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The Wetlands Diversity

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

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"*Lucian Blaga*" University of Sibiu,
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IN MEMORIAM

Eugene Pleasants Odum
(1913-2002)

Eugene Pleasants Odum was an American biologist well known for his pioneering subtle approach, hard work and very valuable results on ecosystem ecology.

Born in September 1913, while his mother was in holiday on Lake Sunapee in New Hampshire to escape the summer heat of Athens, Georgia (USA), he was the son of Howard Washington Odum, a respected scholar in social justice, whose studies of integrated concepts, were certainly an influence on, his son's holistic approach and concepts.

Eugene Odum's studies in zoology started at the age of 15 at the University of North Carolina, when he developed a major interest in ornithology and avian ecology that was to last all his life. Eugene and Martha Huff Odum, whom he had met as a student, moved to the University of Georgia in 1940, where he served his entire career.

In 1946, trying to highlight the fact that ecology was not simply a basic discipline of biology, he began writing the first edition of Fundamentals of Ecology (1953). Later in his life he admited that one of his most satisfying accomplishments was his success in revealing that ecology is not a subdiscipline of biology but a stand-alone discipline.

He worked with his younger brother Howard Thomas Odum, on several major projects including: the second edition of Fundamentals of Ecology, published in 1959; The energetic Basis for Valuation of Ecosystem services, published in 2000. Through her skilled paintings, his wife enriched Eugene′s perspective of nature. Eugene and Martha′s son was a professor of environmental science at the University of Virginia.

Eugene Pleasants Odum carrer shows a clear uninterrupted intellectual growth, evolving from a bird ecologist to an ecosystem ecologist and overall a holistic thinker in his late years.

He supported the establishment of the Savannah River Ecology Laboratory, the Sapelo Island Marine Institute, and the world famous Institute of Ecology.

He stressed the role of mutualism, the mechanism of ecosystem development, and energetics as a comon denominator across different levels of organization.

He was also a philanthropist providing funding for his programmes, an environmentalist recognizing the need to protect ecological systems, and a teacher promoting integrative science.

He was a relentless birdwatcher, a tireless traveler, and an enthusiastic organic gardener until his death.

Although encouraged to retire officially in 1984, he continued to devote his time to writing, contributing to research publications and the fifth edition of Fundamentals of Ecology (2005).

In addition to his reputation as a research ecologist, *Eugene Pleasants Odum* also became a respected environmentalist during the decade of environment and was quoted frequently in Time, Newsweek amd Life magazines.

He played a major role in the passing of the Coastal Marshlands Protection Act of 1990 in the State of Georgia.

He designated in his will that more than half his 26 acre estate at Beech Creek be placed in permanent conservation protection, thus providing habitat for the wildlife he loved.

Eugene Pleasants Odum's legacy of generosity, subtle intelligence and capacity of understanding nature, will benefit generations in pursuit of education, research and service of nature.

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.

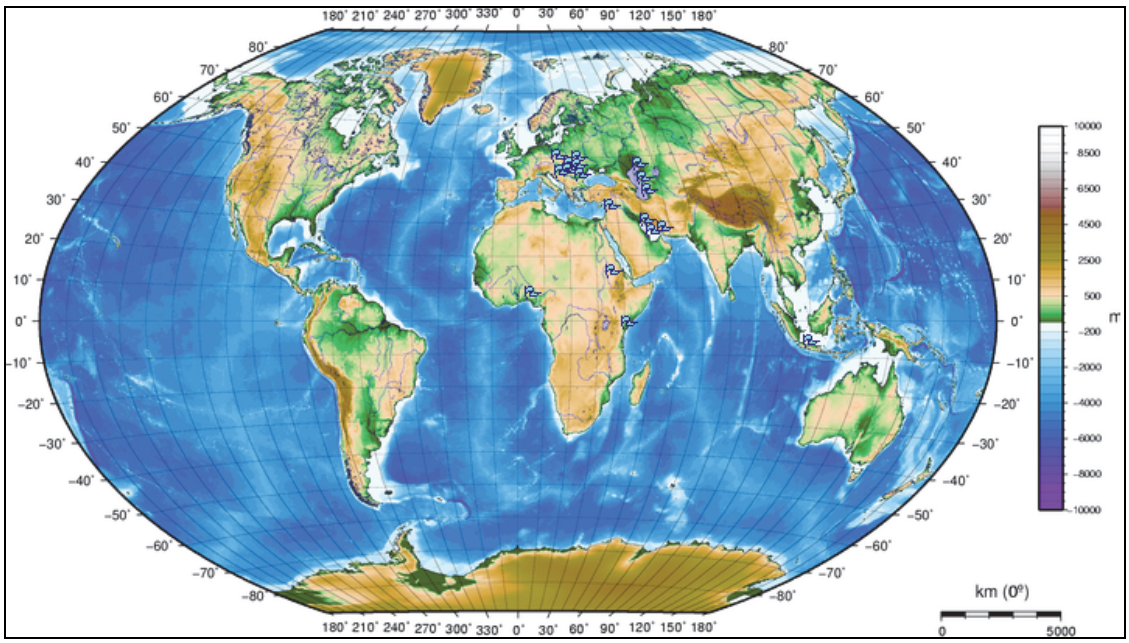
The causes, effects, trends and possibilities of human society to positively intervene to slow down this process or to adapt to it involve a huge variety of aproacess and efforts.

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 sixth volume included variated researches from diverse wetlands around the world.



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

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

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

The Editors

Editorial Office:

„Lucian Blaga" University of Sibiu, Faculty of Sciences, Department of Ecology and Environment Protection, 5-7 Raţiu Street, Sibiu, Sibiu County, Romania, RO-550012, *Angela Curtean-Bănăduc* (ad.banaduc@yahoo.com, angela.banaduc@ulbsibiu.ro)

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ESTIMATING PARTICLE CONCENTRATION IN NATURAL WATER BY SPECKLE CONTRAST

Dan CHICEA *

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Dr. Ion Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, dan.chicea@ulbsibiu.ro

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KEYWORDS: Coherent Light Scattering, Suspension, Particle Concentration, Speckle contrast.

ABSTRACT

A coherent light scattering experiment was carried out on an aqueous clay suspension with an extended range of concentrations. The far field speckle was recorded as a video recording in an unconventional manner using a charged coupled device. A computer code for image processing, written for this purpose, was used to compute the average far field contrast. The variation of average contrast with particle concentration was analysed, and a possible fast procedure for assessing the particle concentration over an extended concentration range was suggested.

ZUSAMMENFASSUNG: Abschätzung der Partikelkonzentration im natürlichen Wasser durch Tupfergegensatz.

Ein koharentes Lichtstreuung Experiment im wasserigen Kleiflussigkeit, mit eine Konzentration das sich uber einen grossen Aktionsradius erstreckt, wird durchgefuhrt. Das erweiterte Bereich Tupfer wurde als Film ausgezeichnet in einem unkonventionellen Art und Weise mit Hilfe der "charged coupled" Geraet. Auch einen speziellen PC Kode fur Bildbearbeitung, geschrieben fur dieses Experiment, wurde benutzt beim Berechnung des erweiterte Bereich Gegensatz. Die Veränderung der mittleren Gegensatz mit dem Partikelkonzentrazion war beobachtet und einen moglichen Ablauf fur das Festsetzen des Partikelkonzentrazion uber einen erweiteren Bereich wird vorgeschlagen.

REZUMAT: Estimarea concentraţiei de particule în apa naturală prin contrastul imaginii de interferenţă.

A fost efectuat un experiment de împrăştiere a luminii pe suspensie de lut, având o concentraţie care se întinde pe un interval extins. Imaginea de interferenţă de câmp îndepărtat a fost înregistrată ca film, folosind un dispozitiv de tip „charged coupled". Contrastul imaginii a fost calculat cu un program scris în acest scop. A fost analizată variaţia contrastului mediu cu concentraţia de particule şi este sugerat un procedeu rapid de estimare a concentraţiei pe un interval extins.

INTRODUCTION

Natural water contains particles in suspension with different proveniences. The particles in suspension are the cause of water opacity. This physical property of natural water is named turbidity (Waterwatch Australia, 2002). Suspended particles can be clay, sand, silt, algae, plankton, micro-organisms and other substances (National Soil Survey Handbook, 2006). Suspended particles absorb visible light and the absorbed energy causes the increase of the particles temperature. Heat is transferred to the water that contains the particles, therefore water temperature increases faster in turbid water than it does in clear water under the same incident light intensity. Gumpinger et al. (2010), state that "water temperature is considered one of the most essential regulating parameters in aquatic ecosystems". Water temperature is also one of the most important ecological parameters of aquatic and semi-aquatic organisms (Fulga and Kiseliova, 2006; Blănaru, 2008; Zubcov et al., 2008; Salem, 2011). 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 an aquatic ecosystem (Coman and Sandu, 2009; Gumpinger et al., 2010).

Turbidity is often used as an indicator of the total amount of material suspended in water, but is not a measure of the concentration or size of the particles in water. Nevertheless, knowing the size and the type of the suspended particles is important also because the fine particles suspended in water can carry bacteria, excess nutrients and toxic materials, which might be a hazard for drinking water and not only.

Optical procedures for assessing the amount of particles in suspension in water are appealing as they are fast and do not require physical or chemical processing of the samples. When coherent light crosses a medium with scattering centres (SC), an un-uniformly illuminated image is obtained, currently named speckled image, with a statistic distribution of the intensity over the interference field. The speckled image appears as a result of the interference of the wavelets scattered by the SCs, each wavelet having a different phase and amplitude in each location of the interference field. The image changes in time as a consequence of the SCs complex movement of sedimentation and Brownian motion, 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, or on the image plane of a diffuse object illuminated by a coherent source, and it is named subjective speckle (Goodman, 1984). The review paper (Briers, 2001) classifies the two types of speckled images as far field speckle and image speckle. In this work the objective speckle, respectively far field speckle is considered.

The speckle parameters like size, contrast, intensity and polarization carry information on the scattering media. Dynamic speckle analysis has become a current method to characterize the dynamic behaviour of scattering medium such as flow, sediment and Brownian motion. The motion of the speckle field was analyzed by correlometric methods (Aizu and Asakura, 1991; Boas and Yodh, 1997; Fedosov and Tuchin, 2001) or by laser speckle contrast analysis (Briers et al., 1999; Zimnyakov et al., 2002). The speckle size can be used to measure the roughness of a surface (da Costa and Ferrari, 1997; Lehmann, 1999; Berlasso et al., 2000) or to assess the thickness of a semi-transparent thin slab (Sadhwani et al., 1996). The above mentioned experiments use the backscattered speckle configuration. Giglio et al. (2001) and other papers report a different optical set-up to measure the correlation function in the near field, and to show the near-field speckle dependence on the particles size. The work reported by Piederrière et al. (2004a, b) and Chicea (2007a) used a transmission optical set-up to measure the far field parameters like contrast and speckle size. The transmission type of setup was used in the work reported in the present paper as well.

In this work, a simple physical experimental procedure that uses coherent light scattering on a clay suspension and a charged coupled device (CCD hereafter) to record the scattered far field, assisted by a set of computer codes, that can be used to assess the average concentration of clay particles suspended in water, over a wide range, from 1.54 g/l to 6.6 g/l is presented in detail. The experimental procedure, the computer codes and the procedure of using them to assess the clay particle concentration are presented in detail in the next sections.

MATERIALS AND METHODS

Clay taken from the bottom of the Trinkbach River that crosses Sibiu locality (Transylvania, Romania) was taken and diluted in water, allowed to sediment for 24 hours and the water was discarded to remove the organic suspension. The sediment was dried, weighed and then was mixed with deionised water to produce samples of clay particles suspension with different concentrations.

Prior to starting the light scattering image experiment, a diluted suspension was subject of a Dynamic Light Scattering experiment using a modified procedure extensively described (Chicea, 2007a; 2012a, b, c; Chicea et al., 2012). The average diameter of the clay particles was found to be 0.6 μm. The experiment scheme is presented in figure number 1.

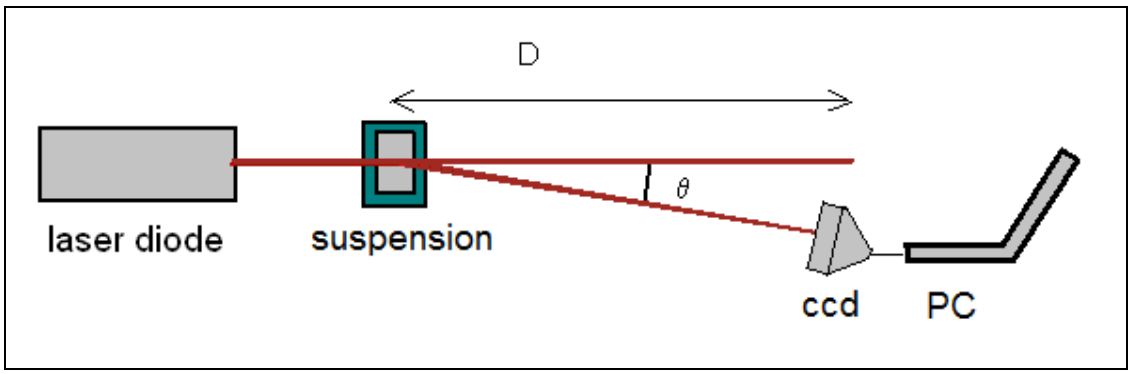

Figure 1: The experiment scheme, above view.

The coherent light source was a laser diode that had a wavelength of 633 nm and a constant power of 20 mW. No polarizer was placed between the laser and the glass cuvette, which was 12 mm thick. D was 0.165 m and the Philips SPC900NC CCD camera was placed 0.01 m apart from the beam making the measurement angle to be 3˚28’5.6’’. The optical system of the camera was removed, therefore the recorded images are the direct interference on the CCD detection matrix; so the far field speckle was recorded. The resolution was 640x480 pixels, the frame rate was 10 frames per second (fps) and the colour depth was 16 bits. More details on the optical setup have extensively been presented (Chicea, 2007a, b; 2013). A frame containing the far field speckle taken from the movie, having a concentration of 3.53 g/l, is presented in figure number 2.

The average speckle size is currently calculated as the normalized auto covariance function of the intensity speckle pattern got in the observation plane (Piederrière et al., 2004a, b). In this paper, a different approach is proposed to relate the particle concentration with one of the first order far field statistics parameter. The average contrast is calculated instead of the speckle size.

The average contrast of the image, either acquired as a bitmap or extracted from the frames of the movie, is currently calculated (Goodman et al., 1984; Briers, 2001) as:

$$K = \frac{\sqrt{\left\langle \left(I(i,j) - \langle I \rangle \right)^2 \right\rangle}}{\langle I \rangle} \qquad (1)$$

In (1) K is a space contrast and not a time contrast, as it was pointed out by Nothdurft and Yao (2005) and by Chicea (2007b). In (1) the angular brackets stand for the average over the entire 640x480 pixels collection of intensity values for an image that is processed.

The movie was processed by a computer program written for this purpose. The program reads the movie, extracts frame by frame in a 640x480 array of intensity levels. We can note I(i,j) = I(xi, yj) the intensity recorded by the cell (i,j) of the CCD, hence by the pixel (i,j) of the array of pixels the image consists of. Once the array of intensities is extracted for each frame, the contrast of each particular frame is calculated using (1). The collection of contrast values is averaged and is considered to be the contrast value for that particular movie, hence for that particular sample. The standard deviation for the collection of values computed for one sample is considered to be the relative error in assessing the contrast for that particular sample; therefore the error bars in figure number 3 are the standard deviations.

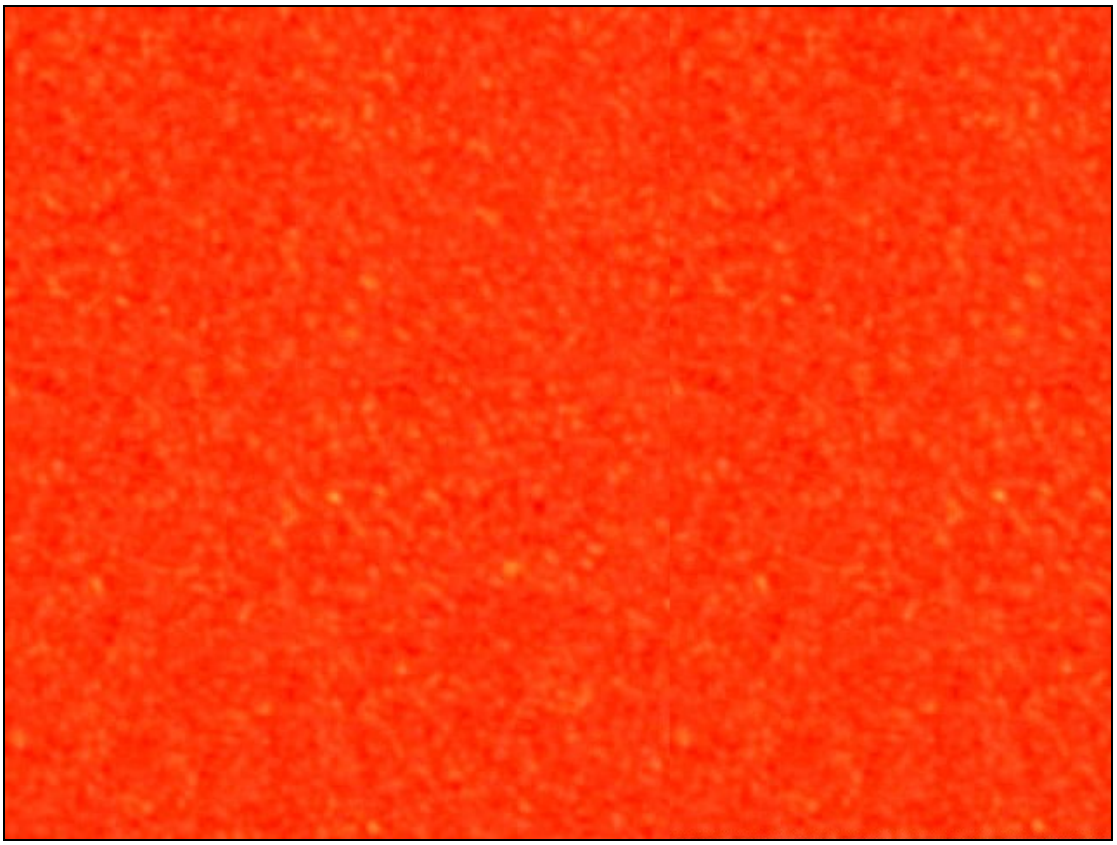

Figure 2: A frame taken from the movie recorded for the sample having a clay concentration of 3.53 g/l.

The procedure presented in this article is an improvement of the procedure previously described (Chicea, 2007b), where a CMOS was used rather than a CCD. The movie recorded was a MPEG4 format and not an uncompressed AVI, which considerably reduced the amount of free space required for data saving and processing on the hard drive of the PC. The program was written in MATLAB. The recorded movie was converted to CINEPAK compression prior to processing it.

A number of 22 samples having clay suspension with different concentrations were prepared. For each sample, the cuvette was filled with the sample and an AVI type of movie lasting for 30 seconds, containing 300 frames was recorded and processed using the contrast algorithm implemented in the computer program written for this purpose (Chicea, 2007a, b).

A simple, but longer lasting procedure was also used to measure the actual amount of sediment in a sample, as an alternative and control method. It consists of weighing an empty and freshly cleaned Petri dish, of adding 50 ml of suspension in the dish and allowing it to slowly evaporate at a temperature around 50^{o}C that was controlled by adjusting the distance from the dish to a 100 W light bulb. After the water evaporation was completed, the dish with the sediment was weighed again. If m_e states for the mass of the empty dish, m_t for the mass of the dish plus sediment, then:

$$m_s = m_t - m_e \qquad (2)$$

where m_s is the mass of the sediment. The error of measuring the sediment mass with this weigh difference procedure can be estimated as:

$$\varepsilon = \frac{2 * 0.001}{m_s} * 100, \quad \% \qquad (3)$$

where 0.001 g is the sensitivity of the electronic scale and m_s is expressed in grams. Equation (3) reveals that the error in measuring the sediment mass by weigh difference is not constant, but increases to unreasonably high values for samples containing very small amounts of sediment.

RESULTS AND DISCUSSIONS

The samples were prepared using the procedure described in the previous section starting with a concentration of 6.6 g/l and decreasing it by successive dilution down to 0.081 g/l. This concentration range is quite extended, as it covers two orders of magnitude. The average contrast was computed for each sample and the results are presented in figure 3.

We notice that the average contrast presents an indefinite trend in the very small concentration range. From 0.08 g/l to 0.35 g/l, the contrast decreases and then increases as the concentration increases up to 1.54 g/l. As the concentration increases further on up to 6.6 g/l the contrast exhibits a monotone decreasing trend. Overall, the curve that can be plot through the data points is smooth and the error bars are small when compared to the range of the contrast K values.

This result is similar with the results reported by (Piederrière et al., 2004b) on latex microspheres, although at a first look (Piederrière et al., 2004a) presents an almost linear decrease. Moreover, in Piederrière et al. (2004b), the decrease for 0.2 μm diameter microspheres is similar with the contrast decrease reported in this work. This can be explained by the much bigger concentration range used in this work. The work presented in Piederrière et al. (2004b) represents just a small area of the extended decreasing part of the curve in figure 3.

If we extract the extended range where the variation is monotone, which is 1.54 to 6.6 g/l, we find the plot in figure number 4. Examining the plot of the average speckle size variation with the concentration, we notice that the curve can be used as a calibration curve for measuring the concentration in the 2-6.6 g/l concentration range.

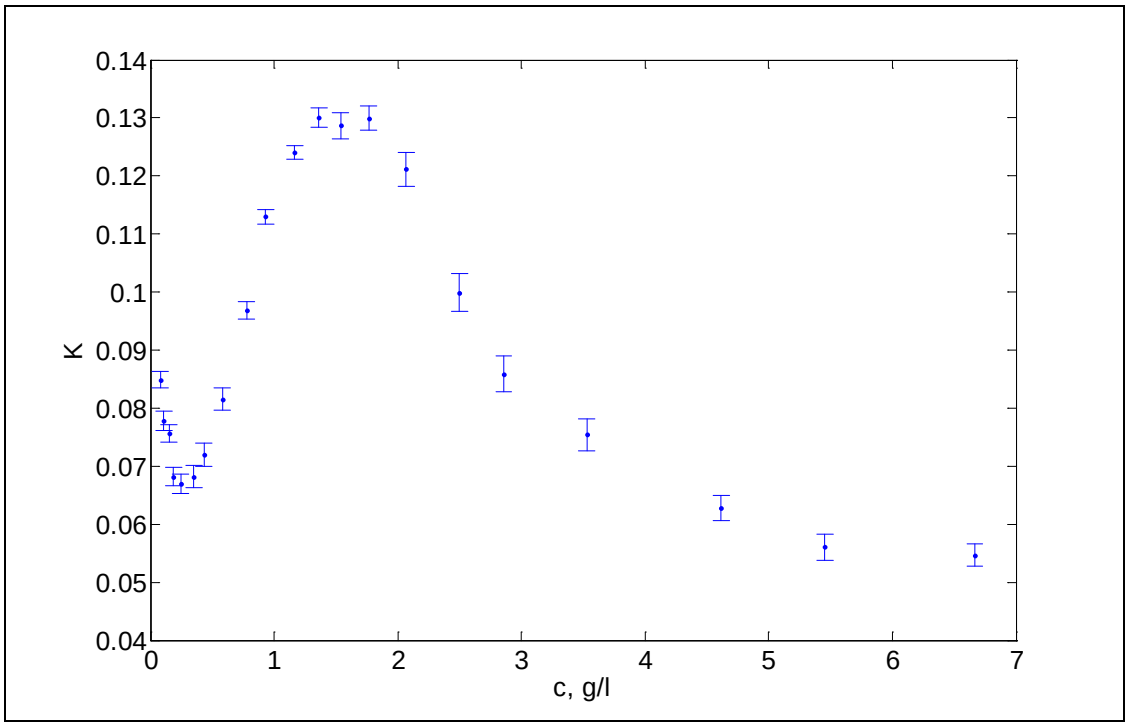

Figure 3: The average contrast versus clay concentration.

The procedure was tested for three samples with unknown clay concentration, obtained by mixing two unmeasured volumes of different diluted samples. The samples were analyzed both by the contrast and the evaporation followed by weight difference. The results are presented in table number 1, where the first column is the clay concentration measured by the sediment mass, after evaporation, divided by the 50 ml volume, the second column contains the concentration measured by average contrast assessment, the third column contains the error of the weight difference method, the fourth contains the error of the average contrast method, and the fifth contains the error of one method relative to the other, considering the weight method as reference.

Examining table number 1 data, we notice that the error of one method relative to the other is comparable with the sum of the relative errors of the two methods. This fact suggests that in the above mentioned concentration range the clay concentration can be assessed by the most rapid method described in the previous section. Moreover, the slope of the curve in figure number 4 is bigger in the smaller clay concentration range, which makes the speckle contrast method more precise in this range, where the weigh difference method has a lower precision, as pointed out by equation (3) and by the third column in table number 1.

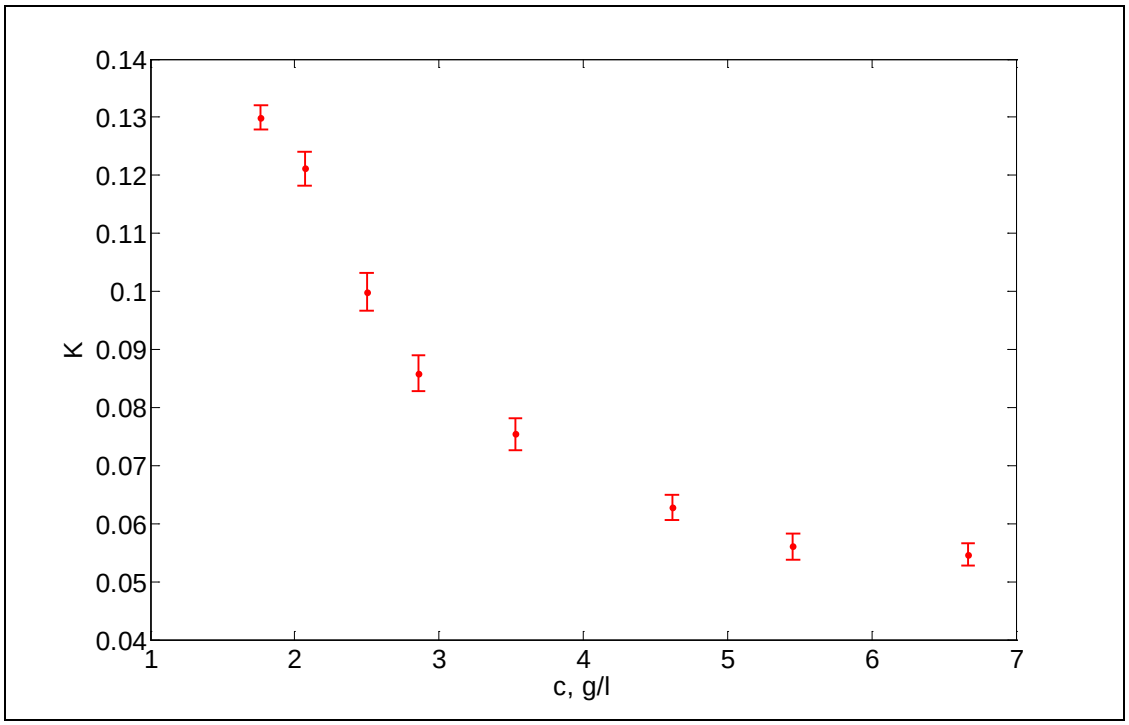

Figure 4: The average contrast versus clay concentration
in the range with a monotone decreasing trend.

The procedure described in the materials and method samples resembles to a certain degree to the physical procedure previously described (Chicea, 2012c), yet it is essentially different. In Chicea (2012c), a time series is recorded using a detector and the time series is processed by averaging the scattered light intensity, while in the work described here image processing is employed.

Table 1: The three unknown samples concentration and errors in measured concentrations.

c, g/l weigh difference	c, g/l contrast	Error of the weigh difference (%)	Error of the contrast method (%)	Error between methods (%)
2.69	2.57	1.6	3.3	4.5
4.61	4.81	0.8	3.5	4.3
5.79	5.94	0.7	3.6	2.6

CONCLUSIONS

A simple physical procedure using the far interference field of a coherent light beam incident on a suspension can be used to assess the clay concentration in natural water over a certain concentration range. The far interference field is recorded using a CCD and the movie is processed later on. The average speckle size is computed using a program written for this purpose and an algorithm previously tested. The average contrast variation with the concentration was found to be monotone (Fig. 4) over an extended concentration range, which is from 1.54 g/l to 6.6 g/l. This is a range with a relatively big concentration in natural water, as the water sample is opaque even for a 12 mm thick cuvette. For such a big concentration, turbidity is not measurable with the simple method using the Secchi disk (Waterwatch Australia, 2002). The monotone variation (Fig. 4) can be used as a calibration curve. An unknown sample can be used as a target for the laser beam and a movie can be recorded, the speckle size can be measured using the above mentioned procedure and the curve (Fig. 4) can be used to assess the clay concentration in that water sample.

The average contrast method has the advantage of being fast, as it does not require chemical or physical sample processing, but simply putting the sample in the cuvette, recording and processing the movie. Once the contrast is computed, finding the concentration from the plot (Fig. 4) is straightforward. A refinement might consist in fitting a polynomial on the data in figure number 4, considering the concentration versus contrast and using the polynomial for a direct calculation of the concentration from the computed contrast, which is the subject of a future work. The above mentioned steps can last less than ten minutes, once the calibration curve in figure number 4 is ready to be used. Nevertheless, a preliminary concentration assessment by sedimentation, evaporation and weighing the sediment has to be performed, in order to make sure that the concentration is in the monotone range (Fig. 4).

REFERENCES

1. Aizu Y. and Asakura T., 1991 – Bio-speckle phenomena and their application to the evaluation of blood flow, *Optical Laser Technology*, 23, 205-219.
2. Berlasso R., Perez F., Quintian Rebollo M. A., Raffo C. A. and Gaggioli N. G., 2000 – Study of speckle size of light scattered from cylindrical rough surfaces, *Applied Optic*, 39, 5811-5819.
3. Blănaru C., Țiculean M. and Sasu G., 2008 – The structure and dynamics of the phytoplankton from Dragomirna and Solca lakes (Moldavia, Romania), *Acta Oecologica Carpatica*, I, 1-6.
4. Boas D. A. and Yodh A. G., 1997 – Spatially varying dynamical properties of turbid media probed with diffusing temporal light correlation, *Journal of American Optical Society*, 14, 192-215.
5. Briers J. D., 2001 – Laser Doppler, speckle and related techniques for blood perfusion mapping and imaging, Physiological Measurement, 22, R35-R66.
6. Briers J. D., Richards G. and He X. W., 1999 – Capillary blood flow monitoring using laser speckle contrast analysis (LASCA), Journal of Biomedical Optics, 4, 164-175.
7. Chicea D., 2007a – Speckle Size, Intensity and Contrast Measurement Application in Micron-Size Particle Concentration Assessment, European Physical Journal Applied Physics, 40, 305-310, DOI: 10.1051/epjap:2007163.
8. Chicea D., 2007b – Biospeckle Size and Contrast Measurement Application in Particle Sizing and Concentration Assessment, *Romanian Journal of Physics*, 52(5-7), 581-587.
9. Chicea D., 2010 – Nanoparticles and Nanoparticle Aggregates Sizing by DLS and AFM, *Journal of Optoelectronics and Advanced Materials*, 4(9), 1310-1315.
10. Chicea D., 2012a – A Study of Nanoparticle Aggregation by Coherent Light Scattering, Current Nanoscience, 8(6), 259-265.
11. Chicea D., 2012b – A Coherent Light Scattering Procedure to Measure Very Small Concentration of Organic Suspension in Natural Water, *Transylvanian Review of Systematical and Ecological Research*, 14(2), 1-8.
12. Chicea D., 2013 – Estimating Particle Concentration in Natural Water by Speckle Size Measurement, *Proceedings of 11th International Conference on Environment, Ecosystems and Development (EED '13), Braşov*, Romania, June 1-3.
13. Chicea D., Indrea E. and Crețu C. M., 2012 – Assessing Fe_3O_4 Nanoparticle Size by DLS, XRD and AFM, *Journal of Optoelectronics and Advanced Materials*, 14(5-6), 460-466.
14. Coman A. and Sandu C., 2009 – Peculiarities of ecological evolution of Musura Bay (Danube Delta) between 2005-2007, *Romanian Journal of Biology* - Zoology, 54(2), 167-180.
15. da Costa G. and Ferrari J., 1997 – Anisotropic speckle patterns in the light scattered by rough cylindrical surfaces, *Applied Optics*, 36, 5231-5237.
16. Fedosov I. V. and Tuchin V. V., 2011 – The use of dynamic speckle field space time correlation function estimates for the direction and velocity determination of blood flow, *Proceeding of Society of Photonics and Imaging Engineering (SPIE)*, 4434, 192-196.
17. Fulga N. and Kiseliova O., 2006 – Sexual maturation of the industrial valuable species of fish females under modified conditions of the Dubăsar water accumulation reservoir, *Acta Ichtiologica Romanica* I, 93-102.
18. Giglio M., Carpineti M., Vailati A. and Brogioli D., 2001 – Near-field intensity correlation of scattered light, *Applied Optics*, 40, 4036-4040.
19. Goodman J. W., 1984 – Statistical Properties of Laser Speckle Patterns, in Laser speckle and related phenomena, vol. 9 in series *Topics in Applied Physics*, Dainty J. C., Ed., Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.
20. Gumpinger C., Höfler S., Berg K. and Scheder C., 2010 – Water temperature as an applicable parameter with a high indicative value for the general condition of a river-ecosystem, drawing on the example of the river Trattnach in Upper Austria, *Transylvanian Review of Systematical and Ecological Research*, 10 (eds Curtean-Bănăduc A. et al.), *The Wetlands Diversity*, 1-14.

21. Lehmann P., 1999 – Surface-roughness measurement based on the intensity correlation function of scattered light under speckle-pattern illumination, *Applied Optics*, 38, 1144-1152.
22. National Soil Survey Handbook Part 618 (42-55) Soil Properties and Qualities, 2006 – United States Department of Agriculture - Natural Resource Conservation Service, May.
23. Nothdurft R. and Yao G., 2005 – Imaging obscured subsurface in homogeneity using laser speckle, *Optics Express*, 13(25), 10034-10039.
24. Piederrière Y., Cariou J., Guern Y., Le Jeune B., Le Brun G. and Lotrian J., 2004 – Scattering through fluids: speckle size measurement and Monte Carlo simulations close to and into the multiple scattering, *Optics Express*, 12, 176-188.
25. Piederrière Y., Le Meur J., Cariou J., Abgrall J. F. and Blouch M. T., 2004 – Particle aggregation monitoring by speckle size measurement; application to blood platelets aggregation, *Optics Express*, 12, 4596-4601.
26. Sadhwani A., Schomaker K. T., Tearney G. J. and Nishioka N. S., 1996 – Determination of Teflon thickness with laser speckle, I, Potential for burn depth diagnosis, *Applied Optics*, 35, 5727-5735.
27. Salem A. H. I., 2011 – Morphometric measurement and field estimation of the size of *Crocodylus niloticus* in lake Nasser (Egypt), *Transylvanian Review of Systematical and Ecological Research - The Wetlands Diversity* 12 (eds Curtean-Bănăduc A. et al.), 53-76.
28. Waterwatch Australia National Technical Manual, Module 4, 2002 – Waterwatch Australia Steering Committee, Environment Australia, July 2002, ISBN 0-6425-4856-0.
29. Zimnyakov D. A., Briers J. D. and Tuchin V. V., 2002 – Speckle technologies for monitoring and imaging of tissues and tissuelike phantoms, chapter 18 in Handbook of biomedical diagnostics, Valery V. Tuchin, Ed. SPIE press, Bellingham.
30. Zubcov N., Zubcov E. and Schlenk D., 2008 – The dynamics of metals in fish from Nistru and Prut rivers (Moldova), *Transylvanian Review of Systematical and Ecological Research* 6 (eds Curtean-Bănăduc A. et al.), 51-58.

GERRIS LACUSTRIS (LINAEUS 1758) AND *GERRIS COSTAE* (HERRICH-SCHÄFFER 1850) SPECIES - HABITAT RELATIONS ON MOUNTAINOUS TRIBUTARIES OF VIŞEU RIVER (MARAMUREŞ, ROMANIA)

Horea OLOSUTEAN * and *Daniela Minodora ILIE* **

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Dr. Ion Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, mesaje.facultate@yahoo.com
** "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Dr. Ion Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, iliedf@yahoo.com

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KEYWORDS: *Gerris lacustris*, *Gerris costae*, Vişeu River basin, habitat characteristics.

ABSTRACT

Semi aquatic Heteroptera species from some mountainous tributaries of the Vişeu River were collected and their relations with habitat variables were investigated. Only two species, *Gerris lacustris* and *Gerris costae* were found, either one or both species, in almost half of the investigated sampling stations. Correlation analysis between samplings and habitat conditions showed that *Gerris lacustris* prefers small deep ponds or river banks with steep slopes and is easily adaptable to habitat changes, while *Gerris costae* is mostly found in large marshes with low, stagnant water and high amounts of vegetation. Both species are relatively tolerant to human impact in their habitat, *Gerris lacustris* more so. The two species are negatively correlated to each other, as an expression of competition between them. Principal Component Analysis resulted in two dominant factors explaining almost 60% of the habitat variation, and their graphic representation proved the observed correlations.

ZUSAMMENFASSUNG: Die Art-Habitat-Beziehungen von *Gerris lacustris* Linaeus 1758 und G*erris costae* Herrich-Schäffer 1853 an den montanen Zuflüssen des Vişeu (Maramuresch, Rumänien).

An einigen montanen Zuflüssen des Vişeu wurden die semiaquatischen Heteropteren gesammelt und ihre Beziehungen zu den Habitatbedingungen untersucht. Lediglich zwei Arten, *Gerris lacustris* und *Gerris costae* wurden allein oder zusammen an fast der Hälfte der untersuchten Probestellen eingefangen. Die Analyse der Korrelation zwischen den Arten und den Habitatbedingungen zeigten, dass *Gerris lacustris* kleinere Seen mit größerer Wassertiefe oder die steilen Ufer der Flüsse vorzieht und sich leicht an die Veränderung der Standortbedingungen anpasst, während *Gerris costae* eher in stehenden Gewässern, und zwar großflächigen Sümpfen mit niedrigem Wasserstand und üppiger Vegetation vorkommt. Beide Arten sind gegenüber menschlichen Eingriffen relativ tolerant, was für *Gerris lacustris* in verstärktem Maß zutrifft. Die beiden Arten stehen, als Ausdruck ihrer gegenseitigen Konkurrenz, in negativer Korrelation zueinander. Hauptkomponenten analyse (PCA) ergab zwei dominante Faktoren, die fast 60% der Variation des Habitats erklären, wobei ihre grafische Darstellung die eingangs erwähnten Korrelationen bestätigt.

REZUMAT: Relaţiile specie-habitat ale speciilor *Gerris lacustris* Linaeus 1758 şi *Gerris costae* Herrich-Schäffer 1853 pe afluenţii montani ai Râului Vişeu (Maramureş, România).

Au fost colectate speciile de heteroptere semiacvatice de pe câţiva afluenţi montani ai Vişeului şi au fost investigate relaţiile acestora cu condiţiile de habitat. Doar două specii, *Gerris lacustris* şi *Gerris costae* au fost capturate, singure sau împreună, în aproape jumătate din staţiile verificate. Analiza de corelaţie între specii şi condiţiile de habitat a arătat că *Gerris lacustris* preferă mici bălţi cu apă adâncă sau malurile abrupte ale râurilor şi se adaptează uşor modificărilor condiţiilor, pe când *Gerris costae* este mai degrabă găsită în mlaştini de dimensiuni mari, cu apă joasă, stagnantă şi vegetaţie abundentă. Ambele specii sunt relativ tolerante la impactul antropic, cu un plus pentru *Gerris lacustris*. Cele două specii prezintă o corelaţie negativă una faţă de cealaltă, ca expresie a competiţiei ce le leagă. PCA a rezultat în doi factori dominanţi care explică aproape 60% din variaţia habitatului, iar reprezentarea lor grafică a confirmat corelaţiile anterioare.

INTRODUCTION

Gerrids are widely spread epineustonic species, tolerant to habitat conditions changes or low anthropic impact, and easily adaptable to different climatic or geological assemblages (Andersen, 1982). For these reasons, they were collected throughout Romania, mostly on plane and hillside rivers and wetlands (Paina, 1975; Davideanu, 1999; Ilie, 2009; Olosutean et al., 2009), as well as in the Danube Delta (Kiss and Davideanu, 1994; Olosutean and Ilie, 2010). A total of nine Gerrid species have been sampled so far in Romania (Paina, 1975; Davideanu, 1999).

Mountainous rivers are scarcely studied from this group's point of view, mostly because of the relative absence of specific habitats, such as ponds, lakeshores, slow flowing creeks or little bays formed at the shore of rivers (Andersen, 1982; Davideanu, 1999). Therefore, little is known about Gerrid species distribution, habitat preferences or community compositions in such high altitude regions.

Vişeu River, a right side tributary of Tisa River, gathers its waters from a few mountainous areas of the Eastern Romanian Carpathians, before entering in the Maramureş Depression and becoming the largest river of this area. Some of its tributaries, springing from Maramureş Mountains - Socolău, Ruscova and Frumuşaua - and Rodna Mountains - Repedea River - were investigated, and the Gerrid species were correlated with habitat variables, in order to point out each species' preferences, following the trend of similar recent date studies (Karaouzas and Gritsalis, 2006; Nosek et al., 2007; Olosutean and Ilie, 2010b; Bloechl, 2010; Skern et al., 2010; Ilie and Olosutean, 2012), presenting a new, more ecologically based approach on the group and opening the discussion of a possible use of this group members as indicators of anthropic intervention in the natural habitats.

MATERIALS AND METHODS

Two field campaign results are at the base of this study, one from autumn 2007, for the mentioned Maramureş Mountains rivers, 11 sampling points, and one from September 2009, for Repede River, part of the Rodna Mountains, 16 investigated sampling points.

Samplings were similar in all sites, taking into consideration the structure of each station: one single sample of five to ten meters in length was taken, aiming to cover each habitat as much as possible (water surface and body, hygrophilous vegetation where present, station bottom); a standardized 25 minutes/station sampling interval was chosen for both campaigns.

The samples were collected with an entomological net with a 600 cm^2 mesh-size and 1 mm meshes. Species identification was made by the morphological features, using a stereo binocular, using keys from Poisson (1957) and Davideanu (1999). Species and higher taxa nomenclatures are according to Fauna Europaea (Aukema, 2004).

Relations between these two studied species and habitat characteristics were analyzed using Pearson Correlation Matrix (Pearson, 1896) and Principal Component Analysis (PCA) (Pearson, 1901). The considered habitat conditions were the speed of the water flow, measured in m^3/s, the size of the sampling stations, measured in m^2, and water depth, measured in m, to which we added vegetation coverage, estimated as percents of the water surface covered by aquatic or semi aquatic vegetation, and the degree of anthropic impact, again estimated as percents of the station surface affected by any type of visible anthropic influence (garbage, oil marks, wood scraps, lumber, etc.). These variables took part in the correlation matrix formation and in the principal component estimation. Species data, as number of individuals, was added as supplementary variables, in order to determine their position relative to the habitat variables, but in such a way that they do not influence principal component formation.

Data analysis and graphical interpretation were conducted in STATISTICA v. 8.0 by StatSoft.

RESULTS AND DISCUSSIONS

Twenty-seven sampling stations were investigated (Tab. 1), encoded after the river basins: F for Frumuşaua Basin, R for Ruscova Basin (including Socolău, a right side tributary of Ruscova) and Re for Repedea Basin. Only two Gerrid species were collected in 13 of the sampling stations.

Gerris (Gerris) lacustris (Linaeus 1758), the common pond-skater, is the most frequent species among European semi aquatic Heteroptera, found from the border of North Africa and the Caucasus (Lindberg, 1948) up to the vicinity of the Arctic Circle (65.5° N - Vepsäläinen, 1974). Its wide extension comes from the modesty concerning habitat preferences (Pfenning, 2008) and from its high tolerance to pollution of any kind (Guthrie, 1989). Fifty-eight individuals of the named species were found in ten out of the 27 station that constituted the base for this study.

Gerris (Gerris) costae (Herrich-Schaffer 1853), the moorland pond-skater, is by far a less frequent species than the previous, mentioned by Davideanu (1999) as rare to Romanian fauna. Although mentioned everywhere in Europe (Aukema, 2004), it has fewer sampling sites than *G. lacustris*, and it seems to prefer colder habitats with less anthropic influence. Because of those preferences, it is known for southern European countries as a mountainous species (Poisson, 1957; Davideanu, 1999), although it is frequent in lowlands in Northern Europe, where the climate is colder (UK National Biodiversity Network, 2011a, 2011b). The species is frequently associated with shallow waters covered by semi-aquatic vegetation, a trademark of the north European moors, hence their popular name. Seventeen *G. costae* individuals were sampled from six out of the 27 stations investigated on the Vişeu River tributaries.

Table 1: Gerrid species and habitat characteristics of the sampling stations (Olosutean and Ilie, 2008; 2010).

Station	Species		Habitat characteristics				
	G. lacustris (no. of individuals)	*G. costae* (no. of individuals)	Flow (m^3/s)	Vegetation (coverage %)	Anthropic impact (coverage %)	Size (m^2)	Depth (m)
F 2	2	-	0.1	50	0	5	0.5
F 3	1	-	0.3	30	20	5	0.3
F 5	10	-	0	10	0	8	1
F 6	4	-	0	70	0	5	0.5
R 2	13	-	0.3	20	70	2.5	0.3
R 4	21	1	0.05	80	40	3.5	1
R 5	1	-	0	0	90	25	0.5
Re 5	4	-	0.3	15	0	6.5	0.3
Re 6	1	1	0.2	15	0	6.5	0.5
Re 7	-	1	0	60	10	12	0.2
Re 8	1	1	0	20	50	3	0.5
Re 10	-	4	0	0	30	4	0.15
Re 11	-	9	0	90	0	30	0.1

The two species share similar features: relative large size (they were part of the former *Macrogerris* Andersen 1994 subgenus), fast water movement, ambush predatorial feeding (Andersen, 1982), the use of vegetation for sheltering and ovipositioning (Vepsäläinen, 1973), being somehow in competition for the same resources and habitats.

The correlation matrix (Tab. 2) shows sufficient correlation between habitat characteristics, making PCA possible. The highest values, around 37%, are referring to the relations between vegetation presence and anthropic impact, and between station size and the speed of the water flow. It is important that both values are negative, meaning the decrease of one variable at the increase of the other, normal values if we consider that aquatic vegetation is sensible to anthropic impact and that larger stations are mostly lotic.

Table 2: Pearson Correlation Matrix for species and habitat conditions.

	Flow	Vegetation	Anthropic impact	Size	Depth	*Gerris lacustris*	*Gerris costae*
Flow	1.000000	-	-	-	-	0.127704	**-0.346852**
Vegetation	-0.264246	1.000000	-	-	-	0.207536	**0.403370**
Anthropic impact	-0.017038	**-0.369321**	1.000000	-	-	0.225576	-0.198191
Size	**-0.368790**	0.227179	0.091308	1.000000	-	**-0.354810**	**0.598018**
Depth	-0.209894	0.009528	0.038736	-0.280527	1.000000	**0.681527**	**-0.454238**

As for the species *G. lacustris*, presents a very high positive correlation with the water depth, and a quite significant negative correlation with station size, meaning it prefers small ponds with relatively high depth; the other variables do not seem to be of importance for the species' distribution, but it is important that all correlations, excepting the one with station size, are positive, in other words, the species is somehow favoured by an increase in the speed of the flow, in the vegetation covering or in the anthropic impact, proving its well known adaptability.

G. costae is much more habitat constricted than its relative: four out of five variables influence in different degrees the species' distribution, the highest correlation being a positive one with the station size, seconded by a negative one to the station's depth; if we add the relatively high positive correlation to vegetation coverage and the similar negative correlation to the speed of the water flow, we can state that the named species prefers large, highly vegetated marshes, where the low water depth and slow current are perfect for the ambush predator it is. Out of our variables, the anthropic impact is the only one not influencing the distribution (probably the larger stations preferred by the species offer enough clean space for its individuals).

PCA performed on the given variables resulted in five Eigenvectors (Tab. 3). The first two factors (highlighted columns for table number 3) are responsible for 57.4% of the entire variation, therefore being the most important of them. The first factor is strongly and positively correlated with vegetation coverage and station size, and negatively correlated to flow speed, while the second factor is positively correlated to water depth, and presents strong negative correlations to anthropic impact or station size.

Table 3: Eigenvectors of the Correlation Matrix.

	Factor 1 (32.29%)	**Factor 2 (25.11%)**	Factor 3 (23.87%)	Factor 4 (10.58%)	Factor 5 (8.15%)
Flow	**-0.543506**	0.118198	**0.505391**	0.437749	-0.493545
Vegetation	**0.587991**	0.350637	0.124517	**0.695145**	0.180524
Anthropic impact	-0.262962	**-0.644547**	-0.389238	**0.557293**	0.230930
Size	**0.534234**	**-0.533260**	0.092804	-0.031097	**-0.648574**
Depth	-0.065670	**0.404074**	**-0.754292**	0.116647	-0.499848

The graphic representation of the species and habitat variables in relation to the first two factors is depicted in figure number 1. The strong positive correlation between *G. lacustris* and water depth, and *G. costae* and station size and vegetation coverage, already discussed, are visible here, as well as the negative one between *G. costae* and flow speed, or the negative one between *G. lacustris* and station size.

Also, an important mention is that the two studied species seem to be negatively correlated to each other, an expression of the competition between them for similar resources, especially on small size stations.

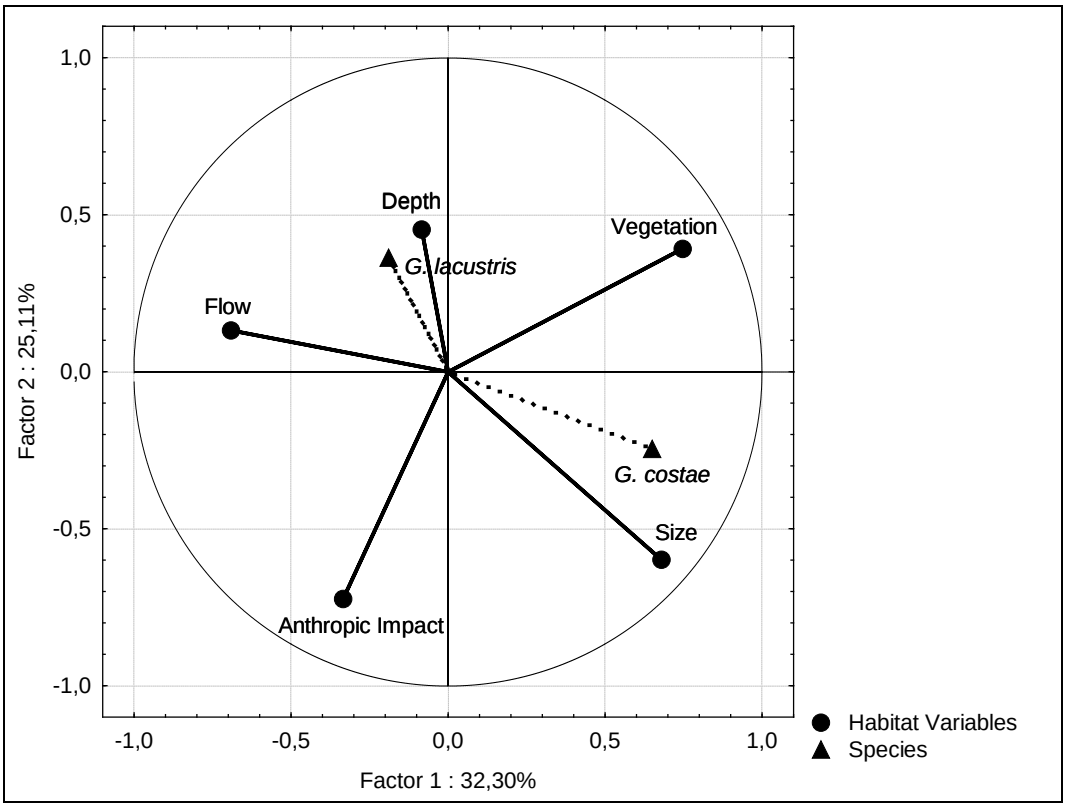

Figure 1: PCA biplot of the collected species
in relation to habitat conditions.

The relations between habitat variables and species distribution is not exactly matching previously published data, at least for *G. lacustris*. In that order, Nosek et al. (2007) found *Aquarius paludum* (Fabricius 1794) as the dominant Gerrid, and *G. lacustris* of secondary importance regardless of habitat conditions, Skern et al. (2010) found *G. lacustris* dominant and correlated with shore semi aquatic vegetation and shade, but indifferent to aquatic vegetation, while we previously found the species dominant in small stations, alone or associated with aquatic Heteroptera, regardless of habitat characteristics (Olosutean and Ilie, 2010b; Ilie and Olosutean, 2012).

This can lead to the conclusion that species-habitat relations are not constant for *G. lacustris*, being more of a local trade-mark, and there is a consistent possibility that they can change with the season or even from one year to another. In that order, large scale studies, on both time and space coordinates, are indicated, before coming up with a general conclusion regarding this aspect.

CONCLUSIONS

Only two of the nine Gerrid species of Romania are adaptable enough to inhabit high latitude studied mountainous regions. The two species are a known cold habitat species, *Gerris costae*, and the most adaptable and wide spread semi aquatic Heteroptera, *Gerris lacustris*.

Not all suitable habitats for the group are occupied by Gerrids, only 13 out of 27 investigated stations (less than 50%) presents members of this group. However, high altitudes are not very favourable in Romania for high densities and diversity of the group's members (Ilie, 2009; Olosutean and Ilie, 2008, 2010a, 2010b).

Gerris lacustris shows a strong positive correlation with water depth and negative correlation with station size, expressing a preference for small, deep puddles or steep river banks; all the other variables were slightly positive correlated with the species, proving once again its high adaptability and its high tolerance to ever-changing habitats.

Gerris costae is much more habitat dependent, presenting strong correlation with four habitat variables: positive correlations with size and vegetation presence, and negative ones with flow speed and water depth, proving its preference for large marshes or low depth puddles, where vegetation grows abundant and the water is almost stagnant. Its slight negative correlation with anthropic impact presents it as much more sensible to this factor than its relative, but still able to resist at low human interferences.

Correlations of different degrees are present between the habitat variables taken into concern for the present study, allowing their decomposition into fewer principal components. The first two obtained factors are representing almost 60% of the habitat variation. The graphical representation of those two factors confirms all correlation presented above.

The results are not identical to other similar studies made on this group, revealing a local specificity of the area. Even more, it seems that relations between habitat and community composition or species distribution vary for at least some semi aquatic Heteroptera from one area to another, proving the necessity for extended further studies in this field of interest.

REFERENCES

1. Andersen N. M., 1982 – The semiaquatic bugs (Hemiptera, Gerromorpha) phylogeny, adaptations, biogeography and classification, Scandinavian Science Press Ltd., 445.
2. Aukema B., 2004 – Fauna Europaea: Heteroptera - Nepomorpha, *Fauna Europaea version 1.1*, http://www.faunaeur.org.
3. Bloechl A., Koenemann S., Philippi B. and Melber A., 2010 – Abundance, diversity and succession of aquatic Coleoptera and Heteroptera in a cluster of artificial ponds in the North German Lowlands, *Limnologica*, 40, 215-225.
4. Davideanu A., 1999 – Contribuţii la studiul heteropterelor acvatice din România, *PhD thesis, unpublished.*
5. Guthrie M., 1989 – Animals of the surface film, Slough, Richmond, 92.
6. Ilie D. M., 2009 – Heteropterele acvatice şi semiacvatice (Heteroptera, Nepomorpha, Gerromorpha) din bazinul mijlociu al Oltului, Ed. Altip, Alba Iulia, 279. (in Romanian)
7. Ilie D. M. and Olosutean H., 2012 – Aquatic and semi aquatic Heteroptera communities from south-east Transylvanian small rivers, *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, 55(2), 206-217.
8. Karaouzas I. and Gritsalis K. C., 2006 – Local and regional factors determining aquatic and semi-aquatic bug (Heteroptera) assemblages in rivers and streams of Greece, *Hydrobiologia*, 573, 199-212.
9. Kiss B. and Davideanu A., 1994 – Heteroptere acvatice şi semiacvatice din Rezervaţia Biosferei Delta Dunării, *Analele Ştiinţifice ale Institutului Deltei Dunării*, 3, 149-154. (in Romanian)

10. Lindberg H., 1948 – Zur kenntnis der insektenfauna im brackwasser des Baltischen Meeres, *Societas Scientiarum Fennica, Commentationes Biologicae*, 10, 1-206. (in German)
11. Nosek J. N., Vásárheli T., Bakonyi T. and Oertel N., 2007 – Spatial pattern of waterbugs (Gerromorpha, Nepomorpha) at different scales in the Szigetköz (Hungary), *Biologia*, 62(3), 345-350.
12. Olosutean H. and Ilie D. M., 2008 – Aspects regarding the diversity of aquatic and semiaquatic Heteroptera from Maramureş Mountains Nature Park, *Transylvanian Review of Systematical and Ecological Research*, Curtean-Bănăduc A. et al., (eds), 5, 63-73.
13. Olosutean H., Ilie M. D., Axinte S. and Drăgoiu A., 2009 – Biodiversity analisys on aquatic and semiaquatic Heteroptera (Heteroptera, Nepomorpha - Gerromorpha) from two Transylvanian (Romania) lake complexes, *Acta Oecologica Carpatica*, II, 141-148.
14. Olosutean H. and Ilie D. M., 2010a – Influence of anthropic impact on aquatic and semiaquatic Heteroptera distribution from Repede River (Rodna Mountains National Park), *Transylvanian Review of Systematical and Ecological Research*, Curtean-Bănăduc A. et al., (eds), 9, 149-158.
15. Olosutean H. and Ilie D. M., 2010b – Relationships between habitat characteristics and aquatic and semi aquatic Heteroptera community structure in Romanian mountainous regions: a preliminary report, *Romanian Journal of Biology - Zoology*, 55(2), 139-148.
16. Paina M. I., 1975 – Lista heteropterelor acvatice şi semiacvatice (Order Heteroptera) din R. S. România, *Nymphaea*, III, 99-115. (in Romanian)
17. Pearson K., 1896 – Mathematical contributions to the theory of evolution III: Regression, heredity and panmixia, *Philosophical Transactions of the Royal Society A*, 187, 253-318.
18. Pearson K., 1901 – On lines and planes of closest fit to systems of points in space, *Philosophical Magazine*, 2(6), 559-572.
19. Pfenning B., 2008 – Seasonal life-history adaptation in the water strider Gerris lacustris, *Ph. D. Thesis*, Julius Maximilians Universität, Würzburg.
20. Poisson R., 1957 – Faune de France: Hétéroptères aquatiques, *Librairie de la Faculté de Sciences, Paris*, 265. (in Frech)
21. Skern M., Zweimüller I. and Schiemer F., 2010 – Aquatic Heteroptera as indicators for terrestrialisation of floodplain habitats, *Limnologica*, 40(3), 241-250.
22. United Kingdom National Biodiversity Network, Aquatic Heteroptera recording scheme, 2011 – Aquatic Heteroptera Dataset (accessed through GBIF data portal, http://data.gbif.org/datasets/resource/960, 2011-02-11)
23. United Kingdom National Biodiversity Network, Biological Records Centre, 2011 – Water Bug (aquatic Heteroptera) data for Britain (accessed through GBIF data portal, http://data.gbif.org/datasets/resource/942, 2011-02-11)
24. Vepsäläinen K., 1973 – The distribution and habitats of Gerris Fabr. species (Heteroptera, Gerridae) in Finnland, *Annales Zoologica Fennici*, 10, 419-444.
25. Vepsäläinen K., 1974 – The life cycles and wing lengths of Finnish Gerris Fabr. (Heteroptera, Gerridae), *Acta Zoologica Fennica*, 141, 1-73.

HABITAT VULNERABILITY FOR THE NILE CROCODILE (*CROCODYLUS NILOTICUS*) IN NASSER LAKE (EGYPT)

Ashraf Hussein Ibrahim SALEM *

* Nature Conservation Sector, South Area Protectorates, Environmental Affairs Agency, Cairo, Egypt, ashraf2404@yahoo.com

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ABSTRACT

The study presents the results of a field investigation of the crocodile nesting sites on Lake Nasser, observed during the breeding season 2009-2010. A relatively low number of nesting sites was found, explained by the intensity of anthropogenic activity in the area and by the low water levels of Lake Nasser. Based on analysis of satellite imaging and its correlation with the biotope data of the lake shores, a classification system of habitats and of their suitability for crocodile nesting was established. Correlated with land use information, the results can lead to the identification of potential nesting sites for the Nile crocodile, establishing a legal protection system for such habitats.

ZUSAMMENFASSUNG: Die Anfälligkeit der Bruthabitate des Nilkrokodils (*Crocodilus niloticus*) im Nasser See (Ägypten).

Vorliegende Untersuchung umfasst die Ergebnisse einer Feldforschungskampagne betreffend die in der Paarungszeit 2009-2010 beobachteten Nilkrokodile aus dem Nasser See. Es wurde eine relativ geringe Zahl von Nestern entdeckt, was auf die Intensität menschlicher Tätigkeiten sowie den niedrigen Wasserstand zurückzuführen ist. Aufgrund der Bearbeitung von Satellitbildaufnahmen und deren Korrelation mit den Biotopdaten der Ufer wurde ein Klassifikationssystem der Habitate hinsichtlich ihrer Kapazität der Beherbergung von Korkodilnestern erstellt. Korreliert mit den Landnutzungsdaten können die Ergebnisse zur Identifizierung potentieller Brutplätze des Nilkrokodils führen und damit die Grundlage eines legalen Schutzsystems dieser Habitate liefern.

REZUMAT: Vulnerabilitatea habitatului de cuibărit a crocodilului de Nil (*Crocodilus niloticus*) în lacul Nasser (Egipt).

Studiul prezintă rezultatele unei campanii de teren asupra crocodililor din lacul Nasser, observaţi în sezonul de împerechere 2009-2010. Un număr relativ mic de cuiburi a fost descoperit, fapt explicat de intensitatea activităţilor antropice şi de nivelul scăzut al lacului Nasser. Pe baza prelucrării imaginilor satelitare şi a corelării acestora cu datele de biotop aferente malurilor a fost stabilit un sistem de clasificare a habitatelor, în funcţie de capacitatea acestora de a găzdui cuiburi de crocodili. Corelate cu datele de utilizare a terenurilor, rezultatele pot conduce la identificarea potenţialelor locuri de cuibărire ale crocodilului de Nil, punând bazele unui sistem de protecţie legală al acestor habitate.

INTRODUCTION

The major conflict between man and crocodile for living space can only be understood once each of the living species necessities is investigated. The fishermen camps and Bedouin communities along the Nasser Lake shoreline require resources from the lake and while acquiring these resources, the community members create disturbances to crocodile life, including their nesting activities. To facilitate the identification of areas of human disturbance and their intensities, the activities and their timing in relation to crocodile nesting need to be assessed in Nasser Lake area.

Throughout the history, humanity's tendency to occupy areas in close proximity to resources and open spaces is obvious. This occupancy is usually detrimental to some natural resources, as human populations continue to increase, while the living space becomes smaller and smaller in time. The inability of man to use the natural resources without depleting stocks or disturbing natural processes is a concern for our world, especially for some species that inhabit it. The Nasser Lake crocodile is just one of the species suffering from human disturbances.

The Nasser Lake in Egypt is certainly an unique water reservoir which not only provides a continuous water supply to Egypt, but also supports many local communities, fishermen and others as well as a huge diversity of fauna and flora; fishing, grazing, tourism, plant collection, mining and agriculture are just some of the common activities associated with the surrounding communities along the shoreline.

The Nile crocodile, *Crocodylus niloticus*, is the fresh water top predator throughout Nasser Lake and in a large part of Africa. They are strict carnivores and relentless predators throughout their lives as they grow from 30/33 cm in total length up to 6.20 m and weighing over 750 kg. Like all true crocodiles, this is a tropical/sub-tropical species, rarely found where mean water temperatures are below 15-20˚C (upland areas and the south of the continent), being rare in moist forest and extensive swamps, where it is replaced by *Crocodylus cataphractus* and *Caiman crocodylus*. Its absence from these habitats is strongly linked to those geomorphological characteristics of rivers and lakes which have a directly influence on the nesting behavior (Hutton and Games, 1992).

The Nile crocodile prefers permanent, still or slow-moving water with high, sunny, sandy banks above flood levels and enough vegetation to provide shade and shelter. Much of rural Africa does not possess modern infrastructure and western-style economic development, water being a scarce commodity and waterways become life support systems (fishing, watering of livestock, irrigation for crops, recreation, etc.), providing water for domestic use and irrigation and supporting transport systems.

High sandy river banks, essential for crocodile ecology, are also good fishing camps and village sites, therefore fishermen activities had a severe influence on the nesting success of crocodiles and on the crocodiles themselves. Illegal hunting practices lead to huge areas of destroyed natural habitat, seconded by illegal trades of hatchlings and/or skins.

Recently, it was observed a severe reduction in the number of adult individuals due to the direct threats. From this study will benefit the scientific and conservation management communities, both nationally and internationally, by creating a comprehensive management plan to control the Nile crocodile life threats in Nasser Lake area. Finally, the low numbers of breeding length adults and a decrease in nest numbers, combined with the associated human activities occurring in lake Nasser area, has led to the question of what influence humans are having on crocodile population due to the disturbance associated with their specific habitats.

The aim of the study is to indicate crocodile habitat/nesting habitat suitability in relation to human disturbances, in order to have the remained suitable habitat protected in the form of a proposed sanctuary based on a GIS framework.

The objectives of the present study are to:

- record all available nesting preferences of crocodiles in lake Nasser by carrying out a thorough diurnal and nocturnal survey of all the available nesting sites;
- create a habitat suitability map based entirely on nesting requirements and ecological criteria obtained from the nesting survey, factors such as distance from water, vegetation structures and location on the lake Nasser are taken into concern;
- establish habitat vulnerability by determining the difference between the habitat suitability map and the habitat disturbance map, which will indicate the extent of non-disturbed or available habitat remaining in the system.

Indentify the remaining suitable habitat (vulnerable) for protection designation in the form of a proposed sanctuary or a nature conservation sector, in order to put lake Nasser as a whole under the protection of the law.

MATERIALS AND METHODS

Georeferences and image rectification

Geographic coordinates of sites were determined by a GPS e Trix H as UTM WGS 1984. The Landsat ETM+ satellite images were rectified using a topographic map (1:50,000) of lake Nasser using ERDAS 9.2 and Arc map 9.1. I used Image to Image rectification using Geometric Correction Tool, recorded GCPs and resample the image. The GCPs were digitized and spread out across the image to form a large triangle. After we digitized the fourth or more GCPs in the first Viewer, the GCP is automatically matched in the second Viewer. This occurred with all subsequent GCPs that were digitized. ERDAS IMAGINE 9.1 automatically updates the transformation on the screen, thus making possible to make visually based judgement for the result as the set of GCPs are changed. Since the true error of each individual position is unknown, the sampling to obtain an optimal set of GCPs was done by "trial and error" until the root mean square (RMS) error was minimized at the same time as the fit between the image and the full reference data set was maximized. ArcGIS 9.2 was used for rectification of the images, in order to set a higher accuracy for the rectification process.

Satellite Data

Landsat ETM+ data and aster images acquired in 2009 (Fig. 1) with ground resolution of 30.0 m false color composite (FCC) of Eight bands (Tab. 1) was used for Nile crocodile habitat features extraction and modeling purpose.

Table 1: Features of Landsat ETM+ sensor.

Bands	Wavelengths (m/s)	Resolution (m)
1	0.45-0.52	30
2	0.52-0.60	30
3	0.63-0.69	30
4	0.77-0.90	30
5	1.55-1.75	30
6	10.40-12.50	60
7	2.09-2.35	30
8	0.52-0.90	14.25

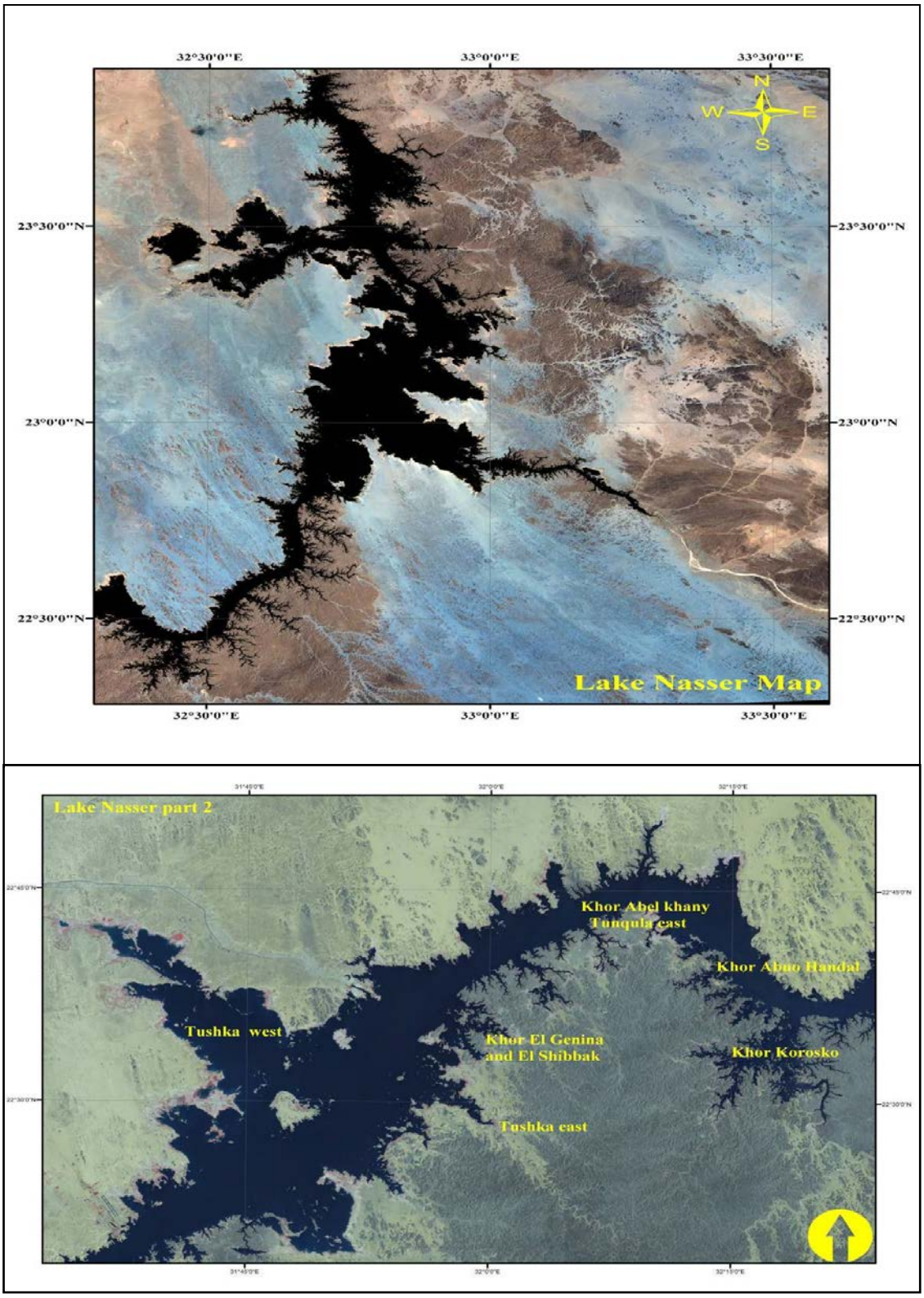

Figure 1: Nasser Lake FCC image.

Different band combinations of the landsat ETM+ data serve for an easy separation of features of interest: band 1 provides increased penetration of water bodies and also allows differentiation between soil or rock surfaces and vegetation; band 2 is sensitive to water turbidity differences, highlighting turbid water, and, because it covers the green reflectance peaking from leaf surfaces, it is capable of separating vegetation (forest, croplands, etc.) from soil, therefore barren lands, urban areas and roads appear as brighter (lighter) tone, while forest, vegetation, bare and cultivated fields appear as darker tone; band 3 is sensitive in a strong chlorophyll absorption region and strong reflectance region for most soils, distinguishing between vegetation and soil; band 4 and band 5 show a high reflectance in healthy vegetated areas, being helpful in comparing flooded areas and vegetated areas; band 6 (thermal infrared) measures the amount of infrared radiant flux (heat) emitted from surfaces; band 7 is capable of sharply distinguishing land and water; band 8 is helpful for improving image resolution at layer stack process.

Mapping of habitat fitness

Based on the survey data and habitat suitability parameters, the specific areas which favor the presence of crocodiles can be identified. Due to the large extent of Nasser Lake, these factors were introduced in Arc GIS (ARC Map 9.2) to create an image for habitats and in ERDAS IMAGINE 9.1 to extract areas that are also suitable for crocodiles, based on the data collected from crocodiles survey. The entire dataset was used to create a habitat suitability map, based on the specific spatial habitat requirements of the studied species. The map reveals all areas within the study area, which have suitable values of the environmental variables required for crocodiles. By identifying the difference between the habitat suitability map and the disturbance map, areas with crocodile suitability which are free of any disturbances can constitute a priority conservation map.

Field work and activities

The fieldwork in Nasser Lake was conducted from October 2009 to August 2010. We censured the crocodile population using spotlight surveys (Bayliss, 1987; Salem, 2010). A five meter fiberglass-boat fitted with an outboard motor 25/15 hp Yamaha/Mariner, was used for every count activity. The boat was always operated at an average speed of about 5-15 km/h in order to scan the water and the shoreline of khors for crocodiles' reflective eyes. The speed of the boat was reduced at each sighting, in order to approach slowly the crocodile and estimate their size. The team consisted of four persons, two observers who spotted and counted the crocodiles, a member of the team who recorded the sightings and a boat driver.

The survey started 15-30 minutes after sunset or as soon as it became dark enough to use the spotlight method. A 100,000 to 200,000 Spot flood Q-beam spotlight "Brinkmann", and 12-volt headlights were used. Total length (TL) was estimated for each spotted crocodile, and its position was obtained with a Garmin etrix®GPS 12.

The purpose of the sampling technique is to estimate the number (N) of individuals present in an area from a sample count (C) of that area, the expected value of the count being given by $E(C) = N*p$, where p is the detection probability (Nichols et al., 2000).

The nesting surveys were carried out by patrolling shorelines by boat or by foot, as close to the water as possible, looking for specific marks on the sandy shoreline banks, or for occurrence of shrubs/trees of *Tamarix nilotica* and other related species known as signs of potential nesting sites.

Environmental parameters were recorded at each site: date and nest number; location name and position; vegetation coverage and type; distances to water (m); height above water (m); the amount of direct sunlight received by each nest, estimated as the daily percentage of direct sunlight on the nest; depth to first egg (cm); depth and breadth of the hole; soil type.

RESULTS

Nile crocodile presence

A total of 528 presence points of crocodile locations were recorded by Garmin GPS and the habitat features of the location were noted for data analysis and interpretation. The survey route was plotted on landsat ETM+ maps of Lake Nasser (as shown in the following images), as well as the crocodiles sighting, on the other hand. In all images, the survey routes represented by the yellow/yellowish color line and the white or red represented the crocodiles sighting using Arc map 9.2 software. This image illustrated the buffer zone border as an example of how the buffer zone was estimated at 100 m in and out of the survey route (maximum distances for the survey tracks and also the distance for maximum point for the nests, based on nesting survey - Annex I).

Database

The GPS locations of the 528 presence points were converted to UTM WGS 84 Zone 36 N projections, similar to FCC. Thus, 528 points were used for creating presence location shape files in Arc GIS and overlayed on FCC (Fig. 2) for revealing Nile crocodile's location in lake Nasser, for each location survey during field trips as well as for nocturnal surveys.

The Landsat ETM and FCC with 30 m ground resolution were used to prepare the land use/land cover map of the study area. We selected the bands 1, 2, 3, 4, 5, 7 and 8 of 30 m resolution (except for band 8, with a 15 m resolution) and layer stacked for further analysis. Supervised classification technique has been used, with a maximum likelihood decision rule for image classification. The band 6 was cancelled in the layer stack process and supervised classification. The shoreline of the lake Nasser is continually undergoing a wide range of geomorphologic and environmental changes, due to natural causes (water levels, depth, temperature, pH, TDS, conductivity, dissolved oxygen, light transparency, phosphate, nitrate, nitrite, ammonium, sulphate, hydrosoil phosphate, nitrate, nitrite, ammonium, organic matter; watersand dunes movement, erosion, climatic changes) and to human activities (settlements, agriculture, fishing, industrial activities, tourism and recreational activities, wastes disposal). (Yacoub, 2009; Salem, unpublished data)

For an effective use of the land cover map in the modeling process, we defined cover classes that were relevant for Nile crocodile: 1) Water, 2) Sand Sheets, 3) Sandy areas, 4) Granite Mountains, 5) Basement rocks and 6) Vegetation, subdivided into natural vegetation and agricultural fields. The classification system focuses on land-cover classes that can be discriminated primarily from satellite remote sensor data.

Land covers classification (Supervised classification)

The supervised image classification was performed to generate land cover classes, and thus the classification map targeted to model the habitat suitability for Nile crocodile (Fig. 3).

Based on image classification, it was observed that *Tamarix nilotica* and other natural vegetation types represented 606 km^2 (7.6%) of the subset image, cultivated land around lake Nasser shoreline about 26.7 km^2 (0.33%), areas with basement rocks about 1,122 km^2 (14.1% of the subset image), sandy areas represented 2,675 km^2 (33.6%), sandy sheets about 595 km^2 (7.5%), granite areas represented 239 km^2 (3%), water bodies, about 2,615 km^2 (33% of the selected area for classification) and desert wadis, 81 km^2 (1.1% of the selected area for classification). All image classifications were carried out for the larger partition of the lake.

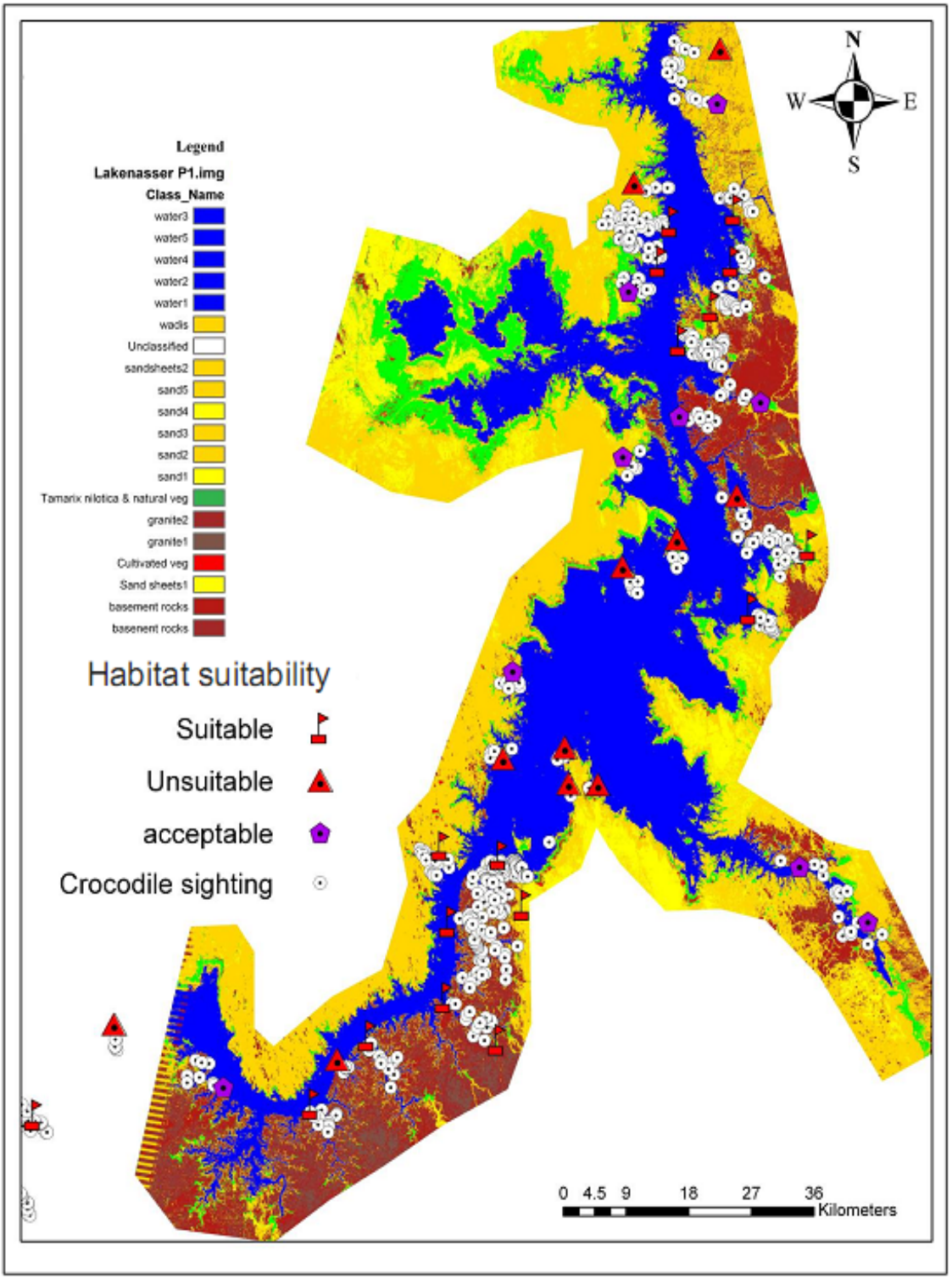

Figure 2: Nasser Lake land cover map/vegetation map,
based on supervised classification.

Based on the nocturnal spotlight survey and the supervised classification scheme of classification, areas with 0-5% occurrence probability were considered as unsuitable, areas with 5-20% probability were considered as acceptable (moderately suitable), and areas with over 20% (up to around 75%) species occurrence probability were considered as suitable habitats (Fig. 3). Briefly, they can be reclassified into two classes - unsuitable (0-5% occurrence probability) and suitable (5-75% occurrence probability).

While suitable habitats include areas currently being used by the Nile crocodile and the areas that could be potentially used (mostly all other land cover types that were in proximity to natural vegetation), the settlement and agriculture areas, fishermen camps, steep and rocky shorelines were classified as unsuitable habitats for the crocodiles.

DISCUSSION

Evaluation of potential area for Nile crocodile can be considered as one of the most important steps towards the conservation of the Nile crocodile in Nasser Lake, as well as the first step towards a true management for the Nile crocodile.

The conservation of the Nile crocodile populations and the effective management of their habitats depend mainly on our ability to recognize and predict species-habitat interactions. Intensive ground surveys cannot keep pace with the rate of land use change and, consequently, habitat composition changes over large areas. We explored how effectively do remote sensing satellite imagery and GIS modeling technique can be used for assessing habitat suitability of Nile crocodile in lake Nasser and which are the habitat factors influencing Nile crocodile distribution in lake Nasser.

The spatial relationship between vegetation types and soil types, the availability of the shoreline, the areas with less and no human disturbance influence the abundance and progress/regress of the Nile crocodile.

The study of the relationships between species and their environment has been traditionally a central issue in ecology and is, at the moment, one of the most important aspects in conservation and management planning of the Nile crocodile in the Nasser Lake. However, dynamic properties of animal distribution can rarely be reflected accurately in a static map, even though we have a good knowledge of the species biology. Moreover, human and logistic limitations make unreasonable the surveillance of large areas and, inevitably, our knowledge of the spatial distribution of most species will have many gaps. Seone et al. (2004) discussed the problem and concluded that the common solution to this problem is to resort the predictive habitat modeling and regard the results concerning the potential habitat, which can be reached and colonized by a species.

Interactions between organisms and their biotic and abiotic environmental conditions strongly influence the habitat use, the spatial habitation of species, and the proportion of each species within the community, and thus, the community composition and structure. In accordance with that, our study results have shown that the areas of sand and sandy-rocky or alluvial deposits-rocky, and other mixed areas which characterize the end part of the khors are the important areas for crocodile presence, and both the GIS analysis and field results confirmed this hypothesis.

Finally, as human population increases in size and demands more resources, their expansion happens in a detrimental way for wildlife habitat (Mwalyosi, 1991). Wildlife management and conservation initiatives are only possible with the appropriate information on wildlife and its habitat. The case of Nasser Lake is not an exception, fact proved by the increasing demand of fishermen for space and resources, the destruction of nests and suitable habitats for crocodiles and by the need to control the number of crocodiles in the lake.

Areas with aquatic vegetation, sandy or alluvial soils, slopes under 30º and low human impact are the best areas for hatchling of the Nile crocodile and that was emphasized by old field works made by the author and is similar with the reports of Hutton (1984) and Botha (2005). Therefore, the availability of contiguous aquatic and semi aquatic vegetation and natural vegetation on the lake's shoreline, along with a sufficient distance from disturbing factors are considered to be suitable conditions for the crocodile's presence.

These parameters can be detected in appropriate resolution satellite imagery, with clear distinction between the features of interest. Landsat ETM+, which was used by the author, because of its availability, is limited to a maximum resolution of 14.25 m, which, at the size of Nasser Lake, may produce some estimation errors.

The results, however, allowed us to create a habitat suitability map based on the ecological factors and disturbance factors, such as fishermen activities occurrence, boats traffic, human disturbance (tourism, agricultural activities, pollution, etc.), settlements, etc. Such disturbances are shoreline erosion, pollution from motor boats and other engines, noise effect due the boat traffics and disturbances of the vegetation and of other environmental variables related with the crocodile presence.

It was observed the fact that the boats passing close to nests creates significant noise and disturbance especially for crocodile females, who quickly enter in the water. According to Nasser Lake authorities, most areas are sometimes crowded by fishermen, this meaning associated noise which represents an important disturbance for nesting crocodiles, especially at the end of the local khors, where suitable nesting habitats are generally found. Field investigations proved that at least one of every eight boats carries and engine, which, along with noise disturbance, is a source of pollution, due to emissions and oil or fuel spills, which impact the aquatic vegetation and the entire local food chain. Agriculture related substances, such as fertilizers and pesticides, also play their role in the local pollution and habitat degradation.

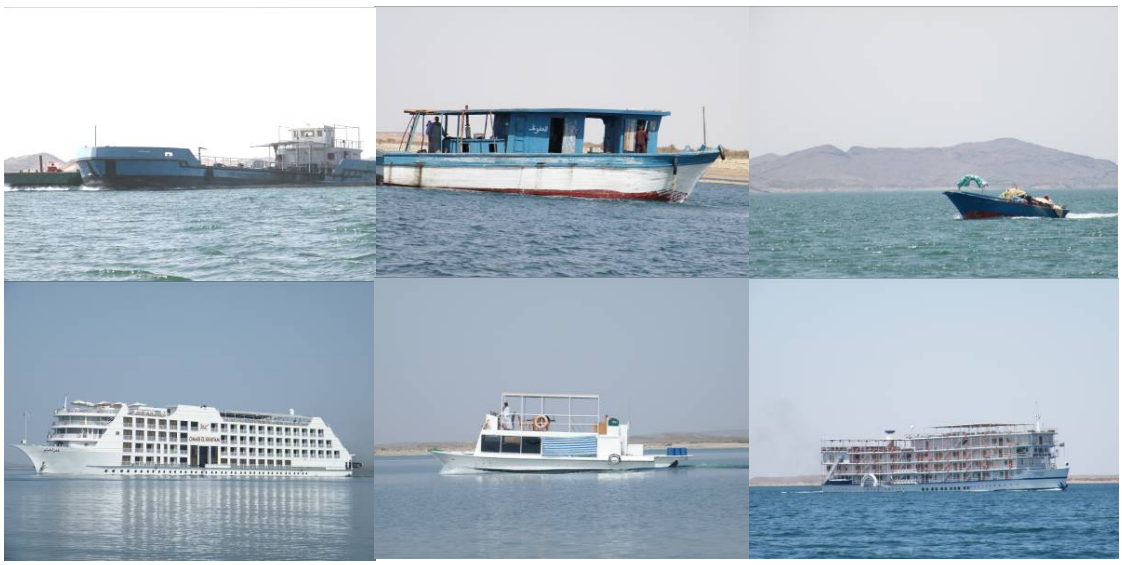

Figure 3: Touristic boats moving on Nasser Lake.

Tourism related impacts represent one of the human impact growing disturbance for crocodiles nesting in the Nasser Lake system. It was noted the fact that during the expedition, cruise ships and tourist boats can quickly produce high waves (Fig. 4), which are eroding the sandy shorelines, one of the suitable areas for the crocodiles. This is in accordance with similar investigations made by Mbaiwa (2002), who studied environmental impacts of tourism development on the Okavango Delta, finding that a major impact on wildlife in that delta was caused by the increased boat traffic on the river.

In the last ten years, with the increasing demand for fish and with the increases in the market price for such fish, fishermen used nets and advanced fishing equipments for large quantities of captures (Fig. 5), restricting in this way the movements of crocodiles in khors. The result has been the radical decrease of crocodile ways and paths number, hence the numerous fishermen claims that the crocodiles destroyed fishing equipments and fishing nets, this being a good reason for killing the crocodiles.

Figure 4: Fishing boats on Lake Nasser.

Based on Bishai et al. (2000) and personal observations (Salem, 2006), it is known that the water level of the lake reaches its maximum in November and December, and then drops gradually till July. The water level drop gives the local inhabitants (Bedouins) and farmers access for grazing and agriculture; unfortunately, these agriculture lands are mostly located on sandy shorelines (Fig. 6), which are a suitable habitat for crocodile nesting.

Figure 5: Agricultural landscape on the shores of Lake Nasser.

Fishing is the main activity that influences shoreline areas, and continues throughout the crocodile nesting period, not being influenced by water levels, as are other activities, like grazing and agriculture. On the other hand, the Nasser Lake fishermen are known to destroy crocodile eggs and nesting sites (Leslie, 2003). Cassidy (2003) reported that humans and crocodiles naturally come into conflict over certain resources, and the damage of this keystone species will have very severe implications for the ecosystems and for the people relying on them for resources. Therefore, I recommend that the human impacts on crocodile habitats in Nasser Lake must be evaluated and monitored, for the sake of both species and the ecosystem on which they rely, and stress the need for further research, as well as for a stronger control and awareness on this problem.

ACKNOWLEDGMENTS

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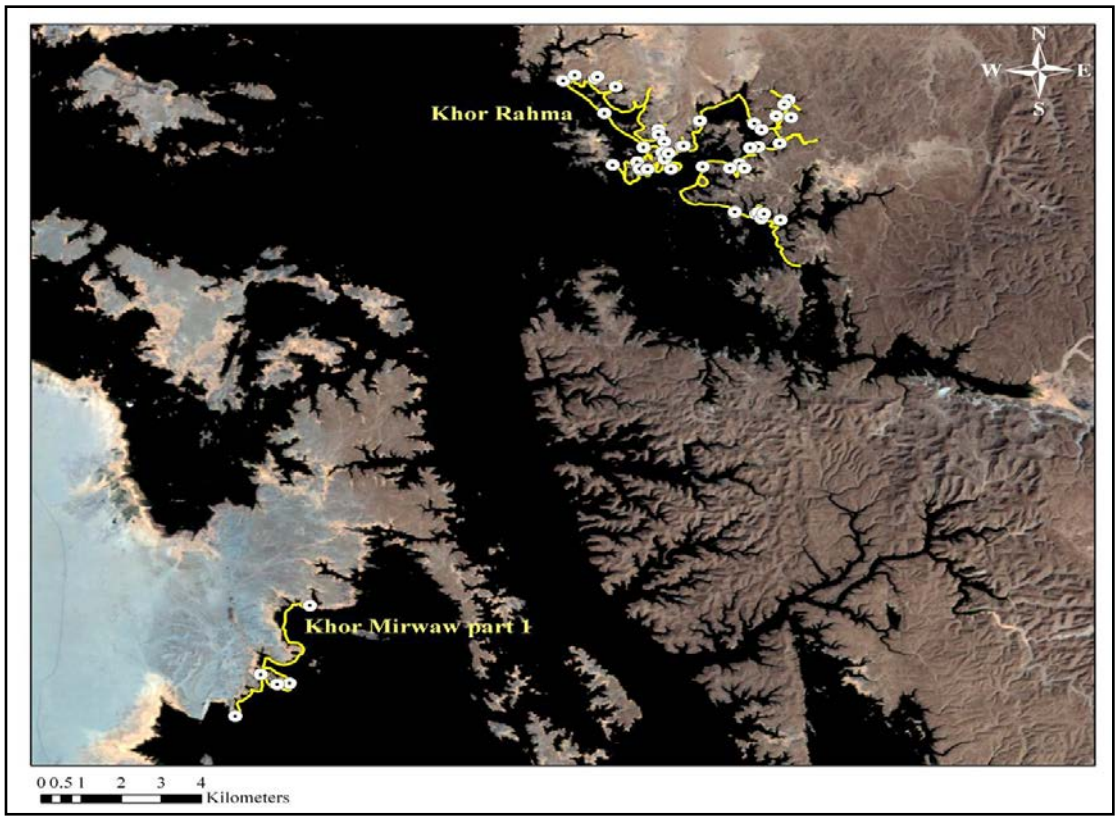
REFERENCES

1. Bayliss P., 1987 – Survey methods and monitoring within crocodile management programs, in Webb G. J. W., Manolis S. C. and Whitehead P. J. (eds), *Wildlife management: crocodiles and alligators*, Surrey Beatty and Sons, Sydney.
2. Bishai H. M., Samir A. A. M. and Magdy T. K., 2000 – Lake Nasser, Cabinet of Ministers, State Ministry of Environment, Egyptian Environmental Affairs Agency.
3. Botha P. J., 2005 – The Ecology and Population Dynamics of the Nile Crocodile *Crocodylus niloticus* in the Flag Boshielo Dam, Mpumalanga Province, South Africa, M.Sc. Thesis, University of Pretoria, South Africa, 172.
4. Cassidy L., 2003 – Anthropogenic burning in the Okavango panhandle of Botswana: Livelihoods and spatial dimensions, M.Sc. Thesis, University of Florida, Miami.
5. Hutton J. M., 1984 – The population ecology of the Nile crocodile, *Crocodylus niloticus* Laurenti 1768, at Ngezi, Zimbawe, Ph.D., Thesis, Univeristy of Zimbawe, Harare.
6. Hutton J. M. and Games I., 1992 – The CITES Nile Crocodile Project, Secretariat of the Convention on International Trade in Endangered Species, Lausanne, Switzerland.
7. Leslie A. J., 2003 – Okavango Crocodile Research Project: Progress Report #1, Department of Conservation Ecology, University of Stellenbosch.
8. Mbaiwa J., 2002 – The socio-economic and environmental impacts of tourism development on the Okavango Delta, north-western Botswana, *Journal of Arid Environments*, 54, 447-467.
9. Mwalyosi R. B. B., 1991 – Ecological evaluation for wildlife corridors and buffer zones for Lake Manyara National Park, Tanzania, and its immediate environment, *Biological Conservation*, 57(2), 171-186.
10. Nichols J. D., Hines J. E., Sauer J. R., Fallon F. W., Fallon J. E. and Heglund P. J., 2000 – A double-observer approach for estimating detection probability and abundance from point counts, *The Auk*, 117(2), 393-408.
11. Salem A. H. I., 2006c – Demographic study on the woody vegetation in Wadi Allaqi, South Eastern Egypt, M.Sc. Thesis, South Valley University, Aswan.
12. Salem A. H. I., 2010 – Nocturnal spotlight count survey methods for the estimation of abundance, distribution and population trend analysis of the Crocodylus niloticus in Lake Nasser, *Transylvanian Review of Systematical and Ecological Research*, Curtean-Bănăduc et al. (eds) 10, 107-136.
13. Seone J., Bustamante J. and Diaz R., 2004 – Competing roles for landscape, vegetation, topography and climate in predictive models, *Ecological Modeling*, 171(3), 209-222.
14. Yacoub H., 2009 – *Najas* ssp. growth in relation to environmental factors in Wadi Allaqi (Nasser Lake, Egypt), *Transylvanian Review of Systematical and Ecological Research*, Curtean-Bănăduc et al. (eds), 8, 1-40.

Annex I; Trip 1.



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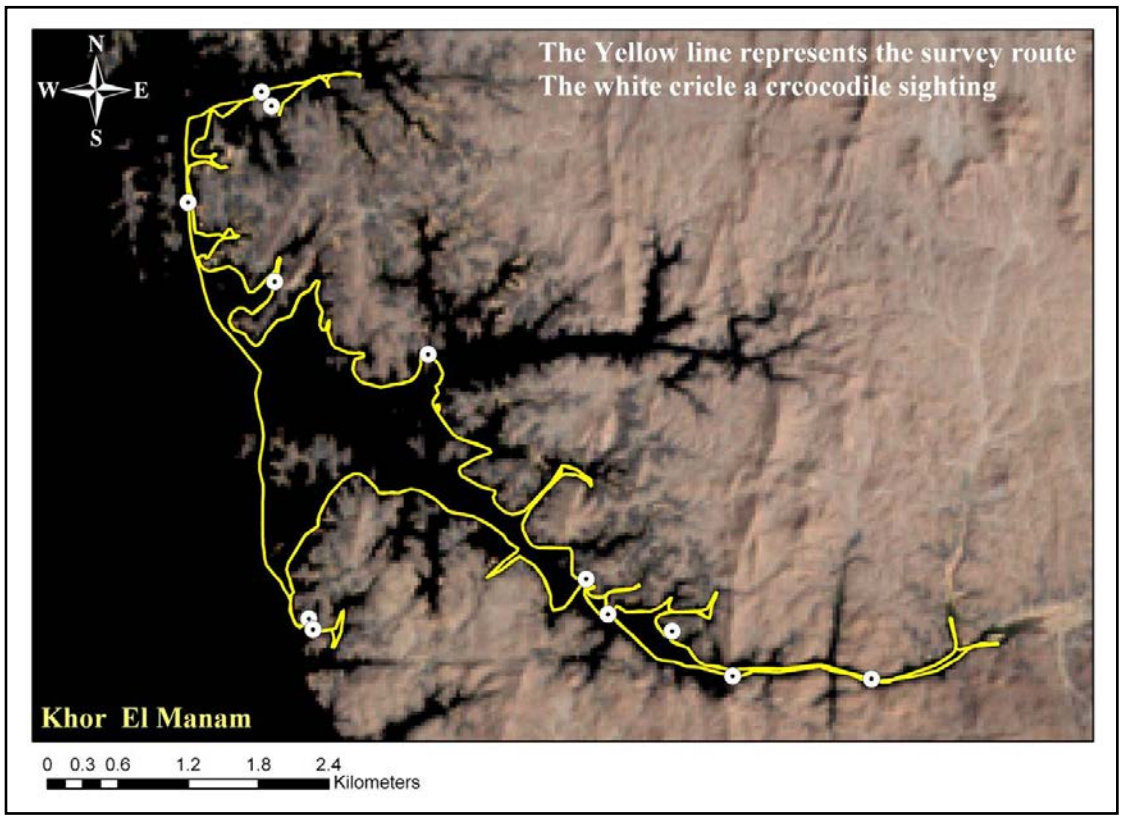

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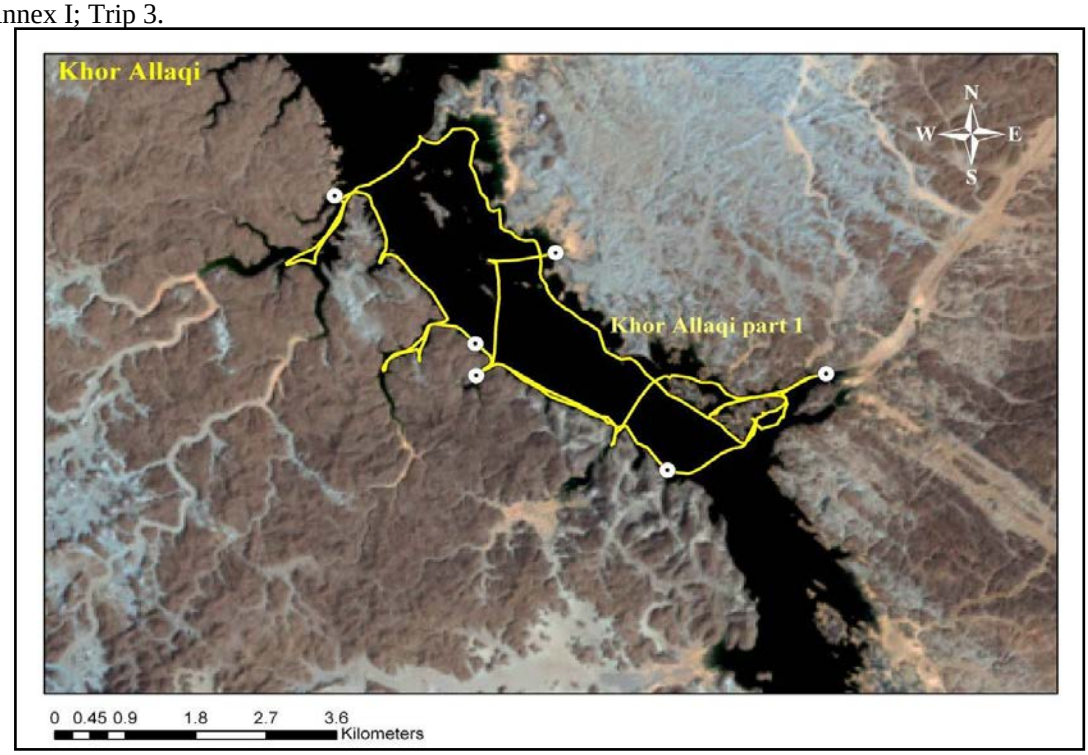

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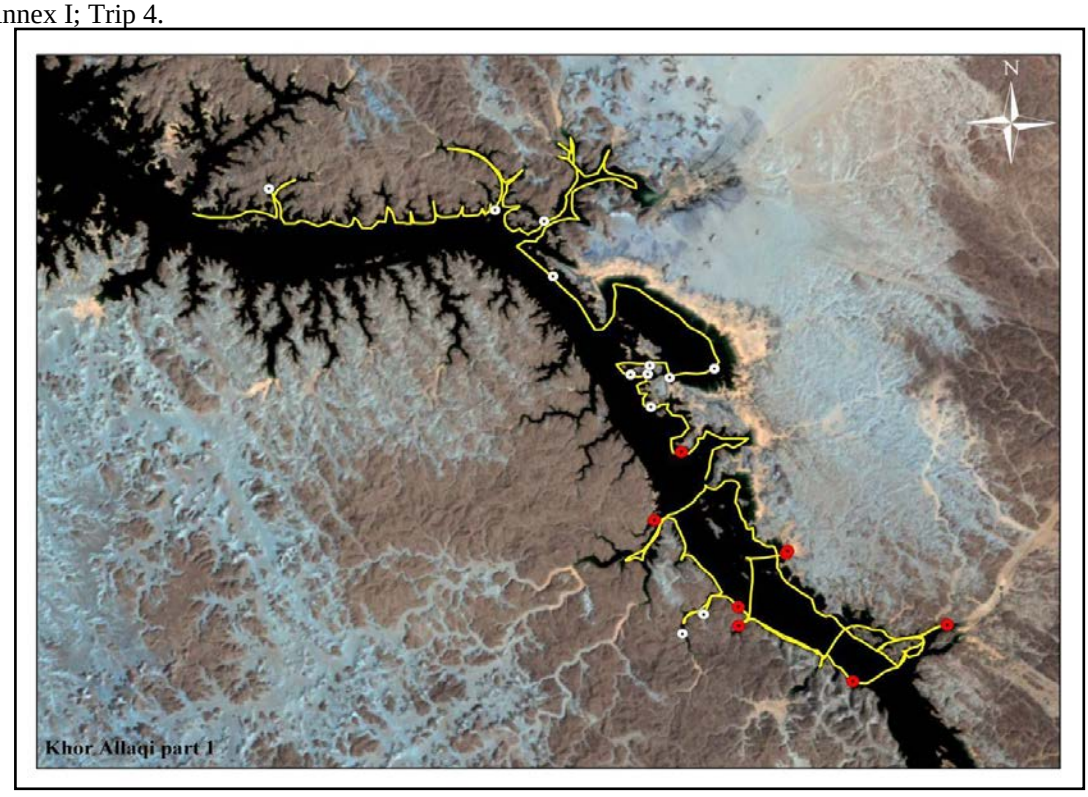

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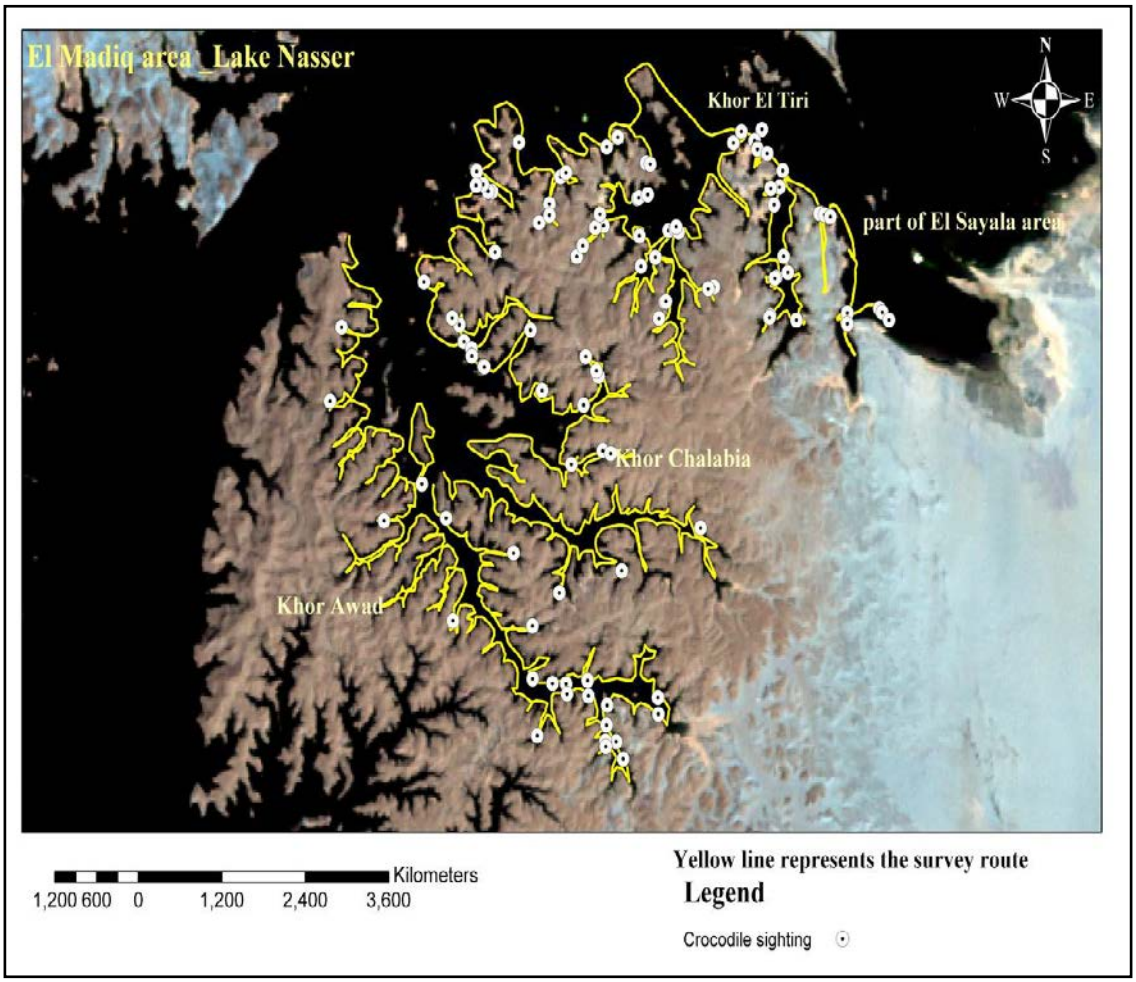

PRELIMINARY OBSERVATIONS ON THE FAMILY MORMYRIDAE IN OYAN DAM LAKE (NIGERIA)

Olaniyi Alaba OLOPADE *

* University of Port Harcourt, Department of Animal Science and Fisheries, Rivers State, Nigeria, oaolopade@yahoo.com

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KEYWORDS: Mormyridae, diversity, length-weight, condition factor, Oyan Lake.

ABSTRACT

This study was carried out to investigate the abundance, distribution, diversity and condition factor of Mormyrids in Oyan Dam lake, Abeokuta North Local Government Area of Ogun State, Nigeria. The fish were sampled from the catches of the fishermen in Oyan Dam lake, which used gillnets of 30-80 mm laterally stretched mesh size. The fish were sampled monthly between February and September 2011, at two different sites (Imala and Ibaro). The results revealed that a total number of 100 fishes of six species belonging to the family Mormyridae were collected. Numerically, catches were dominated by *Mormyrus rume* (34%), *Hyperopisus bebe* (30%) and *Petrocephalus bane* (24%). Together, these species comprised 88% of all collected individuals. *Marcusenius ihuysi* was rare and least in number representing 1% of the fish caught. The results showed that only four species were recorded in the dry season, namely *Mormyrus rume*, *Hyperopisus bebe, Petrocephalus bane* and *Mormyrus deliciosus* while five species were recorded in the wet season particularly in September. *Mormyrus deliciosus*, was not recorded in the wet season. In terms of body weight, the highest mean value was recorded for *Mormyrus deliciosus* (435.71 ± 95.71), followed by *Mormyrus rume* (143.82 ± 5.55) and *Hyperopisus bebe* (123.5 ± 5.26) while *Petrocephalus bane* was the least one (95.00 ± 8.56). The results also showed that the condition factor during the wet season (4.18) was higher than the condition factor of the dry season (3.51). Simpson's index was used to determine the species richness, while Shannon-Wiener's Index was used to evaluate species diversity; species evenness was equally evaluated using Pielou's Index. The indices of diversity included (d) = 0.31 and 0.23, H = 1.18 and 1.53 and E = 0.851 and 0.853 respectively for the two sites at Oyan Dam lake. The estimates from these indices indicated a low fish species composition and richness, also unevenness in the population of Mormyrids in Oyan Dam lake. Therefore, it will be advisable to regulate the activities of fishers in the water body to allow future increase in the abundance of this species.

RÉSUMÉ: Observations préliminaires de la famille des Mormyridés du lac de barrage d'Oyan (Nigeria).

Ce travail a eu pour but l'étude de l'abondance, de la distribution, de la diversité et de l'indice de Fulton des Mormyridés du lac de barrage d'Oyan, dans la Zone Gouvernementale Locale Nord Abeokuta de l'Etat d'Ogun, au Nigeria. Les poissons ont été échantillonnés à partir des captures des pêcheurs du lac d'Oyan qui utilisent des filets de pêche à la mèche de 30-80 mm. Les échantillons ont été collectés chaque mois de février à septembre 2011 dans

deux sites différents (Imala et Ibaro). Un nombre total de 100 poissons appartenant à 6 espèces de la famille de Mormyrides ont été collectés. De point de vue numérique, les captures ont été dominées par *Mormyrus rume* (34%), *Hyperopisus bebe* (30%) et *Petrocephalus bane* (24%). Ces trois espèces constituent 88% de tous les individus collectés. *Marcusenius ihuysi* a été rare, comptant pour moins de 1% des poissons capturés. Les résultats ont montré que seulement quatre espèces ont été inventoriés durant la saison sèche: *Mormyrus rume, Hyperopisus bebe, Petrocephalus bane* et *Mormyrus deliciosus*; cinq espèces ont été récoltées durant la saison humide, surtout durant le mois de septembre. *Mormyrus deliciosus* n'a pas été pêché pendant toute la saison humide. En termes de poids, la plus grande valeur moyenne a été enregistrée pour *Mormyrus deliciosus* (435,71 ± 95,71), suivi par *Mormyrus rume* (143,82 ± 5,55) et *Hyperopisus bebe* (123,5 ± 5,26), alors que *Petrocephalus bane* a eu le plus petit poids moyen (95,00 ± 8,56). Les résultats ont aussi montré que durant la saison humide, l'indice de Fulton (4,18) a été plus grand que celui calculé lors de la saison sèche (3,51). L'indice de Simpson a été utilisé pour déterminer la richesse des espèces, alors que l'indice de Shannon-Wiener a été utilisé dans l'évaluation de la diversité des espèces; l'équitabilité des espèces a été calculée par l'indice de Pielou. Les indices de diversité ont compris (d) = 0,31 et 0,23, H = 1,18 et 1,53 et E = 0,851 et 0,853 respectivement, pour les deux sites du lac de barrage d'Oyan. Les estimations faites à partir de ces indices ont montré une composition spécifique et une richesse basses de l'ichtyofaune ainsi qu'un manque d'équitabilité des populations de Mormyridés dans le lac d'Oyan. Il est donc souhaitable de réglementer les activités de pêche dans ces lacs afin de permettre aux espèces de regagner leur abondance naturelle.

REZUMAT: Observații preliminare asupra familiei Mormyridae în lacul de acumulare Oyan (Nigeria).

Acest studiu a avut ca scop cercetarea faunei de Mormyridae din lacul de acumulare Oyan, situat in Zona Guvernamentală Locală Nord Abeokuta din statul Ogun, Nigeria, sub aspectul abundenței, distribuției, diversității și indicelui Fulton. Peștii au fost colectați din capturile efectuate de pescarii de pe lacul Oyan cu ajutorul plaselor de pescuit cu ochiuri de 30-80 mm. Eșantioanele au fost prelevate lunar din februarie în septembrie 2011, din două puncte diferite (Imala și Ibaro). S-au colectat în total 100 de exemplare aparținând la 6 specii din familia Mormyridae. Din punct de vedere al abundenței, capturile au fost dominate de *Mormyrus rume* (34%), *Hyperopisus bebe* (30%) și *Petrocephalus bane* (24%). Aceste trei specii au format împreună 88% din indivizii colectați. Specia *Marcusenius ihuysi* a fost rară, cuprinzând mai puțin de 1% din peștii capturați. Rezultatele au demonstrat că în timpul sezonului uscat doar patru specii au fost capturate: *Mormyrus rume, Hyperopisus bebe, Petrocephalus bane* și *Mormyrus deliciosus*; în timpul sezonului umed au fost capturate 5 specii, mai ales în luna septembrie, lipsind în acest sezon *Mormyrus deliciosus*. Din punct de vedere al masei, valoarea medie cea mai mare a fost înregistrată pentru *Mormyrus deliciosus* (435,71 ± 95,71), urmată de *Mormyrus rume* (143,82 ± 5,55) și *Hyperopisus bebe* (123,5 ± 5,26) în timp ce *Petrocephalus bane* a avut greutatea medie cea mai mică (95,00 ± 8,56). Rezultatele au mai demonstrat că indicele Fulton pentru sezonul umed (4,18) a fost mai mare ca cel pentru sezonul uscat (3,51). S-au calculat indicii de biodiversitate Simpson și Shannon-Wiener precum și echitabilitatea Pielou. S-au obținut valorile (d) = 0,31 și 0,23, H = 1,18 și 1,53 și E = 0,851 și 0,853 pentru cele două situri de pe lacul Oyan. Estimările făcute pe baza valorilor acestor indici denotă o compoziție specifică și o diversitate scăzute, precum și o lipsă de echitabilitate a populațiilor de Mormyridae în lacul de acumulare Oyan. Se recomandă, deci, reglementarea activităților piscicole în acest acvatoriu în așa manieră încât să permită speciilor să își reconstruiască efectivele.

INTRODUCTION

Nigeria is a country of vast and varied fish germ plasma resources distributed widely in various aquatic ecosystems. Fish stocks in Nigerian inland and marine waters are characterized by heterogeneity of many species which are of commercial importance. There are approximately 230 inland fish species (Ita, 1993) and 199 of brackish marine species (Tobor, 1965, 1968). Notable among the freshwater fish species in Nigeria are *Tilapia, Clarias, Heterobranchus, Synodontis, Chrysichthys, Mormyrus, Lates, Gymnarchus, Alestes, Bagrus, Labeo, Heterotis* spp. and many ornamental fish species.

Mormyrus is the genus of Mormyridae which was described by Linnaeus (1758). Mormyrids or elephant snout fishes are curious looking fish, highly variable in shapes of their head and the extent of their unpaired fins. They are recognized by the possession of upward pointing pectoral fins, narrow gill openings and a layer of muscle covering the opercula bone (Holden and Reed, 1972). In some species, the eyes are very small compared to the size of the fish. The fishes of this family are normally caught in the bottom net, an indication that they are bottom feeders (Adebisi, 1978).

With more than 200 species belonging to 20 genera, the Mormyridae Family is a modern radiation within the Osteoglossomorpha, an ancient lineage of teleost fishes in which most other living groups are species-poor (Bigorne, 1990). Mormyrids reach their highest diversity in the river systems of Central and West Africa and are often from the numerical point of view the most abundant fish in riverine habitats (Harder, 2000). Some form large schools near the bottom of pools; others are adapted for life in and near rapids (Roberts and Stewart, 1976) of smaller streams, marginal habitats, or swamps (Lowe-McConnell, 1987). However, with the construction of dam and weirs on most rivers for irrigation, hydropower or flow management have provided an opportunity to see how freshwater fish adapt to lake type environments. Distributions and abundances of native species may be altered by the reservoir formation, including loss of species from the river system and threatening with extinction of endemic species (Wheeler and McDonald, 1986).

The Volta Lake area on the national territory of Ghana was studied by Petr (1967) both before and after the dam construction. Mormyrids underwent the most dramatic drop in population as a result of the lake formation, nearly disappearing from the fish catches in the southern part of Volta Lake (less than 2% of the biomass of total fish catches), and maintained themselves only in the northern part of the lake, where they had access to river feeding conditions. Before the construction of the dam, the Black Volta River (Ghana) mormyrids comprised over 65% of dry season catches (biomass). A similar decline in Mormyrids was noted for the Niger River after the creation of Kainji Lake in Nigeria (Blake, 1977). Orts (1967) highlight the fact that most mormyrids appear to have a lack of specialization for air breathing, they may thus be poorly adapted to living on deoxygenated lake bottoms. Since many mormyrids appear to feed exclusively upon bottom-dwelling insect larvae, this situation may make lacustrine environments unsuitable in many cases (Petr, 1967).

There is little specific information on diversity of the family Mormyridae in Nigeria particularly with reference to reservoirs ecosystem. In these general circumstances, this scientific study was carried out to investigate the abundance, distribution, diversity and condition of the Mormyridae Family and their contribution to species richness of Oyan Lake (Fig. 1).

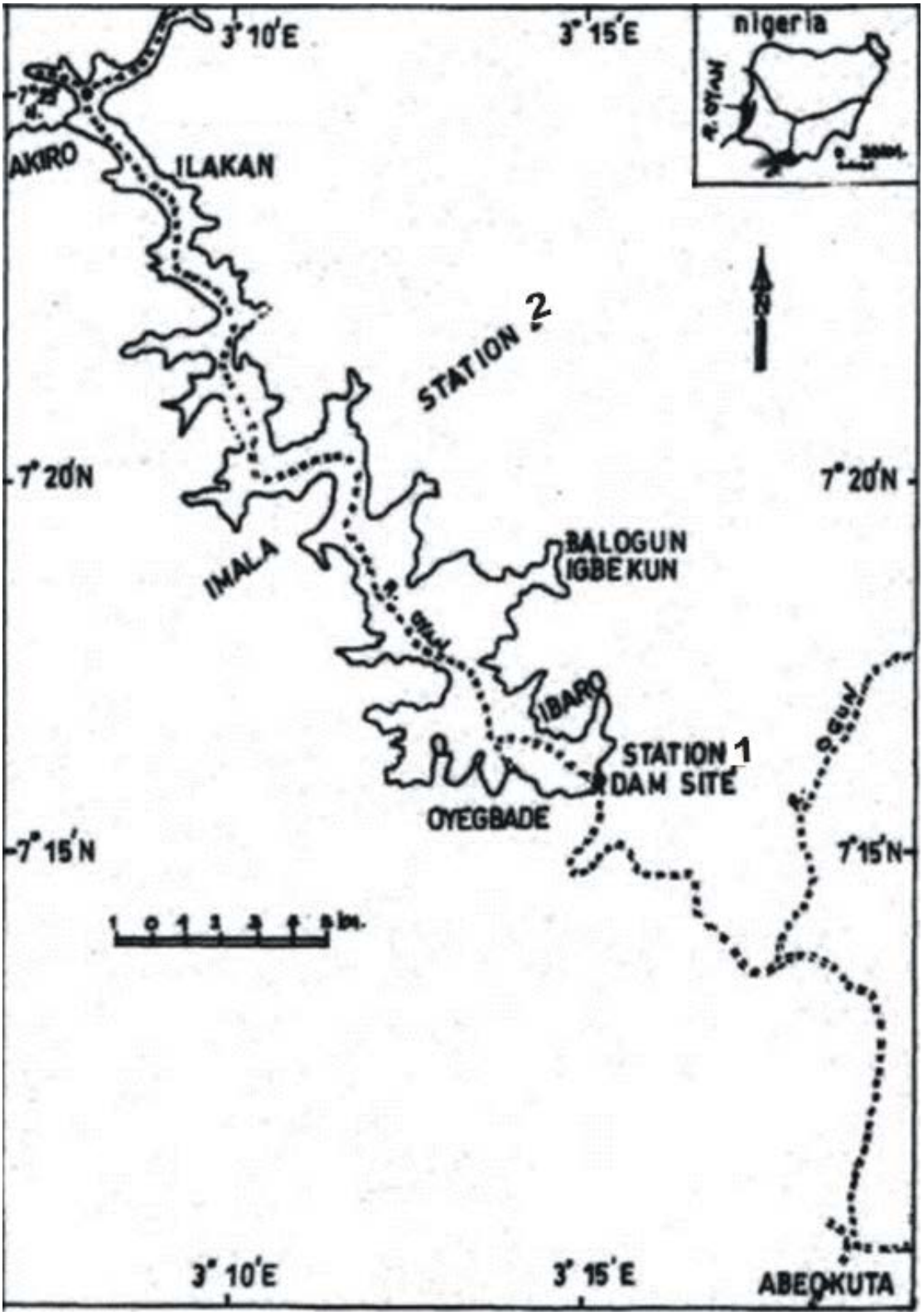

Figure 1: Map of the Oyan Lake with the sampling stations localization.

MATERIALS AND METHODS

Study area

The Oyan River dam is located in Abeokuta North Local Government Area of Ogun State in the west of Nigeria, about 20 km north west of the state capital Abeokuta. The dam crosses the Oyan River, a tributary of the Ogun River. It was used primarily to supply raw water to Lagos and Abeokuta, but has also potential for use in irrigation and power generation. The dam is located on the latitude of 7°15'N and longitude 3°16'E at an elevation of 43.3 m above the sea level on the confluence of Oyan and Ofiki rivers, both tributaries of Ogun river some 20 kilometres north-west of Abeokuta, close to Badagry - Sokoto Highway (O-ORBDA 1998; Ofoezie et al., 1991). The lake is in the savannah region, with sparse trees and grasses and low soil fertility. It covers a total of 4,000 hectares and has a catchment area of 9,000 km^2. The dam has a crest length of 1,044 m, a height of 30.4 m and a maximum storage capacity of 270 million m^3 (Ofoezie and Asaolu, 1997). The dam and lake were designed to supply with raw water Lagos and Abeokuta, and to support the 3,000 hectare Lower Ogun Irrigation Project. Three turbines of 3 megawatts each were installed in 1983, but until 2007 have not been used (Ikenweinwe et al., 2007).

Fish sampling

The fish samples were collected from the catches of the fishermen from two stations in Oyan Lake; they were caught by gillnets of 30-80 mm laterally stretched mesh size. The fish were collected monthly at the two different sites (Imala/site 1 and Ibaro/site 2) from March to September, 2011 to determine the distribution pattern and abundance of momyrids in the lake.

Identification of the various species of mormyrids was done using Daget (1954) and Holden and Reed (1972). The confirmation of the sampled/identified species was carried out based on their color and meristic characters. Standard length (SL), total length (TL) and weight (W) of the specimens were measured to the nearest 0.1 cm and 0.1 g respectively.

Analysis of data

The ecological indexes used to describe the Mormyrids diversity in Oyan Lake are:

a. The relative species abundance % = (n/N) X 100, which refers to the relative representativenes of a species, was determined by dividing the number of species (n) from each catch by the total number of species (N) from the total catch recorded

b. The length-weight relationship (LWR) was estimated by using the equation

$W = a L^b$

Where W = Weight (g)
L = Standard length (cm)
a = Constant
b = Growth exponent.

c. The equation will be linearised by a logarithmic transformation to give:

$\text{Log } W = \text{Log } a + b \text{ Log } L$

d. The value of the compiled growth exponent that will be used to calculate the condition factor, K

$$K = \frac{100 W}{L^b}$$

Where K = Condition Factor
W = Total body weight (g)

L = Standard Length (cm)
b = Growth exponent
Simpson's index (d) = $\sum n(n - 1)$_
$N(N - 1)$

e. The Simpson's index (d) was used to evaluate species richness

f. Shannon - Wiener's Index (H') of species diversity (Shannon and Wiener, 1963)
$H` = - \sum P_i \ln P_i$
eqn (5)
Where P_i = The proportion of the total number of individuals occurring in species
i, n is the number of individuals of each species and
N is the total number of individuals.
The Shannon - Wiener's Index (H') were used to evaluate species diversity.

g. Pielou's Index (J) for species evenness (Pielou, 1969),
J = H'
ln S eqn (6)
Where H' is the species diversity index and S is the number of species

RESULTS

Composition of the family Mormyridae in Oyan Lake

A total number of 100 fishes of six species belonging to the family Mormyridae were collected. Numerically, catches were dominated by *Mormyrus rume* (34%), *Hyperopisus bebe* (30%) and *Petrocephalus bane* (24%). Together, these species comprised 88% of all individuals collected. *Marcusenius ihuysi* was the least in number accounting for 1% of caught fish. *Mormyrops deliciosus* and *Marcusenius ihuysi* were not recorded in the site 1 (Tab. 1).

Table 1: Percentage composition of Mormyrids in Oyan Lake; number (percentage) of fish caught from the sites.

Species	S_1	S_2	Sum total number (%) of fish caught
Mormyrus rume	16	18	34
Hyperopisus bebe	16	14	30
Petrocephalus bane	16	8	24
Mormyrops deliciosus	0	7	7
Marcusenius psittacus	1	3	4

Seasonal distribution of the family Mormyridae species in Oyan Lake

The results of the seasonal distribution of the family Mormyridae in Oyan Lake are presented in table number 2.

Table 2: Summary of Relative Species abundance and seasonal variation of Mormyrids in Oyan Dam, Nigeria.

	2011 (dry season)				2011 (wet season)			
Species	March	April	May	(Total%)	July	August	September	(Total%)
Mormyrus rume	3	10	6	19 (39.6)	3	6	4	15 (35.7)
Hyperopisus bebe	3	9	5	17 (35.4)	4	5	6	13 (30.9)
Petrocephalus bane	4	7	4	15 (31.3)	3	2	4	9 (21.4)
Mormyrops deliciosus	4	1	2	7 (14.6)	-	-	-	- (0)
Marcusenius psittacus	-	-	-	- (0)	3	1	-	4 (9.5)
Marcusenius ihuysi	-	-	-	- (0)	1	-	-	1 (2.4)
Total				48				42

Only four species were recorded in the dry season namely *Mormyrus rume, Hyperopisus bebe, Petrocephalus bane* and *Mormyrus deliciosus* while five species were recorded in the wet season, particularly in September, *Mormyrus deliciosus* was not recorded in the wet season.

The relative abundance decreased with the increase in water level, (Tab. 2).

The dominant species during the dry season were *Mormyrus rume* (39.6%), *Hyperopisus bebe* (35.4%) and *Petrocephalus bane* (31.5%). Similar results were recorded during the wet season with *Mormyrus rume* (35.7%), *Hyperopisus bebe* (30.9%) and *Petrocephalus bane* (21.4%) species which dominated the sampled fish. *Marcusenius psittacus* (0%) and *Marcusenius ihuysi* (0%) were not recorded during the dry season. Likewise, *Mormyrops deliciosus* species was conspicuously absent during the wet season.

Size of Mormyridae in Oyan dam

In terms of fish body weight, the highest mean value was recorded for *Mormyrus deliciosus* (435.71 ± 95.71), followed by *Mormyrus rume* (143.82 ± 5.55) and *Hyperopisus bebe* (123.5 ± 5.26), while *Petrocephalus bane* was the last (95.00 ± 8.56). In terms of length, the highest mean value was recorded for *Mormyrus deliciosus* (35.89 ± 1.67), followed by *Mormyrus rume* (22.85 ± 0.61) and *Hyperopisus bebe* (22.47 ± 0.43), while the last value of 17.2 ± 0.00 was recorded on *Marcusenius ihuysi* (Tab. 3).

Table 3: Sizes of Mormyrids species in Oyan Dam.

	Body weight (g)			Standard length (cm)		
Species	Min	Max	Mean ± SE	Min	Max	Mean ± SE
Hyperopisus bebe	80	210	123.5 ± 5.26	18	28	22.47 ± 0.43
Mormyrus rume	100	230	143.82 ± 5.55	17.4	31.7	22.85 ± 0.61
Petrocephalus bane	60	220	95.00 ± 8.56	14	30.0	19.01 ± 0.74
Mormyrops deliciosus	140	800	435.71 ± 95.71	26.8	40	35.89 ± 1.67
Marcusenius psittacus	100	120	111.25 ± 4.27	16.8	18.6	17.65 ± 0.42
Marcusenius ihuysi	110	110	110 ± 0.00	17.2	17.2	17.2 ± 0.00

Diversity index of family Mormyridae in Oyan Lake

Table 4 shows Simpson's index for the site 1 which was 0.31 and 0.23 for the site 2. This suggests the fact that the species were similar. However, using Margalef's species index (d), the species richness of the site 1 was 0.69 and 0.77 for the site 2. Simpson's reciprocal index was 3.27 in the site 1 and 4.31 in the site 2 while the Shannon's index (H) for site 1 was 1.18 and for the site 2 it was 1.53. Pielou's index (J) for species evenness was 0.851 for site 1 and 0.853 for site 2. The value in the site 1 (0.851) was higher than in the site 2.

Table 4: Diversity Index and Species richness of Mormyrids in Oyan Lake; N = total number of organisms of all species found, n = number of individuals of a particular species, n! = total number of species present in sampled population, k = number of unique species of which only one organism was found in sampled population, D = diversity index, S = species richness. i = an index number for each species present in a sample, pi = ni/N = the number of individuals within a species (ni) divided by the total number of individuals (N) present in the entire sample, ln = natural log. $\sum$ = sum the values for each species.

Diversity indexes	Site 1 (Imala)	Site 2 (Ibaro)
Number of species	4	6
Number of individuals	49	51
Simpson's index $d = \frac{\sum n(n-1)}{N(N-1)}$	0.31	0.23
Margalef's index of diversity (D) = (S-1)	0.69	0.77
Simpson's reciprocal index = (1/d)	3.27	4.31
Shannon-Weiner index H' = $-\sum pi \ln pi$	1.18	1.53
Pielou's Index (J) = H'/ln S	0.851	0.853

Monthly condition factors of Mormyrids species in Oyan Lake

The condition factor of six species of Mormyrids are presented in table 5 in wet and dry season with the minimum and maximum value of 0.44 (*Mormyrops deliciosus*) and 2.19 (*Marcusenius psittacus*). The mean value of the condition factor ranged from 0.97 to 1.65. The condition factor of *Mormyrus rume* for both seasons ranged from 0.14 to 1.54, in the month of May having the lowest and August having the highest value, *Hyperopisus bebe* ranged from 0.94 to 1.21, *Petrocephalus bane* recorded the condition factor of 1.33 to 1.72, *Mormyrops deliciosus* ranged from 0.49 to 1.09, while *Marcusenius psittacus* ranged from 1.96 to 2.19. The only species recorded in August had a condition factor of 2.16 (*Marcusenius ihuysi*).

Table 5: Summary of the Monthly Condition Factor of Mormyrids in Oyan Lake.

	2011 (dry season)			2011 (wet season)		
Species	March	April	May	July	August	September
Mormyrus rume	0.81	1.27	0.14	1.49	1.54	0.63
Hyperopisus bebe	1.07	0.94	1.12	1.02	1.21	0.97
Petrocephalus bane	1.72	1.46	1.45	1.55	1.41	1.33
Mormyrops deliciosus	1.09	0.44	0.59	-	-	-
Marcusenius psittacus	-	-	-	2.19	1.96	-
Marcusenius ihuysi	-	-	-	-	2.16	-
Mean	1.17	1.02	1.32	1.56	1.65	0.97
Total mean		3.51			4.18	

The monthly condition factors of all species studied is shown in table number 5, while the graphical representation of the monthly condition factor for each species is presented in figures number 2 to 5. There were differences in the condition factors for the combined fish species and the monthly factor for each fish species studied. The result revealed that the condition factor during wet season (4.18) was higher than the condition factor of the dry season (3.51).

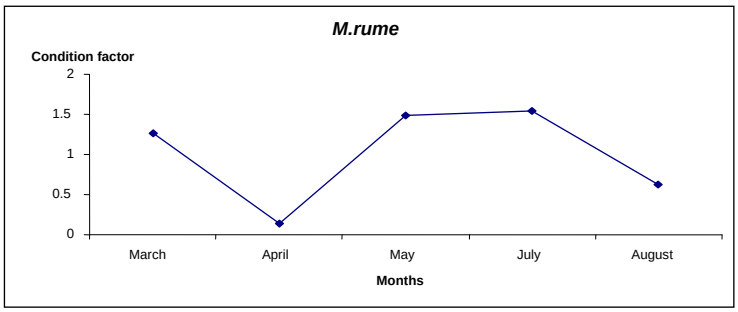

Figure 2: Mean condition factor for *Mormyrus rume.*

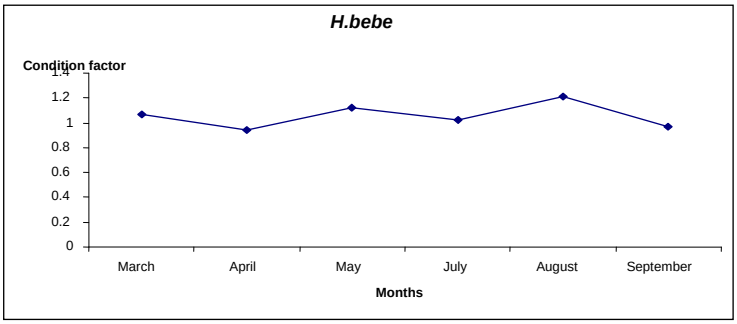

Figure 3: Mean condition factor
for *Hyperopisus bebe.*

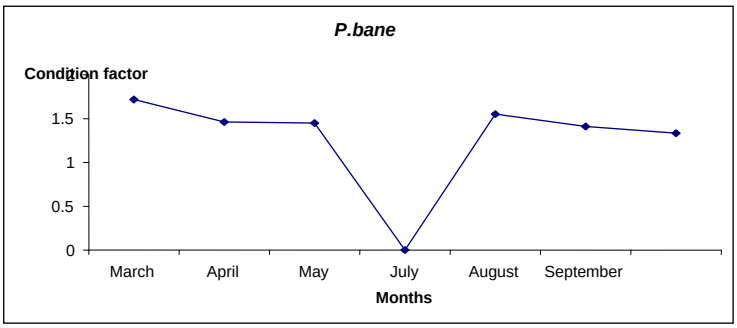

Figure 4: Mean condition factor
for *Petrocephalus bane.*

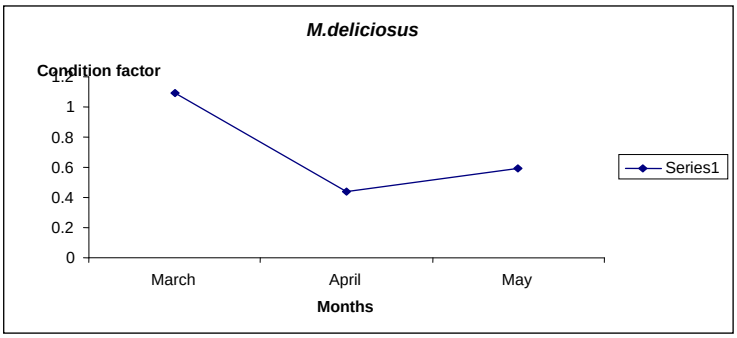

Figure 5: Mean condition factor
for *Mormyrops deliciosus.*

The figures 6-13 show the graphical representations of the relationship between standard length and body weight and between condition factor and standard length.

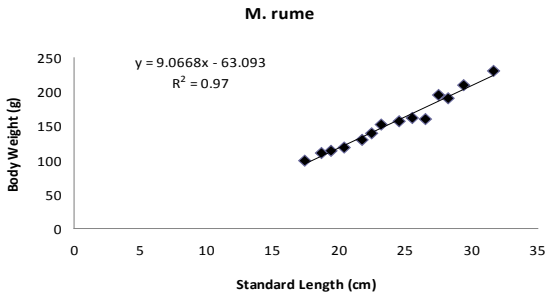

Figure 6: The graphical representation of the relationship between standard length and body weight of *Mormyrus rume*.

A straight-line relationship was shown suggesting that with an increase in the size of the fish there is a corresponding increase in the condition factor. The correlation coefficient R^2 was high (0.92).

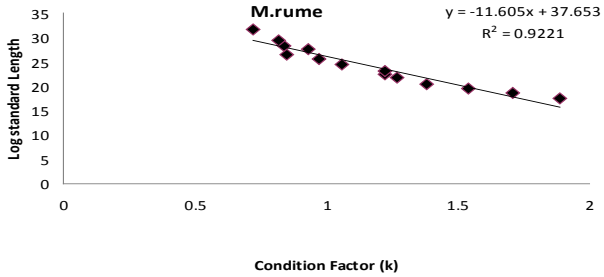

Figure 7: Shows the relationship between the condition factor and standard length of *Mormyrus rume.*

There is a negative relationship between the condition factor and the standard length.

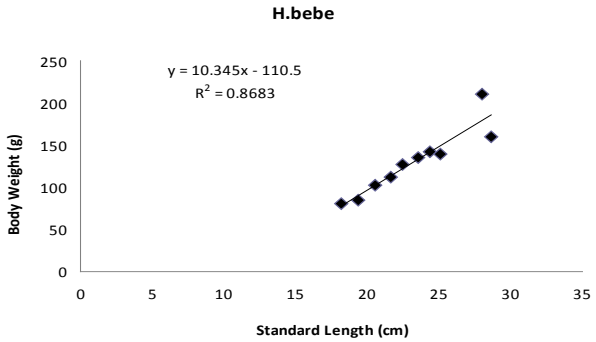

Figure 8: Shows the graphical representation of the relationship between the standard length and the body weight of *Hyperopisus bebe*.

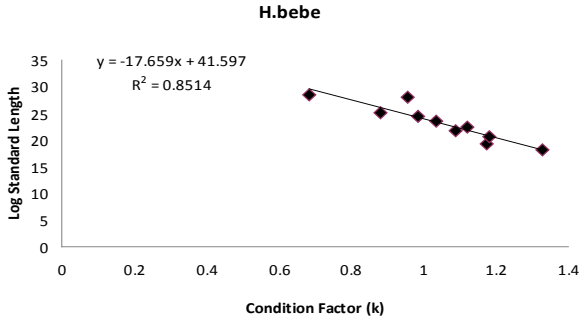

Figure 9: Shows the relationship between the condition factor and the standard length of *Hyperopisus bebe*.

This shows that the condition factor has no relationship with the standard length, R^2 = 0.85.

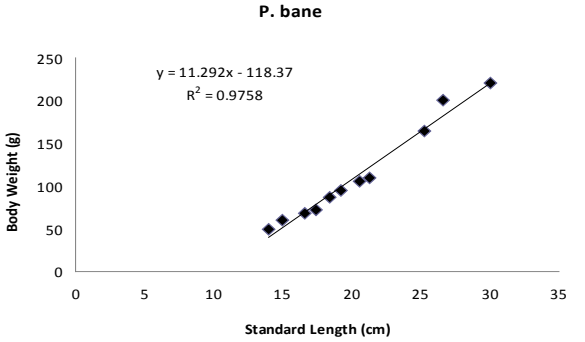

Figure 10: Shows the graphical representation of the relationship between the standard length and body weight of *Petrocephalus bane*.

The length of the fish maintains a steady relationship with the weight, for instance, an increase in length is related to an increase in the weight of the fish. The correlation coefficient R^2 was 0.97.

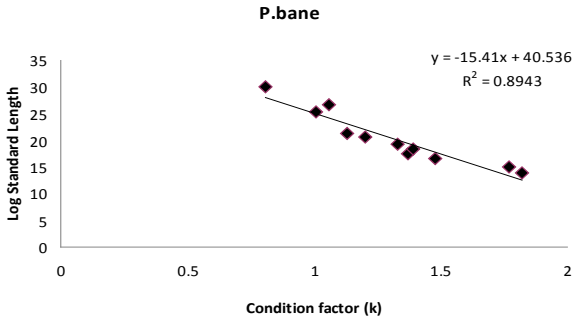

Figure 11: Shows the relationship between the condition factor and the standard length of *Petrocephalus bane*.

As the length of the fish increases, the condition factor also increases negatively.

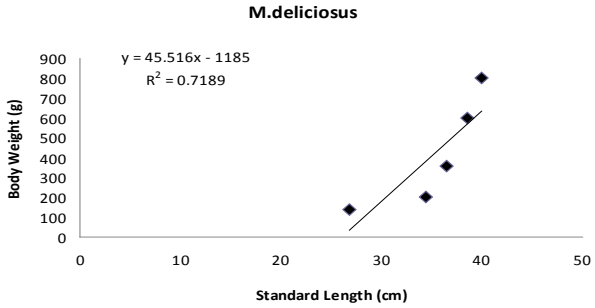

Figure 12: Shows the graphical representation of the relationship between the standard length and the body weight of *Mormyrops deliciosus*.

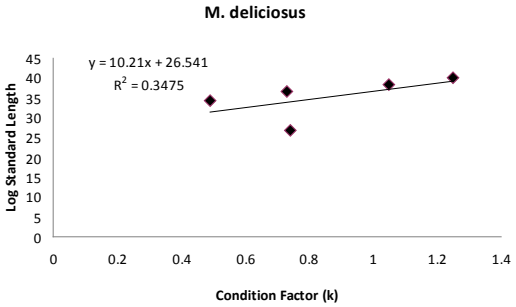

Figure 13: The relationship between the condition factor and standard length of *Mormyrops deiciosus.*

No relationship exists between the condition factor and the standard length of the fish below 30 cm, but as the condition factor increases, a linear relationship was found.

DISCUSSION

Fish composition and diversity

A total of 29 mormyrid species have been described in the Nigerian freshwaters (Adesulu and Sydenham, 2007). This study revealed 6 species belonging to the family Mormyridae. The species composition was lower than the result of another study who revealed 8 species in the same water body (Ita, 1993). The limited number of the Mormyrids obtained during the sampling period could primarily be due to the factors related to the fishing gear deployment. According to Holden and Reed (1972), the majority of species have slender bodies and spines and they are difficult to catch with most normal types of fishing gears and, therefore, they make up only a small part of the commercial catches. Among the 6 species of fish in this study, *Mormyrus rume* was the most dominant. Olopade (2010) also recorded *Mormyrus rume* as the most abundant species of the family Mormyridae in Oyan Lake. The mormyrids fish, being a primitive taxonomic group, appears to have speciated primarily in rivers, not in lakes (Lowe-Mc Connell, 1969), this account for rear occurrence of *Marcusenius ihuysi* in the lake. Most Mormyrids appears to lack speciation for air breathing (Orts, 1967), they may thus be poorly adapted to living on deoxygenated lake bottoms. Since many Mormyrids appear to feed exclusively upon bottom-dwelling insect larvae, this situation may make lacustrine environments unsuitable in many cases (Petr, 1967).

More species were recorded in site 2 than in site 1, in the Volta Lake and Kainji Lake, Mormyrids appear to be restricted to the extensive reed beds on the lake shores (Petr, 1967; Blake, 1977).

The result of seasonal caught composition of the family Mormyridae shows a relatively higher catch in the wet season than in the dry season. This could be attributed to spawning migratory behavior of mormyrids during the raining season. Rainy season spawning migrations from river mouths to upriver breeding habitats have been reported for some taxa (Daget, 1957; Blake, 1977). *Marcusenius psittacus* and *Marcusenius ihuysi* were not recorded in the dry season, but were recorded in the rainy season; indications are that the migratory fish are abundant during the rainy season, not necessarily for reproduction, but in response to changing environmental conditions, particularly temperature, and the movements and abundant of food organisms (Moyle and Cech, 1988).

The estimate of the diversity index (Tab. 4) shows a relative higher value for the downstream region than for the upstream region. This could be attributed to the physiochemical characteristics of the water. Other factors that could influence diversity include food availability and human influence (Fagade, 1983). In the absence of a pre-impoundment study in the Oyan Lake area, it was not possible to determine whether the fish fauna is depleted or not. Kartha (1987) pointed out that during the change of the lotic to lacustrine environment the fish diversity decreases.

In fish, the factor of condition (K) reflects, through its variations, information on the physiological state of the fish in relation to its welfare (Le Cren, 1951). The range of the condition factor values fall below 2.9 to 4.8, documented for optimum living condition for a fresh body weight (Begenal and Teseh, 1978). The values obtained from the study showed that all species studied were in good condition. Gayando and Pauly (1997) reported that certain factors often affect the well-being of a fish. Also, condition factors vary according to seasons and are influenced by environmental conditions. The results revealed that most of the length-weight relationship of the species showed a linear graph. There was a significant correlation between body weight and standard length of species. This study showed an increase in length resulted in corresponding increase in weight. Length-weight relationships give information on the condition and growth patterns of fish (Bagenal and Tesch, 1978).

CONCLUSIONS

A total of six species belonging to the family of mormyrids was observed during the investigation. In the wet season five species were recorded, while only four species were recorded in the dry season. The result also revealed that the condition factor during the wet season was higher than in the dry season. The following species of mormyrids, *Mormyrus rume, Hyperopisus bebe, Petrocephalus bane* and *Mormyrops deliciosus* showed a linear relationship in terms of length-weight relationship. Based on the outcome of this study, it will be advisable that the dam should be replenished with other species of Mormyridae to allow future increasing in abundance and regulatory measures should be enforced particularly in the rainy season which coincides with the breeding season for sustainable fishery in Oyan Dam lake.

REFERENCES

1. Adebisi A. M., 1978 – Analsis of stomach contents of Piscivororous fishes of the Upper Ogun River in Nigeria, *Hydrobiologia*, 79, 167-177.
2. Adesulu E. A. and Sydenham D. H. J., 2007 – The Freshwater Fishes and Fisheries of Nigeria, Macmillan Nigeria Publishers Ltd., Nigeria, 391.
3. Bagenal T. B. and Tesch F. W., 1978 – Methods of assessment of fish production in freshwater, 3rd edition, Oxford, Blackwell, 352.
4. Bazigos G. P., 1972 – The Design of Fisheries Statistical Surveys Inland Water, *FAO Fish Technical Papers*, 133, 120.
5. Bigorne R., 1990 – Mormyridae, in: Lévesque C., Paugy D. and Teugels G. G. (eds), *Faune des poissons d'eaux saumatres d'Afrique de l'Quest*, Tome 1, Faune Trop, 28 Musec Royal de l'Afrique Centrale Tervuren and ORSTOM, Paris, 645.
6. Blake B. F., 1977 – Aspects of the reproductive biology of Hippopotamyrus pictus from Lake Kainji West Africa with notes on four other mormyrid species, *Fish Biology*, 11, 437-445.
7. Daget J., 1991 – Chromidotilapia, in: Check-list of the freshwater fishes of Africa (CLOFFA) (eds) Daget J., Gosse J., Teugels J. P., and Thys van Audenaerde D. F. E., MRAC, Tervuren, and ORSTOM, Paris, 4, 47-50.
8. Fagade D. O., 1983 – The Biology of Chromodotilapia guntheri from a Small Lake, Archive Hydrobiology, 97, 60-72.
9. Gayando F. C. and Pauly D., 1997 – FAO ICLARM stock assessment tools FISAT: References Manual, *FAO Computerized Information Series (Fisheries)*, 8, 262.
10. Harder W., 2000 – The Mormyridae and other Osteoglossomorpha, (CD-ROM), World Biodiversity Database, CD-ROM Series 2000, New York: Springer Verlag, ETI-UNESCO.
11. Holden M. J. and Reed W., 1972 – West African Freshwater Fish, Longman Group Ltd., London, 68.
12. Ikenweirwe N. B., Otubusin S. O. and Oyatogun M. O. O., 2007 – Fisheries of Oyan Lake, South West Nigeria and Potential for Ecotourism Development, *European Journal of Scientific Research*, 16, 3.
13. Ita E. O., 1993 – Inland Fisheries Resources of Nigeria, FAO, CIFA Occasional Paper No. 20, Rome Italy, FAO, 120.
14. Kartha K. N., 1987 – Studies on experimental trawl fishing in Gandhisagar reservoir Mandsur, M. P. India, Ph. D thesis, Vikram University, Ujain India.
15. Le Cren E. D., 1951 – The length-weight relationship and seasonal cycle in gonad weight and condition in the Perca fluviatilis, *Journal of animal Ecology*, 20(2), 201-219.
16. Lek S. and Lek S., 1978 – Etude de quelques especes de petits Mormyridae du bassin du Lac Tchad, I, Observations sur Ia repartition et ecologie, Cah. O.R.S. T.O.M. Ser. *Hydrobiologia*, 12, 225-236.
17. Linnaeus C., 1758 – *Systema Nature per Regna Tria Naturae secundum Classes, Ordinus, Genera, Species cum Characteribus, Differentiis Synonymis*, Locis., 10th ed., 1, Holmiae Salvii, 824.
18. Lowe-McConnell R. H., 1969 – Speciation in tropical freshwater fishes, *Biological Linnean Society*, 1, 51-75.
19. Moyle P. B. and Cech J. J. Jr., 1988 – Fish: An Introduction to Ichthyology 2nd edn., Hall and Cliffs (eds), 559.
20. Ofoezie I. E. and Asaolu S. O., 1997 – Water level regulation and control of schistosomiasis transmission: a case study in Oyan Reservoir, Ogun State, Nigeria, *Bulletin of the World Health Organization*, 75(5), 435-441.
21. Ogun Osun River Basin Development Authority, 1997 – Brief on the activities of OORBD-A (1977-1996), OORBD-A Flyer March 1997, Ogun-Osun River Basin Development Authority 1998 (O-ORBDA), What it is, what it does, how it works, O-ORBDA, 5.

22. Olopade O. A., 2010 – Observations of fishing methods in Oyan Lake, *African Journal of Livestock Extension*, 8, 35-39.
23. Orts S., 1967 – Contribution a l'anatomie coparee et la systematique des mormyrides, *Memuse Academie Royale des Sciences Outremer*, 17, 1-90.
24. Petr T., 1967 – Fish population changes in the Volta Lake in Ghana during its first sixteen months, *Hydrobiology*, 30, 193-220.
25. Pielou E. C., 1969 – An Introduction to Mathematical Ecology, Jonn Wiley & Sons, New York, 288.
26. Robert T. R. and Stewart D. J., 1976 – An ecological and systematic survey of fishes in the rapids of the Lower Zaire or Congo River, *Bulletin of the Museum of Comparative Zoology*, 147, 239-317.
27. Shannon C. E. and Wiener W., 1963 – The Mathematical Theory of Communication, U. Illinois, Urbana, Illinois, 117.
28. Sullivan J. P., Lavoué S. and Hopkins C. D., 2000 – Molecular systematics of the African electric fishes (Mormyroidea, Teleostei) and a model for the evolution of their electric organs, *Journal of Experimental Biology*, 203, 665-683.
29. Swingle H. S., 1950 – Relationships and Dynamics of Balanced and Unbalanced Fish Populations, *Alabama Polytechnic Institution Agricultural Experimental Station Bulletin*, 244, 74.
30. Tang Y. A., 1970 – Evaluation of Balanced between Fishes and Available Fish Foods in Multi-species Fish Culture Ponds in Taiwan, *Transactions of American Fisgeries Society*, 99, 708-718.
31. Tobor J. G., 1965 – Identification notes, fishes of the Nigerian trawling grounds, *Federal Fisheries Occasional Paper*, 9.
32. Tobor J. G., 1968 – Checklist of the less common marine fish of Nigeria, caught in Lagos trawling grounds, *Federal Fisheries Occasional Paper*, 10.
33. Turner J. L., 1970 – Fish population of newly impounded Kainji Lake in Nigeria, *Journal of West African Science Association*, 1(1), 49-58.
34. Wheeler W. B. and McDonald M. J., 1986 – TVA and the Tellico Dam, 1936-1979: A bureaucratic crisis in post-industrial America, Knoxville, TN, University of Tennessee Press.

UTILIZATION OF PERIPHYTIC NATURAL FOOD AS PARTIAL REPLACEMENT OF COMMERCIAL FOOD IN ORGANIC TILAPIA CULTURE - AN OVERVIEW

*Ana MILSTEIN *, Alon NAOR **,*
*Assaf BARKI **** and *Sheenan HARPAZ ****

* Agricultural Research Organization, Fish and Aquaculture Research Station, Dor. M. P. Hof HaCarmel, IL-30820, Israel, anamilstein@agri.gov.il
** Fish and Aquaculture Research Station, Dor. M. P. Hof HaCarmel, IL-30820, Israel, alonn@moag.gov.il
*** Agricultural Research Organization, Bet Dagan, P. O. Box 6, IL-50250, Israel, barkia@agri.gov.il, harpaz@agri.gov.il

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ABSTRACT

This article summarizes the results obtained during five years of research at the Dor Fish and Aquaculture Research Station on partial replacement of commercial food by periphytic natural food in the culture of organic tilapia (hybrid *Oreochromis aureus* (Steindachner) x *Oreochromis niloticus* (L.)). Tilapia culture experiments were conducted in earth ponds with and without substrates, utilizing different substrates. Tilapias of sizes ranging from nursery to market-size fish were tested. Fish were stocked at densities common in organic fish culture, i.e. 5 tilapia/m^2 at the nursery stage, 1.2-1.4 tilapia/m^2 at the grow-out stage. Substrate experiments were carried out in 1 m^3 cages protected from fish grazing to test growth of periphyton on materials with different characteristics. The findings show that the inclusion of substrates in the water body at an amount equivalent to 40-50% of the pond water surface, allows the reduction of commercial food input by 30-40% without significantly hampering fish growth rate. It is recommended to use rough, rigid, white substrates, on which periphyton growth of 2 g dry matter/m^2/day has been measured. A figure and a table are provided as a tool to estimate periphyton contribution to the fish food ration, enabling the adjustment of the remaining daily food portion to be supplied as fish biomass increases during the culture period. Applying this technology will save food and money in the culture of organic tilapia, and it can also be appropriate in the conventional pond culture of tilapia as a method to reduce feed costs and increase sustainability.

RESUMEN: Acuacultura en humedales: uso de alimento natural perifítico como reemplazo parcial de ración comercial en el cultivo de tilapia orgánica.

Este artículo resume los resultados obtenidos en cinco años de investigación en la Dor Fish and Aquaculture Research Station, sobre el reemplazo parcial de ración comercial por alimento natural perifítico en la cría orgánica de tilapias (híbrido de *Oreochromis aureus* (Steindachner) x *Oreochromis niloticus* (L.)). Experimentos de cría de tilapias se llevaron a cabo en estanques de tierra con y sin substratos, utilizando diferentes substratos, con tilapias de diferentes tamaños (desde alevinos a tamaño comercial) a densidades practicadas en cría orgánica (5 alevinos/m^2, 1.2-1.4 juveniles/m^2). Experimentos para medir crecimiento de perifiton sobre substratos de diferentes características se llevaron a cabo en ausencia de peces en jaulas de 1 m^3. Los resultados indican que incluir substratos en el agua en una cantidad equivalente a 40-50% del área del estanque permite reducir la cantidad de ración en 30-40%

sin entorpecer significativamente la tasa de crecimiento de las tilapias. Recomendamos usar substratos rugosos, rígidos y blancos, sobre los cuales hemos medido un crecimiento de perifiton de 2 g/m^2/día de materia seca. Incluimos una figura y una tabla como herramienta para estimar la contribución del perifiton a la dieta de las tilapias y ajustar en consecuencia la cantidad de ración faltante para completar la demanda diaria a medida que la biomasa de peces aumenta durante el periodo de cría. Esta tecnología ahorrará ración y dinero en la cría de tilapia orgánica, y también puede ser apropiada como método de reducir costos en la cría convencional de tilapias en estanques.

REZUMAT: Acvacultura în zone umede: utilizarea de hrană naturală perifitică, ca substitut pentru hrana comercială în creşterea de tilapia organic - o vedere de ansamblu.

Acest articol rezumă rezultatele obţinute în cinci ani de cercetare efectuată la Dor Fish and Aquaculture Research Station asupra înlocuirii parţiale a hranei comerciale cu hrană naturală perifitică în creşterea de tilapa organic (hibrid *Oreochromis aureus* (Steindachner) x *Oreochromis niloticus* (L.)). Experimentele de creştere a tilapiei s-au desfăşurat în iazuri nebetonate cu diferite tipuri de substrat şi fără substrat. Au fost testate exemplare de tilapia de mărimi diferite, de la alevini la peşti de dimensiune comercializabilă. Peştii au fost ţinuţi la densităţile recomandate în piscicultura organică, adică 5 tilapia/m^2 în bazinele de creştere, 1.2-1.4 tilapia/m^2, la vârstă adultă. Experimentele de substrat au avut loc în cuşti de 1 m^3, protejate de consumul de către ierbivori, pentru a testa creşterea perifitonului pe diferite materiale, cu diferite caracteristici. Rezultatele au arătat că introducerea substratelor în acvatoriu într-un raport de aprovimativ 40-50% faţă de luciul de apă, duce la reducerea raţiilor de hrană comercială cu aprovimativ 30-40% fără a afecta semnificativ rata de creştere a peştelui. Se recomandă folosirea de substrate aspre, rigide, de culoare albă, pe care perifitonul creşte până la 2 g masă uscată/m^2/zi. Pentru estimarea contribuţiei perifitonului, la raţia zilnică a peştelui, au fost prezentate o figură şi un tabel ce permit ajustarea porţiei zilnice rămase de hrană comercială, pentru a permite creşterea biomasei piscicole pe durata culturii. Prin aplicarea acestei tehnologii crescătorii de tilapia organic pot face economii de hrană şi de bani. De asemenea, tehnologia se pretează şi utilizării în iazuri piscicole convenţionale ca metodă de reducere a costurilor cu hrana şi pentru a creşte exploatarea durabilă a acestora.

INTRODUCTION

The introduction of hard surfaces into the water column of earthen fish ponds induces the growth of bio-films and periphyton on them. This improves the natural productivity of the water body, thus providing more food for cultured aquatic organisms able of using periphyton as food. Periphyton-based aquaculture systems function like artificial wetlands in which grazing pressure is increased according to the stocking density of the target organism. Stocking density has to be low enough to allow recovery of grazed periphyton and high enough to allow an economically viable aquaculture business. Thus, this technology is applicable in extensive and low density semi-intensive systems, including organic aquaculture (organic meaning those that comply with organic standards) in which low stocking density to ensure welfare of the target animals is a prerequisite.

The cost of food constitutes one of the most expensive components of the running costs of aquaculture production. This is even more pronounced in organic aquaculture due to the specific requirements, to use only organic food ingredients (IFOAM, 2009; Naturland, 2012). Thus, the cost of organic pelleted food is double the cost of regular commercial food used in aquaculture, hampering economic viability.

To cope with this problem in organic tilapia culture, two approaches were simultaneously researched. In the first approach, alternative relatively cheap, food pellet ingredients that comply with organic regulations and are available from organic sources in appropriate quantities, were tested as components of food pellets for organic tilapia culture. One such study researched mainly the effects of different levels of dietary salt supplementation on growth of tilapia hybrids as reported by Cnaani et al. (2010). The second approach in this respect included experiments in periphyton-based conditions, aimed at improving natural food production for tilapia in the ponds while concomitantly reducing the amounts of added food. This approach is in line with the organic culture philosophy and allows a reduction in production costs without negatively affecting fish growth.

Periphyton-based specific systems with no additional feeding have long been practiced in the African Continent (Hem and Avit, 1994) and Asia (Wahab and Kibria, 1994), mainly using bamboo and other locally available natural substrates. In those regions, a positive effect of substrate introduction and consequent periphyton development, on the production of the target species and on water quality has been observed (van Dam et al., 2002).

Bamboo is not readily available in Israel geographical area and the labor required to collect and install other possible natural substrates is prohibitively expensive. Therefore, synthetic substrates were used to evaluate this technology in the culture of organically produced tilapia. The present article summarizes the results obtained during five years of research; some of the data has already been published in detail (Milstein et al., 2005, 2008a, 2008b, 2009).

MATERIALS AND METHODS

Five specific experiments were carried out in 6-12 earthen ponds of a 300 m^2 area and water depth of 1 m at the Fish and Aquaculture Research Station Dor, with the tilapia hybrid *Oreochromis aureus* (Steindachner) x *Oreochromis niloticus* (L.). This type of hybrid is the major commercially cultured tilapia in organic and conventional farms in Israel geographic area. The different specific experiments tested tilapia performance in “periphyton + reduced feed” ponds (Periphyton) in relation to conventional (Control) ponds, for tilapias at different stocking sizes utilizing different substrates for periphyton development. The characteristics of the five tilapia culture specific experiments are shown in table number 1. In all done experiments three ponds were allocated to each treatment or control.

The treatments consisted of the addition of underwater surfaces equivalent to 30-50% of the pond surface area, while simultaneously reducing the amount of pelleted food supplied to the fish by 30-40%. The substrates used and their location in the water column varied in each experiment. As an example, figure number 1 shows one of the experimental ponds with substrates located in the epilimnion before the pond was completely filled with water. In the control ponds no underwater substrates were added and the full amounts of organically certified floating food pellets were supplied. The food amounts supplied in the control ponds were lower than the quantities used in conventional pond culture, because in organic culture a considerable part of the growth of the organisms must originate from natural foods (Naturland, 2012). Except for the nursery experiment (experiment 2) in which only tilapia was stocked, in all other experiments a polyculture system was used.

Table 1: Characteristics of the pond experiments and results (average values); # when differences between treatments were significant, the values shown represent averages in Periphyton / Control ponds, * plastic strips forming "honeycomb" used to avoid erosion in road side slopes, ** used in agriculture, *** plastic bags originally containing fish food, **** shown in figure 1, ***** arrow indicates decreasing feeding rate during culture period.

	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5
Number of ponds	6	6	6	12	6
Culture duration (days)	135	101	87	116	142
SUBSTRATES					
Materials	plastic sheets	strips *	strips *	shadow nets ** and sheets ***	plastic nets ****
Amount (area relative to pond surface area)	40%	50%	50%	30%	38%
Placement	epilimnion	water column	water column	epilimnion	epilimnion
Texture	smooth	smooth	smooth	rough and smooth	rough
Color	transparent	black	black	white	white
Rigidity	rigid	rigid	rigid	flexible	rigid
FEED					
Protein (%)	32	35	30	30	35
Feeding rate in CONTROL ponds (% of tilapia biomass) *****	2% → 1%	5% → 2%	2%	2% → 1.5%	1.5%
Feeding rate in PERIPHYTON ponds (% of control ponds)	60%	60%	60%	66%	70%
TILAPIA#					
In the polyculture (%)	85	100	90	91	92
Stocking weight (g)	90	2.8	330	180	113
Stocking density (fish/m^2)	1.2	5	1.2	1.1	1.4
Stocking biomass (g/m^2)	108	14	396	193	158
Survival (%)	97	70	94	53	84
Harvesting weight (g)	329/356	80	510	500	290
Harvesting biomass (g/m^2)	380/413	300	576	235	330

Table 1: continued.

Growth rate (g/day)	1.77/1.97	0.75	2.00/2.35	3.16	1.21
Growth rate in Periphyton ponds relative to control ponds	-10%	same	-10%	same	same
Wild tilapia spawning relative to tilapia harvested biomass	2%	3%	15%	53%	40%
Stocking density of the predator fish red drum (fish/m^2)	0.02	0	0.10	0.05	0.05
FCR	0.5/0.8	1.1/2.0	2.4/3.6	2.7/4.0	1.1/1.6
FCR improvement in Periphyton ponds relative to control ponds	30%	45%	33%	32%	32%
Reported in	Milstein et al., 2005	Milstein et al., 2008a	Milstein et al., 2009	herein	herein

The treatments consisted of the addition of underwater surfaces equivalent to 30-50% of the pond surface area while simultaneously reducing the amount of pelleted food supplied to the fish by 30-40%. The substrates which were used and their location in the water column varied in each experiment. As an example, figure number 1 shows one of the experimental ponds with substrates located in the epilimnion before the pond was completely filled with water. In the control ponds no underwater substrates were added and the full amounts of organically certified floating food pellets were supplied. The food amounts supplied in the control ponds were lower than the quantities used in conventional pond culture, because in organic culture a considerable part of the growth of the organisms must originate from natural foods (Naturland, 2012). Except for the nursery experiment (experiment 2) in which only tilapia was stocked, in all other experiments a polyculture system was used. Fish stocked consisted of 85-92% hybrid tilapia, an omnivorous fish able to graze on hard surfaces, in combination with small quantities of the plant eating grass carp (*Ctenopharyngodon idella* (Valenciennes)), the phytoplankton filter feeder silver carp (*Hypophthalmychthys molitrix* (Cuvier and Valenciennes)) and the predator red drum (*Sciaenops ocellatus* (L.)). The latter was stocked to control wild spawning of tilapia. In each specific experiment the initial stocking weight of the tilapia individuals varied (from fingerlings to advanced juveniles), but the fish in all ponds in the same experiment had the same initial weight and density. Experiments lasted 3-5 months.

Substrate experiments

Three experiments were carried out in 1 m^3 cage placed in the tilapia culture pond experiments (Fig. 1), to test the growth of periphyton on materials with different characteristics. Strips of substrates were vertically placed in the epilimnion without touching or shading each other. All the strips used during each experiment were installed simultaneously. Sub-sets of substrates were removed at set sampling times to analyze chlorophyll and dry and organic matter attached on them. Each sub-set contained triplicates of each substrate tested. The removed substrates were not reused. Periphyton of all substrates was sampled from the same water depth and measurements were all standardized on a cm^2 basis.

Figure 1: Experimental systems; substrates for periphyton growth in the tilapia culture experiments and the cage in which the substrate experiments were performed; picture taken before the pond was completely filled with water.

In the first experiment, periphyton growth on eight substrates with different textures was tested, including plastic smooth surface sheets and agricultural nets of different mesh (fine and coarse mesh) and type of threads (round or flat) as rough substrates. In the second experiment, the effect of substrate colour on periphyton development was tested using nets of the same type, differing only in their colour (white, black or blue). In the third experiment, the growth rate of periphyton development on a white rigid rough plastic substrate was measured through sampling at short intervals during a 3 week test period.

In all experiments, periphyton was collected to determine chlorophyll-a (methanol extract technique), dry matter (DM) and organic matter as ash free dry matter (AFDM) (weight of matter remaining after drying at 105°C and after burning at 550°C, respectively). The periphyton on the plastic smooth substrates was scraped from a predetermined set area. Periphyton growing on the rough nets was not separated from the substrate for the chemical analyses. For dry and organic matter determinations, blanks of each net type were measured and reduced from the periphyton + substrate measurements.

Statistical analyses

Data were analysed using ANOVA. Differences between treatment levels were tested with the Scheffe mean multi-comparison tests, using a significance level of $P < 0.05$. The analyses were run using the SAS statistical package.

RESULTS

Tilapia culture experiments

Table 1 summarizes the results of the five fish culture experiments. Overall average experimental values are given when no significant differences between periphyton ponds and control ponds occurred, while averages in both treatments are provided when significant differences did occur. In each experiment there were no significant survival differences between treatments. In the periphyton ponds, providing 40% less food did not negatively affect fingerling performance in the nursery (experiment 2). In early juveniles grow-out from 90 g to 350 g and advanced grow-out from 320 g to 520 g, providing 40% less food led to a reduction of only 10% in tilapia's growth rate in relation to the control ponds (experiment 1 and experiment 3). This growth rate reduction did not result in significant differences between treatments in tilapia harvest weight and biomass when the culture period was short (87 days, experiment 3), while it did differ by 10% when the tilapia culture period was significantly longer (135 days; experiment 1).

In the last two experiments (4 and 5), large quantities of tilapia wild spawning occurred. This is problematic in a research experiment, but since wild spawning amounts were similar in all ponds of each experiment, comparisons between treatments can still be considered valid. In these experiments, substrate material was placed only in the epilimnion and more food was supplied to the periphyton ponds (food saving was reduced from 40% to 34% and 30% in experiment 4 and experiment 5, respectively). Under these conditions, even after a long culture period tilapia growth rate was not reduced and their performance was similar in periphyton ponds and in control ponds. In all the experiments similar or only 10% reduced tilapia performance together with the 30%-40% decrease in food amounts supplied to the periphyton ponds led to at least 30% improved food conversion ratio (FCR) in the studied periphyton ponds (45% in the nursery; experiment 2).

Substrate experiments

Results of the first substrate experiment, testing periphyton growth on eight substrates of different texture, and of the second experiment, testing the effect of the colour of the substrate on periphyton development on it, were reported in detail by Milstein et al. (2008b).

In the first experiment the amount of periphytic matter (measured as DM and AFDM) on fine nets more than doubled that on coarse nets (both rough substrates), which in turn about doubled the amount that developed on smooth plastic substrates. Chlorophyll was 60% higher on the fine mesh round thread net substrate compared with the coarse mesh flat thread net and the white flexible smooth surface plastic sheets, while other rough and smooth substrates were intermediate and not significantly different from either.

The second experiment showed that the colour of the substrate did not affect the chlorophyll content of periphyton but did affect its dry and organic matter content. The white substrate had 40% more DM and 50% more AFDM than the blue and black substrates.

In the third experiment, linear growth of periphyton on a white rigid rough plastic net substrate during 22 days was observed (Fig. 2). The regression lines of the chlorophyll, DM and AFDM calculated on the time scale (number of days submerged) were:

Chlorophyll (mg/m^2) = 2.97 day - 5.99
DM (g/m^2) = 1.98 day + 5.24
AFDM (g/m^2) = 0.31 day + 7.64

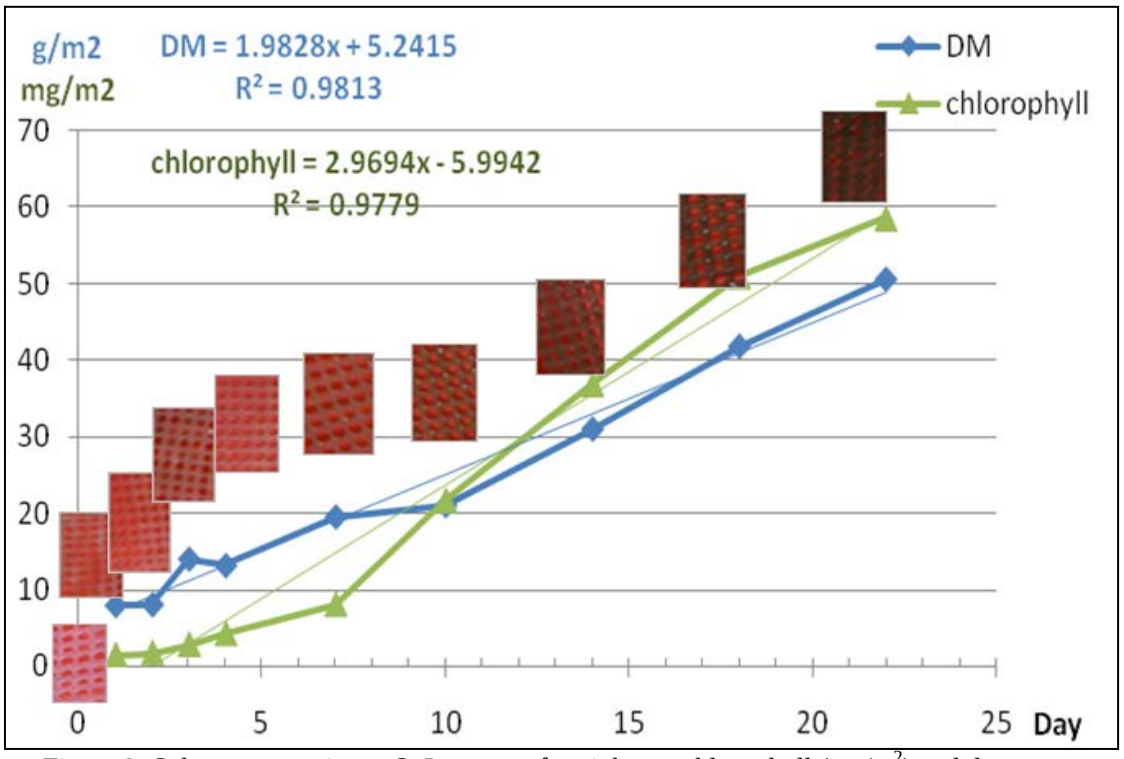

Figure 2: Substrate experiment 3. Increase of periphyton chlorophyll (mg/m^2) and dry matter (DM, g/m^2) in time; thick lines join the measurements, thin lines are the regression lines; the rectangles are photographs of the nets taken before starting the experiment (day 0) and at sampling days with periphyton grown on them.

The first two regressions had coefficients of determination r^2 = 0.98, and that of AFDM r^2 = 0.63. The equations show that periphyton increased daily by 3 mg chlorophyll, 2 g DM and 0.3 g AFDM per square meter of substrate.

DISCUSSION

Manipulation of natural food webs is a method to increase the productivity and efficiency of aquaculture production that conforms to the criteria of ecological and organic aquaculture. The provision of substrates to increase periphyton development on them as natural food for herbivorous and omnivorous aquaculture organisms has been tested with positive results in a range of species, culture systems and environments (van Dam et al., 2002; Azim et al. (eds), 2005; Azim and Little, 2006). Much of the periphyton-based fish culture research has been carried out using natural substrates (mainly bamboo), comparing the growth of the target organism with and without substrates, when commercial food was not supplied (Ramesh et al., 1999; Keshavanath et al., 2001; Milstein et al., 2003; Rai et al., 2008). Studies conducted in fish ponds comparing the effect of food supply versus periphyton, found that the provision of substrates can reduce the need for artificial food and can be an alternative to commercial food in the culture of herbivorous fish and prawn (Azim et al., 2002a; Keshavanath et al., 2002, 2004; Uddin et al., 2008, 2009; Garcia et al., 2011). This approach can be an ideal alternative in resource-limited regions in Asia, Africa and Latin America, where small-scale rural tilapia culture is commonly practiced (El-Sayed, 2006).

Under Israel national territory conditions, in which land is limited and costs (mainly of labor) are rather high, extensive aquaculture practice is not economically viable. The fish densities needed to attain an economically viable production surpass the natural food production capacity of earthen ponds. Under these conditions, food addition is required even at the reduced stocking densities demanded by organic regulations. Thus, the experiments presented herein were directed to partial (not total) replacement of commercial food by periphytic natural food. This, together with the use of artificial substrates that are easy to install, save labor and/or are cheap and available in large amounts at any farm.

The results obtained in the present experiments are that at least under the low tilapia density required in organic aquaculture, the use of substrates in the water body in an amount equivalent to 40-50% to the pond surface allowed a 30-40% reduction in food, while either none or only slightly negative effects were observed on the tilapia performance. Since the price of food ingredients is increasing worldwide with all indications that it will continue to increase, the implementation of periphyton-based aquaculture will save both food and money in tilapia organic culture. The partial substitution of food by periphyton allowed a sustainable more intensive fish production and can also be appropriate in conventional tilapia culture.

Another advantage of the periphyton technology is the reduction of economical losses when something might go wrong. For unknown reasons, tilapia culture experiment 4 experienced high mortality levels in all ponds, which at harvest was found to be around 50%. Thus, the amount of food given was in fact double than planned, which should have reduced competition for food and might account, at least in part, for the lack of differences between treatments. Still, the periphyton ponds received 34% less food than the control ponds, which in this case can be considered as a 34% reduction of economic losses.

Another example of reduction of economical losses in periphyton ponds is related to wild spawning. In organic cultures, hormones are not used for sex reversal, as a result large amounts of tilapia wild spawning might occur. To cope with this problem a predator fish can be stocked. If large amounts of wild spawning occur in spite of the predator fish presence in the pond, tilapia biomass will be higher than expected, hence feeding rate will be lower than planned, competition for food will increase and tilapia performance will be reduced. This occurred in experiment 5, where the losses related to low tilapia performance were similar in

all ponds. However, the food for tilapia supplied by the periphyton that developed on the provided substrates compensated for 30% artificial food reduction, which can be considered as a 30% reduction of economic losses.

The third substrate experiment was done to evaluate the potential of periphyton supply to fish and to estimate the amount of substrate required to have effect on tilapia growth. Thus, periphyton growth rate was measured at short intervals in the absence of grazing fish. This was done in near surface waters where most of periphyton development takes place (Azim et al., 2001, 2002b). The few experiments found in literature that measured periphyton growth in the absence of grazing fish were based on combined samples or samples integrated through depths and/or time, measured at weekly intervals (Azim et al., 2001, 2002a, 2003; Keshavanath et al., 2001; Milstein et al., 2008b). Direct comparisons with our data are thus not possible.

The measured periphyton growth of about 2 g DM/m^2/day in summer in the third substrate experiment provides a rough estimation of the amount of substrate required to supply food at different rates (Fig. 3) and different biomass of tilapias (Tab. 2). Thus, to supply food at a rate of 0.5% of tilapia biomass per day (about a quarter of the daily fish requirements) 2.5 m^2 of substrate per tilapia kg in the pond are required. At this feeding rate this amounts to 250 m^2 of underwater surfaces feed 100 kg of tilapia. Since the surface of substrates installed in a pond is constant while tilapia biomass will change with fish growth (Tab. 2) and (Fig. 3), can be used to estimate periphyton contribution to fish ratio and adjust accordingly the remaining feed portion to be supplied as fish biomass increases during the culture period.

From the point of view of the organic fish farmer, a 10% saving in the artificial food costs, which can be reached with the addition of substrates, would already be an important achievement. Purchasing some materials (like those used in the tilapia culture experiments 2 and 3) to be used specifically as periphyton substrate may not be economically practical. On the other hand, recycled substrate materials can be very cheap and can include discarded plastic irrigation pipes, empty plastic bottles or old leftover plastic sheeting. The use of discarded agriculture shade nets, plastic feed sacks and other such materials (as in experiment 4) requires anchoring them in place when exposed to wind, otherwise it is not appropriate for re-use in the next culture cycle. Some labor is required to install the substrates, yet, if they are strong enough and can be reused in the following culture cycles they do not have to be removed from the pond. Substrates can be tied to poles stacked into the pond bottom (in shallow ponds) or hung from ropes fastened to the banks (in shallow or deep ponds). Considering that most periphyton development occurs in the epilimnion, the proper vertically installation of the substrates, only in the upper half meter of the water column would save material and money. Between the substrates there should be enough space for the fish to swim. Based on the growth results, it is recommended to use rough, rigid, white substrates.

Table 2: Underwater substrate area (m^2) required to supplement feed of different tilapia biomass (kg) at different daily feeding rates (% of fish biomass/day), estimated from the DM equation of the third substrate experiment.

	Feeding rate (% of biomass/day)		
Tilapia biomass (kg)	0.2%	0.5%	1%
50	50	125	250
100	100	250	500
250	250	625	1250
500	500	1250	2500
750	750	1875	3750
1000	1000	2500	5000

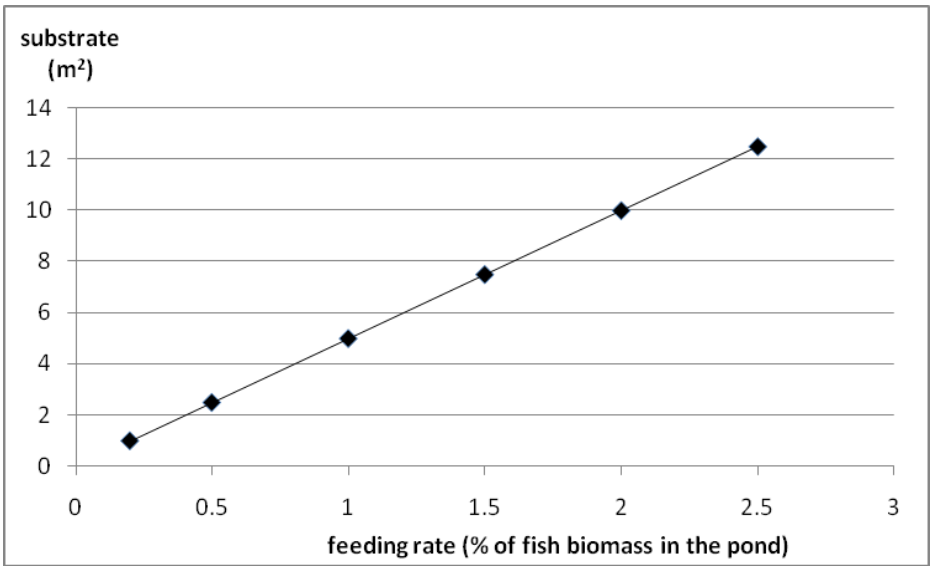

Figure 3: Substrate required per kg fish biomass in the pond under different feeding rates, estimated from the DM equation of the third substrate experiment.

ACKNOWLEDGEMENTS

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REFERENCES

1. Azim M. E. and Little D. C., 2006 – Intensifying aquaculture production through new approaches to manipulating natural food, *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*, 062, 23.
2. Azim M. E., Verdegem M. C. J., van Dam A. and Beveridge M. C. M. (eds), 2005 – *Periphyton: ecology, exploitation and management, CABI Publishing*, UK, 319.
3. Azim M. E., Verdegem M. C. J., Khatoon H., Wahab M. A., van Dam A. A. and Beveridge M. C. M., 2002a – A comparison of fertilization, feeding and three periphyton substrates for increasing fish production in aquaculture in Bangladesh, *Aquaculture*, 212, 231-47.
4. Azim M. E., Verdegem M. C. J., Mantingh I., van Dam A. A. and Beveridge M. C. M., 2003 – Ingestion and utilization of periphyton grown on artificial substrates by Nile tilapia, Oreochromis niloticus L., *Aquaculture Research*, 34, 85-92.
5. Azim M. E., Wahab M. A., van Dam A. A., Beveridge M. C. M., Milstein A. and Verdegem M. C. J., 2001 – Optimization of fertilization rate for maximizing periphyton production on artificial substrates and the implications for periphyton-based aquaculture, *Aquaculture Research*, 32, 749-760.
6. Azim M. E., Wahab M. A., Verdegem M. C. J., van Dam A. A., van Rooij J. M. and Beveridge M. C. M., 2002b – The effects of artificial substrates on freshwater pond productivity and water quality, implications for periphyton-based aquaculture, *Aquatic Living Resources*, 15, 231-241.
7. Cnaani A., Barki A., Slosman T., Scharcanski A., Milstein A. and Harpaz S., 2010 – Dietary salt supplement increases growth rate in freshwater cultured tilapia hybrids, *Aquaculture Research*, 41, 1545-1548.
8. El-Sayed A. F., 2006 – Tilapia culture, *CABI Publishing*, UK, 277.

9. García J. J., Celis L. M., Villalba E. L., Mendoza L. C., Crú S. B., Atencio V. J. and Pardo S. C., 2011 – Evaluación del policultivo de bocachico Prochilodus magdalenae y tilapia Oreochromis niloticus utilizando superficies fijadoras de perifiton, *Medicina Veterinaria y Zootecnia*, 58, 71-83. Downloaded from http://www.scielo.org.co/scielo.php?script=sci_abstract&pid=S0120-29522011000200002&lng=en&nrm=iso. (in Spanish)
10. Hem S. and Avit J. L. B., 1994 – First results on "acadja-enclos" as an extensive aquaculture system (West Africa), *Bulletin of Marine Science*, 55, 1038-1049.
11. IFOAM, 2009 – *The IFOAM norms for organic production and processing*, Version 2005 (Corrected version January 2009), downloaded from www.ifoam.org.
12. Keshavanath P., Ganghadar B., Ramesh T. J., van Rooij J. M., Beveridge M. C. M., Baird D. J., Verdegem M. C. J. and van Dam A. A., 2001 – Use of artificial substrates to enhance production of freshwater herbivorous fish in pond culture, *Aquaculture Research*, 32, 189-197.
13. Keshavanath P., Gangadha B., Ramesh T. J., van Dam A. A., Beveridge M. C. M. and Verdegem M. C. J., 2002 – The effect of periphyton and supplemental feeding on production of the indigenous carps Tor khudree and Labeo fimbriatus, *Aquaculture*, 213, 207-218.
14. Keshavanath P., Gangadha B., Ramesh T. J., van Dam A. A., Beveridge M. C. M. and Verdegem M. C. J., 2004 – Effects of bamboo substrate and supplemental feeding on growth and production of hybrid red tilapia fingerlings (Oreochromis mossambicus x Oreochromis niloticus), *Aquaculture*, 235, 303-314.
15. Milstein A., Azim M. E., Wahab M. A. and Verdegem M. C. J., 2003 – The effects of periphyton, fish and fertilizer dose on biological processes affecting water quality in earthen fish ponds, *Environmental Biology of Fishes*, 68, 247-260.
16. Milstein A., Joseph D., Peretz Y. and Harpaz S., 2005 – Evaluation of organic tilapia culture in periphyton-based ponds, *Israeli Journal of Aquaculture - Bamidgeh*, 57, 143-155.
17. Milstein A., Joseph D., Peretz Y. and Harpaz S., 2008a – Increasing natural food and reducing added feeds in organic tilapia ponds, *World Aquaculture*, 39, 28-29.
18. Milstein A., Peretz Y. and Harpaz S., 2008b – Periphyton as food in organic tilapia culture: comparison of periphyton growth on different substrates, *Israel Journal of Aquaculture - Bamidgeh*, 60, 243-252.
19. Milstein A., Peretz Y. and Harpaz S., 2009 – Culture of organic tilapia to market size in periphyton based ponds with reduced feed inputs, *Aquaculture Research*, 40, 55-59.
20. Naturland, 2012 – *Naturland standards for organic aquaculture*, www.naturland.de.
21. Rai S., Yi Y., Wahab M. A., Bart A. N. and Diana J. S., 2008 – Comparison of rice straw and bamboo stick substrates in periphyton carp polyculture, *Aquaculture Research*, 39, 464-473.
22. Ramesh M. R., Shankar K. M., Mohan C. V. and Varghese T. J., 1999 – Comparison of three plant substrates for enhancing carp growth through bacterial biofilm, *Aquaculture Engineering*, 19, 119-131.
23. Uddin S., M. E. Azim, A. Wahab and M. C. J. Verdegem, 2009 – Effects of substrate addition and supplemental feeding on plankton composition and production in tilapia and freshwater prawn (Macrobrachium rosenbergii) polyculture, *Aquaculture*, 297, 99-105.
24. Uddin M. S., Milstein A., Azim M. E., Wahab M. A., Verdegem M. C. J. and Verreth J. A. J., 2008 – The effects of stocking density, periphyton substrate and supplemental feed on biological processes affecting water quality in earthen tilapia-prawn polyculture ponds/systems, *Aquaculture Research*, 39, 1243-1257.
25. van Dam A. A., Beveridge M. C. M., Azim M. E. and Verdegem M. C. J., 2002 – The potential of fish production based on periphyton, *Reviews in Fish Biology and Fisheries*, 12, 1-31.
26. Wahab M. A. and Kibria M. G., 1994 – Katha and kua fisheries - unusual fishing methods in Bangladesh, *Aquaculture News*, 18, 24.

DIVERSITY AND ABUNDANCE PATTERNS OF AMPHIBIANS IN REHABILITATED QUARRIES OF BAMBURI NEAR MOMBASA (KENYA)

*Dominic Otwori ONG'OA *, Rossa Nyoike NG'ENDO **, Shadrack Muvui MUYA *, Mathew Mugechi NYOIKE ****, Patrick Kenyatta MALOMZ **** and *Zipporah Lagat OSIEMO **

* Jomo Kenyatta University of Agriculture and Technology, P. O. Box, Nairobi, Kenya, KE-62000, dotwori6@gmail.com, smuya@jkuat.ac.ke, zbisieri@yahoo.com
** The Catholic University of Eastern Africa, P. O. Box, Nairobi, Kenya, KE-62157-00200, rossangendo@yahoo.com
*** National Museum of Kenya, P. O. Box, Nairobi, Kenya, KE-40658-00100, pkmalonza@yahoo.com
**** The Lafarge Ecosystems P. O. Box, Mombasa, Kenya, KE-81995, mmugechi@yahoo.com

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KEYWORDS: amphibians, diversity, abundance, quarry rehabilitation, ecological gradient.

ABSTRACT

Amphibians are sensitive to changes in the environment and are, therefore, excellent indicators of success in restoring degraded habitats. As such, a clear understanding on how amphibian populations respond to changes in the environment is required. In order for conservationists to establish if the declining trends are changing, biodiversity recovery studies are essential especially in reclaimed habitats. This study focused on the recovery of amphibians, particularly on frogs, in reclaimed quarries of the Bamburi Cement Plant near Mombasa whereby the diversity, species abundances and composition at different stages of quarry re-establishment were assessed.

The study area was divided into three zones based on the 13-year interval since the beginning of the rehabilitation process. Transect surveys and time-constrained search and size method were used for sampling 20 randomly selected sites. Sampling was done during the rainy and the dry seasons, with searches conducted between 900 and 1,600 hours during the day and between 1,800 to 2,100 hours at night. Recording of basic morphological data of collected specimens was done in the field to aid in grouping specimens before voucher materials were preserved in 10% formalin and stored in 70% alcohol. Further identifications and confirmations matching specimens to species were carried out using specialized classification keys from the National Museum of Kenya.

Twelve species were encountered across the three zones, with *Ptychadena anchietae* and *Phrynobatrachus acridoides*, respectively, the most abundant. It was also noted that amphibian diversity across the quarries was independent of the age of ecological re-establishment ($r = -0.5$). This is indicated by the higher amphibian diversity in the south and north quarries ($N = 1050$ and 506 respectively) despite their relatively younger age since re-establishment compared to the central quarry ($N = 438$). Lower diversity in the central quarry, although the oldest, may be largely attributed to human disturbance. Additionally, exotic plantations across the study area are poor in species since they are monocultures and, thus, not heterogeneous enough to support higher anuran diversity. Since amphibians act as one of the best measure of environmental health, rehabilitation process in the quarries need to embrace mechanisms that support maximum biodiversity recovery such as replanting of more indigenous tree species as opposed to only exotic monocultures.

RÉSUMÉ: Modèles de la diversité et de l'abondance des amphibiens dans les carrières réhabilitées de Bamburi près de Mombasa (Kenya).

Les amphibiens sont sensibles aux modifications de l'environnement et constituent donc d'excellents indicateurs du succès de la restauration des habitats dégradés.

Ainsi, une meilleure compréhension de la réponse des populations d'amphibiens aux modifications de leur environnement s'impose. Afin de permettre aux conservateurs de diagnostiquer des modifications de tendances de déclin, des études de restauration de la biodiversité sont nécessaires, surtout pour les habitats sujets à la dégradation. Cette étude s'est concentrée sur les populations d'amphibiens, en ciblant plus particulièrement les batraciens, dans les carrières réhabilitées de l'Usine de Ciment de Bamburi près de Mombasa où nous avons évalué la diversité, l'abondance et la composition spécifique lors des différentes étapes de la réhabilitation de la zone.

La région étudiée a été divisée en trois zones en fonction des étapes du processus de réhabilitation qui a commencé il y a 13 ans. L'échantillonnage a été effectué à l'aide de transectes, de méthodes de recherche et de mesure pour l'échantillonage de 20 sites choisis au hasard durant des campagnes limitées dans le temps. Le relevé des données a été effectué durant la saison sèche et la saison humide avec 900 à 1600 heures d'échantillonnage de jour et 1800 à 2100 heures d'échantillonnage la nuit. Le prélèvement des principaux paramètres morphologiques des individus collectés a été fait sur le terrain afin de faciliter le regroupement des spécimens qui ont été ensuite conservés dans du formol 10% et mis en dépôt dans de l'alcool à 70%. Par la suite, on a procédé à l'identification et la confirmation des espèces à l'aide des clés d'identification des Musées Nationaux de Kenya.

12 espèces ont été inventoriées dans les trois zones; la plus abondante étant *Ptychadena anchietae* suivie par *Phrynobatrachus acridoides.* Nous avons aussi remarqué que la diversité des amphibiens, sur le territoire étudiée, est indépendante de l'âge de la réhabilitation écologique (r = -0,5). Ceci est montré plus particulièrement dans le cas des diversités d'amphibiens dans les carrières sud et nord (N = 1050 et respectivement 506), malgré leur réhabilitation relativement récente, comparée à celle de la carrière centrale (N = 438). Dans ce dernier cas, l'impact sur la biodiversité peut être due au dérangement produit par l'activité humaine. De plus, les plantations exotiques dans la zone étudiée ont une biodiversité réduite car ce sont des monocultures manquant d'hétérogénéité pourtant nécessaire pour maintenir des diversités plus grandes d'anoures. Puisque les amphibiens sont le meilleur instrument dans l'évaluation de la santé de l'environnement, le processus de réhabilitation des carrières doit adopter des mécanismes permettant une récupération maximale de biodiversité, tel que la plantation de plus d'espèces d'arbres indigènes à l'opposé des monocultures exotiques.

REZUMAT: Modele de diversitate şi abundenţă la amfibieni în carierele reabilitate de la Bamburi, lângă Mombasa (Kenya).

Amfibienii sunt specii sensibile la modificările mediului înconjurător, constituind astfel excelenţi indicatori ai succesului restaurărilor de habitate degradate. În consecinţă, se impune o înţelegere mai bună a modului în care populaţiile de amfibieni răspund la modificările din mediu. Pentru ca ecologii să poată stabili o eventuală modificare a tendinţelor de declin în habitatele reabilitate sunt necesare studii ale refacerii biodiversităţii. Prezentul studiu se concentrează asupra refacerii populaţiilor de amfibieni, în special anure, în carierele reabilitate ale fabricii de ciment din Bamburi, lângă Mombasa; în acest scop, în diferite stadii ale reabilitării carierei au fost evaluate diversitatea, abundenţa şi compoziţia speciilor de amfibieni.

Zona studiată a fost împărțită în trei subzone, în funcție de modul cum a evoluat reabilitarea începută cu 13 ani în urmă. Eșantionarea s-a efectuat în 20 de locații, prin metoda transectelor și prin metoda căutării și măsurării în campanii limitate în timp, pe durata sezoanelor uscat și umed, campaniile acoperind între 900 și 1600 ore, ziua și între 1800 și 2100 ore noaptea. Înregistrarea datelor morfologice principale la specimenele colectate s-a efectuat pe teren pentru a facilita gruparea specimenelor înainte de prelevarea și conservarea eșantioanelor, care s-a făcut cu formol 10%, apoi eșantioanele s-au depozitat în soluție 70% alcool. S-au efectuat, de asemenea, identificări ale specimenelor colectate la nivel de specie cu ajutorul cheilor de clasificare ale Muzeelor Naționale din Kenya.

Pe ansamblul celor 3 zone de studiu s-au identificat 12 specii, cele mai abundente fiind *Ptychadena anchietae* și, respectiv, *Phrynobatrachus acridoides*. S-a remarcat, de asemenea, că diversitatea amfibienilor, în perimetrul carierei, nu a depins de vechimea reabilitărilor ecologice, efectuate în zonele unde aceștia au fost găsiți (r = -0,5). Acest lucru este pus în evidență și de diversitățile mari ale amfibienilor din carierele sud și nord (N = 1050 și respectiv 506), în ciuda reabilitării lor relativ recente, comparativ cu cariera central (N = 438). Diversitatea mai mică din cariera centrală, zona reabilitată cea mai veche poate fi datorată impactului antropic. De asemenea, plantațiile exotice din zona studiată prezintă o diversitate specifică scăzută deoarece sunt monoculturi fără heterogenitatea necesară pentru a susține o diversitate mare de anure. Deoarece amfibienii sunt indicatorii cei mai buni pentru sănătatea mediului, procesul de reabilitare a carierelor necesită adoptarea de mecanisme, care să susțină o recuperare maximă a biodiversității precum replantarea mai multor specii arborescente indigene și nu doar a unor monoculturi exotice.

INTRODUCTION

Amphibians, a unique group of vertebrates containing over 6,300 known species, are threatened worldwide (IUCN, 2013). Clearly, the most important factor leading to most biodiversity losses worldwide is habitat destruction (Sala et al., 2000) and amphibians are not an exception (Amphibia Web, 2013). Surface mining, for instance, constitutes a major threat to amphibians, not only through the associated water pollution, but also through the mechanical destruction of amphibians themselves as well as their habitat. Land use typically changes following the mining process, and post-mining habitat is likely to significantly constitute lesser species diversity and maybe different species appearance (Means et al., 2004). This is likely so because changes in vegetation cover, vegetation type and composition, soil properties, and topography will therefore provide different microhabitats and resources for wildlife than those previously available before destruction (Kozlov et al., 2007).

Understanding the consequences of habitat change for biodiversity is important because the current protected area network is insufficient to safeguard the majority of the world's species (Stuart et al., 2004), and the persistence of many species depends upon the effectiveness of strategies for conserving biodiversity in human-dominated landscapes (Daily, 2001; Lindenmayer and Franklin, 2002; Semlitsch and Rothermel, 2003; Vandermeer and Perfecto, 2007). The establishment of animal communities in mine spoils is typically dependent on the setting up of the native plant communities (McKinney, 2002). This would be expected since most fauna depends on plant communities either as sources of food, nesting areas and hiding places from predators or harsh weather among others (Ireland et al., 1994; Dunger et al., 2001; DeVault et al., 2002) This has been clearly validated by birds, mammals and invertebrates (Burbridge et al., 1992). In examining such habitats, ecologists have long

documented a small subset of native species that can exploit highly altered, anthropogenic habitats in urban and industrial settings (McKinney, 2002). However, the list of native species that have spontaneously settled in these habitats is typically small. A study by Majer et al. (1989) on colonization of mined areas in Western Australia by ants point out that regardless of mine location or substrate characteristics, the pioneers are often of the same species and are generally uncommon in the adjoining undisturbed habitats.

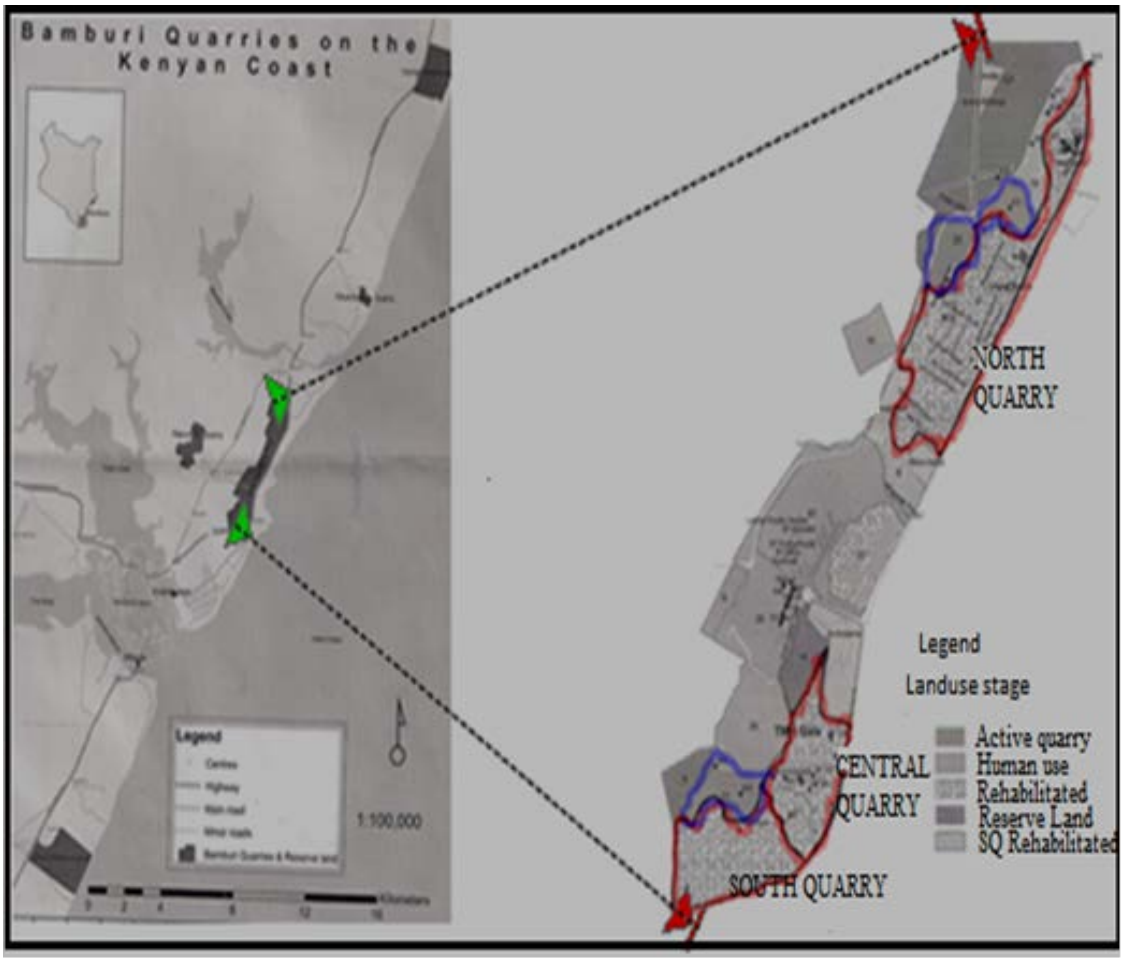

Figure 1: showing the location of the southern, central and north quarries, all at different stages of rehabilitation process.

Various studies have largely concentrated on the declining trends of amphibians (McCoy, 1994; Marsh, 2001; Collins and Storfer, 2003; Stuart et al., 2004; Gardner et al., 2007), with most barely addressing issues on the recovery of amphibian species admitting the biodiversity declines. Furthermore, biodiversity studies have mainly focused on degraded forest ecosystems, since they are presumed to have higher biodiversity (Bwong et al., 2009; Ng'endo et al., 2011; Malonza et al., 2011). In the present study, a census on amphibian populations was carried out in rehabilitated quarries that range between 12 to 42 years of age since the reclamation process. We sought to establish the diversity, abundance and composition of amphibian species in the restored habitats.

The study was carried out in the rehabilitated mines of Bamburi Cement Plant near Mombasa, south of Kenya. This area has an altitude ranging between 0-7 m above the sea level, latitude of 04°03'S and longitude of 39°40'E. The area experiences a warm and humid climate, with temperatures ranging between 20°C and 32°C. The study area is at different gradients of recovery with central quarry, south quarry and north quarry being 42, 27 and 12 years old respectively, since the beginning of the reclamation process. Rehabilitation work started with the planting of the pioneer exotic plant species, the *Casuarina* and *Canocapus* species back in 1970s, which through gradual succession process has helped to create micro-climate conditions necessary for full establishment of the present fauna and flora.

MATERIALS AND METHODS

The study site was grouped into three zones based on their age of establishment across the restored forests, grasslands and wetlands (Fig. 1). Sampled sites were randomly selected within these zones and sampling of amphibians was done using a timed species count method similar to those described by Karns (1986), Heyer et al. (1994) and Sutherland (1996). This entails quietly walking and intensively searching within all possible herpetofauna microhabitats such as under leaves, debris, decomposing tree stumps and logs, on trees, shrubs, bushes, wetlands including digging for burrowing species. Data collection was done during the wet and dry seasons and the searches were conducted between 900 to 1,600 hours in the day and between 1,800 to 2,100 hours at night. Identification of collected species was done with the help of specialized classification keys from the National Museum of Kenya. Where identification was difficult, voucher materials were preserved in 10% formalin, stored in 70% alcohol and transferred to the National Museum of Kenya for further reference and identification.

Dominance plots (Whittaker, 1965) were used to display abundance distribution patterns of species against species rank order plotted using the function *radfit* in package Vegan. Akaike Information Criterion (AIC) was used to select the models which included the Null, Preemption, Lognormal, Zipf and Mandelbrot, following Wilson (1991). Rényi diversities were calculated at varying scales (0, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, Inf) using the function *Rényi* in package Vegan. This form of estimation was preferred because common diversity indices are special cases of Rényi diversity as represented in the formula:

$$\mathrm{H}\, a = 1/1 - a$$

where a is a scale parameter, and Hill (1973) suggested to use the so-called "Hill numbers" defined as $\mathrm{N}a = \exp(\mathrm{H}a)$. Some Hill numbers are the number of species with $a = 0$, exp (H') or the exponent of Shannon diversity with $a = 1$, inverse Simpson with $a = 2$ and 1 = max (pi) with $a = \infty$. According to the theory of diversity ordering, one community can be regarded as more diverse than another only if its Rényi diversities are all higher (Tóthmérész, 1995). In addition, diversity for the three quarries was separately calculated and also total diversity for the entire survey area using several diversity indices to test for robustness (establish if they gave more or less similar results). Species ecological distances at different sites were examined by generating a dissimilarity matrix using species abundance data. Jaccard index was used since it detects underlying ecological gradients (Faith et al., 1987). The matrix was then used to construct clusters using average linkage method which links the same two most similar sites, and at the same minimum dissimilarity. All the above analyses were calculated using package Vegan (Oksanen et al., 2010) and implemented in R (R Development Core Team, 2010).

RESULTS AND DISCUSSIONS

Twelve species were observed (N = 1994) from nine genera. Two frog species (*Phrynobatrachus acridoides* and *Ptychadena anchietae*) were noted as the most abundant/dominant across the three study zones. In the southern quarry, 53.8% of the collected samples were *Phrynobatrachus acridoides*, while 33.7% represented *Ptychadena anchietae* species. A more or less similar pattern was observed in central and northern quarries *Ptychadena anchietae* (55.7%), *Phrynobatrachus acridoides* (40.6%); *Ptychadena anchietae* (55%) and *Phrynobatrachus acridoides* (35.6%) respectively. On the other hand, *Bufo gutturalis* and *Chiromantis xerampelina* were the least encountered species across the study area. Uniquely, *Bufo gutturalis* were only spotted in the northern quarry, *Hyperolius tuberilinguis* at the central quarry and *Hyperolius pusillus* at the southern quarry (Tab. 1). Such relatively high abundances of *Ptychadena anchietae* have been recorded in degraded environments, implying that this species tolerates some habitat modification (Harper et al., 2010).

Table 1: Amphibian species samples collected between October 2011 and February 2012.

Species	South quarry	Central quarry	North quarry	Total
Phrynobatrachus acridoides (Cope, 1867)	565	178	180	923
Ptychadena anchietae (Bocage, 1867)	356	244	279	879
Ptychadena schillukorum (Werner, 1907)	42	3	14	59
Amirana galamensis (Dumeril and Bibron, 1841)	42	0	4	46
Kassina maculate (Dumeril, 1853)	3	6	14	23
Chiromantis xerampelina (Peters, 1954)	12	0	6	18
Xenopus muelleri (Peters, 1844)	11	1	2	14
Hyperolius pusillus (Cope, 1862)	11	0	0	11
Pyxicephalus edulis (Peters, 1854)	2	1	4	7
Hyperolius argus (Peters, 1854)	6	1	0	7
Hyperolius tuberilinguis (Smith, 1849)	0	4	0	4
Bufo gutturalis (Power, 1927)	0	0	3	3
Total	1050	438	506	1994

Notable variation was observed in species abundances across the sampled sites, with sites 2, 4, 6 and 19 revealing higher abundances in relation to other sites. Additionally, certain sites such as 15, 16 and 20 may have had higher alpha diversities but the abundances of their species were relatively low (Fig. 2). In most cases, higher abundances reflected uneven distribution of species within the sites, and this therefore translated to uneven distribution of species across the study zones. This implies that fluctuations in quality breeding sites, resources, or other factors were responsible for such unevenness. Changes in vegetation composition may alter habitat suitability in many ways (Runkle, 1998), particularly in determining insect communities and their distribution (Waltz and Whitman, 1997). It can, therefore, be expected that quarries with suitable breeding sites and also harboring higher diversities of plant species which may act as home for tree frogs and also for potential food sources such as insects, are likely to have high frog abundances and diversity as opposed to quarries with monoculture plantations of Casuarina and Canocapus species.

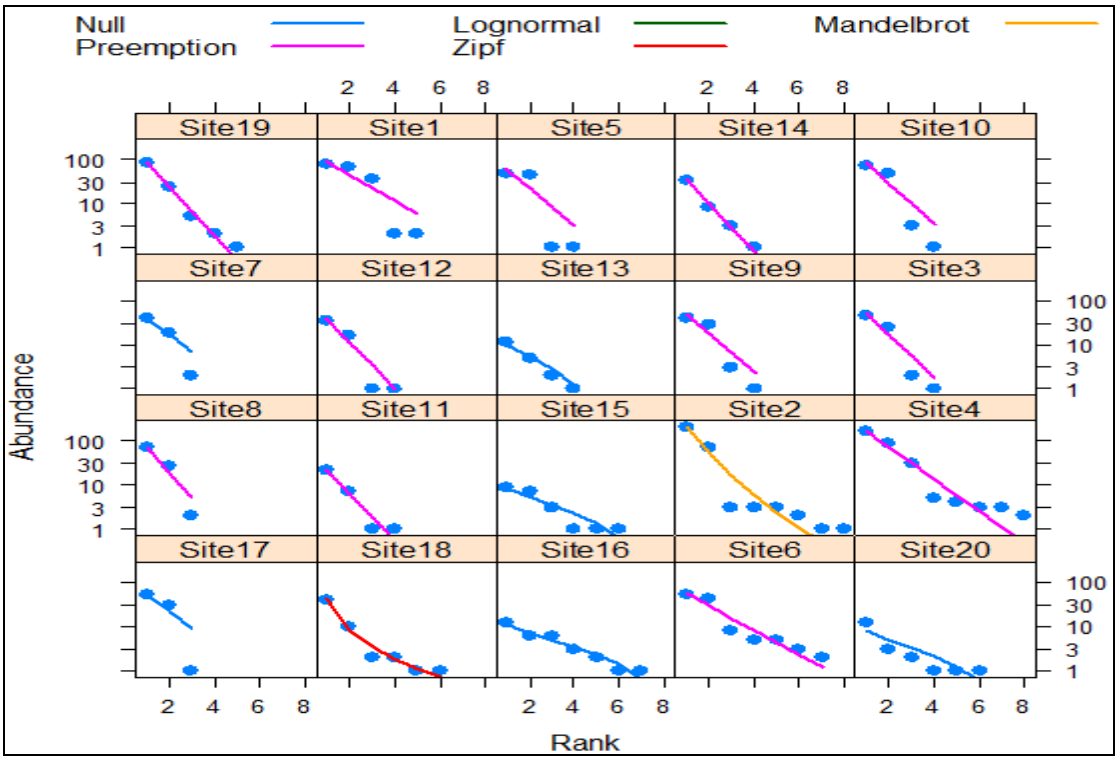

Figure 2: Rank abundance curve plots of species abundances against species rank order for 20 randomized sites using Akaike Information Criterion (AIC). Each dot on a line represents a species within sample sites. Each species is placed in descending order in relation to their abundance ranking in the quarries and as the slope of the line becomes more horizontal, it implies that the evenness level becomes stronger across the quarries. The best model has the lowest AIC, that fits the sampled data as closely as possible (best fit) and is automatically selected for the various plots accordingly.

Further, results revealed that the southern quarry had notably the highest alpha diversity (α-diversity) followed by the northern quarry and lastly the central quarry (i.e. ten species (37%), nine species (33%) and eight species (30%) respectively). Sites 2, 4 and 6 from the southern quarry were the most diverse (i.e. α = 1.33, 1.33 and 1.17, respectively), while sites 15, 16, 18, 19 and 20 were the most diverse in northern quarry (i.e. α = 0.750, 0.875, 0.750, 0.625 and 0.750 respectively; Fig. 3). It is important to note that the above singled sites have contributed immensely towards the species diversity, not only within their units, but generally between other units in the entire quarries. It is imperative however to appreciate the level of diversity contributions of some sites with similar number of species but different alpha diversity. For instance, sites 2 and 4 in the southern quarry have each 8 species, but their alpha indices are slightly different (i.e. 2.92 and 2.08). This observation illustrates that site 2 has many uniquely different species compared to site 4 which has many common species. Similarly the contributory diversity of sites 15 and 20 in the northern quarry differs from site 18, despite of their equal number of species (i.e. with alpha diversity measures of 1.56, 1.56 and 1.26, respectively). On the other hand, most sites from the central quarry were less diverse (e.g. sites 7, 8 and 10; Fig. 3).

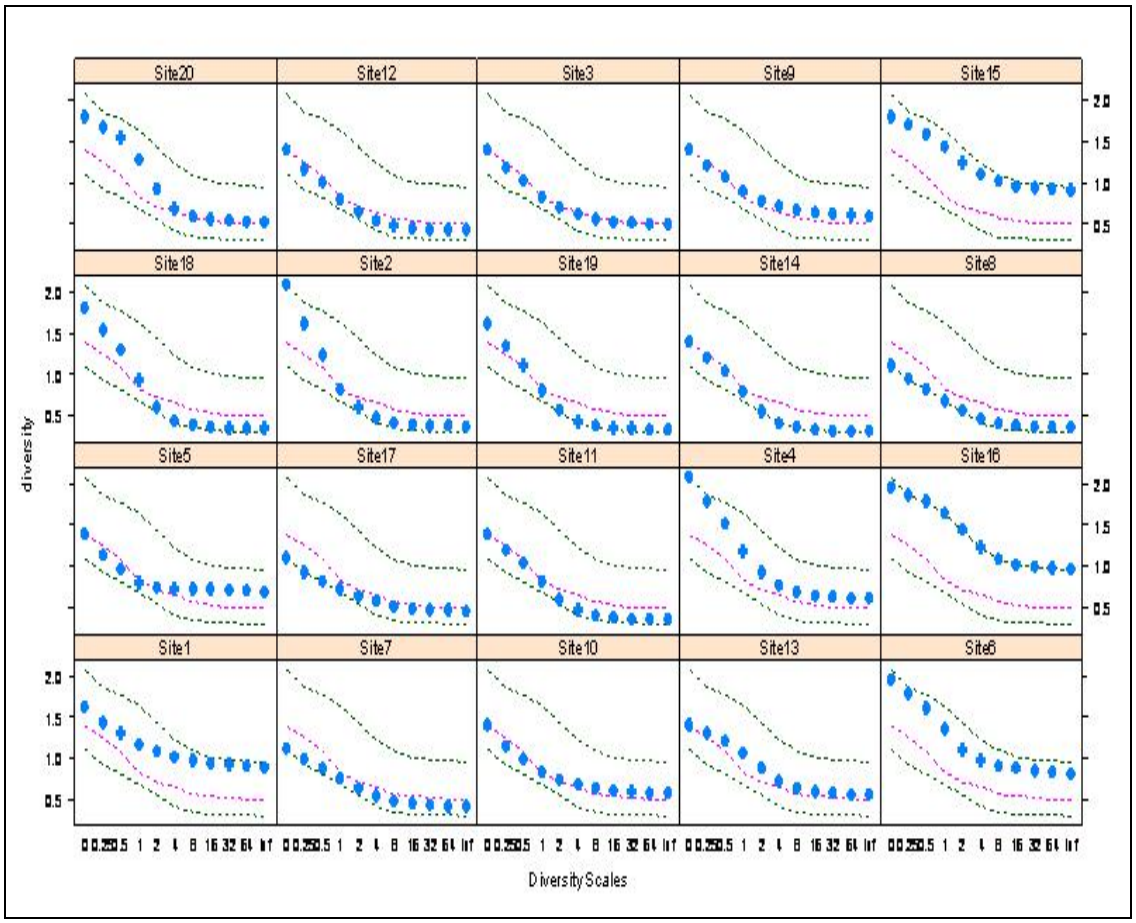

Figure 3: Rényi diversities for the 20 sampled sites within the three study sites; the dots show the values for sites, and the lines the extremes and median in the data set; a site can be regarded as more diverse if all of its Rényi diversities are higher than in another site.

These higher diversities in southern and northern quarries may be attributed to the availability of suitable breeding conditions, food and relatively stable habitats for colonization. Most ecological aspects of these places were naturally thriving without any anthropological setbacks. The ponds were bursting with life ranging from the aquatic and semi-aquatic vegetation blooms like the spirogyra, the phytoplankton and the reeds to aquatic fauna, which is important for the energy flow in the local ecosystem. Water vegetation provides attachment places for the eggs of most amphibians such as the *Hyperolidae* family. Besides that, phytoplankton acts as a source of food to the tadpoles in their young stage, and they also regulate nutrients, such as excess salts (bio filtration), as well as purifying water gases. Vegetation as well acts as shelter against amphibian predators. On this basis, the water vegetation occupies an important part in the rapid growth of the amphibian population in the southern quarry. This is a signal that the southern quarry is rapidly recovering its health status more than the central quarry irrespective of its age of reestablishment.

Studies by Lehtinen et al. (2001) and Petranka et al. (2007) indicate that colonization of restored wetlands happened after many months or years. However, this concept does not fit for the central quarry, although it is the oldest since restoration process, has many artificial ponds and multispecies of indigenous vegetation in addition to the monocultures of *Cassuarina* and *Canocapus* species. Comparatively, the younger south and north quarries have higher species diversities than the central quarry. This surprisingly low α-diversity, as well the low species richness (n = 8 and n = 438 respectively) in the Central quarry are likely caused by human disturbance, since most tourism activities take place here. Forest harvesting and also the not easily biodegraded dead leaves from *Cassuarina* trees largely interfere with the breeding sites and also movement of ground dwelling frog species. This has direct implication on species colonization into suitable surrounding habitats as a result of reductions in dispersal potential. The quarry lacked some amphibian species, especially the tree frogs. Species such as *Hyperolius pusillus, Bufo gutturalis, Chiromantis xerampelina* and *Amnirana galamensis* were completely not spotted at this quarry. This may imply that the alterations of the vegetation structure and microhabitats inadequacy restricted their occurrence in this area (Urbina-Cardona et al., 2006). Furthermore, the wetlands available in the form of ponds interconnected by channels are as well getting extinct due to suffocations by the mangrove ferns, which are characteristically invasive species. This has made the water volume and flow to reduce drastically. Even though shallow water points with a surface mat of vegetation are considered ecologically valuable especially to the life and breeding of amphibians, for the case of the mangrove ferns it is unlikely true because the ferns propagate siltation, which might ultimately dispel water from the grounds, thus, affecting the habitat quality. These findings confirm a study at the Brazilian Atlantic rain forest by Becker et al. (2007), which showed that amphibian species that hang on aquatic habitats may be threatened if the ground conditions are not carefully assessed during rehabilitation process. On overall, there were no significant differences across the quarries ($P > 0.05$).

Species composition characteristics in the three studied quarries provided a dual revelation that perhaps predicts and explains the ecological position of the amphibian species at the rehabilitated quarries. The results from the clustering show that the pairing of sites was largely independent of the age of quarry re-establishment. However, there were sites from the same quarry that showed similarities in species composition. For example, sites 13 and 20 and sites 2 and 4 among others. Most sites, however, seem to have a relatively large ecological distance though occurring in the same quarry, where as for some the ecological distance is small. For instance, sites 8 and 11 in the central quarry have a large ecological distance and, thus, most species occurring in these sites are different. On the contrary, the sites 7 and 12 in the same quarry have a small ecological distance and, therefore, imply that their species composition is more or less similar (Fig. 4). There is no continuity in the dispersion of particular amphibian species within any given quarry and this may be suggesting that the habitat heterogeneity in the underlying ecological influence the composition of species at different quarries.

Most species are stringent habitat specialists and it appears that slight habitat encroachment or modification will affect their population size. The *Chiromantis xerampelina* species, for instance, was seen to prefer emergent hydrophytes, such as the water lilies and water hyacinth on shallow waters for breeding purposes. Similar preference was also observed in *Hyperolius tuberilinguis*, which had preference for water-reeds. Destruction of such reeds could, therefore, mean an interruption on their life cycle and, consequently, population

declines. A similar behaviour was witnessed in the African Bull frog (*Pyxicephalus edulis*), which was found to survive in created or restored wetlands with long hydro-periods (more permanent water bodies). Freda et al. (1991) observed that Bull frogs' embryonic and larvae stages were highly sensitive to high acidic levels within their habitats. Although quantification of acidic levels of the quarry wetlands was not done, this would be a reason for the absence of Bull frogs in the central quarry (Monello et al., 1999; Henning et al., 2006; Fuller et al., 2011).

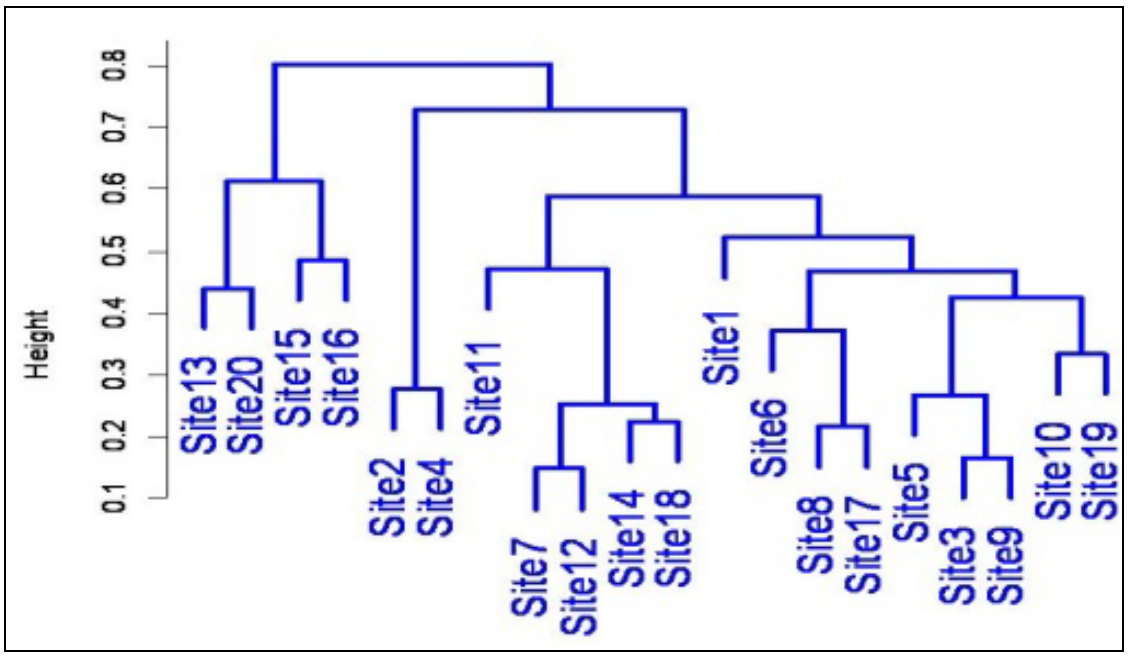

Figure 4: Cluster dendrogram for all 20 sites (using Jaccard index) showing analysis of ecological distance to examine species composition for the entire area of study area; each cluster starts by combining the two most similar sites to each other and then proceeds by combining groups to groups; fusion of sites/groups was done using average linkage method.

CONCLUSIONS

The species diversity patterns and composition in the reclaimed mining quarries provide interesting information that helps to infer into the ecological conditions currently prevailing at the region and also the conservation measures that can be taken to improve the habitat quality for higher species diversity.

The noted species patterns are perhaps due to unfavourable conditions for the tenancy of amphibians that ranges from breeding, shelter, hydrological cycle, food web complexity, dispersal corridors in the neighbourhood and the edge effect.

The results indicate that the observed amphibian species list does not exhaust the known pool of amphibian species of the coastal region of Kenya, which is of about 30 (Malonza et al., 2006; Malonza et al., 2011).

In order to maximize on biodiversity recovery as a whole in the rehabilitated quarries, the restoration process should embrace the use of indigenous plant species, as well as to improve the habitat quality such as the artificial and natural breeding areas. These aspects perhaps would be the cradle of the missing amphibian species.

REFERENCES

1. AmphibiaWeb., 2013 – Information on amphibian biology and conservation, Web application, 2013, http://amphibiaweb.org, accessed Jul 17, 2013.
2. Becker C. G., Fonseca C. R., Haddad C. F. B., Batista R. F. and Prado P. I., 2007 – Habitat split and the global decline of amphibians, *Science*, 318, 1775-1777.
3. Burbridge A. H., Leicester K., MacDavitt S. and Majer J. D., 1992 – Ants as indicators of disturbance at Yanchep National Park, Western Australia, *Journal of the Royal Society of Western Australia*, 75, 89-95.
4. Bwong B. A., Chira R., Schick S., Veith M. and Lötters S., 2009 – Diversity of Ridged Frogs (Ptychadena) in the easternmost remnant of the Guineo-Congolian rain forest: morphology, bioacoustics, molecular markers, *Salamandra*, 45, 129-146.
5. Collins J. P. and Storfer A., 2003 – Global amphibian declines: sorting the hypotheses. Diversity and Distributions, 9: 89-98.
6. Daily G. C., 2001 – Ecological forecast, *Nature*, 411, 245.
7. De Vault T. L., Scott P. E, Bajema R. A. and Lima S. L., 2002 – Breeding birds of reclaimed coal-mine grasslands in American Midwest, *Journal of Field Ornithology*, 73, 268-275.
8. Dunger W., Wanner M., Hauser H., Hohberg K., Schulz H. J., Schwalbe T., Seifert B., Vogel J., Voigtlander K., Zimdars B. and Zulka K. P., 2001 – Development of soil fauna at mine sites during 46 years after afforestation, *Pedobiologia*, 45, 243-271.
9. Faith D. P., Minchin P. R. and Belbin L., 1987 – Compositional dissimilarity as a robust measure of ecological distance, *Vegetation*, 69, 57-68.
10. Freda J., Sadinski W. J. and Dunson W. A., 1991– Monitoring of amphibian populations with respect to the effects of acidic deposition, *Water, Air and Soil pollution*, 55, 445-462.
11. Fuller T. E., Pope K. L., Ashton D. T. and Welsh H. H. Jr., 2011 – Linking the distribution of invasive amphibians to habitat conditions in a managed river system in Northern Carolina, *Restoration Ecology*, 19, 204-213.
12. Gardner T. A., Barlow J. and Peres C. A., 2007 – Paradox, presumption and pitfalls in conservation biology: The importance of habitat change for amphibians and reptiles, *Biological Conservation*, 138, 166-179.
13. Harper E. B., Measey G. J., Patrick D. A., Menegon M. and Vonesh J. R., 2010 – Field guide to the amphibians of the Eastern Arc Mountains and Coastal Forests of Tanzania and Kenya, *Nairobi Camerapix Publishers International.*
14. Henning J. A. and Shirato G., 2006 – Amphibian use of Cheralis River flood plain Wetlands, *North Western Naturalist*, 87, 209-214.
15. Heyer W. R., Donnelly M. A, Diarmid M. R. W., Hayek L.-A. C and Foster M. S. (eds), 1994 – Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington D. C., 364.
16. Hill M. O., 1973 – Diversity and evenness: a unifying notation, *Ecology*, 54, 427-473.
17. International Union for the Conservation of Nature - IUCN, 2013 – IUCN Red list of threatened species, Version 2013.1, http://www.iucnredlist.org, accessed Jul 17, 2013.
18. Ireland T. T., Wolters G. L. and Schemnitz S. D., 1994 – Recolonization of wildlife on a coal strip-mine in Northwestern New-Mexico, *Southwestern Naturalist*, 39, 53-57.
19. Karns D. R., 1986 – Field Herpetology: Methods for the study of Amphibians and Reptiles in Minnesota, *James Ford Bell Museum of Natural History, University of Minnesota, Occasional Paper*, 18 September.
20. Kozlov M. V. and Zvereva E. L., 2007 – Industrial barrens: extreme habitats created by non-ferrous metallurgy, *Reviews in Environmental Science and Biotechnology*, 6, 231-259.
21. Lehtinen R. M. and Galatowitsch S. M., 2001 – Colonization of restored wetlands by amphibians in Minnesota, *American Midlands Naturalists*, 145, 388-396.
22. Lindenmayer D. B. and Franklin J. F., 2002 – Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach, *Conservation Biology*, 11, 1053-1068.

23. Majer J. D., 1989 – Long-term colonization of fauna in reclaimed land, in: Animal in primary succession - the role of fauna in reclaimed lands, Majer J. D., (ed.), Cambridge University press, Cambridge, 143-174.
24. Malonza P. K., Wasonga V. D., Muchai V., Rotich D., Bwong B. A. and Bauer A., 2006 – Diversity and biogeography of herpetofauna of the Tana River Primate National Reserve, Kenya, *Journal of East African Natural History*, 95, 95-109.
25. Malonza P. K., Bwong B. A. and Muchai V., 2011 – Kitobo Forest of Kenya, a unique hotspot of herpetofaunal Diversity, *Acta Herpetologica*, 6, 149-160.
26. Marsh D. M., 2001 – Fluctuations in amphibian populations: a meta-analysis, *Biological Conservation*, 101, 327-335.
27. Marsh D. M. and Trenham P. C., 2001 – Metapopulation dynamics and amphibian conservation, *Conservation Biology*, 15, 40-49.
28. McCoy E. D., 1994 – "Amphibian decline": a scientific dilemma in more ways than one, *Herpetologia*, 50, 98-103.
29. McKinney M. L., 2002 – Urbanization, biodiversity, conservation, *Bioscience*, 52: 883-890.
30. Means D. B., Dodd C. K Jr., Johnson S. A. and Palis J. G., 2004 – Amphibians and fire in longleaf pine ecosystems, *Conservation Biology*, 18, 1149-1153.
31. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians, Smithsonian Institution Press, Washington D. C., 364.
32. Monello R. J. and Wright R. G., 1999 – Amphibian habitat preferences among artificial ponds in the Palouse region of Northern Idaho, *Journal of herpetology*, 33, 298-303.
33. Ng'endo R., Kairu E., Osiemo Z. and Ogol C., 2011 – Morphological variation of Ridged Frogs of the Taita Hills, Kenya, *Acta Herpetologica*, 6, 275-288.
34. Oksanen J., Blanchet F. G., Kindt R., Legendre P., O'Hara R. B., Simpson G. L., Solymos P., Henry M., Stevens H. and Wagner H., 2010 – *Community Ecology Package Version*, 1, 17-2.
35. Petranka J. W., Harp E. M., Holbrook C. T. and Hamel J. A., 2007 – Long-term persistence of amphibian populations in restored wetland complex, *Biological conservation*, 138, 371-380.
36. R Development Core Team., 2010 – R: a language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria, (http://www.Rproject.org).
37. Sala O. E., Chapin F. S., Armesto J. J., Berlow R., Bloomfield J., Dirzo R., Huber-Sanwald E., Huenneke L. F., Jackson R. B., Kinzig A., Leemans R., Lodge D., Mooney H. A., Oesterheld M., Poff N. L., Sykes M. T., Walker B. H., Walker M. and Wall D. H., 2000 – Global biodiversity scenarios for the year 2100, *Science*, 287, 1770-1774.
38. Semlitisch R. D. and Rothermel B. B., 2003 – A foundation of conservation and management of amphibians, 242-259, in R. D. Semlitisch, (ed.), Amphibian Conservation, *Smithsonian Books*, Washington D. C.
39. Stuart S., Chanson J. S., Cox N. A., Young B. E., Rodrigues A. S. L., Fishman D. L. and Waller R. W. 2004 – Status and trends of amphibian declines and extinctions worldwide, *Science*, 306, 1783-1786.
40. Sutherland W. J., 1996 – Ecological Census Techniques, Cambridge University Press.
41. Tóthmérész B., 1995 – Comparison of different methods for diversity ordering, *Journal of Vegetation Science*, 6, 283-290.
42. Urbina-Cardona J. N., Olivares-Peres M. and Reynoso V. H., 2006 – Herpetofauna diversity and micro environment correlates across a pasture edge interior ecotone in tropical rain forest in Los Tuxtlas Biosphere Reserve of Veracruz, Mexico, *Biological conservation*, 132, 61-75.
43. Vandermeer J. and Perfecto I., 2007 – The agricultural matrix and a future paradigm for conservation, *Conservation Biology*, 21, 274-277.
44. Waltz A. M. and Whitman T. G., 1997 – Plant development affects arthropod communities: opposing impacts of species removal, *Ecology*, 78, 2133-2144.
45. Whittaker R. H., 1965 – Dominance and diversity in plant communities, *Science*, 147, 250-260.
46. Wilson J. B., 1991 – Methods for fitting dominance/diversity curves, J*ournal of Vegetation Science*, 2, 35-46.

FISHERIES MANAGEMENT INFLUENCE ON SOME ECOPHYSIOLOGICAL GROUPS OF BACTERIA IN LOTIC ECOSYSTEMS OF THE CEFA NATURE PARK (ROMANIA)

*Marioara Nicoleta FILIMON *, Patricia DRĂGUŞIN *, Cristina DRĂGUŞIN *, Roxana POPESCU **, Maria MUGUR *, Claudia RATIS ** and *Sorin VOIA ****

* West University, Faculty of Chemistry-Biology-Geography, Department of Biology, Timișoara, Romania, nicoleta_filimon@yahoo.com, patry_ema@yahoo.com, cristina_dragusin18@yahoo.com, mimi_8929@yahoo.com, palitoknrm@yahoo.com

** University of Medicine and Pharmacy "*Victor Babeş*", Department of Cellular and Molecular Biology, Timișoara, Romania, popescurxn@yahoo.com

*** Banat University of Agricultural Sciences and Veterinary Medicine from Timișoara, Faculty of Animal Science and Biotehnology, Timișoara, Romania, sorin_voia@yahoo.com

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KEYWORDS: lotic ecosystems, microorganisms, fishery management.

ABSTRACT

The nutrient circuit in aquatic ecosystems may seem simple, but the truth is that nutrient biochemical circuits are rather complex. Circuits are established by a series of interconnected biological, chemical and physical processes. Human activities lead to degradation of wet fields. Water quality and quantity have been changed, especially the quantity of polluting substances. Bacteriological studies in lotic ecosystems from Cefa Nature Park were carried out to establish four ecophysiologic microorganism groups: nitrogen-fixing bacteria, amonifying bacteria, nitrifying bacteria and denitrifying bacteria. Recorded values differ greatly from one species to the other according to sample points and season. Higher values in autumn are due to an increased intake of organic matter at the end of the vegetation period. Decomposition processes are intensified because of a growing number of microorganisms. Fishery management influences qualitative and quantitative variations in the microorganism communities of the lotic ecosystems in Cefa Natural Park.

RÉSUMÉ: L'influence de la gestion piscicole sur certains groupes écophysiologiques de bactéries des écosystèmes lotiques du Parc Naturel Cefa (Roumanie).

Le circuit des éléments nutritifs dans l'écosystème aquatique semble être très simple, mais en réalité, les circuits biogéochimiques nutritifs sont complexes et sont assurés par un large éventail de processus biologiques, chimiques et physiques interconnectés. Les activités humaines dégradent les milieux humides en altérant la qualité et la quantité de l'eau et en augmentant la quantité de substances polluantes. Les études bactériologiques réalisées dans les écosystèmes lotiques du Parc Naturel Cefa ont été considérées pour déterminer les quatre groupes de microorganismes écophysiologiques suivant: les bactéries fixatrices d'azote, les bactéries ammonifixatrices, les bactéries nitrifiantes et les bactéries de dénitrification. Les valeurs enregistrées par groupes de bactéries écophysiologiques analysées sont très différentes d'un sexe à l'autre en fonction du point d'échantillonnage et selon la saison. Les valeurs plus élevées de l`automne dans les points d'échantillonnages sont déterminées par la contribution accrue de la matière organique à la fin de la saison de croissance, indiquant un processus de décomposition accrue sous l'action d'un grand nombre de microorganismes. La gestion piscicole influence dans une moindre mesure les variations quantitatives et qualitatives des communautés de microorganismes provenant d'écosystèmes lotiques du Parc Naturel Cefa.

REZUMAT: Influenţa managementului piscicol asupra unor grupe ecofiziologice de bacterii din ecosistemele lotice din Parcul Natural Cefa (România).

Circuitul nutrienţilor în ecosistemele acvatice pare simplu, însă în realitate, circuitele biogeochimice ale nutrienţilor sunt foarte complexe, fiind realizate printr-o gamă largă de procese biologice, chimice şi fizice interconectate. Activităţile umane determină degradarea zonelor umede prin modificarea calitativă şi cantitativă a apei, în special prin creşterea cantităţii substanţelor cu efect poluant. Studiile bacteriologice realizate în ecosistemele lotice ale Parcului Natural Cefa au avut în vedere determinarea a patru grupe ecofiziologice de microorganisme: bacterii fixatoare de azot, bacterii amonificatoare, bacterii nitrificatoare şi bacterii denitrificatoare. Valorile înregistrate în ceea ce priveşte grupele ecofiziologice de bacterii analizate diferă foarte mult de la un gen la altul, atât în funcţie de punctul de prelevare a probei, cât şi în funcţie de sezon. Valorile ridicate din sezonul de toamnă la nivelul punctelor de prelevare sunt determinate de aportul crescut de materie organică de la sfârşitul perioadei de vegetaţie, ceea ce indică intensificarea proceselor de descompunere sub acţiunea unui număr mare de microorganisme. Managementul piscicol influenţează într-o mică măsură variaţiile calitative şi cantitative ale comunităţilor de microorganisme din ecosistemele lotice ale Parcului Natural Cefa.

INTRODUCTION

Soggy fields have natural filters playing a significant part in bringing about the results of an improved water quality. This is due to a surface overflow, mostly coming from urban systems and agricultural land in order to decrease pollution. It is well known that soggy fields and other ecological ecosystems have a certain kind of support: the ability to assimilate nutrients. Nutrient over retention leads to structure alteration in soggy fields. Also, nutrients are kept in separate divisions: plant tissues, microorganism biomass, detritus, sediment and water (Mihăescu, 2000).

There are three procedures for the nutrients to be immobilized or recycled in soggy fields: plant and microorganism absorption, sedimentation, denitrifying, ammonium and molecular nitrogen volatilization. Nitrogen discharge from the ecosystem into the atmosphere has been made in form of molecular nitrogen (N_2). In the first two procedures, nutrients are immobilized and retained in the soggy fields (Denovan et al., 2000).

Nitrogen compounds retained in the soggy field depend on vegetation, season and their ability to survive. It has been established that, as long as the nutrient input grows, their retention grade decreases. Nutrient concentration from the soggy fields has a negative effect on the ecological system. Tsushima et al. (2002) identified possible causes for floods during the nitrogen's biochemical cycle. They also recorded species in the aquatic dynamics, the inorganic nitrogen from river Tama.

Several researches have been interested in which is the appropriate concentration of nitrogen in order to protect the systems. Based on certain studies, it has been established that the nitrate concentration (NO_3^-) higher than 2 mg/l or the total nitrate concentration higher than 1.35 mg/l interfere with plant development. In spring, we have a higher concentration of nutrients which put in danger the macrophyte development. It is important for us to mention that limit concentrations vary a lot from one region to the other. Concentrations depend on multiple facts according to every region.

Two of the most important factors are: the soggy field type (swamps, pools and riparian areas) and the vegetation type (as we have previously mentioned). Nutrient circuit in aquatic ecosystems may seem to be easy, but the truth is that nutrient biochemical circuits are rather complex. Circuits have been established with the help of many biological,

chemical and physical procedures, connected among them. Each process influences another type of process. Human activities determined soggy field degradation because of changes in water quality and quantity, in the hydrological balance and in the growing number of pollutants. Species are changed by size because of the damage that has been caused (UCMP, 2004).

Ecophysiologic bacteria groups from the biochemical circuits are of a great importance and are even more studied lately. Thus, bacterial communities implied in nitrogen recycling (heterotrophic, denitrifying, nitrifying, proteolytic bacteria) have been determined in the aquatic divisions from river Olt (Astratinei, 2000).

Microbiological studies of sediment from a polluted area like river Mureş pointed out ecophysiologic groups of bacteria during the nitrogen cycle: heterotrophic, aerobic, desulfying and iron-reducing bacteria (Ştef et al., 2004). Identifying pollution sources and their effects on the ecophysiologic microorganism group from water and river sediment from Timiş River has enabled us to identify pollution coming from nearby livestock farms. The number of microorganisms has been reduced as well as the nitrogen fixing microorganism activity from the aquatic sediment (Filimon et al., 2009). Nitrogen fixing aerobe bacteria (*Azothobacter chroococcum* and *Azothobacter vinellandi*) and nitrogen fixing anaerobic bacteria from the *Clostridium* sp. recorded numerical variations in sediments from Timiş and Bega rivers (Filimon et al., 2010).

The aim of this work has been to identify the influence of fishery management on microorganism communities from Cefa Nature Park`s aquatic ecosystems, based on ecophysical bacteria groups implied in nitrogen`s biochemical circuit.

MATERIAL AND METHODS

Bacteriological studies

Nitrogen fixing bacteria was emphasized using the Ashby method, with the following chemical composition: K_2HPO_4 0,5 g, NaCl 0,5 g, $MgSO_4$ 0,2 g, K_2SO_4 0,1 g, $CaCO_3$ 5 g, 5 g of commercial sugar, 1000 ml distilled water. Samples are incubated for a week at 27°C, then for each sample and dilution, the number of positive tubes are read. For the aerobic fixing of nitrogen, the appearance of a mantle on the surface is considered positive or at least, the appearance of a ring on the tube walls. Often the color of this mantle is fluorescent yellowish-green (characteristic of *A. vinellandii*). Most often the color is brown (typical for *A. chroococcum*). For anaerobic fixing (the *Clostridium* sp.) a positive feature is the appearance of gas bubbles (Dunca et al., 2004).

Numerical determination of ammonifying bacteria was realized using the culture medium with peptone, which has the following chemical composition: NaCl 0.5 g, peptone 2 g, distilled water 1000 ml. The incubation was carried out at 22ºC for 14 days. Highlighting ammonia produced by the ammonifying bacteria activity is made by a specific color reaction with Nessler reagent. Intense yellow coloration is obtained with or without precipitation (Cuşa, 1996).

For the growth of nitrifying bacteria, the Barjac culture medium with the following chemical composition is used: KNO_3 2 g, glucose 10 g, $CaCO_3$ 5 g, Sol. Vinogradski 50 ml, distilled water 950 ml. The nitrate freed following the nitrifying bacteria's activity can be evidenced through a blue colour reaction with diphenylamine-sulfuric acid reactant (Drăgan-Bularda, 2000).

To highlight the denitrifying process dilutions of sediment are seeded in a liquid medium where the nitrogen is present as nitrate. The culture medium has the following composition: standard saline solution 50 ml, KNO_3 20 g, $C_6H_{12}O_6$ 10 g, $CaCO_3$ 5 g, oligoelemental solution 1 ml, distilled water until 1000 ml. The incubation is carried out at 28^oC for 7-15 days after which diphenylamine-sulfuric acid is added in the tubes. A blue coloration appears (negative reaction) in the tubes where nitrate remained. The eprubetes where nitrates disappeared are colourless (positive reaction) (Dunca et al., 2007).

According to the ecophysiologic bacteria group, the bacterial indicator of soil quality (BISQ) has been established, based on a formula proposed by Muntean (1995-1996, 1996): BISQ = 1/n x Σ log10 N, where: BISQ - bacterial indicator of soil quality, n - number of ecophysiologic groups, N - number of bacteria appertaining which belongs to each ecophysiologic group.

Sample point description

Sample points have been chosen from Cefa Nature Park, a lotic aquatic habitat. Three stations have been established:

Station 1: collecting channel (Criş in local toponymy). Stronger water flow, in north-west, the channel is a link between Crişul Repede and Crişul Negru rivers. Water depth: 2-3.5 m, gritty sediment, macrophyte algae fields, silt deposits and detritus, loamy banks with swamp vegetation (*Typha* sp., *Phragmites* sp.).

Station 2: Ateaş evacuation channel - depth 1.5 m, width 3-4 m. Sandy and loamy surface, weak submerged vegetation.

Station 3: Lake 14 feed channel - riverbed width 4-5 m. Maximum depth 2 m, loamy surface, silt deposits and detritus.

RESULTS AND DISCUSSIONS

Bacteriological studies had in view to establish four types of ecophysiological microorganism groups: nitrifying, amonifying, denitrifying and nitrate fixing bacteria. As concerning studied ecophysiologic bacteria groups, the recorded values are rather different from one species to the other. The highest values have been recorded for the amonifying bacteria (10^5-10^6), followed by the nitrifying, denitrifying bacteria, *Azothobacter vinellandi* aerobic nitrate fixing bacteria and *Clostridium* sp. anaerobic nitrate fixing bacteria (10^3-10^4).

Lower values have been recorded for the *Azothobacter chroococcum* species, aerobic nitrate fixing bacteria (10^3). Nitrate fixing bacteria form two separate groups: *Azothobacter vinellandi* and *Azothobacter chroococcum*, aerobic nitrate fixing bacteria and *Clostridium* sp. anaerobic nitrate fixing bacteria. Anaerobic and aerobic nitrate fixing bacteria have been found in every sample point. Nitrate fixing bacteria in sediment from the lotic ecosystem found in Cefa Nature Park reveal nitrate organic and inorganic compounds. Nitrate fixing bacteria have a higher content of N_2 taken in from the atmosphere.

A higher value of nitrates increases vegetal mass and it also improves other nitrate procedures. Aerobic nitrate fixing bacteria like the *Azothobacter vinellandi* are much better represented numerically as compared to *Azothobacter chroococcum* and *Clostridium* sp.

In summer and autumn a higher number of *Azothobacter vinellandi*, aerobic nitrate fixing bacteria is in accordance with vegetal mass development. In spring, we established a higher number of *Clostridium* sp., anaerobic nitrate fixing bacteria. The aquatic ecosystem has nitrate compounds in it. *Clostridium* sp. species enable molecular nitrates to reach into the sediment. This is beneficial for the productivity and for the nitrate circuit. Three nitrate fixing bacteria groups have the same values as in spring, meaning an efficient nitrate circuit in the studied aquatic system (Fig. 1).

Maximum values in summer and autumn for nitrate fixing bacteria in sample point II are determined according to a higher concentration of molecular nitrates. Higher concentration of molecular nitrates is recorded due to decomposing organic substances (Fig. 2).

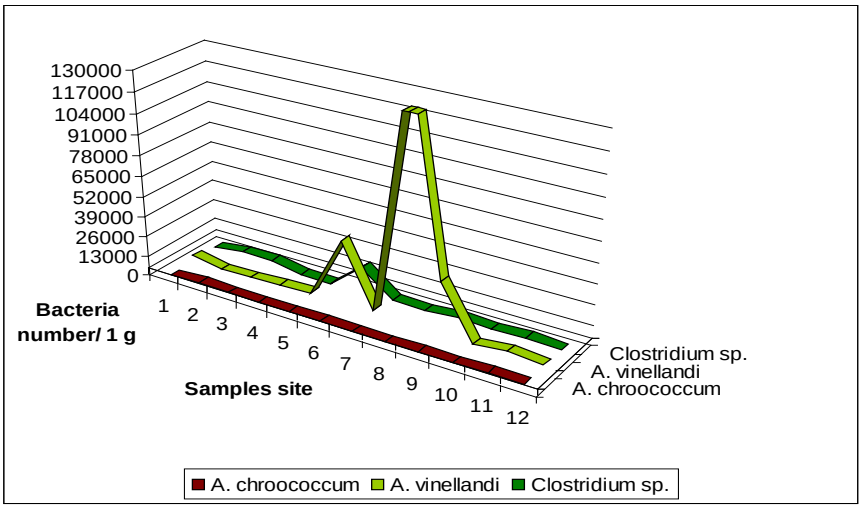

Figure 1: Nitrogen fixing bacteria in studied samples.

Higher values of the amonifying bacteria in summer, at each sample point, reveal that the nitrogen compound improves the development of the amonifying bacteria and, implicitly, the ammonia concentration. Vegetation influences the sediment rate of nutrient particles, the vegetation overtake and the nutrient release in autumn and winter. Plant biomass and seasonal conditions influence the quantities of organic substance and also the carbon and oxygen from the sediment. Organic substances and carbon from sediment have to undergo series of procedures like overtaking, transforming, denitrifying and other chemical and physical procedures in sediment and at the interface between water and sediment (Fisher et al., 2009).

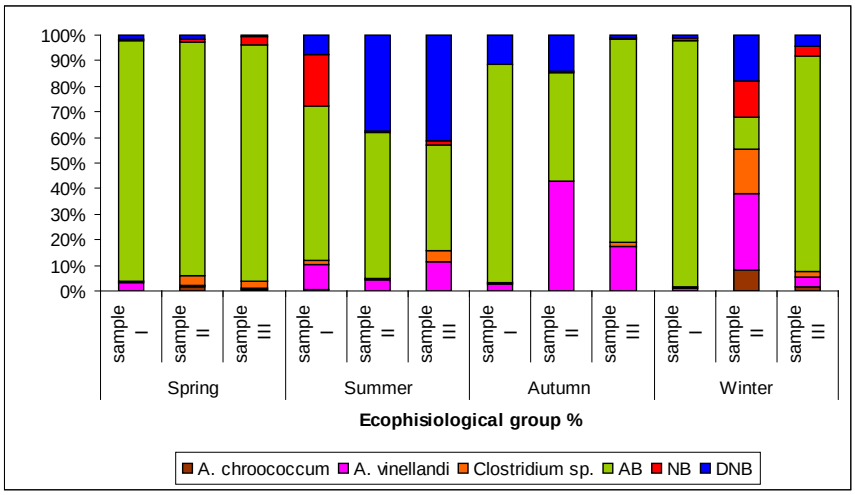

Figure 2: Bacteria division during the nitrogen circuit (AB - amonifying bacteria, NB - nitrifying bacteria, DNB - denitrifying bacteria).

In soggy fields, ammonium decreases and nitrate increases. This is the result of an incomplete denitrification. A complete oxidation requires ammonium oxidation in the nitrates. Nitrates are later transformed in molecular nitrogen. This is the reason why the first procedure is developing faster, when compared to the second one (Camargo and Alonso, 2007).

The existence of anaerobic conditions or the organic carbon's availability (forming a donor electron) has a vital importance in nitrate reduction. As water and the interface between water and sediment are oxygenated, the complete denitrifying procedure shall be limited. These conditions establish nitrate reduction, increasing denitrifying bacteria, donor electrons and the nitrate substrate. It is important to mention the link between aerobic and anaerobic conditions. Due to the fact that the anaerobic ones are predominant, micro-organism diversity and denitrifying efficiency may be reduced.

In this case, we should take into consideration the depth and flood rate. The nutrient resistance has been reduced (three hours) and is directly related to nutrient recycling due to the difference between water and sediment, bacteria or plants (LPELC, 2009).

Nitrifying bacteria are spreading quickly, but are few in number when compared to the other two groups. Nitrates are less toxic for creatures living in aquatic sediments. For plants, it is even beneficial. Nitrates are the ultimate link in a nitrogen change. Nitrates gather together in time. For biocenosis, nitrites' and nitrates' toxicity acts differently according to species, age and exposure period.

Denitrifying bacteria are well represented in summer and autumn. It reveals nitrite and nitrate decomposure in water and sediment. There is an inverse proportionality between denitrifying and nitrifying bacteria (Fig. 3).

Denitrifying capacity depends on vegetation type. As denitrifying capacity increases, certain submerged species produce a high quality organic substance. It is a support for heterotrophic bacteria. Vegetation offers more space to bacteria, bringing into existence many new populations.

It has been proved that the nutrient recycle has a higher rate when there are plants nearby. Plants may also inhibit denitrifying processes through the oxygen loss. The effect depends on species, development and on plant biomass. Plants fill bacteria with carbon. Denitrifying processes become carbon and an energy source. Recycling rate is higher when there are different kinds of species (Bastviken et al., 2005).

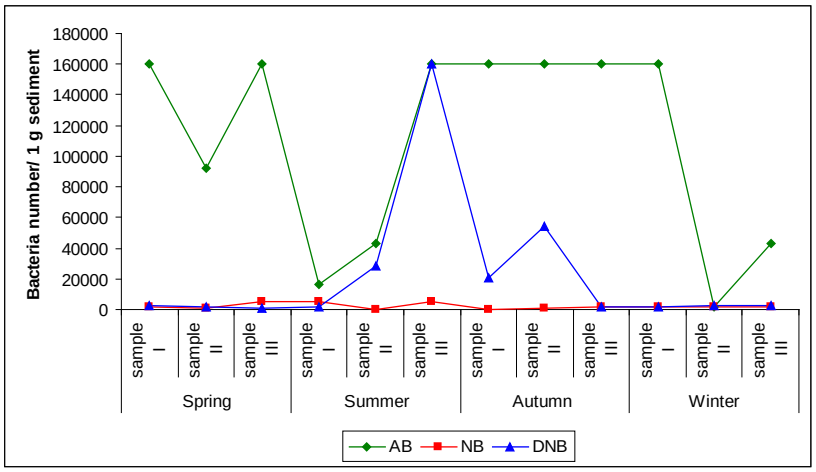

Figure 3: Ecophysiologic bacteria groups (AB - amonifying bacteria, NB - nitrifying and DNB - denitrifying bacteria) in sample points from lotic ecosystems in Cefa Nature Park.

Sample point number III has higher values in every studied ecophysiological group due to sediment consistency with mud deposits and detritus.

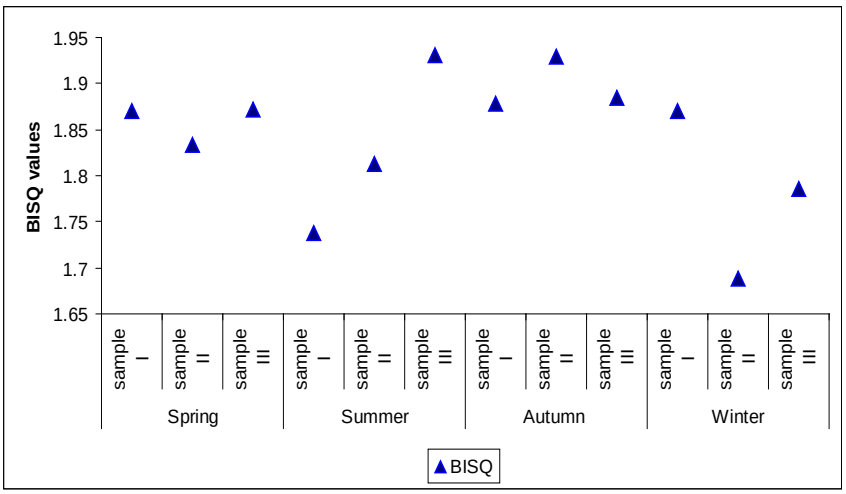

Figure 4: Bacterial indicator of sediment quality in sample point taken from lotic ecosystems in Cefa Nature Park.

Based on absolute values from every microorganism group, the bacterial indicator of sediment quality has been established (BISQ). BISQ offers an overview about the decomposing process in the studied aquatic ecosystem. Pollution sources and their influence on microorganisms have been identified. The bacterial indicator of sediment quality has values between 0.93 at the level of L14 feed channel in summer and 0.69 at the level of Ateaş evacuation channel in winter (Fig. 4). Bacterial indicator of sediment quality from the lotic ecosystem varies according to every sample point and every season. Higher values are recorded in summer and autumn. Lower values are recorded in spring and winter. Higher values are probably due to a favourable temperature. In summer, water temperature is higher. In winter, the water is frozen. Higher values in autumn are determined by a large amount of organic substance at the end of the vegetation period. Organic substances are decomposing intensively.

CONCLUSIONS

Ecophysiologic bacteria groups implied in the nitrogen cycle from the lotic ecosystem of Cefa Nature Park record quantitative values according to every sample point and every season.

Higher values in autumn in 3 sample points have been established by a large amount of organic matter at the end of the vegetation period. Decomposing procedures are intensified, the number of microorganism is higher.

Fishery management influences in a certain way the qualitative and quantitative variations of microorganism communities from lotic ecosystem of Cefa Nature Park.

REFERENCES

1. Astratinei V., 2000 – Associations of bacteria involved in matter recirculation in continental aquatic ecosystems, *Studii şi Cercetări Ştiinţifice, Seria Biologie, Bacău*, 5, 157-164.
2. Bastviken S. K., Eriksson P. G., Premrov A. and Tonderski K., 2005 – Potential denitrification in wetland sediments with different plant species detritus, *Ecological Engineering*, 25, 183-190.
3. Camargo A. J. and Alonso A., 2007 – Inorganic nitrogen pollution in aquatic ecosystems: causes and consequences, *The Encyclopedia of Earth, Environmental chemistry, Ecology, Marine ecology*, 12.
4. Cusa V., 1996 – Instrucțiuni metodologice pentru analiza microbiologică a sedimentelor din ecosistemele acvatice, (in Romanian), Institutul de Cercetări în Ingineria Mediului, București, 4: 14-20.
5. Denovan D. and Wotze C., 2000 – Wetlands and water quality entrancement, School of Applied Environmental Sciences, University of Natal.
6. Drăgan-Bularda M., 2000 – Lucrări practice de microbiologie generală, Univ. „Babeș-Bolyai", Cluj-Napoca. (in Romanian)
7. Dunca S., Ailiesei O., Nimitan E. and Ştefan M., 2004 – Microbiologie aplicată, Editura Demiurg, Iaşi. (in Romanian)
8. Filimon M. N., Gotia S. R., Gotia S. L., Borozan A., Popescu R. and Gherman V. D., 2009 – Bacteriological studies on River Timiş with a role in evaluating pollution, Annals of RSCB, XIV, 2, 284-288.
9. Filimon M. N., Borozan A., Sinitean A., Popescu R., Török-Oance R. and Verdeş D., 2010 – Bacteriological studies on Timiş and Bega Rivers with a role in apreciating pollution, *Annals of the Romanian Society for Cell Biology*, XV, 2, 217-220.
10. Fisher J., Stratford C. J. and Buckton S., 2009 – Variation in nutrient removal in three wetland blocks in relation to vegetation composition, inflow nutrient concentration and hydraulic loading, *Ecological Engineering*, 35, 1387-1394.
11. Mihăescu G., 2000 – Microbiologie generală şi virusoligie, Edit. Universităţii Bucureşti. (in Romanian)
12. Muntean V., 1995-1996 – Bacterial indicator of mud quality, Institutul de Cercetări Biologice, *Contribuții Botanice*, 73-76.
13. Ştef L. C., Muntean V. and Drăgan-Bularda M, 2004 – Microbiological research on the Mureş sediments from Ocna Mureş affected by pollution, *Contribuţii Botanice*, XXXIX, 227-232.
14. Tsushima K., Ueda S. and Ogura N., 2002 – Nitrate loss for denitrification during high frequency research in floodplain groundwater of the Tama River, *Journal of Water, Air and Soil Pollution*, 137(1-4), 167-178.
15. http://UCMP, 2004.
16. http://twitter.com/LPELC, 2009.

THE INFLUENCE OF SOME ENVIRONMENTAL VARIABLES ON DIVERSITY OF EPHEMEROPTERA, PLECOPTERA AND TRICHOPTERA ASSEMBLAGES - VIŞEU BASIN CASE STUDY

Angela CURTEAN-BĂNĂDUC * and *Horea OLOSUTEAN* **

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Environmental Sciences, 5-7 Dr. Ion Raţiu Street, Sibiu, Sibiu County, Romania, RO-550012, angela.banaduc@ulbsibiu.ro
** "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Department of Environmental Sciences, Applied Ecology Research Center, 5-7 Dr. Ion Raţiu Street, Sibiu, Sibiu County, Romania, RO-550012, mesaje.facultate@yahoo.com

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KEYWORDS: Ephemeroptera, Plecoptera, Trichoptera, environmental variables, Romanian Carpathians.

ABSTRACT

The study analyses the influence of certain biotope parameters, such as hydro-morphological characteristics, channel modification, bank vegetation and riverine land use, on the diversity of Ephemeroptera, Plecoptera and Trichoptera (EPT) larvae communities, in the case of the Vişeu Basin.

The results show that river bed embankments, mineral substrate exploitation, and forest exploitation of the hillsides of the river basin cause a loss in diversity of EPT communities. Based on the principle that simplification of the structure of these communities has a negative impact on the self-regulating capacity of the lotic system, several steps are necessary in order to preserve the diversity of EPT communities in the types of Carpathian rivers analysed: preserving the natural morphodynamics of the river bed, limiting substrate exploitation, avoiding changes in the substrate structure due to the extraction of boulders and large cobbles from the riverbed and preserving riparian tree vegetation on the river banks.

ZUSAMMENFASSUNG: Der Einfluss einiger Biotop-Variablen auf die Vielfalt der Ephemeropteren-, Plecopteren- und Trichopteren-Gesellschaften - Fallstudie Einzugsgebiet des Vişeu.

Die Studie analysiert den Einfluss einiger Biotop-Parameter wie hydro-morphologische Charakteristika des Niedrigwasserbetts, Veränderung des Abflusskanals, Typus der Ufervegetation, Landnutzung der angrenzenden Gebiete auf die Diversität der Larvengemeinschaften von Ephemeropteren, Plecopteren und Trichopteren.

Die Ergebnisse weisen deutlich darauf hin, dass die Eindeichung des Flusses, die Materialentnahme aus dem Fluss sowie die Abholzung der Wälder von den Hängen im Einzugsgebiet den Verlust der Diversität der Ephmeropteren-, Plecopteren- und Trichopterengemeinschaften zur Folge haben. Ausgehend von der Idee, dass die strukturelle Vereinfachung der Gemeinschaften negative Auswirkungen auf die Selbstregelungskapazität des Flusses hat, erweisen sich einige Maßnahmen für den Erhalt der Diversität der Ephmeropteren-, Plecopteren- und Trichopterengemeinschaften aus der Kategorie der untersuchten Karpatenflüsse dieses Typs als erforderlich: die Bewahrung der natürlichen Morphodynamik des Niedrigwasserbettes, die Begrenzung der Auskiesung des Substrats, die Vermeidung der Strukturveränderungen des Substrats im Flussbett durch Entnahme von Steinen und Grobschotter sowie die Bewahrung der Gehölz-Ufervegetation.

REZUMAT: Influenţa unor variabile de biotop asupra diversităţii comunităţilor de efemeroptere, plecoptere şi trichoptere - studiu de caz bazinul hidrografic Vişeu.

Studiul analizează influenţa unor parametri de biotop, precum caracteristicile hidro-morfologice ale albiei minore, modificarea canalului de scurgere, tipul de vegetaţie ripariană, utilizarea terenurilor riverane asupra diversităţii comunităţilor larvelor de efemeroptere, plecoptere şi trichoptere.

Rezultatele obţinute relevă faptul că îndiguirea albiei minore, exploatarea substratului, exploatarea pădurilor pe versanţii bazinului râului determină pierderea diversităţii comunităţilor de efemeroptere, plecoptere şi trichoptere. Pornind de la ideea că simplificarea structurală a acestor comunităţi are impact negativ asupra capacităţii de autoreglare a râului, se impun câteva măsuri pentru păstrarea diversităţii comunităţilor de efemeroptere, plecoptere şi trichoptere în râurile carpatice din categoria celor analizate: păstrarea morfodinamicii naturale a albiei minore, limitarea exploatării substratului, evitarea modificării structurii substratului albiei minore prin extragerea bolovanilor și a pietrelor mari, păstrarea vegetaţiei ripariene arboricole pe maluri.

INTRODUCTION

Ephemeroptera, Plecoptera and Trichoptera larvae communities are key components of stream ecosystems bioeconomy, because of their role in uptake and cycling the alochtonous organic matter, contributing, therefore, to the self regulation processes of the lotic systems (Rawer-Jost et al., 2000; Whiles et al., 2000; Gage et al., 2004; Kreatzweiser et al., 2005; Jiang et al., 2011). The structure of these communities is an indicator of both integrality and support capacity of lotic ecosystems (Wang et al., 2008; Infante et al., 2009; Dudgeon, 2010; Bauernfeind and Moog, 2000; Leunda et al., 2009; Diggins and Newman, 2009; Gabriels et al., 2010; Varnosfaderany et al., 2010; Aura et al., 2011; Sedeño-Díaz et al., 2012; Manko et al., 2012).

In this context, our study analyses the influence of some biotope parameters, such as hydro-morphologic characteristics (altitude, slope, riverbed width and depth, substratum, presence of pools, riffles, runs and bends), channel modification, bank vegetation and riverine land use on the diversity of Ephemeroptera, Plecoptera and Trichoptera larvae communities, highly relevant for the management of Carpathian rivers of the same category as the analyzed ones in this study.

The Vişeu Watershed was selected for this analysis due to its dimensions, geomorphologic characteristics, for the existence of natural and semi-natural lotic systems and for the variability of the human impact.

Vişeu River is a second order tributary of Danube River, located in the northern part of Romania. The largest part of the Vişeu River basin was included in the Maramureş Mountains Nature Park. The Vişeu River has its headwater in the Rodna Mountains, and has an 80 km length, 1,606 km^2 basin surface and a multiannual average flow at the confluence with Tisa River of 30.7 m^3/s (Badea, 1983).

Some of the most important tributaries of the Vişeu River are (from upstream to downstream): Ţâşla River (20 km length, 106 km^2 drainage surface), Vaser River (42 km length, 422 km^2 drainage surface, 9 m^3/s multiannual average flow at the confluence with Vişeu River) and Ruscova River (39 km length, 435 km^2 drainage surface, 11 m^3/s multiannual average flow at the confluence with Vişeu River) (Roşu, 1980; Posea, 1982).

MATERIAL AND METHODS

The results of this study are based on quantitative samples of benthic macroinvertebrates (290 samples), taken in 2007 (June-September) from 29 stations of the studied zone (Fig. 1). The sampling stations were chosen according to the valley morphology, the confluence with the main tributaries and the human impact types and degrees on the river sectors (hydro-technical works, pollution sources, exploitation of the river bed and riverine land use).

In each sampling station of this study, quantitative samples were taken from five different points, in order to highlight the specific diversity of local micro-habitats.

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 a Zeiss (65X) stereomicroscope.

The analyzed biological material included 4,160 Ephemeroptera, 3,760 Plecoptera and 3,250 Trichoptera larvae individuals, in life cycle periods which allowed their identification to the species level.

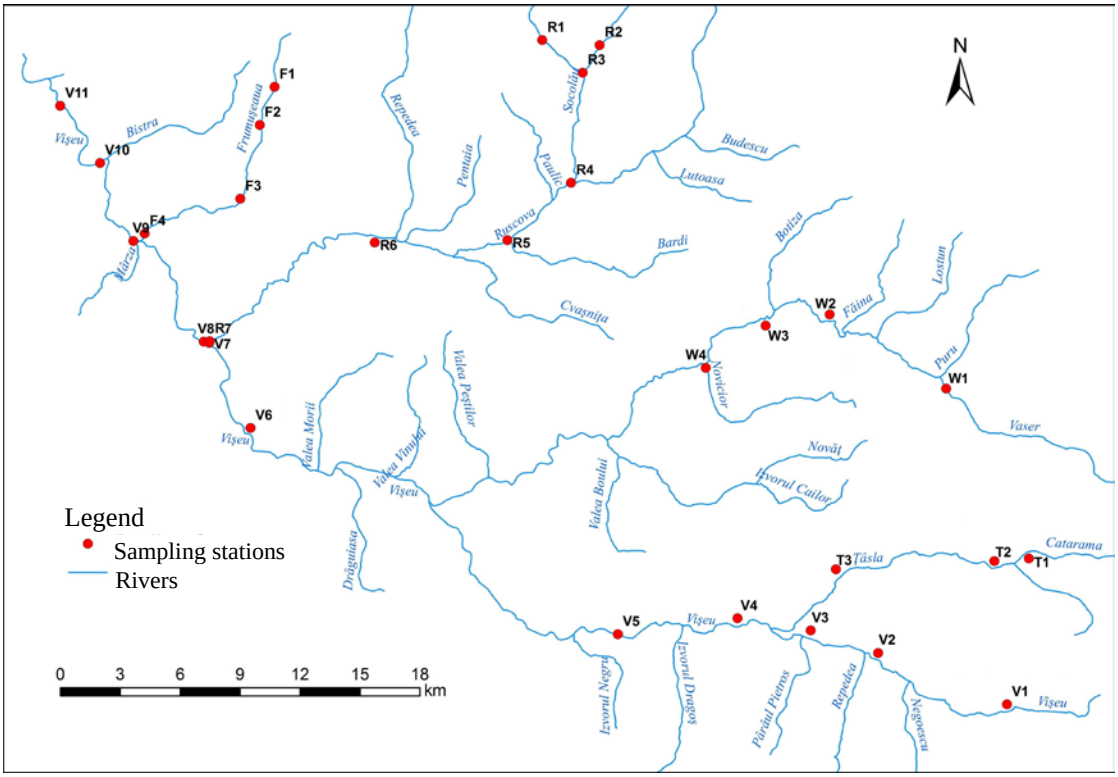

Figure 1: The sampling stations location in the Vişeu Watershed.

The assessed biotope variables were: altitude, slope, riverbed width, depth, substratum types, presence of pools, riffles, runs and bends, bank vegetation, channel modification and riverine land use.

The substratum types were expressed as percentages of the transversal section surface (20 m length), and transformed into the following categories: 1 - large cobbles, 2 - boulders, 3 - large boulders and bed rock, 4 - sand and pebbles.

In order to describe the human induced changes of the minor river bed structure, the following categories were considered: 1 - natural banks, 2 - straightened banks/bankline modification, 3 - stabilized banks/embanked with stone or wood, 4 - stabilized banks/embanked with concrete, 5 - mineral substrate exploitation, 6 - mineral substrate exploitation and embankment, 7 - logs transportation through the river bed.

The classes of riverine land use considered in this study were: 1 - natural/quasi-natural regime, 2 - forest exploitation, 3 - agricultural land, 4 - localities/main road, 5 - mining facilities.

The Ephemeroptera, Plecoptera and Trichoptera larvae community's diversity is expressed by the Gini-Simpson Index (Jost, 2007).

Those relations were also analyzed using the Correspondence Analysis (CA - Benzécri, 1973).

Because diversity is expressed as continuous variables, their transformation into category variables was needed (1 - low biodiversity: 0.000-0.499; 2 - medium biodiversity: 0.500-0.749; 3 - high biodiversity: 0.750-1.000).

Correspondence Analysis was performed using STATISTICA v. 8.0, resulting in correspondence charts showing the relative position of the diversity categories in relation to habitat categories.

RESULTS AND DISCUSSIONS

In the studied reference zone, a total number of 24 mayfly species (belonging to 12 genera and six families) (Curtean-Bănăduc, 2009), 21 stonefly species (belonging to nine genera and six families) (Curtean-Bănăduc, 2010) and 30 caddisfly species (belonging to 19 genera and 11 families) (Curtean-Bănăduc and Radu, 2010) were identified.

A higher Plecoptera diversity is associated with river sectors with natural or quasi-natural riverine lands (Fig. 2), with natural banks dynamics (Fig. 5) and with substrate characterized by large cobbles (Fig. 8); lower diversity of this group of organisms appears in river sectors affected by forest exploitations (Fig. 2), where logs are transported through the river bed (Fig. 5) and the substrate is dominated by sand and pebbles (Fig. 8).

A higher Ephemeroptera diversity is found in river sectors characterized by natural bank dynamics (Fig. 6) and with natural or quasi-natural riverine terrains (Fig. 3); lower diversity is associated with embanked river sectors, where the mineral substrate is exploited (Fig. 6) and in sectors from the proximity of agricultural land or mining facilities (Fig. 3).

Trichoptera have a higher diversity in river sectors with natural bank dynamics (Fig. 7) and with substrate with boulders (Fig. 10); lower diversity appears in river sectors close to mining facilities (Fig. 4), where substrate is exploited or where logs are transported through the river bed (Fig. 7).

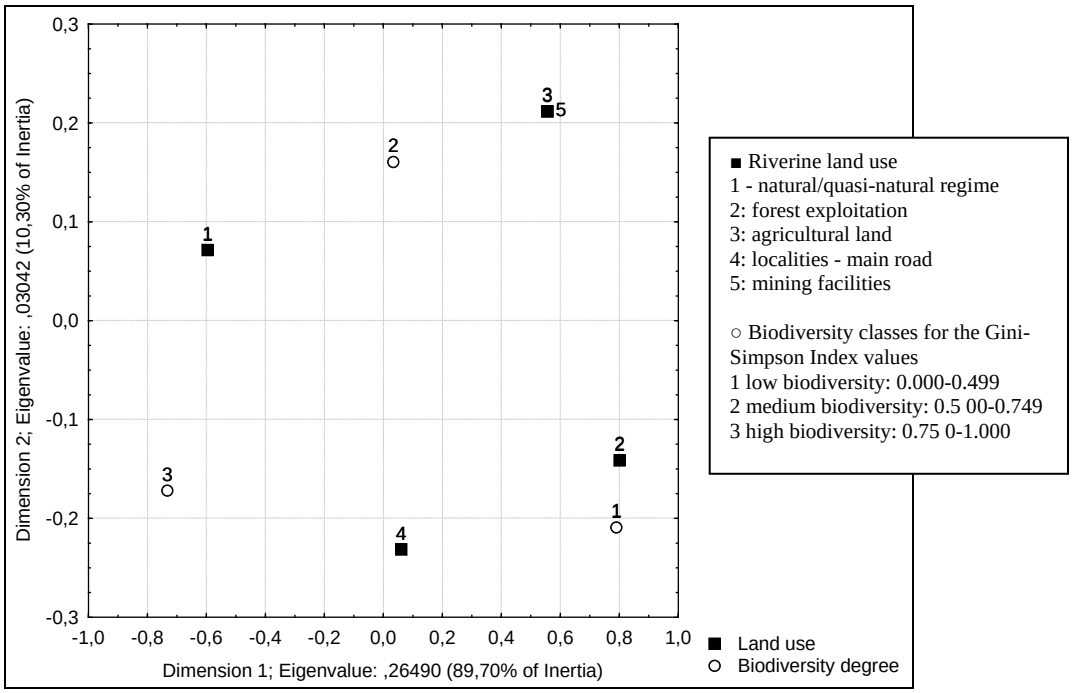

Figure 2: Correspondence analysis (CA) between riverine land use and Plecoptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

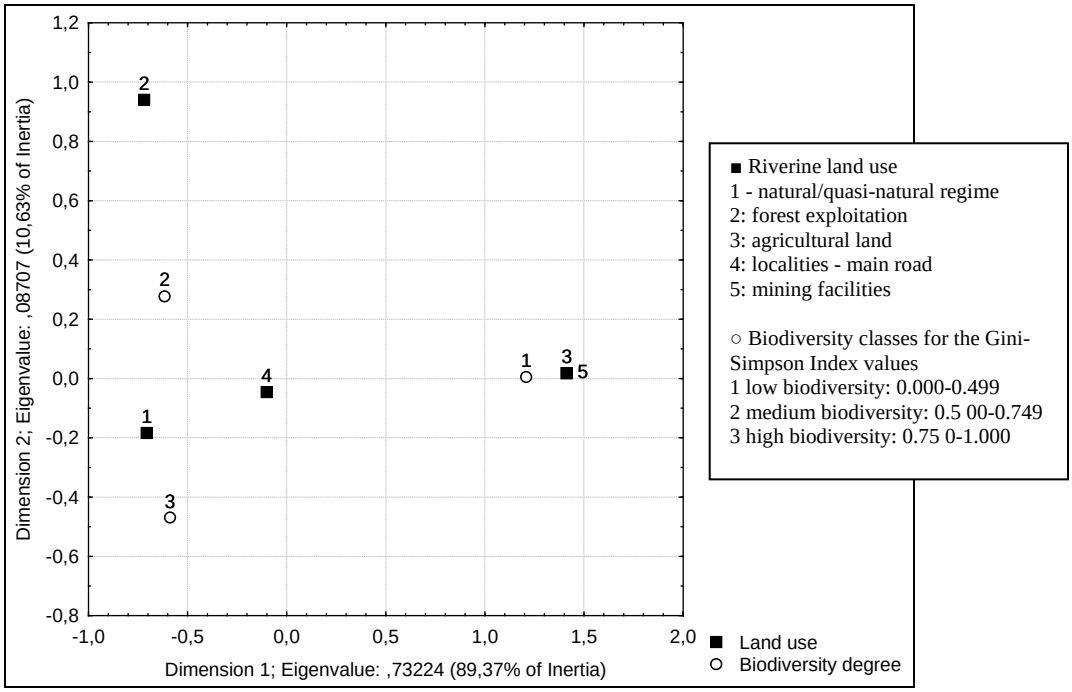

Figure 3: Correspondence analysis (CA) between riverine land use and Ephemeroptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

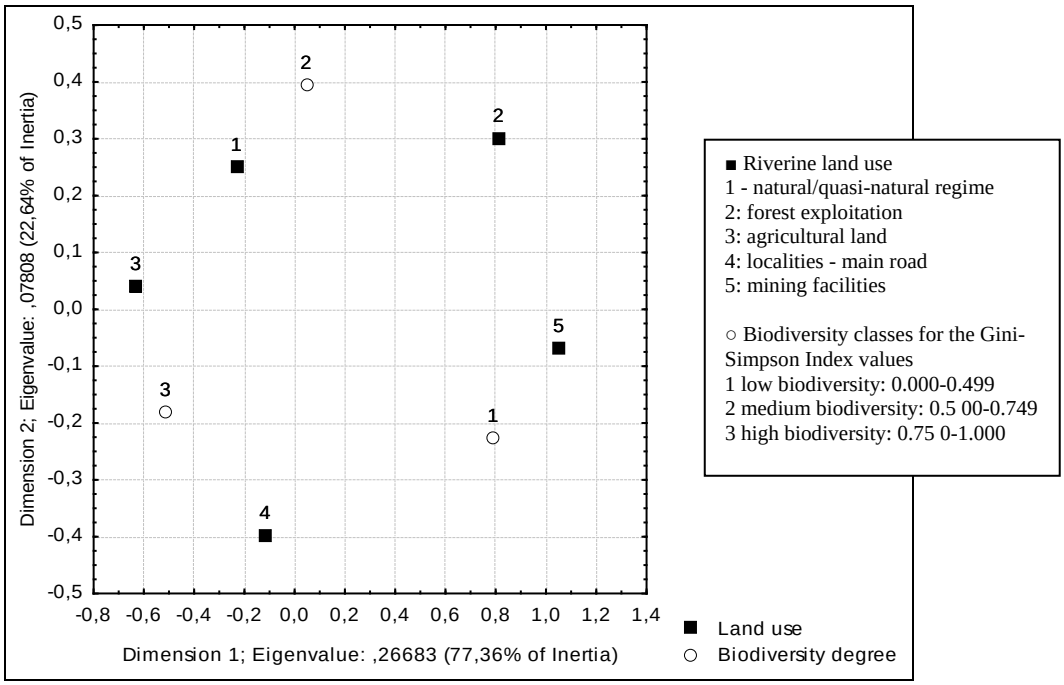

Figure 4: Correspondence analysis (CA) between riverine land use and Trichoptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

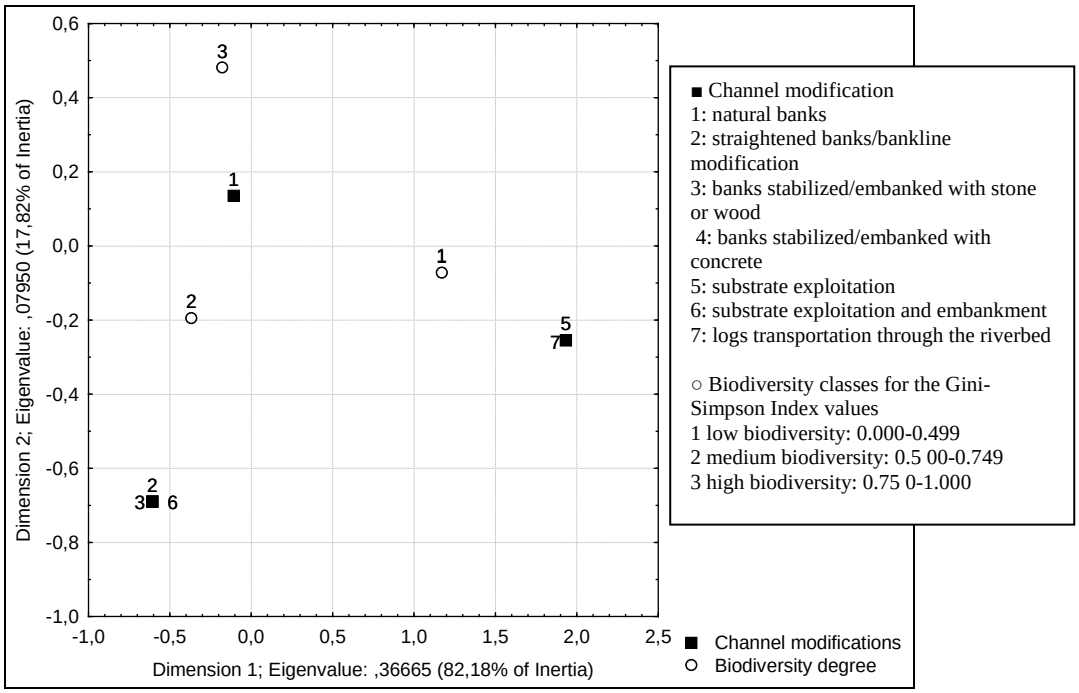

Figure 5: Correspondence analysis (CA) between the degree of channel modification and Plecoptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

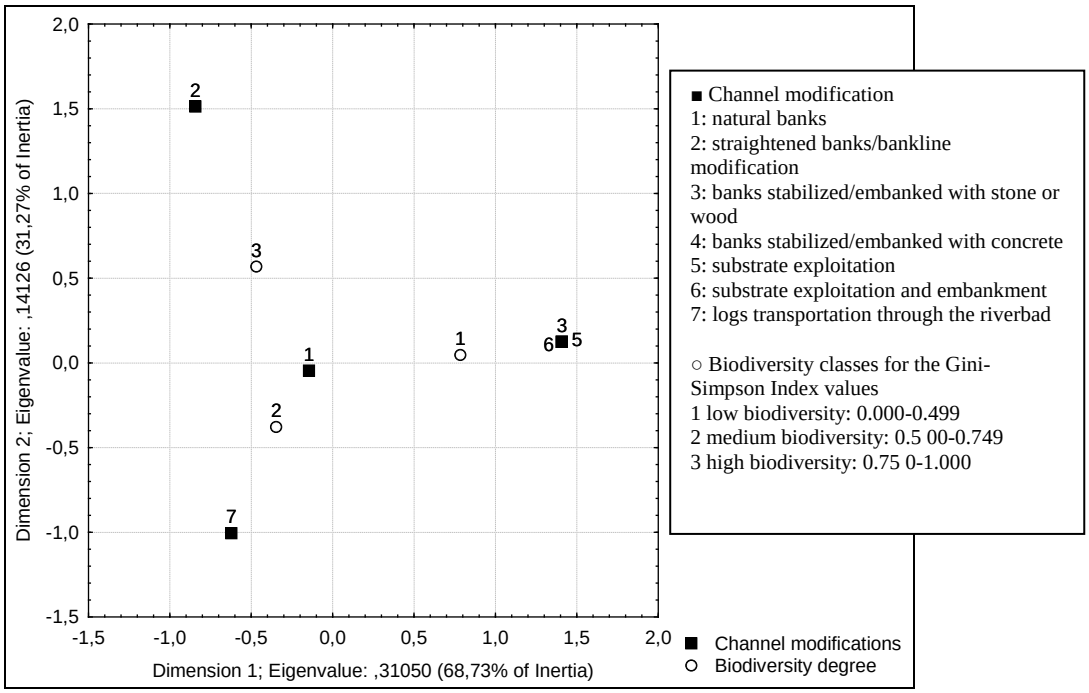

Figure 6: Correspondence analysis (CA) between the degrees of channel modification and Ephemeroptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

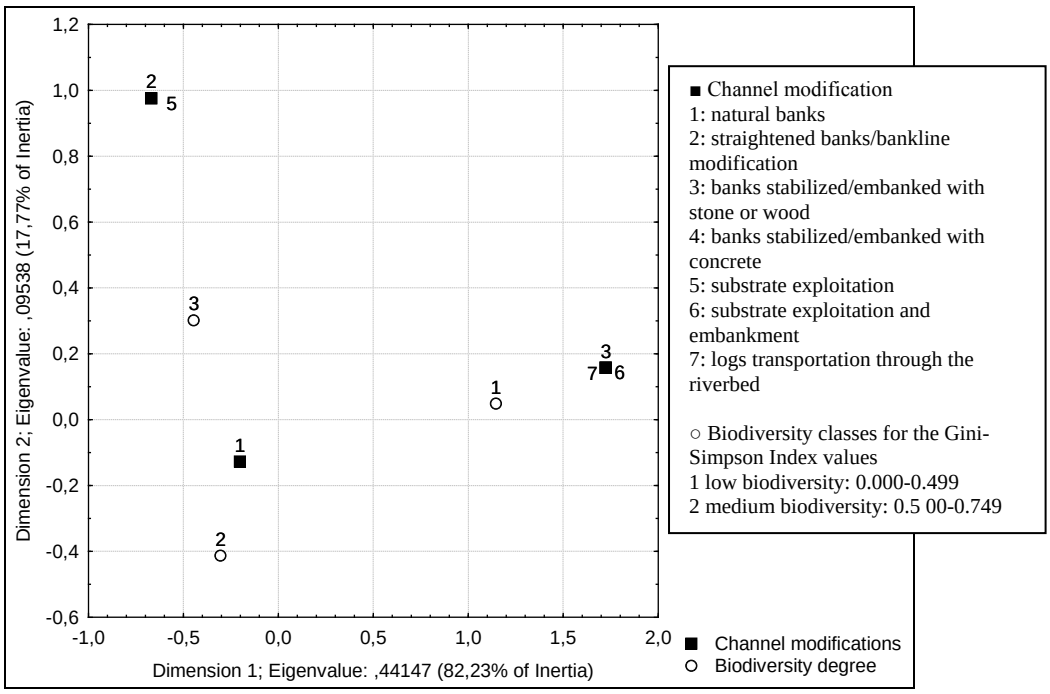

Figure 7: Correspondence analysis (CA) between the degrees of channel modification and Trichoptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

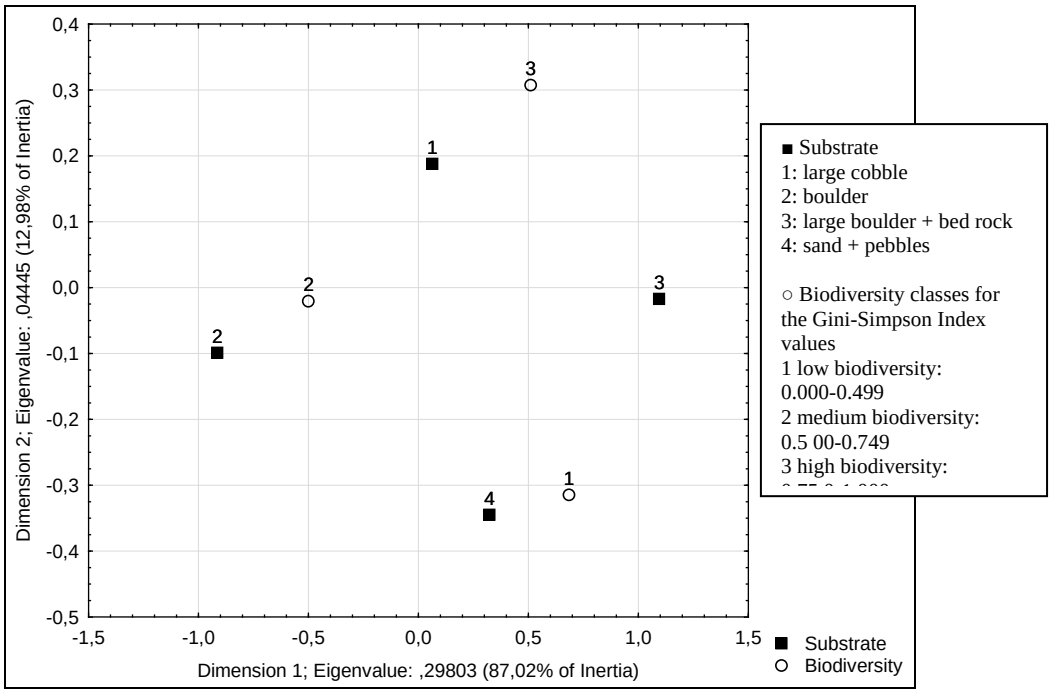

Figure 8: Correspondence analysis (CA) between substrate types and Plecoptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

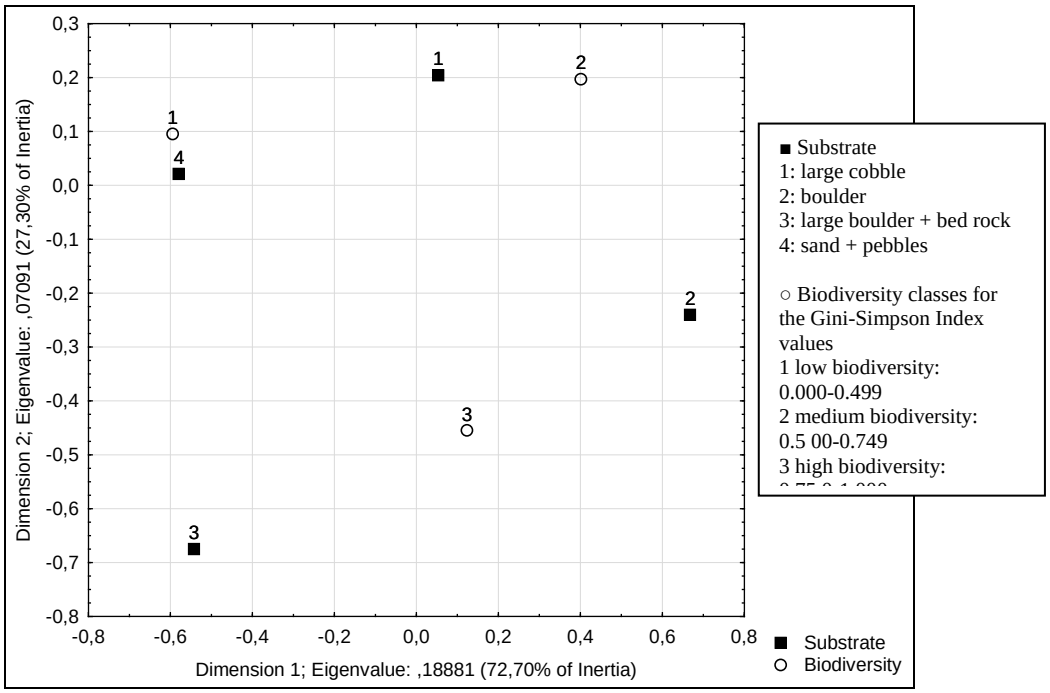

Figure 9: Correspondence analysis (CA) between substrate types and Ephemeroptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

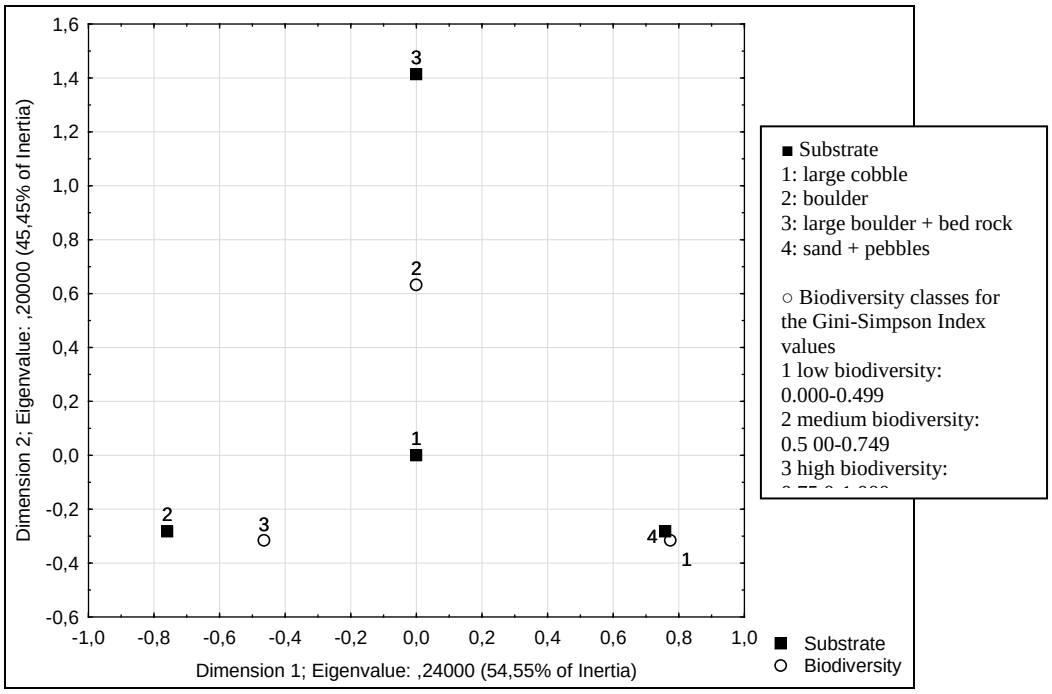

Figure 10: Correspondence analysis (CA) between substrate types and Trichoptera community diversity (expressed as the Gini-Simpson Index), for the Vișeu River Basin.

CONCLUSIONS

The results show that the river bed embankments, the mineral substrate exploitation, the forest exploitation from the hillsides of the river basin cause a loss in the diversity of Ephemeroptera, Plecoptera and Trichoptera larvae communities.

Starting from the idea that the simplification of these communities structure has a negative impact on the self-regulating capacity of the lotic system, several steps are necessary in order to preserve the diversity of Ephemeroptera, Plecoptera and Trichoptera larvae communities in the analyzed types of Carpathian rivers: preserving natural morphodynamics of the river bed, limiting mineral substrate exploitation, avoiding changes in the substrate structure due to the extraction mainly of boulders and large cobbles from the riverbed, preserving riparian tree vegetation on the river banks and banning the logs transportation through the riverbed.

Beyond the management of the river itself, a proper lotic system management can not avoid the watershed management regarding the riverine semi-aquatic and terrestrial areas.

REFERENCES

1. Aura C. M., Raburu P. O. and Herrmann J., 2011 – Macroinvertebrates' community structure in Rivers Kipkaren and Sosiani, River Nzoia basin, Kenya, *Journal of Ecology and the Natural Environment*, 3(2), 39-46.
2. Badea L., (coord.), 1983 – Geografia României I, Geografia Fizică, Editura Academiei Române (in Romanian).
3. Bauernfeind E. and Moog O., 2000 – Mayflies (Insecta, Ephemeroptera) and the assessment of ecological integrity: a methodological approach, *Hydrobiologia*, 422/423, 71-83.
4. Benzécri J. P., 1973 – L'Analyse des Données II: L'Analyse des Correspondances, Éditions Dunod, Paris.

5. Curtean-Bănăduc A., 2009 – The Maramureş Mountains Nature Park (Romania) mayfly (Insecta, Ephemeroptera) communities diversity analyse, *Transylvanian Review of Systematical and Ecological Research, The Wetlands Diversity*, Curtean-Bănăduc et al. (eds), 8, 95-104.
6. Curtean-Bănăduc A., 2010 – The Maramureş Mountains Nature Park (Romania) stonefly (Insecta, Plecoptera) communities diversity analyse, *Romanian Journal of Biology - Zoology*, 55(2), 129-137.
7. Curtean-Bănăduc A. and Radu G., 2010 – Caddisfly (Insecta, Trichoptera) assemblages in the Vişeu River basin (Romania), *Transylvanian Review of Systematical and Ecological Research, The Wetlands Diversity*, Curtean-Bănăduc et al. (eds), 10, 83-92.
8. Diggins T. P. and Newman A. M., 2009 – Environmental and spatial influences on benthic community composition in wooded headwater streams in Zoar Valley, New York, USA, *Hydrobiologia*, 630, 313-32.
9. Dudgeon D., 2010 – Prospects for sustaining freshwater biodiversity in the 21st century: linking ecosystem structure and function, *Current Opinion in Environmental Sustainability*, 2, 422-430.
10. Gabriels W., Lock K., De Pauw N. and Goethals P. L. M., 2010 – Multimetric Macroinvertebrate Index Flanders (MMIF) for biological assessment of rivers and lakes in Flanders (Belgium), *Limnologica*, 40, 199-207.
11. Gage M. S., Spivak A. and Paradise C. J., 2004 – Effects of land use and disturbance on benthic insects in headwater streams draining small watersheds, *Southeastern Naturalist*, 3, 345-350.
12. Infante D. M., Allan D. J., Linke S. and Norris R. H., 2009 – Relationship of fish and macroinvertebrate assemblages to environmental factors: implications for community concordance, *Hydrobiologia*, 623, 87-103.
13. Jiang X., Xiong J., Xie Z. and Chen Y., 2011 – Longitudinal patterns of macroinvertebrate functional feeding groups in a Chinese river system: A test for river continuum concept (RCC), *Quaternary International*, 244(2), 289-295.
14. Jost L., 2007 – Partitioning biodiversity into independent alpha and beta components, *Ecology* 88(10), 2427-2439.
15. Kreatzweiser D. P., Capell S. S. and Good K. P., 2005 – Macroinvertebrate community response to selection logging on riparian and upland areas of headwater catchments in a northern hardwood forest, *Journal of the North American Benthological Society*, 24, 208-222.
16. Leunda P. M., Oscoz J., Miranda R. and Arino A. H., 2009 – Longitudinal and seasonal variation of the benthic macroinvertebrate community and biotic indices in an undisturbed Pyrenean river, *Ecological indicators*, 9, 52-63.
17. Manko P., Koščo J., Košuthová L., Barabas D. and Lešková J., 2012 – Aquatic invertebrates in Olšava River (Slovakia), *Acta Oecologica Carpatica*, V, 115-127.
18. Posea G., (coord.), 1982 – Enciclopedia Geografică a României, Ed. Ştiinţifică şi Enciclopedică, Bucureşti. (in Romanian)
19. Rawer-Jost C., Bohmer J., Blank J. and Rahmann H., 2000 – Macroinvertebrate functional feeding group methods in ecological assessment, *Hydrobiologia*, 422/423, 225-232.
20. Roşu A., 1980 − Geografia României, Ed. Didactică şi Pedagogică, Bucureşti. (in Romanian)
21. Sedeño-Díaz J. E., Kohlmnan B. and López-López E., 2012 – Benthic macroinvertebrates as indicators of water quality in streams of Costa Rica: using an adaptation of the BMWP score, *Transylvanian Review of Systematical and Ecological Research, The Wetlands Diversity*, Curtean-Bănăduc et al. (eds), 14, 163-175.
22. Varnosfaderany M. N., Ebrahimi E., Mirghaffry N. and Safyanian A., 2010 – Assessment of the Zayandeh Rud River, Iran, using benthic macroinvertebrates, *Limnologica*, 40, 226-232
23. Wang Z. Y., Lee J. H. W., Cheng D. and Duan X., 2008 – Benthic invertebrates investigation in the East River and habitat restoration, *Journal of Hydro-environment Research*, 2, 19-27.
24. Whiles M. R., Brock B. L., Franzen A. C. and Dinsmore S. C., 2000 – Stream invertebrate communities, water quality, and land-use patterns in an agricultural drainage basin of north-eastern Nebraska, USA, *Environmental Management*, 26, 563-576.

ENVIRONMENTAL INDICATORS OF WATER QUALITY IN THE CIBIN RIVER (TRANSYLVANIA, ROMANIA)

*Ramona IANCU *, Letiţia OPREAN *, Diana STEGĂRUŞ **, Ovidiu TIŢA *, Adrian BOICEAN **** and *Ecaterina LENGYEL **

* "*Lucian Blaga*" University of Sibiu, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, Department of Biotechnologies, Raţiu Street 7-9, Sibiu, Sibiu County, Romania, RO-550012, ramy11us@yahoo.com, letitia.oprean@ulbsibiu.ro, ovidiu.tita@ulbsibiu.ro, ecaterina.lengyel@ulbsibiu.ro
** National Research-Development Institute for Cryogenic and Isotopic Technologies, 4 Uzinei Street, O. P. 4, C. P. 10, RO-240050, Râmnicu Vâlcea, Romania, bociu_diana@yahoo.com
*** Academic Emergency Hospital, 2-4 Corneliu Coposu Bvd., RO-550245, Sibiu Romania, adrian.boicean@gmail.com

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KEYWORDS: water, pollution, physical-chemical tests, Cibin River, Transylvania, Romania.

ABSTRACT

Water pollution has become a worldwide problem and its influence over the health of human populations grows every day. This study was carried out to determinate the rate level of pollution of the Cibin River (Transylvania, Romania) via physical-chemical and microbiological tests. Water samples were measured at six different locations along the Cibin River for a period of 12 months. Analysis methods used to determine physical-chemical quality indices for water were as follows: O_2 - ISO 5814/99, pH - SR ISO 10523-97, PO^{4-} KIT Merck, SO^{4-} - PS/LE 17, conductivity - Sonda, NH_{4+} - SR ISO 7150-1/2001, NO_{3-} - SR ISO 7890/2000, NO_{2-} - SR EN 26777 - ISO 6777/2002, chlorides - SR ISO 9297/2001, CCOCr - SR ISO 6060/96, CBO_5 - SR ISO 5815/95, suspended solids - STAS 6953/81, residues - STAS 9187/95. The water samples were analyzed also from a sanitary and public health point of view, for example: total number of mesophilic bacteria, total number of yeasts and moulds, total coliforms, total fecal coliforms, *Enterococcus* and *Escherichia coli*, according to current Romanian legislation and normatives (Order 1146/2002). The significant results place the river in the first (sampling stations 1, 2 and 3) and second (sampling stations 4, 5 and 6) water Quality Class. Due to the fact that the upper dam reservoir at Gura Râului is the main source of drinking water for Sibiu, it is certain that this water presents optimal characteristics for human consumption and is thus declared to be one of the healthiest water sources in Romania.

ZUSAMMENFASSUNG: Umweltindikatoren der Wasserqualität des Zibin-Flusses (Transylvanien, Rumänien).

Die Wasserverschmutzung ist zu einem globalen Problem geworden und ihr Einfluss auf die Gesundheit der Bevölkerung wächst von Tag zu Tag. Die vorliegende Forschung hatte zum Ziel, den Verschmutzungsgrad des Zibin-Flusses (Rumänien) mit Hilfe physikalisch-chemischer und mikrobiologischer Teste zu ermitteln. Die Wasserproben wurden von sechs verschiedenen Stellen entlang des Zibins über eine Zeitspannne von 12 Monaten entnommen. Die Analysemethoden für die zur Bestimmung der physikalisch-chemischen

Wasserqualitätszeiger waren wie folgt gekennzeichnet: O_2 - ISO 5814/99, pH - SR ISO 10523-97, PO^{4-} KIT Merck, SO^{4-} - PS/LE 17, Leitfähigkeits-Sonde, NH_{4+} - SR ISO 7150-1/2001, NO_{3-} - SR ISO 7890/2000, NO_{2-} - SR EN 26777, - ISO 6777/2002, Chlor - SR ISO 9297/2001, CCOCr - SR ISO 6060/96, CBO_5 - SR ISO 5815/95, Schwebstoffe - STAS 6953/81, Rückstände - STAS 9187/95. Die Wasserproben wurden auch von sanitärem Standpunkt und jenem der öffentlichen Gesundheit mikrobiologisch untersucht und zwar: die Gesamtzahl der mesophilen Bakterien, der Hefen und Schimmelpilze, die der Coliformen und der Fäkalcoliformen *Enterococcus* und *Escherichia coli*, gemäß der derzeit in Rumänien gültigen Gesetzgebung und Regelungen (Erlass 1146/2002). Die signifikanten Ergebnisse der Untersuchung gliedern den Zibin in: einen Abschnitt der Qualitätsklasse I. (Entnahmepunkte 1, 2 und 3) und einen Abschnitt der Qualitätsklasse II (Probestellen/Entnahmepunkte 4, 5 und 6). Da der Stausee von Gura Râului die Hauptversorgung an Trinkwasser für die Stadt Sibiu/Hermannstadt gewährleistet, ist sichergestellt, dass das Wasser von Gura Râului optimale Eigenschaften für Trinkwasserversorgung aufweist und sogar zu einem der landesweit gesundesten Trinkwassergebiete erklärt wurde.

REZUMAT: Indicatori de mediu pentru calitatea apei în râul Cibin (Transilvania, România).

Poluarea apei a devenit o problemă la nivel mondial, iar influența acesteia asupra stării de sănătate a populației umane crește zi de zi. Prezentul studiu are drept scop determinarea gradului de poluare a râului Cibin (România), prin analize fizico-chimice și microbiologice. Probele de apă au fost recoltate din șase locații diferite de-a lungul râului Cibin pe o perioadă de 12 luni. Metodele de analiză utilizate pentru determinarea indicilor de calitate fizico-chimici pentru apă au fost după cum urmează: O_2 - ISO 5814/99, pH - SR ISO 10523-97, PO^{4-} KIT Merck, SO^{4-} - PS/LE 17, conductivitate - Sonda, NH_{4+} - SR ISO 7150-1/2001, NO_{3-} - SR ISO 7890/2000, NO_{2-} - SR EN 26777, - ISO 6777/2002, cloruri - SR ISO 9297/2001, CCOCr - SR ISO 6060/96, CBO_5 - SR ISO 5815/95, suspensii solide - STAS 6953/81, reziduuri - STAS 9187/95. Probele de apă au fost analizate și din punct de vedere microbiologic, determinându-se: numărul de bacterii mezofile, numărul total de drojdii și mucegaiuri numărul total de coliformi şi coliformi fecali, *Enterococcus* şi *Escherichia coli,* în conformitate cu legislaţia şi normativele actuale ale României (O. M. 1146/2002). Rezultatele obţinute împart Râul Cibin în clasele I (punctele de prelevare 1, 2 şi 3) şi II (punctele de prelevare 4, 5 şi 6) de calitate. Ţinând cont de faptul că barajul de la Gura Râului reprezintă principala sursă de apă potabilă pentru oraşul Sibiu, prin rezultatele obţinute se poate certifica faptul că apa Râului Cibin prezintă caracteristici optime pentru consumul uman şi se declară una dintre cele mai sănătoase ape din România.

INTRODUCTION

The key to reducing dead zones will be to keep fertilizers on the land and out of the sea. For agricultural systems in general, methods that close the nutrient cycle from soil to crop and back to agricultural soil need to be developed. (Diaz and Rosenberg, 2008)

With the increase in the age of the earth, clean water is becoming more precious as water is being polluted by several man related causes like: rapid population growth, alarming speed of industrialization and deforestation, urbanization, increasing living standards and other wide spheres of other human activities. Ground water, surface water, rivers, sea, lakes, ponds, etc., are finding it more and more difficult to escape from pollution (Shrikanta, 2005; Sandu et al., 2008; Milanović et al., 2011).

Rivers provide an array of ecosystem goods and services, including biodiversity, attenuation of flood waters, abstraction, recreation, production of power, food and other marketable goods. However, human activities in river catchments over prolonged periods, such as settlement, agriculture and forestry, damaged the freshwater ecosystem and have substantially altered riverine processes (Malmqvist and Rundle, 2002; Gurzău et al., 2010).

Rivers, as ecosystems, have been modified and interfered at different levels. This has developed a requirement for effective management with the ultimate aim to effectively preserve rivers in their natural state (Boon, 1992).

The main sources of water pollution are defined as "any discernable, confined and discrete conveyance, including but not limited to, any pipe, ditch, channel not including agricultural storm water and return flow from irrigated agriculture" (Edwards and Withers, 2008).

Indeed in recent years, efforts to improve water quality were focused on these sources, which have led to an improvement but have also uncovered the previously concealed influence of non-point sources, or diffuse pollution sources, on the aquatic environment (Heathwaite et al., 2005b; Ashbolt, 2004; Sanja et al., 2009).

The Water Framework Directive (WFD - 2000/60/EC) is a European-wide piece of legalization as a response to the degradation of aquatic ecosystems (Carstensen, 2007). This is a significant piece of legislation agreed upon in 2000 and was the result of a 12-year long policy process (Kallis and Butler, 2001). It aims, by 2015, to return waters (fresh, estuaries, coastal and ground) to good ecological and chemical status (Environment Agency, 2006). It is an ambitious goal with an overarching framework approach and is revolutionary with its blend of natural sciences and social elements (Steyaert and Ollivier, 2007).

An interesting approach is that it leaves the translation of aims and objectives of the legislation to member states and local levels (Kallis and Butler, 2001).

World Health Organization (WHO) states that the "infectious diseases caused by pathogenic bacteria, viruses and protozoa or by parasites are the most common and widespread health risk associated with drinking water", frequently as a result of fecal matter from sewage discharges, leaking septic tanks, and runoff from animals (EPA, 2001b; WHO UNICEF, 2004; Balzer et al., 2010).

Potable or drinking water is defined as having acceptable quality in terms of its physical, chemical, and bacteriological characteristics so that it can be safely used for drinking and cooking (Patoli, 2010; Medema et al., 1997; Eleria, 2002).

The rationale of this study is to evaluate the Cibin River, as a water supply for Sibiu citizens, from a sanitary and public health point of view, providing fundamental concepts of water quality control.

MATERIAL AND METHODS

In the Sibiu Depression, the Cibin meadow has two clearly differentiated sectors: the sector upstream of Sibiu (Gura Râului - Sibiu) in the west-east direction and the sector downstream of Sibiu (Sibiu - Tălmaciu) with a north-west-south-east orientation (Sandu, 1998). The water samples were collected from six different locations along Cibin River (Figs. 1-7).

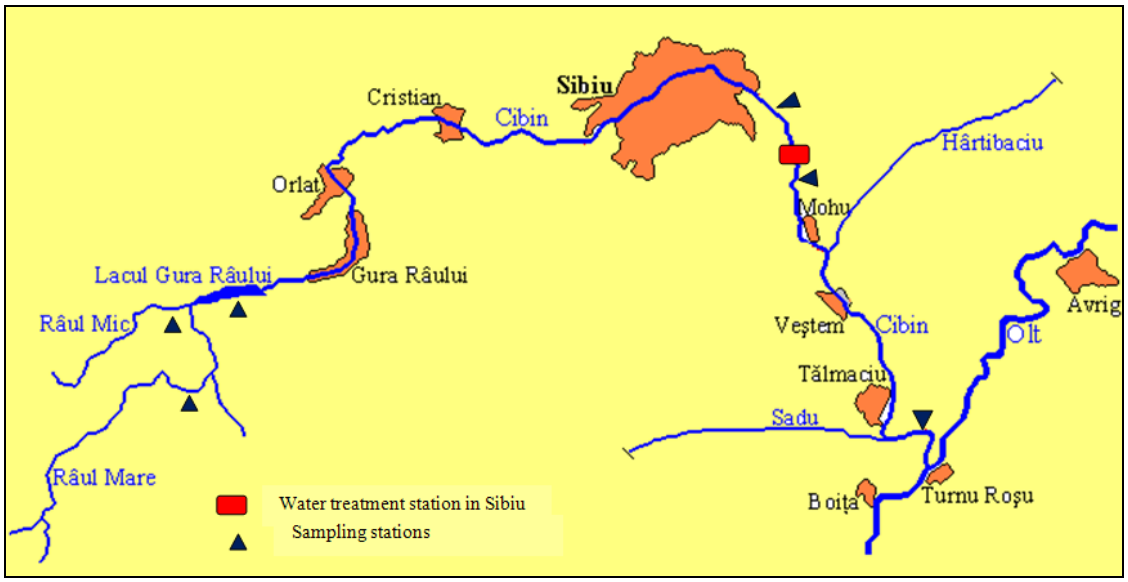

Figure 1: Cibin River in Sibiu Depression
with sampling stations.

Figure 2: Sampling station 1; Râul Mic,
forming together with Râul Mare the Cibin River.

Figure 3: Sampling station 2; Râul Mare, forming together with Râul Mic the Cibin River.

Figure 4: Sampling station 3 at Gura Râului Lake.

Figure 5: Sampling station 4, downstream Sibiu city, upstream the Water Treatment Station.

Figure 6: Sampling stations 5, downstream the Water Treatment Plant.

Figure 7: Sampling station 6, 1 km upstream the Cibin River confluence with Olt River.

The water samples were collected during 2012 period, in three different seasons: spring, summer and autumn. Water samples were collected in sterile bottles for physical-chemical and microbiological tests according to ISO SR EN 17.025/2005 (General requirements for the competence of testing and calibration) and sent to Microbiology and Biotechnology Research Department ("*Lucian Blaga*" University of Sibiu). During transportation, the samples were kept at 4°C, otherwise the determination of microorganisms is not relevant.

Analysis methods used to determine the physical-chemical quality indices for water were as follows: O_2 - ISO 5814/99, pH - SR ISO 10523-97, PO^{4-} KIT Merck, SO^{4-} - PS/LE 17, conductivity - Sonda, NH_{4+} - SR ISO 7150-1/2001, NO_{3-} - SR ISO 7890/2000, NO_{2-} - SR EN 26777 - ISO 6777/2002, chlorides - SR ISO 9297/2001, CCOCr - SR ISO 6060/96, CBO_5 - SR ISO 5815/95, suspended solids - STAS 6953/81, residues - STAS 9187/95.

Maximum admitted values for potable water quality should be according to the Law no. 458/2002 on potable water quality modified and completed by the Law no. 311/2004.

Categories and technical requirements for surface water, rivers, lakes, natural or artificial, should be according to Order 1146/2002 - Normative regarding the objectives of reference for surface water quality classification.

The water samples from Cibin River were also analyzed from a sanitary and public health point of view, such as: total number of mesophilic bacteria, total number of yeasts and moulds, total coliforms, total fecal coliforms, *Enterococcus* and *Escherichia coli*, in accordance with the current Romanian legislation and normative (respectively the Order 1146/2002).

Total mesophilic bacteria (TMB); Total yeasts and moulds (TYM)

The presence of mezofile (aerobic) bacteria is accomplished by ten-fold dilutions of seeding the water samples. This is accomplished through the incorporation into nutrient solid medium incubated at 22°C, respectively 37°C for 48 h, followed by counting the colonies developed, thereby determining the degree of impurity; method used according to STAS 6222/2004. The medium used for TMB was Nutrient Agar (MERCK, KgaA, Germany) and the medium used for TYM was CZAPEK-DOX Agar (Scharlau Chemie S. A., Barcelona, Spain), sterilized in autoclave at 121°C.

Total Coliforms (TC)

The presence of coliforms is accomplished by the presumption (preliminary examination) and confirmed by the confirmatory test (final exam). The presence of coliform bacteria in water indicates the contamination of this river.

The presumptive test for coliform was made in small tubes containing Durham tube placed in the thermostat at 37°C ± 0.50°C for 48 h, according to STAS 3001/1991. After 24 h, the first reading is made for the confirmation of turbidity and gas. It is considered positive vials and test tubes in which the lactose fermentation is highlighted by the presence of gas in the fermentation, no matter how small the amount of gas evolved in the tube. After 48 h, the final reading and passage for the confirmatory test is made for vials and test tubes in which a microbial development (turbidity) with or without gas, with the exception of those who have been confirmed in 24 h.

The confirmation test for coliform was made by inoculating the positive tubes in selective medium Eosin Methylene Blue Agar - EMB (Scharlau Chemie S. A., Barcelona, Spain), incubated at 37°C ± 0.50°C for 24 h. The number of total coliforms was calculated through statistical tables depending on the amount of samples analyzed, taking into account the vials and phials confirmed.

Total fecal coliforms (TFC)

The presence of coliform bacteria in water indicates recent fecal contamination. The presence of coliforms was made from the vials of presumptive test positive for faecal coliforms bacteria content, through confirmation in Brilliant Green Bile 2% Broth (Scharlau Chemie S. A., Barcelona, Spain) at 44°C ± 0.50°C, incubated for 24 h, according to STAS 3001/1991. Stain environment in yellow (acidification) in conjunction with the production of gas as a result of lactose fermentation in fermentation tubes, indicates the presence of faecal coliforms.

Total enterococci and *Escherichia coli*

The procedures employ presumptive test, followed by confirmation, according with STAS 3001/1991. The primary selective agent for enterococcus was Azide Dextrose Broth According to Rothe (Scharlau Chemie S. A., Barcelona, Spain) and for *Escherichia coli* was Eosin Methylene Blue Agar (Scharlau Chemie S. A., Barcelona, Spain).

RESULTS AND DISCUSSIONS

The results of our study have shown a number of interesting points regarding the sanitary parameters and chemical status of Cibin River water quality. These results are comparable to the classification on the classes of water quality, according to the national normative, Order no. 161/2006 - Classification of surface waters in order to establish the ecological status of water bodies: for class I the classification is very good, for class II is good, for class III is moderate, for class IV is bad and for class V is very bad.

The selected water quality concentrations are the results meant to provide information regarding the quality of the Cibin River, each parameter being explained in detail.

Water temperature has important effects on almost every aspect of biodiversity. Temperature influences the amount of oxygen which is dissolved in water, the colder the water is, the higher the amount of oxygen in the water.

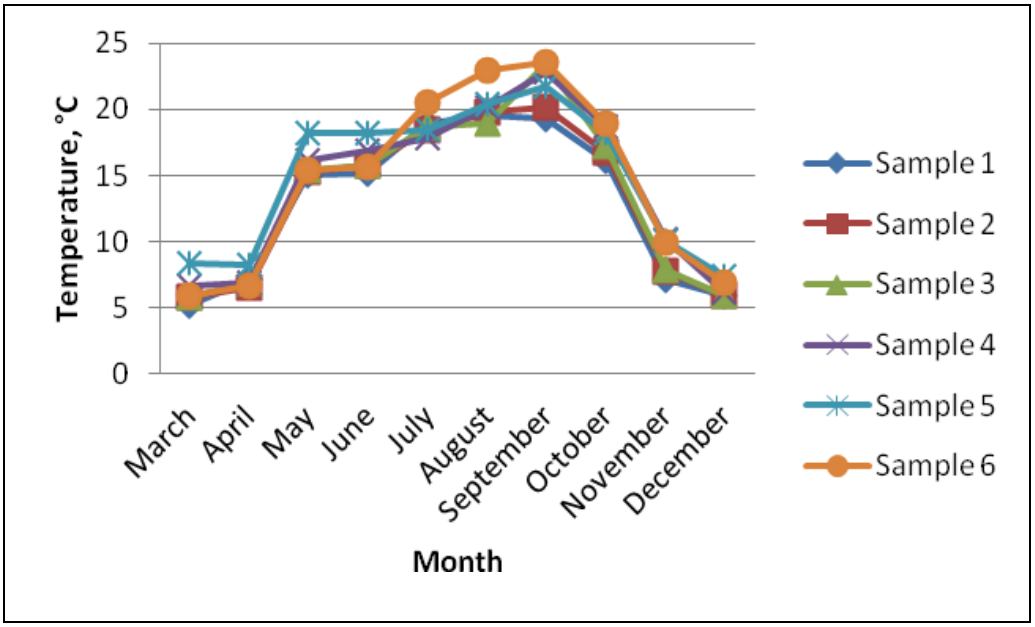

Figure 8: Temperature values during 10 months in the Cibin River monitored points.

As it is shown in figure number 8, Cibin River's temperature oscillates between 5.2°C in early spring and 23.5°C in autumn. Because the river's sources are located in the mountain area, the temperatures don't exceed 24°C, not even in the summer time. The river in the outfall has a higher temperature because it reaches open lowland with large opening areas to the sun light. The temperature has a special influence in mesophilic microorganism's development, as shown in figures 9 and 10. They have a positive evolution depending on the determination period and the month when the water samples were collected. It seems that mesophilic bacteria cultivated on nutritive agar at 22°C presents maximum values in August in the fifth sample point, those values reaching 10,000 germs/ml. The most reduced values in this case are found in April in Gura Râului Lake (Fig. 10). Mesophilic bacteria which are developed at 37°C (Fig. 10) oscillate from 11 germs/ml (at Râul Mic in March and October) to 5,500 germs/ml (in August) at the fourth sample point, just upstream the wastewater plant.

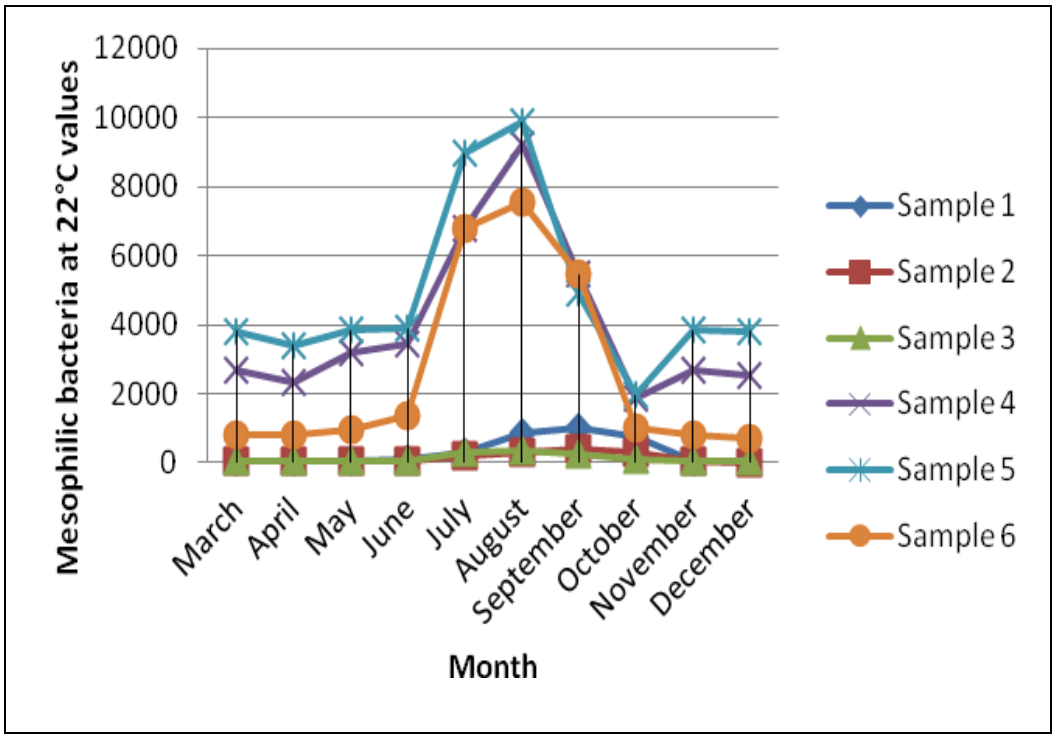

Figure 9: Mesophilic bacteria values at 22°C over 10 months
in the monitored points of the Cibin River.

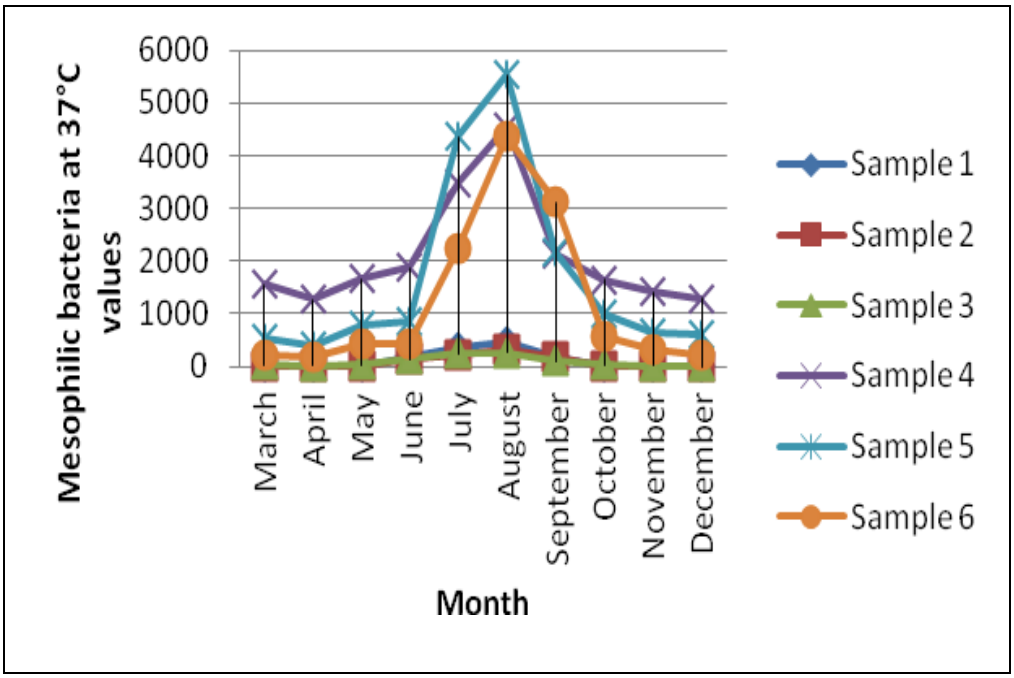

Figure 10: Mesophilic bacteria values at 37°C during 10 months
in the monitored points of the Cibin River.

Yeasts and molds were developed in a higher number, up to 4,300 germs/ml in August at the wastewater plant entrance. The minimum values were found at the Gura Râului Lake (Fig. 11). The yeast and mold species developed and multiplied at 37°C (Fig. 12) were found in a lower number in sampling stations 1, 2 and 6 (river sources and 1 km upstream the confluence with the Olt River).

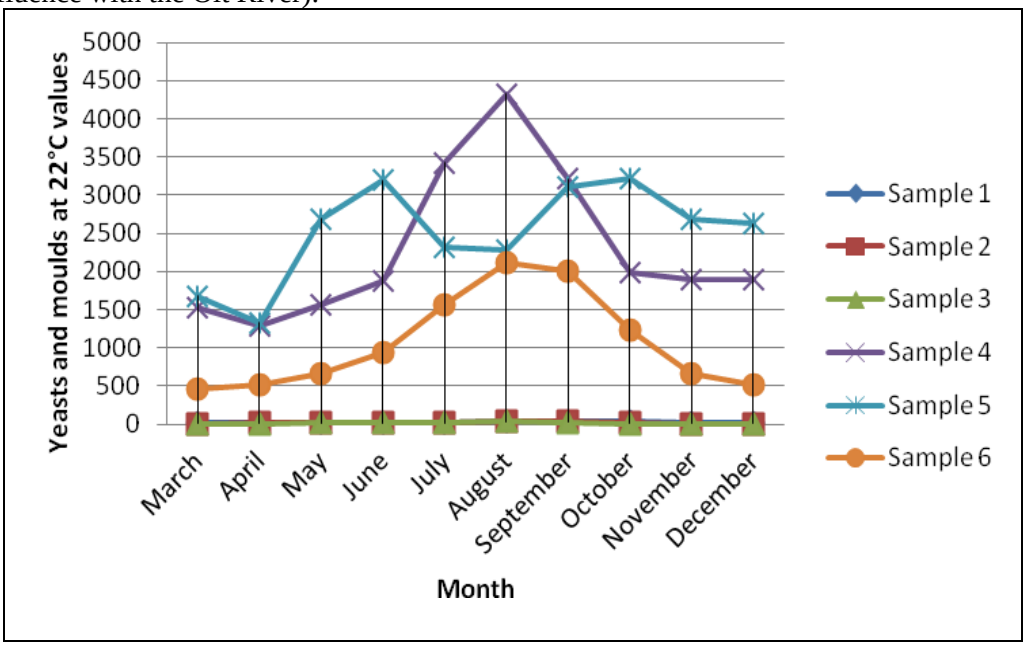

Figure 11: Yeasts and moulds values at 22°C during 10 months in the monitored points of the Cibin River.

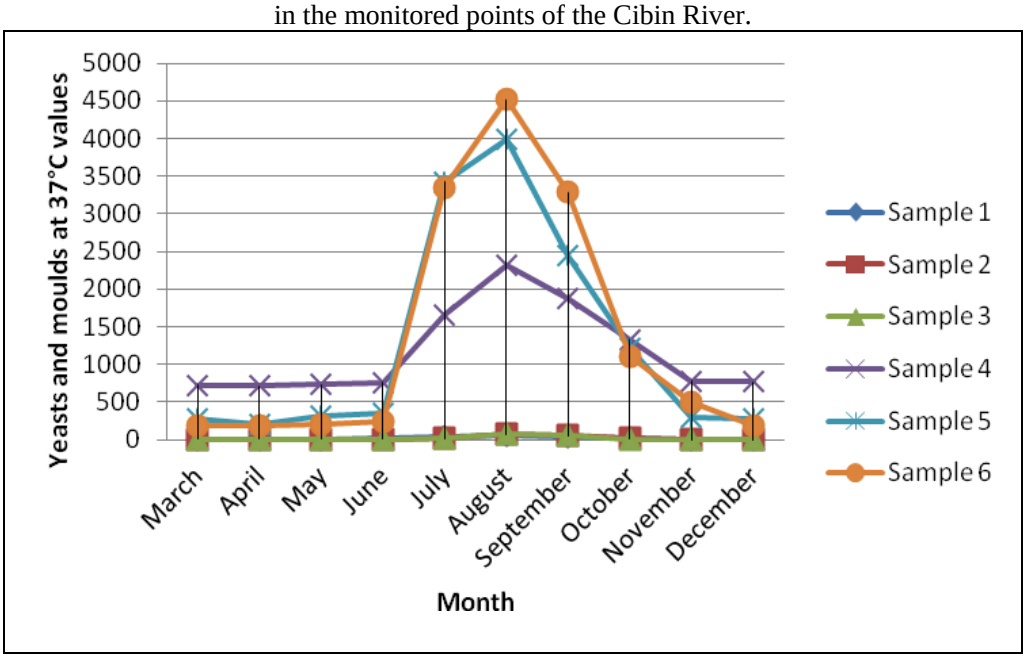

Figure 12: Yeasts and moulds values at 37°C during 10 months in the monitored points of the Cibin River.

River systems are used for disposal of waste, from industries that are near their courses. These effluents from industries have a great deal of influence on the pollution of the water body (bacteria, yeasts and moulds), these effluents can alter the physical, chemical and biological nature of the receiving water body. (Sangodoyin, 1991) Increased industrial activities have led to pollution stress on surface waters, and agricultural and domestic sources are in this situation too. Wastes entering these water bodies are both in solid and liquid forms.

As a result, the water bodies which usually are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted. The resultant effects of this on public health and the environment are usually high in magnitude. (Osibanjo, 2011)

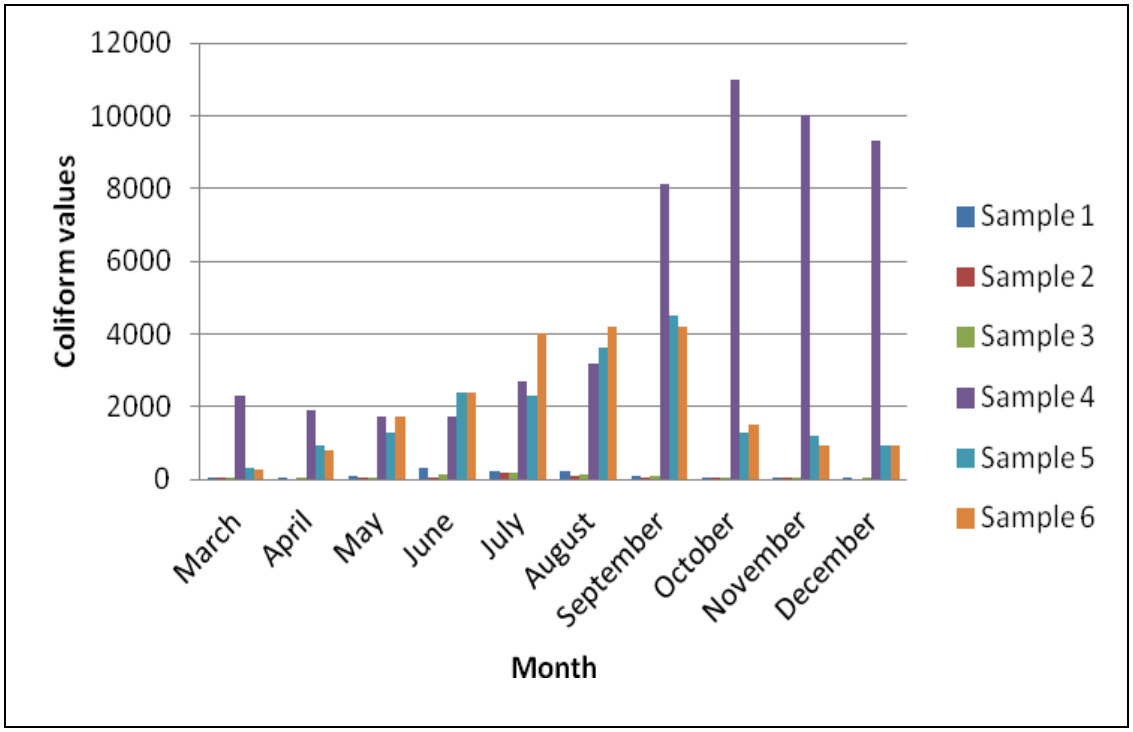

Figure 13: Coliform values over 10 months
in the monitored points of the Cibin River.

To determine the likelihood of contamination by organisms, we need to know exactly the coliform concentration. It is well known that the presence of these coliforms, especially of faecal coliforms, will cause diseases such as dysentery, gastroenteritis and hepatitis A. The presence of faecal coliform in a water sample is used to indicate potential contamination. A common source of coliforms and faecal coliform occurs naturally in the digestive tract of warm-blooded animals, where they aid in the digestion of food. The total coliform and faecal coliform amount will indicate if the water is acceptable for drinking, or it is forbidden to drink untreated water from a river or lake.

The coliforms are the primary water's health indicator, found in different forms as *E. coli*, faecal coliform, *Enterobacter*.

In our study, the total coliforms value is between 0 and 10.000 germs/100 cm^3 water, but missing from "Râul Mic" Source (Figs. 13 and 14).

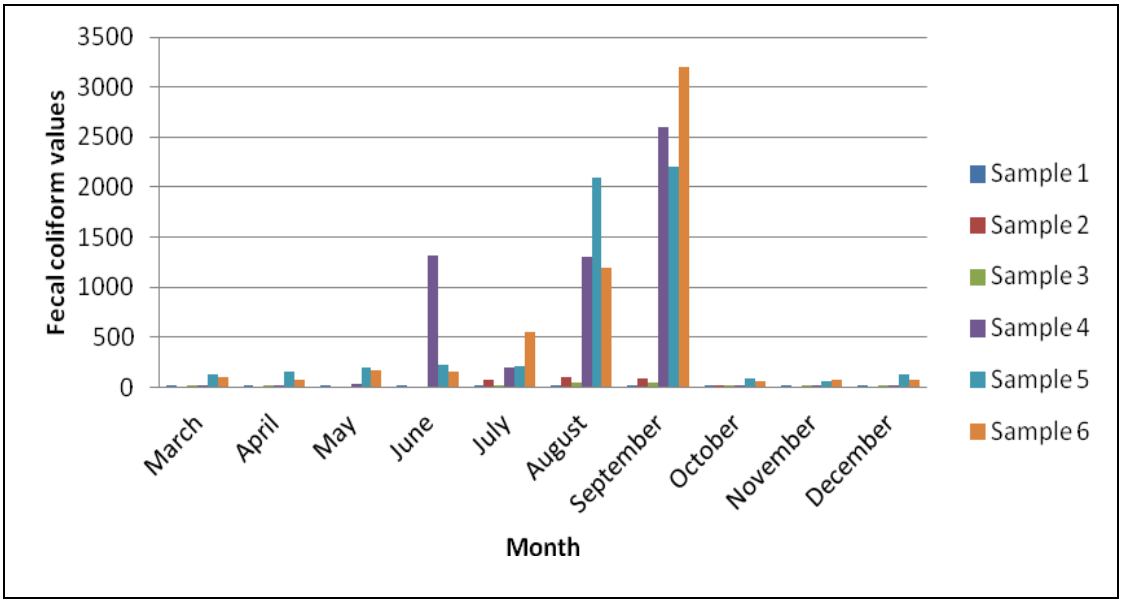

Figure 14: Fecal coliform values during 10 months
in the monitored points of the Cibin River.

Escherichia coli and ***Enterobacter*** have been the foremost indicators of faecal contamination in water quality monitoring for many decades. *Escherichia coli* have also been shown to be a significant reservoir of genes coding for antimicrobial drug resistance and therefore is a very useful indicator for resistance in the bacterial communities. (Bucknell, 1997; Patoli, 2010)

The number of coliform bacteria, respectively *Escherichia coli*, faecal coliform, *Enterobacter* (Figs. 14, 15 and 16) is increasing substantially in the summer, values reaching between 8.000 and 11.000/100 cm^3 per sample because in the summer period the tourists camp frequently.

Escherichia coli reaches values of 22/100 cm^3 per sample at the source zone and increases to 600 at the outfall. There is a lower number of coliforms, so the water from Cibin River has a good quality.

The water from the Gura Râului Lake has very low number of coliform bacteria, bacteria which do not exceed 170/100 cm^3 per sample, water which is considered as being safe for drinking.

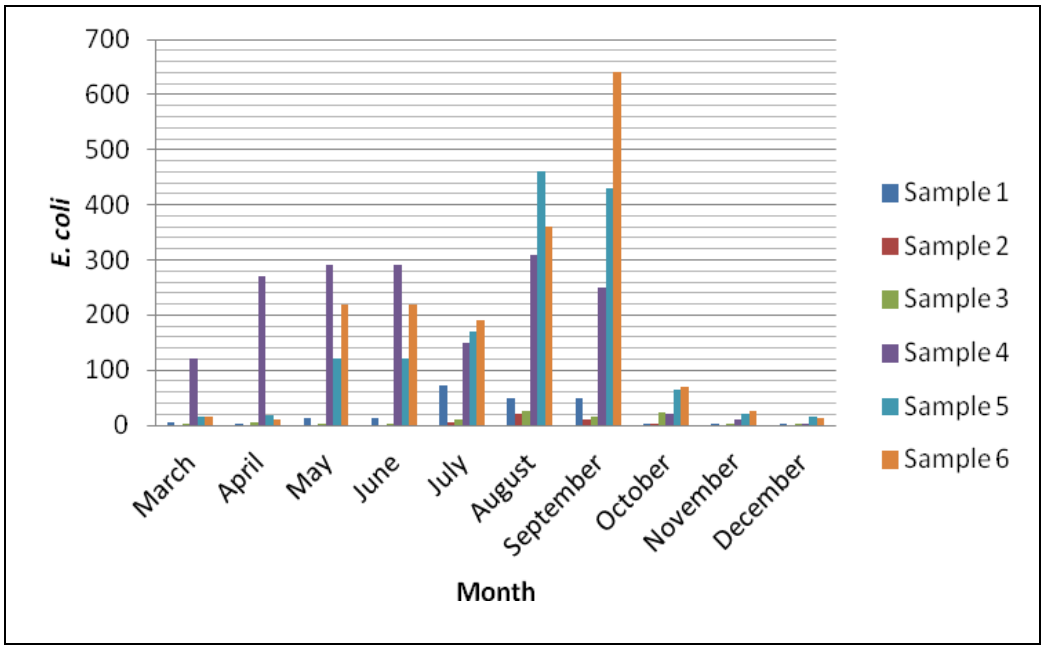

Figure 15: *Escherichia coli* values during 10 months
in the monitored points of the Cibin River.

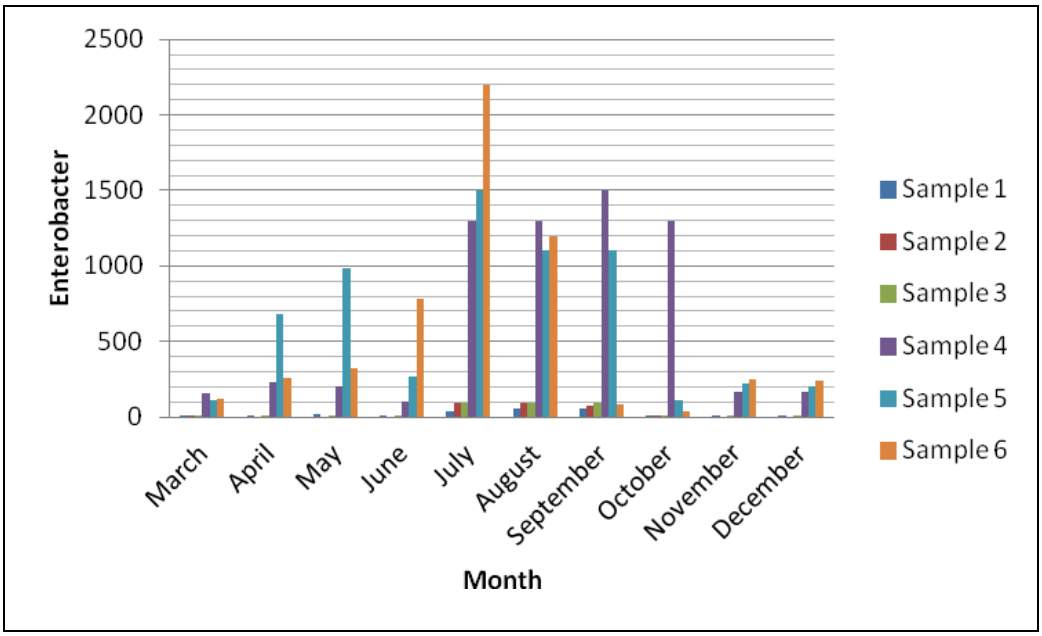

Figure 16: *Enterobacter* values during 10 months
in the monitored points of the Cibin River.

pH is an important factor that determines the suitability of water for various purposes, including toxicity to animals and plants (Venkatesharaju, 2010).

The pH is around 7, being neutral in most of the water samples.

Figure number 17 shows minimum values reaching 6.4 and maximum to 7.66.

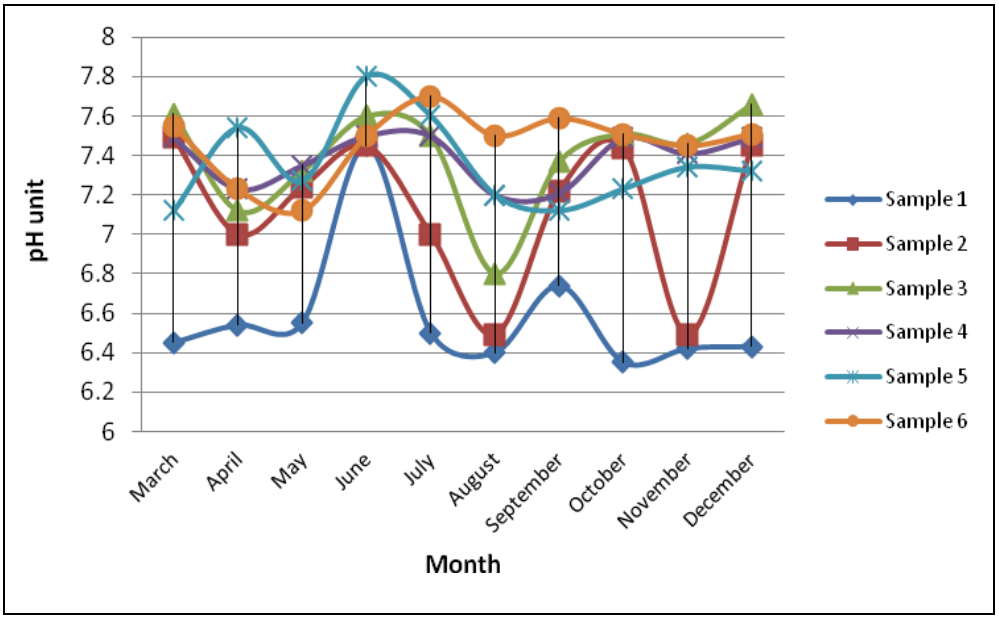

Figure 17: pH values during 10 months in the monitored points of the Cibin River.

As shown in figure number 18, we can see that sulphates show constant values throughout the period monitored for the first 3 points of the Cibin River.

The values increase by 3-4 times in the extra urban areas of the Cibin River, downstream and upstream of the water treatment plant, upstream the Olt River.

The determined values do not constitute a major factor of degradation; the results classify Cibin River in the 1st class of quality.

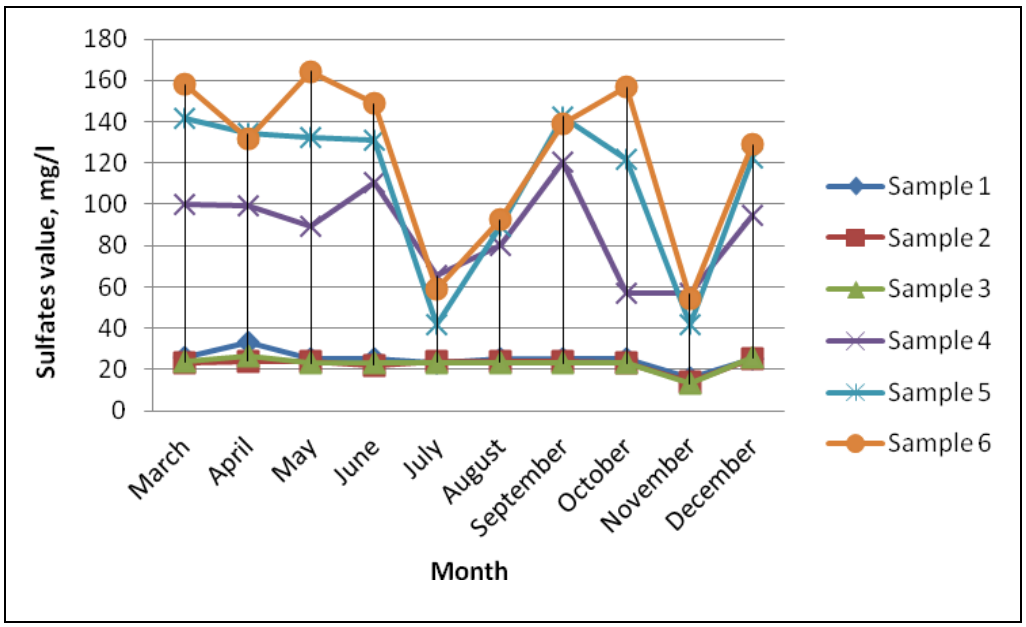

Figure 18: Sulphates values during 10 months in the monitored points of the Cibin River.

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, on their total concentration, mobility and valence and on the temperature of measurement (Venkatesharaju, 2010).

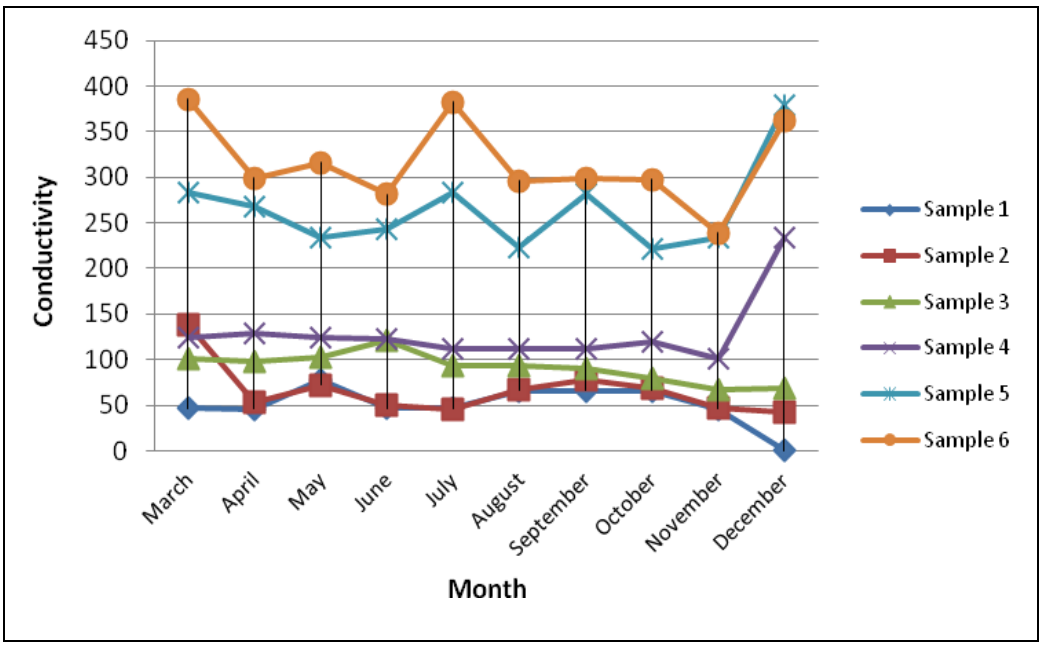

Figure 19: Conductivity values during 10 months in the monitored points of the Cibin River.

Figure number 19 shows the conductivity values from a minimum of 38µS/cm to 387 µS/cm maximum, at the river sources area and at the confluence area with the Olt River.

Conductivity increases with the passage of the river through inhabited areas, being directly proportional to the fixed residue presented in figure number 20.

The suspended solids are the solids remaining in a water sample filtered through a 1.2 µm filter. According to the World Health Organization (WHO, 1997), the compounds and elements remaining after filtration are commonly calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, silica and nitrate-n. A high amount of suspended solids affects the taste and odor of water, knowing that at levels above 300 mg/l become noticeable to consumers. If the suspended solid increases, the river water becomes increasingly unacceptable.

Residues existence can reduce the clarity of the water, it can degrade the aquatic habitats and can increase the temperature, negative effects that shouldn't happen, and that are decreasing the photosynthesis activity and will have a higher mortality for aquatic animals.

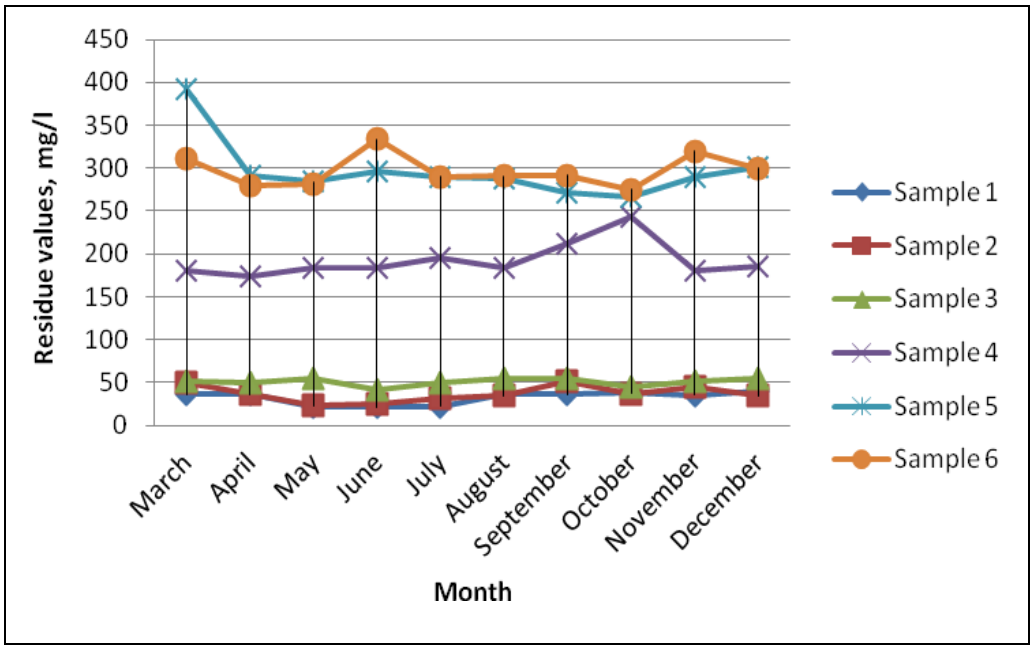

Figure 20: Residue values during 10 months
in the monitored points of the Cibin River.

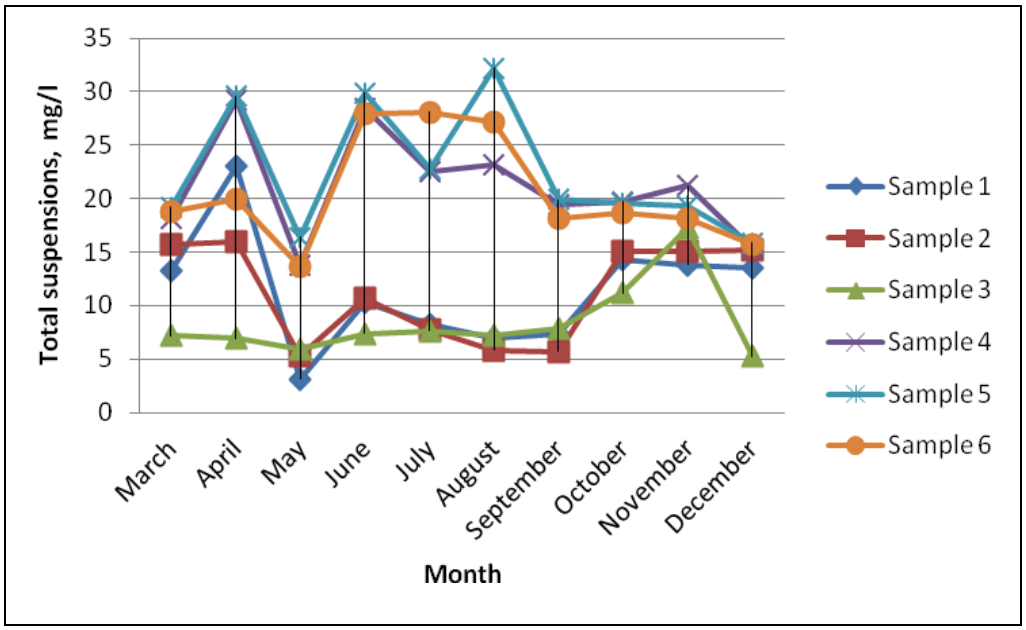

Figure 21: Suspended solid values during 10 months
in the monitored points of the Cibin River.

A special characteristic of the Cibin River is the fact that the suspensions are found in low amounts ranging between 5.3 and 29.2 mg/l, which strengthens the decision of the Cibin River insertion in 1st class of quality.

The variability of the suspension is an indication of banks hygiene both for the source and of the points of collection, the variations being among 30-40%.

Once the snow melts, in the spring, a series of natural elements engage in the sources, this is why they appear in a higher volume in the first two monitoring months (March and April). The values registered in October, November and December is the consequences of human pollution.

During the winter period, with low irradiance conditions, primary nutrients including also NH_4 accumulate due to continuing inputs and low phytoplankton nutrient uptake activity. In spring period, increases in seasonal irradiance create conditions for phytoplankton growth and NH_4 concentrations decrease due to dilution by spring runoff (Peterson et al., 1985).

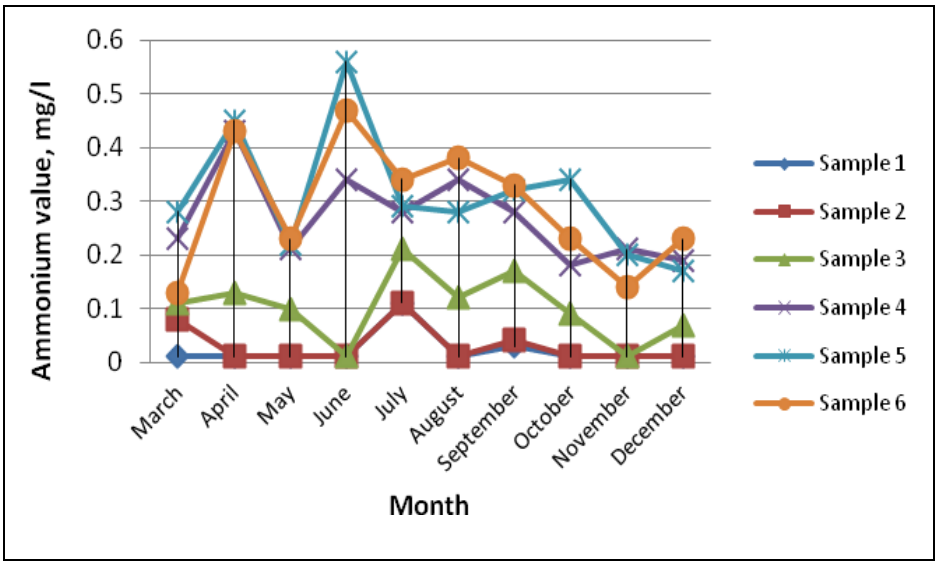

Figure 22: Ammonium values during 10 months
in the monitored points of the Cibin River.

Nitrate and nitrites determinations are important in assessing the potential biological productivity of surface waters. Increasing concentration of phosphorus and nitrogen compounds in lakes and reservoirs leads to eutrophication. Phosphates and nitrates can be present due to agricultural runoff during rainy season and used as nutrients by algae and other aquatic plants. (Venkatesharaju, 2010)

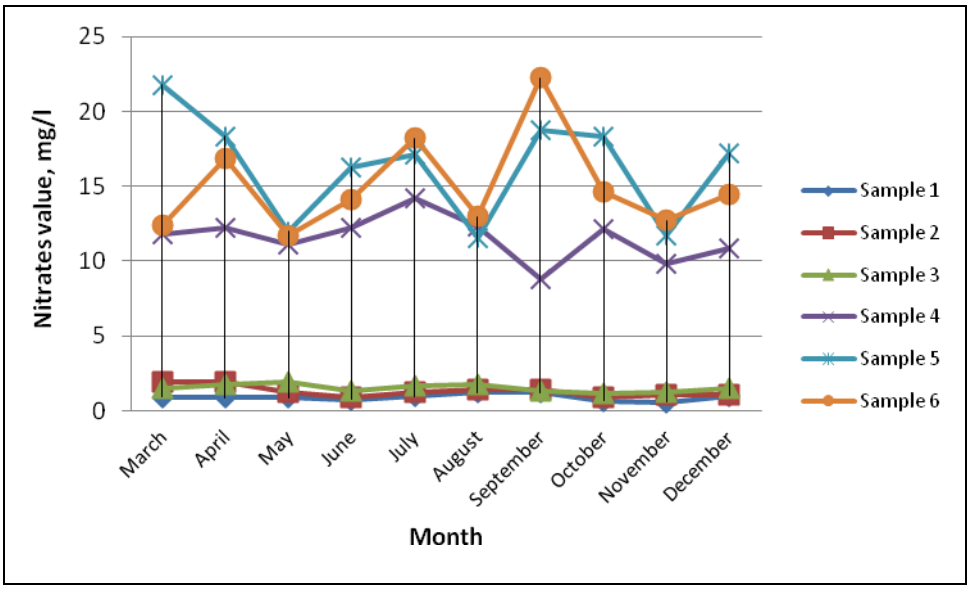

Figure 23: Nitrates values during 10 months
in the monitored points of the Cibin River.

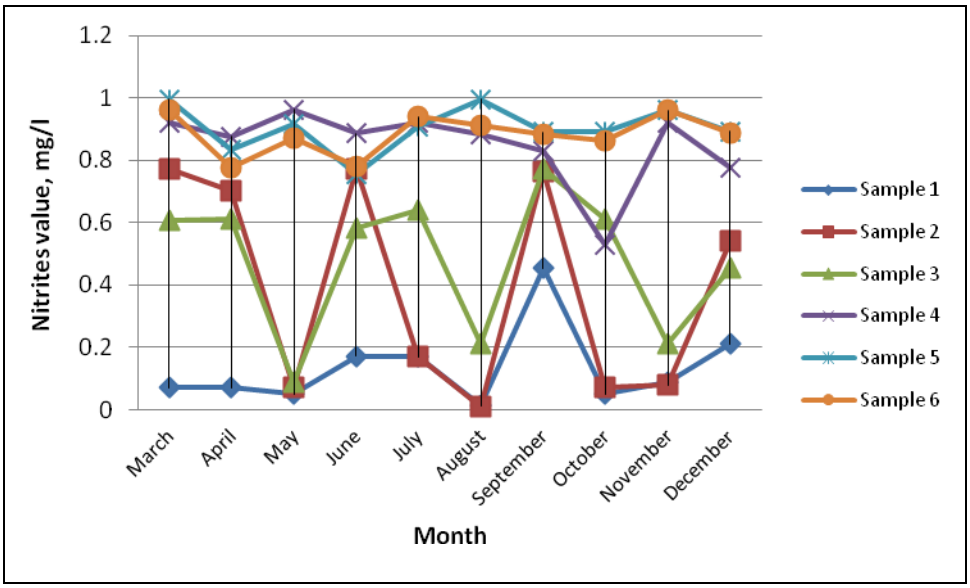

Figure 24: Nitrites values during 10 months
in the monitored points of the Cibin River.

After the monitoring of Cibin River it seems like nitrite and ammonia values classify this river in first quality class (values even 100 times lower than the maximum admitted limits).

On the other hand, the nitrites exceed the maximum admitted limits for the first quality class in downstream zones of wastewater treatment plant and also at the confluence area of Cibin River with Olt River. The nitrate concentration varies in these two points, being influenced by the spills from the rural zones. These values are higher in the summer time; this portion of river being in the second quality class. The minimum values are below 1 mg/l to 2 mg/l in the source zones and dam reservoir and they become higher than 8 mg/l to 23 mg/l at the final formation of the river.

Chlorides occur naturally in all types of waters. High concentrations of chlorides are considered to be the indicators of pollution due to organic wastes of animal or industrial origin. Chlorides are troublesome in irrigation water and also harmful to aquatic life. (Rajkumar, 2004).

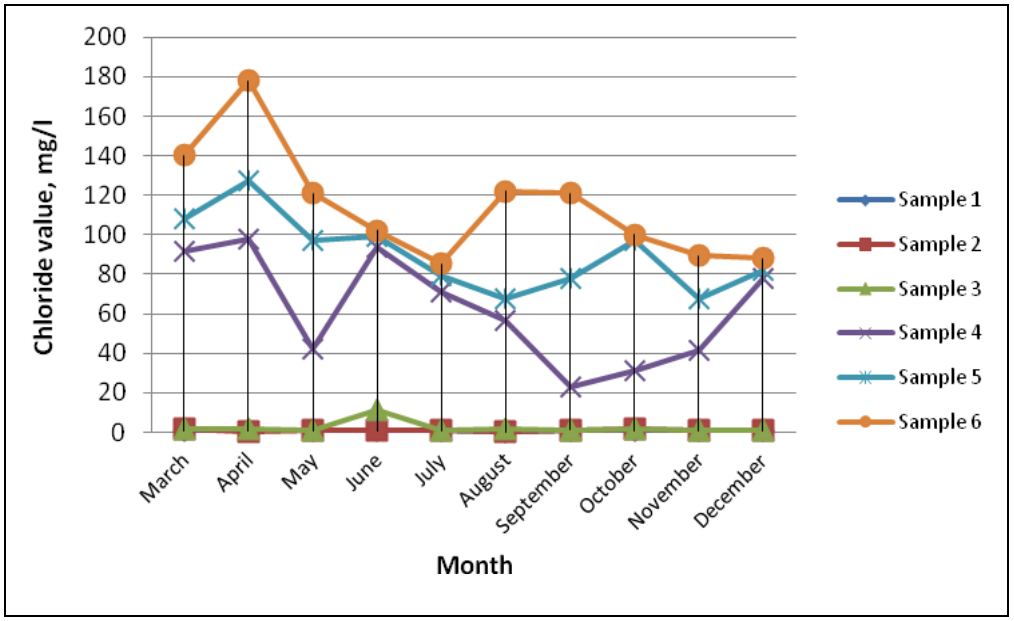

Figure 25: Chloride values during 10 months
in the monitored points of the Cibin River.

The chlorates values are below 250 mg/l (Fig. 25), proving once again the efficiency of the antipollution implementation programs of Cibin River but also the fact that the river receives water at good standard parameters from the wastewater treatment plant.

Oxidation processes, which take place into the river's water, provide the necessary energy for the biochemical processes which sustain the aquatic life. The water quality is represented in a certain way by the existing and consumed quantity of O_2 in water.

Biochemical oxygen demand is an important indicator of the consumption of oxygen, necessary quantity, of its decomposition and mineralization of organic matter in aerobic conditions.

From this point of view, the value of monitored waters framed the first three sections of River Cibin (sources and the lake) in the first class of quality, and the last three sections in the second class of quality.

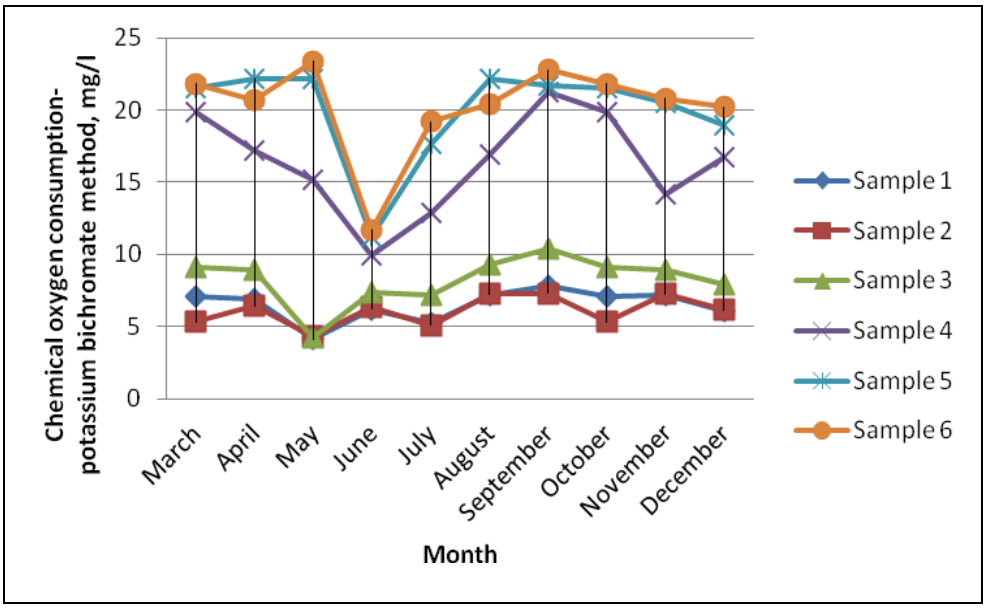

Figure 26: CCOCr values during 10 months in the monitored points of the Cibin River.

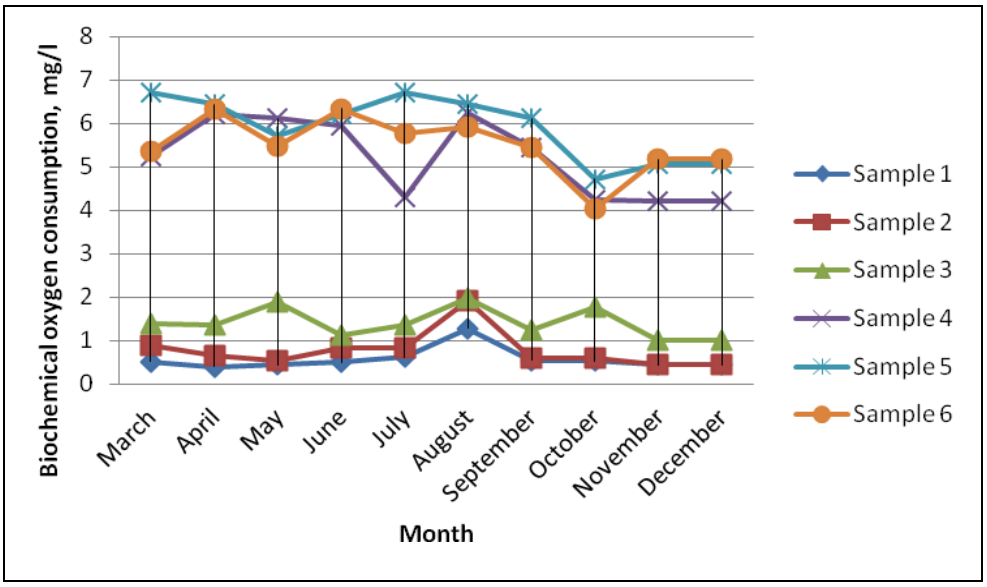

Figure 27: CBO_5 values during 10 months in the monitored points of the Cibin River.

In direct line with the biochemical oxygen consumption is the chemical oxygen expressed in CCOCr, which is basically the amount of oxygen supplied to the oxidizing chemical decomposition of organic matter in the water, which is not biodegradable. This leads to the framing of the Cibin River into the first class of quality.

Because only green plants and some bacteria can split oxygen from water for aquatic animal through photosynthesis and similar processes, it is important that this element should exist in high amounts in the river. Oxygen is essential for most aquatic life in natural surface waters and because of that, dissolved oxygen is the most important water quality parameter to indicate the health of a water body. (Delft, 2002)

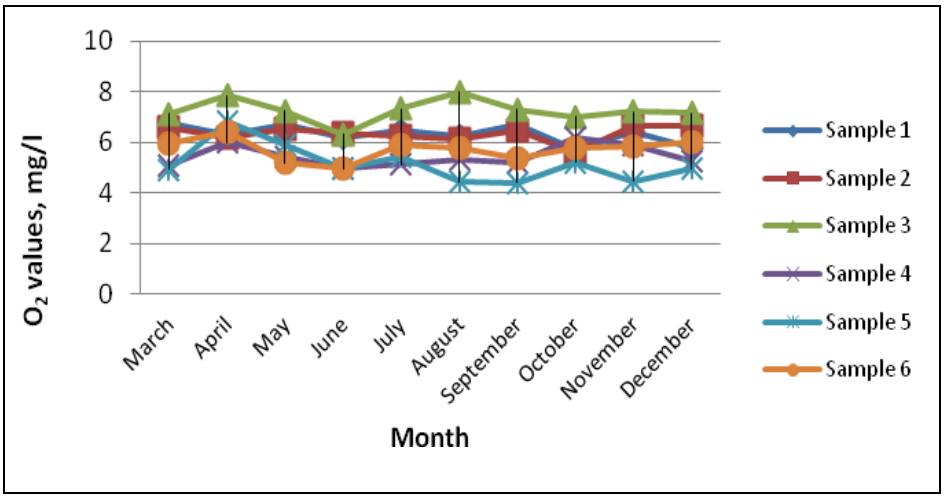

Figure 28: O_2 values during 10 months
in monitored points of the Cibin River.

The dissolved O_2 ranges in the first quality class accepted limits for Cibin River and oscillates between 4.4 mg/l and 8 mg/l. The most important quantities are found in the sources and dam reservoir decreasing with 30-40% to the Cibin River confluence area with Olt River.

CONCLUSIONS

After the study was made, it seems that Cibin River has physical-chemical and microbiological values which frame it in the first (sample points number 1, 2 and 3) and second water quality class (sample points 4, 5 and 6).

The river's sources, Râul Mare and Râul Mic lotic systems and Gura Râului Lake, are characterized by drinkable water specific parameters both in spring and autumn periods. Because there is a picnic place in the summer period, the human pollution increases especially the total coliform, nitrite, nitrate and suspensions. After the evaluation, all the elements above lead to an increase with 100% for the present values in spring and autumn.

The elements that define human settlements lead to significant increases of the phisical-chemical parameters like: nitrate, residues, CBO_5 and CCOCr that frames Cibin River in the second quality class in its lower sections.

The tributary streams contribution from the mountain zone lead to a dilution on the outfall in Olt River section and the result frame Cibin River on the first quality class.

Because of the existence of the wastewater treatment plant of Sibiu, with significantly improved new technology, running at optimal parameters, some water pollution parameters are decreasing substantially lately. It is noticed that there are significant differences between the parameters determined downstream the wastewater treatment plant and upstream of it.

By the fact that the principal source of drinkable water of Sibiu is the upstream dam reservoir from Gura Râului, there is a certainty that this water presents optimal characteristics for human consumption and is declared one of the healthiest water from Romania.

In order to reduce human contamination, the implementation of educational programs is recommended, so that the negative human impact on the natural sources of water to be minimal.

ACKNOWLEDGMENTS

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REFERENCES

1. Abida B. and Harikrishna M., 2008 – Study on the Quality of Water in Some Streams of Cauvery River, *E-Journal of Chemistry*, 5, 2, 377-384.
2. Ashbolt N. J., 2004 – Microbial contamination of drinking water and disease outcomes in developing regions, *Toxicology*, 198, 229-238.
3. Balzer M., Witt N., Flemming H. C., Abida B. and Harikrishna Wingender J., 2010 – Faecal indicator bacteria in bio films, *Water Science and Technology*, 61, 5, 1105-11.
4. Blanch A. R., Belanche-Muñoz L., Bonjoch X., Ebdon J., Gantzer C., Lucena F., Ottoson J., Kourtis C., Iversen A., Kühn I., Moce L., Muniesa M., Schwartzbrod J., Skraber S., Papageorgiou G., Taylor H. D., Wallis J. and Jofre J., 2004 – Tracking the origin of faecal pollution in surface water: an ongoing project within the European Union research programme, *Journal of Water Health*, 2, 249-260.
5. Boon P. J., Calow P. and Petts G. E., 1992 – Essential elements in the case for river conservation, *River Conservation and Management*, Chichester: John Wiley & Sons Ltd., 9-30.
6. Bucknell D. G., Gasser R. B., Irving A. and Whithear K., 1997 – Antimicrobial resistance in Salmonella and Escherichia coli isolated from horses, *Austrian Veterinary Journal*, 75, 355-356.
7. Carstenen J., 2007 – Statistical principles for ecological status classification of Water Framework Directive monitoring data, *Marine Pollution Bulletin*, 55, 3-15.
8. Cumming G. S., Cumming D. H. and Redman C. L., 2006 – Scale mismatches in social-ecological systems: causes, consequences and solutions, *Ecology and Society*, 11(1), 14.
9. Delft Hydraulics and DHV Consultants BV, 2002 – Oxygen balance in Surface Waters, *Hydrology Project Training Module*.
10. Donovan E., Unice K., Roberts J. D., Harris M. and Finley B., 2008 – Risk of gastrointestinal disease associated with exposure to pathogens in the water of the lower Passaic River, *Applied and Environmental Microbiology*, 74, 994-1003.
11. Edwards A. C. and Withers P. J. A., 2008 – Transport and delivery of suspended solids, nitrogen and phosphorus from various sources to freshwaters in the UK, *Journal of Hydrology*, 350, 144-153.
12. Environment Agency, 2006 – *Diffuse pollution and the Water Framework Directive*, December.
13. Eleria A. L., 2002 – Forecasting Fecal Coliform Bacteria in the Charles River Basin, Master's Thesis, Tufts University, Medford, Massachusetts, 5-38.
14. Folland C. K., Karl T. R. and Christy J. R., 2001 – Observed climate variability and change, in: Climatic Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the IPCC (eds Houghton J. T., Ding Y., Griggs D. J., Noguer M., van der Linden P. J., Dai X., Maskell K. and Johnson C. A.), 101-181, Cambridge University Press, Cambridge, UK (http://www.grida.no/climate/ipcc_tar/wg1/index.htm).
15. Gurzău A. E., Popovici E., Pintea A., Popa O., Pop C. and Dumitrașcu I., 2010 – Quality of surface water sources from a Central Transylvanian area as a possible problem for human security and public health, *Carpathian Journal of Earth and Environmental Sciences*, 5, 2, 119-126.
16. Heathwaite A. L., Quinn P. F. and Hewett C. J. M., 2005b – Modelling and managing critical source areas of diffuse pollution from agricultural land using flow connectivity simulation, *Journal of Hydrology*, 204, 446-461.
17. Kallis G. and Butler D., 2001 – The E. U. water framework directive: measures and implications, *Water Policy*, 3, 125-142
18. Kaur S. and Mehra P., 2011 – Status of water quality of River Yamuna at Nigambodh ghat-a major cremation ground in Delhi, India, *International Journal of Advances in Engineering*, 2, 183-187.

19. Kumar A. Y. and Reddy M. V., 2009 – Assessment of seasonal effects of municipal sewage pollution on the water quality of an urban canal - a case of Buckingham canal at Kalpakkam (India): NO^-_3, PO^{3-}_4, SO^{2-}_4, BOD, COD and DO, *Environmental Monitoring and Assessment*, 157, 1-4, 223-234.
20. Malmqvist B. and Rundle S., 2002 – Threats to the running water ecosystems of the world, *Environmental Conservation*, 29, 2, 134-153.
21. Medema G. J., Bahar M. and Schets F. M., 1997 – Survival of Cryptosporidium parvum, Escherichia coli, faecal enterococci and Clostridium perfrigens in river water: influence of temperature and autochthonous microorganisms, *Water Science and Technology*, 35, 11-12, 249-252.
22. Meyer J. L., Paul M. J. and Taulbee W. K., 2005 – Stream ecosystem function in urbanizing landscapes, *Journal of the North American Benthological Society*, 24, 3, 602-612.
23. Milanović A., Milijašević D. and Brankov J., 2011 – Assessment of polluting effects and surface water quality using water pollution index: case study of hydro-system Danube-Tisa-Danube, Serbia, *Carpathian Journal of Earth and Environmental Sciences*, 6, 2, 269-277.
24. Muyasar L. A. F. M., 2004 – Microbial Water Quality in Nablus District Thesis, Microbial Water Quality in Nablus District.
25. Osibanjo O., Daso A. P. and Gbadebo A. M., 2011 – The impact of industries on surface water quality of River Ona and River Alaro in Oluyole Industrial Estate, Ibadan, Nigeria, *African Journal of Biotechnology*, 10, 4, 696-702.
26. Parmesan C. and Yohe G., 2003 – A globally coherent fingerprint of climate change impacts across natural systems, *Nature*, 421, 37-42.
27. Patoli A. A., Patoli B. B. and Mehraj V., 2010 – High prelevance of multi-drug resistant Escherichia coli in drinking water samples from Hyderabad, *Gomal Journal of Medical Sciences*, 8, 1, 23-26.
28. Peters D. P. C., Groffman P. M., Nadelhoffer N. B., Collins S. L., Michener W. K. and Huston M. A., 2008 – Living in an increasingly connected world: a framework for continental scale environmental science, *Frontiers in Ecology and the Environment*, 6, 229-237.
29. Petersen T. M., Rifai H. S., Suarez M. P. and Stein A. R., 2005 – Bacterial loads from point and nonpoint sources in an urban watershed, *Journal of Environmental Engineering*, 131, 10, 1414.
30. Peterson D. H., Smith R. E., Hager S. W., Harmon D. D., Herndon R. E. and Schemel L. E., 1985 – Interannual variability in dissolved inorganic nutrients in northern San Francisco Bay estuary, *Hydrobiologia*, 129, 37-58.
31. Pickett S. T. A., Cadenasso M. L., Grove J. M., Nilon C. H., Pouyat R. V., Zipperer W. C. and Costanza R., 2001 – Urban ecological systems: linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas, *Annual Revue of Ecology and Systematics*, 32, 127-57.
32. Pietilainen O. P. and Niinioja R., 2001 – Nitrogen and phosphorus as algal growth limiting factors in a boreal lake, *International Association of Theoretical and Limnology*, 27, 2944-2947.
33. Podgornik M. and Pintar M., 2007 – Causes of nitrate leaching from agriculture land in Slovenia, *Acta Agriculturae Slovenica*, 89, 207-220.
34. Rajkumar S., Velmurugan P., Shanthi K., Ayasamy P. M. and Lakshmanaperumalasamy P., 2004 – Water Quality of Kodaikanal lake, Tamilnadu in Relation to Physico-Chemical and Bacteriological Characteristics, Capital Publishing Company, 339-346.
35. Rasmussen P. P. and Ziegler A. C., 2003 – Comparison and Continuous Estimates of Fecal Coliform and Escherichia Coli Bacteria in Selected Kansas Streams, May 1999 Through April 2002 - US Geological Survey Water Resources Investigations Report OS4056, Lawrence, Kansas, 80.

36. Robert J. D. and Rutger R., 2008 – Spreading Dead Zones and Consequences for Marine Ecosystems, *Science*, 321, 5891, 926-929.
37. Rose S. and Peters N. E., 2001 – Effects of urbanization on streamflow in the Atlanta area (Georgia, USA): a comparative hydrological approach, *Hydrological Processes*, 15, 1441-57.
38. Sandu M., 1998 – Culoarul Depresionar Sibiu-Apold, Studiu geomorphologic, Editura Academiei Bucureşti, 176.
39. Sandu C., Bloesch J. and Coman A., 2008 – Water pollution in the Mureş catchment and its impact on the aquatic communities (Romania), *Transylvanian Review of Systematical and Ecological Research, The Wetlands Diversity*, Curtean-Bănăduc et al., (eds) 6, 97-108.
40. Sangodoyin A. Y., 1991 – Groundwater and Surface Water Pollution by Open Refuse Dump in Ibadan, Nigeria, *Journal of Discovery and Innovations*, 3, 1, 24-31.
41. Sanja M. S., Dragana S. D. and Dragan D. M., 2009 – Trace elements as tracers of environmental pollution in the canal sediments (alluvial formation of the Danube River, Serbia), *Environmental Monitoring and Assessment*, cited references, 167, 219-233.
42. Schriewer A., Miller W. A., Byrne B. A., Miller M. A., Oates S., Hardin D., Yang H. H,. Melli A., Jessup D., Dominik C. and Wuertz S., 2010 – Presence of Bacteroidales as a predictor of pathogens in surface waters of the Central California Coast, *Applied and Environmental Microbiology*, 76, 17, 5802-14.
43. Shrikanta N., 2005 – Studies on pollution status of Bondamunda area of Rourkela industrial complex, Department of Chemistry, National Institute of Technology, Rourkela - 769008 (Orissa).
44. Steyaert P. and Ollivier G., 2007 – How ecological assumptions frame technical and social change, *Ecology and Society*, 12, 1-18.
45. US Environmental Protection Agency (EPA), 2001b – Controlling Disinfection byproducts and Microbial Contaminants in Drinking Water, EPA.
46. Venkatesharaju K., Ravikumar P., Somashekar R. K. and Prakash K. L., 2010 – Physico-chemical and bacteriological investigation on the river stretch in Karn, *Kathmandu University Journal of Science, Engineering and Technology*, 6, 1, 50-59.
47. World Health Organization (WHO), 1997 – Guidelines for drinking water quality: Surveillance and control of community supply, Geneva, 2, 2.
48. WHO and UNICEF, 2004 – Meeting the Millennium Development Goals (MDG) Drinking Water and Sanitation target - A mid-term Assessment of Progress, WHO/UNICEF, Geneva, 1-47.

EFFECTS OF THE INVASIVE CTENOPHORE SPECIES, *MNEMIOPSIS LEIDYI*, ON THE CASPIAN SEA

*Zahra KHOSHNOOD *, Reza KHOSHNOOD *** and *Mehdi GHOBEITIHASAB **

* Islamic Azad University, Department of Experimental Sciences, Dezful Branch, Dezful, Iran, Zkhoshnood@gmail.com, Ghobeiti@yahoo.com

** Islamic Azad University, Department of Experimental Sciences, Dezful Branch, Tehran, Iran, Rezakhoshnood@gmail.com

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KEYWORDS: invasive species, Caspian Sea, *Mnemiopsis leidyi*.

ABSTRACT

Human interventions on the Earth's natural systems are evident even in remote regions of the Antarctic and rain forests deep within the Amazon. In addition to human-induced climate change and habitat destruction, an emerging anthropogenic threat to biodiversity is the drastic species re-distribution (the movement of species from one place to another due to human intervention) at a global scale.

This creates fertile conditions for biological invasions which in turn cause substantial economic and ecological losses. These human-mediated invasions, often referred to as "biological pollution", are a worldwide problem that is increasing in frequency and magnitude, causing significant damage to the environment, economy and human health. Bioinvasions have strong impact on biodiversity and ecosystem functioning and stability. They are ranked as the second most important threat to biodiversity (after habitat destruction) by the World Conservation Union.

The Ctenophore, *Mnemiopsis leidyi*, is one of the invasive species that naturally lives in the Atlantic coastal waters of North America and South America, but discovered in Azov, Black, Caspian, North, Baltic and Mediterranean (north-eastern part) seas in early 1980s.

It seems that the main factor of its redistribution was the ballast waters of ships. As an alien species, *Mnemiopsis leidyi* caused many alterations in the Caspian Sea ecosystems. The fact that it feeds on the eggs of native fish *Clopeonella* spp., has resulted in a significant decline of its population; *Clopeonella* spp. were the main source of industrial fishing in the Caspian Sea and also the main source of food for precious fish species, the sturgeons, and therefore, their decline has caused a huge economical loss for the area's inhabitants and a significant decline of sturgeon populations.

This species has caused massive ecosystem changes and substantial economic losses in the late 1980s-1990s, and it has been recognized as a problem of main ecological concern for the sustainable development of the region, together with the high level of anthropogenic pressures on the Caspian Sea ecosystems. Some special characteristics of this species, such as adaptation to a wide range of salinity and temperature, high capability of reproduction, hermaphroditism and dissogeny, have led to huge increases of its mass, especially in southern regions of the Caspian Sea, the coastal waters of Iran. In addition, it has become clear that this species does not have any natural predators in the Caspian Sea, and also that it can feed on any organisms smaller than itself in size. Owing to these facts, it is a huge ecological threat for the Caspian Sea ecosystems. The aim of the present paper is to review the biological and ecological impacts of this invasive species on the Caspian Sea ecosystems.

ZUSAMMENFASSUNG: Die Auswirkungen der invasiven Ctenophoren-Art *Mnemiopsis leidyi* im Kaspischen Meer.

Die menschlichen Eingriffe in die natürlichen Ökosysteme der Erde sind unübersehbar sogar auch in den isolierten Gegenden der Antarktis und den Dickichten der tropischen Regenwälder des Amazonas. Zusätzlich zu den vom Menschen bedingten Klimaveränderungen und der Zerstörung der Lebensräume stellt eine drastische Umverteilung der Arten auf globaler Ebene, d.h. eine ebenfalls durch den Menschen bedingte Wanderung und Ausbreitung der Arten aus einem Gebiet in ein anderes, eine zunehmende Bedrohung für die Biodiversität dar.

Diese Tatsache schafft günstige Bedingungen für biologische Invasionen, die ihrerseits erhebliche wirtschaftliche und ökologische Verluste zur Folge haben. Die vom Menschen verursachten Invasionen, die oft als "biologische Verschmutzung" bezeichnet werden, stellen ein weltweites Problem dar, das an Häufigkeit und Ausmaß zunimmt und wesentliche Gefahren für Umwelt, Wirtschaft und menschliche Gesundheit in sich birgt. Bioinvasionen haben eine starke Auswirkung auf die Biodiversität, auf die Funktionsfähigkeit und Stabilität der Ökosysteme und werden von der Weltnaturschutzunion IUCN nach der Habitatzerstörung als die zweitgrößte Gefahr für die Biodiversität angesehen.

Die Ctenophoren/Rippenquallen-Art *Mnemiopsis leidyi* ist eine der invasiven Arten, die ihre natürlichen Lebensräume in den nord- und südamerikanischen Küstengewässern des Atlantischen Ozeans haben, jedoch in den frühen 1980-er Jahren im Asof'schen, Schwarzen und Kaspischen Meer, der Nord- und Ostsee sowie im nordöstlichen Teil des Mittelmeeres entdeckt wurden.

Der Hauptfaktor für ihre Neuverteilung scheint das Ballastwasser von Schiffen gewesen zu sein. Als fremde Art hat *Mnemiopsis leidyi* viele Veränderungen im Ökosystem des Kaspischen Meeres verursacht. Die Tatsache, dass sich die Art von Eiern der einheimischen Fische *Clopeonella* spp. ernährt, hat zu einem erheblichen Niedergang deren Populationen geführt. *Clopeonella* Arten waren die Hauptquelle für industrielles Fischen im Kaspischen Meer sowie auch die Hauptnahrungsquelle für wertvolle Arten wie Störe. Daher hat ihr Rückgang zu einem gewaltigen wirtschaftlichen Verlust für die einheimische Bevölkerung und einem signifikanten Niedergang der Stör-Populationen geführt.

Mnemiopsis leidyi hat in den späten 1980-er und 1990-er Jahren massive Ökosystemveränderungen und beachtliche wirtschaftliche Verluste verursacht und wurde als ein ökologisches Hauptproblem für die nachhaltige Entwicklung der Region erkannt, so wie auch der hohe anthropogene Druck auf das Ökosystem des Kaspischen Meeres. Einige spezifische Kennzeichen der Art, wie die Anpassung an eine weite Spanne des Salzgehaltes und der Temperatur, eine hohe Reproduktionsfähigkeit, Hermaphroditismus und Dissogenie, haben zu einer gewaltigen Entwicklung ihrer Biomasse geführt, besonders in den südlichen Gebieten des Kaspischen Meeres, den Küstengewässern des Iran. Zusätzlich wurde die Erkenntnis gewonnen, dass die Art im Kaspischen Meer keine natürlichen Feinde hat und dass sie sich von beliebigen Organismen ernähren kann, die kleiner sind als sie selbst. In Anbetracht dieser Tatsachen stellt sie eine gewaltige Gefahr für das Ökosystem des Kaspischen Meeres dar. Ziel der vorliegenden Arbeit ist es, die biologischen und ökologischen Auswirkungen dieser invasiven Rippenqualle auf das Ökosystem des Kaspischen Meeres zu überprüfen und zu bewerten.

REZUMAT: Efectele ctenoforei invazive, specia *Mnemiopsis leidyi* în Marea Caspică.

Intervenţiile umane asupra sistemelor naturale ale Pământului sunt evidente chiar şi în regiunile izolate ale Antarticii şi în profunzimea pădurilor tropicale ale Amazonului. Pe lângă schimbările climatice şi distrugerea habitatelor induse de om, o ameninţare antropogenă iminentă asupra biodiversităţii este redistribuirea drastică a speciilor (migraţia speciilor dintr-un loc în altul datorită intervenţiilor umane) la scară globală. Acest fapt generează condiţii propice pentru invaziile biologice care pot cauza pierderi ecologice şi economice substanţiale. Aceste invazii mijlocite de oameni se referă adesea la „poluarea biologică" şi sunt o problemă la scară globală. Această problemă creşte de la o zi la alta în frecvenţă şi magnitudine generând impact negativ semnificativ asupra mediului, economiei şi sănătăţii umane. Bioinvaziile au impact puternic asupra biodiversităţii, funcţiilor şi stabilităţii ecosistemelor. Sunt clasate de către Uniunea Internaţională pentru Conservare ca fiind după degradarea habitatelor a doua categorie de importanţă în ceea ce priveşte ameninţarea asupra biodiversităţii. Specia *Mnemiopsis leidyi*, aparţinând încrengăturii Ctenophora, este una dintre speciile invazive care populează în mod natural apele de coastă ale Atlanticului în America de Nord şi de Sud dar a fost descoperită şi în mările: Azov, Neagră, Caspică, Nordului, Baltică şi Mediterană (partea de nord-est) la începutul anilor 1980. Se pare că principalul factor care a contribuit la răspândirea acestei specii au fost transporturile navale. Ca specie alohtonă, *Mnemiopsis leidyi* a cauzat multe modificări negative în ecosistemele Mării Caspice. Faptul că se hrăneşte cu ouăle speciei autohtone *Clopeonella* sp. a determinat un regres numeric semnificativ al populaţiilor acesteia. *Clopeonella* a fost principala sursă a pescuitului industrial din Marea Caspică şi de asemenea principala sursă trofică pentru specii valoroase de peşti, precum sturionii. De aceea declinul lor a generat pierderi economice majore pentru locuitorii zonei şi un declin considerabil al populaţiilor de sturioni.

Această specie a cauzat schimbări masive ale ecosistemelor şi pierderi economice substanţiale între anii 1980-1990 şi a fost percepută ca o problemă prioritară de natură ecologică pentru dezvoltarea sustenabilă a regiunii împreună cu gradul mare al presiunilor antropice asupra ecosistemelor Mării Caspice. Caracteristicile speciei precum adaptarea la variaţiile mari ale salinităţii şi temperaturii, capacitatea sporită de reproducere, hermafroditismul şi disogenia au dus la răspândirea în masă a speciei mai ales în regiunea sudică a Mării Caspice, în apele de coastă ale Iranului. De asemenea a devenit clar faptul că această specie nu are prădători naturali în Marea Caspică şi se poate hrăni cu orice organism mai mic decât ea. Din această cauză, reprezintă o ameninţare ecologică de proporţii asupra ecosistemelor Mării Caspice. Scopul lucrării de faţă este evaluarea impactului ecologic şi biologic al acestei specii invazive asupra ecosistemelor Mării Caspice.

INTRODUCTION

Human interventions on the Earth's natural systems are evident even in remote regions of the Antarctic and rain forests deep within the Amazon. In addition to human-induced climate change and habitat destruction, an emerging anthropogenic threat to biodiversity is the drastic species re-distribution (the movement of species from one place to another due to human intervention) at a global scale.

In the aquatic systems, non-indigenous species, are occurring at an alarming rate and are causing global concern (Mack et al., 2000; Occhipinti-Ambrogi and Savini, 2003; Reusser and Lee, 2008). Yet, the consequences or ecological impacts of non-indigenous species are not always well understood, especially regarding the plankton organisms (Parker et al., 1999).

Typically, it is only when the non-indigenous species are widespread that it will cause some sort of ecological or economic harms, and thus earn the name invasive. However, there are several complicated stages along the path to becoming a successful invader. Several life cycles (i.e. quantitative shifts at the individual level) and life history (i.e. quantitative fluctuations at the population level) adaptations enable the invasive species to pass between each of the invasion stages and overcome several ecological barriers (Boero et al., 2008).

Over the last decades some cases of invasions of gelatinous plankters (medusae and/or Ctenophores) have been documented (Greve, 1994; Shiganova et al., 2001 a; Shiganova et al., 2001b; Zhilyakova et al., 2004; Purcell, 2005; Xian et al., 2005; Kawahara et al., 2006; Link and Ford, 2006). The impact of gelatinous plankton predation on marine biota became too obvious to be neglected when *Mnemiopsis leidyi*, an Atlantic ctenophore, was brought in the Caspian Sea, presumably by the ballast waters of oil tankers, and developed huge populations. Its massive occurrence was held responsible for the collapse of industrial fishing in this basin, impairing fish recruitment via predation on fish larvae and on their food as like as the other affected areas such as the Azov, Black, North, Baltic and Mediterranean (north-eastern part) seas (Belyaev and Solov'eva, 1995; Avsar, 1997; Berdnikov et al., 1999; Brodeur et al., 2002).

The Caspian Sea is the biggest enclosed water located between Iran, Azerbayjan, Russia, Kazakhstan and Turkmenistan, with a maximum length of 1,024 km and a maximum width of the 566 km and with a mean depth of 184 m. The low biodiversity, low salinity and being enclosed with high input of pollutants, made this environment, an endangered area.

The aim of the present paper is to review the biological and ecological impacts of this invasive species on the Caspian Sea.

MATERIALS AND METHODS

The ctenophores were sampled in the ports, coastal and offshore areas of the Iranian coastal waters of the Caspian Sea between April 2012 and March 2013 (Fig. 1).

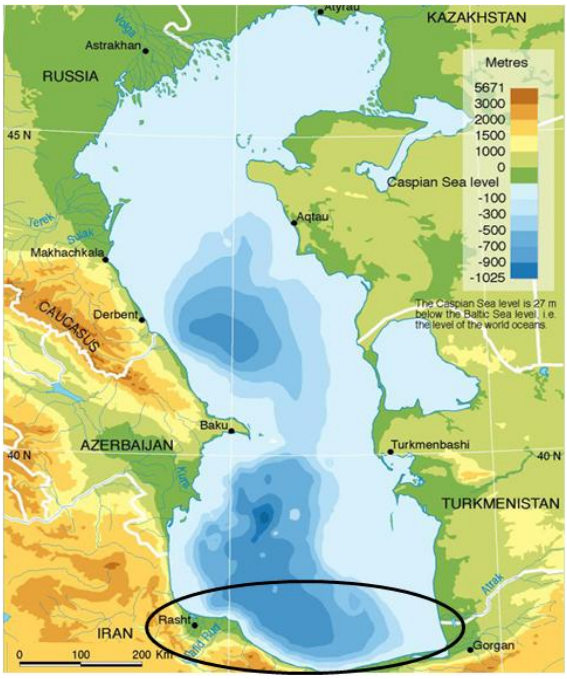

Figure 1: Sampling area; Iranian coastal waters of the Caspian Sea, showed by the circle.

Samples were collected by using the zooplankton net (1 m diameter, 500 µm mesh size, fitted with a flow meter) and Nansen bottles.

Samples of the Ctenophores were immediately transferred to the laboratory after their collection and the observations were performed on living specimens.

Anatomical features of the Ctenophore samples were performed by using the light microscopy and stereomicroscopy.

RESULTS AND DISCUSSION

Morphological Features

Results of the microscopically studies of the *Mnemiopsis leidyi* showed that the ctenophore has a flattened ovoid body and the larger diameter of the ovoid is twice bigger than the smaller diameter. The body has two large lobes. The diameter of the specimens was 1.5-5 cm, and eight rows of cilia covered the body, these cilia rows were started at the ending part of the digestive system (anal part) to the oral portion of the body. Among these eight rows of cilia, four of them are longer and have more cilia and are located at the narrower parts of the body (Fig. 2).

Each row of the cilia has 240-450 cilia and at the end of them there were tentacles. The rows of cilia have bioluminescence. The digestive system is simple without any lateral canals and was composed of the mouth, pharynx and the stomach. The stomach contents of the specimens were mainly composed of zooplanktons (mainly *Acartia* sp. and *Calanodia* sp.), other species of copepods, larvae of the molluscs, larvae of the crustaceans, microbenthos and fish eggs. Results showed that 85% of the specimens have full or semi full stomach.

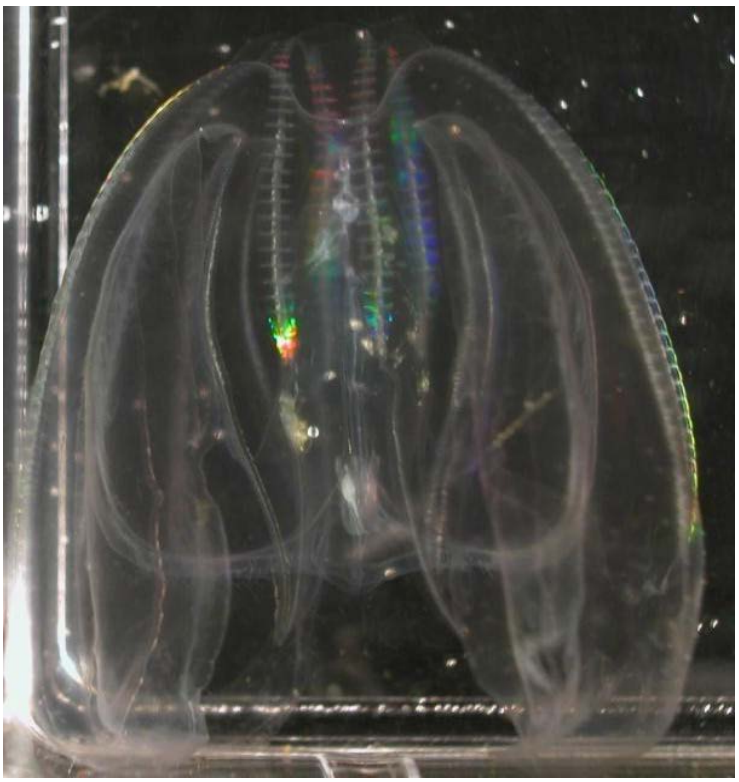

Figure 2: *Mnemiopsis leidyi* sampled from Caspian Sea.

Dispersion and abundance

Our results showed that in different depths (5, 10 and 20 m) of the Iranian coastal waters of Caspian Sea, the abundance of *Mnemiopsis leidyi* ranged between 425 g to 4,563 g. Data also showed that from the first occurrence of the *Mnemiopsis leidyi* in the Caspian Sea, in 2000 until the next couple of the years, the abundance of *Mnemiopsis leidyi* has increased.

Effects of *Mnemiopsis leidyi* on industrial fisheries

Ecological adaptations, food availability, higher water temperature and absence of major predators for the *Mnemiopsis leidyi* in the Caspian Sea ecosystem, were the most important reasons of the increases and dispersion of this invasive species in the southern parts of the Caspian Sea. Feeding on eggs and larvae of the *Clopeonella* spp. and being also in an intense feeding competition with these species were the most important reasons of significant decline in *Clopeonella* spp. community. Data records of the fish catching during 1989-1998 showed that the amounts of industrial fish catching (mainly *Clopeonella* spp.) increased from 7,902 t to 85,000 t, but after the increasing of the number of the *Mnemiopsis leidyi* in the next years, the industrial fish catching had a descending process until the complete shutdown of the industrial catching of the *Clopeonella* spp. Took place in 2001. The decline of the *Clopeonella* spp. population also has a negative effect on the population of the precious fish species, the sturgeons, because *Clopeonella* spp. was the main source of food for these species.

Effects of the *Mnemiopsis leidyi* on Caspian Sea

It is clear that *Mnemiopsis leidyi* has a significant effect on the zooplankton populations and the food webs. Its effects on the decline of the *Clopeonella* spp. and sturgeons was described previously, but the other ecological aspects that were affected by the invasion of the *Mnemiopsis leidyi* in the Caspian Sea were as follows:

- significant decline in planktonic population especially the zooplankton;
- significant decline of the Caspian Sea seal population, *Phoca caspica*;
- changes in the food web;
- chemical changes of the environment due to the decomposition of the dead ctenophores;
- decreasing and changing of the biodiversity.

Fighting strategies against the *Mnemiopsis leidyi*

In general, removing the invasive species from the new environment can be performed by different fighting strategies or combination of the different methods. These methods divided into different categories, like physical or mechanical, chemical, genetic methods, physiological methods and biological methods. Every one of these methods has different benefits and limitations, for example, physical or mechanical methods practically are impossible for the huge size environments like the Caspian Sea. Also genetic and physiological methods need expended investigations and financial resources. It seems that the biological fighting has fewer limitations except for the risk of the fact that the introduced species for elimination of the invasive species may become the new invasive species itself. For using of a predator species for the elimination of the *Mnemiopsis leidyi* from the Caspian Sea environment, this species must have these properties:

- high capacity of adaptation to the Caspian Sea environment;
- high capacity of breeding;
- high capacity of feeding on the ctenophore;
- being not a competitor for the endemic species;
- as far as possible with economic value.

In recent years one of the ctenophores of the Beroidae family accidentally (probably by the water currents) has entered in the Black Sea. This species, *Beroe ovata* (Fig. 3), has a great apetite for the *Mnemiopsis leidyi* and its breeding capacity is higher than the *Mnemiopsis leidyi*. Investigations in the Black Sea showed that it has a significant effect on the decline of the *Mnemiopsis leidyi*'s population. Unfortunately, one of the limiting factors for using *Beroe ovata* as the predator of the *Mnemiopsis leidyi* in the Caspian Sea is the different salinity in different parts of the Caspian Sea (i.e. higher salinity in southern and eastern parts and lower salinities mainly in northern parts), because it is cleared that *Beroe ovata* was basically adapted to lower salinities of less than the 10 ppt, while the southern parts of the Caspian Sea has a salinity of 13-14 ppt. Up to now no presence of *Beroe ovata* is reported in the Caspian Sea.

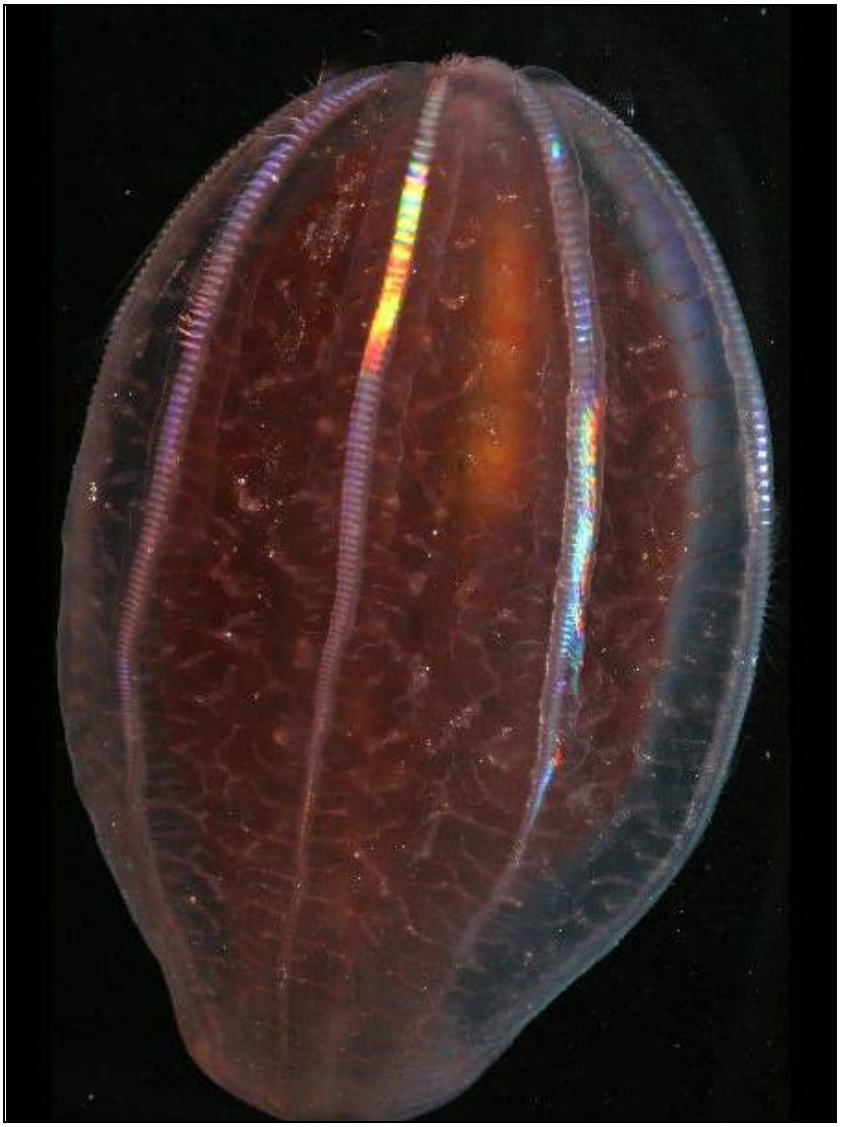

Figure 3: *Beroe ovata*, natural predator of the *Mnemiopsis leidyi*.

CONCLUSIONS

Invasion of the ctenophore species in the Caspian Sea resulted in ecological and economical damages. This invasive ctenophore, *Mnemiopsis leidyi*, known as the main factor of significant decline of the economically and ecologically important fish species, *Clopeonella* spp., also caused significant alterations in the Caspian seafood webs. Previous experience of the invasion of this species in the Black Sea showed that lack of the attention to the monitoring of the environment and establishment of new organisms as a result of transportation between different sea environments could result in the destruction of some ecosystems.

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REFERENCES

1. Avsar D., 1997 – Possible reasons for the abundance of Black Sea sprat (Sprattus sprattus phalericus Risso, 1826) in relation to anchovy (Engraulis encrasicolus L., 1758) and a lobate ctenophora (Mnemiopsis leidyi Agassiz, 1865), *Cercetări Marine*, 29-30, 275-285.
2. Belyaev V. I. and Solov'eva N. V., 1995 – Modelling of the Black Sea ecosystem components with the comb *jelly Mnemiopsis leidyi*, *Dopovidi Akademii Nauk Ukrainskoi*, 1, 85-87.
3. Berdnikov S. V., Selyutin V. V., Vasilchenko V. V. and Caddy J. F., 1999 – Trophodynamic model of the Black and Azov Sea pelagic ecosystem: consequences of the comb jelly, Mnemiopsis leidyi, invasion, *Fisheries Research*, 42(3), 261-289.
4. Boero F., Bouillon J., Gravili C., Miglietta M. P., Parsons T. and Piraino S., 2008 – Gelatinous plankton: irregularities rule world (sometimes), *Marine Ecology-Progress Series*, 356, 299-310.
5. Brodeur R. D., Sugisaki H. and Hunt G. L., 2002 – Increases in jellyfish biomass in the Bering Sea: implications for the ecosystem, *Marine Ecology - Progress Series*, 233, 89-103.
6. Greve W., 1994 – The 1989 German Bight invasion of Muggiaea atlantica, *Ices Journal of Marine Science*, 51, 355-358.
7. Kawahara M., Uye S., Ohtsu K. and Izumi H., 2006 – Unusual population explosion of the giant jellyfish Nemopilemia nomurai (Scyphozoa: Rhizostomeae) in East Asian waters, *Marine Ecology-Progress Series*, 307, 161-173.
8. Link J. S. and Ford M. D., 2006 – Widespread and persistent increase of Ctenophora in the continental shelf ecosystem of NE USA, *Marine Ecology - Progress Series*, 320, 153-159.
9. Mack R. N., Simberloff D., Lonsdale W. M., Evans H., Clout M. and Bazzaz F. A., 2000 – *Biotic invasions, Ecological Applications*, 10, 689-710.
10. Occhipinti-Ambrogi A. and Savini D., 2003 – Biological invasions as a component of global change in stressed marine ecosystems, *Marine Pollution Bulletin*, 46, 542-551.
11. Parker I. M., Simberloff D., Lonsdale W. M., Goodell K., Wonham M., Kareiva P. M., Williamson M. H., Von Holle B., Moyle P. B., Byers J. E. and Goldwasser L., 1999 – Impact Toward a Framework for Understanding the Ecological Effects of Invaders, *Biological Invasions*, 1, 3-19.
12. Purcell J. E., Uye S. I. and Lo W. T., 2007 – Anthropogenic causes of jellyfish blooms and their direct consequences for humans: a review, *Marine Ecology - Progress Series*, 350, 153-174.
13. Reusser D. A. and Lee H., 2008 – Predictions for an invaded world: a strategy to predict the distribution of native and non-indigenous species, *ICES Journal of Marine Science*, 65, 742-745.
14. Shiganova T. A., Bulgakova Y. V., Volovik S. P., Mirzoyan Z. A. and Dudkin S. I., 2001a – The new invader Beroe ovata Mayer 1912 and its effect on the ecosystem in the northeastern Black Sea, *Hydrobiologia*, 451, 187-197.
15. Shiganova T. A., Mirzoyan Z. A., Studenikina E. A., Volovik S. P., Siokou-Frangou I., Zervoudaki S., Christou E. D., Skirta A. Y. and Dumont H. J., 2001b – Population development of the invader ctenophore *Mnemiopsis leidyi* in the Black Sea and other seas of the Mediterranean basin, *Marine Biology*, 139, 431-445.

THE SURVEY OF SEA CUCUMBER FISHERIES ON QESHM ISLAND COASTS (PERSIAN GULF)

*Majid AFKHAMI *, Maryam EHSANPOUR **, Amin MOKHLECI **** and *Kazem DARVISH BASTAMI **

* Islamic Azad University Central Tehran Branch, Yung Researchers Club, Tehran, Iran P. B. 15655/461, m_afkhami82@yahoo.com, aida.khazaali@yahoo.com, darvish_60@yahoo.com
** Islamic Azad University Central Tehran Branch, Young Researchers Club, Tehran, Iran, P. O. Box 15655/461, mehsanpour@yahoo.com
*** Islamic Azad University, Central Tehran Branch, Young Researchers Club, Tehran, Iran, P. O. Box 13185-768, aminmokhleci@gmail.com

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KEYWORDS: sea cucumber, *Holothuria scabra*, fishing status, Qeshm Island, Persian Gulf.

ABSTRACT

Sea cucumbers are aquatic animals of wide variety, useful for human health. Sea cucumbers are among the aquatic creatures that have many important and useful properties known for human health. Increasing demand for beche-de-mer, along with steady price increases, has led to worldwide intensification of sea cucumber harvesting. The rearing of sea cucumbers with shrimps controls environmental pollution that results from over- enrichment in nutrients, built up on the pond bottom.

These animals eat detritus and, together with devouring organic materials on the surface, not only do they clean the environment, but also they cause the fast growth of shrimps and themselves. *Holothuria scabra* is the main species for production of beche-de-mer and is exploited especially in the tropical regions of the world. The wall of the body used in the process of beche-de-mer production forms 56% of the whole body. *Holothuria scabra* (sandfish) is an aspidochirote holothurian widely distributed in coastal regions throughout the Indo-Pacific region. *H. scabra* is often found on inner reef flats and near estuaries, half-buried in silty sand during the day and emerging at night to feed.

In this study, based on information from local fishermen on Qeshm Island, we provide some data about the fishing methods, processing and distribution on the Qeshm Island coastline. Comparative study of fishing status with another part of the world determined that the status of sea cucumber stocks in Qeshm Island is sustainable. For prevention of over-exploitation of the sandy sea cucumber, prohibition on capturing should continue.

In this study, seven exploited sites are recognized, the target size for fishermen was more than 20 cm and sandy cucumber was the target species in Qeshm Island. In this area, the fishing operation was only carried out by scuba diving and was done only by men; although in another countries women have an important role in sea cucumber fishing activities. Among the coasts around Qeshm Island, it is found at Hmoon, Tolla, Kovei, Ramchah, Messen and Hengam. A maximum length of 35 cm and maximum weight of 1,080 g was recorded.

RÉSUMÉ: L'étude de la pêche de concombres de mer sur les côtes de l'île de Qeshm (Golfe Persique).

Les concombres de mer sont des animaux aquatiques ayant une large utilisation dans la médicine naturaliste, avec les plus nombreuses et utiles applications comparé aux autres organismes aquatiques. La demande croissante pour la bêche de mer ainsi que l'augmentation constante des prix ont mené à une recrudescence au niveau global de la récolte des holothuries comestibles. Leur élevage avec des crevettes permet le maintien de la pollution de l'eau suite à la formation des dépôts benthiques riches en nutriments à des niveaux acceptables.

Ces animaux consomment des détritus et d'autres substances organiques déposées sur différentes surfaces, nettoyant ainsi le milieu et permettant une prise de poids plus rapide des crevettes. *Holothuria scabra* est la principale espèce de bêche de mer et également la plus exploitée dans les régions tropicales. La partie de la bêche de mer utilisée est obtenue à partir de la paroi de la cavité corporelle de ces animaux et représente jusqu'à 56% de la masse corporelle d'un individu. *Holothuria scabra* (sandfish) est une holothurie aspidochirote largement répandue dans les zones côtières de la région Indopacifique. *Holothuria scabra* vit notamment sur les fonds plats à l'intérieur des récifs ainsi qu'à la proximité des estuaires, partiellement enterrée dans la vase durant la journée et sortant pour se nourrir durant la nuit.

À la suite de l'étude effectuée à partir des informations obtenues des pêcheurs de l'île de Qeshm, nous présentons ici des données concernant les méthodes de pêche, préparation et distribution dans la zone côtière de l'île de Qeshm. L'étude compare le statut de ces animaux sur l'île de Qeshm avec les stocks disponibles dans d'autres régions du monde. L'interdiction de la cueillette est recommandée afin de prévenir la surpêche de cette espèce.

Dans cette étude sont répertoriées sept sites d'exploitation comportant pour chacun d'entre eux les données des pêcheurs de la côte de l'île de Qeshm capturant des animaux appartenant à l'espèce *Holothuria scabra* et ayant plus de 20 cm de long. Dans cette région, la pêche est pratiquée uniquement par les hommes, munies d'équipement de plongée. Néanmoins, il y a des pays où cette activité est pratiquée surtout par des femmes. Sur les côtes de l'île de Qeshm, *Holothuria scabra* est exploitée à Hmoon, Tolla, Kovei, Ramchah, Messen et Hengam. Le plus grand individu enregistré mesurait 35 cm de longueur pour une masse de 1.080 g.

REZUMAT: Studiul pescăriilor de castraveți de mare de pe coastele insulei Qeshm (Golful Persic).

Castraveții de mare sunt animale acvatice cu o largă utilizare în medicina naturistă, având cele mai numeroase și utile aplicaţii dintre organismele acvatice. Creșterea din ce în ce mai mare a cererii pentru trepang precum și creșterea constantă a prețurilor au dus la o recrudescență la nivel mondial a recoltării castraveţilor de mare comestibili. Creșterea în regim de acvacultură a acestora împreună cu creveții permite menținerea sub control a poluării mediului cauzată de depunerea detritusului foarte bogat în nutrienți.

Aceste animale consumă detritus și alte substanțe organice depuse pe diferite suprafețe submerse, curățând astfel mediul și ducând la o creștere mai accelerată atât proprie cât și a speciilor asociate în cultură. *Holothuria scabra* este principala specie de trepang și cea mai exploatată în regiunile tropicale ale lumii. Trepangul este peretele musculos al cavității corporale a holoturiilor comestibile și ajunge la aproximativ 56% din masa corporală a acestora. *Holothuria scabra* este o holoturie din ordinul Aspidochirota răspândită pe scară largă în zonele costiere ale regiunii Indo-Pacifice. *Holothuria scabra* se găsește cel mai adesea pe platourile nisipoase intrarecifale și în apropierea estuarelor, parțial îngropată în mâl pe timpul zilei și hrănindu-se activ pe timpul nopții.

În urma studiului efectuat pe baza informațiilor obținute de la pescarii de pe Insula Qeshm, furnizăm aici date cu privire la metodele de pescuit, procesare și distribuție în zona costieră a insulei Qeshm. Se impune studiul comparativ al statutului piscicol al acestor animale în insula Qeshm cu cel al stocurilor existente în alte părți ale lumii. Prohibiția recoltării acestei specii este recomandabilă pentru a preveni supraexploatarea speciei.

În acest studiu, sunt recunoscute şapte situri de exploatare, pescarii recoltând animale din specia *Holothuria scabra* de minim 20 cm lungime în apele de coastă ale insulei Qeshm. În această zonă pescuitul se practică numai cu echipament de scufundare cu tuburi de oxigen și practicanții sunt exclusiv bărbați. Cu toate acestea, există țări unde femeile sunt cele ce se îndeletnicesc preponderent cu această ocupație. Specia este exploatată în apele de coastă ale insulei Qeshm în Hmoon, Tolla, Kovei, Ramchah, Messen și Hengam. Lungimea maximă înregistrată a fost de 35 cm, iar greutatea maximă a fost de 1080 g.

INTRODUCTION

No studies have been conducted on sea cucumber harvesting and management in Iran until now. The primary species harvested in Iran is the sandfish, *Holothuria scabra* (called "khiar daryaei" in the local language, which means "sea cucumber"). Although there are a growing number of studies focusing on echinoderms and holothurians worldwide, the Persian Gulf has not received much attention. There are no (to our knowledge) first hand records of sea cucumbers fisheries and stock assessment in this region.

Until now, 1,400 species of sea cucumber have been identified and reported in the seas around the whole world (Conand, 2006a). Sea cucumbers are aquatic creatures that have many important and useful properties known for human health (Mamelona et al., 2007). The wall of the body is used in the process of beche-de-mer production that forms 56% of the whole body. The amount of the sea cucumber protein is high and equivalent to 81.8% of the dry body weight (Alexander et al., 2005).

A lot of researches have been done on medicinal and therapeutic properties of different species (Murray et al., 2001). There are different types of toxic species among sea cucumbers. The fish called holothurians is used as an anti-cancer drug (Thomas et al., 1997). In addition, sea cucumber oils contain anti-inflammatory substances, which contain fatty acids. It is effective for reducing inflammations and strengthening the brain (Mamelona et al., 2007). The rearing of sea cucumber with shrimp controls the environmental pollution results from extra enriched nutritious built on the pond bottom. These animals eat detritus and devour organic materials on the surface, making the environment clean, and also causing the fast growth of shrimp and themselves (James, 2001).

Sandfish are usually observed partially buried in the water bottom sediments. The daily burrowing cycle varies according to environmental conditions. The growth rate of sandfish depends on environmental conditions and the time of year. At medium size, sand fish grow on average with 0.5 cm per month, corresponding to 14 g per month. Under favourable conditions they grow up to a size of 300 g in one year. We still do not know how long sandfish live, but it may be around 10 years. Sandfish can become sexually mature at a size of 200 g. There is no apparent relationship between fecundity (egg production) and body size (FAO, 2006).

The preferred habitats of sandfish are shallow tropical waters, usually less than 20 m deep, such as sheltered areas with high levels of nutrients, including muddy substrata and sea grass beds.

They can tolerate reduced salinity (20 ppt) for a short period and so are sometimes found in brackish water (FAO, 2006).

The sea cucumber *Holothuria scabra versicolor* (golden sandfish) is one of the most highly sought species in Asia. *Holothuria scabra* and *Holothuria scabra versicolor* are distributed throughout the tropical Indian and Western Pacific oceans area and their occurrence was noted from Madagascar to the Solomon Islands and New Caledonia (Conand, 1998a). Although *Holothuria scabra* and *Holothuria scabra versicolor* are both found over a large geographical range, they often inhabit dissimilar microhabitats, with *Holothuria scabra versicolor*, often found in deeper waters than *Holothuria scabra* (Conand, 1990).

The sea cucumber *Holothuria scabra*, yield one of the largest sea cucumber catches worldwide (Brookes and Shannon, 2004).

Increasing demand for beche-de-mer along with steady price increases has led to worldwide intensification of sea cucumber harvesting (Conand, 2004). The worldwide supply of high quality beche-de-mer would not be sufficient to satisfy the Asian market demand, unless a viable sea cucumber aquaculture develops to partially replace the steady decrease in wild stocks (Ivy and Giraspy, 2006).

In this study, the status of sea cucumber resources in the existing fishery area in Qeshm Island is assessed and compared with other neighbouring countries, and it also provides management recommendations.

MATERIAL AND METHODS

Information regarding the status of this Iranian fishery was obtained through a questionnaire developed by the authors of this scientific paper. Information on the species exploited, fishing techniques, processing and trading was obtained through direct field observations and through a questionnaire that was given during interviews with sea cucumber fishers and local authorities around the Qeshm Island. More than 16 people/fishermen answered the questionnaire.

During each field survey, we interviewed fishermen about the length (duration) of their fishing trip, the number of involved fishermen, and the method and location of the collection. We also recorded the number and species of the collected sea cucumbers. In this survey, data were collected from a local fisherman, involved in this activity during 2004-2006, and the selected sampling area was based on the information provided by them. The study area covered the north coast of Qeshm Island (26°58’ N 56°14’ E), near Hamon jetty to left port (26°56’ N 55°47’ E) at 20-25 m from the coast line, where the water depth was 5-12 m. Sampling was carried out in two seasons (summer and autumn of 2010) (Fig. 1).

Sea cucumbers were harvested by scuba diving. According to the information from the fishermen, this species was caught in 15-18 m depth easily. Because this species is nocturnal (James, 2001), during the day they are under the sand so they are not visible. Due to the turbidity in these areas, hand spraying method was used for fishing. As such, the diver moved his palms over the sediments bed to touch, extract and collect the sea cucumber. This method requires experienced divers to decry the risk and dangers. Fishing operations have been done sporadically during the day until sunset. The individuals were caught and brought to the surface immediately to reduce stress and prevent them from leaving the internal organs as a defensive mechanism; they were put into sea water tanks.

Figure 1: Position of sampling site of *Holothuria scabra* in the Persian Gulf, Qeshm Island area.

RESULTS AND DISCUSSIONS

Sea cucumber fishing in Qeshm Island area began in 2004, based on the current demand in Qeshm Island from Indian and Bangladesh traders. Exploitation of this species has been high during 2004-2006 in Iran, especially in Qeshm Island. Fishing operations by local fishermen have taken place in recent years based on current demand in Qeshm Island from Indian and Bangladesh traders.

During these years, around 5-6 diving groups, (each group contained at least 4-5 experienced divers) with the diving mask technique, tried to harvest sea cucumbers. Qeshm Island fishing operation was performed only by men, but throughout many parts of the world women have a significant role in fishing and collecting sea cucumbers (Al-Rashdi et al., 2007). This group of samples have been delivered completely fresh to those foreign nationals illegally, at 3000-4000 RLS per one sea cucumber in 2004. However, the cost in 2006 has been 10000-9000 RLS per piece. They processed the sea cucumber producing the final product (beche-de-mer) and transported it by air to the UAE and then transferred it from there to international markets. There were seven main *Holothuria scabra* fishing grounds in Qeshm Island: Hamoon, Kovei, Hormoz, Tolla, Ramchah, Messen and Hengam (Fig. 2).

The estimated number of fishermen was 150-200 in 2004-2006, indicating an increase in demand for beche-de-mer and resulting in a high income for the fishers and traders. The average fishing hours per fisher per working day were five to six hours with an average collection of 150-200 live sandfish per fishing trip. Men involved in this fishery perform a 100% of other income-generating activities.

Table 1: Comparison of sea cucumber fishery indicators between sultanates of Oman and Iran (2004-2008).

2004-2005 (Iran)	2007-2008 (Oman)	2004-2005 (Oman)	Indicator
Targeted size	> 25 cm	All sizes (including < 15 cm)	> 20 cm
CPUE (ind.h^{-1})	25 ind.h^{-1}	< 5 ind.h^{-1}	> 30 ind.h^{-1}
Price to fisher (Iranian rials)	3000-7000	35000-50000	4000-9000
Targeted species	*Holothuria scabra*	*Holothuria scabra*, *Holothuria atra* and *Holothuria lecospilata*	*Holothuria scabra*
Fishing grounds	6 recorded in Mahut Bay	7 recorded grounds in Mahut Bay plus 2 recorded in Marish strait	7 recorded in Qeshm Island
% of women and children	50%	15%	100%
Fishing methods	Low tide collection by hand	Low tide collection by hand (70%) skin - diving (30%)	Skin - diving (100%)

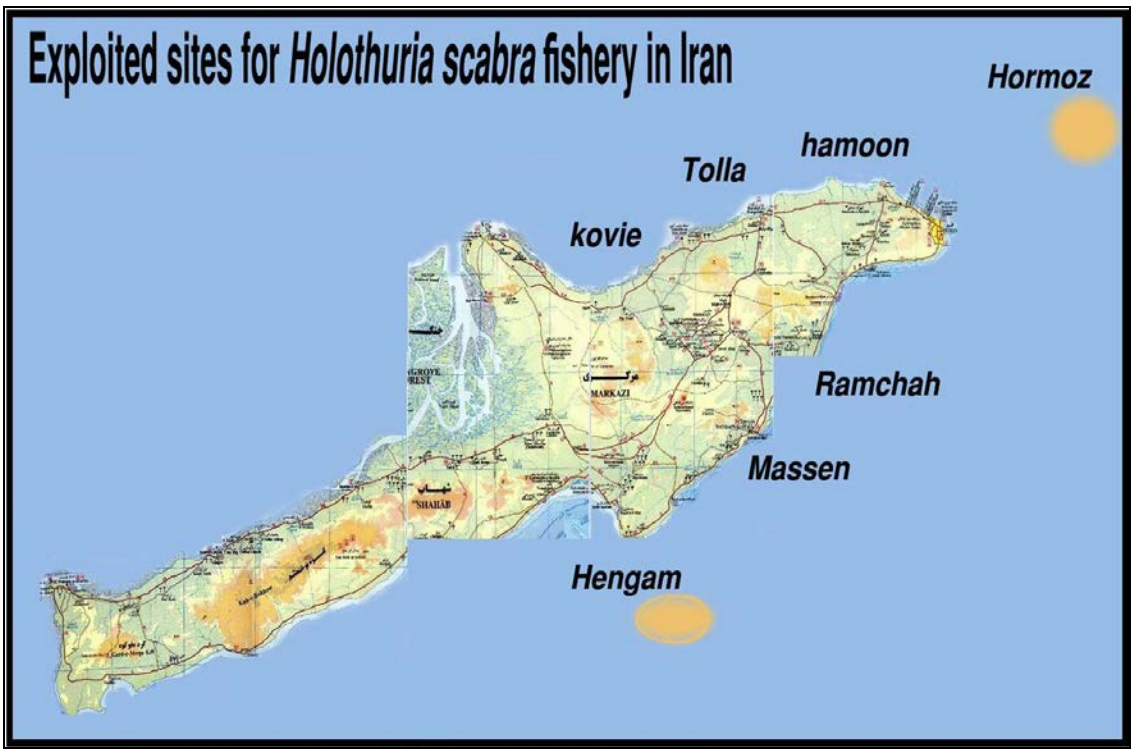

Figure 2: Exploited sites for *Holothuria scabra* fishery in the Persian Gulf, Qeshm Island area.

Qeshm Island, which is in the north coast of the Persian Gulf, is the main area of sea cucumber harvesting in Iran. All the processing expenditures for the fishery in Qeshm Island (gutting, first cooking, preserving and storing, cleaning, second cooking, first drying and second drying) were done by the traders.

Customs inspectors at the border check post (airport) are unfamiliar with or do not recognize sea cucumbers, especially the dried ones, and so the product passes through the border without identification. Fortunately, given proper management practices and timely cooperation with the Hormozgan Fisheries Department, Qeshm Free Zone Organization, the International Qeshm Airport and Foreign Nationals Department are to deal with illegal fishing, the demand for this product is worth less, so the local fishing operations were stopped from 2006. To achieve its real protected species status, efforts should be done to prevent overexploitation.

Holothuria scabra is an aspidochirote holothurian widely distributed in coastal regions throughout the Indo-Pacific region (Conand, 1997). *Holothuria scabra* is often found on the inner reef flats and near estuaries, half buried in the silt sand during the day and emerging at night to feed (Mercier et al., 1999). *Holothuria scabra* is among approximately 20 aspidochirote species that constitute the beche-de-mer fishery in the Indo-Pacific and is among the most valuable species for trade (Conand and Byrne, 1993). Because this fishery is quite recent, there are currently no traditional or state-directed management strategies in place (i.e. it is a fully open access fishery) (Charles, 2001).

Although Holothuroidea have been exploited for at least 1,000 years in India, Indonesia and Philippines (Conand, 2004), their exploitation in Iran is recent. Because of the illegal activities of fishermen and traders in Qeshm Island accurate information regarding the amount of fishing does not exist for the years 2004-2006, so the value of this species is unknown, while in the rest of the world beche-de-mer production is revenue industry.

Six fishing regions have been reported in Mahout Bay in the Sultanate of Oman (Al-Rashdi et al., 2007), while the Qeshm Island has seven areas in the north and south that are known by fishermen.

Al-Rashdi et al. (2005) reported the most active sea cucumber fishing activities occurs in the spring low tide by walking in the Oman coast. During 2007-2008, about 30 percent of fishermen used the diving mask technique for deeper depths; also reported was the fact that about 50% of the local women and children of fishermen collected sea cucumbers, while in 2007-2008 this rate dropped to about 10%. But, in this study was observed that the hunting and fishing operations in the area of Qeshm Island were done only by men. Al-Rashdi and colleagues during 2005 to 2008 showed that due to excessive exploitation of natural reserves of *Holothuria scabra* species, their density was reduced in Oman coast. The size of the target of 25 cm in 2004-2005 was reduced to 15 cm in 2007-2008. Due to the sharp decline of this species reserve, fishermen started looking for other species that have less commercial value, and that are exploited.

Most exploited sea cucumber populations around the world experience similar declines at the onset of commercial exploitation (Conand, 1997; Uthicke and Conand, 2005). The frequency of *Holothuria scabra* reported in Qeshm Island (24.86 ± 3.58 cm) has a similar situation in areas where it’s not exploited in the Red Sea (Hassan, 2005) and Mahout Bay in Oman in 2005 (Al-Rashdi et al., 2007). So, it seems that the area of Qeshm Island has adequate reserves and similar areas in other highly ecosystem and nearly unexploited sea cucumber population.

Figure 3: *Holothuria scabra* observed in Qeshm Island.

The average sizes of harvested species in Qeshm Island show that there is an optimal level of stockpiles and higher than first maturity (equivalent to 18-16 cm for the species *Holothuria scabra*) reported by (Conand, 1989; Kithakeni and Ndaro, 2002; Hassan, 2005). However, the smaller size individuals fetch have a much lower price than the larger ones, more sea cucumbers needed to be caught. This, in turn, led to the collection of immature individuals (Richmond, 1996). But in Qeshm Island where *Holothuria scabra* was exploited, it seems there are ideal reserves situations in this region. The recent addition of low-value species (*Holothuria atra* and *Holothuria leucospilota*) to catches indicates the poor status of the fishery in Mahout Bay (Friedman et al., 2008).

These soon-to-be implemented regulations and several closure experiments in the Indo-Pacific have shown that overfished sea cucumber stocks were slow to recover. This is partially because holothurians are broadcast spanners, whose fertilization rate drops rapidly at low population densities. Modelling experiments indicate that individuals separated by only a few meters do not contribute practically to larvae production because of the dilution of sperm in the water column (Claereboudt, 1999).

The high demand for beche-de-mer in Asia and the systematic overexploitation of wild populations support the call for sea cucumber farming. Aquaculture is a potential alternative source for the market and can also sustain wild harvest fisheries. Over the past decade, efforts to develop hatchery techniques for the culture of commercially important sea cucumber species have increased significantly (James et al., 1994; James, 1996a; Ramofafia et al., 1995; Ito, 1995; Asha and Muthiah, 2002; Lovatelli et al., 2004; Giraspy and Ivy, 2005).

Sea ranching of sea cucumbers has become very popular in the recent years. Results suggest that the substrata of the seeding area play an important role in the survival of the released juveniles, as they need protection from predators and require an abundant natural food (Jiaxin, 2003).

From the above description of the situation of the sea cucumber fishery in Qeshm Island, several management suggestions have been identified in this study:

1 - research projects are needed on evaluation of existing resources to identify species, density and distribution of sea cucumber species, especially in the Persian Gulf Coast of Qeshm Island;

2 - research projects on ecological studies, biological, rebuild stocks, to make certain reproductive biology and to certainly identify the size of first maturity;

3 - continue the ban on fishing until the determination of the stock assessment;

4 - harvest only to provide brood stock for hatchery centre;

5 - planning for commercial production of larvae for culture and sea ranching projects;

6 - capacity building programmers - training, study tours, participation in national and international meetings and workshops on sea cucumbers, should be conducted and supported by government organizations;

7 - protection of natural habitats such as Qeshm Island to supply broodstock of *Holothuria scabra* species in the country.

REFERENCES

1. Alexandra S., Silchenko S., Avilov A., Alexander S., Antonov S., Anatoly I., Kalinovsky P., Dmitrenok S., Vladimir I., Kalinin V., Stonik A., Woodward C. and Collin P. D., 2005 – Glycosides from the sea cucumber Cucumaria frondosa. III. Structure of frondosides A2-1, A2-2, A2-3, and A2-6, four new minor monosulfated triterpene glycosides, *Canadian Journal of Chemistry*, 83, 21-27.
2. Al-Rashdi K. M., Al-Busaidi S. S. and Al-Rassadi I. H., 2007a – Status of the sea cucumber fishery in the Sultanate of Oman, *SPC Beche de mer Information Bulletin*, 25, 17-21.
3. Al-Rashdi K. M., Claereboudt M. R. and Al-Busaidi S. S., 2007b – Density and size distribution of the sea cucumber, Holothuria scabra (Jaeger, 1935), at six exploited sites in Mahout Bay, Sultanate of Oman, *Agricultural and Marine Sciences*, 12, 43-51.
4. Asha P. S. and Muthiah P., 2002 – Spawning and larval rearing of sea cucumber *Holothuria (Theelothuria) spinifera* Theel, *SPC Beche-de-Mer Information Bulletin*, 16, 11-15.
5. Brooke Y. and Shannon R., 2004 – Ecological assessment of the developmental Moreton Bay beche-de-mer fishery. A report to Environment Australia on the ecologically sustainable management of a highly selective dive fishery, 25.
6. Charles A. T., 2001 – Sustainable fishery systems, Blackwell Science, Oxford, 370.
7. Claereboudt M. R., 1999 – Fertilization success in spatially distributed populations of benthic Free-spawners: a simulation model, *Ecological Modelling*, 121, 221-233.
8. Conand C., 1990 – The fishery resources of Pacific Island countries, part 2, Holothurians, *FAO Fisheries Technical Paper*, 142.
9. Conand C., 1997 – Are holothurians fisheries for export sustainable? International Congress of Reefs, Panama, 2: 2021-2026.
10. Conand C., 1998 – Holothurians, in: Carpenter K. and Niem V. (eds), FAO species identification guide, *The marine living resources of the Western Central Pacifici*, 2, cephalopods, crustaceans, holothurians and sharks, 1157-1190.
11. Conand C., 2004 – Present status of world sea cucumber resources and utilization: An international overview, 13-23, in: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds), Advances in sea cucumber aquaculture and management, FAO Fisheries Technical Paper, Geneva, D'Silva D., 2001, The Torres Strait beche-de-mer (sea cucumber) fishery, *Beche-de-Mer Information Bulletin*, 15, 2-4.

12. Conand C., 2006 – Sea cucumber biology: taxonomy, distribution, biology, conservation status, 33-50, in: *The Proceedings of the CITES workshop on the conservation of sea cucumbers in the families Holothuriidae and Stichopodidae*, Bruckner A. W. (ed.). OAA Technical Memorandum, 244.
13. Conand C. and Byrne M., 1993 – A review of recent developments in the world sea cucumber fisheries, *Marine Fisheries Review*, 55, 1-13.
14. FAO, 2006 – Sandfish hatchery techniques, by Natacha Agudo.
15. Friedman K., Purcell S. W., Bell J. D. and Hair C., 2008 – Sea cucumber fisheries: A manager's toolbox, Australian Government, Australian Centre for International Agricultural Research, Canberra, Australia, 32.
16. Giraspy D. A. B. and Ivy W., 2005 – Australia's first commercial sea cucumber culture and sea ranching project in Hervey Bay, Queensland, Australia, *SPC Beche-de-Mer Information Bulletin*, 21, 29-31.
17. Grisilda I. and Giraspy D. A. B., 2006 – Development of large-scale hatchery production techniques for the commercially important sea cucumber *Holothuria scabra* var. *versicolor* (Conand, 1986) in Queensland, Australia, *SPC Beche-de-mer Information Bulletin*, 24.
18. Hasan M. H., 2005 – Destruction of a *Holothuria scabra* population by overfishing at Abu Hamada Island in the Red Sea, *Marine Environmental Research*, 60, 499-511.
19. James D. B., Gandhi A. D., Palaniswamy N. and Rodrigo J. X., 1994 – Hatchery techniques and culture of the sea cucumber *Holothuria scabra*, *CMFRI (Central Marine Fisheries Research Institute, Cochin, India) special publication*, 57, 120-126.
20. James D. B., 1996 – Culture of sea cucumber, in: Rengarajan K. (ed.), Artificial reefs and sea farming technologies, *Bulletin of the Central Marine Fisheries Research Institute*, 48, 120-126.
21. James D. B., 2001 – Twenty sea cucumbers from seas around India, Naga, ICLARM Quart., 24, 4-8.
22. Jiaxin C., 2003 – Overview of sea cucumber farming and sea ranching practices in China, *SPC Beche-de-Mer Information Bulletin*, 18, 18-23.
23. Kithakeni T. and Ndaro S. G. M., 2002 – Some aspects of the sea cucumber, Holothuria scabra (Jaeger, 1935), along the coast of Dar-es-Salaam, *Western Indian Ocean Journal of Marine Science*, 1, 163-168.
24. Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J.-F. and Mercier A. (eds), 2004 – Advances in sea cucumber aquaculture and management, *FAO Fisheries Technical Paper*, 463, Rome: FAO, 425.
25. Lto S., 1995 – Studies on the technological development of the mass production for sea cucumber juvenile, Stichopus japonicas, Saga Prefectural Sea Farming Center, Japan, 87.
26. Mamelona J., Pelletier E., Girard-Lalancette K., Legault J., Karboune S. and Kermasha S., 2007 – Quantification of phenolic contents and antioxidant capacity of Atlantic sea cucumber, Cucumaria frondosa, *Food Chemistry*, 104, 1040-7.
27. Mercier A., Battaglene S. C. and Hamel J.-F. 1999 – Daily burrowing cycle and feeding activity of juvenile sea Cucumbers Holothuria scabra in response to environmental factors, *Journal of Experimental Marine Biology and Ecology*, 239(1), 125-156.
28. Ramofafia C., Gervis M. and Bell J. 1995 – Spawning and early larval rearing of Holothuria atra, *SPC Beche-de-Mer Information Bulletin*, 7, 2-6.
29. Richmond R. H., 1996 – Introduction and overview's, 2-6, in: Richmond R. H. (ed.), Suggestions for the management of sea cucumber resources in Micronesia, Results of the Workshop, A regional Management Sustainable Sea Cucumber Fishery for Micronesia, University of Guam Marine Laboratory, Technical Report, 101, 75.
30. Thomas J. D. and Hatrel L. W. 1997 – Characterizations of the Anglicans of the toxic principle of the sea cucumber Holothuria atra, *Toxicom*, 15, 461-462.
31. Uthicke S. and Conand C. 2005 – Local examples of beche-de-mer overfishing: an initial summary and request for information, *SPC Beche-de-mer Information Bulletin*, 21, 9-14.

HEALTH RISKS EVALUATION OF HEAVY METALS IN SEAFOOD

Zahra KHOSHNOOD * and *Reza KHOSHNOOD* **

* Islamic Azad University, Dezful Branch, Department of Experimental Sciences, Dezful, Iran, Zkhoshnood@gmail.com
** Islamic Azad University, Tehran Central Branch, Young Researchers Club, Tehran, Iran, RezaKhoshnood@gmail.com

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ABSTRACT

Fish is an excellent, low-fat source of protein and provides many benefits, such as contributing to low blood cholesterol. Heavy metals are increasingly being released into natural waters from geological and anthropogenic sources. Due to the rapid development of agriculture and industry, and a historical lack of enforcement of regulations, the study areas have become contaminated by metals, especially cadmium (Cd) and lead (Pb) which has been emitted into the environment through atmospheric deposition, solid-waste emissions, sludge applications, and irrigations with wastewater.

The health risks posed to the local inhabitants by exposure to Pb and Cd in two coastal regions of Iran through the consumption of contaminated fish were investigated, based on estimated target hazard quotients (THQs). The results showed that THQ values are less than 1 for both adults and children by either group consuming fish alone.

The distribution of several heavy metals (Cd and Pb) was investigated in muscle and liver in six different fish species seasonally collected in the Persian Gulf (autumn 2008 - summer 2009). The concentrations of all metals were lower in flesh than those recorded in liver due to their physiological roles. The THQ index for fish was calculated. Estimation of target hazard quotients calculations for the contaminated fish consumption was calculated to evaluate the effect of pollution on human health. Total metal THQs values (Pb and Cd) for adults were 0.05 and 0.04 in Bushehr and Bandar-Genaveh, respectively, and for children was 0.08 and 0.05 in Bushehr and Bandar-Genaveh, respectively.

The dietary intake of Pb estimated for the inhabitants in this area is far below the limit considered tolerable. The Cd intake through the consumption of fish is also less than the limit of daily dietary intake considered tolerable by FAO/WHO.

RÉSUMÉ: L'évaluation des risques pour la santé des métaux lourds présents dans les produits alimentaires d'origine marine.

Le poisson est un aliment excellent, une source de protéine maigre qui offre des nombreux bénéfices, tel que la contribution à la diminution du taux du cholestérol dans le sang. Les métaux lourds sont de plus en plus présents dans l'eau en provenance des sources géologiques et anthropiques. Dû au développement rapide de l'agriculture et de l'industrie ainsi qu'au manque historique d'application de la législation, la zone d'étude est devenue contaminée par des métaux lourds, plus particulièrement par le cadmium (Cd) et le plomb (Pb) qui se sont retrouvées dans le milieu en provenance des poussières atmosphériques, des déchets solides, des application des boues des usines de traitement des eaux usées ainsi que due à l'irrigation des cultures avec de l'eau usée.

Les risques pour la santé représentées par l'exposition au Pb et au Cd des habitants de deux régions côtières d'Iran par la consommation des poissons contaminés ont été investigués en utilisant les quotients de danger cible estimés (les THQs). Les résultats ont montré que les valeurs THQ sont moins de 1 pour les adultes tout comme pour les enfants si la consommation de poisson est la seule prise en compte.

On a étudié la distribution de ces deux métaux lourds (Cd et Pb) dans le tissu musculaire et le foie de six espèces de poissons différentes collectées de manière saisonnière dans le Golfe Persique (automne 2008 - été 2009). Les concentrations de tous les métaux ont été plus faibles dans le muscle que dans le foie, due aux rôles physiologiques différents des deux organes. L'indice THQ pour poissons a été calculé. L'estimation des quotients de risque cible pour la consommation de poisson contaminé a servi aux calculs de l'évaluation de l'effet de la pollution sur la santé humaine. Les valeurs totales des THQ des métaux étudiées (Pb et Cd) pour les adultes ont été de 0,05 à Bushehr, et respectivement de 0,04 à Bandar-Genaveh, pendant que pour les enfants, les valeurs ont été de 0,08 à Bushehr et de 0,05 à Bandar-Genaveh.

L'apport alimentaire de Pb estimé pour les habitants de la zone se trouve bien en dessous des limites admises. Cela va de même pour l'apport alimentaire de Cd à travers le poisson, qui est moindre que la valeur établie par FAO et OMS en tant que limite admissible pour l'apport alimentaire journalier.

REZUMAT: Evaluarea riscurilor pentru sănătate reprezentate de metalele grele din alimentele de origine marină.

Peștele este o sursă de proteine excelentă, cu conținut scăzut de grăsimi, consumul său contribuind la scăderea concentrației colesterolului în sânge. Din păcate, o cantitate din ce în ce mai mare de metale grele provenind din surse geologice și antropice se acumulează în acvatoriile naturale. Datorită dezvoltării rapide a agriculturii și industriei pe fondul unei neglijări istorice în aplicarea legislației pentru protecția mediului, zonele studiate au fost contaminate cu metale, în special cu cadmiu (Cd) și plumb (Pb). Acestea au provenit din depunerea pulberilor atmosferice, din deșeuri solide, din aplicări de nămol și irigații cu apă uzată din stațiile de epurare.

S-au investigat riscurile existente pentru sănătatea locuitorilor a două regiuni de coastă din Iran, cauzate de expunerea la Pb și Cd prin consumul de pește contaminat. În acest scop s-au folosit coeficienți de risc țintă (THQ). Valorile găsite pentru acești coeficienți au fost mai mici de 1, atât pentru adulți, cât și pentru copii, dacă s-a luat în considerare ca unică sursă de contaminare peștele consumat.

S-a studiat distribuția acestor metale grele (Cd și Pb) în țesutul muscular și în ficatul a șase specii diferite de pește colectate sezonier în Golful Persic (toamna 2008 - vara 2009). Concentrațiile găsite au fost mai mici în țesutul muscular decât în ficat, datorită rolului lor fiziologic diferit. S-au calculat indicatorii THQ pentru pește, iar estimările obținute pentru consumul de pește contaminat au fost folosite pentru măsurarea impactului poluării asupra sănătății umane. Valorile totale ale THQ pentru metalele investigate (Pb și Cd) la adulți au fost de 0,05 la Bushehr și, respectiv, 0,04 la Bandar-Genaveh, iar pentru copii au fost de 0,08 la Bushehr și respectiv de 0,05 la Bandar-Genaveh.

Aportul alimentar de Pb estimat pentru locuitorii acestei zone se găsește mult sub limita admisibilă. De asemenea, și aportul de Cd, provenit din consumul de pește, se găsește sub limita admisibilă pentru aportul zilnic alimentar fixat de FAO/OMS.

INTRODUCTION

Fish is an excellent, low-fat source of protein and provides many benefits, such as contributing to low blood cholesterol (Anderson and Wiener, 1995). Fish contains omega-3 (n-3) fatty acids that reduce cholesterol levels and the incidence of heart disease, stroke and preterm delivery (Daviglus et al., 2002; Patterson, 2002). Fish constitutes an important source of proteins, minerals, vitamins and unsaturated essential fatty acids (PUFAs), especially omega-3 PUFAs.

Scientific data indicate that fish consumption reduces the risk of coronary heart disease, decreased mild hypertension and prevents certain cardiac arrhythmias (Kris-Etherton et al., 2002). At the same time, seafood consumption has been reported as an important route of human exposure to a variety of chemical contaminants (Storelli, 2008).

Protection of human health against diseases and injuries caused by heavy metals present in the environment is one of the ultimate goals of risk assessment. Diet is a major route for human exposure, especially through consumption of fish from contaminated waters such as the Persian Gulf is (Mora et al., 2004).

The rights of all human individuals to a safe and adequate diet were expressed at the World Health Organization Forum in 2007 which led to the Beijing Declaration (WHO, 2007). This Declaration, adopted by over fifty countries, stresses the importance of a safe diet and provides guidelines for food controls that should be asserted by each country. Over the past three decades, organizations have been developed to support food safety through assessment of food contamination along with issuing food contamination alerts and recalls where necessary (Hugas et al., 2007).

Metals tend to accumulate in aquatic organisms, and concentrations of some metals can be magnified through the food webs. Humans can be exposed to metals through their diet, and over time metals can accumulate to potentially toxic concentrations (Sofuoglu and Kavcar, 2008).

With the exception of occupational exposure, fish are acknowledged to be the single largest source of heavy metals for humans. In some instances, fish catches were banned for human consumption because their total mercury content or other metals content (like as cadmium) exceeded the maximum limits recommended by the FAO and WHO (FAO/WHO, 1972).

Due to the rapid development of agriculture and industry, and a historical lack of enforcement of regulations, the studied areas becomes contaminated by metals especially including Cd and Pb, which have been emitted into the environment through atmospheric deposition, solid-waste emissions, sludge applications, and irrigation with wastewater.

The suburban and urban areas of Bandar-Abbas and Bandar-Lengeh cities of Iran, are polluted by some sources of heavy metals, but information on the health risks of these elements is quite limited. The main objective of this study is to estimate the health risks of heavy metals, such as Pb and Cd, via consumption of fish to the general public in the above districts by using the target hazard quotient (THQ) concept.

MATERIAL AND METHODS

Fish samples were collected along the coast of the north Persian Gulf. Six species, *Lutjanus johnii*, *Lutjanus lemniscatus*, *Liza subviridis*, *Sillago sihama*, *Acanthopagrus latus* and *Pampus argentus* have been caught from autumn 2008 to summer 2009. These six fish species were collected from two fishery regions, Bandar-Bushehr and Bandar-Genaveh. The

fish species were randomly collected from commercial catches that landed at the local fishing ports. Immediately after the collection, fish samples were stored on ice in an isolated box and transferred to the reference laboratory of the Hormozgan environmental deputy. Body weight and length of fishes were measured. A part of the dorsal muscle from each was dissected as a sample. The fish liver tissue was also removed and prepared for processing. All of the samples were dried at 60˚C for 48 h in a laboratory oven (Crinnion, 2000).

All glass wares were cleaned by soaking in 10% v/v HNO_3 for 12 h and then rinsing with ultra-pure water. Between 0.2 and 0.4 g of dried sample material were weighed and then digested in acid-cleaned teflon microwave vessels with 5 ml of ultra-pure nitric acid (65% v/v). A microwave digester was used for 30-40 min at a target digestion temperature of 200°C, after which that the samples were cooled 1 h. The digested samples were transferred to a graduated plastic test tube and brought up to volume (50 ml) with Mili-Q-water. (Chien et al., 2002)

Statistical analyses were done using the SPSS software (version 11.5). The data were tested to check normality using the Kolmogorov-Smirnov test, which showed that they have normal distribution. Pearson's correlation test was used to assess any significant relationship of Cd concentration in tissue with fish length and weight (level of significance, $p < 0.05$). In addition, the paired sample t-test was used to compare tissue Cd concentrations between stations.

The health risks through consumption of fish by the local inhabitants were assessed based on the THQ. A THQ below 1 means that the exposed human population is unlikely to experience obvious adverse effects. The methodology for estimating THQ is described in details by the US EPA (US EPA, 2000a). The dose calculations were carried out by using the standard assumption from an integrated US EPA risk analysis considering an average adult body weight of 55.9 kg, and 32.7 kg for children. The health risks were separately considered the contact pathway with each exposure medium (e.g., food) changes with age. Furthermore, children are more sensitive to pollutants. There will be a certain amount of discrepancy in health risks between age groups and the locality of the inhabitants. In this respect, the THQ was determined based on the methods of Chien et al. (2002) described by the equation:

$$THQ = \frac{E_F\, E_D\, F_{IR}\, C}{R_{FD}\, W_{AB} T_A} \times 10^{-3}$$

E_F is exposure frequency (365 days/year); E_D is exposure duration (70 years), equivalent to the average lifetime in Iran; F_{IR} is food ingestion rate (g/person/day); C is metal concentration in food (Ag/g); R_{FD} is the oral reference dose (mg/kg/day); W_{AB} is average body weight (55.9 kg for adults and 32.7 kg for children) and T_A is averaging exposure time for noncarcinogens (365 days/year number of exposure years, assuming 70 years in this study).

It was further assumed that cooking has no effect on the toxicity of heavy metals in seafood (Cooper et al., 1991; Chien et al., 2002).

For adult inhabitants of the two studied areas, the daily fish consumption was 19.17 g/person/day and 14.06 g/person/day for children.

Mean concentration of Pb and Cd for fishes in the two studied areas are presented in table number 2. Because the residents of the two studied areas consume six fish species, we used the average of heavy metal concentrations to calculate THQ.

RESULTS

Mean concentration of Pb ranging from 0.09 to 0.55 µg/g in Bandar-Bushehr and 0.01 to 0.3 µg/g in Bandar-Genaveh, and for Cd, ranging from 0.02 to 0.4 µg/g in Bandar-Bushehr and 0.01 to 0.32 µg/g in Bandar-Genaveh. The average concentrations of the two metals are higher in Bandar-Bushehr than in Bandar-Genaveh. This situation exist mainly due to the unmanaged shipping activities, river runoff, and untreated sewage discharge by coastal settlements, and dumping of toxic and industrial wastes into the sea which occur adjacent of Bandar-Bushehr. Since fish catching in the surrounding district area are randomly sold and use for food by the residents of the two areas, and this six selected fish are usually eaten by the people, averaged heavy metal concentrations in fish were used for THQ calculation.

Table 1: Biometry results of fish samples.

Species	Station	Length	Weight	No. of samples		
		Range	Mean	Range	Range	
Lutjanus johnii	Busheher	24.5-36.5	32.3	240-710	585	10
	Genaveh	24-41	32.1	209-1010	604	10
Lutjanus lemniscatus	Busheher	39-58	48.1	754-2650	1672	10
	Genaveh	31.5-1	43.0	497-2286	1309	10
Sillago sihama	Busheher	12-17	14	100-180	135	10
	Genaveh	11-20	16	90-215	143	10
Liza subviridis	Busheher	16-26	21.7	150-470	310.5	10
	Genaveh	20-28	25.8	325-790	582.9	10
Acanthopagrus latus	Busheher	23-39	27	234-321	268.5	10
	Genaveh	26-41	32	251-345	273	10
Pampus argentus	Busheher	26-45	37	319-469	421.4	10
	Genaveh	30-41	35	345-435	367.5	10

Table 2: Average concentrations in four fish species.

Areas	Average concentrations of heavy metals in four fish species	
	Pb	Cd
Bandar-Bushehr	0.20	0.14
	(0.09-0.55)	(0.02-0.4)
Bandar-Genaveh	0.16	0.11
	(0.01-0.3)	(0.01-0.32)

Table 3: Estimated target quotients (THQ) for individual metals caused by the consumption of fish.

	Pb	Cd
Adults		
Bandar-Bushehr	0.01	0.04
Bandar-Genaveh	0.01	0.03
Children		
Bandar-Bushehr	0.02	0.06
Bandar-Genaveh	0.01	0.04

DISCUSIONS

The health risks imposed by exposure to Pb and Cd to the local inhabitants in two coastal regions of Iran through the consumption of contaminated fishes were investigated based on estimated target hazard quotients (THQs). The results showed that THQ values are less than 1 for both adults and children by either consuming fish alone.

The consumption of fish provides health benefits, but some of them have high heavy metals levels, contributing to possible adverse effects, particularly in foetuses and young children. Health benefits and risks from consumption of fish have mainly focused on recreational and subsistence fish, and only more recently on commercial fish (Burger and Gochfeld, 2007a), although Yess (1993) reported on levels of canned tuna much earlier.

While the definition of subsistence is arguable, fish comprise an important part of the diet of the people living in the coastal area (Patrick, 2002; Hamrick and Smith, 2003) and especially in our study area. Providing these people with information about contaminants in the fish that they consume are thus an important public health mandates.

Oral reference doses were based on 1 × 10 mg/kg/day for Cd (USEPA, 2000a) and 1.5 mg/kg/day for Pb (USEPA, 2000). The target hazard quotients (THQs) of studied metals through consumption of fish for residents (adults and children) from the two studied districts were derived and listed in table number 3. It is shown that there are no THQ values over 1 through the consumption of fish, suggesting that health risks associated with heavy metals exposure is insignificant, the tolerable weekly Pb intake limit recommended by the FAO/WHO for adults being 25 µg/g body weight (Wang, 2005b).

With corresponds to 3.5 µg Pb/kg body weight/day, taking into account the average body weight of 55.9 kg for adults in these areas, the tolerable daily intake of Pb will be 200 µg/g.

The dietary Pb intake estimated for the inhabitants of the area is far below the accepted tolerable limit. The Cd intake through the consumption of fish is also less than the tolerable daily dietary intake limit (57-71 µg/day) sustained by FAO/WHO (Wang, 2007) (Fig. 1).

Providing information on risk from single-meal exposures, especially for pregnant women, is a risk communication challenge that we feel should be considered by the FDA. Egeland and Middaugh (1997) have called attention to the countervailing nutritional importance of fish, which increases the importance of identifying suitable local fish with low contaminant levels, especially during pregnancy. It is a matter of risk balance (Gochfeld and Burger, 2007b).

We caution that fish consumption, is a matter of risk balancing (Egeland and Middaugh, 1997; Gochfeld and Burger, 2007b). There are clearly both benefits and risks from fish consumption, and the public should be provided with as much information as possible to allow them to maximize the positive health benefits, while minimizing the risks from contaminants. The availability of information on both of the risks and benefits of specific species of fishes from particular areas is the key for decisions about fish consumption. To be effective, development of risk communication tools should involve not only scientists, health professionals, and regulators, but the public as well (Gochfeld and Burger, 2007b).

To further elucidate the specific risk contribution in each district, detailed information on food consumption structure and the metals concentrations in these areas would hopefully be obtained by future efforts.

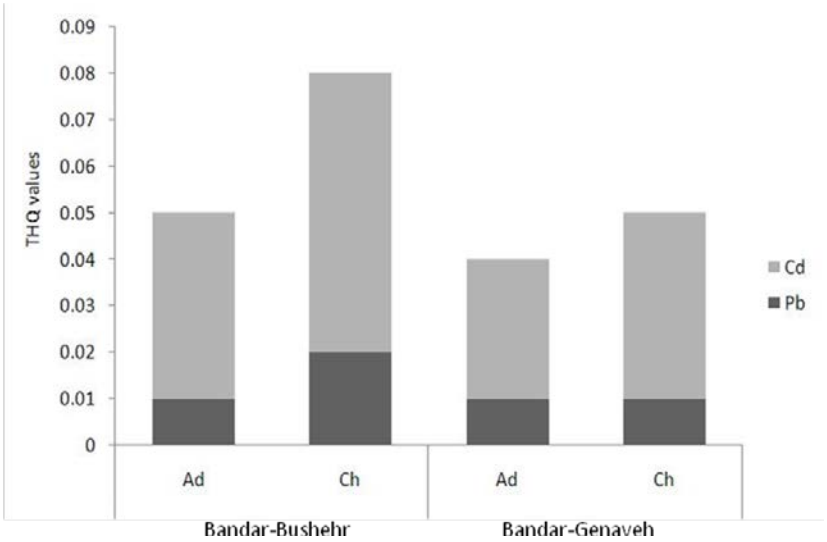

Figure 1: Total metal THQ values due to consumption of fish.

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REFERENCES

1. Anderson P. D. and Wiener J. B., 1995 – Eating fish, in: Graham J. D. and Wiener J. B. (eds), Risk Versus Risk: Tradeoffs in Protecting Health and the Environment, Harvard University Press, Cambridge, MA.
2. Burger J., Gochfeld M., Jeitner C., Burke S. and Stamm T., 2007a – Metal levels in flathead sole (Hippoglossoides elassodon) and great sculpin (Myoxocephalus polyacanthocephalus) from Adak Island, Alaska: potential risk to predators and fishermen, *Environmental Research*, 103, 62-69.

3. Burger J. and Gochfeld M., 2007b – Risk to consumers from mercury in Pacific cod (Gadus macrocephalus) from the Aleutians: Fish age and size effects, *Environmental Research*, 105, 276-284.
4. Chien L. C., Hung T. C., Choang K. Y., Yeh C. Y., Meng P. J. and Shieh M. J., 2002 – Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan, *Science Total Environment*, 285, 177-85.
5. Crinnion W. J., 2000 – Environmental medicine, part three: long-term effects of chronic low-dose mercury exposure, *Alternative Medicine Review*, 5(3), 209-223.
6. Daviglus M., Sheeshka J. and Murkin E., 2002 – Health benefits from eating fish, *Comments Toxicology*, 8, 345-374.
7. Egeland G. M. and Middaugh J. P., 1997 – Balancing fish consumption benefits with mercury exposure, *Science*, 278, 1904-1906.
8. Food and Agriculture/World Health Organization (FAO/WHO), 1972 – "Evaluation of Certain Food Additives and the Contaminants Mercury, Cadmium and Lead", *WHO Technical Report Series*, 505, Geneva.
9. Cooper C. B., Doyle M. E. and Kipp K., 1991 – Risk of consumption of contaminated seafood, the Quincy Bay case study, *Environment Health Perspectives*, 90, 133-40.
10. Hamrick K. and Smith J., 2003 – Subsistence Food Use in Unalaska and Nikolski, Aleutian Pribilof Island Association, Anchorage, AL.
11. Hugas M., Tsigarida E., Robinson T. and Calistri P., 2007 – Risk assessment of biological hazards in the European Union, *International Journal of Food Microbiology*, 120, 131-135
12. Mora S. D., Fowler S. W., Wyse E. and Azemard S., 2004 – Distribution of heavy metals in marine bivalves, fish and coastal sediments in Gulf and Gulf of Oman, *Marine pollution bulletin*, 49, 410-424.
13. Patrick R., 2002 – How local Alaska native communities view the Amchitka issue, in: *Proceedings of the Amchitka Long-term Stewardship Workshop*, CRESP/University of Alaska, Fairbanks, AK.
14. Patterson J., 2002 – Introduction comparative dietary risk: balance the risks and benefits of fish consumption, *Comments Toxicology*, 8, 337-344.
15. Penny M., Kris-Etherton R. D., William S., Harris D., Lawrence J. and Appel M. D., 2002 – MPH, for the Nutrition Committee "Fish Consumption, Fish Oil, Omega-3 Fatty Acids, and Cardiovascular Disease" Circulation, 106, 2747.
16. Sofuoglu S. C. and Kavcar P., 2008 – An exposure and risk assessment for fluoride and trace metals in black tea, *Journal of Hazards Mater*, 158, 392-400.
17. Storelli M. M., 2008 – Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: estimation of target hazard quotients (THQs) and toxic equivalents (TEQs), *Food Chemical Toxicology*, 46, 2782-2788.
18. US EPA, 2000a – Risk-based concentration table, Philadelphia PA: United States Environmental Protection Agency, Washington D. C.
19. US EPA, 2000 – Risk-Based Concentration Table, Environmental Protection Agency, Philadelphia P. A., Washington D. C., United States.
20. Wang X. L., Tao S., Dawson R. W. and Xu F. L., 2002 – Characterizing and comparing risks of polycyclic aromatic hydrocarbons in a Tianjin wastewater-irrigated area, *Environmental Research*, 90, 201-206.
21. WHO, 2007 – High-Level International Food Safety Forum adopts the Beijing Declaration on Food Safety, http://www.who.int/foodsafety/fs_management/meetings/forum07/en/index.html
22. Yess N. J., 1993 – Food and Drug Administration survey of methylmercury in canned tuna, *Journal AOAC*, 76, 36-38.
23. Wang X., Sato T., Xing B. and Tao S., 2005 – Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish, *Science of Total Environment*, 350, 28-37.

THE RELEVANCE OF DATA INTERCHANGE FOR THE EFFECTIVE PROTECTION OF THREATENED SPECIES BY EXAMPLE OF NEW RECORDS OF ENDANGERED CADDISFLY SPECIES (INSECTA, TRICHOPTERA)

Christian SCHEDER * and *Clemens GUMPINGER* *

* Aquatic Biology and Engineering, Gärtnerstraße 9, Wels, Austria, AT-4600, scheder@blattfisch.at, gumpinger@blattfisch.at

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KEYWORDS: Trichoptera, red list, applied investigations, records, distribution, data interchange, databases, *Anomalopterygella chauviniana*, *Hydropsyche fulvipes*.

ABSTRACT

All over the world, comprehensive data on aquatic communities are collected in the course of applied investigations (e.g. environmental impact assessments for road or railway construction projects, assessments of wastewater treatment plants, hydropower plants, etc.). At the same, little is known about certain endangered or rare species, their distribution or their actual conservation status, as the data collected in applied projects are usually not published. It can be stated that applied investigations would offer valuable information on the distribution of endangered species if there was sufficient data interchange within or data transfer to the scientific community. This thesis is supported by the fact that the authors were able to demonstrate that 72 caddisfly species that are quoted in the Austrian Red List in the course of applied investigations in Austria, but that none of the data have been published so far. The present study provides a list of endangered Trichoptera species that were observed by the authors in the context of routine surveys over the past five years. It is intended thus to provide an example of how data that could be relevant for obtaining a comprehensive picture of certain species are often lost on their way to publication.

ZUSAMMENFASSUNG: Die Bedeutung von Datenvernetzung für den erfolgreichen Schutz bedrohter Tierarten am Beispiel neuer Funddaten gefährdeter Köcherfliegenarten (Insecta, Trichoptera).

Im Rahmen von angewandten Projekten (beispielsweise Umweltverträglichkeitserklärungen, Vorfluteruntersuchungen o. ä.) werden mitunter umfassende Daten über aquatische Lebensgemeinschaften erhoben. Dennoch gibt es etliche seltene oder bedrohte Arten, über deren Verbreitung oder Gefährdungsgrad aktuell noch zu wenig bekannt ist, weil Daten aus angewandten Projekten üblicherweise nicht publiziert werden. Es kann davon ausgegangen werden, dass angewandte Untersuchungen wertvolle Informationen über die Verbreitung gefährdeter Tierarten liefern könnten, wenn ein ausreichender Datenaustausch stattfände. Diese These wird beispielhaft anhand der Tatsache erörtert, dass die Autoren des vorliegenden Artikels im Rahmen von angewandten Projekten in Österreich bislang 72 Köcherfliegenarten der Roten Liste nachweisen konnten, die entsprechenden Daten aber bisher nicht veröffentlicht wurden. Die hier präsentierte Artenliste soll stellvertretend für eine Vielzahl an Daten stehen, die einen Beitrag zu einem möglichst umfassenden Verständnis gefährdeter Spezies leisten könnten, wenn sie beispielsweise in Form von Publikationen der wissenschaftlichen Gemeinschaft zur Verfügung gestellt würden.

REZUMAT: Importanţa interconectării datelor pentru succesul protecţiei unor specii periclitate, exemplificat pe baza de noi date de colectare a unor specii de trichoptere (Insecta, Trichoptera).

În cadrul unor proiecte aplicate (de exemplu studii de impact ecologic al şoselelor şi căilor ferate, cercetări privind staţii de epurare a apelor, hidrocentrale, etc.), deseori se prelevează date cuprinzătoare asupra biocenozelor acvatice. Totuşi, există unele specii rare sau periclitate, despre răspândirea cărora sau despre gradul lor de periclitare, în prezent se cunoaşte încă prea puţin, deoarece datele din proiectele aplicate de obicei nu sunt publicate. Putem considera, că cercetările aplicate ar putea oferi informaţii valoroase asupra răspândirii unor specii periclitate, dacă ar exista un schimb satisfăcător de date. Această presupunere se exemplifică prin cercetările autorilor prezentei lucrări, care au reuşit să documenteze în cadrul unor proiecte aplicate din Austria 72 de specii de trichoptere, aparţinând listei roşii din Austria, datele acestea nefiind, însă, publicate până acum. Lista prezentată în lucrarea de faţă este menită să servească drept exemplu pentru o mulţime de alte date, care ar putea contribui la o înţelegere mai amplă a unor specii periclitate, dacă ar fi puse la dispoziţia comunităţii ştiinţifice sub forma unor publicaţii.

INTRODUCTION

There is a wide range of applied studies that are carried out all over the world without their results ever being published.

The Council of the European Communities, for instance, passed a directive on Environmental Impact Assessments (EIA) in 1985. Therefore, the environmental compatibility for certain larger public and private projects must be declared before they can be approved by the authority in charge. Major road or railway construction projects, hydropower plants or landfill sites are, amongst others, subject to that directive. For projects that affect aquatic habitats the compatibility with aquatic organisms and coenoses must be proven according to the EU Water Framework Directive (European Parliament and Council of the European Communities, 2000). Urban development has become a major topic in this context, as soil sealing and river control structures adversely affect aquatic coenoses. In addition to fish, macrophytes, phytobenthos and benthic invertebrate communities must be investigated in the course of EIAs in order to prove that a planned project does not deteriorate the current situation or does not inhibit the achievement of the good ecological status, respectively. Member states of the European Union have worked out their own specific guidelines for the standardised survey of those four biological quality elements. In Austria, where the paper at hand originates from, the guidelines were elaborated and are frequently updated by the ministry in charge (Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2010a, 2010b, 2010c and 2010d).

Wastewater treatment plants that discharge the treated sewage into a receiving watercourse must be controlled at regular intervals. Usually, benthic invertebrates are used as indicator organisms for this purpose. The modus operandi varies between different member countries of the European Union; in Austria there is a special standard for the examination of sewage treatment plants and the effects of the effluents on aquatic coenoses (Austrian Standards Institute, 1997).

Sometimes local authorities call for investigations on aquatic communities after the restoration of brooks and rivers in order to prove the achieved improvement of the ecological status.

Surveys of the types mentioned above could contribute considerably to the knowledge of species. However, data that spring from applied investigations are rarely published, either because principals avoid making data available, or because, more often, there is too little time in consultancies or agencies that carry out applied surveys for a living, not for scientific reputation.

Endangered species are listed in several national and international guidelines. In the European Union, the European Communities Habitats Directive (Council of the European Communities, 1992) represents one of the most important tools for the protection of species. The IUCN Red List of Threatened Species™ (IUCN, 2010), which was introduced in 1994 as a scientifically rigorous approach to determine the risks of extinction of species, has become a world standard meanwhile. However, for some taxonomic groups only local red lists exist, as there is too little knowledge of the actual distribution, the reason for the decline or the species' requirements. In Austria, for instance, a red list of stoneflies only exists for the province of Carinthia (Graf and Konar, 1999). Scientific studies that aim for basic ecological information on species are scarcely carried out nowadays, as microbiological, genetical or biochemical research with its higher economical applicabiliy is funded preferentially. Hence, new information on species that could permit the compilation of further or the adjustment of existing red lists are rare.

In Austria, there is a biogeographical database called ZOBODAT (www.zobodat.at), that was founded and developed by the Upper Austrian State Museum; however, as data from applied projects do not have to be reported to that database obligatorily, many data still sink into obscurity.

The paper at hand offers a list of records of endangered caddisfly species that were proven in the course of applied surveys over the past five years. All the records have remained unpublished so far. The list shall give an idea of how much information could be gained from existing data if there was a sufficient data interchange.

MATERIALS AND METHODS

The present paper is based on quantitative, semi-quantitative and qualitative samples taken in the course of different types of applied investigations on benthic invertebrates. For the determination of caddisfly larvae the key provided by Waringer and Graf (1997), as well as the corresponding addendum (2004) were used. Pupae and adults were identified by means of the key provided by Waringer and Graf (2000). We condensed the results of biological success controls and monitoring, examinations of sewage treatment plants, EIAs, ascertainments of loss due to hazmat accidents and applied projects in which accessory data on benthic invertebrates were collected though invertebrates were not the actual target organisms. Data taken from 22 examinations of wastewater treatment plants, eight projects dealing with success controls, seven EIAs, two basic research projects, two ascertainments of loss and one fish-migration project in which caddisflies colonized weir constructions were summarized in this study. A list and characterization of the involved projects are given in table number 1, the localization of the project areas is depicted in figure number 1.

A list of threatened caddisfly species was derived from the Red List of Austrian Caddisflies (Malicky, 2009) and positive proofs of threatened species in any of the treated projects were registered. We distinguished between occurrence and non-occurrence without including numbers of specimens, as data were collected according to different sampling strategies.

Table 1: Description of the 42 applied projects from which data on endangered caddisfly species were gained.

Survey type	Consecutive Number	Project/name of river or brook	Number of individual sampling sites	Elevation (m a.s.l.)	Catchment area (km²)	Geology (Predominant bedrock type)
Success control, monitoring	1	River Erlauf	8	345	314	limestone
	2	Waldzeller Ache brook	4	425	64	limestone
	3	Kandlbach brook	2	485	< 10	limestone
	4	Grömerbach brook	4	550	< 10	limestone
	5	Vordernbergerbach brook	3	585	191	limestone
	6	Aiterbach brook	7	330-390	< 10-70	limestone
	7	River Enns	2	250	6,080	limestone
	8	Leitenbach and Sandbach brooks	4	350	43-75	granite/ limestone
Examination of sewage treatment plants	9	River Url 2005a	2	295	235	limestone
	10	River Url 2005b	2	295	235	limestone
	11	River Url 2006a	2	295	235	limestone
	12	River Url 2006b	2	295	235	limestone
	13	River Url 2007	2	295	235	limestone
	14	River Url 2008a	2	295	235	limestone
	15	River Url 2008b	2	295	235	limestone
	16	River Url 2008c	2	295	235	limestone
	17	Feistritz brook	2	550	51	granite
	18	Reisingerbach brook	2	870	< 10	granite
	19	River Gusen	2	270	251	granite
	20	Kößlbach brook	2	380	85	granite

Table 1 (continued): description of the 42 applied projects from which data on endangered caddisfly species were gained.

Examination of sewage treatment plants	21	Klambach brook	2	270	90	granite
	22	Kettenbach brook	2	650	< 40	granite
	23	Gaflenzbach brook	2	380	92	limestone
	24	River Steyr 2006	2	580	142	limestone
	25	River Steyr 2008	2	580	142	limestone
	26	River Antiesen 2005	2	510	< 10	limestone
	27	River Antiesen 2008	2	510	< 10	limestone
	28	River Ager	2	400	963	limestone
	29	Sipbach brook	2	355	< 40	limestone
	30	Dambach brook	2	575	81	limestone
EIAs	31	EIA 1	7	570 - 1,100	< 10 - 855	granite/ limestone
	32	EIA 2	2	1,250	2 - 11	granite/ limestone
	33	EIA 3	6	570 - 1,100	< 10 - 855	granite/ limestone
	34	EIA 4	2	345	> 7,000	limestone
	35	EIA 5	2	370	> 7,000	limestone
	36	EIA 6	2	390	> 7,000	limestone
	37	EIA 7	19	440 - 1,070	< 10 - 472	limestone
Basic research	38	Schönreithbach brook	3	350	< 10	granite
	39	Weyerbach brook	4	380	< 10	limestone
Accident research	40	Innbach brook	3	440	< 20	limestone
	41	River Waldaist	4	560 - 680	265	granite
Non-Target	42	River Aist	1	245	647	granite

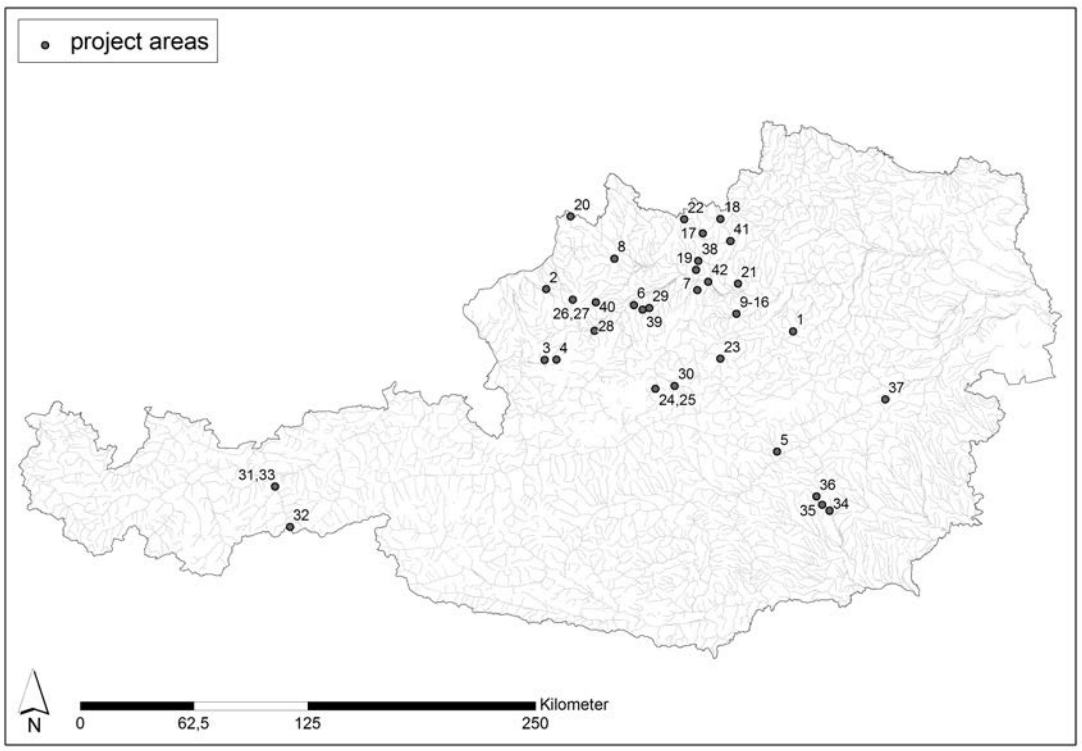

Figure 1: Situation of the project areas,
in which endangered caddisfly species could be recorded.

RESULTS AND DISCUSSIONS

In the course of the 42 applied projects, 72 endangered caddisfly species from 15 families were proven. A total of 292 records of threatened Trichoptera species could be compiled. Eleven of the recorded species are categorised as "near threatened", 45 as "vulnerable", 14 as "endangered" and two as "critically endangered", according to Malicky (2009). The complete list of all detected species, arranged according to families, is provided in table number 2.

Some of the findings are especially noteworthy, as the regarded species are extremely rare and exceptionally seldom found. For *Anomalopterygella chauviniana* (Stein 1874), for example, there has only been one single published record in Austria so far, which dates back to the year 1975 (Malicky, 2009). In 2009, the authors of the present study could prove the presence of *Anomalopterygella chauviniana* in the course of an examination of a wastewater treatment plant in the Feistritz brook in Lasberg, Upper Austria, thus contributing to the knowledge of this extremely rare species by publishing the record in the present paper. In the course of the research for this article, the authors came to know that a few more records of *Anomalopterygella chauviniana* in Austria are supposed to exist (Graf, pers. comm.), but they have not been published and are therefore not available for the scientific community.

Another critically endangered species that is threatened with extinction, *Hydropsyche fulvipes* (Curtis 1834), was found in high numbers in an unnamed Lower Austrian headstream in the context of an EIA. This small brook can, by all means, be regarded as one of the species' few hot-spots in Austria.

The distribution of some caddisfly species is confined to special geological conditions. *Rhyacophila evoluta*, for example, prefers watercourses in granitic areas, whereas *Rhyacophila aurata* is bound to calcareous water, and *Rhyacophila pubescens* is even restricted to calcareous sinter springs (Malicky, 2009). For many species, however, little is known about the preference to either granitic or calcareous watercourses.

The data presented in this paper at hand suggest the assumption that for numerous species there is no obvious correlation between the bedrock type and the occurrence of that specific species. This turned out to be obvious for the frequently found species *Rhyacophila tristis* (Pictet 1834), *Ithytrichia lamellaris* (Eaton 1873), *Hydropsyche angustipennis* (Curtis 1834), *Hydropsyche siltalai* (Döhler 1963), *Plectrocnemia conspersa* (Curtis 1834), *Polycentropus flavomaculatus* (Pictet 1834), *Psychomyia pusilla* (Fabricius 1781), *Micrasema minimum* (McLachlan 1876), *Silo nigricornis* (Pictet 1834), *Silo pallipes* (Fabricius 1781), *Lasiocephala basalis* (Kolenati 1848), *Lepidostoma hirtum* (Fabricius 1775), *Athripsodes albifrons* (Linnaeus 1758) and *Odontocerum albicorne* (Scopoli 1763). All of them were frequently found in the course of applied projects in the Bohemian Massif as well as in the Limestone Alps or the Molasse.

Only a few studied species showed a noticeable preference towards calcareous watercourses, as they never occurred in any of our projects carried out in the Bohemian Massif or the Central Alps. We could detect this preference in *Cheumatopsyche lepida* (Pictet 1834), *Hydropsyche bulbifera* (McLachlan 1878) and *Ceraclea dissimilis* (Stephens 1836). Records found in the ZOBODAT database fully confirmed our assumptions as far as *Hydropsyche bulbifera* is concerned - no data from granitic bedrocks could be found there for this species. Only very sporadic data on the occurrence of *Cheumatopsyche lepida* and *Ceraclea dissimilis* in granitic watercourses exist in the ZOBODAT database, the vast majority of the records originate from calcareous areas - so these species might also prefer limestone to granite, as far as it can be deduced from the available data. Some more species were exclusively found in limestone areas in the course of our applied projects, but their frequency of occurrence was too small to draw some conclusions from that.

Six species were only proven in project areas with granitic bedrock in the projects analysed for the present study, but all of them were so scarcely found that this distribution pattern might not really reflect their actual preference. One of the respective species is *Micrasema longulum* (McLachlan 1876), that was found only in brooks with granitic catchment areas in the course of our applied projects. The records that are listed in the ZOBODAT database confirm the thesis that this species seems to occur exclusively in granitic areas, as the few available data, all originate from the Bohemian Massif. Most of the other species that were restricted to granitic brooks in our surveys appeared to occur in calcareous watercourse areas, as well when the data found in the ZOBODAT database were considered. For the species *Anomalopterygella chauviniana*, at last, the only two published records suggest a preference for granitic areas, but as further records have never been published, it is not possible to confirm that thesis.

Table 2: List of threatened caddisfly species proven in applied projects between 2005 and 2010. EN = Endangered; NT = Near Threatened; VU = Vulnerable.

			Rhyacophilidae	*Rhyacophila fasciata*	*Rhyacophila hirticornis*	*Rhyacophila laevis*	*Rhyacophila obliterate.*	*Rhyacophila polonica/pra.*	*Rhyacophila producta*	*Rhyacophila pubescens*	*Rhyacophila tristis*	**Glossosomatidae**	*Agapetus fuscipes*	*Agapetus ochripes*	*Glossosoma boltoni*	*Glossosoma intermedium*	**Hydroptilidae**	*Hydroptila sparsa*	*Ithytrichia lamellaris*	**Philopotamidae**	*Wormaldia occipitalis*
		IUCN		VU	NT	NT	VU	EN	VU	EN	VU		EN	VU	VU	VU		EN	NT		NT
Success control, monitoring	1	Erlauf									x										
	2	Waldz.											x						x		
	3	Kandlb.									x										
	4	Grömerb.																			
	5	Vordernb.																			
	6	Aiterb.									x										
	7	Enns									x										
	8	Leitenb.																	x		
Examination of sewage treatment plants	9	Url																			
	10	Url																			
	11	Url																			
	12	Url																			
	13	Url																x			
	14	Url																			
	15	Url																			
	16	Url																			
	17	Feistritz																			
	18	Reising.		x							x										
	19	Gusen																			
	20	Kößlb.									x								x		
	21	Klamb.																			
	22	Kettenb.					x														
	23	Gaflenzb.																			
	24	Steyr									x										
	25	Steyr			x						x										
	26	Antiesen						x											x		
	27	Antiesen																	x		
	28	Ager																			
	29	Sipbach									x										
	30	Damb.									x										
EIAs	31	EIA 1														x					
	32	EIA 2							x		x					x					
	33	EIA 3									x					x					
	34	EIA 4									x			x	x						
	35	EIA 5												x							
	36	EIA 6												x							
	37	EIA 7			x	x	x			x	x		x	x							x
Basic research	38	Schönr.																			
	39	Weyerb.																			
Acident research	40	Innbach																			
	41	Waldaist											x								
Non-target	42	Aist																			

Table 2 (continued): List of threatened caddisfly species proven in applied projects between 2005 and 2010; CR = Critically endangered, EN = Endangered, VU = Vulnerable.

			Hydropsychidae	*Cheumatopsyche lepida*	*Hydropsyche angustipen.*	*Hydropsyche bulbifera*	*Hydropsyche fulvipes*	*Hydropsyche incognita*	*Hydropsyche instabilis*	*Hydropsyche saxonica*	*Hydropsyche siltalai*	**Polycentropodidae**	*Cyrnus trimaculatus*	*Plectrocnemia brevis*	*Plectrocnemia conspersa*	*Plectrocnemia geniculata*	*Polycentropus flavomac.*	*Polycentropus irroratus*
		IUCN		VU	VU	VU	CR	VU	VU	VU	EN		VU	VU	VU	VU	VU	VU
Success control, monitoring	1	Erlauf			x													
	2	Waldz.						x	x		x						x	
	3	Kandlb.			x					x								
	4	Grömerb.							x									
	5	Vordernb																
	6	Aiterb.			x			x							x			
	7	Enns						x									x	
	8	Leitenb.				x		x	x		x						x	
Examination of sewage treatment plants	9	Url		x	x								x				x	
	10	Url			x					x							x	x
	11	Url		x	x													
	12	Url		x	x								x		x		x	
	13	Url			x								x				x	
	14	Url		x									x					
	15	Url		x		x							x			x	x	
	16	Url		x	x													
	17	Feistritz						x			x					x	x	
	18	Reising.			x										x			
	19	Gusen						x										
	20	Kößlb.			x			x									x	
	21	Klamb.						x							x			
	22	Kettenb.									x							
	23	Gaflenzb.			x													
	24	Steyr				x				x								
	25	Steyr								x								
	26	Antiesen								x								
	27	Antiesen		x		x		x			x						x	
	28	Ager		x				x			x						x	
	29	Sipbach			x			x									x	
	30	Damb.				x				x								
EIAs	31	EIA 1																
	32	EIA 2																
	33	EIA 3																
	34	EIA 4						x								x	x	
	35	EIA 5			x			x										
	36	EIA 6						x									x	
	37	EIA 7					x	x							x	x		
Basic research	38	Schönr.													x			
	39	Weyerb.							x	x	x			x				
Accident research	40	Innbach			x													
	41	Waldaist						x										
Non-target	42	Aist																

Table 2 (continued): Threatened caddisfly species proven in applied projects in 2005 - 2010. CR = Critically endangered; EN = Endangered; NT = Near Threatened; VU = Vulnerable.

			Psychomyiidae	*Lype phaeopa*	*Lype reducta*	*Psychomyia pusilla*	*Tinodes unicolor*	**Brachycentridae**	*Micrasema longulum*	*Micrasema minimum*	*Micrasema setiferum*	*Oligoplectrum maculatum*	**Limnephilidae**	*Acrophylax zerberus*	*Anabolia furcata*	*Anomalopterygella chauv.*	*Chaetopteryx major*	*Chaetopteryx fusca/villosa*	*Consorophylax consors*	*Drusus chrysotus*
		IUCN		EN	EN	VU	VU		EN	VU	EN	EN		EN	EN	CR	VU	VU	NT	NT
Success control, monitoring	1	Erlauf								x	x									
	2	Waldz.				x														
	3	Kandlb.				x														
	4	Grömerb.																		
	5	Vordernb.								x										
	6	Aiterb.																x		
	7	Enns				x					x									
	8	Leitenb.				x									x					
Examination of sewage treatment plants	9	Url				x														
	10	Url				x														
	11	Url				x														
	12	Url																		
	13	Url		x														x		
	14	Url																		
	15	Url									x									
	16	Url																		
	17	Feistritz				x						x			x	x				
	18	Reising.																		
	19	Gusen				x						x								
	20	Kößlb.				x			x	x										
	21	Klamb.				x					x									
	22	Kettenb.				x									x		x	x		
	23	Gaflenzb.																		
	24	Steyr								x									x	
	25	Steyr								x										
	26	Antiesen																x		
	27	Antiesen																		
	28	Ager				x														
	29	Sipbach																		
	30	Damb.								x									x	
EIAs (Environmental Impact Assessments)	31	EIA 1																		
	32	EIA 2																		
	33	EIA 3																		
	34	EIA 4				x														
	35	EIA 5				x						x								
	36	EIA 6				x														
	37	EIA 7					x			x				x				x		x
Basic research	38	Schönr.																		
	39	Weyerb.																		
Accident research	40	Innbach			x															
	41	Waldaist				x			x	x										
Non-target	42	Aist										x								

Table 2 (continued): List of threatened caddisfly species proven in applied projects between 2005 and 2010. EN = Endangered; VU = Vulnerable.

			Limnephilidae (cont.)	*Drusus monticola*	*Ecclisopteryx dalecarlica*	*Ecclisopteryx guttulata*	*Halesus digitatus*	*Halesus radiatus*	*Halesus tesselatus*	*Micropterna lateralis*	*Potamophylax cingulatus*	*Potamophylax luctuosus*	*Potamophylax rotundip.*	**Goeridae**	*Goera pilosa*	*Silo nigricornis*	*Silo pallipes*	*Silo piceus*
		IUCN		EN	VU	VU	VU	VU	VU	VU	VU	VU	EN		VU	VU	VU	VU
Success control, monitoring	1	Erlauf															x	
	2	Waldz.														x		
	3	Kandlb.														x	x	
	4	Grömerb.					x											
	5	Vordernb.		x													x	
	6	Aiterb.														x		
	7	Enns																
	8	Leitenb.					x		x				x			x		
Examination of sewage treatment plants	9	Url							x						x			
	10	Url																
	11	Url													x			
	12	Url																
	13	Url																
	14	Url																
	15	Url														x		
	16	Url																
	17	Feistritz							x				x					
	18	Reising.					x		x								x	
	19	Gusen																x
	20	Kößlb.														x	x	
	21	Klamb.																
	22	Kettenb.					x						x				x	
	23	Gaflenzb.																
	24	Steyr																
	25	Steyr																
	26	Antiesen																
	27	Antiesen																
	28	Ager																
	29	Sipbach																
	30	Dambach																
EIAs	31	EIA 1								x								
	32	EIA 2																
	33	EIA 3																
	34	EIA 4															x	
	35	EIA 5																
	36	EIA 6															x	
	37	EIA 7				x	x		x			x	x			x	x	
Basic research	38	Schönr.																
	39	Weyerb.						x			x	x						
Accident research	40	Innbach																
	41	Waldaist			x											x	x	
Non-target	42	Aist																

Table 2 (continued): List of threatened caddisfly species proven in applied projects between 2005 and 2010. CR = Critically endangered; NT = Near Threatened; VU = Vulnerable.

			Lepidostomatidae	*Crunoecia kampnyi*	*Lasiocephala basalis*	*Lepidostoma hirtum*	**Leptoceridae**	*Adicella filicornis*	*Adicella reducta*	*Athripsodes albifrons*	*Athripsodes bilineatus*	*Athripsodes cinereus*	*Ceraclea dissimilis*	*Oecetis testacea*	**Sericostomatidae**	*Sericostoma flavicorne/person.*	**Beraeidae**	*Beraea pullata*	*Ernodes articularis*	**Odontoceridae**	*Odontocerum albicorne*
		IU CN		NT	VU	VU		NT	NT	VU	VU	VU	VU	VU		VU/ CR		NT	NT		VU
Success control, monitoring	1	Erlauf																x			
	2	Waldz.				x										x					x
	3	Kandlb.														x					
	4	Grömerb.																			
	5	Vordernb.																			
	6	Aiterb.														x					x
	7	Enns				x															
	8	Leitenb.				x						x	x	x							
Examination of sewage treatment plants	9	Url			x					x		x	x								
	10	Url			x																
	11	Url								x		x	x								
	12	Url				x															
	13	Url																			
	14	Url																			
	15	Url								x	x	x	x								
	16	Url				x						x									
	17	Feistritz			x	x			x		x										
	18	Reising.																			
	19	Gusen			x																
	20	Kößlb.			x				x							x					
	21	Klamb.				x															
	22	Kettenb.			x					x	x			x							x
	23	Gaflenzb.			x											x					
	24	Steyr																			x
	25	Steyr																			
	26	Antiesen																			
	27	Antiesen																			
	28	Ager				x				x			x								
	29	Sipbach			x																
	30	Damb.																			x
EIAs (Environmental Impact Assessments)	31	EIA 1																			
	32	EIA 2														x					
	33	EIA 3																			
	34	EIA 4									x					x					
	35	EIA 5				x															
	36	EIA 6																			
	37	EIA 7		x				x								x			x		x
Basic research	38	Schönr.																			
	39	Weyerb.																			
Accident research	40	Innbach																			
	41	Waldaist			x											x					x
Non-target	42	Aist																			

The frequency of occurrence (the total number of project areas in which each species could be proven) differed markedly between the detected species. There was a high number of species that were found only in one location, whereas only very few species appeared in more than ten different project areas (Tab. 3).

Table 3: Frequency of occurrence of the 72 proven caddisfly species.

Frequency of occurrence	Species	Number of species
1	*Rhyacophila fasciata, R. laevis, R. polonica/praemorsa, R. producta, R. pubescens, Glossosoma boltoni, Hydroptila sparsa, Wormaldia occipitalis, Hydropsyche fulvipes, Plectrocnemia brevis, Polycentropus irroratus, Lype phaeopa, L. reducta, Tinodes unicolor, Acrophylax zerberus, Anomalopterygella chauviniana, Chaetopteryx major, Drusus chrysotus, D. monticola, Ecclisopteryx dalecarlica, E. guttulata, Halesus radiatus, Micropterna lateralis, Potamophylax cingulatus, Silo piceus, Crunoecia kempnyi, Adicella filicornis, Beraea pullata, Ernodes articularis*	29
2	*Rhyacophila hirticornis, R. obliterata, Micrasema longulum, Consorophylax consors, Potamophylax luctuosus, Goera pilosa, Adicella reducta, Oecetis testacea*	8
3	*Agapetus fuscipes, Glossosoma intermedium, Anabolia furcata*	3
4	*Agapetus ochripes, Hydropsyche instabilis, Plectrocnemia geniculata, Micrasema setiferum, Oligoplectrum maculatum, Potamophylax rotundipennis, Athripsodes bilineatus*	7
5	*Ithytrichia lamellaris, Hydropsyche bulbifera, Cyrnus trimaculatus, Chaetopteryx villosa/fusca, Halesus digitatus, H. tesselatus, Athripsodes albifrons, A. cinereus, Ceraclea dissimilis*	9
6	*Plectrocnemia conspersa*	1
7	*Hydropsyche siltalai, H. saxonica, Odontocerum albicorne*	3
8	*Cheumatopsyche lepida, Silo nigricornis, Micrasema minimum*	3
9	*Lasiocephala basalis, Lepidostoma hirtum, Sericostoma flavicorne/personatum*	3
10	*Silo pallipes*	1
14	*Rhyacophila tristis*	1
15	*Hydropsyche angustipennis, Polycentropus flavomaculatus*	2
16	*Hydropsyche incognita/pellucidula*	1
17	*Psychomyia pusilla*	1

A plot of the frequency of occurrence versus the number of species having occurred with a certain frequency is given in figure number 2. It is clearly discernible that species that were found only in one or a few project areas outnumbered those that occurred in many

different investigated areas by far. Furthermore, it is obvious that the most endangered species, being listed as either "critically endangered" or "endangered", exhibit a low frequency of occurrence, whereas those that were found in many different project areas all over Austria are mostly considered "vulnerable".

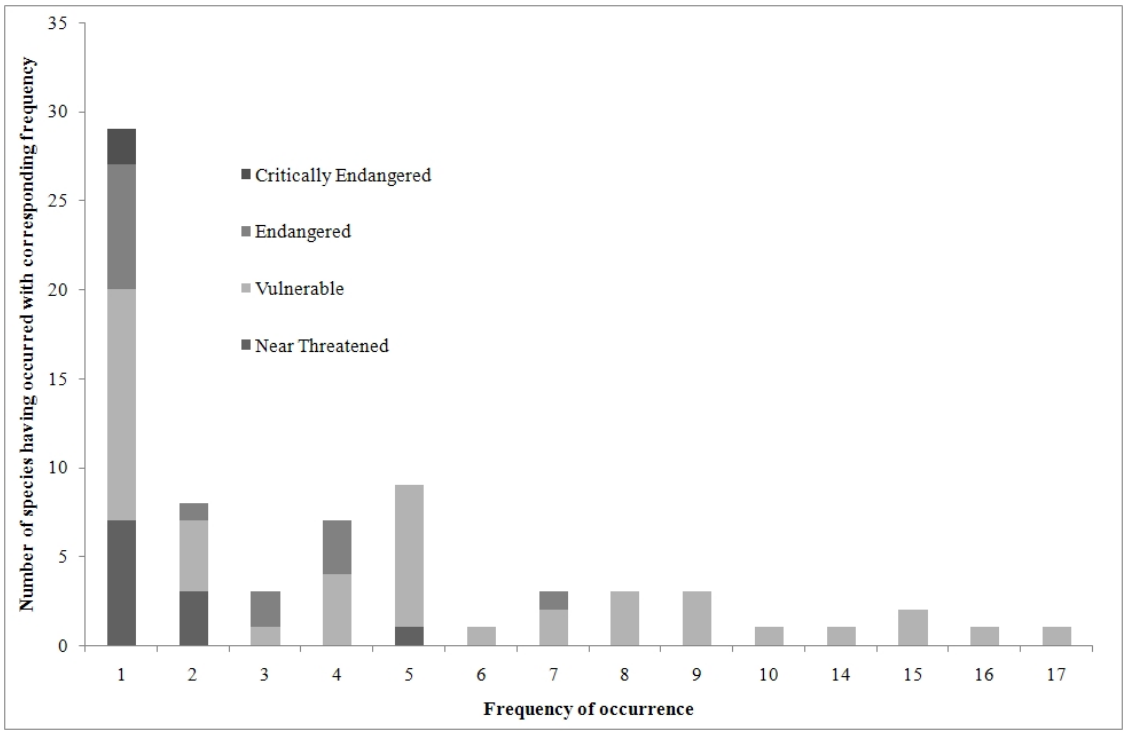

Figure 2: Frequency of occurrence plotted versus number of species having occurred with corresponding frequency.

Critically endangered species are threatened with extinction. This risk category means that a species' number have already decreased or will decrease by 50% within ten years or three generations, respectively (IUCN, 2001). In the paper at hand, two species listed in this category can be recorded. In the case of both *Anomalopterygella chauviniana* and *Hydropsyche fulvipes*, the main reason for their endangerment is habitat loss (Malicky, 2009). Both species could only be recorded in one single out of 42 possible project areas, which reflects their obviously highly justified classification.

On the other hand, we found a variety of species considered "vulnerable" (which means that their probability of extinction within the next 100 years equals 10%), that occurred in many different project areas. The species with the highest frequency of occurrence, *Psychomyia pusilla*, was found in the course of 17 different projects all over Austria. An even wider distribution was worked out for *Rhyacophila tristis* that occurred in 14 areas from the westernmost to the easternmost investigated project site (Fig. 3). For both species habitat loss is considered to be the reason for their decrease. The frequent appearance of the two species all over the country, mostly even in high numbers, suggests the assumption that an analysis of all recent records might, if interlinked, possibly reveal higher actual population numbers than currently assumed.

Finally, there is quite a large number of species that are currently listed in the lowest risk category, “near threatened”, but were only found in one or two different project sites by the authors of the paper at hand. This narrow range of distribution, combined with consistently low numbers of specimens, suggests that the actual populations might be really scarce and endangered.

The assumptions derived from our results are only to be perceived as general ideas suggested by the distribution patterns and numbers of specimens we have found; for a statistically significant verification of the thesis given a synopsis of as many current data as possible is indispensable.

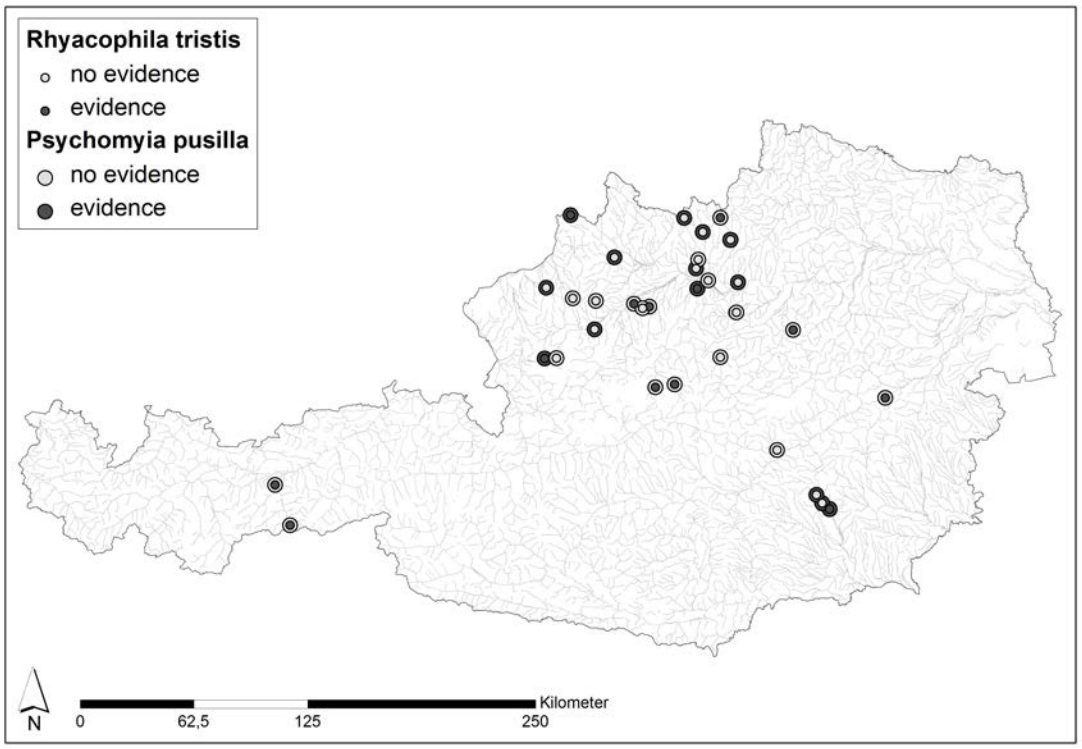

Figure 3: Recent records of the threatened species *Rhyacophila tristis* and *Psychomyia pusilla* in Austria.

CONCLUSIONS

The results of applied projects can provide the scientific community with essential information on the distribution of endangered species. In the present paper recent records of 72 caddisfly species from the current red list are published. These records were obtained in the course of 42 applied projects all over Austria. As the observed watercourses covered a wide range of different types of running waters with very small to very large catchment areas and different predominant bedrock types, the results can be considered highly representative.

Several national and European Union wide guidelines request a considerable amount of applied surveys that are the basis for decision-making in the course of planned construction projects. As in the context of new guidelines, such as the European Union Water Framework Directive or the European Community Habitats Directive, large quantities of data have to be collected, a consolidation of these data appears to be the reasonable next step. Currently, data from EIAs, efficiency controls or ascertainments of loss are usually not published. Therefore, institutions that try to collect data, like in the ZOBODAT specific database, deserve to be financially and with in kind work supported. Presently, data found in such databases originate mostly from scientific treatises or were provided by interested naturalists and often date back to the early 20th century or even further, whereas current data are comparably scarce. The paper at hand shows how much information can be gained from current data collected by consultancies, agencies or engineering offices in the course of applied projects.

As a matter of fact, the aspects mentioned above do not apply only to the subject of this paper, but to all taxonomic groups. In respect to the fish fauna, for example, the collection of data from applied projects is comparably well advanced in Austria. The Federal Ministry of Agriculture, Forestry, Environment and Water Management have developed an Austrian Fish Database (FDA) where data from projects that are carried out in the course of the European Union Water Framework Directive are collected. But yet again, the circulation of data from applied surveys is optional. As with benthic invertebrates, applied projects can offer the opportunity to detect notable species. In Upper Austria, for example, the golden spined loach, *Sabanejewia balcanica* (Karaman 1922), was recorded for the first and second time in the course of two applied studies (Gumpinger et al., 2008; Csar and Gumpinger, 2009).

To sum it all up, the large amounts of data that are produced in the course of applied projects all over Europe, be it due to national or EU-wide guidelines and directives, are a relevant source of information in both basic research and species conservation. The interchange of data must be given priority in order not to lose valuable information on the current distribution of endangered species.

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REFERENCES

1. Austrian Standards Institute, 1997 – Guidelines for the ecological study and assessment of rivers (bilingual edition), *ÖNORM* M6232, 1-84.
2. Council of the European Communities, 1985 − Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, *Official Journal*, no. L 175, 05/07/1985, 0040-0048.
3. Council of the European Communities, 1992 – Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
4. Csar D. and Gumpinger C., 2009 – Die Migration der Fischfauna im Unterlauf der Aist, i. a. des Amtes der Oö, Landesregierung, Direktion Umwelt und Wasserwirtschaft, *Abteilung Oberflächengewässerwirtschaft*, Wels, 100. (in German)
5. European Parliament and Council of the European Communities, 2000 – Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
6. Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2010a – Leitfaden zur Erhebung der biologischen Qualitätselemente, Teil A1 - Fische, Vienna, 82. (in German)
7. Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2010b – Leitfaden zur Erhebung der biologischen Qualitätselemente, Teil A2 - Makrozoobenthos, Vienna, 226. (in German)
8. Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2010c – Leitfaden zur Erhebung der biologischen Qualitätselemente, Teil A3 - Phytobenthos, Vienna, 96. (in German)
9. Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2010d – Leitfaden zur Erhebung der biologischen Qualitätselemente, Teil A4 - Makrophyten, Vienna, 66. (in German)
10. Graf W. and Konar M., 1999 – Rote Liste der Steinfliegen Kärntens, in: Holzinger W. E., Ildner P. M., Rottenburg T. and Wieser C. (eds): Rote Listen gefährdeter Tiere Kärntens, Naturschutz in Kärnten 15, 489-496. (in German)
11. Gumpinger C., Ratschan C., Schauer M., Wanzenböck J. and Zauner G., 2008 – Artenschutzprojekt Kleinfische und Neunaugen in Oberösterreich. Bericht über das Projektjahr 2008, i. a. des Amtes der Oö. Landesregierung, Abt. Naturschutz, Abt. Oberflächengewässerwirtschaft, Abt. Land- und Forstwirtschaft, Oö, *Umweltanwaltschaft, Oö. Naturschutzbund und Landesfischereiverband Oö*., Wels, 116. (in German)
12. IUCN, 2001 – IUCN Red List Categories and Criteria: Version 3.1, IUCN Species Survival Commission, Gland, Switzerland and Cambridge, 30.
13. IUCN, 2010 – IUCN Red List of Threatened Species, Version 2010.1.
14. Malicky H., 2009 – Rote Liste der Köcherfliegen Österreichs (Insecta, Trichoptera), in: K. P. Zulka (ed.) - *Rote Listen gefährdeter Tiere Österreichs, Lebensministerium, Grüne Reihe Band* 14/3, 319-358. (in German)
15. Waringer J. and Graf W., 1997 – Atlas der österreichischen Köcherfliegenlarven unter Einschluss der angrenzenden Gebiete, Facultas Universitätsverlag, Vienna, 286. (in German)
16. Waringer J. and Graf W., 2000 – Trichoptera Austriaca, Bestimmungstabellen für die österreichischen Köcherfliegenarten (Imagines), based on Malicky H., Junk Publishers, 1983, 103. (in German)

17. Waringer J. and Graf W., 2004 – Ergänzungen und Berichtigungen zum „Atlas der österreichischen Köcherfliegenlarven unter Einschluss der angrenzenden Gebiete", Facultas Universitätsverlag, Vienna, 30. (in German)

BARBUS MERIDIONALIS RISSO 1827 (SYN. *BARBUS BALCANICUS*): PROPOSAL FOR MONITORING ELEMENTS FOR CROATIA, IN THE CONTEXT OF NATURA 2000

Doru BĂNĂDUC *
and *Angela CURTEAN-BĂNĂDUC* **

* "*Lucian Blaga*" University of Sibiu, Faculty of Sciences, Dr. Ion Raţiu Street 5-7, Sibiu, Sibiu County, Romania, RO-550012, ad.banaduc@yahoo.com

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KEYWORDS: Mediterranean barbell, specific monitoring, Croatia, Danube Watershed.

ABSTRACT

The action framework at the European Union level for the protection of biodiversity was established based on the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC). One main element of the future implementation of these Directives in Croatia is the establishment of a Natura 2000 network of special protection sites, a network which should rely on a specific monitoring plan at national level for each species of community interest. In this context, the present study proposes a set of monitoring elements for *Barbus meridionalis* for the Croatian Continental Biogeographical Region. The proposal is based on seven main criteria: proximity of national border, high quality populations, habitats which should be ecologically reconstructed, key habitats/sectors with high importance for connectivity, point sources of industrial pollution, areas/sectors influenced by diffuse sources of agricultural pollution, and areas/sectors influenced by habitat modifications.

ZUSAMMENFASSUNG: *Barbus meridionalis* Risso 1827 (Syn. *Barbus balcanicus*) Vorschläge von Monitoringelementen für Kroatien im Natura 2000 Kontext.

Der Aktionsrahmen auf EU-Ebene für den Schutz der Biodiversität wurde auf Grundlage der FFH Richtlinie (92/43/EEC) und der Vogelschutzrichtlinie (79/409/EEC) festgelegt. Ein Hauptelement der zukünftigen Umsetzung dieser Richtlinienin in Kroatien ist die Einrichtung auf nationaler Ebene des Natura 2000 Netzwerks besonders geschützter Gebiete, ein Netzwerk das auf einem spezifischen, auf nationaler Ebene für jede Art von gemeinschaftlichem Interesse angelegten Monitoringplan beruhen muss.

In diesem Kontext beabsichtigte die vorliegende Studie ein Paket von Monitoringelementen für *Barbus meridionalis* für die Kontinentale Biogeographische Region Kroatiens vorzuschlagen. Der Vorschlag beruht auf sieben Hauptkriterien: die Nähe der nationalen Grenze, Populationen von hoher Qualität, Habitate, die ökologisch renaturiert werden müssen, Schlüssel-Habitate/Abschnitte von besonderer Bedeutung für die Konnektivität, für Quellen punktueller industrieller Verschmutzung durch, Bereiche/Abschnitte, die durch diffuse Verschmutzung aus der Landwirtschaft beeinflusst sind sowie Bereiche/Abschnitte, die von Veränderungen der Habitate beeinflusst sind.

REZUMAT: *Barbus meridionalis* Risso 1827 (sin. *Barbus balcanicus*) propuneri de elemente de monitoring pentru Croaţia, în contextul Natura 2000.

Cadrul de acţiune la nivelul Uniunii Europene, pentru protecţia biodiversităţii a fost stabilit pe baza Directivei Habitate (92/43/EEC) şi a Directivei Păsări (79/409/EEC). Un element principal al implementării acestor directive în Croaţia este stabilirea reţelei de arii de protecţie specială Natura 2000, o reţea care trebuie să se bazeze pe monitoringul la nivel naţional pentru fiecare specie de interes comunitar.

În acest context, prezentul studiu are ca finalitate propunerea unui set de elemente de monitoring pentru *Barbus meridionalis* pentru Regiunea Biogeografică Continentală din Croaţia, propunere bazată pe şapte criterii principale: proximitatea graniţelor naţionale, populaţii de calitate ridicată, habitate care trebuie reconstruite din punct de vedere ecologic, habitate/sectoare cheie cu importanţă ridicată pentru conectivitate, surse de poluare industrială punctiforme, arii/sectoare influenţate de surse difuze din agricultură, arii/sectoare influenţate de modificări ale habitatelor.

INTRODUCTION

In the near future (June-July 2013), it is expected that a new country, Croatia, will join the European Union, which will bring new obligations for this country in terms of nature protection and conservation, in a similar manner with all the older E. U. countries.

The primary aims of the European Community administration representatives in the environment field of interest are the protection, conservation and improving of the environment elements and structure quality for a better use of the natural resources and services of the ecosystems, including the aquatic ecosystems. During the past decades the biodiversity was one of the main issues in this respect.

The action frame at the European Community level, to handle the biodiversity issue was established based on the Habitats Directive (92/43/EEC) and Birds Directive (79/409/EEC). These two very important European Directives have as their main objective to conserve the biodiversity in the European Union based on a protected areas network, namely the Natura 2000 net, to protect essential habitats and species characteristic for all the European biogeographic regions: Arctic, Boreal, Atlantic, Continental, Alpine, Pannonian, Mediterranean, Macaronesian, Steppic, Black Sea and Anatolian (Fig. 1).

Croatia has a relatively high biogeographic diversity among the current and future European Union countries, comprising a total of four biogeographic regions: Continental, Alpine, Pannonian and Mediteranean (Fig. 1).

One main element of the future implementation of the Directives is the establishment of an optimum Natura 2000 network in Croatia too, a network which should rely on a specific monitoring plan at the national level for each habitat and species of European conservative concern. The near future joining of Croatia to EU makes this type of monitoring proposal an important element for future management and conservation related plans in this country.

The range of *Barbus meridionalis* includes the Danube, Nistru/Dniester, Odra, Vistula and Vardar watersheds. It is present also in the Croatian national territory, only in the Danube Watershed, and also in its neighboring countries: Slovenia, Hungary, Serbia, Bosnia and Herzegovina and Montenegro. This species can be found also in the proximity of Croatia, in Italy and Macedonia. Until now, distribution data about *Barbus meridionalis* in Croatia were not systematically collected. It often disappeared/was not found in some areas and reappeared in nearby areas. The sporadic presence/knowledge regarding this species in Croatia is known based on the last few decades of studies in Sava, Drava, Kupa and their tributaries basins. In some of the Croatian Danube Basin areas this species is common or very common.

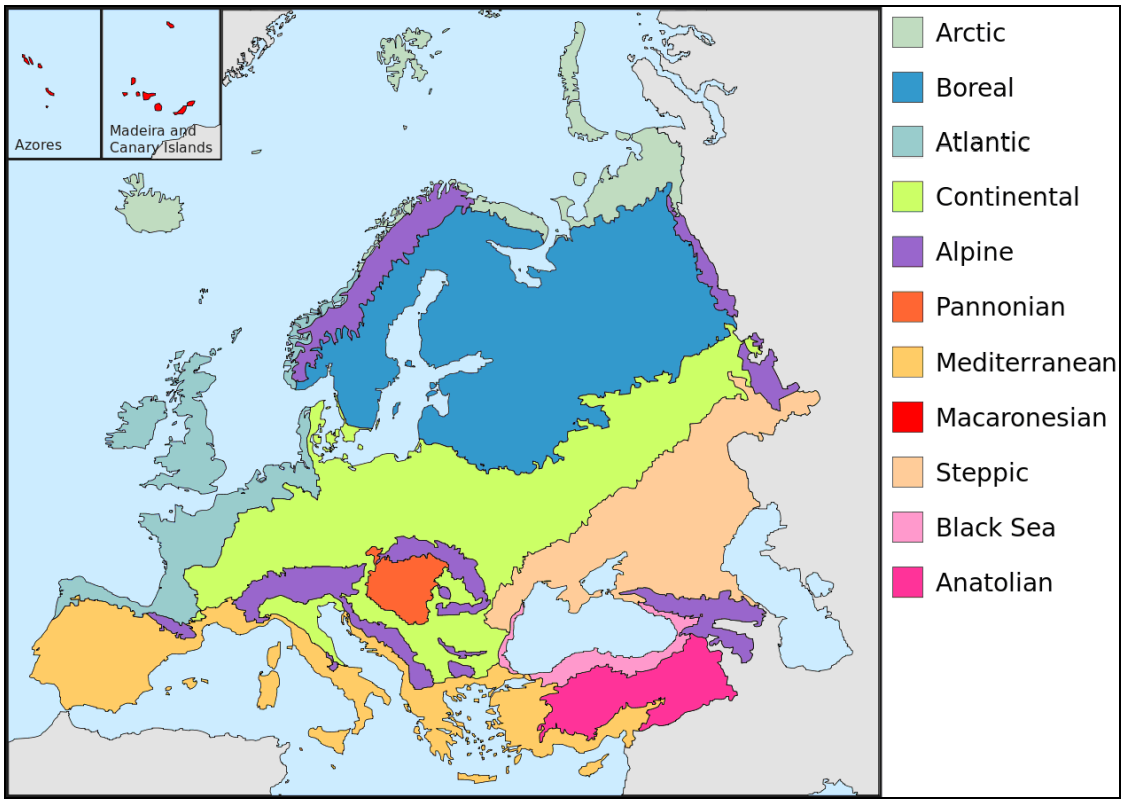

Figure 1: European biogeographic regions;
European Environment Agency - www.eea.eu.in.

There has been no national permanent/long term specific monitoring on the distribution or population, ecologic status of this fish species, not all areas were studied in this respect, including those for the proposal of Natura 2000 sites. Still, it is considered relatively well spread and common on the Croatian territory, in the Danube Basin, mainly in the European Continental Biogeographical Region, in the suitable habitats, with an exception of the Alpine Biogeographical Region, in the Kupa River area, in the very proximity of the Continental Biogeographical Region. There has been no national permanent/long term specific monitoring on distribution or population, ecologic status of this fish species, not all areas were studied in this respect, including those for the proposal of Natura 2000 sites. Still, it is considered relatively well spread and common on the Croatian territory, in the Danube Basin, mainly in the European Continental Biogeographical Region, in the suitable habitats, with an exception of the Alpine Biogeographical Region, in the Kupa River area, in the very proximity of the Continental Biogeographical Region. That is why it was considered needing a monitoring program only for the Continental Biogeographical Region in Croatia.

The range and abundance of this species in the Croatian Continental Biogeographical Region, in suitable habitats, can be considered as relatively high. Assessments have been done so far in the following areas, proposed as pSCI sites: rivers Kupa (15-30% considered proportion of the population in relation to the size of the population at the national level), Korana (2-15%), Dobra (15-30%), Mrežnica (15-30%), Petrinjčica (2%), Bednja (2%), Sutla (2%) and streams in Medvednica (2%) and Papuk (2%) areas.

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

Barbus meridionalis was included in the Habitats Directive (92/43/EC). In the Central and Eastern Europe it is a rather a common species with a high potential as an umbrella species, a similar situation exists in Croatia as well.

In spite of the fact that no exhaustive data about this fish species distribution in the Croatian national territory is available in the present, a relatively common situation in other European countries as well, the present known data represent reliable data for the proposal of a long term monitoring elements proposal for Croatia.

Barbus meridionalis is reophilic, lithophilic and benthopelagic freshwater fish that lives in habitats with water temperature which does not exceed 25˚C in streams up to 500 m above sea level. It is a short-living species which is found in mountainous, hilly and some lowland rivers with suitable habitats. It prefers clear and fast flowing water sectors and hard substrata.

It reaches sexual maturity in the second or third year of life. Reproduction happens is taking place in the spring, sometimes is prolonged till the summer (from May to July). At the time of spawning, it gathers in flocks and moves upstream in search of favourable habitats with gravel and stones. The food of young fish consists mainly of benthic aquatic invertebrates (tendipedes, ephemeropterans, trichopterans, gamarids, oligochetes, etc.) and vegetation debris. There is also information about the fact that the adults feed on fish fries and alevines too.

Barbus meridionalis is listed in Annexes II and IV of the Habitats Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC), in the Annex III of the Berne Convention, and in the Croatian Nature Protection Law (a strictly protected species). In the Croatian territory, it is considered to be a vulnerable (VU) species.

Barbus meridionalis is threatened in general by the decrease of the proper habitats (for spawning, schooling, feeding, sheltering, etc.) quality due to pollution, habitat modification, degradation, destruction, disappearance (channelling, watercourses regulation, remodelling, etc.), flow regulation and water abstraction. Non-indigenous species can have a negative impact on this species. At present, significant fluctuations are noted in the number of this species location and subpopulations are noted.

The conservation measures should target a good conservation status, which should reflect a good balance of the sum of the influences acting on this species that may affect its long-term survival. In this respect specific measures are needed where the local situation requires action: preserving and improving the favorable ecological balance of the natural waters inhabited by this species, protected areas for fish (reserves) of conservative interest, preventing and avoiding of water and sediment flow regulation as much as possible keeping them close to the natural regime, bans of alien/invasive species entry and reproduction, construction of appropriate devices for water recycling, avoiding lotic fragmentations due to different categories of buildings in the river bed, etc. All of these issues cannot be approached on long therm without a functional monitoring system, specific for this species.

RESULTS AND DISCUSSIONS

The main result of this study is intended to be a proposal of a set of monitoring elements for *Barbus meridionalis* for the Croatian Continental Biogeographical Region. The monitoring elements are based on the present distribution data of this species and on the existing main human induced threats in the area of interest. Based on the overlapping of the actual data of distribution of this species on the human induced disturbed/hot spots lotic

sectors, the scale of a monitoring grid can be established and the monitoring frequency in time and space can be revealed and proposed. Any other "theoretical/blind" approach in establishing the spatial and temporal frame of this species monitoring can be in the best case an intellectual exercise, which will more or less fail sooner or later in terms of accuracy of the obtained results, and bring to many important and costly later on adjustments of the initial monitoring system. As far as the lotic systems are dynamic, even in the best approached monitoring proposals, in time, the monitoring systems will require some adjustments.

The proposed *Barbus meridionalis* monitoring sites, at the Croatian national level/Continental Biogeographical Region, were selected based on seven main criteria: ❶ national border proximity areas/sectors coverage; ❷ high quality populations of *Barbus meridionalis* in terms of populational structure/density (ex. protected areas but not only) in characteristic/optimum/good habitats; ❸ habitats which should be ecologically reconstructed to allow *Barbus meridionalis* populations structure improving or natural repopulation; ❹ key habitats/sectors with high importance for connectivity (ex. rivers confluence areas; intermediate lotic sectors between different important populational areas); areas/sectors negatively influenced by human impact, such as: ❺ industrial pollution point sources, ❻ areas/sectors influenced by agricultural pollution diffuse sources, ❼ areas/sectors influenced by habitats modifications (channeling, watercourses regulation, remodeling, etc.).

It should also be stated that the potential future improvement of the *Barbus meridionalis* species distribution data on the Croatian territory, can improve the monitoring proposals situation, the process of improving this specific monitoring system should be a permanent one.

Spatial monitoring elements

❶ National border proximity areas of interest coverage

These monitoring sections were selected due to their importance for future international monitoring methods and systems intercalibrations, and for real time data exchange and checking. Also, these sections represent the national limits of the Croatian responsibility for preserving/improving this fish species conservation status. These monitoring stations should be done once every year.

Based on this monitoring criterion, nine monitoring sections (Fig. 2, ❶) were selected/proposed.

Three sampling sections were proposed on Kupa River, which would be monitored once per year, along the 118 km long north-west Croatian - south-east Slovenian border, with around 50 km among them (section 1, road access to Kupa River from Mandli locality; section 2, aproximativelly 50 km downstream; section 3, road access to a bridge over Kupa River from Cerje Vivodinsko or Preseka Ozaljska localities).

Two sampling sections were proposed on Sutla River, which would be monitored once per year, along the Croatian - Slovenian border, with an around of 50 km among them (section 1, road access to Sutla and bridge from Gruškovje locality; section 2, aproximativelly 50 km downstream).

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

One station should be on Korana River, which would be monitored once per year, on the Croatian - Bosnia-Hertzegovina border (road access and bridge in proximity of Kosa locality).

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

Another sampling station was proposed in the proximity of the southern Croatian-Bosnia and Herzegovina border on the Una River, in the Hrvatska Dubica locality, with road access from the road number 47.

Any human impact from the upstream located countries which can induce qualitative (species disappearance) and quantitative (relative abundance) modifications of the monitored populations, will create a negative future prospects related to this species habitat quality, range and conservation status, long-term viability, situation which should be assessed once a year at a national level.

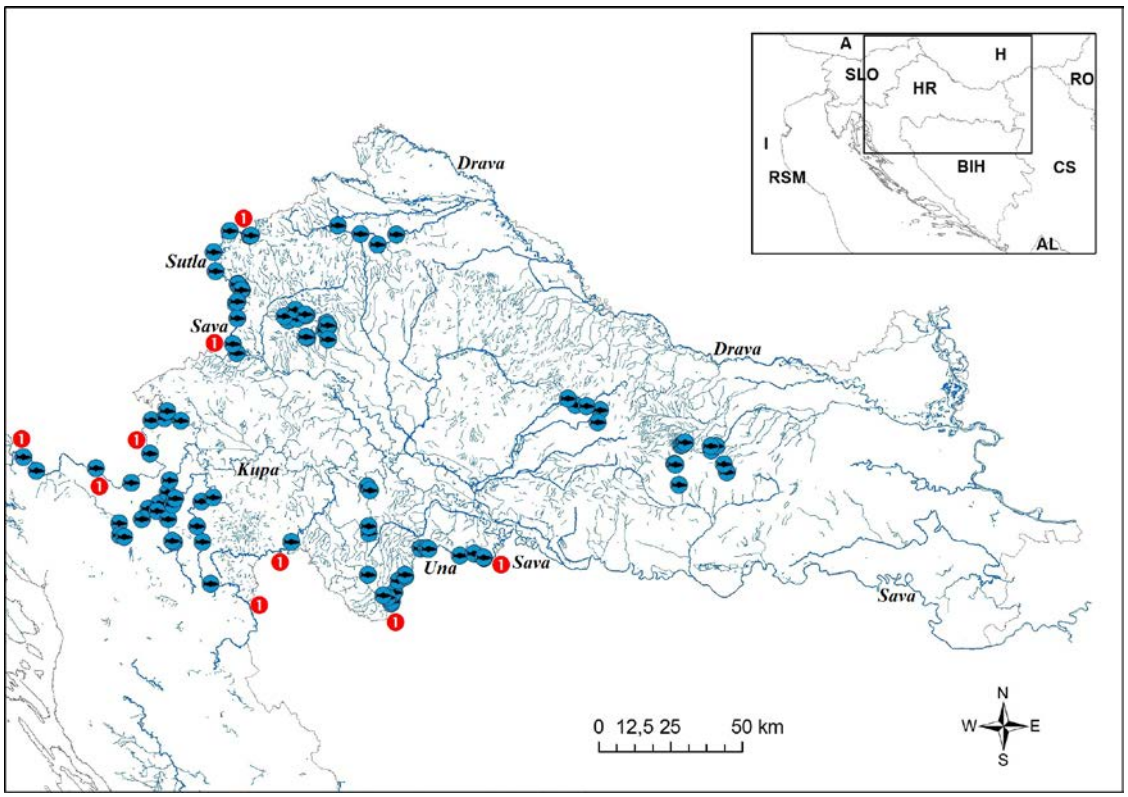

Figure 2: *Barbus meridionalis* proposed monitoring sections (❶),
based on the Croatian national border proximity areas of interest coverage criteria.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

❷ Excellent quality populations of *Barbus meridionalis* in terms of population structure/density in characteristic/optimum/good habitats.

This second category of monitoring sections were chosen due to their genetic value/importance for keeping a healthy status of this species populations in Croatia and in the neighboring countries, and for the potential of natural repopulation of areas where this species can exist and spread in the future. Based on this monitoring criteria three monitoring sections (Fig. 3; ❷) were selected/proposed.

One sampling section was proposed in the Nature Park Žumberak - Samoborsko gorje, at 30 kilometers south-west of Zagreb, with tributaries of Sava River, sampling activities are needed once per every six years if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

One sampling section should be in the Nature Park Medvenica, in the vicinity of Zagreb, with tributaries of Sava River, sampling activities are needed once per every six years if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

One sampling section should be in the Nature Park Papuk, with tributaries both of Drava and Sava rivers basins, sampling activities are needed once per six years if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

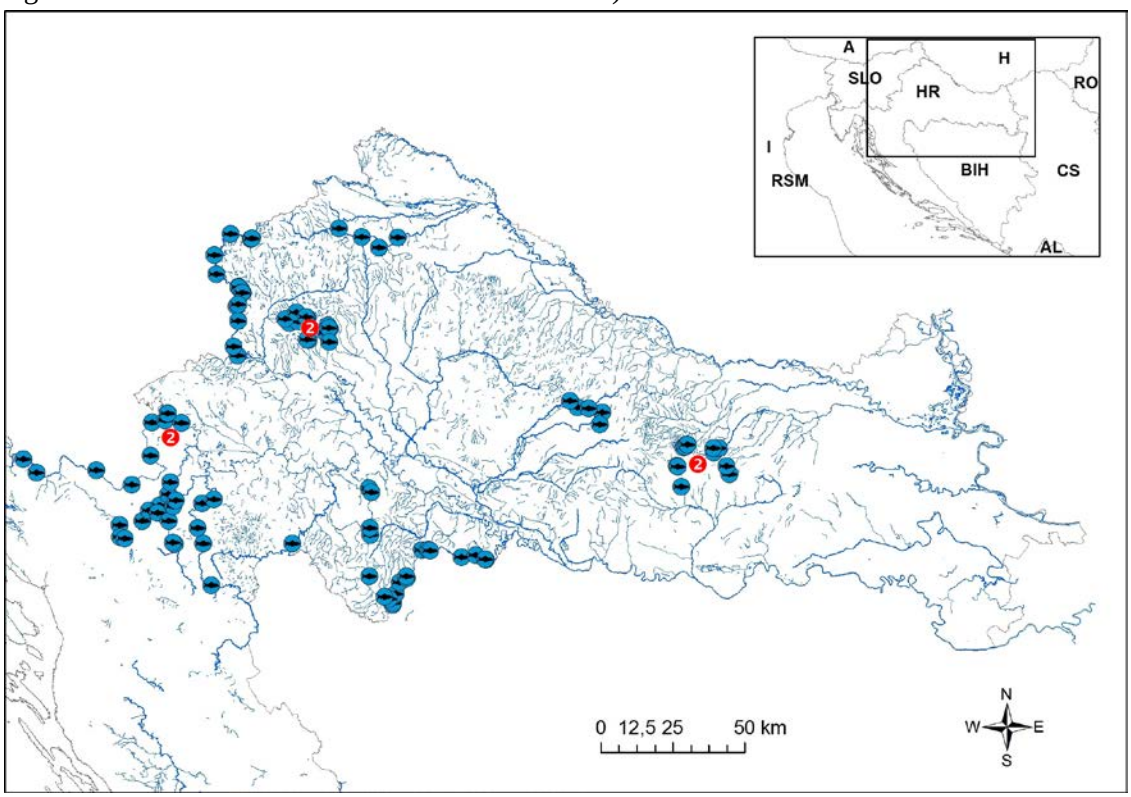

Figure 3: *Barbus meridionalis* proposed monitoring sections ❷, based on the high quality populations of *Barbus meridionalis* in terms of populational structure/density in characteristic/optimum/good habitats.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

Any human impacts or pressures in these protected areas which can induce qualitative (disappearance of the species) and quantitative (changing in relative abundance, age structure) modifications of the monitored populations, will create negative future prospects related to the species habitat quality, long-term viability, range and conservation status, situation which should be assessed once in every six years period at national level, if no extraordinary events appear (natural and/or human events which have as results major or significant biocoenosis and/or habitat modifications).

❸ Lotic sectors/habitats which should be ecologically reconstructed/proposed for ecological reconstruction to allow the *Barbus meridionalis* populations structure improving or natural repopulation. This is the case only if the lack of actual data did not induce some fake gaps in continuity of distribution data/knowledge.

This third category of monitoring sections was chosen due to the gaps in continuity of this species, possibly as a result of human impact, but also due to the gaps in the actual scientific knowledge. Based on this monitoring criteria, six monitoring sections (Fig. 4; ❸) were selected/proposed.

Four sampling sections should be on Kupa River, under an once per six years monitoring, along the 118 km long north-west Croatian - south-east Slovenian border, between each couple of sites where the presence of this fish species is known (and marked in Fig. 4 map). If new scientific data about the presence of the species in these actual gaps on the map become available in the future, these proposals will no longer be taken into consideration.

One sampling station should be on Glina River, which would be monitored once per six years, along the Croatian - Bosnia-Hertzegovina border (road access and bridge near Katinovac locality). One sampling station should be on Korana River, which would be monitored once per six years, along the Croatian - Bosnia-Hertzegovina border (road access and bridge in the relative proximity of Kosa locality).

Any human impact or pressures in these lotic sectors, which cause the absence of the species, create a negative future prospects related to its habitat quality, long-term viability, range and conservation status, situation which should be assessed once in every six year period at the national level.

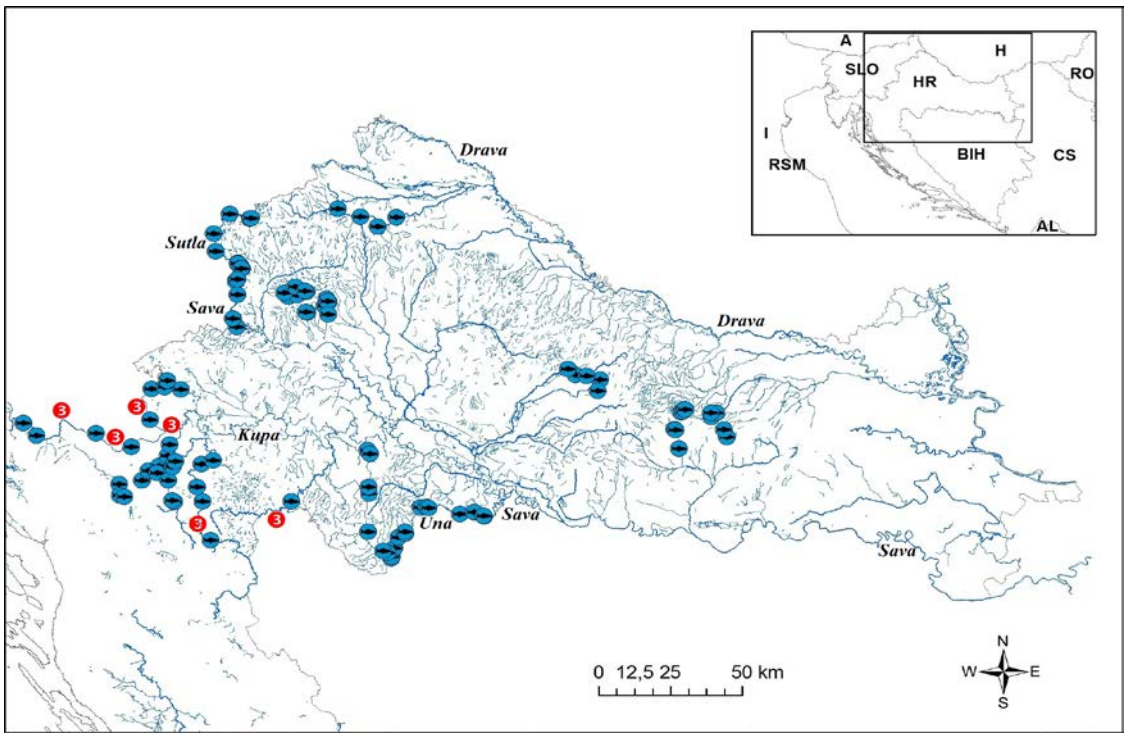

Figure 4: *Barbus meridionalis* proposed monitoring sections (❸), based on the lotic sectors/habitats which should be ecologically reconstructed/proposed for ecological reconstruction to allow *Barbus meridionalis* population structure improving or natural repopulation criteria, potential sectors to be proposed for ecological reconstruction. *Barbus meridionalis* distribution , update situation.

❹ key habitats/sectors with high importance for connectivity (ex. rivers confluence areas; intermediate lotic sectors between different important fish populations' areas).

This fourth category of monitoring sections was chosen due to their potential role as connectivity culloars with importance in the continuity of this species, but they can also represent gaps in the actual scientific knowledge. If these sections will prove to be only gaps in the knowledge, gaps which will be covered by future information, they can be removed from the proposed list of sampling/monitoring sections.

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

One section, monitored once per six years, on the Dobra River, between the last downstream sampling point where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Kupa River at Karlovec.

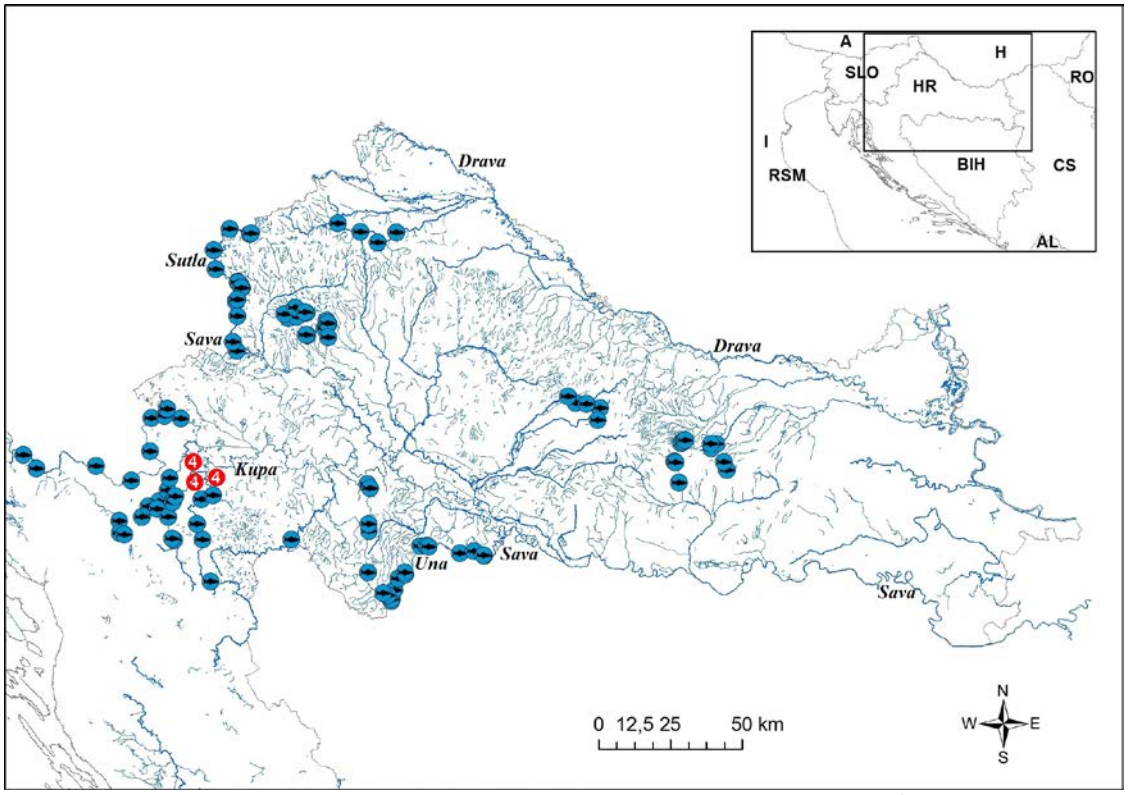

Figure 5: *Barbus meridionalis* proposed monitoring sections ❹,
based on key habitats/sectors with high importance for connectivity.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

One section, monitored once per six years, on the Mrežnica River, between the last downstream sampling point, where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Korana River.

One section, monitored once per six years, on the Korana River, between the downstream last sampling point, where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Kupa River at Karlovec.

One section, monitored once per six years, on the Glina River, between the last downstream sampling point, where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Kupa River.

One section, monitored once per six years, on the Kupa River, between the last downstream sampling point where *Barbus meridionalis* presence is known and marked on the map and downstream of the confluence with Sava River at Sisak.

Any human impact in these lotic sectors which can cause the absence or at least accidental presence of *Barbus meridionalis*, will create negative future prospects about this species conservation status and range, situation which should be assessed once per six years at national level.

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

Kupa River needs once per year monitoring of a section downstream of the Karlovac locality, where partially treated waste water is released.

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

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

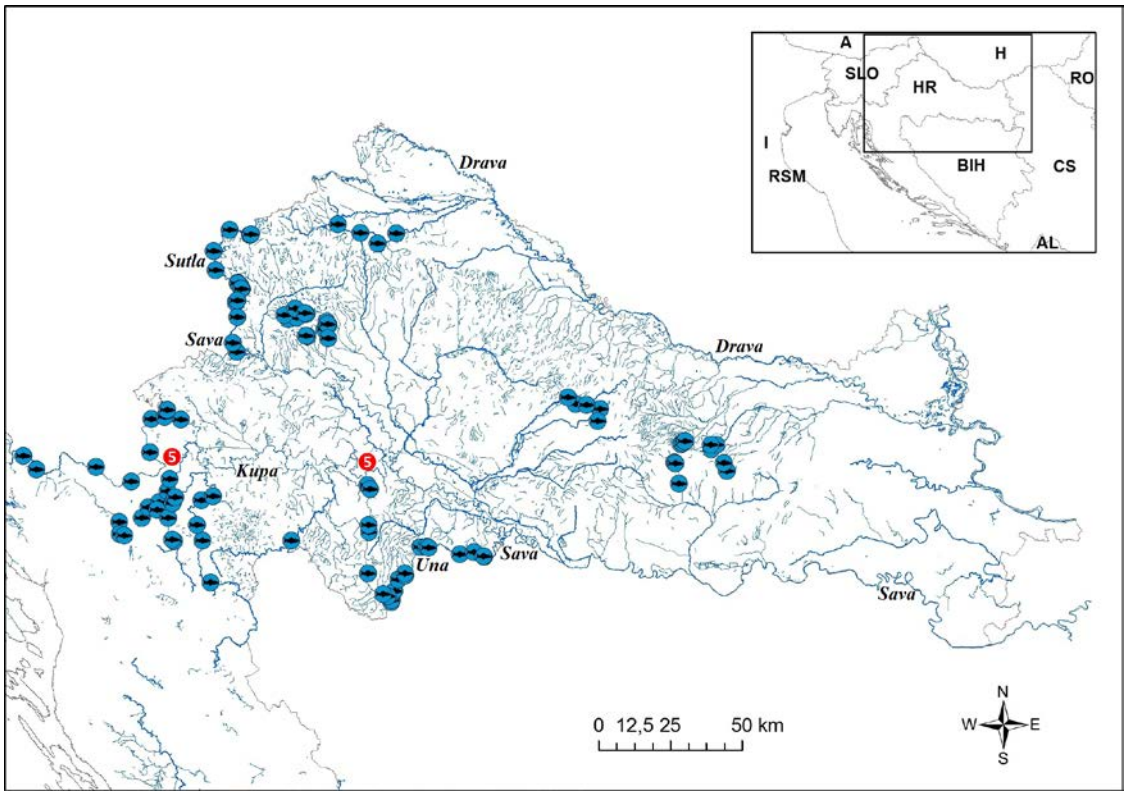

Figure 6: *Barbus meridionalis* proposed monitoring sections ❺,
based on the industrial/waste water pollution point sources data criteria;
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

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

The following Sava River tributary was approached regarding the agricultural pollution diffuse sources, which need monitoring sectors.

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

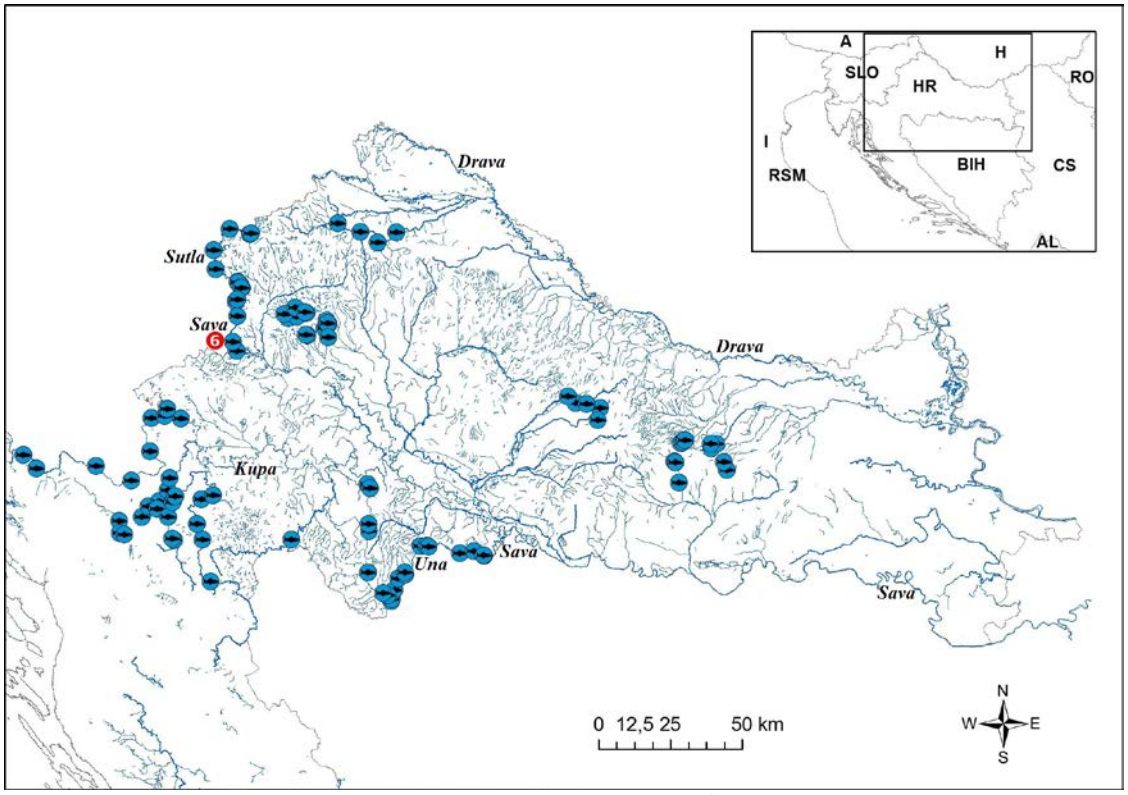

Figure 7: *Barbus meridionalis* proposed monitoring sections ❻, based on areas/sectors influenced by agricultural pollution diffuse sources data criteria.
Barbus meridionalis distribution, update situation (Duplić, SNIP, 2012).

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

Kupa (15-30% considered proportion of this fish species population in relation to the size of the population at the state level), needs monitoring in the following areas: upstream and downstream of Ozalj Dam on Kupa River; Kupa-Kupa natural channel.

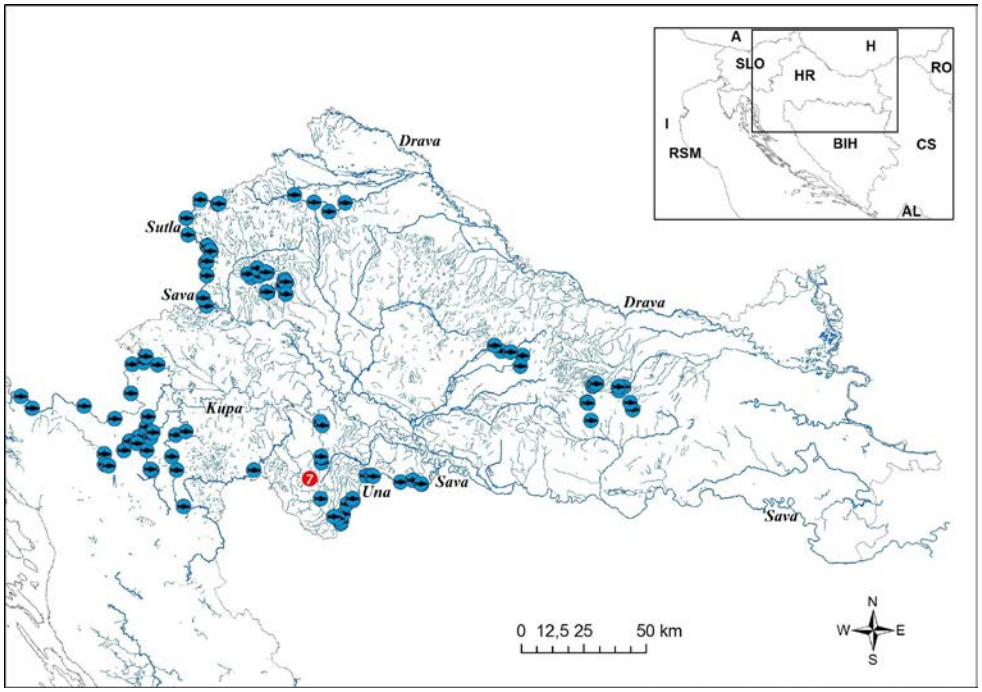

Figure 8: *Barbus meridionalis* proposed monitoring sections (❼), based on the habitats modifications criteria. *Barbus meridionalis* distribution , update situation (Duplić, SNIP, 2012).

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

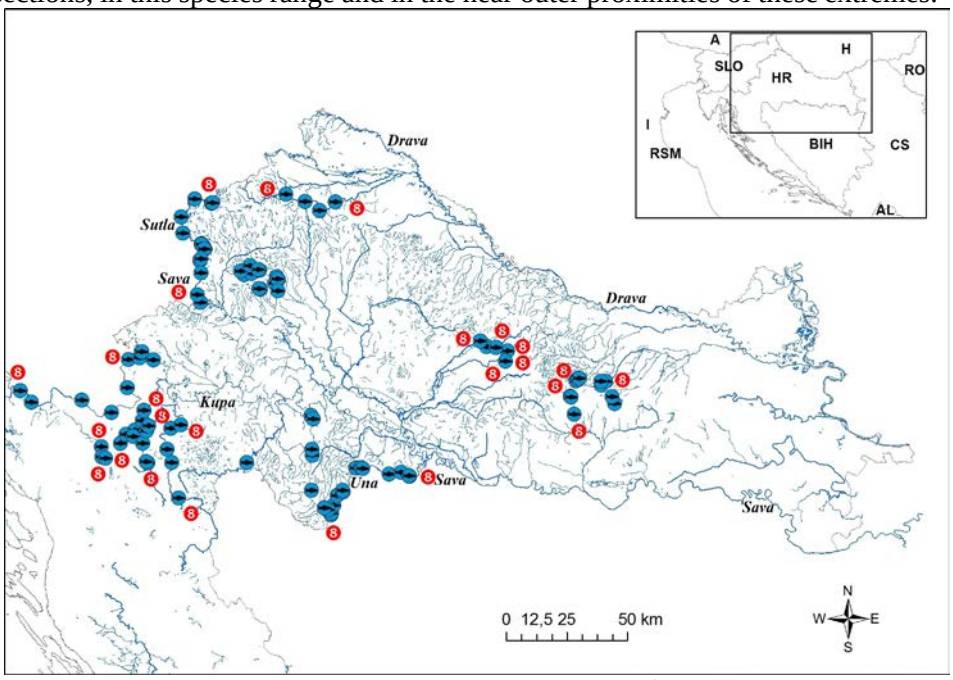

Figure 9: *Barbus meridionalis* proposed monitoring sections (❽), based on the geographically extreme monitoring sections. *Barbus meridionalis* distribution , update situation (Duplić, 2012).

Evaluation of the conservation status

First a complete systematic survey of this species range on the national territory should be done and the range should be continuously compared with the future monitoring data.

These fish species population quantitative and qualitative elements, selected in the upper monitoring sections can be based on some specific fish biotic index criteria. The selected combination of metrics was designed to reflect insights of assemblage and population comparable perspectives. Each metric value should be compared with the values estimated from other similar sites. It should be considered that when the biotic integrity (based on the following metrics) decreases, the population, habitat and lotic ecosystem quality decreases as well.

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

Ratings of 5 to 1 should be assigned to each metric according to whether its assessed value approximates deviates somewhat or strongly from the value expected by the best expert judgement at a comparable site that is relatively similar, but also relatively undisturbed.

The total obtained score for each site should represent all the nine-metrics sum and the scores can be interpreted with the following interval comparison: 45-43-excelent, this score reflects excellent, comparable to pristine conditions, exceptional assemblage of fish species; 42-36-very good, this score shows a decreased species richness, intolerant species in particular, sensitive species present; 35-31-good, this score describes fair intolerant and sensitive species absent, skewed trophic structure; 30-24-fair, this score reflects some expected species absent or rare, omnivorous and tolerant species dominant; 23-17-fairly poor score shows few species and individuals present, tolerant species dominant; 16-10-poor, this scores describes very few species and individuals present, tolerant species dominant; 9-1-very poor, this score reflects extremely low number of species and individuals present, tolerant species or no fish.

A real assessment of any fish species population conservation status can be done only in the ichthyocenosys assessment context!

Any other simplified monitoring/assessment approaches will have a lower and/or uncertain quality of the obtained results!

The use of these integrated ichthyologic metrics allows the possibility to assess both the conservation status of the target population/populations in the local specific ichthyologic assemblage context and of the fish habitat as well!

At every six years period, supplementary sampling stations should be done in all the upstream and/or downstream extreme (concerning the geographical position) areas in order to highlight the potential territorial expansion of the species.

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

Evaluation Grid

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

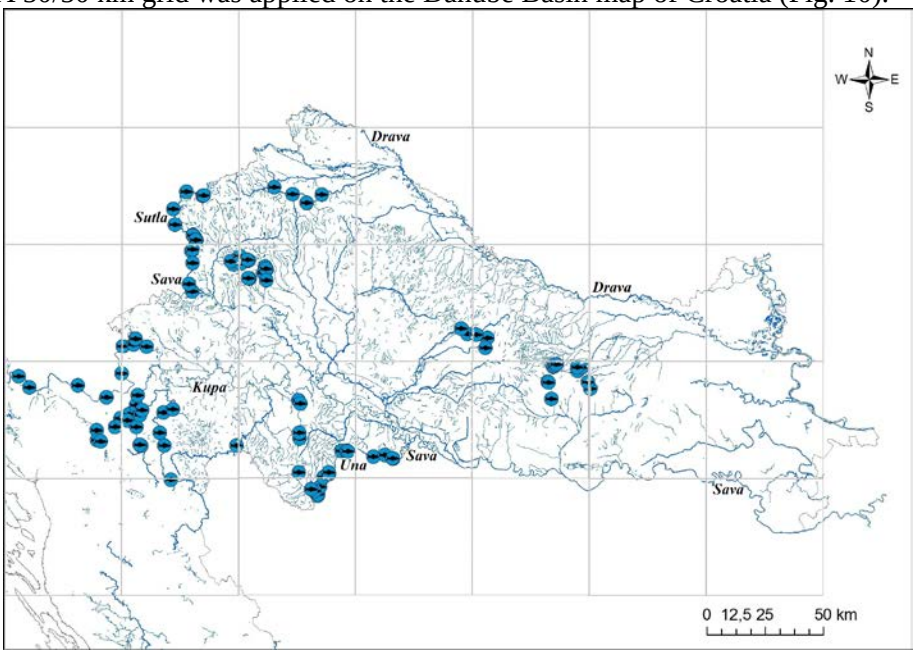

Figure 10: 50/50 km (grey) grid, used as a base for *Barbus meridionalis* monitoring areas.
Barbus meridionalis distribution, update situation (Duplić, 2012).

The minimum number of monitoring areas - 12, for *Barbus meridionalis* should have at least one monitoring section in every 50/50 km plot (✵), plots are proposed based on the eight selected criteria, (Fig. 11).

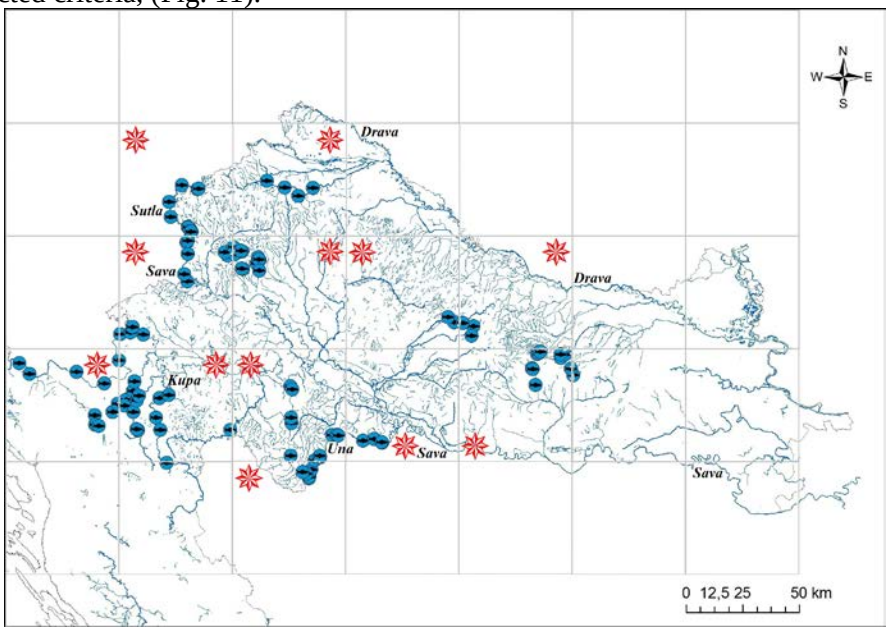

Figure 11: The minimum 12 sampling stations for *Barbus meridionalis* should be in the marked 50/50 km plots (✵).
Barbus meridionalis distribution, update situation (Duplić, 2012).

The 12 minimum sampling/monitoring areas, one in each 50/50 km plots, were selected in those points/areas where as many as possible monitoring sections, proposed based on the eight criteria) overlapping; thus each of these 12 minimum sampling areas correspond to as many criteria as possible, with the lowest possible costs, effort and time.

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

1. From a **qualitative** point of view, the data on the presence of the monitored fish species in each of the 12 50/50 km plots, present a first level of information regarding the species conservation status in Croatian Danube Basin, in terms of future prospects, suitable habitats, populations, as well as area and range. The presence of the species in all 12 50/50 km plots will reveal an excellent conservation status in the Croatian national territory, in 11 very good conservation status, in 10 good conservation status, in 9 fair conservation status, in 8 fairly poor conservation status, in 7 poor conservation status and in 6 or less a very poor conservation status.

2. The second level needed is also a **qualitative** approach, in respect to: age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals. Every plot of 50/50 km is evaluated based on the presence/absence of the age classes. A plot with all 6 age classes will be evaluated as being in an excellent conservation status; 5 age classes presence will reflect a very good conservation status, 4 classes mean a good conservation status, 3 classes fair conservation status, 2 classes fairly poor conservation status, 1 class poor conservation status. This approach should be made independently for each 50\50 km plot, and in the end an average value for all the plots will represent a mean national conservation status.

3. The third level is also a **qualitative** approach, in respect of species composition; only *Barbus meridionalis* presence will represent a poor conservation status; *Barbus meridionalis* + another (indigenous) species represents a fairly poor status of conservation, *Barbus meridionalis* + two fish (indigenous) species represent a fair conservation status, *Barbus meridionalis* + three fish (indigenous) species represent a good conservation status, *Barbus meridionalis* + four fish (indigenous) species represent a very good conservation species, *Barbus meridionalis* + five or more (indigenous) fish species represent an excellent conservation status. This approach should be made independently for each 50\50 km plot and in the end an average value for all the plots, will indicate the mean national conservation status.

4. The fourth needed level is the **integrated** approach. For every monitoring section, results should be obtain in terms of the following IBI (Bănăduc and Bănăduc, 2002) scores (45-43-excellent, 42-36-very good, 35-31-good, 30-24-fair, 23-17-fairly poor, 16-10-poor, 9-1-very poor), which will reveal at quantitative level the conservation status of the *Barbus meridionalis* population in the ichthyocenosys assessment context. This approach is made independently for each 50\50 km plot and in the end an average value for all the plots, will indicate the mean national conservation status.

5. Finally, an average value from the previous 4 steps at national level should be estimated for every plot, and finally for all the plots, and this will be the obtained national conservation status for *Barbus meridionalis*, as a result of the monitoring activities programme.

CONCLUSIONS

The proposed *Barbus meridionalis* monitoring sites, at the Croatian national level, were selected based on eight main criteria: (1) national border proximity areas/sectors coverage; (2) high quality populations of *Barbus meridionalis* in terms of population structure/density (ex. Protected areas, but not only) in characteristic/optimum/good habitats; (3) habitats which should be ecologically reconstructed to allow *Barbus meridionalis* populations structure improving or natural repopulation; (4) key habitats/sectors with high importance for connectivity (ex. Rivers confluence areas; intermediate lotic sectors between different important populational areas); areas/sectors negatively influenced by human impact such as: (5) industrial pollution point sources, (6) areas/sectors influenced by agricultural pollution diffuse sources, (7) areas/sectors influenced by habitat modifications (physico-chemical, watercourse regulation, remodeling, etc.); (8) geographically extreme monitoring sections in the most-upstream and most-downstream sections of the rivers, in this species range and in the near outer proximities of these extremes. These criteria based monitoring site selection represent a significant sum of various influences which can affect this fish species distribution, conservation status, survival and abundance of its populations.

It was considered that these criteria elements exist currently in Croatia and can influence the future conservation status of this fish species. The monitoring sites selections were based on these criteria and the monitoring sections were identified one by one on the maps, based on the existent fish related bibliography.

It should be stated that the potential future improvement of *Barbus meridionalis* distribution data on the Croatian territory, can improve the monitoring sites present situation, the process of improving this specific monitoring system being a permanent and flexible one.

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

Species conservation status components

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

The ***habitat*** of the species is the second component of its conservation status, related to the area and quality of the suitable habitats. Thus, also the trends regarding the occurrence areas of this species, increasing versus decreasing areas situations, increasing versus decreasing habitat quality situations can be highlighted. For these purposes, monitoring sites criteria based on selection was also done, involving criteria like: national border proximity areas/sectors coverage; high quality populations; habitats which should be ecologically reconstructed; key habitats/sectors with high importance for connectivity; areas/sectors negatively influenced by human impact. Also in this respect some specific metrics were selected: I presence/absence; II age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals; III species composition; IV relative abundance in the local ichthyofauna context.

The ***population*** is the third component of the conservation status for this species. It is assessed based on population size and population structure in terms of reproduction and age structure. To cover this component, respectively the favorable reference populations which are considered as able to ensure the long-term viability of the species, the following metrics were selected: I presence/absence; II age structure, presence/absence of 0+ age individuals, presence/absence of 1+ age individuals, presence/absence of 2+ age individuals, presence/absence of 3+ age individuals, presence/absence of 4+ age individuals, presence/absence of 5+ age individuals; II species composition; IV relative abundance in the local ichtyofauna context.

The fourth component of the species conservation status is the ***range***, which represents the spatial limits within which this species permanently occurs. The trend of the range increasing or decreasing dynamics can be spotted based on the following criteria, which were used for the selection of some monitoring sites: national border proximity areas/sectors coverage; key habitats/sectors with high importance for connectivity; geographically extreme monitoring sections in the upstream-most and downstream-most sections of rivers, in this species range and in the near outer proximities of these extremes.

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SELECTED REFERENCE

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

22.. Karr J. R. and Dudley D. R., 1981 – Ecological perspective on water quality goals, *Environment Management*, 5, 55-68.
23. Karr J. R. and Fausch K. D., 1986 – Assessing Biological Integrity in Running Waters A Method and Its Rationale, Illinois Natural History Survey, Special Publication 5 September 1986, 1-20.
24. Picer M., Perkov S. and Picer S., 1995 – Contamination of Bela Krajna, Slovenia with polychlorinated byphenyls, 1, Levels of some high molecular chlorinated hydrocarbons in the water and fish of the Kupa River in Croatia, Water, Air and Soil Pollution, 82(3-4), 559-581.
25. Popović I., 2008 – Implementation of the Water Framework Directive and Urban Waste Water Treatment Directive in the Republic of Croatia - Investments, operation-maintenance, adaptation.
26. Povz M. and Sket B., 1990 – Naše slatkovodne ribe. Založba Mladinska knjiga. (in Croatian)
27. Schwarz U. and Bloesch J., 2004 – GIS-supported mitigation of the impact of hydropower dams on the flood plains of the Drava-Mura rivers in Croatia/Hungary.
28. Šmit Z., Drevenkar V. and Kordić-Šmit M., 1987 – Polychlorinated biphenyls in the Kupa River, Croatia, *Chemosphere*, 16, 2351-2358.
29. Mrakovčić M., Brigić A., Buj I., Ćaleta M., Mustafić P. and Zanella D., 2006 – Red Book of Freshwater Fish of Croatia/Cravena Knjiga Slatkovodnih Riba Hrvatske.
30. Mrakovčić M., Kerovec M., Mišetić S., Schneider D., Tomaskovic N. and Šurmanović D., 1996 – Ichthyofauna of the Drava River (Croatia), *Internationale Arbeitsgemeinschaft Donauforshung*, 1, 345-348.
31. Mrakovčić M., Mustafić P., Ćaleta M., Zanella D., Buj I. and Marčić Z., 2008 – Ihtiološka raznolikost rijeke Mure, PMF Zagreb. (in Croatian)
32. Mrakovčić M., Ćaleta M., Mustafić P., Marčić Z. and Zanella D., 2010 – Značajke ihtiofaune rijeke Sutle, PMF Zagreb. (in Croatian)
33. Mrakovčić M., Ćaleta M., Mustafić P., Marčić Z., Zanella D. and Buj I., 2010 – *Barbus balcanicus* iz Slatkovodne ribe. Izvješće za potrebe izrade prijedloga potencijalnih NATURA 2000 područja. PMF Zagreb. (in Croatian)
34. National Study - Croatia, 2010 – Transnational Strategy for the Sustainable Territorial International Commission for the Protection of the Danube River, Danube Facts and Figures - Croatia.
35. Teskeredžić E. Z., Teskeredžić M., Tomec B., Kurtović B., Raspor D., Kapetanović D., Dragun I., Vardić D., Valić Z., Strizzak B., Španović Z., Šoštarić V. and Roman Z., 2009 – Programme for the monitoring of the freshwater fishery status in the year 2009 - Group D - Fishing area Sava, River Sutla.
36. Vidaček Ž., Bogunović M., Sraka M. and Husnjak S., 1998 – Triazine herbicides in drained soils and water in the part of river Drava catchement area, in Abstracts 16th World Congress of Soil Science, Montpellier, France, CD, 1-8.
37. Znaor D., Pretty J., Morrison J. and Todorović S. K., 2005 – Environmental and macroeconomic impact assessment of different development scenarios to organic and low-input farming in Croatia, University of Essex.

THE COMPARATIVE ANALYSIS OF PRESSURES AND THREATS TO THE NATURA 2000 SITES FOR WILD BIRDS PROTECTION - CASE STUDIES IN WETLANDS IN ROMANIA AND BULGARIA

Doina CIOACĂ *

* Ministry of Environment and Climate Changes - Biodiversity Directorate, 12 Libertăţii Boulevard, Sector 5, Bucharest, Romania, RO-040129, doina2004bio@yahoo.com

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KEYWORDS: Romania, Bulgaria, Cernica Lake and Forest, Natura 2000, management planning, wetlands.

ABSTRACT

The Natura 2000 concept and wetlands protection are relatively new for Romania and Bulgaria, because they are former communist countries and, after the 1990s, had too little value placed on nature conservation in favour of infrastructure development and agriculture. The development of the European ecological network Natura 2000 on these territories has come as an obligation for accession of these countries to The European Union on 01.01.2007.

During the period 2006-2009 I made an analysis for the management of protected areas along the Danube Green Corridor, between Romania and Bulgaria, especially for wetlands, similar to the results of the WWF Germany project "Lower Danube - Green Corridor (LDGC): Freshwater protected area management and freshwater restoration in Bulgaria, Romania and trans-boundary conservation along the Lower Danube". To have a complete view of the situation of the protected areas management between Romania and Bulgaria, along the Lower Danube Green Corridor, and the perspectives for the next years, I carried out some evaluation for more than 20 Natura 2000 sites, which are alike in many ways, such as: the object of protection (Sites of Community Importance, SCI, under the Habitats Directive; Special Protection Areas for birds, SPAs, under the Birds Directive; natural protected areas of national importance for these two countries, or other natural and semi natural areas with the potential to be protected), human activities, pressures and threats, and other aspects.

Later, I used these results to make a comparative analysis of the Cernica area (Ilfov County, Romania), to add another argument to include it in the Natura 2000 Network from Romania, as ROSPA0122 Cernica Lake and Forest.

This analysis showed that Cernica faces approximately the same pressures and threats as other protected areas and has almost the same efficiency in management planning as the highest assessed Natura 2000 SPAs, respectively Iezer-Călăraşi in Romania and Srebarna of Bulgaria, which is an argument to establish this area as a Natura 2000 site.

ZUSAMMENFASSUNG: Vergleichende Analyse der Belastungen und Bedrohungen für Natura 2000 Vogelschutzgebiete - Fallstudie in Feuchtgebieten Rumäniens und Bulgariens.

Das Natura 2000-Konzept und der Schutz von Feuchtgebieten ist relativ neu für Rumänien und Bulgarien, da in diesen ehemaligen kommunistischen Ländern auch nach 1990 im Vergleich zu Infrastrukturentwicklung und Landwirtschaft weniger Wert auf Naturschutz gelegt wurde. Die Einrichtung und Entwicklung des europäischen, ökologischen Netzwerks Natura 2000 gehörte jedoch zu den Voraussetzungen und Verpflichtungen im Hinblick auf den Beitritt dieser Länder in die EU zum 01.01.2007.

Im Zeitraum 2007-2009 hat die Verfasserin eine vergleichende Analyse des Managements von Naturschutzgebieten im „Grünen Korridor Untere Donau“ zwischen Rumänien und Bulgarien vorgenommen und zwar vorwiegend in Feuchtgebieten. Die Studie war Teil der Ergebnisse eines Projektes der Umweltstiftung WWF-Deutschland “Grüner Korridor Untere Donau - Green Corridor (LDGC): Management und Renaturierung von Süßwasser- und Auenschutzgebieten in Bulgarien und Rumänien sowie grenzüberschreitender Naturschutz entlang der unteren Donau“. Um einen umfassenden Eindruck zur Lage der Naturschutzgebiete sowie ihrer Zukunftsperspektive entlang der Donau in Rumänien und Bulgarien zu gewinnen, wurden Evaluierungen für mehr als zwanzig Natura 2000-Gebiete beider Länder vorgenommen. Dabei ging es um Gebiete, die einander in vieler Hinsicht ähnlich waren und zwar um nach der FFH-Richtlinie ausgewiesene Gebiete von Gemeinschaftlicher Bedeutung (SCI), um solche, die nach der Vogelschutzrichtlinie ausgewiesen sind (SPA), um Naturschutzgebiete von nationaler Bedeutung sowie um andere natürliche oder naturnahe, als Naturschutzgebiete auszuweisende Bereiche, um die menschlichen Tätigkeiten in diesen Gebieten, um Belastungen und Bedrohunegn, denen sie ausgesetzt sind und andere wichtige Aspekte.

Die Ergebnisse der Studie und die daraus gewonnenen Erkenntnisse wurden danach für einen Vergleich einiger Natura 2000 Gebiete mit dem Gebiet Cernica (nahe Bukarest), Kreis Ilfov, Rumänien herangezogen, wodurch ein Beitrag für die Aufnahme des Feuchtgebietes unter ROSPA0122 Cernica-See und Cernica-Wald (Lacul şi Pădurea Cernica) in das Netzwerk Natura 2000 geleistet wurde.

Die Analyse hat gezeigt, dass das Cernica-Gebiet etwa den gleichen Belastungen und Bedrohungen ausgesetzt ist, als die anderen zum Vergleich herangezogenen Naturschutzgebiete. Auch hat es fast die gleiche Effizienz in der Managementplanung als die nach der Vogelschutzrichtlinie (SPA) ausgewiesenen und sehr gut bewerteten Natura 2000-Gebiete wie Iezer Călăraşi/Rumänien und Srebarna/Bulgarien, was zusätzliche Argumente für die Aufnahme in das Natura 2000-Netzwerk lieferte.

REZUMAT: Natura 2000 este un concept relativ nou pentru România şi Bulgaria, venind ca o obligaţie pentru aderarea acestor ţări la Uniunea Europeană.

În perioada 2007-2009 am realizat o analiză a managementului ariilor protejate din Coridorul Verde al Dunării de Jos, între România şi Bulgaria, în special pentru zonele umede, ca rezultat al proiectului WWF Germania “Lower Danube-Green Corridor (LDGC): Freshwater protected area management and freshwater restoration in Bulgaria, Romania and transboundary conservation along the Lower Danube”. Pentru a avea o imagine completă a situaţiei ariilor naturale protejate de-a lungul Dunării, din România şi Bulgaria, precum şi a perspectivei acestora pentru următorii ani, am realizat câteva evaluări pentru peste 20 de situri Natura 2000 din ambele state, care se aseamănă în multe privinţe, cum ar fi: obiectul protecţiei (Situri de Importanţă Comunitară - SCI, în baza Directivei Habitate, Arii de Protecţie Specială Avifaunistică - SPA, în baza Directivei Păsări, arii naturale protejate de importanţă naţională, precum şi alte zone naturale sau seminaturale potenţial a fi incluse în sistemul de arii protejate), activităţile din aceste arii, presiunile şi ameninţările la care sunt supuse, alte aspecte importante.

Ulterior, am folosit rezultatele obţinute pentru a pune în comparaţie câteva situri Natura 2000 cu zona Cernica din judeţul Ilfov (România) şi a contribui la munca de includere a zonei umede ROSPA0122 Lacul şi Pădurea Cernica, în Reţeaua Natura 2000.

Analiza a arătat că Cernica se confruntă aproximativ cu aceleaşi ameninţări ca şi celelalte arii naturale protejate şi are eficienţă similară în planificarea managementului faţă de cele mai bine cotate situri Natura 2000 de tip SPA, respectiv Iezer Călăraşi din România şi Srebarna din Bulgaria, constituind astfel un argument pentru constituirea în sit Natura 2000.

INTRODUCTION

According to Wetlands Convention, the wetlands are swamps, marshes, bogs, natural or artificial water, permanent or temporary, that is stagnant or flowing water, fresh, brackish or salt water, including stretches of sea water whose depth at low tide does not exceed six meters.

Wetlands are refuges for many species of organisms found only in such optimum places for survival. Such sites are centers for these species spreading when climatic factors are changing. Wetlands are places for breeding, feeding, wintering, etc., for many aquatic and semi-aquatic species. In certain areas tens of thousands of birds (especially ducks, geese, garlic and shore birds) are regularly seen. Some mammals (otter, mink, etc.) exist only in places less disturbed by humans and many species of wild animals survive only in natural wetlands.

Wetlands play an important role in the development of natural processes in ecosystems, but in the same time they have a high economic importance.

Wetlands take some of the flood, spread them on large areas and thus contribute to considerably reducing the destructive power of floods. Wetlands play an important role in stabilizing banks (reducing erosion). They also act as a filter and retain sediments (solid particles of various sizes floating in the water). The importance of the protection and sustainable development of wetlands in Romania resides in the fact that it has acceded to the Convention on Wetlands of International Importance, especially as Waterfowl Habitat, which was signed in Ramsar (Iran) on by February 2, 1971 and ratified by National Law no. 13/1993.

As a condition for joining the European Union on 1 January 2007, the two countries, Romania and Bulgaria were required to prepare a list of Natura 2000 sites within their territories, to expand the European ecological network Natura 2000.

Due to a rich flora and fauna, many of the Natura 2000 sites from the two states were designated in wetlands, mostly along the Danube River.

In the Natura 2000 networks from Romania and Bulgaria were introduced other wetlands types too, like marshes, bogs or natural and semi natural lakes, which host important species of flora and fauna.

MATERIALS AND METHODS

To obtain the results of the comparative analysis it is important to use a specific questionnaire of my own method for Estimating the Efficiency of Management Planning in Natura 2000 Sites that can be adapted to sites under evaluation. This method was created by myself, in 2007, from the WWF Germany project, and it is innovated from the RAPPAM method (Rapid Assessment and Prioritization for Protected Areas Management), of WWF International (Ervin, 2002).

With this method, I have demonstrated which are the most important pressures and threats for each site and which site needs rapidly intervention for conservation. Also, it can be used for any Natura 2000 site from Europe, whether it has a legal administrator or not. It is simple to apply this method. It is based on a specific questionnaire and much information for the assessed sites.

A range of information is required, such as: legal base; type of the Natura 2000 site or the protected area; the existence of one legal custodian or administrator of the protected area / Natura 2000 site; the existence of the regulation and management plan for each protected area and how were they made; the informations considering the existence of infrastructure for a management guarantee (buildings, transport vehicles and equipments for interventions, access roads to the protected area, access ways for visiting the protected area, the informative panels

in the proximity of the protected areas, etc.); scientifical information (collecting the information pointed out by other scientifical researchers, observations for the flora and fauna elements on field, including the alien species); the pressures and threats for these natural areas; the information regarding the financial aspects of these natural areas or the future financial possibilities, especially for the Natura 2000 sites; the information regarding the existing ecological reconstruction cases, or to the possibilities of making ecological reconstruction in some areas; the information about the human interventions through hidrotechnical buildings, rivers controls, ponds, pools, lakes for fishing, banks protections, dams etc.; the industrialization and urban expansion information, including transboundary ones; the information regarding the communication level between the stakeholders from these areas and other persons, including the informational transboundary exchanges; the information for the possibility of implementation of a double management into the transboundary region and other information, including maps, pictures, etc.

The specific evaluation questionnaire is divided into nine points (themes), each having a set of relevant questions. The responses to specific questions in the questionnaire are numbered after a certain algorithm and then placed in graphics to have an image of the entire situation. The efficiency of Natura 2000 sites management planning was calculated according to site objectives (item 6), financial resources (item 8) and management planning (item 9), whose sets of questions are found in the specific questionaire. To each answer to the questions is given a score between 0 and 5, which means: blank = no answer; 0 = no; 1 = mostly not; 3 = mostly yes and 5 = yes. Depending on how many questions are in each set of the questionnaire, the minimum score can be 0 and the maximum for some sets of questions, may be 40. For Natura 2000 sites objectives - maximum 20, the financial resources - maximum 15 and for the management planning - maximum 40. The final score obtained on the basis of answers to sets of questions above, will have the cumulative values.

The pressure level is calculated based on the expansion, impact and duration. The threat level is calculated according to the appearance, expansion, impact and duration. The expansion values are: generalized - 4, extensive - 3, isolated - 2 and local - 1. The impact is calculated from severe - 4, high - 3, moderate - 2 and low - 1. Duration values are: permanent - 4, long term - 3, average - 2 and short time - 1. The appearance of threats is calculated with the next scores: possible - 1, somehow possible - 2, very possible - 3, almost sure - 1 and constant - 0. The pressure and threat levels are calculated according to their magnitude and duration. Magnitude is the product of multiplying the expansion and the impact.

The author conducted the study to assess the Natura 2000 sites along the Danube between 2006 and 2009, but the necessary information for comparative analysis with Cernica has been updated so far. To obtain the special Natura 2000 status for Cernica area in 2011, the author conducted an extensive scientific study during 2001 to 2010.

RESULTS AND DISCUSSIONS

From the nature conservation point of view, in the interest areas are noticed a large variety of habitats (riparian and meadow woods, temporary and permanent wetlands, flooding areas, rivers, lakes and the old branches of the Danube River), and a rich biological diversity, represented by many wild flora and fauna species, protected by national law, by the European Commission Directives (Birds and Habitats Directives) and also by the other International Conventions and Agreements signed by Romania (Ramsar, Berna, Bonn, the Agreement on the Conservation of African-Eurasian Migratory Waterbirds - AEWA, etc.). A high biological diversity exists in the areas with the minimum accessibility for the humans, especially on the neutral islets between Romania and Bulgaria. The wild fauna is rich and diverse, because of

the aquatic and terrestrial ecosystems diversity. The species inventory of both terrestrial and aquatic habitats from lower Danube reveals an impressive number of species, many of them globally important, including 906 species of terrestrial plants, 502 species of insects, 10 species of amphibians, 8 species of reptiles, 56 species of fish, 160 species of birds, and 37 species of mammals (WWF Romania, 2007). In Cernica Lake and Forest Natura 2000 Site were inventoried many wild species: 141 invertebrates, 5 amphibians, 23 fish, 5 reptiles, 123 birds, 11 mammals and 185 plants (Gogu-Bogdan, 2003; Botnariuc and Tatole, 2005; Cioacă, 2012).

The selected Natura 2000 sites for the comparative analysis are: ROSPA0010 Bistreţ, ROSPA0102 Suhaia Lake and ROSPA0051 Iezer-Călăraşi from Romania and BG0000182 Orsoya Fishpond, BG0002024 Ribarnitsi Mechka and BG0000241 Srebarna from Bulgaria.

These Natura 2000 sites were chosen based on several criteria like: all are wetlands (all Romanian sites and Srebarna from Bulgaria are listed in 2012 as Ramsar Sites), all are protected for wild birds as SPA's, according to the Birds Directive of the European Union, all sites are IBA's (Important Birds Areas), according to Bird Life International criteria, in all sites run fishing and hunting activities and all are close to the inhabited areas.

Those Natura 2000 sites were designated for the wild birds' protection and all the pressures and threats were assessed and the proposal motivation of these sites recorded. These pressures and threats are: poaching, including the fishing out of the rules established by law; hunting in the breeding period or in the nests places of the endangered species; destruction of the nests or of the youngest birds; disturbing the wild birds during the nesting period, in the singulars cases or in their colonies; the draining of wetlands; the industrialization and urban expansion in the existent natural assets' detriment; burning reed and the shore vegetation; uncontrolled waste disposal of, with any type of waste, including from the agriculture; using pesticides in agriculture and uncontrolled storing of these, especially nearby the water banks; uncontrolled tourism; forestry activities in nesting areas of birds; uncontrolled reproduction of alien species and the list can go on. Moreover beside of these pressures and threats, can be other, at the national level, which were taken in the estimation of the management planning efficiency for the Natura 2000 sites, for example: not all the stakeholders from these areas are aware of the importance of these Natura 2000 sites; the limits of these sites were not clearly established on the field in both countries, the present or the future methods for financing these Natura 2000 sites have not been established yet; the poverty and low level of mentality of the population from these areas, in terms of nature conservation.

To compare these sites I used four commonly found indicators: poaching, burning reed and the shore vegetation, the uncontrolled tourism and the continue urbanization.

The chart of the general pressures and threats levels (Fig. 1) showed a somehow balanced situation between these Natura 2000 sites. The charts for each indicator are listed below (Figs. 2-5).

The maximum general level of the pressures recorded at Cernica, with 41, can be explained by the fact that it was not yet included in the Natura 2000 network when I made the comparison. The highest general level of the threats is in Suhaia, which is explained by the fact that in this area a conflict between those who are concerned about nature conservation and the fisheries' administrator still exists. The areas least subject to pressures and threats are found in Iezer-Călăraşi and Srebarna.

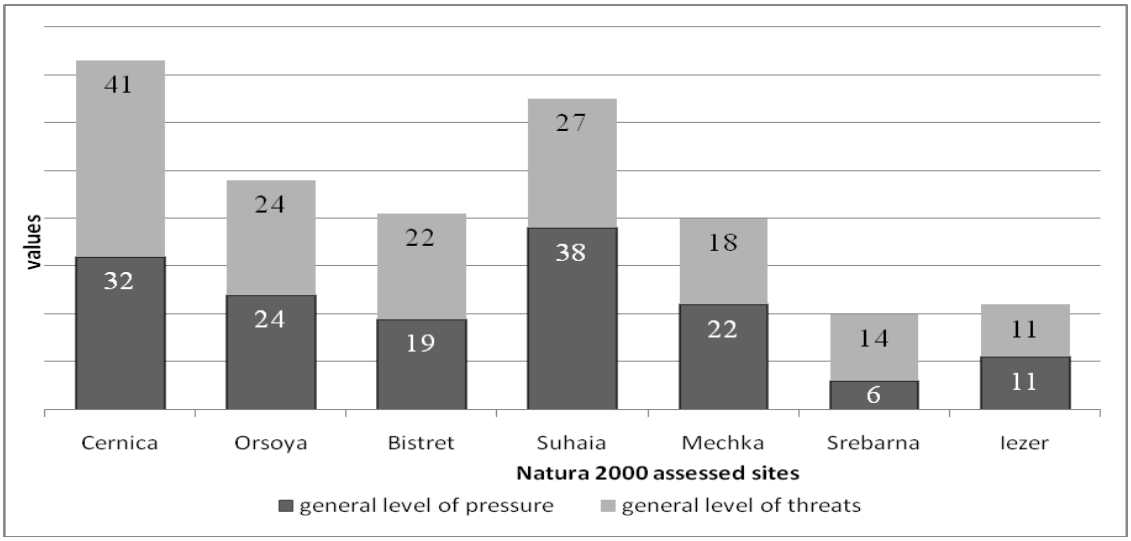

Figure 1. The general levels of pressures and threats.

Burning reeds and vegetation around the water (Fig. 2), especially in the spring when wild birds are nesting, has become lately a more commonly practice used by various dealers of fish ponds, including those under Natura 2000 SPA's.

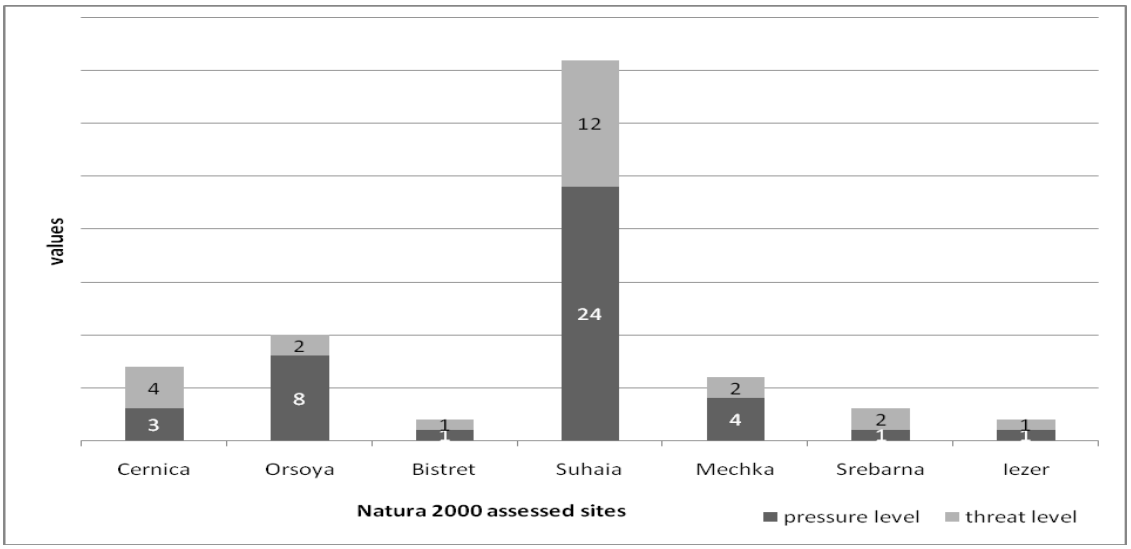

Figure 2. The burning reed and the shore vegetation level.

The highest pressure - 24 is recorded in Suhaia, while the threat is halved - 12, due to the more active involvement of various researchers in order to maintain the natural values of this site. The pressure - 3 and threat - 4 levels of this indicator on the site Cernica comes rather from some traditional practices, less nature friendly, used by locals.

The lowest value - 1, insignificant, is recorded at Bistreţ, Iezer-Călăraşi and Srebarna, explained by the occurrence of accidental burning reed in these areas.

For poaching indicator, both types were considered, from fishing and hunting (Fig. 3).

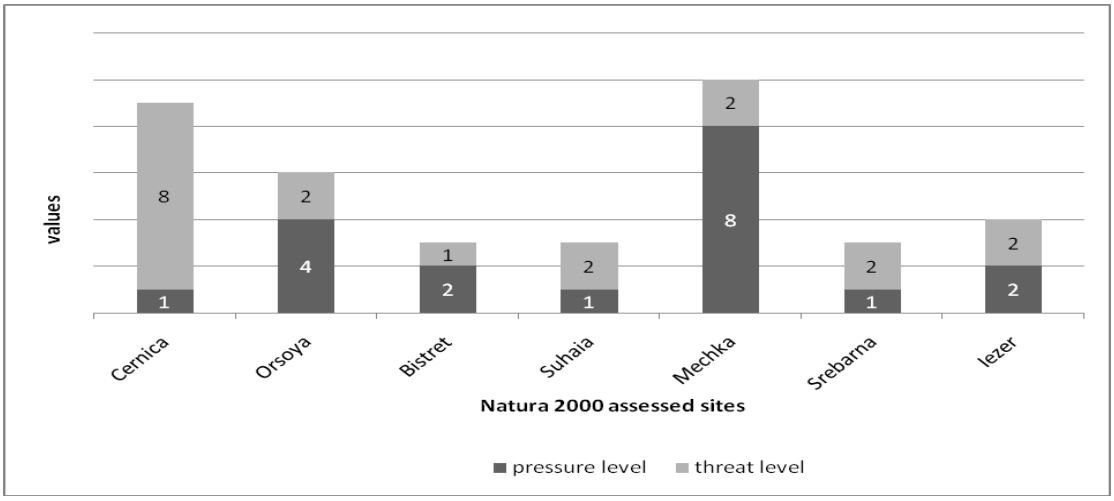

Figure 3. The poaching level.

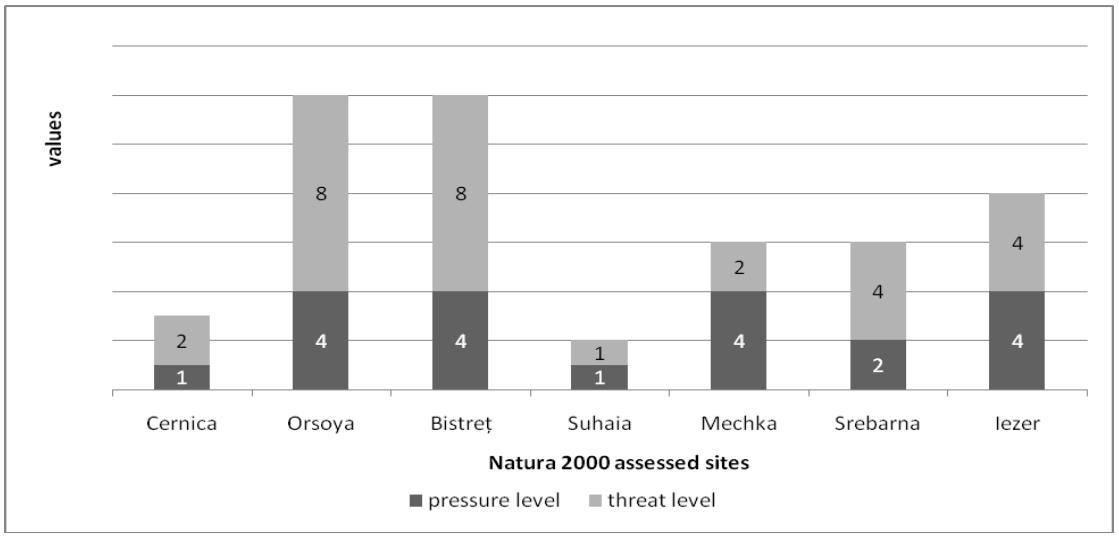

Figure 4. The uncontrolled tourism.

The highest value for this threat is recorded at Cernica - 8, while for pressure Mechka - 8 is the highest. The lowest value for pressure - 1 is recorded at Suhaia, Srebarna and Cernica sites and also the lowest threat - 1 is in the Bistreţ. The tourism is preferably made in natural areas, causing extensive damage: garbage disposal, fire, disturbance of species, etc. The chart of the uncontrolled tourism showed some similarities between the evaluated Natura 2000 sites (Fig. 4). The maximum pressure level is recorded in Bistreţ and Iezer-Călăraşi (RO) and Orsoya and Srebarna (BG). The lowest pressure level is recorded at Cernica and Suhaia, because of the fact that in Cernica are several locations for organized leisure and in Suhaia the access of weekend tourists is restricted by the administrator of the fisheries.

The desire for urban expansion in natural areas comes from the fact that the population has increased over time, but also due to the need for peace and relaxation, resulting from intensive activities. The highest level of pressure and threat for urbanization is recorded at Cernica and the lowest, in case of threat only, at Iezer-Călăraşi (Fig. 5).

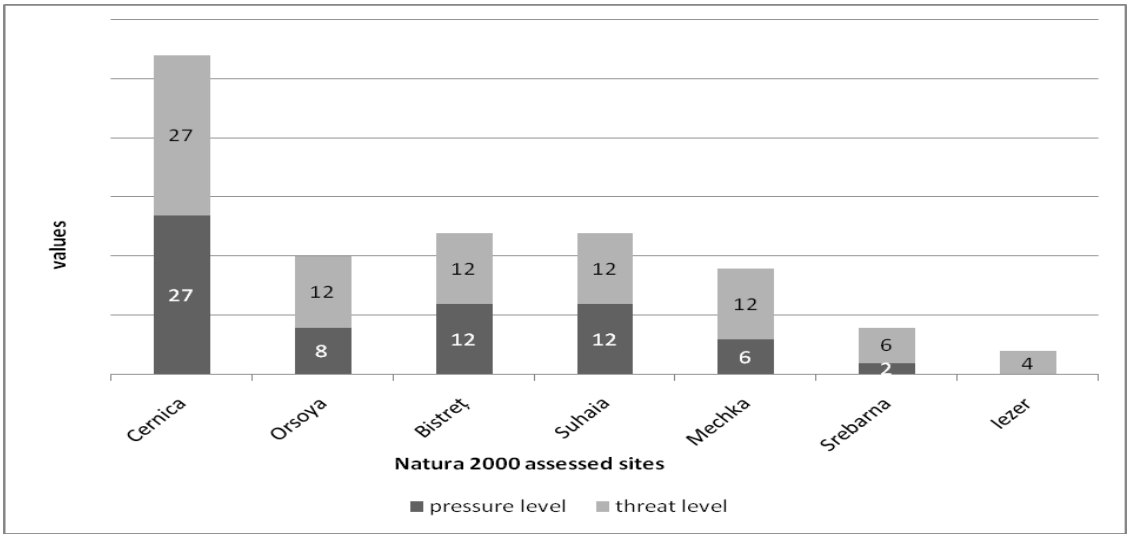

Figure 5: The urbanization level.

Once a Natura 2000 site is designated, the question is if their administrators are able to maintain a favorable conservation status of the protected natural elements. To have success in management it is necessary to establish clear objectives for the protection of the site, finding the necessary funds to support and organize a long-term action plan. The chart for management planning efficiency in the assessed Natura 2000 sites showed the rated sites (Fig. 6).

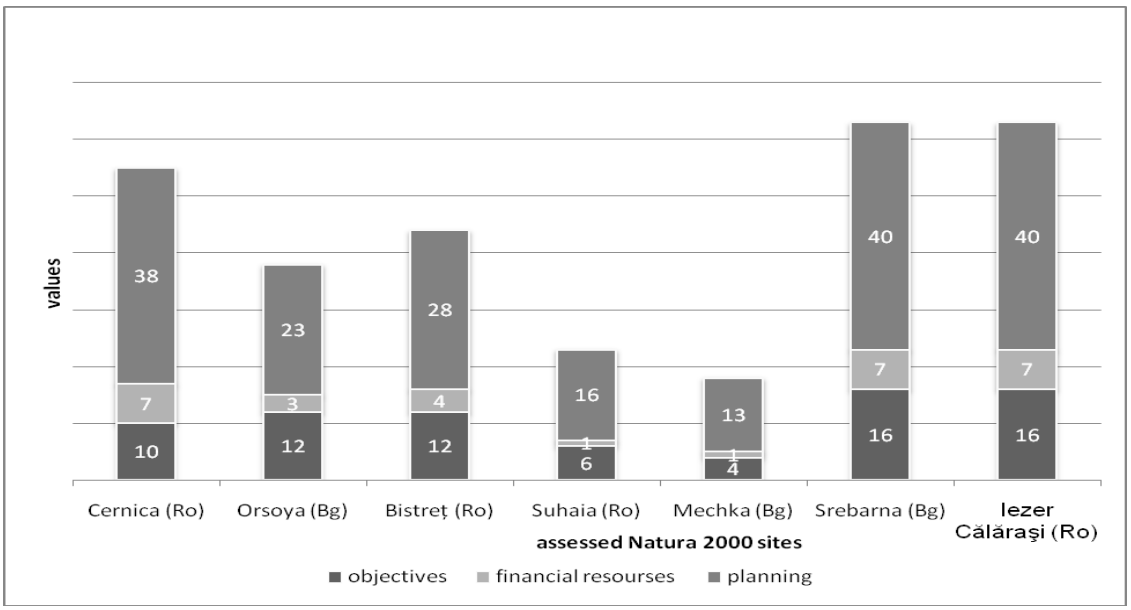

Figure 6: The management planning efficiency.

By comparing the management planning efficiency between Cernica and 6 other Natura 2000 sites, the results shows that Srebarna and Iezer-Călăraşi have the best efficiency in the management of these protected areas. Cernica has values close to these sites, which means that it is able to maintain a good state of preservation, after setting up the Natura 2000 site. The poorest efficiency in Natura 2000 site management planning appears to be at Mechka, followed by Suhaia.

CONCLUSIONS

In present, in Cernica area there are two Natura 2000 Sites, ROSPA0122 Cernica Lake and Forest, in 2006, revised and accepted in 2010 and it was published in The Official Journal of Romania no. 715 from 11.10.2011 by Government Decision no. 971/2011.

The other Natura 2000 Site, ROSCI0308 Cernica Lake and Forest, proposed in 2006, was accepted by Order no. 2387/2011 of the Minister of Environment and Forests.

REFERENCES

1. Botnariuc N. and Tatole V., 2005 – Cartea Roşie a vertebratelor din România (Red Book of Vertebrates from Romania), Academia Română - Muzeul Naţional de Istorie Naturală ”Grigore Antipa”, Bucharest, 260, ISBN 973-0-03943-7
2. Bruun B., Delin H. and Svensson L., 1999 – *Hamlyn Guide*: *Păsările din România şi Europa*, *determinator ilustrat*, Octopus Publishing Group Ltd, Londra, 54. (in Romanian)
3. Cioacă D., 2007 – Raport final privind evaluarea situaţiei ariilor naturale protejate şi a zonelor de reconstrucţie ecologică din lungul Dunării în România, 94, Raport intern din cadrul proiectului “The Lower Danube - Green Corridor: Freshwater protected areas management and freshwater restoration in Bulgaria, Romania and transboundary conservation along the Lower Danube” al WWF Germania. (in Romanian)
4. Cioacă D., 2008 – Final Report: Integration of results of assessment in Romania and Bulgaria on the conservation and ecological restoration practices in protected area along The Lower Danube Green Corridor, 47, Raport intern din cadrul proiectului “The Lower Danube - Green Corridor: Freshwater protected areas management and freshwater restoration in Bulgaria, Romania and transboundary conservation along the Lower Danube” WWF Germania.
5. Cioacă D., 2012 – Animal species and habitats protected in “Natura 2000” sites Cernica Lake and Forest (Ilfov County, Romania), *Romanian Journal of Biology - Zoology*, 57(1), 29-37).
6. Ervin J., 2002 – Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) Methodology, WWF International.
7. Kostadinova I. and Gramatikov M. (eds), 2007 – Important Bird Areas in Bulgaria and Natura 2000i, BSPB Conservation Series 11. Sofia: Bulgarian Society for the Protection of Birds. (in Bulgarian and English).
8. Papp T. and Fântână C. (eds), 2008 – Ariile de Importanţă Avifaunistică din România. Tîrgu-Mureş: Societatea Ornitologică Română, Bucureşti şi Asociaţia pentru Protecţia Păsărilor şi a Naturii 'Grupul Milvus'. (in Romanian)
9. *** Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (Directiva Consiliului Europei 79/409/EEC privind conservarea păsărilor sălbatice, adoptată la 2 aprilie 1979) cu modificările ulterioare.
10. *** Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Directiva Consiliului Europei 92/43/EEC referitoare la conservarea habitatelor naturale, a faunei şi florei sălbatice, adoptată la 21 mai 1992).
11. *** Legea nr. 13 din 11 martie 1993 pentru aderarea României la Convenţia privind conservarea vieţii sălbatice şi a habitatelor naturale din Europa, adoptată la Berna la 19 septembrie 1979.
12. *** Legea nr. 13 din 8 ianuarie 1998 pentru aderarea României la Convenţia privind conservarea speciilor migratoare de animale sălbatice, adoptată la Bonn la 23 iunie 1979.
13. *** Legea nr. 5 din 25 ianuarie 1991 pentru aderarea României la Convenţia asupra zonelor umede, de importanţă internaţională, în special ca habitat al păsărilor acvatice (Convenţia Ramsar).
14. *** http://www.ramsar.org/pdf/sitelist_order.pdf
15. *** Bulgarian Society for the Protection of Birds, 2007 – Important Birds Areas in Bulgaria and Natura 2000, Conservation Series - Book 1, Sofia.
16. *** Association of Parks in Bulgaria, 2007 – WWF Germany Project, Overview of the Lower Danube Green Corridor Declaration Implementation in Bulgaria.
17. *** Gogu-Bogdan M., 2003 – Listă cu specii de păsări prezente în zona Cernica, Ilfov.
18. *** http://bd.eionet.europa.eu/activities/Natura_2000/reference_portal
19. *** http://ec.europa.eu/environment/nature/natura2000/.Natura 2000 network

NUSA PENIDA MARINE PROTECTED AREA (MPA) BALI - INDONESIA: WHY NEED TO BE PROTECTED?

Toni RUCHIMAT *, *Riyanto BASUKI* *and *Marthen WELLY* **

* Directorate of Marine and Aquatic Species Conservation, Ministry of Marine Affair and Fisheries, truchimat@yahoo.com, riyanbas@yahoo.com
** Coral Triangle Center (CTC), mwelly@coraltriangle.org

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KEYWORDS: marine protected area, biodiversity, Nusa Penida.

ABSTRACT

Nusa Penida comprises a group of islands in the south-east of Bali. This archipelago contains a high level of marine biodiversity and has significant tourism potential. In addition, Nusa Penida has aquaculture and fishing areas, which continue to be developed. Efforts towards conservation and sustainable use by means of Marine Protected Areas (MPAs) provide an important solution to counteract increasing pressure on natural resources due to economic activities. Zoning system arrangements to protect marine biodiversity, as well as sustainable economic activities, form the highest priority in the management of the Nusa Penida MPA.

The paper provides an overview of the coastal ecosystem of Nusa Penida and the potential for sustainable utilization of natural resources, as well as demonstrates the socio-economic condition of the Nusa Penida community. Rapid Ecological Assessment (REA) in 2009 for the marine ecosystems in the waters of Nusa Penida serves as baseline data to provide inputs for defining the MPA, including a zoning system and a management plan.

The ecological survey revealed 1,419 ha of coral reef with 296 species, 230 ha of mangrove with 13 species, and 108 ha of seagrass beds with 8 species. The assessment of fish biodiversity revealed 296 species of fish, including five that are new to science. Nusa Penida's waters are home to marine megafauna such as sea turtles, sharks and cetaceans, also unique and charismatic fish such as ocean sunfish (*Mola mola*) and manta rays (*Manta birostris*), that occur predictably annually.

Marine tourism, seaweed farming and capture fisheries are the main economic activities for the income of the coastal community. Nusa Penida is visited by more than 200,000 tourists each year. The tourists dive in 20 dive-spots arround the waters. There are 308 ha of seaweed farming that produce more than 50 tons per month. About 850 local fishermen depend for their livelihood on the fishing grounds around the waters of Nusa Penida for their livelihood. In total, some 46,000 residents depend on the marine biodiversity of the archipelago for their livelihood.

Destructive fishing and over-fishing are serious threats to the reef ecosystem within the Nusa Penida MPA, as well as to the sustainable fisheries. The lack of a clear zoning system and its attendant regulation of uses for Nusa Penida's coastal area and marine resources mean potential conflicts between marine tourism, seaweed farming and the fisheries. The establishment of the MPA with a management plan is imperative to regulate the sustainable use of marine resources.

RÉSUMÉ: La zone marine de protection (MPA) de Nusa Penida Bali - Indonésie: Pourquoi la protéger?

Nusa Penida fait partie d'un petit groupe d'îles situées au sud-ouest de Bali. Cet archipel abrite une grande biodiversité marine et a un potentiel touristique important. De plus, à Nusa Penida on pratique l'aquaculture et la pêche qui connaissent un important essor. Les efforts de conservation et d'utilisation durable des ressources marines à l'aide de l'MPA sont devenus une solution non-négligeable devant la pression croissante exercée par les activités économiques sur les ressources naturelles. Les aménagements du système de zonage pour la protection de la biodiversité marine ainsi que pour le soutien des activités économiques sont hautement prioritaires dans la gestion d'MPA Nusa Penida.

Cet article se propose d'offrir une vue d'ensemble sur l'écosystème côtier de Nusa Penida et de la potentielle utilisation durable des ressources naturelles mais aussi de présenter le contexte socio-économique de la communauté locale. L'Evaluation Ecologique Rapide (REA) de l'écosystème marin qui a eu lieu en 2009, sert en tant que donnée de départ pour l'établissement du système de zonage, y compris pour la MPA et pour le plan de gestion.

L'étude écologique a montré que la zone récifale couvre une surface de 1 419 ha et contient 296 espèces de coraux; les mangroves sont formées par 13 espèces couvrant 230 ha et l'herbier couvre 108 ha et contient 8 espèces d'herbe de mer. L'évaluation de la biodiversité des poissons a révélé 296 espèces parmi lesquelles 5 qui sont des espèces nouvelles pour la science. Les eaux environnantes abritent une mégafaune marine formée de tortues de mer, de requins, de cétacés ainsi que l'unique et charismatique poisson lune (*Mola mola*) et des raies manta (*Manta birostris*) dont l'apparition reste prédictible et annuelle.

Le tourisme marin, les fermes d'herbe de mer et la pêche sont les principales activités économiques assurant le revenu de la communauté côtière. Nusa Penida accueille plus de 200 000 touristes chaque année. Les touristes font de la plongée au niveau de 20 points autour de l'île. Les 308 hectares cultivés à l'herbe de mer produisent environ 50 tonnes par mois. Environ 850 pêcheurs gagnent leur vie en exploitant les terrains de pêche autour de Nusa Penida. A peu près 46 000 habitants gagnent leur vie aux dépens de la biodiversité marine de Nusa Penida.

La pêche destructive et la surpêche sont des menaces sérieuses pour l'écosystème du récif de la MPA Nusa Penida ainsi que pour les activités de pêche durable. Le manque d'un système clair de zonage et de réglementation d'usage pour la zone côtière de Nusa Penida et pour les ressources marines créent les prémisses d'un potentiel conflit entre le tourisme marin, les fermes d'herbe de mer et les activités de pêche. La mise en place de la MPA et la rédaction de son plan de gestion sont impératives afin de permettre une utilisation durable des ressources marines.

REZUMAT: Zona de protecție marină (MPA) Nusa Penida Bali – Indonezia: De ce este nevoie de protecție?

Nusa Penida face parte dintr-un grup de insule situat în sud-estul insulei Bali. Acest arhipelag conține un grad mare de diversitate a vieții marine și are un potențial turistic însemnat. În plus, Nusa Penida are activități de acvacultură și pescuit care continuă să se dezvolte. Eforturile de conservare și utilizare durabilă a resurselor marine cu ajutorul MPA au devenit o soluție importantă în fața presiunii tot mai mari exercitate de activitățile economice asupra resurselor naturale. Amenajarea sistemului de zonare pentru protejarea biodiversității marine precum și susținerea activităților economice sunt de cea mai mare prioritate în gestionarea MPA Nusa Penida.

Acest articol îşi propune să ofere o vedere de ansamblu asupra ecosistemelor costiere de la Nusa Penida şi asupra potenţialului utilizării sustenabile a resurselor naturale precum şi să arate contextul socio-economic al comunităţii din Nusa Penida. Evaluarea Ecologică Rapidă (REA) a ecosistemului marin din apele din jurul insulei, ce a avut loc în 2009 a oferit datele de plecare pentru stabilirea sistemului de zonare inclusiv pentru MPA şi pentru redactarea planului de management.

Studiul ecologic a arătat că zona de recif acoperă o suprafaţă de 1.419 ha şi conţine 296 specii de corali, mangrovele sunt formate din 13 specii pe 230 ha iar zona de pajişte submarină acoperă 108 ha şi conţine 8 specii de iarbă de mare. Evaluarea biodiversităţii piscicole a descoperit existenţa a 296 specii de peşti din care 5 sunt specii noi pentru ştiinţă. Apele din jurul Nusa Penida găzduiesc o mega faună marină formată din ţestoase marine, rechini, cetacee, precum şi peştele soare, atât de unic şi carismatic (*Mola mola*) şi diavoli de mare (*Manta birostris*) a căror apariţie este predictibilă şi anuală.

Turismul marin, creşterea ierburilor de mare şi pescuitul sunt principalele activităţi economice desfăşurate de comunitatea costieră de pe Nusa Penida. Insula are peste 200.000 turişti anual. Aceştia practică scufundări în 20 de puncte situate în proximitatea insulei. Fermele de iarbă de mare acoperă 308 ha şi produc peste 50 tone/lună. În jur de 850 de pescari locali depind pentru hrana zilnică de peştele din jurul insulei. Biodiveristatea marină asigură traiul zilnic pentru aproximativ 46.000 localnici din Nusa Penida.

Pescuitul distructiv şi supraexploatarea sunt ameninţări serioase pentru ecosistemele de recif din MPA Nusa Penida precum şi pentru pescăriile durabile. Lipsa unui sistem de zonare clar şi a regulamentului pentru utilizările zonei costiere şi a resurselor marine din Nusa Penida duc la conflicte potenţiale între turismul marin, fermele de iarbă de mare şi activităţile piscicole. Stabilirea şi punerea în aplicare a planului de management al MPA sunt imperative pentru reglementarea utilizării sustenabile a resurselor marine locale.

INTRODUCTION

The Indonesian government is committed to protect the coastal and marine area of about 20 million hectares by 2020. This commitment also parallels with the Coral Triangle Initiative (CTI) where Indonesia is already appointed as CTI secretariat. Currently, the Ministry of Marine Affairs and Fisheries (MMAF) in collaboration with provincial, district and community authorities, NGOs and universities are already establishing 13.9 million hectares of marine protected area (MPA) to sustain Indonesia, including coral triangle marine biodiversity.

The Nusa Penida Marine Protected Area (Penida MPA) is one of the MPA that lies just a few kilometres south-east of Bali-Indonesia and within the Coral Triangle - an area of exceptional marine biodiversity. The total area of Nusa Penida MPA is 20.057 hectares that covers water surrounding the Penida, Ceningan and Lembongan islands. The Minister of Marine Affair and Fisheries together with the Bali Governor and Head of Klungkung District declared Nusa Penida MPA in November 2010. The MPA is legalized under the Klungkung District Decree no. 12/2010.

Marine Biodiversity

Based on the ecological surveys of 2002-2009 period, 1,419 hectares of coral reef, 230 hectares of mangrove with 13 species and 108 hectares of seagrass bed with 8 species were found in Nusa Penida (Sanjaya, 2009). Furthermore, a marine rapid ecological assessment (REA) in Nusa Penida's water found 296 species of coral reef (Turak and Vantier, 2009). There is also a tremendous fish biodiversity; the REA found 576 species of fish, five of which

are new species (Allen and Erdmann, 2008). Nusa Penida water bodies are also home to unique marine *mega-fauna* such as sea turtles, sharks, whales, and dolphins.

The water bodies of Nusa Penida are world-famous for aggregations of ocean sunfish (*Mola mola*) and manta rays (*Manta birostris*) that occur predictably on the south coast of Penida each year. The ocean sunfish season is between July-September and divers can find manta rays during this period of the year. Whales and dolphins also migrate through the straits to the east and west of the island.

However, the Nusa Penida's coastal area is intensively used for economic activities such as seaweed farming, marine tourism and fisheries. Nusa Penida has 20 dive spots around Nusa Penida water bodies, with more than 200,000 tourists visiting Nusa Penida each year. There are 308 hectares of seaweed farming area with an average production of about 50 tons/month.

Nusa Penida water bodies also serve as fishing grounds for almost 900 local fishermen. Snapper, grouper, travelly and other reef fish are common fish that are found there. More than 46,000 residents depend on the marine biodiversity in Nusa Penida for their day by day survival (Sanjaya, 2009).

Regarding the climate changes issue, based on regular sea-temperature observation, the water temperature ranges between 14-31^{o}C. Fortunately, there is no "coral bleaching" event recorded till now in Nusa Penida. The local coral communities are maybe more resilient to "coral bleaching" due to the local cold water upwelling's - creating a coral refuge during warm water episodes (CTC, 2010).

Socioculture of the community

Nusa Penida is a part of the Klungkung District administration, Bali Province. This sub-district includes three major islands, Nusa Penida, Nusa Lembongan and Nusa Ceningan, with a total area of about 20,000 hectares. There are 46,000 people who inhabit the 16 administrative villages and 40 pakraman villages in Nusa Penida.

The main livelihood sources in Nusa Penida are seaweed farming, fisheries, marine tourism, livestock and farming. There are four high schools and three junior high schools on these islands. Out of the 90 km coastline of Klungkung District, 70 km are part of Nusa Penida, while the rest are located in the mainland.

The majority of the Nusa Penida community belongs to the Balinese with Hindu religion. The temple of Sad-Khayangan Ped in Nusa Penida is one of the central temples of Bali. Nusa Penida has several big-temples, such as Batu Medau and Giri Putri temple. Puncak Mundi is the highest point in Nusa Penida where another temple is located, that is frequently visited by the Nusa Penida community and the Balinese from the mainland, for prayers.

The traditional structure that overlooks pakraman villages in Nusa Penida is the Alit Assembly. The assembly coordinates, performs and supervises religious and customary rituals. The community of Nusa Penida also performs the Nyepi Segara ritual every year to honour the sea. The ritual is usually held on sasih kapat, which falls on October. During Nyepi Segara, fishing activity in the sea is not allowed for a full day.

Economic activities

Marine Tourism. Over 20 diving sites are distributed around the water of Nusa Penida. Crystal Bay, Manta Point, Ceningan Wall, Blue Corner, SD-Sental, Mangrove-Sakenan, Gamat Bay and Batu Abah are favorite diving sites in Nusa Penida. Three major cruises give an attractive daily trip to Nusa Penida for about 600 tourists, with their own pontoon facility.

Marine tourism attractions in Nusa Penida include diving, surfing, snorkelling, sailing, fishing, flying-fish, para-sailing, kayaking and sea-walking. There are six diving operators based in Nusa Lembongan and Nusa Penida. About 200,000 tourists visit Nusa Penida every year. The peak season usually falls in August and September, while the low season falls in January and February.

Figure 1: Diving sites in Nusa Penida.

Seaweed Cultivation. Nusa Penida has approximately 308 hectares with maximum potential for seaweed cultivation (Sanjaya, 2009). The used seaweed farming method is the line-culture technique. *Euchema spinossum* is the most abundantly grown seaweed in Nusa Penida and specifically in Lembongan, *Euchema cotonii* grows well in the strait between Lembongan and Ceningan. Seaweed farmers in Nusa Penida are able to harvest an average of about 40-50 tons per harvest cycle (every 35 days). Market price fluctuates significantly, the current price for a kilogram of *Spinossum* with 30% water content is 2,000-2,900 Rp. In contrast, the *Cotonii* can reach about 4,000-5,300 Rp. per kilogram.

The average net-income from 1 acre (10 m x 10 m) plot of seaweed is around 300,000 Rp. Middlemen coordinate the seaweed sales and send them to Surabaya before being exported to China, Taiwan, Korea and Japan.

Figure 2: Seaweed farming area
in Nusa Penida sub-district.

Fisheries. About 850 fishermen live in the Nusa Penida sub-district who are divided into 40 fishermen groups.

Batununggul and Suana villages have the largest number of fishermen. Most fishermen in Nusa Penida are using seven meter fishing boats with 15 PK outboard engines power. Usually, the fishing grounds are located mostly between 40-200 meters in water depth, with a distance range of 5 miles from the mainland, even reaching Lombok.

In general, the fishermen catch fishes such as *Auxis* spp., lutjanidae, grouper/ ephinepelus, sharks/elasmobranch, skipjack/katsuwonus pelamis and other species depending on the season.

Fishermen usually depart at dawn and return later in the morning.

Prices for a medium-sized skipjack range from 3,000-5,000/fish Rp.

Fishing grounds of consumption of fish for local people such as grouper and other reef fish are found in the north and west of Nusa Penida.

Figure 3: Fishing grounds around Nusa Penida.

Threats to Nusa Penida Marine Biodiversity

Unfortunately, the tremendous Nusa Penida marine biodiversity is facing threats from human activities and nature's dynamics. Destructive fishing (poison and bom fishing) and overfishing pose a serious threat to the reef ecosystems of the proposed Penida MPA and sustainable fisheries.

Local communities of Nusa Penida rely on these reefs as an income and livelihood source - directly through fishing and seaweed farming, and indirectly through the expanding marine tourism industry which provides employment opportunities. While tourism development offers opportunities for local communities, it is important to ensure that the environmental values of the area are not compromised.

The lack of a clear marine zoning system and regulation of the uses in Nusa Penida's coastal area and marine resources can create potential conflicts between marine tourism, seaweed farming and fisheries activities.

The region's marine biodiversity is under threat of over-exploitation, which would mean that it could no longer sustain ecosystem services for local people's livelihood.

MPA as a Long-Term Solution

For sustaining the marine biodiversity in Nusa Penida area that would bring benefits to the local people, the Ministry of Marine Affairs and Fisheries (MMAF) in collaboration with the Klungkung District Government and Coral Triangle Center (CTC) - an Indonesia's NGO focused on capacity building within the coral triangle region and have supported an establishment of collaborative management, the Marine Protected Area (MPA).

The Nusa Penida MPA establishment initiative itself has three objectives: 1) marine biodiversity protection; 2) sustainability in fisheries and 3) sustainability in marine tourism. The objectives are meant to guarantee the local community's livelihood from marine resources.

The establishment of Nusa Penida MPA is based on scientific evidences, as well as law and regulation guidance such as the Ministery of Marine Affairs and Fisheries Decree no. 2/ 2009 regarding MPA Establishment Procedures and Decree no. 30/2010 regarding the MPA Management Plan and Zoning System. The MPA establishment approach combines a top-down and bottom-up approach to accommodate proportionally the interests of key stakeholders.

Public consultation with Nusa Penida key stakeholders was done to get inputs and development agreements on the Nusa Penida MPA establishment through 33 meetings at Focus Groud Disscusion (FGD), village, sub-district and district levels. More than 1,200 participants among them like fishermen, seaweed farmers, marine tour operators, district and sub-district government officials, teachers, students and traditional leaders involved actively and the majority showed support for the MPA establishment.

As follows-up on the agreement from Nusa Penida's key stakeholders, the Klungkung District Government has established Nusa Penida MPA Task-Force that consists of an official government local agency, community group representatives and NGOs representatives that work under the Head of the Klungkung District Decree no. 216/2009. The Task-Force's main objective is to do preparations for the Nusa Penida MPA launch. In November 2010, the Minister of Marine Affairs, together with the Bali Governor and Head of Klungkung District launched the MPA.

This year, Nusa Penida MPA is in the process of developing a zoning system, a 20 years management plan, as well as a management body, including a joint patrol before the proposal of getting a Ministerial Decree. For the time being, CTC in collaboration with the Brawijaya University have already developed a marine tourism profile in Nusa Penida as inputs on sustainable financing mechanism for Nusa Penida MPA. Study on willingness to pay will be conducted in October to find out how many visitors or tourists would contribute with an entrance fee and conservation fund. If all the instruments that are needed for Nusa Penida MPA are set in place and fully operated, hopefully the MPA will effectively work to sustain the local community's source of livelihood.

Zoning system in Nusa Penida MPA

The development of the zoning system in Nusa Penida MPA is based on ecological and socioeconomic baseline data, as well as public consultation inputs and policy assessment. According to the Minister of Marine Affairs and Fisheries Decree no. 30/2010, an MPA should consist of a core zone, a sustainable fisheries zone, an utilization zone and other zones. The core zone is about 2% of the total area of the MPA.

As a result of the public consultation through 14 meetings at Focus Group Disscusion (FGD), village and sub-district levels along with fishermen, seaweed farmers, traditional leaders, dive operators, heads of villages and sub-districts and the key stakeholders, in Nusa Penida agreed on a core zone, sustainable fisheries zone, marine tourism zone, seaweed

farming zone, and holy zone in front of a temple in the coastal areas. From a total of 20,057 hectares of the Nusa Penida MPA, the sustainable fisheries zone is about 17,000 hectares, which is about 80% of the Nusa Penida MPA. In contrast, the no take zone (core zone and marine tourism zone) is about 20% of the critical habitat.

The regulations for each zone are 1) core zone - fisheries and marine tourism activities are allowed, limited research and education activities with permit are allowed, 2) marine tourism zone - fishing is not allowed in this zone, marine tourism activities are allowed, 3) sustainable fisheries zone - fishermen can perform fishing activities in this zone with no destructive methods and fishing gear, compressor-hookah is not allowed in this zone based on local fishermen is request, 4) seaweed farming zone - this zone is only for seaweed farming, fishing with traditional gear such as pole and line, small net and traditional spear-gun are allowed, 5) holy zone for temple - boat parking, especially diving boats are not allowed in front of the temple since sometimes tourists have inappropriate dressing, before and after diving, but diving activities in front of the temple are allowed.

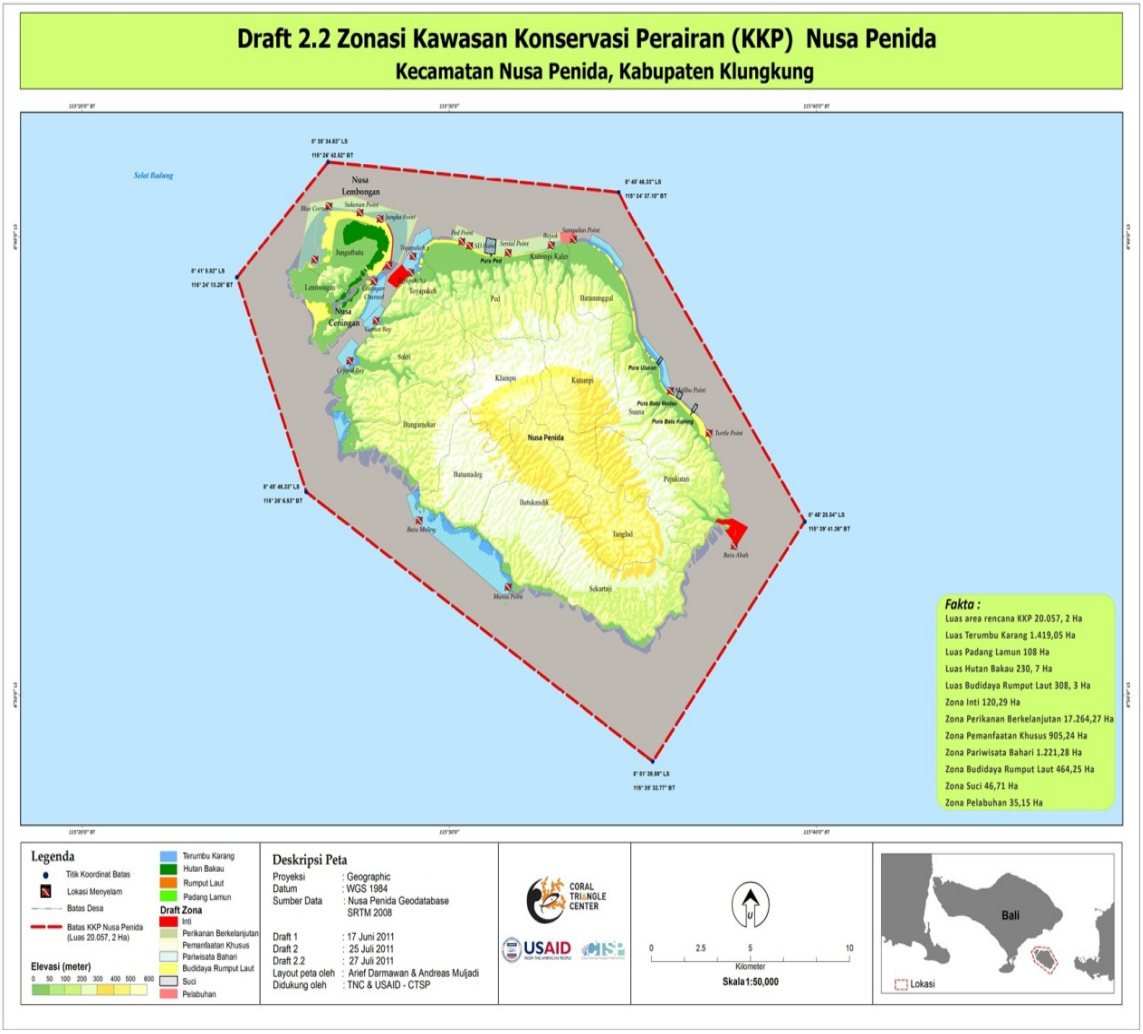

Figure 4: Nusa Penida MPA with Outer Boundary and Draft of Zoning System.

REFERENCES

1. Allen G. R. and Erdman M. V., 2008 – Reef Fish of Nusa Penida, Indonesia, Final Report to Conservation International, 22.
2. Sanjaya W., 2009 – Monitoring Terumbu Karang dan Ikan Nusa Penida, Dinas Peternakan, Perikanan dan Kelautan (DPPK) Klungkung, Yayasan Bahtera Nusantara, The Nature Conservancy Indonesia Marine Program (TNC-IMP), 64.
3. Turak E. and De Vantier L., 2009 – Biodiversity and Conservation Priorities of Reef-Building Corals in Nusa Penida, Final Report to Conservation International, 66.