de Eudontomyzon danfordi en el Parque Natural Montañas Maramureş varió significativamente, 19.05% están en excelente estado de conservación, 47.62% están en un estado de preservación bueno/regular y el 33.33% están en condiciones parcialmente degradadas.

En este estudio, las categorías identificadas de impacto humano que indujeron deterioro del hábitat de *Eudontomyzon danfordi* son: caza ilegal o furtiva, cambios morfodinámicos de pequeños cauces, modificación del flujo natural de líquidos y sólidos, destrucción de la vegetación riparia, fragmentación del hábitat de poblaciones de peces, actividades orgánicas contaminantes y minería.

REZUMAT: Starea ecologică a populațiilor de *Eudontomyzon danfordi* (Regan, 1911) în Parcul Natural Munţii Maramureşului (România).

Starea habitatelor caracteristice speciei *Eudontomyzon danfordi* din Parcul Natural Munţii Maramureşului variază mult, 19,05% sunt într-o stare de conservare excelentă, 47,62% într-o stare bună/medie şi 33,33% într-o stare redusă/degradată.

Categoriile de impact uman care induc scăderea stării de favorabilitate a habitatelor speciei *Eudontomyzon danfordi* în aria studiată sunt: braconajul, modificarea morfodinamicii naturale a albiilor minore, dereglările debitelor naturale lichide şi solide, distrugerea vegetaţiei ripariene arboricole şi arbustive, fragmentarea habitatelor – izolarea populaţiilor de peşti, poluarea organică şi poluarea cauzată de activităţile miniere.

INTRODUCTION

The lotic ecosystems of the Maramureș Mountains Nature Park are in majority part of the Vișeu River catchment and some of the Bistrița Aurie catchment (Fig. 1), in northern Romania. The Vișeu Basin is bordered by the Maramureș Mountains in the northeast, by Rodna Mountains in the south, and by the Maramureș hills in the west and southwest. The lowest point of the basin is 303 m above sea level at the confluence of the Vișeu and Tisa rivers, while the highest point reaches 2,303 m altitude, the Pietrosul Rodnei Peak in Rodna Mountains. Due to its geological, tectonic and geographical complexity (glacial, karst, exokarst relief forms, etc.), the catchment area is largely diverse in landscapes, implicitly having a large variety of biotopes, biocoenosis, including ichtyocoenosis. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

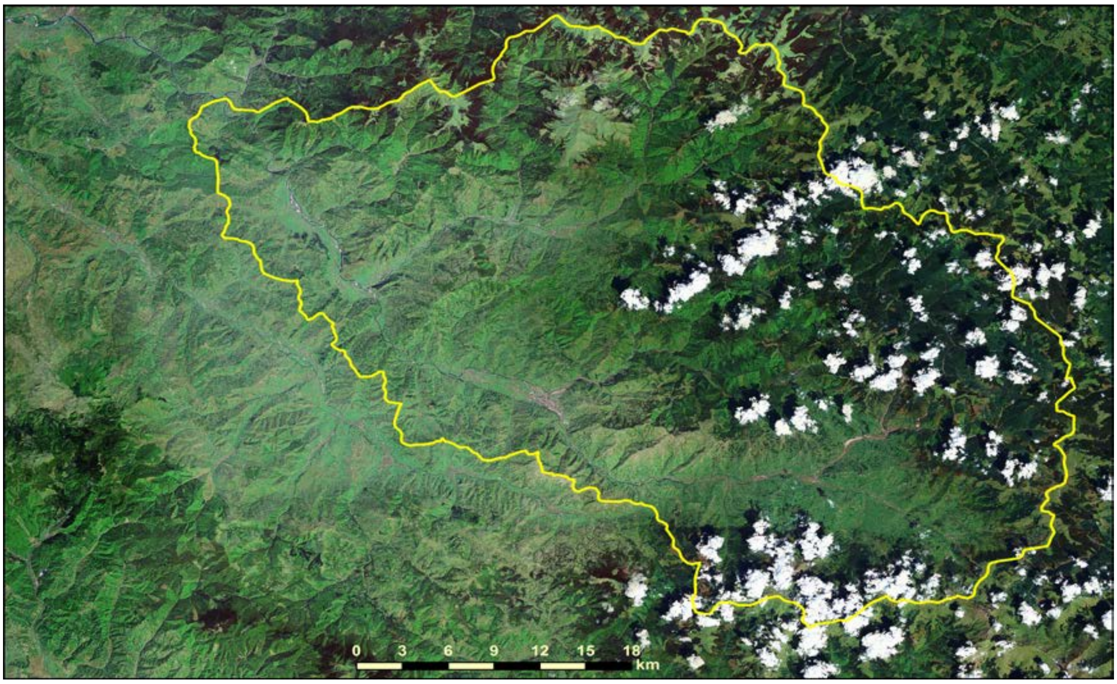

Figure 1: Vișeu River basin.

The Vişeu River is a second degree tributary of the Danube, flowing into the Tisa River. It has 80 km in length and a multiannual average flow 30.7 m^3/sec. at its confluence with the Tisa River. The origin is located in Prislop Pass (1,416 m) and it flows into Tisa near Valea Vișeului Village, the catchment area covering 1,606 km^2. In its upper part, from springs to the town of Moisei, the Vișeu River has a large slope (20-50 m/km) and is locally named Borșa or Vișeuț. From Moisei, the Vișeu enters the Maramureș Depression where the valley is wider, although some narrow gorge-like passages subsist: Rădeasa Gorges between Moisei and Vișeu de Sus, Oblaz Gorges between Vișeu de Jos and Leordina, and Vișeu Gorges between Bistra and Valea Vișeului. The hydrography of Vișeu River is of Eastern-Carpathian-Moldavian type in its upper part and of Eastern-Carpathian-Transylvanian type in its lower half. Its discharge is substantial in the springtime (39.4% of the annual discharge) subsequently decreasing during the summer (27% of the annual discharge) as well as during the autumn (18.6% of the annual discharge) and reaching its lowest during wintertime (15% of the annual discharge). (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

The fact that the Vișeu Catchment area is situated mainly in mountainous areas (67%) leads to a high density of the hydrographic network (0.7-1 km/km^2) and to one of the largest specific discharges in Romania, due to rain and snowfall of more than 1,100 mm/year. In the upper part, the tributaries originating in the glacial-type Rodna Mountains, have an elevated discharge (approximatively five m^3/sec.). The most important Rodna-originating tributaries of Vişeu are: Fântânilor Valley (seven km length), Negoiasa Valley (six km), Repedea Valley (10 km), Pietroasa Valley (seven km), Vremeșu Valley, Hotarului Stream, Dragoș's Valley (11 km) and Izvorul Negru (seven km). From the Maramureș Mountains, the right side tributaries are: Hășmașul Mic, Cercănel (11 km), Țâșla (20 km), Vaser (52 km in length and catchment area of 422 km^2, with an average flow of nine m^3/sec. contributing by 27% to the total flow of Vișeu), Novăț (16 km, 88 km^2 tributary of the Vaser), Ruscova (39 km in length and 435 km^2 catchment area, average discharge of 11.3 m^3/sec.), Socolău (13 km in length and 72 km^2 catchment area, tributary of the Ruscova), Repedea (19 km in length and 87 km^2 catchment area, tributary of the Ruscova), Bardi (11 km in length and 32 km^2 catchment area, tributary of the Ruscova), Covașnița (11 km in length and 34 km^2 catchment area, tributary of the Ruscova), Frumușeaua (14 km in length) and Bistra (nine km in length). From the Maramureș hills originate the left-side tributaries with small water input: Drăguiasa, Cocicoi, Spinului, Plăiuț, Neagră and Luhei. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

In the Vişeu River basin, water quality is locally influenced in a natural way by mineral springs (150 in Maramureş Mountains, about six in Rodnei Mountains and around five in Maramureş hills) with a relatively varied composition (bicarbonate, ferrous, sulphurous and saline) (Curtean-Bănăduc et al., 2008).

In the Rodnei and Maramureş mountain areas the lotic ecosystems continuity is sometimes interrupted by sizeable waterfalls and series of rapids, we mention the biggest of these waterfalls from the Rodnei Mountains: Cailor, Cimpoioasa Valley, Repedea Valley and Izvorul Verde, and from Maramureş Mountains we mention: Criva, Tomnatic and Bardău. Besides lotic ecosystems, there are also lentic ecosystems. Glacial lakes from Rodnei Mountains are located at an altitude over 1,900-1,950 m and were formed behind some deposits: Iezer Lake, Gropi Lake, Buhăiescu Lake, Rebra Lake, Negoiescu Lake and Cimpoieş Lake. As wetlands there are also eutrophic and oligotrophic marshes: Strungi Marsh, Tăul Obcioarei, Tăul Ihoasa, Jneapănul Hânchii, Pietrosul Barcăului Marsh, Tăul Băiţii, Preluca Meşghii, Vârtopul Mare Marsh, Tăul cu Muşchi and Bedreasca. The lakes from Maramureş Mountains are Lutoasa, Bârsănescu, Budescul Mare, Măgurii and Vinderel. On the Vişeu River couloir near Petrova locality, there is an area of ponds. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

The diversity of aquatic and semi-aquatic habitats and their associated rare, endangered and endemic species from Vişeu Basin is complex, high and valuable under conservative aspect. The fish species are no exception in this area, as reported by different researchers relatively continuous over more than a century of ichthyologic studies in the area of interest (Bănărescu, 1964; Staicu et al., 1998; Curtean-Bănăduc et al., 2008). A half of the fish species are of conservative interest.

MATERIAL AND METHODS

The study for *Eudontomyzon danfordi* species populations mapping and conservation status assessment and the identified causes of the present situation, in the Maramureşului Mountains Nature Park was realised between January and July 2015, based on 370 sampling stations (Fig. 2, Tab. 2).

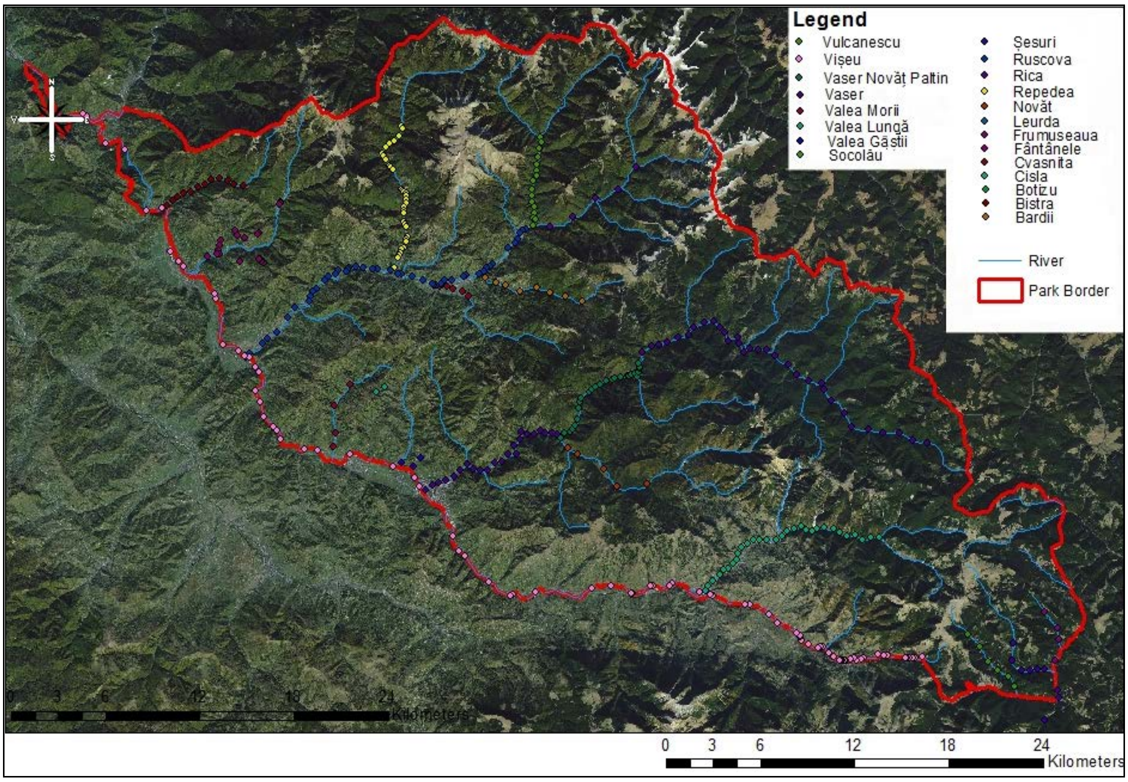

Figure 2: The 370 sampling stations location.

To assess the distribution and status of the fish species populations of conservative interest, quantitative samples were collected from around three to three kilometres between two consecutive stations along all watercourses included in the reference area, in areas with suitable habitats for the species of interest. This distribution of the sampling sectors ensures the representativeness of the collected data and allows the assessment of the effects on the target populations of the biotope condition changes, presence of pollution sources, of hydrotechnical works, substratum exploitation, poachers, etc.

Ichthyofauna quantitative sample collection was performed by the reversible electro narcosis capture method, per unit of time and effort per section (two hours on Vişeu River, one hour on Ruscova River, 30 minutes on the other rivers of the references zone), on five longitudinal sections of 100 m length. After species identification and counting individuals, the captured individuals were released in their habitat.

The number of individuals caught in the unity of time and effort can be transformed through correspondence in the classes: (C) – common species, (R) – rare species, or (V) – very rare, according to the guidelines for Natura 2000 standard data form filling, “In mammals, amphibians, reptiles and fishes, no numeric information can be indicative and then the size/density of the population is evaluated as (C) – common species, (R) – rare species, or (V) – very rare species”.

The criteria used to assess the population status are: population size, balanced distribution of individuals by age classes, distribution areal size and the percentage of individuals of the species of interest in the structure of fish communities.

According to Natura 2000 guidelines, standard data form filling the criteria "The conservation degree of specific habitats" includes subcriteria: i) the degree of conservation of the habitat features which are important for the species; ii) possibilities for recovery.

The criteria i) requires a global evaluation of the features of the habitat regarding the needs of the species of interest. "The best expertise" is used to rank this criterion in the following way: I. elements in excellent condition, II. well preserved elements, III. elements in average or partially degraded condition.

In the cases in which the subclass I is granted "I: elements in excellent condition" or "II: well preserved elements," the criteria B (b) should be classified entirely as "A: excellent conservation" or "B: good conservation", regardless of the other sub-criterion classification.

In the case of this sub-criterion ii) which is taken into account only if the items are averagely or partially degraded, an evaluation of the viability of the analysed population is necessary. The obtained ranking system is: I. easy recovery; II. restoration possible with average effort; III. restoration difficult or impossible.

The synthesis applied for classification is based on two sub-criteria: A-excellent conservation = elements in excellent condition, regardless of classification of recovery possibility; B-good conservation = well preserved elements, regardless of classification of recovery possibility; B-good conservation = elements in average or partially degraded condition and easy to restore; C-average or reduced conservation = all other combinations.

In every sampled sector, the following were assessed: condition, pressures/threats of habitats and populations of interested fish species.

The monitoring stations for fish population conservation status of the above mentioned species in the survey reference area were established not only in the river sectors in which these species populations are stable, presenting a favourable conservational status, well preserved characteristic habitats, but also in the river sectors situated at the limit of the distribution area in this site for the investigated species, sectors under human pressure that can jeopardize the populations status – the Representativity Criteria.

The economical criterion was also considered for establishing the monitoring stations, thus a medium number was set to supply the necessary information for the management decision process in order to be able to preserve a favourable status for the interest species population in the reference area.

Eudontomyzon danfordi Regan, 1911, Code Natura 2000: 4123, Cyclostomata – Petromyzoniformes – Petromyzonidae (Fig. 4), was present in the studied area in the last century (Bănărescu, 1969; Telcean and Bănărescu, 2002; Bănăduc et al., 2013; Homei, 1963).

This fish species body is relatively compressed laterally in the anterior part with a height of 5.0 to 7.7% of the total length. The two dorsal fins have a space, which represents 2.3 to 6.8% of the body length between them.The first dorsal fin is round and not so high, while the second one is higher. Adults are dark grey and the ventral side is yellowish-whitish.

The larvae and adults feed on invertebrates. They live in mud, especially mixed with sand. The depth of which they are buried varies from 10 to 40 cm. They are night hunters.

This species lives in rivers with mountain characters, in the trout, grayling and Mediterranean barbell zone, and is less frequently present in the nase upper area. The frequency of individuals of this species in various rivers and even in different parts of the same river is uneven, probably depending on the presence and abundance of sectors with slow water and silt in which the larvae are developing and the food is abundant. (Bănăduc, 2007a, b, 2008a, b, 2011; Bănăduc et al., 2012; Bănărescu, 1964, 1969; Bănărescu and Bănăduc, 2007).

RESULTS

The lotic sectors where the species *Eudontomyzon danfordi* (Fig. 3) was identified during the study are presented in table 2 (Fig. 4), for each sector the catch index values were specified (individuals number per time and effort unit).

Figure 3: *Eudontomyzon danfordi* Regan, 1911.

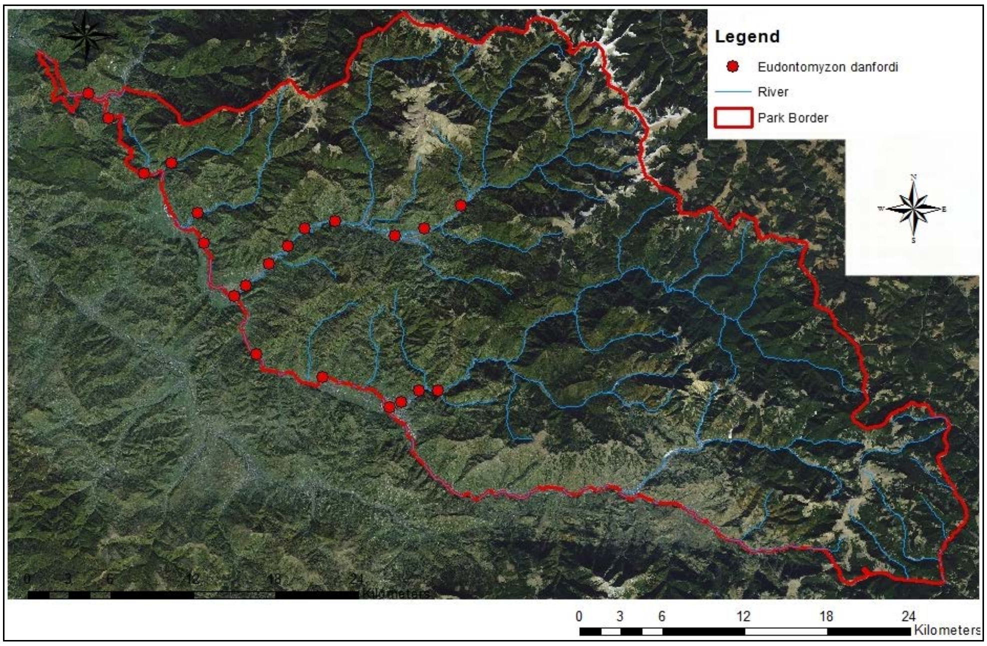

Figure 4: *Eudontomyzon danfordi* Regan, 1911 distribution/sampling stations location.

Table 2: *Eudontomyzon danfordi* sampling points in Maramureş Mountains Nature Park.

No. crt.	River	Station code	Lat. (N')	Long. (E')	Catch index no. ind./50 m x 30 min	Characteristic habitat state
1.	Vişeu	54	47 43 48.9	24 21 42.8	1	good/average
2.	Vişeu	59	47 44 42.4	24 17 50.5	1	good/average
3.	Vişeu	65	47 46 58.8	24 16 32.2	2	good/average
4.	Vişeu	70	47 49 03.6	24 14 45.05	4	good/average
5.	Vişeu	75	47 51 48.5	24 11 12.4	10	excellent
6.	Vişeu	77	47 54 00.9	24 09 07.36	7	excellent
7.	Vişeu	79	47 54 58.5	24 07 55.7	6	good/average
8.	Ruscova	5	47 50 39.7	24 29 41.7	1	reduced
9.	Ruscova	11	47 49 44.9	24 27 34.2	1	reduced
10.	Ruscova	18	47 49 25.8	24 25 49.8	1	reduced
11.	Ruscova	26	47 49 59.8	24 22 19.9	2	reduced
12.	Ruscova	33	47 49 41.7	24 20 34.1	1	reduced
13.	Ruscova	37	47 48 59.9	24 19 38.6	3	good/average
14.	Ruscova	40	47 48 17.8	24 18 29.9	5	good/average
15.	Ruscova	43	47 47 25.7	24 17 12.1	1	reduced
16.	Vaser	46	47 43 18.5	24 28 22.7	1	excellent
17.	Vaser	49	47 43 19.3	24 27 18.3	1	excellent
18.	Vaser	52	47 42 52.6	24 26 15.3	2	good/average
19.	Vaser	54	47 42 38.7	24 25 34.6	5	good/average
20.	Frumuşeaua	18	47 50 16.8	24 14 22.1	7	good/average
21.	Bistra	10	47 52 15.7	24 12 48.2	2	reduced

Eudontomyzon danfordi individuals constitute in the studied area permanent populations on an average total surface of five hectares; the adequate surface of the habitat in this protected area is around 10 hectares (in the following basins: Vişeu – lower sectors, Ruscova – middle and lower, Vaser – lower, Frumuşeaua – lower and Bistra – lower). The habitat surface of the species is big enough and the present tendency and quality of the habitat is adequate for the long term species survival.

The human impact, respectively the identified pressures in the studied area, have a medium cumulative effect, partially affecting the long-term viability of the species, with the condition that no new type of human impact will be involved and the existing ones will not increase in the future.

DISCUSSION

Based on the results obtained from field activities, correlated with *Eudontomyzon danfordi* species biological and ecological needs, the following risk elements were identified (pressures and threats): poaching, minor riverbed morphodynamic changes, liquid and solid natural flow disruption, destruction of riparian vegetation, habitats fragmentation/fish populations fragmentation.

Poaching. During the field campaigns poaching activities were noticed with electric energy from car accumulators and equipment involved in forestry activities and from other types of rechargeable batteries. In other cases, poachers were seen during illegal activities using various substances (natural and synthetic) for killing fish and harvesting them downstream. By interviewing various people encountered in Maramureș Mountains Nature Park, it seems that poaching is a relatively frequent activity in all seasons through the Vișeu River basin. The inefficiency of controlling this phenomenon may lead to the number reduction of *Eudontomyzon danfordi* individuals and populations.

We propose increasing the number of field work hours for rangers in order to stop poaching in the protected area. The lack of financial resources that these activities involve for rangers can be partially offset through collaborative arrangements with forestry, police and gendarmerie personal, and last but certainly not least with the Romanian National Agency for Fishing and Aquaculture agents which should become the main player in this respect for controlling poaching at a national level, as well as a creation of volunteer structures.

Minor riverbed morphodynamic changings. Specific different habitat and microhabitat needs for this fish species, according to its life cycle stages, induce requirements for a natural variability of riverbed morphodynamics. Dikes, sills, dams, roads in riverbeds, changed riverbeds, riverbed mineral exploitation (Fig. 5), changed dynamics of liquids and solids flow, etc., all have a primary effect of modifying the natural morphodynamics of major and minor riverbeds and secondarily affected ones, if not all habitats and/or microhabitats predeterminant for the life cycle stages of the *Eudontomyzon danfordi* individuals, which could result in decreasing numbers of this species' populations.

Apparently harmless, a number of facilities on watercourses of interest (dikes, too high sills, dams, microhydropowerplants, water extractions, modifications in the riverbeds, riverbed mineral overexploitations, etc.) should not be allowed by Maramureș Mountains Nature Park Scientific Council and Administration without a proper/specific technical expertise for this species of conservation interest.

Figure 5: Minerals' overexploitation in the lower Vișeu River riverbed, banks and terraces.

Liquid and solid natural flow disruption. The liquid and solid natural flow disruption that created the conditions for formation and persistency of habitats and microhabitats adequate for the occurrence and development of the *Eudontomyzon danfordi* species population, may lead, in the context of modification of the natural morpho-dynamics of the riverbed, to the declining number of individuals of the species. The accidental episodes of artificial increase of water turbidity, due to negligent forestry in the proximity or in the very riverbed, are an example of the cause for disrupting the equilibrium of the liquid and solid natural flow.

The liquid and solid natural flow can be maintained as close as possible to the natural state if the forestry practices and/or riverbed grabble exploitations will not affect the capacity of the watershed to have a self-sustainable condition of practice, which can be achieved by correlating the human activities with the seasons and the periods when the natural conditions are similar to those to be created (high turbidity). Apparently harmless, a series of existing (Fig. 6) or possible works on the rivers of interest, such as embankments, crossings, dams, water extractions, bank modifications (Fig. 7), thalweg alterations by exploitations of construction materials from the riverbed, etc., are not allowed by the administrator of the site without the consent of specialists studying the species, based on the corroboration of the specific/local stress factor and the biological and ecological needs of the species of interest. In this particular case, for instance, no crossing should be higher than 10-15 cm in the shallow and dry season. We also suggest the monitoring of the forestry regulation surveillance including the interdiction of dragging and storage lumber through/in creeks and rivers. We also recommend the surveillance of the development works for lumber storage and exploitation platforms, (Fig. 8) and the mandatory requirement to reforestation. In this context, the rotation of exploitations in the sub-basins of the Vişeu River is preferable.

Figure 6: Concrete threshold of three m height, with no fish ladder on the upper Vişeu River.

Figure 7: Frumuşeaua River concrete riverbank/completely modified.

Figure 8: Logs transport and deposit on the Vaser River banks and in the riverbed.

Destruction of riparian trees and bush vegetation. Diminishing the riverine vegetation (Fig. 9), by partial/total destruction, both in the context of lessening the microclimate protection and that of trophic resources (Curtean-Bănăduc et al., 2014), can lead to a numerical reduction of ichthyofauna including the *Eudontomyzon danfordi* individuals populations. The arboreal and shrubs riparian vegetation must be as intact as possible on a minimum of 5-10 m width in the upper part of the rivers and of 10-25 m in their lower part.

Figure 9: Destructed riparian vegetation on the Ruscova River banks.

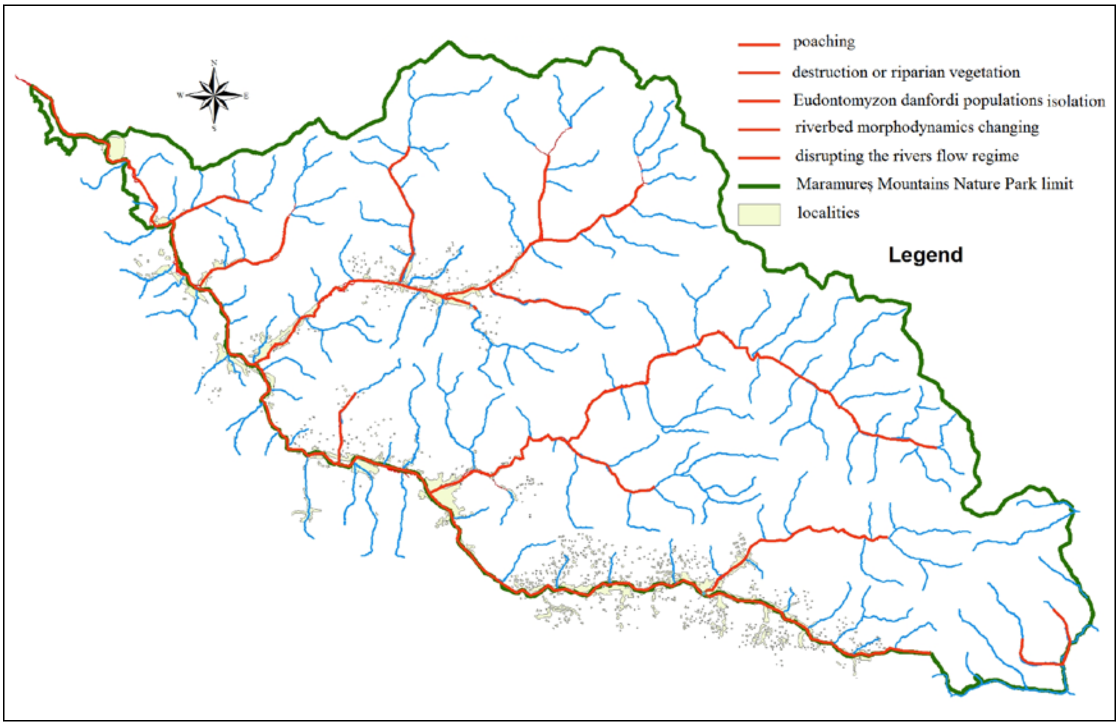

Figure 10: Identified combined pressures and threats for *Eudontomyzon danfordi*.

Habitat fragmentation/isolation of population invariably leads to genetic isolation, reduction of gene variability and, sooner or later, species inbreeding and local or regional extinction. The free upstream and downstream displacement, including the various sub-drainage basins of the Vişeu catchment area, are a highly important element for their protection and conservation. The relatively low motor skills of the species enhances the importance of this type of man-made impact.

We suggest treating the possible future investments located on the water courses very carefully, since some of them could reduce or completely cut off the longitudinal connectivity on the interest water courses, not only by creating various transversal obstacles in the riverbed, but also by reducing the water flow or even water depriving of some river sectors.

The organic pollution. It is a chronic problem related to the sewage and wastewater treatment as well as to the farms, in the large majority of the Vişeu catchment area, mainly on the Vişeu River, are a permanent stress source for the interest species. Comprehensive sewage systems must be implemented in the Vişeu Basin and the wastewaters of the localities alongside the main water courses must be treated.

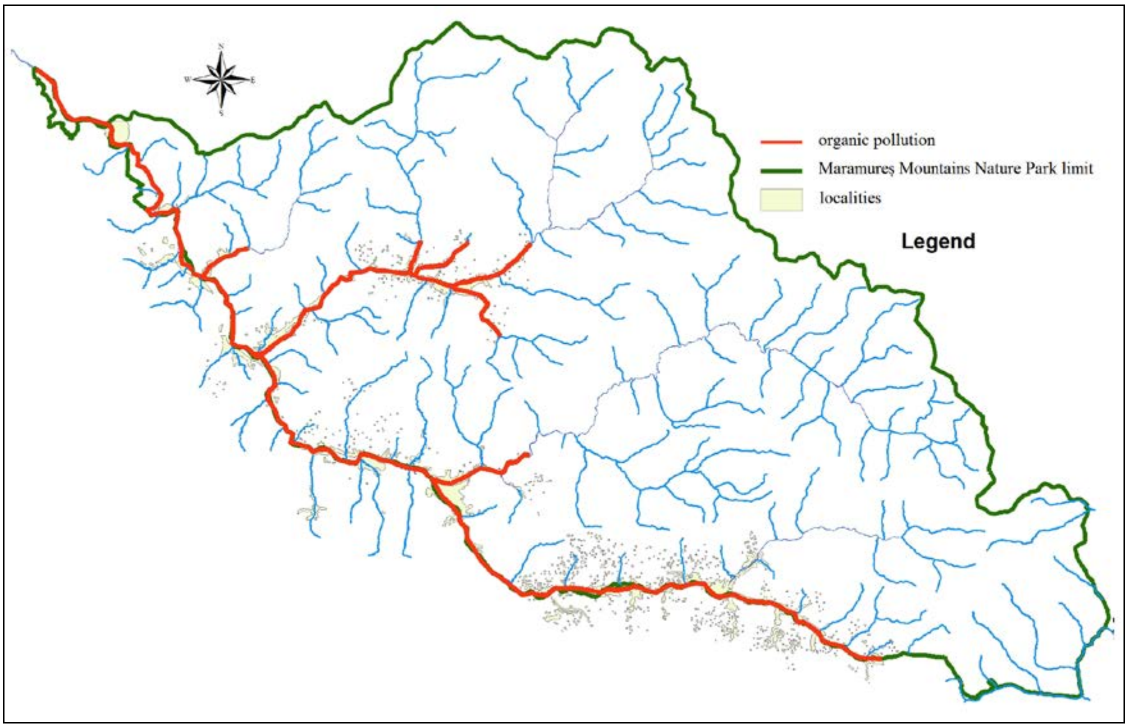

Figure 11: Lotic sectors negatively influenced by organic pollution.

The pollution caused by mining activities. The historical pollution resulting from heavy metal mining activities in the Ţâşla drainage basin are not affecting only the Ţâşla River aquatic habitats but also the interest habitats and species of the upstream Vişeu River. The impact of the meteoric washing waters of the non-isolated mine galleries and greened refuse heaps is ranked as major on the Ţâşla River and significant on the upstream Vişeu.

The impacts of meteoric waters washing the non-isolated mine galleries and rehabilitated refuse heaps can be significantly reduced by isolating/filling the ancient mine galleries and by isolating (not greening) the refuse heaps from the water courses in the drainage basin of the Ţâşla River.

Of course the synergism among all the identified human impact effects influence many lotic sectors in the area of interest (Figs. 10 and 11) and evaluating the studied fish species in the area as rare.

The following minimal management measures should be implemented in the studied area: creation of lotic systems buffer zones; coordination of water use; regulation of sewage and waste water and surface water pollution as well; readjust the hydroenergetic use of streams and rivers; implementation of integrated water resource management for the watershed; build and authorize ecological networks; restore streams and rivers connectivity; support high scientific quality inventories and watershed integrated management oriented research.

CONCLUSIONS

The *Eudontomyzon danfordi* characteristic habitats state of Maramureş Mountains Nature Park varies greatly among bad, average and good. The identified human impact categories which induce the decreasing habitat state in the studied area are: poaching, minor riverbeds morphodynamic changings, liquid and solid natural flow disruption, destruction of riparian trees and bush vegetation, habitat fragmentation-fish populations isolation, organic pollution and those caused by mining, as a consequence of the identified human impact effects, the *Eudontomyzon danfordi* species can be considered in the present as a relatively rare species in the studied area.

19.05% of the studied lotic sectors (in Vişeu and Vaser rivers) were found in excellent conservation status, 47.62% of the studied lotic sectors (in Vişeu, Vaser, Ruscova and Frumuşeaua rivers) are in good/average conservation status where medium term restoration is possible with average effort and 33.33% of the studied lotic sectors (Ruscova and Bistra streams) are in reduced/degraded conditions where long term restoration is difficult. Ruscova and Bistra streams are in the worst situation as from the *Eudontomyzon danfordi* fish species perspective.

ACKNOWLEDGEMENTS

These data were obtained in the project "Inventarierea, cartarea și evaluarea stării de conservare a speciilor de pești din Parcul Natural Munții Maramureșului (ROSCI 0124 Munții Maramureșului)/Inventory, mapping and assessment of the conservation status of fish species of Munții Maramureșului Nature Park (ROSCI 0124 Maramureșului Mountains)". Special thanks for the continuous support of the Parcul Natural Munții Maramureșului Administration and Scientific Council members especially to: Bogdan C., Bucur C., Szabo B., Brener A. and Mărginean M.

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COMPLIANCE WITH ICHTHYOFAUNAL DIVERSITY CONSERVATION MEASURES IN LAKE LANAO, LANAO DEL SUR PROVINCE (PHILIPPINES)

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DOI: 10.1515/trser-2015-0072

KEYWORDS: Conservation measures, fisheries management, fisheries resources.

ABSTRACT

This study was conducted to probe the effectiveness of, and compliance with, legislated fish diversity conservation measures in lake Lanao employing structured interview techniques. Results showed respondents' age from 19 to 70.

Most of the respondents are educated, having taken vocational courses, with a general weekly income of PhP 2,000-2,499 ($42.92-$53.62). The respondents are knowledgeable of the fisheries laws, ranging from 39.29% to 76.43% whilst their compliance is high, ranging from 81.31% to 100%.

RESUMEN: Cumplimiento de las Medidas de Conservación de Diversidad de la Ictiofauna en el Lago Lanao, Provincia de lanao Del Sur (Filipinas).

Este estudio se realizó con el objetivo de estudiar la eficacia y el cumplimiento de las medidas de conservación de la diversidad de peces legislados en el Lago Lanao empleando la técnica de entrevista estructurada. Los resultados muestran que la edad de hijos encuestados oscila entre 19-70.

La mayoría de los encuestados están escolarizados, habiendo tomado cursos de formación profesional, con un ingreso semanal general de PhP 2,000-2,499 ($42.92-$53.62). Los encuestados tienen conocimiento de las leyes de pesca, que van desde 39.29% al 76.43%, mientras que su cumplimiento es alto, desde 81.31% a 100%.

REZUMAT: Respectarea măsurilor de conservare a diversității ihtiologice din Lacul Lanao, Provincia Lanao del Sur (Filipine).

Acest studiu a fost inițiat pentru a testa efectivitatea și respectarea legislației privind măsurile de conservare a diversității ihtiologice din lacul Lanao aplicând tehnica interviului structurat. Vârsta respondenților variază între 19 și 70 ani.

Majoritatea subiecților sunt educați, având cursuri de vocație, cu venituri săptămânale cuprinse între 2.000-2.499 PhP ($42.92-$53).

2). Numărul respondenților care au cunoștințe privind legislația de pescuit se încadrează între 39,29% și 76,43% în timp ce numărul celor care respectă legea este mare încadrându-se între valorile 81,31% și 100%.

INTRODUCTION

The Philippines, being an archipelagic country, has an abundance of marine resources that play an important role in the nation's economy. In addition, it possesses a number of inland water bodies that contribute further to its fishery resources. It is therefore appropriate that there is an institutional framework, with policies and legislation, rules and regulations, and ordinances both at the national and at the local level, to protect these resources so as to ensure their sustainability, because the economy and the local population are dependent on them. A vital component in ensuring the successful management and conservation of the country's aquatic resources, especially inland resources, is the fisher folks, fisher folks' knowledge and awareness of these laws, and most essentially, their compliance with the laws.

In 1998, the Philippine Congress enacted into law Republic Act 8550, also called the Philippine Fisheries Code. It is an extensive piece of legislation for the development, management and conservation of the Philippines' aquatic resources, and incorporates all appropriate laws. Chapter VI of the Code provides for certain prohibitions (and corresponding penalties) in fishery and the use of fishery techniques that have negative effects on aquatic resources.

Studies on compliance with fisheries laws in the Philippines have been conducted prior to and after the enactment of the Fisheries Code. Most of these researches were undertaken in marine environments. Palma (2006), in her study on the suitableness of the Philippine policy, legal, and institutional framework to combat illegal, unregulated, and unreported (IUU) fishery, concluded that they are inadequate to address IUU fishing based on criteria established in the international fisheries instruments. In their work conducted in San Salvador Island, Katon et al. (1999) discussed how the fisher community and the local government rose above the obstacles associated with a *de facto* open-access fishery by highlighting the creation, management and impact on ecosystem health, both natural and human, of a marine reserve and sanctuary. Capistrano (2010) examined the impact of local and national policies such as property rights on the participation of indigenous peoples, specifically the Tagbanua of the Philippines in relation to fisheries management. Dalabajan (2005) examined the socioeconomic context and the legal and political milieu in which the problems around cyanide fishing are carried out. Adan (2009) examined the public policies on fisheries as contained in national and local legislations and how they are transformed into management actions at the local government level in Panguil Bay, concluding that intervention programs to build capacity for local government units to curb illegal and destructive exploitation of Panguil Bay had hardly any impact on the problem. Other studies conducted on implementation and compliance with fisheries policies includes those of Espectato and Serofia (2014), Fabinyi (2007), McClellan (2010), Napata et al. (2014) and Knudsen (2012). No studies on this topic have previously been conducted on lake Lanao.

For the present study, provisions in the Fisheries Code which would guarantee sustainable fish biodiversity in lake Lanao were probed as to the compliance and effectiveness of their implementation.

These statutes with the corresponding penalties

A. Section 88. Fishing Through Explosives, Noxious or Poisonous Substance, and/or Electricity which specifically stipulate that:

1. It shall be unlawful for any human being to catch, take or collect, fish or any fishery species in Philippine waters with the use of electric energy, explosives that blows up, toxic or harmful substances in the Philippine fishery areas, which will asphyxiate, harm, stupefy, mutilate or render senseless aquatic species: Provided, that the Department, subject to such conditions regard mandatory and endorsement from the concerned LGUs, may allow, for study, scientific and/or educational aims, the use of electric energy, toxic or harmful substances to catch, or gather aquatic species: Provided, further, that the use of toxic or harmful substances to eliminate predators in bodies of water in conformity with authorized scientific procedures and without inducing negative impact in waters and grounds shall not be defined as prohibited fishing. It will be against the law for any entity to have, trade, or dispose of, any fish or fishery species which have been illegally captured, or collected. The finding of any explosives and/or chemical substances which include able to be exploded elements, or toxic or harmful substances, or gears or devices for electrofishing in any vessel or in the possession of any fisher folk, operator, fishing boat official or fish worker shall constitute prima facie proof, that was used for fishing in breaking of this Code. The finding in any vessel of fish captured or killed with the use of toxic or harmful substances, by electric energy, or by explosive, shall represent prima facie proof that the fisher folk, operator, boat official or fish worker is fishing with the use thereof; 2. Mere ownership of toxic or harmful substances, electrofishing devices or explosives, for fishing shall be culpable by imprisonment between six (6) months to two (2) years; 3. The use of toxic or harmful substances, electrofishing devices, or explosives, for fishing shall be culpable by imprisonment ranging from five (5) years to ten (10) years without prejudice to the filing of separate criminal cases when the use of the same result to physical injury or loss of human life; 4. Trading, or in any manner deal with, for income, capture fisheries species shall be culpable by imprisonment ranging from six (6) months to two (2) years. The toxic or harmful substances, electrical devices, and/or explosives, as well as the vessels, fishing gears and catch shall be forfeited.

B. Section 89. Use of Fine Mesh Net.

It shall be against the law to fishing using nets with mesh smaller than that with which may be fixed by the Department: Provided, that the forbiddance on the use of fine mesh net shall not apply to the collecting of fry, elvers, glass eels, tabios, and species which by their nature are small but adult to be recognized in the enforce rules and supervision by the Department. Abuse of the subject the offender to a fine from Two thousand pesos (P2,000.00) to Twenty thousand pesos (P20,000.00) or detention from six (6) months to two (2) years or both such fine and imprisonment at the judgment of the court: Provided, that if the offense is committed by a commercial fishing vessel, the ship captain and the master fisherman shall also be under the punishment provided herein: Provided, that the person who has possession of/one who operates the commercial fishing vessel who contravene this provision shall be subjected to the same punishment provided herein: Provided, that the Department is authorized to demand upon the offender an administrative fine and/or cancel his above shall authorization or certificate or both.

C. Section 97. Fishing or Taking of Rare, Threatened or Endangered Species.

It shall be against the law to fish or take rare, threatened or endangered species as recorded in the CITES and as determined by threatened or the Department. Breaking of the provision of this section shall be penalized by forcible detention of twelve (12) years to twenty (20) years and/or fine of one hundred and twenty thousand pesos (P120,000.00) and forfeiture of the catch and the revocation of fishing license.

D. Section 98. Capture of Sabalo and Other Breeders/Spawners.

It is illegal for any entity to catch, gather, capture or possess mature milkfish or sabalo and such other breeders or spawners of other fishery species as may be determined by the Department: Provided, that catching of sabalo and other breeders/spawners for local breeding intention or scientific or study meanings may be admitted subject to guidelines to be make known by the Department. Breaking of the provision of this section shall be penalized by imprisonment of six (6) months and one (1) day to eight (8) years and/or a fine of Eighty thousand pesos (P80,000.00) and forfeiture of the capture, and fishing gears used and cancellation of authorization.

E. Section 102.

Aquatic Pollution. Aquatic pollution, as defined in this Code shall be illegal. Breaking of the provision in this section shall be penalized by imprisonment of six (6) years and one (1) day to twelve (12) years and/or a fine of eighty thousand pesos (P80,000.00) and an additional fine of eight thousand pesos (P8,000.00) per day until such abuse ceases and the fines are compensated.

The present study investigated whether the local population, the fisher folks in particular, are knowledgeable of and abide to the stated conservation measures. The results will support planners and policy makers in the Province of Lanao del Sur in their formulation of more acceptable and effective strategies for fisheries conservation. Moreover, this study will provide feedback on the effectiveness and adequacies of the fisheries conservation laws implemented in the province, leading to their re-evaluation for the improvement of the Province' fishing industry and community economic benefit. Finally, the findings of the present study provide useful data for the formulation of more relevant fishery resource conservation policy at the local, regional, and to a broader extent, at the national level.

MATERIAL AND METHODS

Location of the study

Lake Lanao is located in the province of Lanao del Sur, Mindanao Island, in the southern Philippines, north of the equator with coordinates 8^0 0' N, 123^0 5' E (Figs. 1 and 2). Frey (1969) summarizes several morphometric data of the lake as follows: area − 357 km^2; volume − 21.5 km^3; maximum depth − 112 m; mean depth (volume/area) − 60.3 m; and replacement time (volume/mean annual discharge) − 6.5 years.

Surrounding the lake are 17 municipalities and one city (Marawi City) of Lanao del Sur inhabited by the Muslim ethno linguistic group, the Meranaos ("people of the lake"). The lake is of great importance to them as a fishery and aquatic resource, as a transport route, as water source for domestic use (both for the household and for religious ablution), and also for waste disposal. Regionally, the lake is important to the island of Mindanao as a source of hydropower generation through a series of hydropower plants starting at the lakeshore near the mouth of the Agus River (the sole outlet of lake Lanao) and along the Agus River itself which provides around 65% of the energy requirements of Mindanao.

Figure 1a: Mindanao Island and Lanao Lake in Philippines (Google Map, 2015).

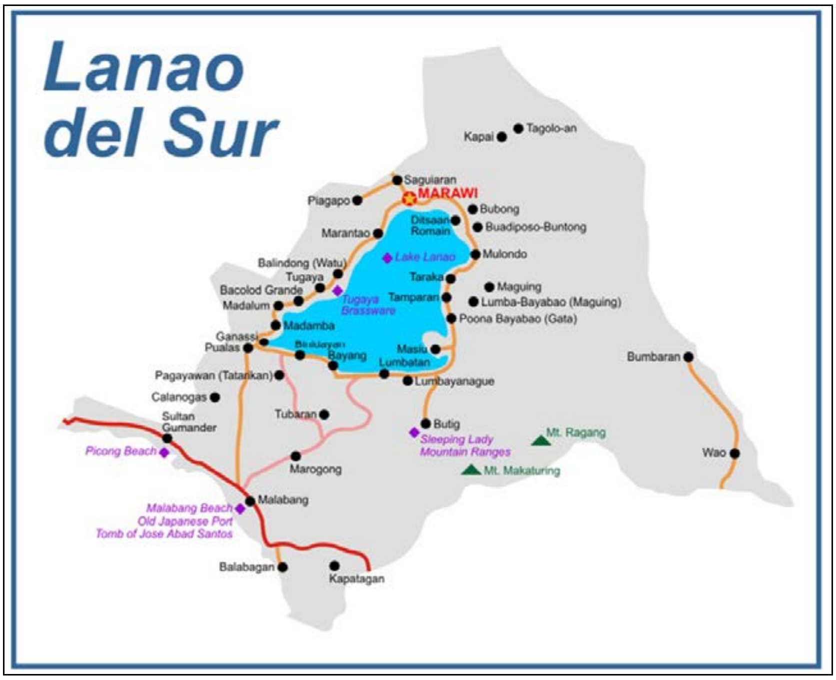

Figure 1b: Lanao Lake and the Province of Lanao del Sur (Source: “Interagency meeting to discuss Lanao Lake watershed management set” accessed at https://tigbalita.wordpress.com/).

Sampling Procedure

The respondents of the present descriptive-evaluative research were registered fisher folks of the Fishermen Association from three lakeshore municipalities of Lanao del Sur (Masiu, Madalum, and Bacolod). Fifty percent (50%) of the total number of registered fisher folks in each municipality were opportunistically selected and had the structured interview administered. A total of 140 fisher folks were surveyed in the study. The structured survey covered the respondents' socio-economic profile, their knowledge, and compliance with the ichthyofauna conservation measures, and additionally included information on the fish species caught, fishing gear used, and the fishing activities at the site. During the conduct of the interview, formal and informal conversation was undertaken using the local vernacular. Only those respondents who were knowledgeable of the ichthyofauna conservation measures were asked about their adherence to the stated legislative protection measures. This is based on the assumption that those who do not have knowledge of the laws cannot be expected to have a reasonable evaluation of such statutes. Prior to the administration of the interview, a pre-test was conducted on 20 respondents (not part of the survey sample) amongst fisher folks in Kauswagan Lanao del Norte, situated 50 kilometers from Marawi Ctiy. This is to weed out ambiguous questions and statements in the questionnaire and to check its validity.

A survey on the collection of fish samples was conducted at various landing sites in each sampled municipality, from December 2014 to May 2015, in the early morning, a period when fishermen and fish landing areas are very active. The purchased samples from fishermen were photographed and identification was carried out using Fishbase (2015).

Data Analysis

The data collected in the study was analyzed using Systat version 13.0 (2005) and discussed using the following statistical tools:

a. Descriptive statistics in discussing the socio-economic-demographic profile of the respondents, their knowledge, and their obedience to the ichthyofauna conservation measures which include: 1. Measures of central tendency such as frequency distribution and mean which would yield the average of the obtained data; 2. Percentage Analysis in treating data on respondents' socio-economic-demographic characteristic, knowledge and obedience to the posed laws; 3. Measures of Dispersion (scatter or spread) which indicate the extent to which the observations tend to spread-out. This include the maximum-minimum range which is the simplest dispersion measure, standard deviation which considers not only extreme observed values but all observations thereby giving more accurate description of the observation; and coefficient of variation which depicts the size of a standard deviation relative to the mean.

b. Multiple Linear Regression in determining the relationship of the respondents' socio-economic characteristics with their knowledge and their obedience towards the ichthyofauna diversity conservation measures. The H_o states that there is no relationship between the respondents' socio-economic characteristics and their knowledge and obedience to the ichthyofauna conservation measures. The significance level was set at 0.05.

RESULTS AND DISCUSSION

The descriptive statistics of the respondents are presented (Tab. 1, Figs. 2-5). As shown in the table, the youngest respondent in the study was aged 19 and the oldest was ages 70 years old. The number of dependent children ranged from one to a maximum of eight. In the case of their educational attainment, most of the respondents were educated, having taken vocational courses, and had a general weekly income of PhP 2,000-2,499 ($42.92-$53.62).

Table 1: Descriptive statistics of the respondents.

Socio-Economic Profile	N	Mean	Range (min-max)	Coefficient of variation
Age	140	38.6 ± 9.77	19.00-70.00	0.254
Number of dependent children	140	4.16 ± 1.5	1.00-8.00	0.39
Educational Attainment	140	4.17 ± 1.00	2.00-6.00	0.24
Weekly Income	140	5.15 ± 0.95	2.00-6.00	0.19

Table 2 reflects the knowledge and obedience of the respondents to the various ichthyofauna conservation measures employed in the study. This result is graphically presented in figures 6 and 7. Majority of the respondents are knowledgeable of the fisheries laws, ranging from 39.29% (sec. 102) to 76.43% (sec. eight). As previously stated, only those who were knowledgeable of the fisheries laws were asked with regard to their obedience thereto. The obedience of the respondents to the fisheries laws is high, ranging from 81.31% to 100%. The relationship between the respondents' socio-economic characteristics and their knowledge of ichthyofauna conservation measures is presented in table 4. There is a relationship between the respondents' ages ($p < 0.05$) and number of children ($p < 0.05$) with their knowledge of the posed fisheries laws. As the respondents get older, there is an increase of their knowledge on the illegality of gathering fish with the use of electricity, explosives, and noxious or poisonous substance. This is attributed to the fact that as the fisher gets older, he would accumulate more knowledge and elucidations that fishing using electricity, poisonous substances, and explosive is dangerous. There is an inverse relationship between the respondents' number of children and others. The greater the number of children the respondents has, the less knowledgeable they are of the illegality of gathering fishes with the use of electricity, explosives, and noxious or poisonous substance. This may imply that those having more children have a lack of community awareness, such as the importance of family planning, that is transferred over to their lack of awareness and knowledge of fisheries conservation laws. The rest of the respondents' socio-economic characteristics do not have any relationship with their knowledge of the stated fisheries statutes. The proportion of influence of socio-economic factors to the respondents' knowledge is low, ranging from 1.0% (sec. 89) to 34.40% (sec. 88). The remaining, large, proportion is inferred to be contributed by non-socio-economic factors such as societal mores, religious beliefs, and other such cultural factors. In the course of interviews and conversations with the respondents, almost all of them disclosed that their understandings of the posed laws were based on their rigid Islamic indoctrination. Respondents specifically mentioned the following Qur'anic verses as providing the base of their knowledge: Qur'an 16:14, Qur'an 5:96, Qur'an 18:61-63, Quran 2:205, amongst others. This observation is supported by Jamil (1999) and Abubakar (2015) who both identified that in Islam, all human beings are ordered to conserve water. Abu Hurayrah reported that the Prophet said: "Avoid urinating into still water (in a reservoir or pond, i.e. water that does not flow), and then bathing with it".

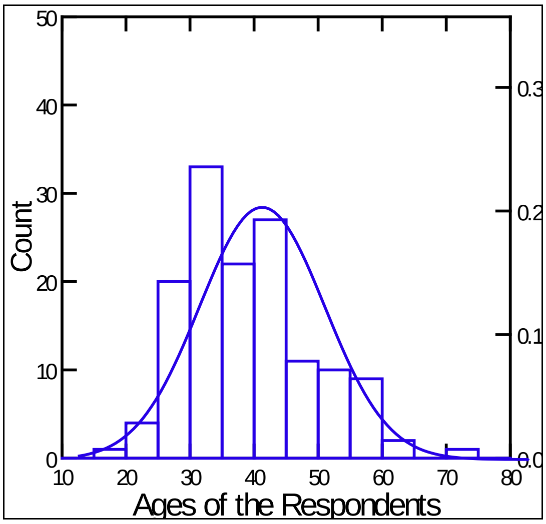

Figure 2: Respondents' ages.

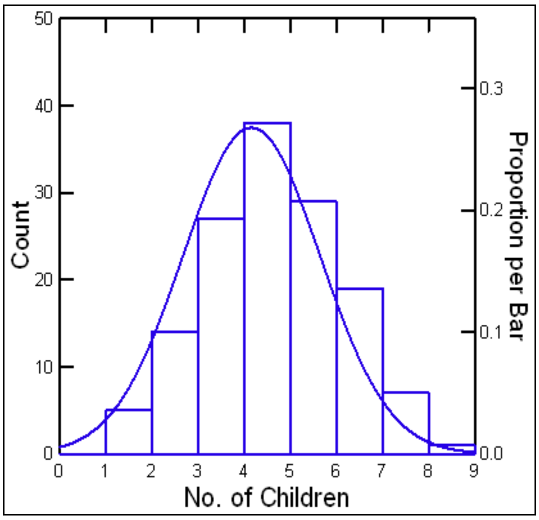

Figure 3: Respondents' number of children.

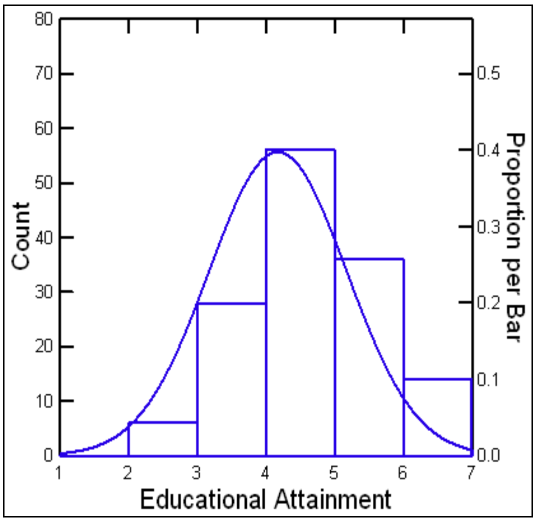

Figure 4: Respondents' educational attainment.

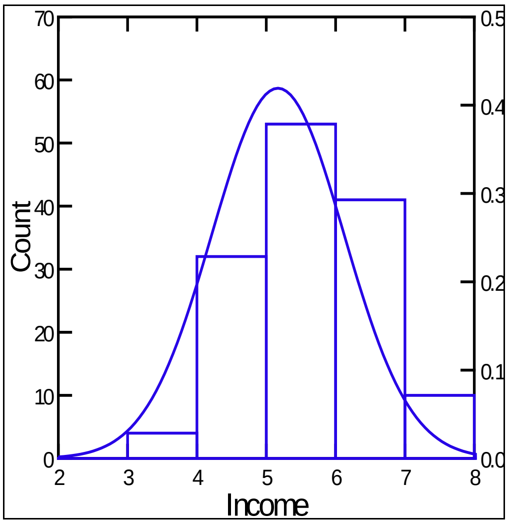

Figure 5: Respondents' income.

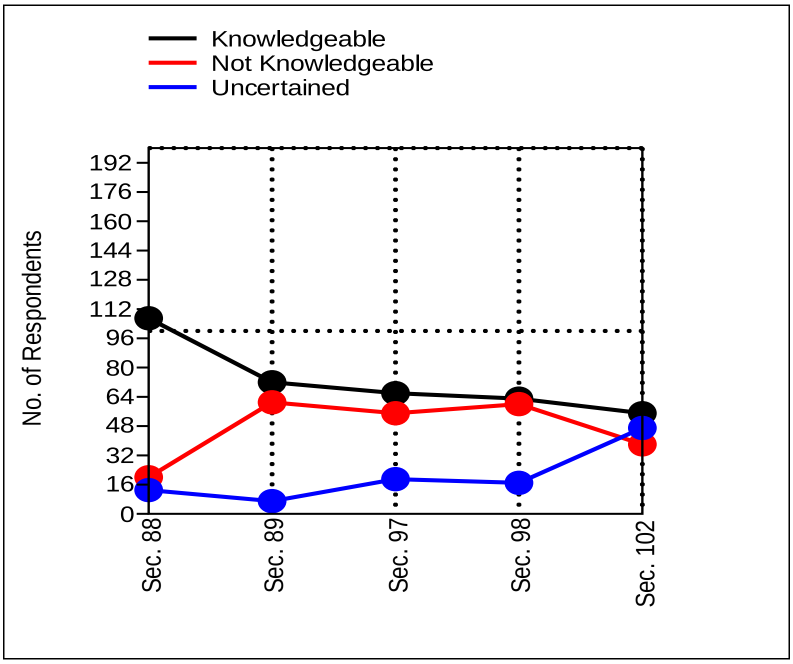

Figure 6: The respondents' knowledge to the ichthyofaunal conservation measures.

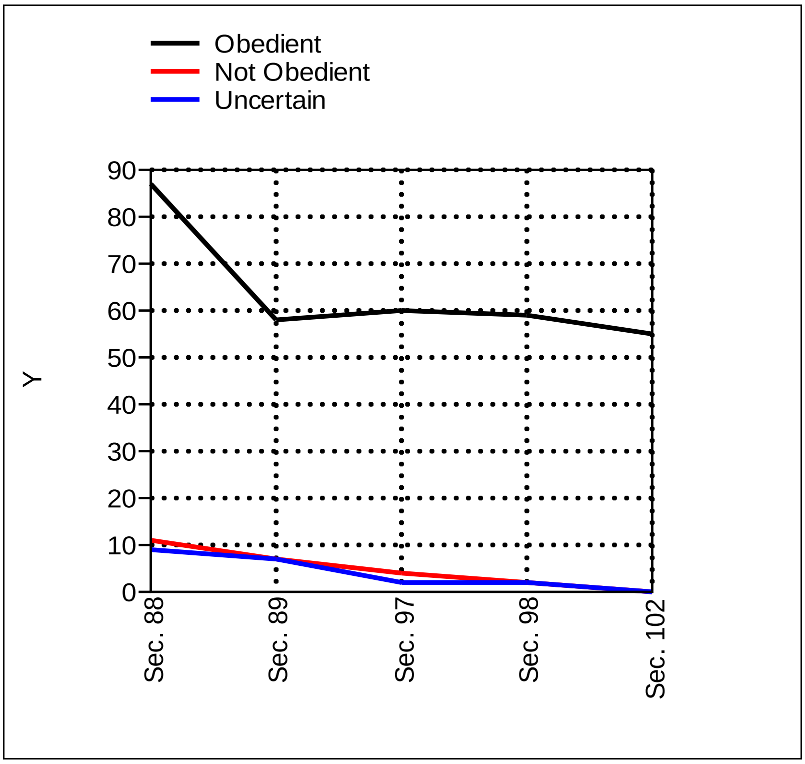

Figure 7: The respondents' obedience to the ichthyofaunal conservation measures.

Table 2a: The frequency distribution of the knowledge and obedience of the respondents towards the fisheries laws.

Fisheries Laws (RA 8550, Ch. VI)	Knowledge						
	Knowledgeable		Not knowledgeable		Uncertain		Total
	F	%	F	%	F	%	
Section 88	107	76.43	20	14.29	13	9.29	140
Section 89	72	51.43	61	43.57	7	5.0	140
Section 97	66	47.14	55	39.29	19	13.57	140
Section 98	63	45.0	60	42.86	17	12.14	140
Section 102	55	39.29	38	27.14	47	33.57	140

Table 2b: The frequency distribution of the knowledge and obedience.

Fisheries Laws (RA 8550, Ch. VI)	Obedience						
	Obedient		Not obedient		Uncertain		Total
	F	%	F	%	F	%	
Section 88	87	81.31	11	10.28	9	8.41	107
Section 89	58	80.56	7	9.72	7	9.72	72
Section 97	60	90.91	4	6.06	2	3.03	66
Section 98	59	93.65	2	3.17	2	3.17	63
Section 102	55	100	0	0	0	0	55

Table 3a: Multiple Linear Regression between the respondents' socio-economic characteristics and their knowledge of various ichthyofaunal diversity conservation measures.

Socio-economic characteristics	Ichthyofauna Diversity Conservation Measures (RA 8550, Ch. IV)			
	Section 88		Section 89	
	Coeff. of correl.	*p*-value	Coeff. of correl.	*p*-value
Age	0.327	0.008*	0.025	0.828
No. of children	– 0.125	0.032*	– 0.008	0.855
Education	0.098	0.182	– 0.047	0.422
Family Income	0.119	0.068	0.034	0.533
	$R^2 = 0.344$		$R^2 = 0.010$	

Table 3b: Multiple Linear Regression between the respondents' socio-economic characteristics and their knowledge of various ichthyofaunal diversity conservation measures.

Socio-economic characteristics	Ichthyofauna Diversity Conservation Measures (RA 8550, Ch. IV)					
	Section 97		Section 98		Section 102	
	Coeff. of Correlation	*p*-value	Coeff. of Correlation	*p*-value	Coeff. of Correlation	*p*-value
Age	– 0.037	0.785	– 0.063	0.636	0.197	0.238
No. of children	– 0.009	0.857	– 0.019	0.696	– 0.002	0.973
Educational Attainment	– 0.001	0.983	– 0.009	0.891	– 0.084	0.312
Family Income	– 0.074	0.252	– 0.070	0.265	0.056	0.477
	$R^2 = 0.013$		$R^2 = 0.014$		$R^2 = 0.021$	

On the other hand, the obedience of the respondents to the stated fisheries laws does not show any relationship (Tab. 5). This means that their obedience is not dependent on their socio-economic characteristics. The proportion of influence of socio-economic characteristics on the respondents' obedience to the posed fisheries laws is very low, ranging from 1.4% (sec. 98) to 4.9% (sec. 88). As indicated above, the remaining large proportion of compliance is inferred to be due to the respondents' societal mores and religious beliefs, as the local dominant religion, Islam, demands compliance from its adherents. Furthermore, in Islam environmental conservation is a religious duty as well as social obligation, and not an optional matter. The exploitation of a particular natural resource is thus directly related to accountability and maintenance of the resource.

Table 4a: Multiple Linear Regression between the respondents' socio-economic characteristics and their obedience toVarious ichthyofaunal diversity conservation measures.

Socio-economic characteristics	Ichthyofauna Diversity Conservation Measures (RA 8550, Ch. IV)			
	Section 88		Section 89	
	Coeff. of correlation	*p*-value	Coeff. of correlation	*p*-value
Age	– 0.249	0.065	0.349	0.059
No. of children	0.059	0.250	– 0.040	0.554
Educational Attainment	– 0.017	0.801	0.076	0.392
Family Income	0.091	0.168	0.020	0.808
	$R^2 = 0.049$		$R^2 = 0.061$	

Table 4b: Multiple Linear Regression between the respondents' socio-economic characteristics and their obedience toVarious ichthyofaunal diversity conservation measures.

Socio-economic characteristics	Ichthyofauna Diversity Conservation Measures (RA 8550, Ch. IV)					
	Section 97		Section 98		Section 102	
	Coeff. of correlation	*p*-value	Coeff. of correlation	*p*-value	Coeff. of correlation	*p*-value
Age	– 0.018	0.889	– 0.063	0.636	– 0.003	0.597
No. of children	– 0.040	0.367	– 0.019	0.696	0.016	0.620
Educational Attainment	– 0.003	0.969	– 0.009	0.891	0.055	0.175
Family Income	– 0.016	0.779	0.070	0.265	0.025	0.506
	$R^2 = 0.030$		$R^2 = 0.014$		$R^2 = 0.075$	

Table 5 shows the kinds of fish observed during the survey. Although these endemic cyprinids are classified as critically and vulnerably endangered, *Puntius amarus*, *Puntius lindog* and *Puntius tumba* are still being sold at the fish landing sites at $0.21 apiece. There is a high demand for these fish species as they are favorite delicacies amongst the Meranao. The presence of *Puntius lindog* and *Puntius tumba* during the sampling reflects the findings of Ismail et al. (2014) in their study on the status of lake Lanao endemic cyprinids (*Puntius* species). While it is true that these endemic cyprinids are classified as critically endangered, the respondents were unaware of their status when asked whether they know that the species are vulnerable and critically endangered. In fact, most of them do not understand the concept of a rare or threatened organism.

CONCLUSIONS

Inasmuch as religious beliefs seem to be a major factor in the awareness of and obedience to ichthyofauna diversity conservation measures, a massive and intensified information drive regarding the law among fisher folks and other stakeholders should be conducted that would associate the law with their religious beliefs. This will result to a change in their values that will increase their sense of stewardship of the fisheries resources they have. From our findings, we would recommend that such an information drive should include the "imams" (religious teachers). All types of mass media should be included in the campaign. An extension worker should be assigned in the area so as to head this long-term information drive and to serve as liaison between the government and the local fisher folks in order for them to have strong community cooperation that will lead to the success of any ichthyofauna diversity conservation and sustainable fisheries projects.

Table 5: List of various sampled ichthyofauna with their conservation status.

Order	Family	Name of the species	Local name	IUCN conservation status*
Perciformes	Eleotridae	*Hypseleotrisagilis* (Herre, 1927)	Katulong	LC
Perciformes	Gobiidae	*Glossogobius guirus* (Hamilton, 1822)	Kadurog	LC
Perciformes	Gobiidae	*Glossogobius celebius* (Valenciennes, 1837)	Kadurog	DD
Perciformes	Cichlidae	*Oreochromis niloticus* (Linnaeus, 1758)	Tilapia, mampawi	NE
Cypriniformes	Cyprinidae	*Puntius amarus* (Herre, 1924)	Pait	CR
Perciformes	Channidae	*Ophicephalus striatus* (Bloch, 1793)	Aruan	LC
Perciformes	Cichlidae	*Oreochromis mossambicus* (Peters, 1852)	Tilapia, Mampawi	NT
Cypriniformes	Cyprinidae	*Cyprinus carpio* (Linnaeus, 1758)	Bongkaon	VU
Siluriformes	Clariidae	*Clariasbatrachus* (Linnaeus, 1758)	Katipa	LC
Siluriformes	Clariidae	*Clarias macrocephalus* (Günther, 1864)	Katipa	NT
Perciformes	Anabantidae	*Anabas testudineus* (Bloch, 1792)	Puyo	DD
Cypriniformes	Cyprinidae	*Puntius lindog* (Herre, 1924)	Lindog	VU
Cypriniformes	Cyprinidae	*Puntius tumba* (Herre, 1924)	Tumba	VU
Perciformes	Osphronemidae	*Trichopodus pectoralis* (Regan, 1910)	Gorami	LC

*Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Near Threatened (NT), Extinct (EX) species, Data Deficient (DD), Not Evaluated (NE), Least Concern (LC).

ACKNOWLEDGEMENTS

The authors of the paper are indebted to the editors of Transylvanian Review of Systematical and Ecological Research.

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DEVELOPING A SYSTEM FOR FISH FAUNA MIGRATION RESTORATION ABOVE THE SPILLWAY SILL NEAR THE CITY HALL OF ORADEA (ROMANIA)

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DOI: 10.1515/trser-2015-0073

KEYWORDS: weir, system for fish migration, Crişul Repede River.

ABSTRACT

The channel of the river Crișul Repede inside the town affects both the biodiversity and implicit functionality of Crișul Repede River, therefore, this article aims to provide a solution for fish fauna migration in a system designed to restore longitudinal connectivity. The proposed migration system is based on the gravitational fall of water and will lead to the restoration of the longitudinal connection of Crişul Repede River near the weir selected as the study case. It will reconnect approximately three kilometers of habitat that will contribute to ensuring the optimal conditions for the development of migratory fish species present in the area.

RESUMEN: Desarrollo de un sistema para la migración de la fauna de peces por encima del travesaño vertedero cerca de la ciudad de Oradea.

El canalizado del río Crişul Repede dentro de la ciudad afectó la biodiversidad y la funcionalidad implícita del Rio Crişul Repede. Por lo tanto, este artículo tiene como objetivo proporcionar una solución para la migración de la fauna de peces, diseñada para restaurar la conectividad longitudinal. El sistema de migración propuesto se basa en la caída gravitacional del agua y dará lugar a la restauración de la conexión longitudinal del Río Crişul Repede cerca del vertedero seleccionado como caso de estudio. Se volverá a conectar un hábitat con una longitud de aproximadamente tres km que contribuirá para asegurar las condiciones óptimas para el desarrollo de especies de peces migratorias presentes en el área.

REZUMAT: Dezvoltarea unui sistem de restaurare a migrației faunei piscicole deasupra deversorului de lângă Primăria Oradea.

Canalul Crișului Repede în oraș afectează atât biodiversitatea, cât şi funcționalitatea implicită a râului Crișul Repede. Prin urmare, acest articol își propune să ofere o soluție pentru migrarea faunei piscicole, un sistem conceput pentru a restabili conectivitatea longitudinală. Sistemul de migrare propus se bazează pe căderea gravitațională a apei și va conduce la restaurarea conexiunii longitudinale a râului Crișul Repede în apropierea pragului selectat, ca studiu de caz. Acesta va reconecta un habitat cu o lungime de aproximativ trei km, care va contribui la asigurarea condițiilor optime pentru dezvoltarea speciilor de pești migratori prezente în zonă.

INTRODUCTION

There are many hydrotechnical facilities along the Crișul Repede River, including spillway sills. In the city of Oradea, there are sills located at the CFR Bridge, the City Hall of Oradea, the Dacia Bridge and many other locations. These spillway sills negatively affect the connectivity of the Crișul Repede River, strongly reducing its biodiversity and intrinsic ecological value. The need for longitudinal connectivity of rivers represents an essential condition of the Water Framework Directive approved by the European community and, therefore, should be applied to all streams containing migratory species. The subject of this case study proposes an ecotechnical solution consisting of frontal connectivity in the city of Oradea. The solution proposed for fish fauna migration upstream – downstream of the spillway sill situated at the City Hall of Oradea is practical, it can be developed without any expensive technology and does not affect the spillway sill structure and associated construction.

RESULTS AND DISCUSSION

The fish fauna migration proposal

To ease the migration of ichthyofauna above the spillway sill (Figs. 1 and 2), a system consisting of four winches with waterproof metal cables is developed using a rubbery, inelastic textured material with rhombic spacing connected to the cables of the winches. When it is raised, the material will hold the fish fauna (Fig. 3).

Around the edge of the textured material there will be a metal cable on which four symmetrical metal rings are welded (Fig. 3). Two metal or concrete pillars are affixed on both sides of the Crișul Repede River spillway sill (Fig. 4).

Figure 1: Spillway sill near the City Hall of Oradea.

Figure 2: Spillway sill near the City Hall of Oradea.

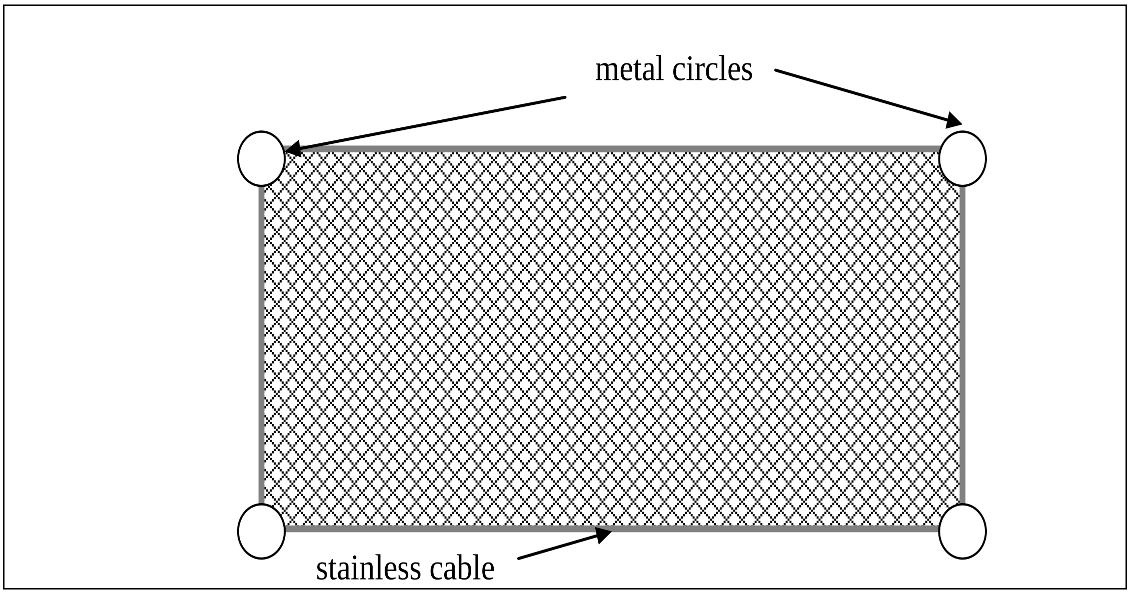

Figure 3: Schematic of system using rubbery inelastic texture with rhombic spacing.

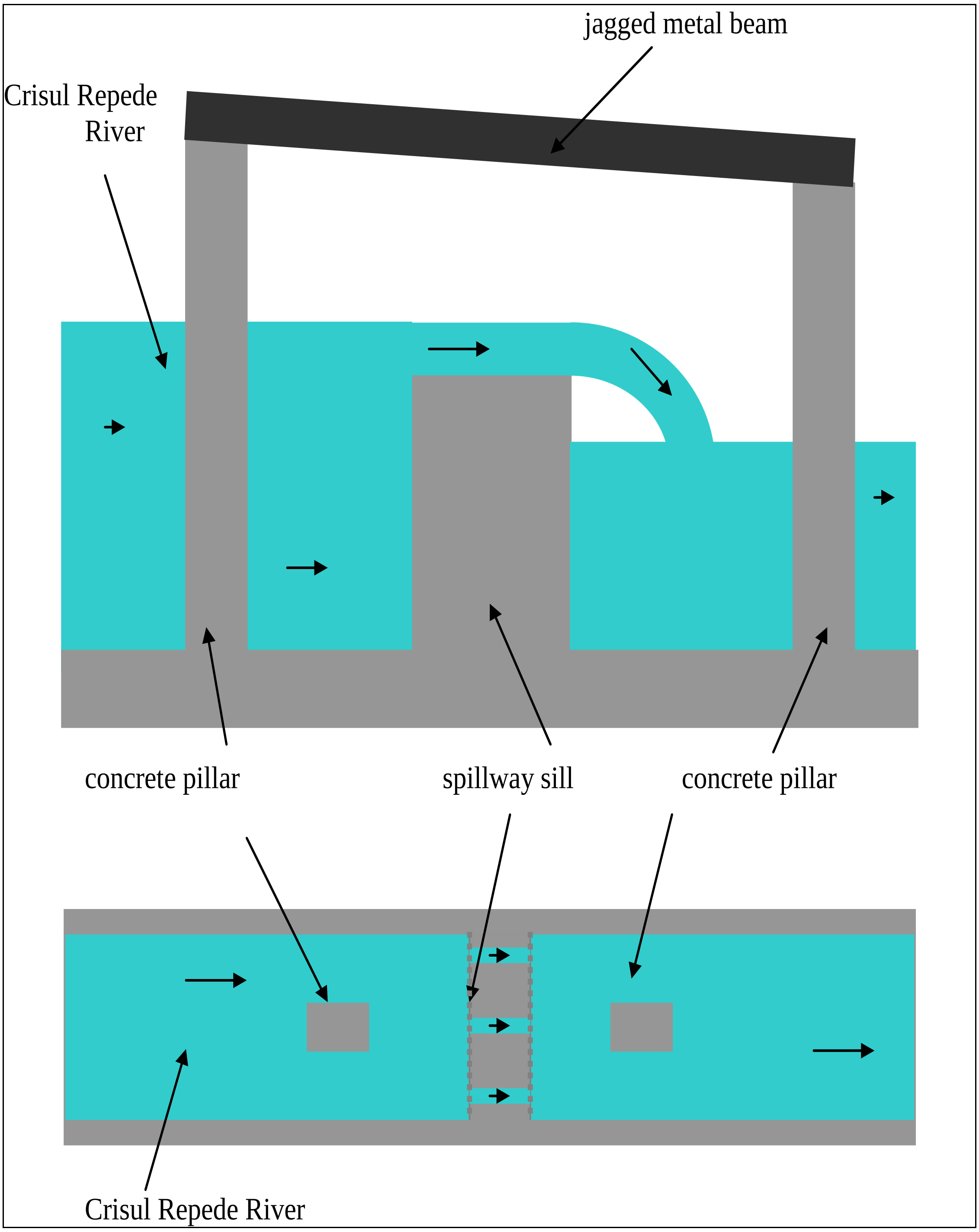

Figure 4: Schematic of positioning metal or concrete pillars.

A jagged metal beam is positioned on the two pillars on an inclined plane (Fig. 4). An electric rack-driven motor is attached to the upper side of the jagged metal beam (Fig. 5), and the metal rectangular housing of the electric motor is situated on the jagged metal beam using four bearings.

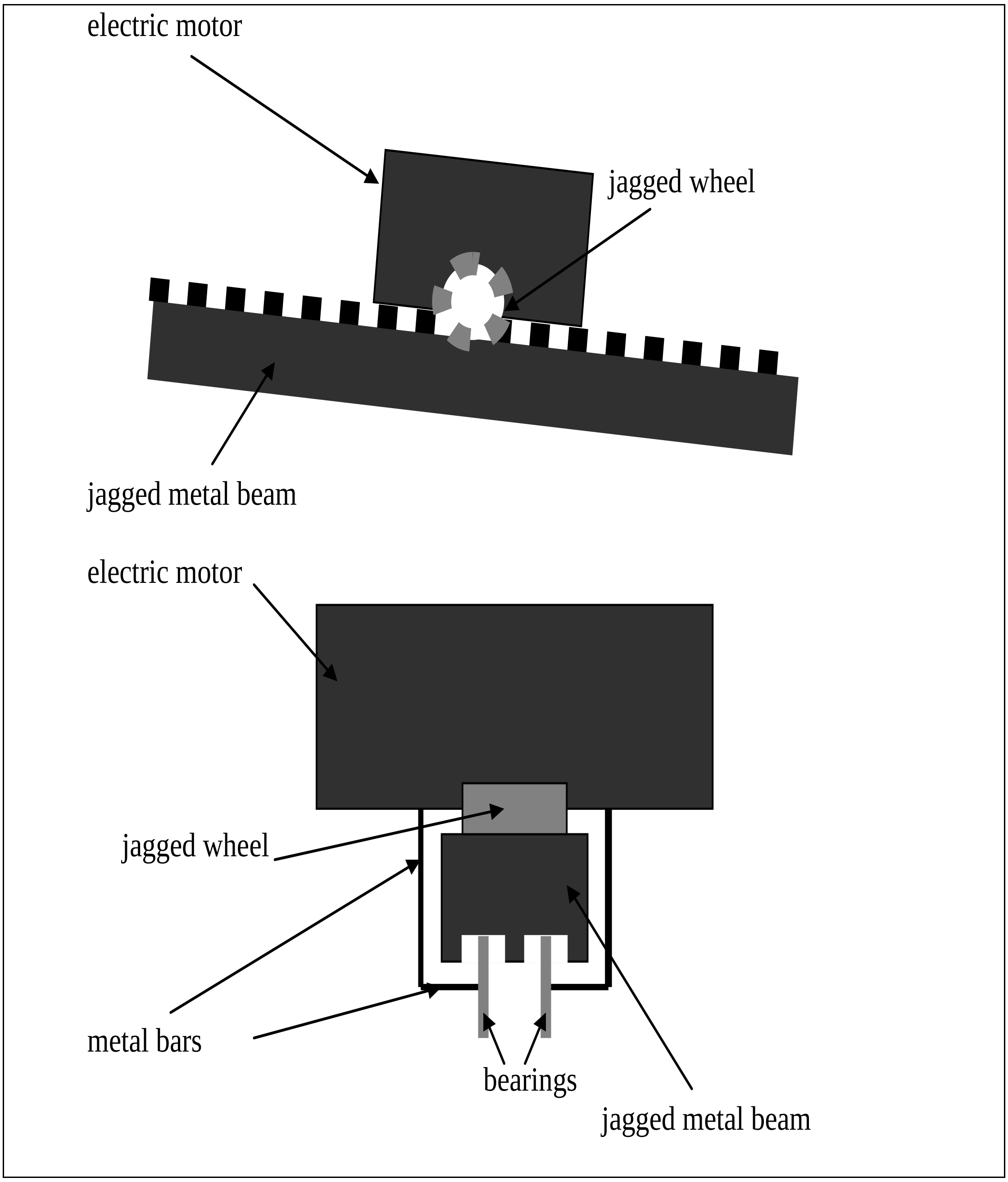

Figure 5: Schematic – Attaching the electric motor
to the jagged metal beam.

The rack will spin moving the motor up and down on the jagged rail. Both upstream and downstream, the maximum distance at which the electric motor can come close to the two pilings is about one meter. Four winches like those used on SUVs are attached to the flat edges of the electric motor housing (Fig. 6). Also, on each edge of the motor housing, a spacer is welded a few inches below the winch. On the main bar each spacer is provided with a mobile cylinder to assist with the traction (Fig. 7). Spacers will help the winches and dragging cables to function so that the cables will not interfere with each other while raising the rubbery textured material (Fig. 8). The electric motor is supplied with electric power from the right bank of the river where the local electricity supply is located (Fig. 9).

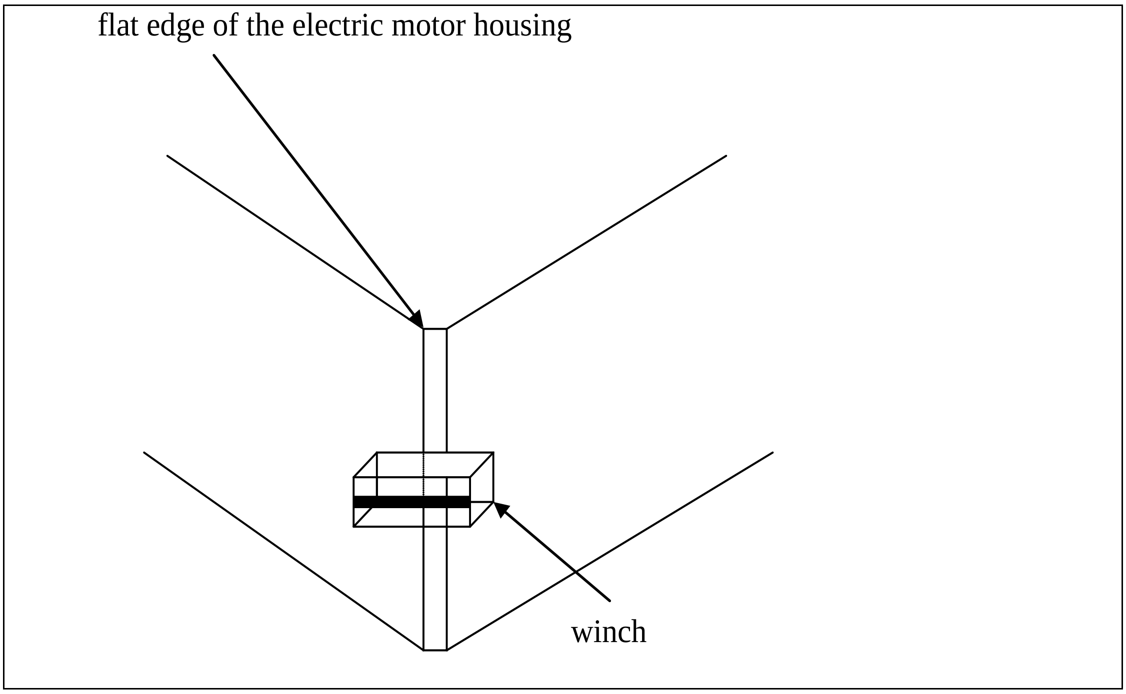

Figure 6: Schematic – Positioning of the winch on the electric motor.

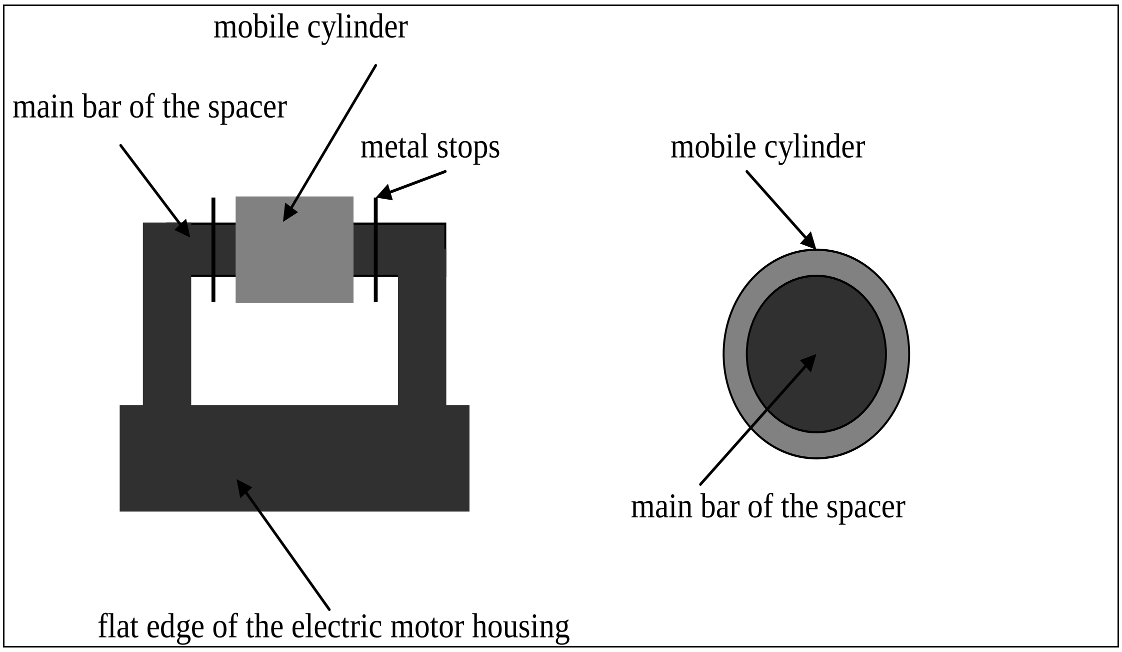

Figure 7: Schematic – Positioning the spacer.

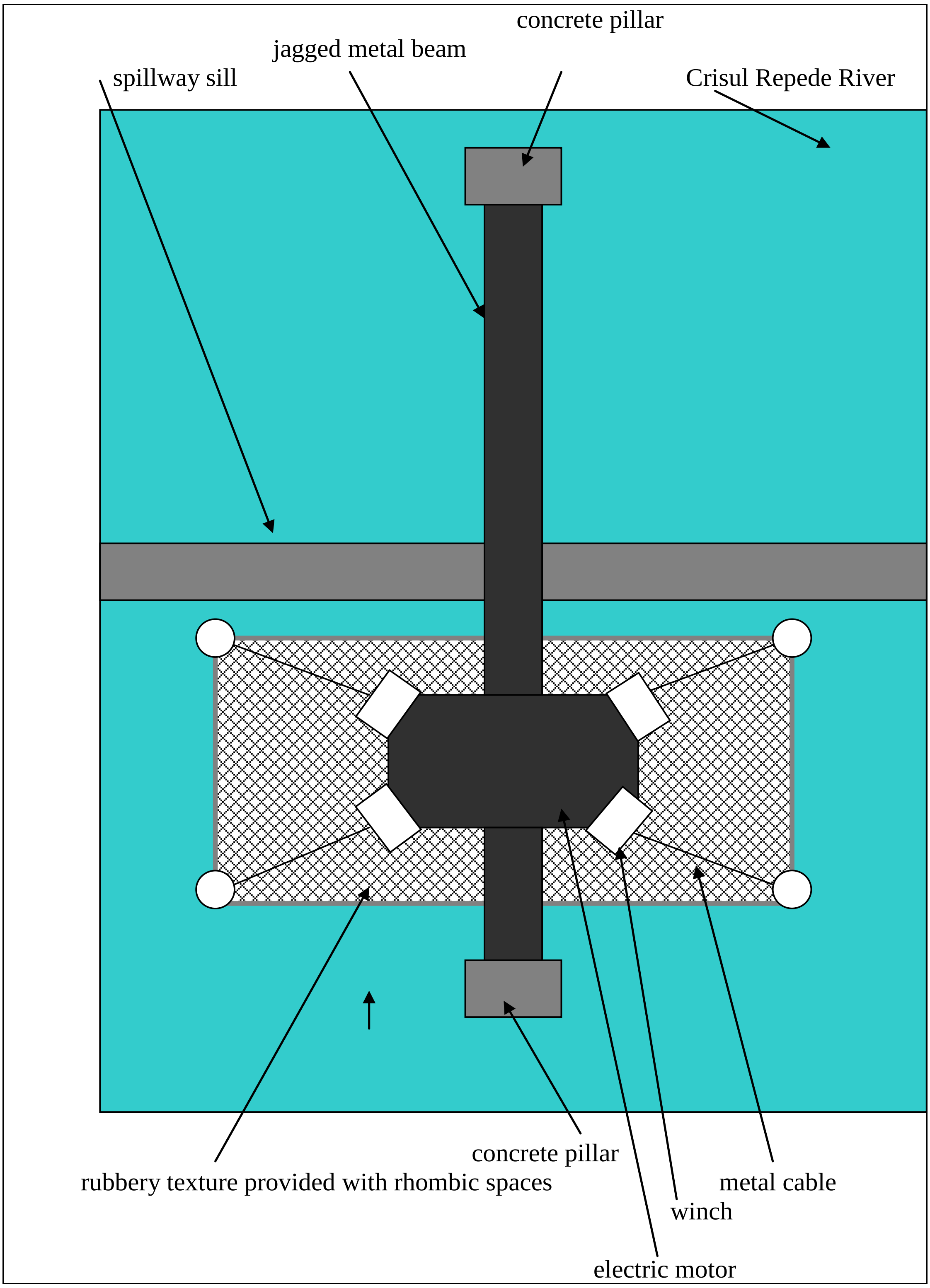

Figure 8: Schematic – Positioning the electric motor.

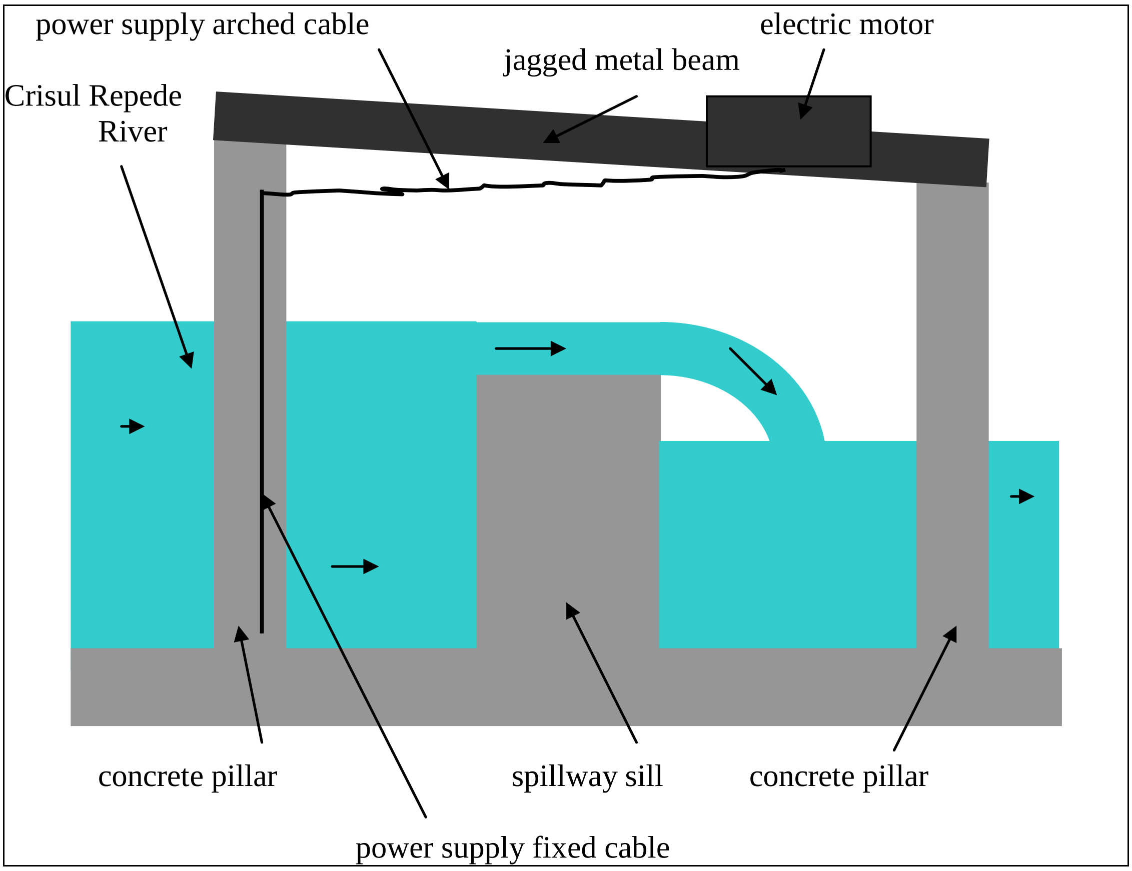

Figure 9: Schematic – Power supply system of the electric motor.

The motor will be attached by a fixed cable near the jagged bar. The fixed cable then turns into an arched cable that can be extended up to the spillway sill. Surveillance cameras will be installed on both banks of the river in order to observe various species of fish gathering together near the sill at the rubbery texture. The electric motor and the winches are connected to a computer to allow for them to be activated from tens of kilometres away using informational software. For migratory fish species to reach the rubbery texture, some electromagnetic field systems will be set using floating generators obliquely positioned on the spillway sill (Fig. 10). The advantages of this solution are; the possibility of application in almost any area of the world, an average execution cost, low maintenance costs and, in the case of invalidity, the technology already installed can be transferred to another spillway sill in another area.

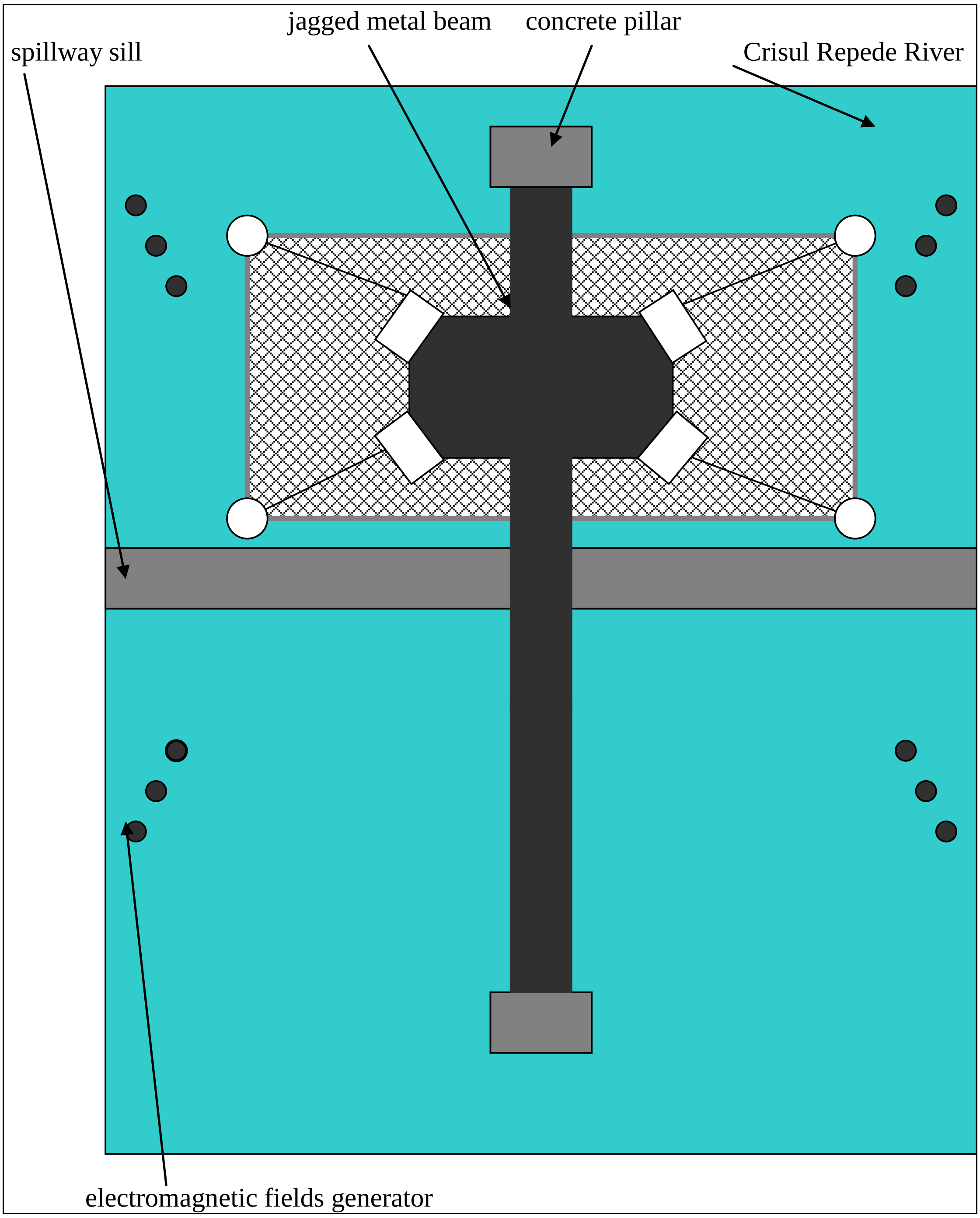

Figure 10: Schematic – Positioning the electromagnetic field generators.

CONCLUSIONS

This specific system of fish migration upstream-downstream of the spillway sill provides longitudinal connectivity of the Crișul Repede River and represents a major benefit to the local lotic ecosystem restoration. The technical solution proposed here is practical, can be developed without any expensive technology, and does not affect the spillway sill structure and associated construction. Ichtyofauna modality transfer upstream – downstream of the weir is done considering all safety issues and avoids stresses largely above the spillway passage for fish. This system can be used in all existing discharge sills in the city of Oradea.

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ENVIRONMENTAL ASPECTS OF IMPLEMENTATION OF MICRO HYDRO POWER PLANTS – A SHORT REVIEW

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DOI: 10.1515/trser-2015-0074

KEYWORDS: micro hydro power plants, economy, ecology.

ABSTRACT

The economic importance of micro hydro power plants is obvious around the world and the development trend will continue well into the future.

Unfortunately the effects on the local lotic systems habitats and biocoenosis are not studied, and in some cases or are known only to a small degree.

A variety of taxa were identified in the study case areas as being significantly affected by the micro hydro power plants: macrophytes, macroinvertebrates and fish.

ZUSAMMENFASSUNG: Mikrohydrozentralen – ein wirtschaftliches und oekologisches Problem.

Die wirtschaftliche Bedeutung der Mikrohydrozentralen ist weltweit augenscheinlich und ihre Entwicklungstendenz wird sich sicherlich auch in Zukunft fortsetzen.

Leider sind ihre Auswirkungen auf die lotischen Habitate und Biocoenosen fallweise nicht untersucht worden oder sind lediglich graduell unterschiedlich bekannt.

Zu der grossen Vielfalt taxonomischer Gruppen, die von den Mikrohydrozentarlen in den Bereichen der Fallstudien als erheblich betroffen eingestuft wurden, gehoeren die Makrophyten, Makrinvertebraten und Fische.

REZUMAT: Microhidrocentralele – o problemă economică şi ecologică.

Importanţa economică a microhidrocentralelor este evidentă în toată lumea iar tendinţa de dezvoltare a acestora va continua cu certitudine în viitor.

Din păcate, efectele acestora asupra habitatelor şi biocenozelor sistemelor lotice nu sunt studiate în unele cazuri sau sunt cunoscute în diferite grade.

O varietate ridicată de grupe taxonomice au fost identificate în aria studiilor de caz ca fiind afectate semnificativ de microhidrocentrale: macrofite, macronevertebrate, peşti.

Economic context

Implementation of Micro Hydro Power Plants

The power captured from moving water has been a source of energy for thousands of years. In the last 500 years more interest has blossomed within the energy arena for hydropower with the invention of the overshot wheel, which efficiently converts the power of falling water into useful mechanical energy. Micro hydro represents a small, but technically secure and reliable source of energy that we should be utilized as part of our drive to promote renewable energy. (*, 2005)

Micro hydro is characterized, as a plant between 10 kW to 200 kW, it is a small scale, decentralized energy supply technology used in many countries. In certain situations micro hydro can be successful in economic terms; while in others, unprofitable plants can display positive impacts on the lives of people and the environment that legitimize the financial aid. (Fulford et al., 2000)

The field of micro hydro is developing, especially in relationship to the interest of project planners. Currently, the most primary installations were the outcome of a technology push. This knowledge has influenced the technical soundness of the micro hydro systems, decreased their expenses, and increased their technical quality. Micro hydro is now a rather advanced technology that has been significantly improved by low cost turbine designs, electric load controllers, and the use of plastics in pipe work and penstocks.

Allocation of resources

Financial incentives are chiefly intended to expand the adoption of micro hydro, and it has to be economically viable within the geographic location in which it will be situated with sufficient consumer demand for the bulk of the power generated. This could also involve the sale of energy where there is an ease of access to the grid and significant consumer demand. Nonetheless, communities who lack the resource but can incur the cost of the energy frequently live a great distance from those with the considerable necessities.

Strategies for implementation

If the expense of micro hydro is too large for poor communities, involving the community in the project development can decrease the cost (Gurung et al., 2013). It allows people to contribute their labour (or another communally possessed asset such as land to the project). If people are under-employed, this favourable circumstance allows the expense of the work to be decreased; involving the whole community to facilitate the richer entities (wealthy donors, landowners, mills and shop owners, etc.) to carry the cost, and allow the impoverished members of the community to contribute to the trading price (a “lifeline tax”); growing the number of people associated with the project can decrease the price for everyone when the micro hydro project has reached economies of scale.

While the involvement of the community is an indispensable situation for a favourable outcome of the project, and decreasing development costs, the process itself is expensive and is time consuming.

Worldwide financial institutions are now taking an interest in micro hydro. In the 1960’s and 1970’s worldwide assistance agencies contributed financial support to rural electrification, but this was done primarily through grid enlargements. This practice suggests a hesitancy to fund new projects that do not distribute power over less concentrated systems. However, they have begun to reassess decentralized energy alternatives, stimulated by their new attraction in renewable energy.

One of the better examples of an application of a strategy for micro hydro has been the project developers themselves. In numerous countries, micro hydro projects are profitable. However, there are cases where individual entrepreneurs have advanced their own projects. Disregarding the strategies of governments and aid agencies, because have they have the financial resources to bring all the proper elements of a micro hydro project together and execute the development project through to operation.

Necessary conditions

The best geographic areas for exploiting small-scale hydro power are those with steep river gradients flowing all year round, for example, the hill and mountain areas of countries with high year-round rainfall, or the great mountain ranges and their foothills, like the Andes and the Himalayas. Islands with moist marine climate, such as the Caribbean Islands, the Philippines and Indonesia are also suitable. The low-head turbine types have been especially developed for small-scale exploitation of streams and rivers where there is available a small head but enough flow to provide the needed power.

To evaluate the appropriateness of a potential site, the hydrological characteristics of the site needs to be known and a site monitoring carried out, to determine the real flow and head data. The load factor is the amount of power used divided by the amount of power that is available, if the turbine were to be used continuously. Unlike technologies relying on costly fuel sources, the fuel for hydropower generation is free and therefore the plant becomes more cost effective if run for a high percentage of the time. Water turbines, like gas or diesel engines, will vary in speed as load are applied or relieved. Although not as great of a problem with machinery, which uses direct shaft power, the speed variation will greatly affect both frequency and voltage output from a generator.

Benefits

If the proper site can be identified, there are strong reasons to support the implementation of micro hydro. It only takes a small amount of flow, as little as two gallons per minute or a drop as low as two feet to generate electricity with micro hydro. The electricity can then be delivered far away from the location for use (Borkowski and Wegiel, 2013).

Hydro produces a continuous supply of electrical energy in comparison to other small-scale renewable technologies. Micro hydro is considered to function as a run-of-river system, meaning that the water passing through the generator is directed back into the stream with relatively little impact on the surrounding ecology.

Micro hydro systems can be a very effective source of energy in the right context. Building a small-scale hydropower system can range from 1,000-20,000 Euro, depending on the site requirements and location. Maintenance fees are relatively small in comparison to other technologies.

Given the low-cost versatility and longevity of micro hydropower, it can be a great energy solution. It is probably best suited in developing countries; if they have the ability to develop and implement the technology to help supply much needed electricity to small villages.

Installed Kw costs

Data was gathered from five different countries in which they evaluated the capital costs of micro hydro plants. In the study evaluated, it is important to note that the installed kilowatt is higher than what other resources claimed in their numbers. In studies with lower numbers, they did not evaluate the local labour costs.

In the examples examined in, the capital cost of micro hydro plants limited to shaft power, ranged from US$714 (Nepal, Zimbabwe) to US$1,233 (Mozambique). The average cost is US$965 per installed kilowatt. The installed costs for electricity generation schemes are much larger. The installed cost per kilowatt ranged from US$1,136 (Pucara, Peru) to US$5,630 (Pedro Ruiz, Peru) with an average installed cost of US$3,085 (Khennas, 2000).

Potential ecologic problems

There are some problems with micro hydro, some of which are obvious and some that may not be as easily identifiable but can create problems if not appropriately addressed. In order to take advantage of the electrical potential, a suitable site must include favourable factors such as the distance from power to source, or where the energy is needed. The stream size, including flow rate, output, drop, and also the balance of systems components are factors to consider when evaluating prospective sites, as well as trying to identify the potential need of expansion and whether or not it would be feasible for the stream and system to support.

Given the source of this power is based on the free flow of water, what is the summer time implications associated with seasonal variability from decreased run off and water flow of the site location (Khennas, 2000).

Building on that, last but for sure not least, how do these projects affect the local ecosystems? The ecological impact of small-scale hydro is sometimes minimal but sometimes significant as the following study cases reveal; however the low level of environmental effects must be taken into consideration before construction begins. Stream water will be diverted away from a portion of the stream and proper caution must be executed to ensure there will be no damaging impact on the local ecosystems or civil infrastructure.

Small hydropower plants can have environmental impacts, some of which start as soon the construction phase. Habitat degradation associated with tree cutting, excavation, fill areas, road construction, blasting, construction of water storage systems, construction of supply canals, excavations, loss of riparian zone and destruction of wetlands is a main environmental concern in hydropower plants under construction (Başkaya et al., 2011). Such activities are carried out in pristine areas, which can lose their associated tourist attractiveness.

The disruption of longitudinal connectivity by dams can have severe impacts on migratory fish, especially salmonids (Stakėnas and Skrupskelis, 2009). Significant reductions in the numbers of salmonids were observed after the construction of small hydropower plants on small mountain rivers (Almodóvar and Nicola, 1999; Ovidio et al., 2004). Thus, one of the principal environmental challenges, which face small hydropower plants, is efficient fish passage (Therrien and Bourgeois, 2000). E.g., among the studied fish passage facilities in Portugal, only 44.4% were found to be suitable for target fish species (Santos et al., 2006). The populations fragmented by dams are often characterized by lower genetic diversity, higher morphological asymmetry, and a lower effective population size compared with populations below dams (Morita and Yokota, 2002). However, dams of small hydropower plants seem to cause a lesser effect on fish than large dams on large rivers because of their smaller size. Usually, the escape of a certain number of fish from upstream into downstream populations occurs through fish passes or with high water during flood periods that can be sufficient to prevent genetic divergence between these populations (Santos et al., 2006).

Another problem associated with small hydropower plants is the reduction in stream flow, which can have a substantial ecological impact. Flow reductions can cause up to 90-95% removal of the average annual discharge that can affect the physical characteristics of a stream (e.g. water velocity, water temperature, suspended solids, fine particles and nutrients) and alter the quantity and quality of aquatic habitat, with cascading impacts on stream biota (Anderson et al., 2006; Vaikasas et al., 2015). Such alterations can affect not only fish but also macroinvertebrate communities in terms of abundance, species composition, and the ratios of their different ecological groups (Xiaocheng et al., 2008). However, some authors noted that the regulation by small dams did not impoverish the invertebrate fauna but sometimes induced subtle changes in faunal composition (Pett et al., 1993; Almodóvar and Nicola, 1999). The impacts on water quality and macroinvertebrate communities may be significant but usually are local (Vaikasas et al., 2015). Nevertheless, the lack of control over environmental flow remains a highly serious problem in already functioning small hydropower plants (Başkaya et al., 2011).

Ecologic context – study cases

Capra Stream (Southern Romanian Carpathians) study case

The analysed Capra Stream ecological state based on biotic integrity indexes (HBI and EPT/C) and IBI Carpathian Fish Index revealed that the impacts of micro hydro-power plants development (Fig. 1), dams, and pollution are significant in space and time.

Figure 1: Heavy construction equipment work in the Capra Stream.

The macroinvertebrate and fish fauna are directly affected by the lithological substrate change (in conditions of which they and their trophic base depend on the substrate) and by the flow regime changes. As an effect of the human impact along the Capra Stream there are three main ecological zones. The first ecological zone is characterised by a good ecological state due to the insignificant anthropic impact. The second is characterised by an unsatisfactory ecological state mainly because of the micro hydro-power plants system construction and of the untreated wastewater discharges in the stream have a hydrological and morphological change which generate stress for the aquatic communities, which determines changes in their structure, the river banks configuration change also determined the river bed deepening due of the rotational flow with negative effect on the aquatic communities.

The third ecological zone is better than the previous one from the ecological point of view because of the left and right tributaries contribution of the Capra Stream. In this sector the anthropic impact is still significant because of the development of micro hydro-power plants, the tributaries connection blocking and the untreated wastewater discharge. The building works simultaneous with the significant river bed damage determined the *Cottus gobio* local extinction and the drastic reduction of *Salmo truta fario* individuals (the presence of *Salmo truta fario* in just one river sector of 17 sampling stations).

After finishing the micro hydro power plants chain on this stream it is compulsory to repopulate with trout and bullhead, which before had stable populations. The extinction of every fish species in all sampling stations except one with low abundance though is due to major interventions of the micro hydro-power plants construction.

The final situation resulted due to factors with synergic effects that have accumulated throughout time such as lodges rafting in the first part of the XIX century, fractioning the ichthyofauna connectivity because of the anti-bottom sediments dams without the construction of a fish ladder built on the tributaries (especially the one built on Capra at the Vidraru Lake edge); damage of the river bed for pipe burial constructed for the micro hydro-power plants chain in different states of development; the secondary impact of the untreated wastewater discharges of Piscul Negru chalet (in the last two decades) (Curtean-Bănăduc et al., 2014).

Shypit River (Ukrainain Carpathians, Zakarpattia region) study case

The issue of small hydropower plant construction drew attention in Ukraine, when in 2009 the Ukrainian government introduced the so-called “green tariff” for power plants producing electricity from alternative energy sources, which was aimed at stimulating the operation and development of renewable energy sources. The green tariff introduced a guaranteed minimum feed-in tariff for electricity produced from small hydropower power plants with the generation capacity not exceeding 10 MW. In addition, a number of tax incentives were implemented for producers of electricity from renewable energy sources.

As a result, these initiatives boosted the development of new small hydropower projects in the Ukranian Carpathians. E.g., the “Programme of the multipurpose use of water resources in the Zakarpattia (Transcarpathian) region of Ukraine” adopted in 2011 envisaged the construction of 330 small hydropower plants in the region.

The Tur’ya-Polianska hydropower plant (48°44’26.88” N, 22°50’19.17” E) of run-of-river type (Fig. 2) with the projected power generation capacity of up to 1.2 MW was built in 2012 in the middle part of the Shypit River, four km upstream of the Tur’ya-Poliana Village. The Shypit River is a typical mountain stream of 20 km in length with river bed width of 5-10 m. The construction resulted in the creation of a reservoir with an area of approx. 1,700 m^2 and a depth of up to 4.6 m. The hydropower water intake was equipped with a fish pass structure, however, it was not functional during the first years of operation and was rebuilt in 2014.

Figure 2: Tur'ya-Polianska small hydropower plant.

A significant amount of water is now diverted into a three km penstock placed underground that reduced the water content in a three km river reach located immediately downstream of the reservoir. The residual flow is sometimes insufficient to fill this river reach with water especially during dry months. Local people started complaining on decreased water levels in their wells that may be related to the reduced soil moisture level beneath the stream bed. However, some claim that this was due to dry years.

The newly created reservoir of the small hydropower plant is located on a mountain river with rapid current and erosion processes along the shore that results in the accumulation of sediments and creation of a new biotope, which is not typical for mountain rivers and where anaerobic processes develop (Kovalchuk et al., 2013). Relatively rapid sedimentation results in a decrease in the volume of the reservoir that may require the removal of sediments in the future. Rearing of trout in a cage containing up to 1.5 tonnes of fish was practiced in the reservoir that formed additional organic input in water. However, it was discontinued in 2015.

The small hydropower plant was built in a transient zone of the river where the trout zone inhabited mainly by brown trout (*Salmo trutta fario*) and Siberian bullhead (*Cottus poecilopus*) gradually changes into the grayling zone inhabited by European grayling (*Thymallus thymallus*) and Carpathian barbell (*Barbus carpathicus*) (Harka and Bănărescu, 1999). A fish survey of 2009 conducted on the river reach located approx. 0.5 km upstream of the current site of the reservoir showed the presence of all these species. The same fish species were recorded upstream of the reservoir in 2012, a couple of months after the hydropower plant was built.

However, neither European grayling nor Carpathian barbell were recorded upstream of the reservoir in 2013 (Kovalchuk et al., 2013). After the fish pass was reconstructed, these two species reappeared in the sampling site immediately upstream of the reservoir (Kovalchuk et al., 2013). In addition, certain amounts of brown trout are stocked artificially in the river reaches upstream and downstream of the reservoir every year. However, local people complain that the amount of fish decreased considerably in the river after the small hydropower plant was built.

In 2013, the residents of Tur'ya-Poliana raised against the second phase of the small hydropower plant construction on the Shypit River. One of their main concerns was the absence of direct economic benefits for them and their village. Nevertheless, the second small hydropower plant Shypit-2 was built in 2015 approximately 4.8 km upstream of the first plant.

When the construction of small hydropower plants began in the Carpathian region of Ukraine, environmental activists and NGOs raised concerns about their negative effects on the environment. In fact, the programme for their construction was adopted in violation of the legislation of Ukraine without discussion and approval by the competent state authorities because many small hydropower projects were planned to be built in ecologically sensitive areas inhabited by rare and endangered species. In 2014, the Administrative Appeal Court declared illegal the plans for the construction of 330 small hydropower plants in the Zakarpattia region. As a result, the construction of at least four plants was recently cancelled and few more are still disputed.

Bystrzyca River (Lublin Upland, eastern Poland) study case.

Polish accession to the European Union resulted in the need to adjust Polish legislation concerning the management and protection of water to the applicable Community legislation. On 22 December 2000 entered into force on Water Framework Directive (WFD/2000/60/WE), whose main aim was to protect water resources for future generations. The Directive indicated that it was necessary to integrate the protection and sustainable management of water with other branches including energy

Poland does not have good conditions for the hydropower development, due to slight declines in land, low rainfall, and high permeability grounds (Warać et al., 2010).

Generally hydroelectric power plants are divided into groups of small and large. Most adopt a definition of small hydro based on the total installed generators. In Poland, small hydropower plants are facilities with a capacity is five MW (installed capacity: micro – hydro power plants 100 kW, mini – one MW and small – from one to five MW)

In Poland in the 30s of the last century there were about 8,000 various types of plants using water energy, currently operate only 743 hydropower plants (Warać et al., 2010).

Small hydro power plant on the Bystrzyca River (Fig. 3) was built in 1974, whereas in 2013 was modernized. The power generation capacity amounts to 27.5 kW. Construction of the dam reservoir (Zemborzycki Reservoir) would help to increase the retention and protection of water in the basin of the river, as well as protect Lublin city from floods (Michalczyk, 1997).

The Bystrzyca River (51°11'36.09" N, 22°32'9.96" E) has a length of 70.3 km, its basin is dominated by farmland (70.7%), forests cover 10.8% and 8.4% urban areas. The Bystrzyca Basin inhabited 0.5 million people.

Figure 3: Small hydropower plants on Bystrzyca River.

Construction of the dam reservoir and their functioning for more than 40 years led to the creation of new ecosystems which are subject to rapid degradation.

The Bystzyca River above Zemborzycki Reservoir is a mountain river with the typical fish species: trout and grayling (IBI index indicate very good ecological state). After crossing 27 km flows into three other rivers that change its character (IBI index moderate). Complete reconstruction of the structure of fish fauna occurs in dam reservoir. Every year, the reservoir is stocked with predatory species (pike, perch). This is related to these treatments in the tank biomanipulation, in order to improve its ecological potential. The reservoir is now very high eutrophic. Often in the summer devoid of recreational function due to the presence of toxic blue-green algae blooms.

In the Bystrzyca River and the dam reservoir occurred 30 fish species. There are no fish pass on the Zemborzycki Dam (Radwan, 2006). Macrophyte communities occurred particularly at the mouth of the river to the reservoir creating here the most favourable conditions for fish spawning (Sender, 2007). Isolation causes the depletion of fish fauna below the dam (only 10 species) The ecological status according to IBI index, on the section 50 m from the dam was defined as moderate, whereas in the next sections (municipal) as poor.

The cause considerable depletion of the fish fauna and macrophytes communities below the dam are unnatural fluctuations in water level caused by the work of SHP. Water level changes significantly reduce the occurrence of macrophytes, and thus spawning grounds.

The creation of the stagnating reservoir above the damming caused major changes in the environment of the river (Radtke et al., 2012). Rheophile fish species lost here their habitat. The fragmentation of the watercourse prevented fish and other organisms (e.g. *Lampetra planeri* and *Astacus astacus*) migration, resulting in the isolation of the population.

Džepska River (Southeastern Serbia) – study case

In the Law on Spatial Planning of the Republic of Serbia from 2010 to 2020 (“Official Gazette of RS” no. 88/2010), in the chapter Sustainable development of the technical infrastructure, it was found that the potential of small river flows on which it is possible to build small hydropower plants is 4.7% of total electricity production in Serbia, or around 15% of energy produced in hydropower plants. Possible locations for the construction of small hydropower plants and the potential production of electricity are determined based on the Cadastre of small hydropower plants of Serbia from 1987. This cadastre determined 856 potential locations for construction of small hydropower plants with a total output of 450 MW, with the production of 1.590 GWh per year (http://www.srbijavode.rs/home/Aktuelno/mhe.html).

Based on available data from November 2014, on the territory of Serbia there are 44 sites with already constructed small hydropower plants. On the basis of two public calls that the Ministry of Energy announced in 2013 it was granted a total of 293 additional locations for construction of small hydropower plants (Vasić and Jahić, 2014, http://www.javno.rs/baza-podataka/mini-hidroelektrane-u-srbiji/detaljna-pretraga).

Džepska River is the right tributary of Južna Morava. It is formed out of two smaller watercourses Garvanica and Mutnica that rise on the western side of the mountain Čemernik. Džepska River and its tributaries represent typical salmon water. Brown trout (*Salmo trutta*) is present in the whole system, while the cyprinid species occur only near the confluence with the Južna Morava, with the dominance of brook barbell (*Barbus peloponnesius*), shcneider (*Alburnoides bipunctatus*) and chub (*Leuciscus cephalus*).

Figure 4: Garvanica water intakes
of hydroelectric power plant Džep.

According to cadastre from 1987 in the Džepska River system, 11 locations are provided for construction of small hydropower plants, three of which were approved and one was constructed (Fig. 4). Built hydropower plant Džep, has the power of one MW, with the production of 883 KW of electricity. It is built about one km from the mouth of Džepska to Južna Morava River at the altitude of 340 m (42°45'58" N, 22°05'49" E). For the purposes of hydropower plant, two water intakes with the tubes were built at about three km from hydropower plant, one of which is on Mutnica at the altitude of 428 m (42°46'18" N, 22°07'56" E) and the other on Garvanica at the altitude of 430 m (42°45'59" N, 22°07'52" E). Intensive construction work on the whole system completely devastated natural habitat to about four km of river flow.

Genetic analysis of phylogeographic structure of brown trout from the territory of Serbia (Marić et al., 2006), in the middle part of the Džepska River detected a new haplotype Da*Dž. So far, this river is the only site of mentioned haplotype across the species area. Kohout et al. (2013), named this haplotype DaBS9, and stated that beside that haplotype there are three more present in the lower part of the river. This finding suggests that the lower part was probably stocked with allochthonous material. However, last year's analysis of 17 samples from the upper part of Garvanica, detected the presence of only DaBS9 haplotype, suggesting that the upper part of the Džepska River system is inhabited by indigenous trout.

Marić et al. (2006) and Kohout et al. (2013) reported that DaBS haplotypes form a separate group within the Danubian phylogenetic lineage of brown trout, which as such deserves a special conservation treatment. Introduction of the alochthonuous materials and constructing of small hydropower plants, i.e. genetic contamination and deterioration of habitat can certainly threaten the survival of indigenous population. In terms of conservation of this population, the upper part of the Džepska River system is very important, and thus the above mentioned activities should be prevented.

La Realidad micro hydroelectric plant (México) – study case

In México, the installed hydroelectric capacity in 2012 was 11,603 MW, generated by 181 hydroelectric plants, representing almost 20% of the country's electric energy; the country's growth potential is five times this figure. More than 40% of the realized capacity comes from the power plant complex located along the Grijalva and Balsas rivers basins (from the power plants called Angostura, Chicoasén, Malpaso, Peñitas, Caracol, Infiernillo and La Villita). Mexican government's long term objective for the year 2025 is to reach 35% of installed sustainable capacity, which means an additional 18,716 MW to the existing power. This renewable energy will rely on eolic (60%) and hydraulic (24%) generators, including mini and micro hydroelectric plants (Ortega-Méndez and Diez-León, 2013).

There is limited information concerning the micro-hydraulic potential power in Mexico. An estimate made in 1995, indicated that roughly 2.5% of such potential (3,200 MW) was developed by approximately 57 micro-plants, with an average power of 364 MW (Valdéz Ingenieros, 2005, 2006; Ramos-Gutiérrez and Montenegro-Fragoso, 2012; González-García, 2014). In 2013, the installed power generated by micro-hydraulic systems was 980 MW (Valdéz-Báez, 2008) and the challenge for the next 20 years is to double the current capacity (Liu et al., 2013). Although there is a favorable legal and political climate for achieving this goal, there is also a pressing need to assess the totality of the hydraulic network in Mexico (more than 130 rivers and tributaries), which is the base for an adequate energy generation planning.

The mini and micro-hydraulic power is mainly concentrated in Puebla, Veracruz, Chiapas and Oaxaca, although there are at least another four states with potential for generating energy at this scale. Actually, 17 small power plants (224 MW) are already operating in damns of Michoacán, Chihuahua, Nuevo León and Guerrero. A few mini and micro-hydraulic plants are owned by the Federal Government (through the Federal Commission of Electricity) but they mostly belong to foreign particulars. In terms of cost-benefit, the axial type turbines have proven to be an adequate kind of small sized hydroelectric technology for domestic; depending the plant capacity costs vary between $8,000 USD (three kW) and 13,000 USD (eight kW; González-García, 2014). In Mexico, important societal and environmental benefits of using these kinds of plants are access to renewable energy by isolated human settlements, reduction of dependence to large-scale power plants and to fossil fuels, comparatively small-sized facilities and, thus, minimization of habitat alterations (Hernández-Huitrón et al., 2013).

The work of Micangeli and Cataldo (2013) is one of the few available documented studies on micro hydroelectric plants in Mexico; this study case is entirely based on such study. The project aimed at the implementation of a 50 kW micro hydro plant at “La Realidad”, a village in the Lacandona Forrest (Fig. 5), Chiapas. Taking into account the community needs, a Micro Hydro Plant was locally assembled. Then, the project continued with a second phase consisting in the installation of an OSEC system that uses the electricity generated from the Micro Hydro Turbine to produce chlorine, a very common good and the first choice to disinfect water in emergencies.

A zone with the presence of a small river together with some small waterfalls (18 m drop) was chosen as the place to intercept the water flow to the powerhouse. Considering the impact on the local environment of a complete deviation of the water flow, the community chose a solution with an embankment of grounds lots in the river and a nominal flow of about 400 L/s to the powerhouse. Floods could potentially carry away the lots, but it is quite easy and cost-free for the community to repair an embankment of lots while a small dam in reinforced concrete could become an environmental problem and could need an expensive repairing.

From the concrete intake, water is guided in a channel to a sedimentation tank. Then, from this tank water is received, through another channel, by a charge tank where the penstock begins. In the powerhouse, the turbine is coupled with a synchronous brushless alternator. The load control has been made with an electronic system working with five resistances of 10 kW, each resistance subdivided in 15 steps of 660 W. The power produced but not engaged by the loads connected to the grid is wasted on the resistances that are dipped in the water of the river exiting the turbine. In this way, the voltage is kept constant to the grid. Complex hydraulic or mechanical speed governors altered flow as the load varied, but more recently developed ELC has increased the simplicity and reliability of modern micro hydro sets. ELC has no moving parts and is virtually maintenance-free.

One of the main results of this project was that the community is now free from external energetic dependence and contributes to local self-development. This represents a success from the technological, political, and social point of views. The project is a good example of an efficient cooperation among different organizations and people coming from heterogeneous backgrounds.

No data was obtained till now on the effects of this micro hydroelectric plant in terms of the local biocenosis/ecosystems, fact that pinpoints an urgent need of basic ecological research.

Figure 5: Type of stream in the Lacandona Forrest, Chiapas, used for hydrotechnical works.

Sardabroud River (Kelardasht, Mazandaran Province, Iran) Case study

It is clear that using the sustainable hydropower energy has economic benefits, less environmental pollution compare to fossil fuel burning, solving the energy security issues of impassable villages, decreasing the cost of agricultural products and finally decreasing the use of fossil fuels.

Great potential exists in the Zagros and Alborz mountain ranges, the increasing demand and cost of energy, support of local markets, job creation, providing remote areas with energy, cost reduction of power transmission, and less diesel use for power generation are some reasons that have lead Iran's government to start using micro hydro power plants.

Due to the presence of large rivers in different areas of Iran, such as Karoon, Karkheh, Dez, Sefidrood, Arass and etc. there are plenty of large dams providing hydropower all over the country, but the education regarding microhydro power plants has lead to the identification and localization of over 2,500 suitable locations for construction of micro hydro power plants in Iran, which some are under construction and others are operational.

Sardabroud River is one of the important rivers of Mazandaran province due to the use of its water for urban and agricultural activities. This river originated from Alborz Mountains at the north side of the Iran's capital.

The Sardabroud small hydro power plant (Fig. 6) is located at the 25°36'29.36" N 2°51'6.51" E at the southeast of Kelardasht in Mazandaran Province, Iran (south of the Caspian Sea). The total capacity of power production of this plant is about five MW.

Figure 6: Sardabroud micro hydro power plant.

Environmental studies during the construction time showed that the most significant negative effect of this facility is the dust and soil destruction during the excavation and transportation activities. This also results in increasing water turbidity, depletion of oxygen content of water and mortality of fish fauna due to changes in water parameters (Abbasspour et al., 2010).

Other negative effects, was the decrease of the aquatic plants due to decreasing the water flow of the river downstream of the dam with negative effects on some herbivorous fish fauna such as the *Ctenopharyngodon idella*.

On the other hand, the reservoir of the dam made a suitable place for migratory birds coming from northern parts of the Caspian Sea to this region (which is located at the south of the Caspian Sea).

Also, increasing the aquatic plants upstream of the river near the reservoir which make a good place as a spawning and nursery ground for native species such as the *Salmo trutta fario*.

The other major fish species of the Sardabrud River are rainbow trout, *Oncorhynchus mykiss*; Spirlin, *Alburnoides bipunctatus* and *Luciobarbus barbulus* (Kiabi et al., 1999; Abdoli, 1994).

In total construction and operation of Sardabrud hydropower plant, there were some short term negative effects on fauna and flora of the river at the dam and its reservoir site. Due to minor chemical pollutions and small scale of the reservoir, it seems there will not be any serious long term effects on the aquatic and terrestrial organisms of the region.

Rui River (Perak, Malaysia) study case

Malaysia has abundant water resources with average rainfall about 3,549 mm annually (Shafie et al., 2011). Rivers in Malaysia originated from mountainous areas and become favourable for hydropower projects (Ahmad and Tahar, 2014). Malaysia has 12 large-scale hydropower and 50 mini-scale hydropower stations (Raman et al., 2009), making micro hydro power plant not significant in this country because most of the areas are well electrified. But, micro hydro power plant still very important as alternative renewable energy source in future. In fact, Raman et al. (2009) showed that a total of 109 sites have been identified as micro hydro potential sites.

There are a few numbers of micro hydro power plants in Malaysia. Some of them are inactive. One of the plant that still operated is Pong Micro Hydro Power Station that located near Gerik-Klian Intan road that was built around 1924 (Fig. 7). The dam, an ex-mining pond, was built in Rui River to generate electricity to mobilise the cable cars that transport tin ore from Klian Intan to tin smelter due to mountainous surface. The dam supplies about 11,000 kW of power per day for the tin mining operations.

Figure 7: Water intake of Pong Dam,
Perak, Malaysia.

However, one of the challenges in macro hydro power plant is water scarcity that would expect to occur in the next 10-15 years due to sedimentation and water pollution. Siltation and sedimentation problems had resulted in chokage of microwire filters especially during rainy season (Wai and Abdullah, 2002). The silt abrasion on hydraulic installed at power plant due to the sedimentation reduced the energy capacity production. Changes in land use and vegetation cover in the catchment area could lead to major modifications in freshwater run-off, sediment transport and nutrient fluxes. Excessive siltation leads to suffocation of fish eggs, thus adversely affecting fish populations especially intolerant species such as Malayan mahseer (*Tor tambroides*) (Gordon et al., 1996). Besides, this river is known as a spawning ground for the Tiny scale barb (*Thynnichthys thynnoides*) (Amal et al., 2015).

The potential of micro hydropower in Malaysia is yet to be discovered. Micro hydropower is a good option for providing electricity in the remote areas at lower costs.

CONCLUSIONS

Micro hydropower can be a very cost effective and easy way for rural communities in developing countries to acquire electricity. Proper locations do need to be identified. Both social and environmental risks need to acknowledged and appropriately managed. As well, a system or scheme needs to be installed that can accommodate the local energy needs but not be scaled too large to where the costs for larger system exceed what is needed and what is affordable for the local community.

Costs associated with installation are fairly reasonable and there are ways of significantly reducing costs by utilization of local labour. The use of local labour to install systems not only brings the price down, but also gives a sense of ownership to the community. This ownership will create an inherent level of pride, which can be leveraged to the benefit for the longevity to micro hydro within the areas it is applied. Using local labour also creates the market for maintenance personnel, knowing how the system was built and operates, allows those who worked on the project to potentially gain employment as the individuals that maintain the systems.

Under the right conditions and in the right circumstance, micro hydro power plants can be the answer for a low cost, steady supply for localized energy needs. The greatest areas of applications are within developing countries with areas exhibiting significant topographic relief with decentralized power needs.

Current studies in the field of hydropower industry show that it can be considered an environmentally-friendly source of energy alongside other sources such as wind or solar, because it is generated in natural rivers.

The development of small hydropower construction has created mixed feelings in society and caused social tensions in the Carpathian region. To regulate conflicts of interests between local communities, businesses and environmentalists, it is necessary to take into account the protected areas with high conservation value and principles of priority and expedience when making decisions and selecting sites for construction. These principles should be based on environmental criteria and should not go beyond the local and international legislation.

Last but not least, it should be highlighted that the wrong ecological approach or know-how in these projects implementation can be a major cause for which the ecological costs are sometimes higher than the economic benefit!

ACKNOWLEDGEMENTS

The authors of the paper are especially indebted to the editors of Transylvanian Review of Systematical and Ecological Research, for launching fruitful discussions on the topic in dealing with this paper approach and subject.

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