Proiect de conservare *ex situ* a roșioarei termale (*Scardinius racovitzai* Müller 1958). Date privind dinamica recentă a parametrilor fizico-chimici ai apei din Lacul Ochiul Mare, Rezervația Naturală Pârâul Pețea (jud. Bihor)

Thermal Rudd (*Scardinius racovitzai* Müller 1958) *ex situ* Conservation Project. Considerations Regarding the Recent Dynamic of Physical and Chemical Water Parameters from Ochiul Mare Thermal Lake, Pârâul Peţea Nature Reserve (Bihor County)

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Rezumat

Degradarea continuă a ecosistemului termal Ochiul Mare, rezervația naturală Pârâul Pețea, jud. Bihor, a fost evaluată prin intermediul factorilor fizico-chimici ai apei. Un proiect pentru salvarea speciilor animale termale, endemice în acest lac, s-a derulat în perioada 2013 – 2014 şi a fost finanţat de The Mohamed bin Zayed Species Conservation Fund. Mediul abiotic al lacului Ochiul Mare a fost analizat în detaliu, cu ajutorul datelor obținute din teren în 2013 cât și prin consultarea studiilor publicate în ultimii ani, cu scopul elaborării unui model al factorilor hidro-fizico-chimici. Acest studiu a precedat experimentele de replicare, în acvarii, a principalilor factori fizico-chimici care caracterizează ecosistemul termal – condiție esențială pentru succesul reproducerii ex situ a roșioarei termale (Scardinius racovitzai Müller 1958) și obținerii de descendenți care să susțină populația din mediul natural. În ceea ce privește regimul termic, o depresie a curbei temperaturilor se produce în perioada octombrie – martie, cu valori minime în lunile de iarnă și variații multianuale. Există zone ale lacului (ex. „dud”) unde temperatura se menține în general peste 20^{0}C, considerată limita minimă de toleranță și supraviețuire. Evoluția catastrofală a regimului termic în ultimii ani pe durata iernii este corelată cu variația de nivel al apei, suprafața inundată, debitul izvorului geotermal. pH-ul apei este ușor alcalin, cu excepția perioadei de reproducere când reacția apei devine neutră sau slab acidă. Marea majoritate a celorlalți factori fizico-chimici se încadrează între limitele de toleranță pentru o apă piscicolă.

Keywords: roșioară termală, conservare *ex situ*, calitatea apei

Introduction

The Pârâul Pețea nature reserve is located in Bihor County, north-western Romania. The Ochiul Mare thermal lake in the Pârâul Peţea nature reserve is a single spring-fed lake, with an initial area of occupancy of 4 km².

Ochiul Mare Lake was formed in the second half of the Holocene (SÜMEGI *et alii*, 2012 quoted by SÎRBU *et alii*, 2013) and is an unique ecosystem where endemic species are living; the lake is the only site in Europe where the Egyptian white water-lily, *Nymphaea lotus* L. var. *thermalis*, grows naturally, here represented by an endemic thermal variety; the thermal Rudd *Scardinius racovitzai* Müller, 1958 and the thermal snail, *Melanopsis parreyssii* Philippi, 1847, are both critically endangered species (FREYHOF & KOTTELAT, 2008; FEHÉR, 2013).

Since December 2011 it is dramatically restricted because the underwater spring has ceased its activity, probably as a result of excessive extraction of thermal water. Overexploitation of geothermal mineral waters in the area is the main factor that affects the water level and temperature.

A precise defining and modelling of the abiotic environment of the thermal ecosystem in Pârâul Peţea nature reserve was realized in order to simulate in aquariums an artificial ecosystem corresponding to the ecological requirements of the target species. This was a preliminary step, critical for studying the biology and ecology of the thermal Rudd for inducing captive reproduction by controlling environmental parameters.

Material and Methods

Chemical parameters of water, having a limiting effect on aquatic animals, including by transportation stress, were assessed in the field: <u>total dissolved salts</u> (TDS), with a digital TDS-meter (0-9990 ppm, ± 2% accuracy), <u>pH</u>, with a digital pH-meter (AF PH1, range 0-14, ± 0.1 accuracy), <u>dissolved oxygen</u>, with a mobile kit (Aquamerck Sauerstoff-Test) and Winkler's titration method, and <u>carbonate/total hardness</u>, with a mobile kit (Aquamerck Compact Laboratory) and a titrimetric method. Laboratory chemical analyses were performed periodically with adequate equipment.

Dissolved oxygen and its saturation were measured with an OAKTON pH-oxymeter. Ammonia, ammonium, ammonia nitrogen, nitrites, and nitrite nitrogen, nitrates, phosphates, total iron, total chlorine and chlorides were measured with a DR890/HACH photo colorimeter. Alkalinity, GH and KH were measured with a HACH digital titration. A graphical and statistical multivariate approach was applied by using Systat 10.2.

Results and Discussion

During the field trips in 2013, sampling points were established for collecting hydro biological samples (Table 1), taking into account their distance from the emission area of the geothermal spring and the cold tributary Valea Glighii (Fig. 1).

Table 1. Hydrobiological sampling points
Tabel 1. Stații de colectare probe hidrobiologice

Crt. nr.	Sampling point	Nr. of sample	Date of collecting	Observations
1.	1	1	20 Aug.2013	”Ochiul Mare”
2.	2	2	20 Aug. 2013	temporary, cold tributary (Valea Glighii)
3.	3	3	27 Oct. 2013	”Ochiul Mare”
4.	4	4	27 Oct. 2013	”Ochiul Mare”
5.	1	5	27 Oct. 2013	”Ochiul Mare”

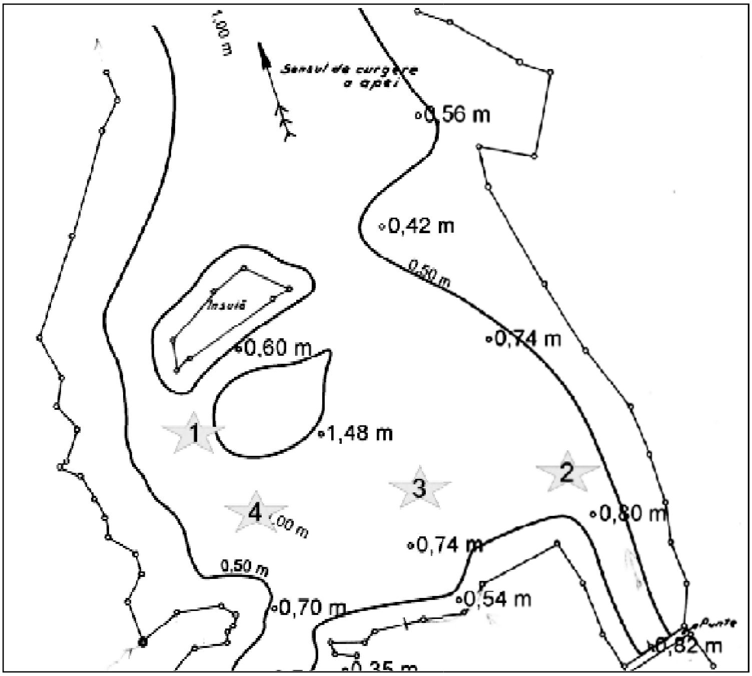


Fig. 1. Sampling points in Ochiul Mare Lake, Pârâul Pețea natural reserve (18 – 20 Aug. 2013 and 27 – 28 Oct. 2013)
Fig. 1. Punctele de colectare probe din lacul Ochiul Mare, Rezervația naturală Pârâul Pețea (18 – 20 Aug. 2013 și 27 – 28 Oct. 2013)

The results of chemical analyses on the samples collected in 2013 are listed in Table 2.

Table 2. Water quality in the Ochiul Mare Thermal Lake in 2013

Tabel 2. Parametrii fizico-chimici ai apei din lacul termal Ochiul Mare

Parameters	**Number of sample**				
	1	**2**	**3**	**4**	**5**
Date	23rd Aug	23rd Aug	29th Oct	29th Oct	29th Oct
Temperature (^0C) 10^{00}	25	-	20	24	25
16^{00}	29				
Dissolved oxygen (mg/l)	2	-	1.1		2.5
Saturațion (%)					
pH	7.1 – 7.3		7.1	6.9	6.9
TDS (mg/l)			313	338	315
Free chlorine (mg/l)	0.01	0.02	0.03	0.03	0.01
Total chlorine (mg/l)	0.02	0.02	0.03	0.03	0.01
Chlorides (mg/l)	60	30	30	29	29
Fe^{2+} (mg/l)	0,04	0.03	0.07	0.05	0.05
CO_2 (mg/l)	160	88	200	160	180
NO_2^- (mg/l)	0.012	0.036	0.012	0.001	0.005
NO_3^- (mg/l)	1.3	0.9	1.3	1.8	1.4
NO_2-N (mg/l)	0.004	0.011	0.004	0	0.001
$NaNO_2$ (mg/l)	0.018	0.054	0.018	0.002	0.007
PO_4^{3-} (mg/l)	0.66	0.27	0.32	0.41	0.47
P (mg/l)	0.21	0.09	0.12	0.13	0.15
P_2O_5 (mg/l)	0.49	0.20	0.28	0.31	0.35
NH_3 (mg/l)	0.09	0.28	0.05	0.01	0.01
NH_4^- (mg/l)	0.09	0.30	0.05	0.01	0.01
NH_3-N (mg/l)	0.07	0.23	0.004	0.01	0.01
Total alkalinity (mg/l)	6.0	4.0	5.8	6.0	6.0
Total hardness (^0G)	17.41	11.98	18.53	16.68	15.45
Carbonates hardness (mg/l)	12.65	8.9	15.12	13.72	18.44
Acidity (mg/l)	0	80	100	80	90

A low oxygen level and a relatively high diurnal thermal amplitude (ΔT 4^0C) were noticed at sampling time, as well as moderate hardness, in accordance to the main geothermal source of the lake, and a low level of nutrients duet o their consumption by the abundant aquatic vegetation.

Limiting physical parameters. Temperature. Water temperature is an environmental parameter exerting the most powerful influence on fish metabolism and other biological processes and phenomena.

Yearly thermal dynamics. Correlations between sampling points and influence by rainfall regime. The annual dynamic of water temperature in three sampling points is represented in Fig. 2, based on weekly measurements recording during the 2005 (DANCIU, 2007).

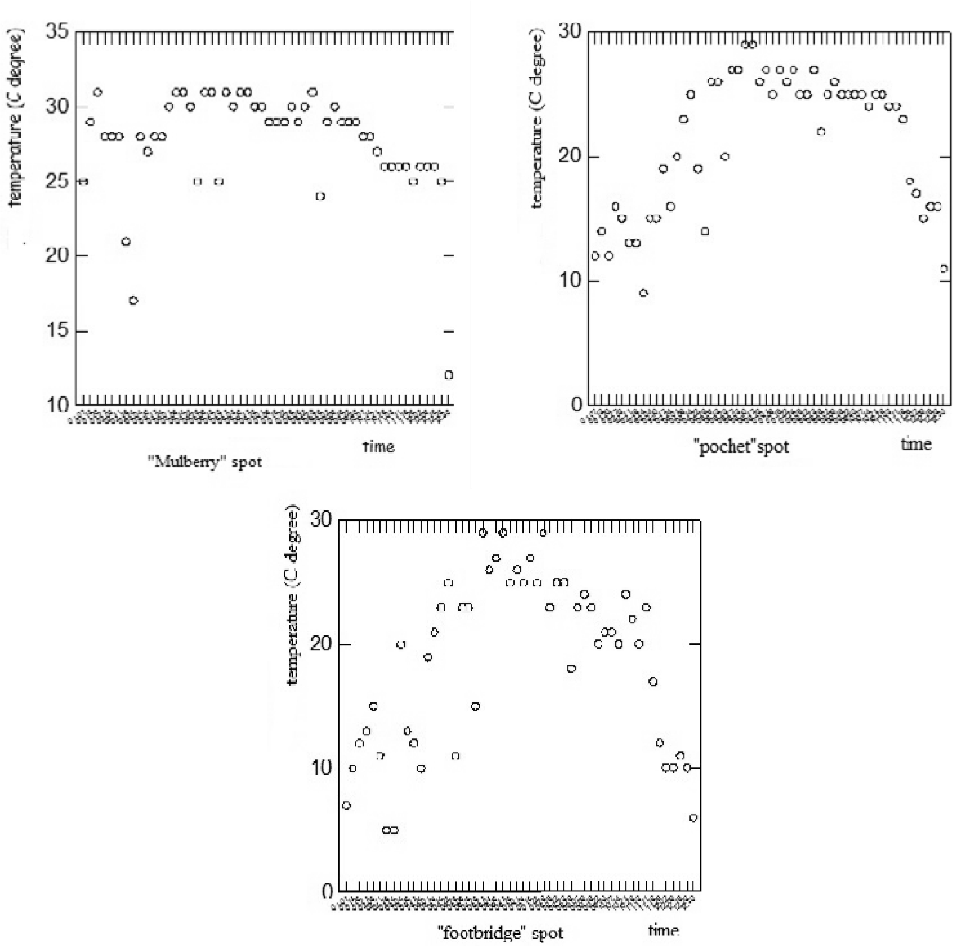


Fig. 2. Water temperature in three sampling points in the Ochiul Mare thermal ecosystem („mulberry", „pocket", „footbridge")

Fig. 2.Temperatura apei în trei puncte de colectare din ecosistemul termal Ochiul Mare ("dud", "buzunar", "podeț")

The correlation of temperature values in various sampling points evaluated with the Pearson correlation matrix (WILKINSON *et alii*, 2005) was positive and had a coefficient above 0.5 (Table 3), thus the thermal regime evolved similarly in the various sampling points. There was a close correlation between the thermal regimes in the shore areas of the lake (footbridge and pocket, with a correlation coefficient of 0.924, where the influence of Pețea Brook and climatic factors prevails) while the thermal dynamic of the central area was determined by the geothermal spring flow.

Table 3 Pearson correlation coefficients for the temperature measurements in the Ochiul Mare thermal ecosystem in 2005 (52 values per sampling point)

Tabel 3. Coeficienții de corelație Pearson pentru valorile de temperatură înregistrate în ecosistemul termal Ochiul Mare în anul 2005 (52 de valori per stație de colectare)

Sampling point	TMulberry	TPocket	TFootbridge
TMulberry	1.000		
TPocket	0.618	1.000	
TFootbridge	0.688	0.924	1.000

Statistical differences between sampling points were performed in order to evaluate the degree of homogeneity of the environment, to identify its potential to provide conditions for survival, and to define the ecological optimum. The analysis was performed by applying the T test (CHAKRABORTY *et alii*, 2005) and showed significant statistical differences between sampling points, due to the influence by the thermal spring and the allochtonous contribution by Pețea Brook (Table 4).

Table 4. Statistical analysis of differences (95% significance) between water temperature measurements at 3 sampling points in the Ochiul Mare thermal ecosystem (”mulberry”, ”pocket”, ”bridge”) in 2005 (52 values per sampling point)

Paired samples t test on TMulberry vs. TPocket with 52 cases

Mean TMulberry	27.673
Mean TPocket	21.154
Mean Difference	6.519
95.00% CI	5.297 to 7.741
SD Difference	4.390
t	10.708
df	51
Prob	0.000

Paired samples t test on TMulberry vs. TBridge with 52 cases

Mean TMulberry	27.673
Mean TBridge	18.635
Mean Difference	9.038
95.00% CI	7.585 to 10.492
SD Difference	5.220
t	12.485
df	51
Prob	0.000

Paired samples t test on TPocket vs. TBridge with 52 cases

Mean TPocket	21.154
Mean TBridge	18.635
Mean Difference	2.519
95.00% CI	1.741 to 3.298
SD Difference	2.797
t	6.495
df	51
Prob	0.000

In some areas of the lake water temperature values exceed the minimum tolerance limit for the thermal species (20^{0}C according to literature) and populations` survival depends on the duration of exposure to this critical factor. The area adjacent to the thermal spring has temperature values above 20^{0}C, a value considered minimal for tolerance/ survival of *Scardinius racovitzai*. Also, if the annual thermal dynamics, winter season included, did not meet the cumulating of degrees-days needed to trigger reproduction in the thermal Rudd, species survival and conservation of its gene pool are under threat.

Maintaining water temperature close to the comfort range for the thermal species depends on the equilibrium between hydrological factors (thermal spring flow, Pețea Brook flow), climatic factors (air temperature, rainfall regime), lake volume and intensity of evaporation. From the available hydro-climatic data, the influence of the monthly mean volume of rainfall on water temperature in all three sampling points was evaluated.

Rainfall volume in 2005 in the Pârâul Pețea nature reserve (47.35 mm, annual mean value) was comparable to the annual mean values recorded between 1978 and 1997 (51.48 mm multi-annual mean value) (DANCIU, 2007). See Table 5.

Table 5. Statistical data on rainfall volume

Tabel 5. Date statistice privind volumul precipitațiilor

Month	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**
Multi-annual monthly mean value (mm)	37.2	27.9	33.9	46	66.7	93.2	77	52.8	48.3	42.4	41.3	51
Monthly mean value in 2005 (mm)	48.8	39	0	61.6	46.6	51.6	75.6	122.4	35.8	5.6	15.8	65.4

Through regression analysis, the influence of rainfall volume on the thermal dynamics of Lake Pețea was found to be statistically insignificant under the conditions stated above and specific to the reference year and to the measurements interval.

Thermal dynamics during reproductive season. Based on literature data before the gradual degradation of the ecological condition of the thermal ecosystem, temperature dynamics during the interval October – March (critical for the physiological transformations prior to reproduction and spawning) was analyzed.

The available data for the reference interval are weekly measurements (15th Oct 1999 – 25th Feb. 2000) from the three sampling points in the lake, which are relevant for the ecological model (DANCIU, 2006). Temperature dynamics is shown in the diagrams below.

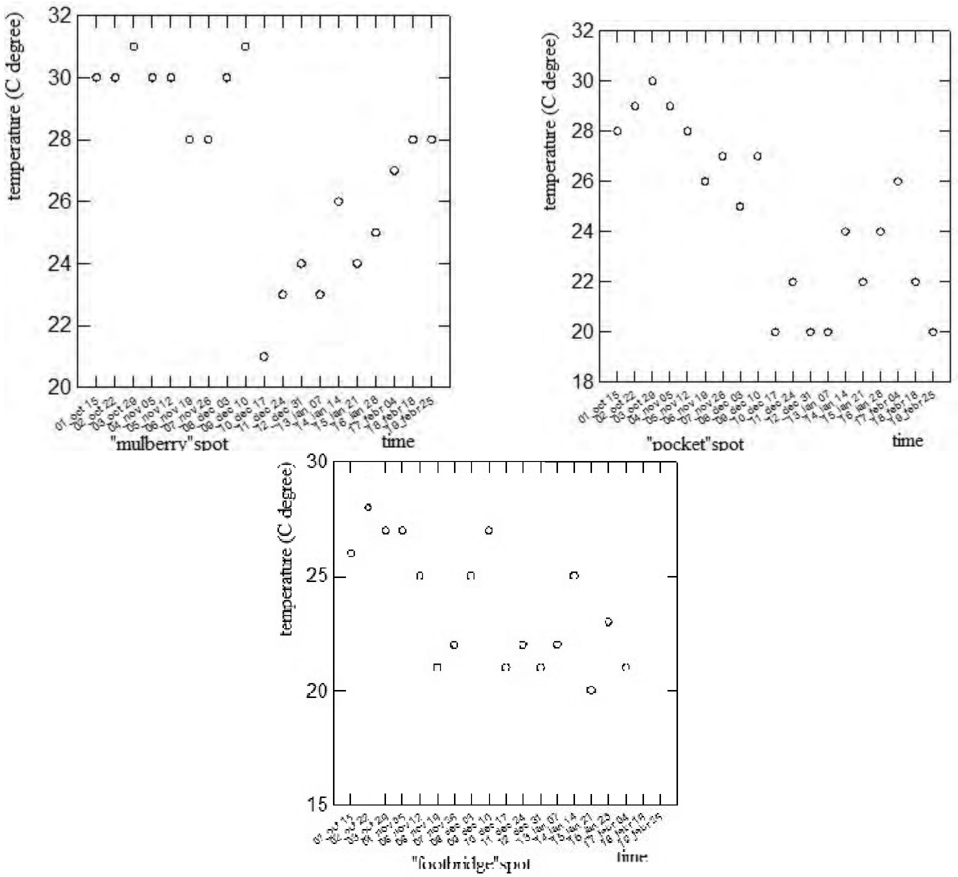


Fig. 3 Water temperature (^{0}C) in three sampling points of the Ochiul Mare thermal ecosystem (”mulberry”,”pocket”,”bridge”) during the cold season (15th Oct 1999 – 25th Feb. 2000)

Fig.3 Temperatura apei în trei stații de colectare (”dud”, ”buzunar”, ”podeț”) din ecosistemul termal Ochiul Mare, în timpul sezonului rece (15 oct. 1999 – 25 feb. 2000)

Correlations between the rows of temperature values from the 3 sampling points showed the influence of the thermal spring on lake temperature, leading to conclusions about its flow (Table 6). The effect of compensation of aerial heat loss by the geo-thermal spring decreased with the distance from the thermal spring.

Table 6. Pearson correlation matrix (WILKINSON *et alii, 2005)*
Number of observations: 17
Tabel 6. Matricea corelației Pearson (WILKINSON *et alii, 2005)*
Număr observații: 17

	TMulberry	TPocket	TBridge
TMulberry	1.000		
TPocket	0.926	1.000	
TBridge	0.782	0.746	1.000

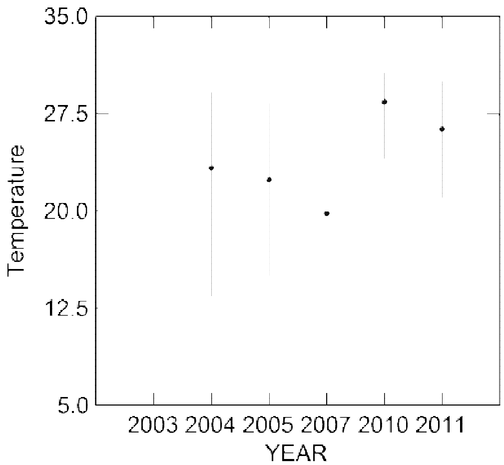


Fig. 4. Mean, minimum and maximum water temperature values in Ochiul Mare
Fig. 4. Valorile minime și maxime ale temperaturii apei din Ochiul Mare

There were statistically significant differences between the rows of temperature values from the three sampling points, which may have been a result of the antagonistic action by the thermal tributary and of external hydrological factors (the temporary, cold tributary Valea Glighii), as well as of climatic factors characteristic to the cold season.

Multi-annual temperature limits in the Ochiul Mare thermal ecosystem. In recent years, water temperature during the cold season has become the most critical risk factor for the survival of the thermal species. A comparison of the thermal dynamics in 1999 – 2000 (27.21^{0}C, ”mulberry” sampling point), to the interval 2003 – 2011 (from available data, DANCIU, 2006), a general decrease of annual mean values and frequent values of water temperature below 20^{0}C in winter, excepting the area close to the thermal spring.

The decrease of annual mean temperature was constant in recent decades. Historical observations in 1938 mentioned a mean value of 29,1^{0}C (April 1938-March 1939, quoted in DANCIU, 2007). The cause of this phenomenon was the decrease of the thermal spring flow (Table 5, DANCIU, 2006). Water temperature is a critically limiting factor for the survival of the endemic, thermal species in the Pețea Basin, thus more thorough studies to identify and help eliminate the possible causes (spring clogging, overexploitation of thermal water) affecting the optimal state of the lake, as well as the contribution of all responsible institutions need to be the main objective for managing the situation, save the species and restore the ecosystem.

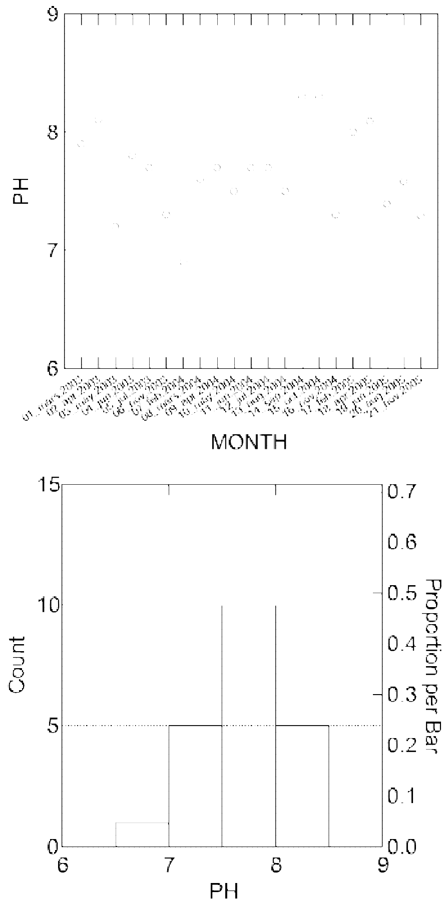


Fig. 5 Water pH dynamics in Ochiul Mare

Fig. 5. Dinamica valorilor de pH în Ochiul Mare

Limiting factors: pH. For *ex situ* conservation of the critically endangered, endemic, thermal species in the Pârâul Pețea nature reserve important information is provided by their tolerance limits to pH variation. The reconstruction of an optimal abiotic environment in aquariums is an important condition for the ex situ conservation program: animal welfare, stimulation of natural behavioural reaction, including physiological mechanisms of sexual maturation, triggering of reproduction, and obtaining viable offspring.

The analysis of available data about the pH in the natural ecosystem was used to define the variation range of water pH and to identify its dynamics during the degradation of the ecosystem. Water pH has an influence on the carbon dioxide content. In a neutral or alkaline environment a slowing down in the respiratory rhythm of organisms is recorded. Any sudden change in pH has an influence on the toxicity of heavy metals: copper, chrome, manganese and nickel (WEDEMEYER *et alii*, 1977).

pH values below 6.9 increase the toxic effect of free ions in water and values below 5.0 are lethal for most fishes. Only a few fish species can survive for a short time in such an acidic environment (WEDEMEYER *et alii*, 1977). SCHLOTFELDT *et alii* (1995) quoted in MUNTEANU *et alii* (2003) recommends values of 5.5-8.0 for various species in aquaculture.

Yearly pH dynamics. Mean monthly values available in recent publications (DANCIU, 2006) are represented in the graphic and histogram above.

The main statistical parameters of the pH values available for 2003-2005 (DANCIU, 2006) are represented in the Table 7.

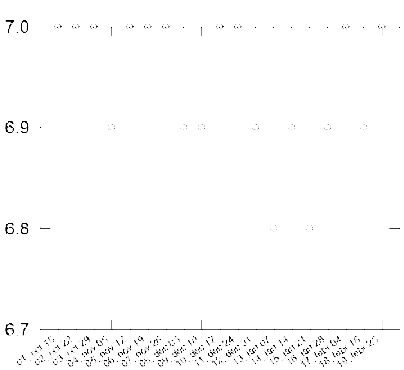
The confidence interval, with 95% certainty of affirmation, shows a slightly alkaline domain (7.4-7.8). The histogram and frequency of pH values are represented in the figure above, showing also exceptional values below 6 and above 8.

Table 7 The main statistical indices of limiting hydro-chemical parameters measured in Lake Ochiul Mare in 2003-2005

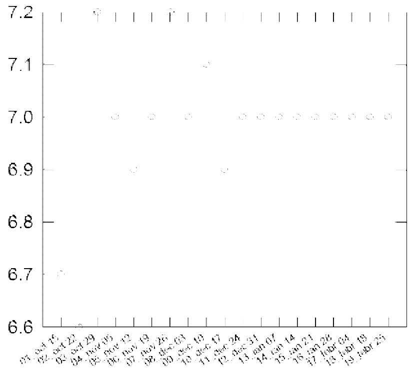
Table 7 Principalii indici statistici ai parametrilor fizico-chimici limitativi ai apei măsurați în lacul Ochiul Mare între 2003-2005

	PH	COD	CBO5
N of cases	21	18	18
Minimum	6.900	0.560	0.500
Maximum	8.300	9.200	12.500
Range	1.400	8.640	12.000
Sum	160.850	44.210	46.500
Median	7.700	1.640	1.500
Mean	7.660	2.456	2.583
95% CI Upper	7.827	3.537	3.983
95% CI Lower	7.492	1.375	1.184
Std. Error	0.080	0.512	0.663
Standard Dev	0.369	2.174	2.814
Variance	0.136	4.728	7.919
C.V.	0.048	0.885	1.089
Skewness (G1)	0.044	1.830	2.914

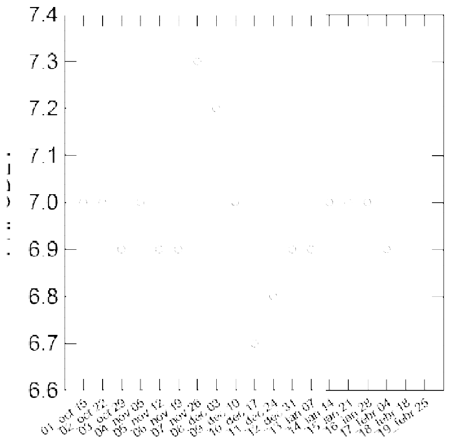
pH dynamics during reproductive season and differences between sampling points. The analyzed data are referring to the sampling results that were weekly collected during 1999-2000 and data were published by DANCIU (2006). The dynamics of this parameter is represented in Fig. 6.



”mulberry” spot



”pocket” spot



”footbridge” spot

Fig. 6. Dynamics of water pH in 3 sampling points in the Ochiul Mare thermal ecosystem (”mulberry”, ”pocket”, ”bridge”) during the cold season (15th Oct 1999 – 25th Feb. 2000)
Fig. 6. Dinamica valorilor de pH în trei stații de colectare din ecosistemul termal Ochiul Mare (”dud”, ”buzunar”, ”podeț”) în timpul sezonului rece (15 oct. 1999-25 feb. 2000)

Correlation of measured pH values was applied in order to evaluate the impact of tributaries (geothermal and temporary) and of genuine mechanisms of the thermal ecosystem on water reaction.

The two main sources are different: the thermal spring originates in the limestone substrate, rich in vegetal impressions and gastropod fossils determining alkaline pH values in the water, while the Valea Glighii brook has hydro-chemical characteristics typical for flowing water (Table 7). Yet there is no correlation of water reaction at various places in the lake, which is more influenced by biogenic processes such as respiration.

Table 7 Pearson correlation matrix
Tabel 7 Matricea corelației Pearson

	PHMulberry	PHPocket	PHBridge
PHMulberry	1.000		
PHPocket	-0.199	1.000	
PHBridge	-0.162	0.204	1.000

Samples taken at fish collecting time showed a significant CO_2 concentration (with direct impact on pH), higher in the lake than in the allochtonous source (cold brook). The statistical differences were evaluated with the T test, having 95% confidence of affirmation. A high degree of water homogeneity was noticed with respect to the concentration of hydrogen ions, differences between sampling points being statistically insignificant.

Multiannual limit pH values in the Ochiul Mare thermal ecosystem.

Based on the data available from the Criș Basin Water Department (Direcția Apelor Crișuri Oradea), consisting of 5 – 10 measurements per year during 2003 – 2011, the multiannual variation range for pH in the Pârâul Pețea nature reserve is represented as being between 6.9 and 8.3.

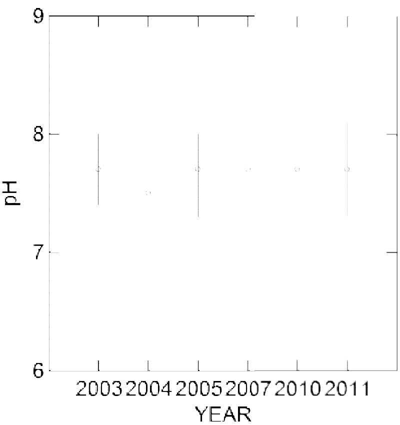
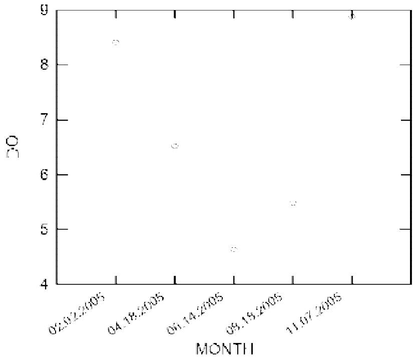
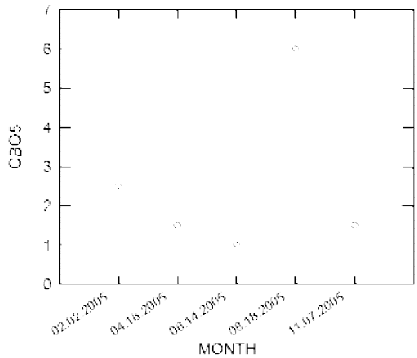


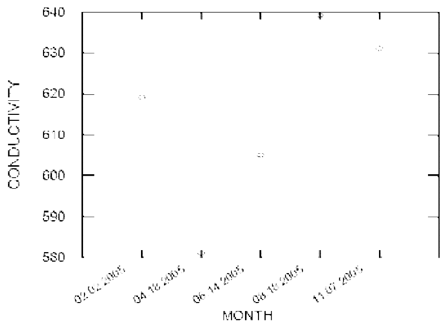
Fig. 7. Multiannual variation range of pH in the Ochiul Mare Thermal Lake
Fig. 7. Domeniul multianual de variație a pH-ului în lacul termal Ochiul Mare

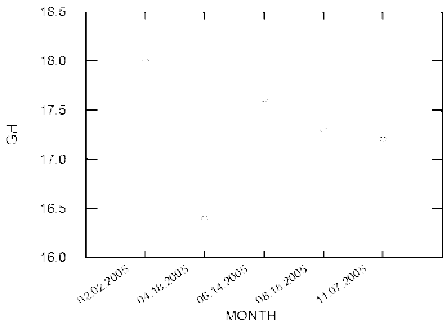
There are no available data on the duration of exposure to extreme (minimal and maximal) values of that range.

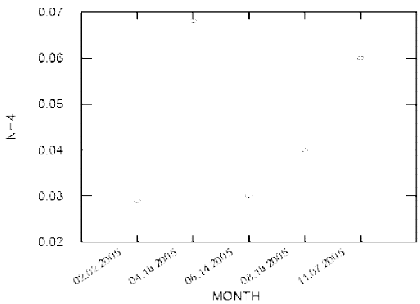
Other water chemistry data. There is little available information on the complete chemical analysis of water from the Pârâul Pețea natural reserve at various moments of its existence. From available data (DANCIU, 2007), information on hydro-chemical measurements were extracted and statistical analysis was applied to extrapolate results and to obtain a better understanding of the thermal ecosystem model and a more faithful application of results in the reconstruction of that environment in the aquarium.

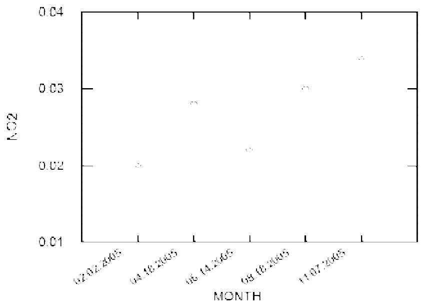












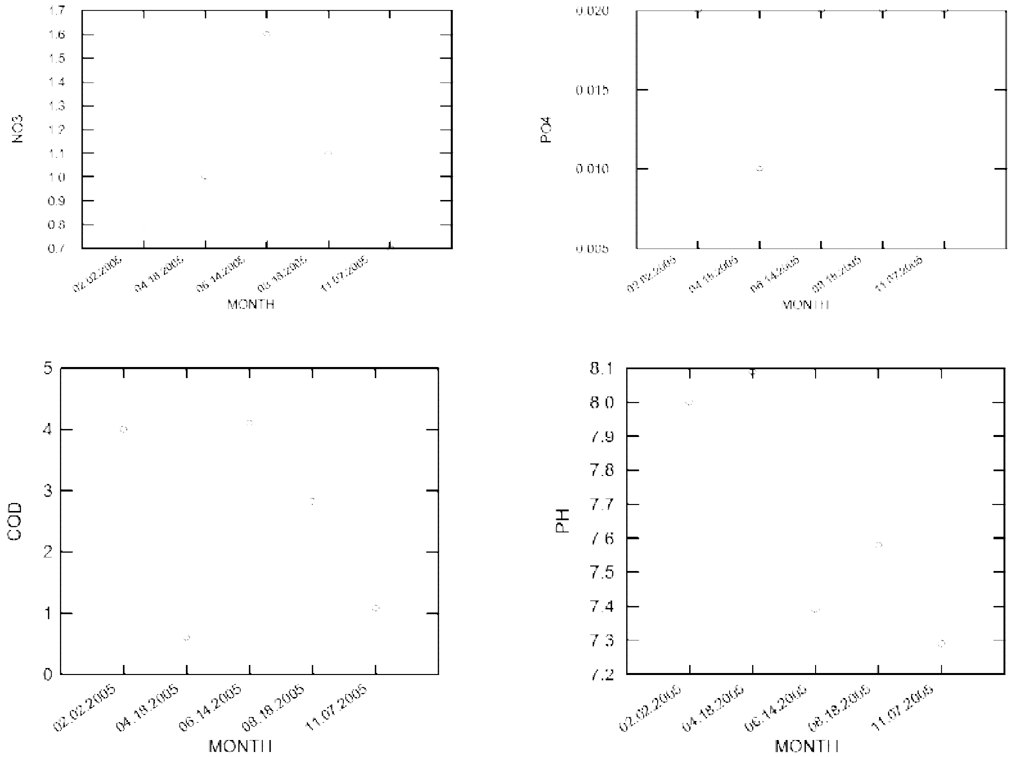


Fig. 8. Dynamics of chemical parameters of water in the Pârâul Pețea nature reserve in 2005 (DO – concentration of dissolved oxygen, ppm; CBO_5 – biochemical consumption of oxygen, ppm; conductivity, µS/cm; GH – total hardness, ^0G; NH_4 – concentration of ammonium, ppm; NO_2 – concentration of nitrites, ppm; NO_3 – concentration of nitrates, ppm; PO_4 - concentration of phosphates, ppm; COD – chemical consumption of oxygen, mg O_2/l)

Fig.8. Dinamica parametrilor apei din rezervația naturală Pârâul Pețea în 2005

Factorial analysis of water chemistry, based on few historical data, offered additional information about ecological features and interactions between abiotic and biotic environments (PREIN *et alii* 1993, STENSON, 2005). The first two factors total 71.466 % of the total variance (Table 8).

FACTOR 1 includes the significant and positive contribution of conductivity, hardness, COD and phosphates, in contrast with ammonium and nitrites.

Table 8 Factorial analysis of water quality for Ochiul Mare
based on chemical measurements in 2005. Component loadings
Tabel 8 Analiza factorială a calității apei din Ochiul Mare
pe baza măsurătorilor chimice efectuate în 2005

Parameter	**Factor**			
	1	**2**	**3**	**4**
pH	- 0.341	- 0.465	- 0.606	- 0.548
CONDUCTIVITY	0.516	0.832	0.134	- 0.156
GH	0.918	0.145	- 0.352	0.109
DO	- 0.266	0.603	- 0.722	0.211
COD	0.956	-0.261	- 0.129	- 0.042
NH4	- 0.973	0.175	0.123	0.083
NO2	- 0.573	0.678	0.460	0.026
NO3	0.414	- 0.675	0.599	0.120
PO4	0.843	0.500	0.049	0.189
CBO5	0.268	0.388	0.273	- 0.838

Variance Explained by Components

1	2	3	4
4.440	2.707	1.710	1.144

Percent of Total Variance Explained

1	2	3	4
44.400	27.066	17.097	11.437

Chemical oxygen demand (COD) is an indicator of organic accumulation due mostly to algal development, implying intense decomposing activity and growth of phosphates concentration (0.843, Table 8) exceeding their consumption for photosynthesis and assimilation by plants. The mineralization of organic substances produces nutrient, but there is a high rate of nitrification and of their exhaustion by aerobic nitrifying bacteria: NH_4 - 0.973 and NO_2 - 0.573, Table 8). Conductivity and GH depend on the ionic concentration of the thermal spring (by a factor of 0.918, see Table 8).

FACTOR 2 (27.066% from the total variance, Table 8) includes the significant and positive contribution of conductivity, OD, nitrites and phosphates, in contrast to the concentration of nitrates. Dissolved oxygen accumulates in water as a result of photosynthesis, while nitrates are assimilated by plants in the same metabolic process.

Conclusions

A depression in the temperatures diagram occurs for the Oct.-March interval, having minimal values for winter months and multiannual variations.

In certain points in the lake (the „mulberry” area) temperature was generally above 20^0C, a value previously considered minimal limit for tolerance and survival.

In recent winters, a catastrophic process occurred regarding water temperatures, in correlation with lake depth, and surface and the flow of the geothermal spring.

pH values oscillated between 6.9 and 8.3 (multiannual measurements), having a mean value of 7.66, and this range is the optimum for Cyprinids in the temperate zone.

Historical data for pH during the reproductive season indicate a neutral or slightly acidic environment (6.8 – 7.0). Discontinuous data about other chemical parameters showed the following multiannual variation:

- Chemical oxygen demand (COD): 1.375 – 3.537 mg /l (confidence interval 95%);
- CBO5: 1,184 – 3,983 mg /l (confidence interval 95%);
- Dissolved oxygen level: 4,5 – 8,5 mg/l (minimal level in summer, maximal in winter);
- Water conductivity: 600 – 640 µS;
- Total hardness (GH): 16 – 18^0G;
- Low concentration of nutrients (nitrates, phosphates, or ammonium, nitrites).

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