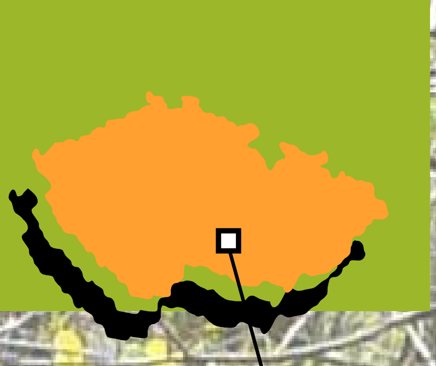
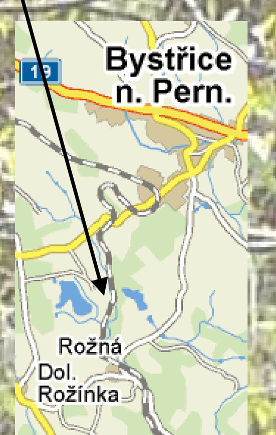
Do species feel overheated in the River Nedvědička?

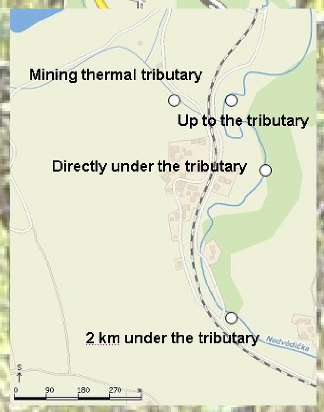
Veronika Konvičková & Bohuslav Uher

Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, 611 00 Brno, Czech Republic

v.konvickova@mail.muni.cz







The thermal regime of rivers plays an important role in the overall health of aquatic ecosystems. One of the most significant water quality parameters affected by urbanization is the temperature of water. The unnatural change in water temperature caused by human activities is thermal pollution. Numerous studies have demonstrated the danger of increased temperature on aquatic species. The importance of natural temperature for the ecosystem in running waters is undisputed; however there is still a lack of details in temperature research, especially a detailed study of herbivore assemblage influenced by thermal pollution is missing. The aim of this study is to investigate algal community and influence of herbivores in thermal polluted stream.

Thermal tributary 27.8.2008

In the river Nedvědička, a unique situation was found in the place where heated decontamination mining tributary (size 1m wide, from power plant) flows into the river. The quality of the water in the tributary was better than in the river. The only differences were found in increased temperature (20°C in winter), high conductivity (1500 µS.cm^{-1}) and higher sulphates (690 mg.l^{-1}).

We sampled quantitatively a macrozoobenthos and algae once a month over the course of the year. We also monitored temperatures (by thermometer) in four sampling places every 15 minutes from November 2007 until today. The main objectives of this study are to analyse the river at four representative places (the first - mining thermal tributary (**MT**), the second - up to the tributary of the river (**UP**), the third – directly under the tributary of river (**UN**), and the fourth – 2 km under the tributary (**UT**) with emphasis on thermal variability; also to observe the effects on the development of herbivore species and to relate variation in the phytobenthic assemblages to temperature.

The analysis of temperature data-sets

The temperature data-sets were tested for a normal distribution using Shapiro-Wils W Test. For all temperature parameters, the W statistic was significant ($p < 0.05$), indicating data-sets were not normally distributed. We used this test for all testing in all data, which was used in analyses. We used Wilcoxon test to test data-sets to confirm differences between localities. The difference between UP and UN is highly significant (p-value < 2.2e-16) and between UP and UT is significant too. (Fig. 1) The main temperature characteristic shown in Tab 1. The temperature under the tributary was on average 1,6 C higher than in UP and the temperature in MT was on average 7,1 C higher than in UN.

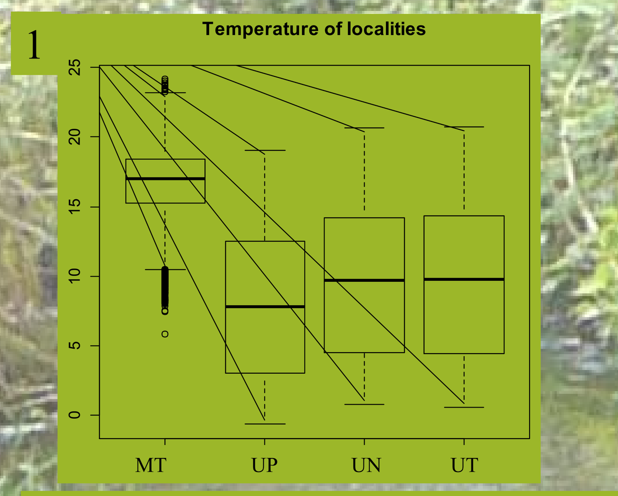
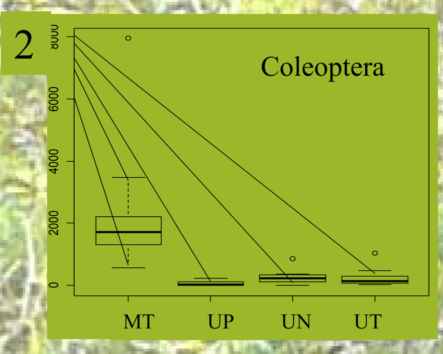


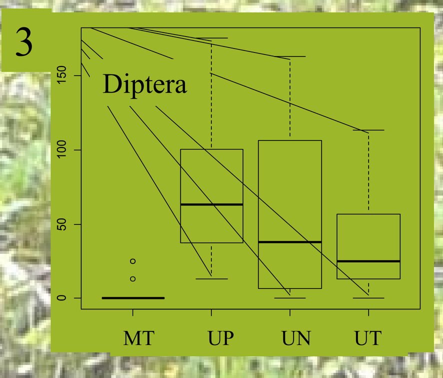
Fig. 1 Boxplots of temperature in localities.

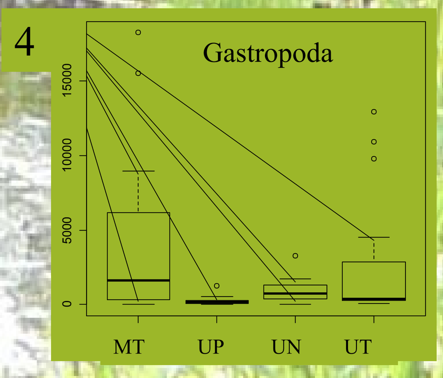
Mean values °C	MT	UN	UT	UP
mean summer	17.70	15.90	15.97	14.78
mean spring	16.23	9.88	9.93	8.27
mean autumn	17.96	11.89	12.24	10.12
mean winter	13.75	4.29	4.40	2.83
Extreme values				
max. temperature	24.15	20.63	20.75	19.03
max in this days	26/05/2009 16:45	31/05/2008 17:15	31/05/2008 16:15	23/06/2008 18:15
min. temperature	5.87	0.80	0.58	-0.06
min in this days	18/12/2007 20:30	19/12/2007 07:30	09/01/2008 08:30	09/01/2008 06:30
max. absolut temp in MT	24.15	26/05/2009 16:45		
min. absolut temp in UP	-0.06	09/01/2008 06:30		
Daily amplitudes				
summer max	7.73	9.54	9.62	8.63
winter max	5.82	4.02	4.75	4.68
summer mean	1.09	2.53	2.43	2.74
winter mean	2.62	2.14	2.51	2.47
spring mean	3.09	3.20	2.76	2.90
autumn mean	2.35	2.17	2.51	2.43
Cumulative degree-days				
23.11.2007-22.6.2009 (578 days)	565	288	288	246

Tab. 1 Temperature parameters

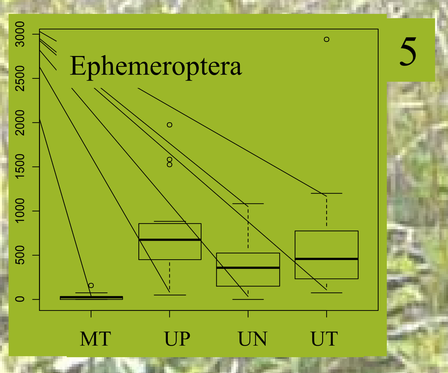
The analysis of herbivores among localities influenced by thermal pollution

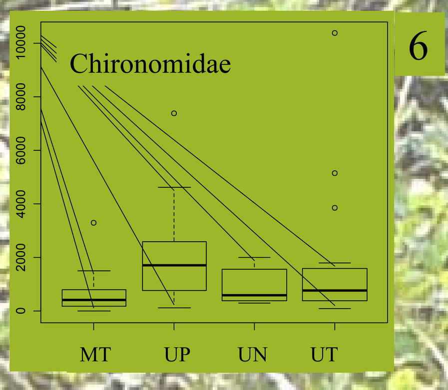


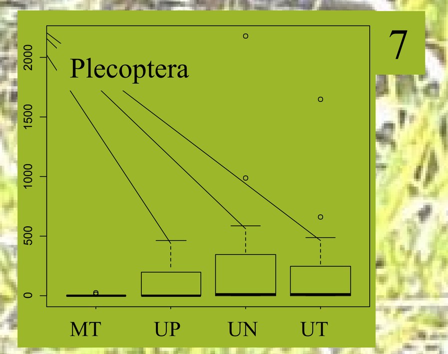




Boxplots (Figs 2-8) showed the difference of abundance of particular herbivores in localities. The abundance of **Coleoptera** was very high in the thermal tributary (next MT) and slightly increased the abundance in under to the tributary (next UN, UT). The abundance of **Diptera** in up to the tributary (next UP) was higher and there was reduction of abundance in UN, UT. The **Gatropoda** contained only too species. The high abundance was due to only one species ***Potamopyrgus antipodarum***. This is very invasive species, which we didn´t find in UP. In MT have very good condition and higher temperature due to dispersion under the tributary. The opposite effect was appeared on the ***Ancylus fluviatilis***, which its abundance was due to increasing the temperature under the tributary. The order **Ephemeroptera**, **Trichoptera** and suborder **Chironomidae** had lower abundance in UN and UT than UP, but caddisflies have higher abundance in MT. MT is locality full of algal mats and there live a few herbivorous caddisflies, which we didn't find in other localities (*Tinodes unicolor*, *Hydroptila vectis*). The opposite effect was appeared in **Plecoptera**, which their abundance was higher in UN, UT. We used Student's t-test for comparing the abundance (N.m²) of particular taxons in particular localities. The significant difference between up the tributary and under the tributary was in Coleoptera, Gatropoda, Ephemeroptera, Chironomidae and Trichoptera (Tab 2).

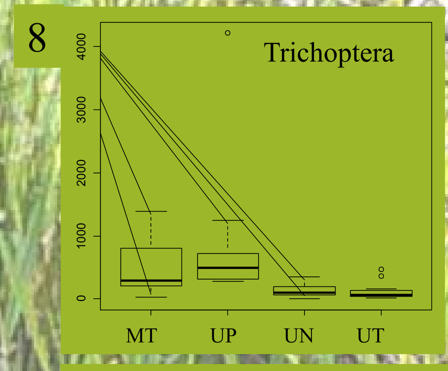






p<0.05	UP-UN	UN_UT	UT-UP
Coleoptera	**0.003721**	0.9232	**0.02142**
Diptera	0.4077	0.3965	0.05138
Gatropoda	**0.008669**	**0.04785**	0.1362
Ephemeroptera	**0.04712**	0.2545	0.6532
Chironomidae	**0.04564**	0.2328	0.7899
Plecoptera	0.2406	0.7005	0.3431
Trichoptera	**0.02447**	0.6121	**0.02079**

Tab. 2 Results of t.test in abundance (N.m²) between localities, p value < 0.05.



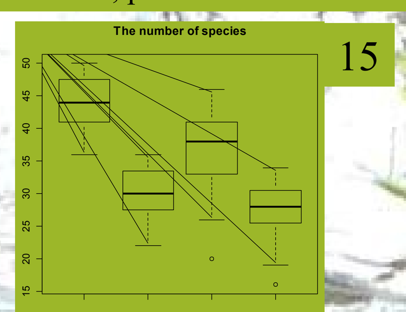
Figs 2-8. Boxplots showed the difference among localitites in particular herbivores.

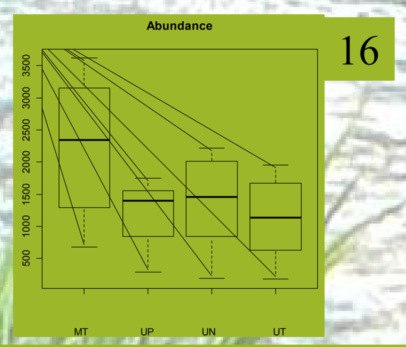
Benthic algal community

We found 76 species of algal communities. The graph 3 shows the proportional representation of benthic groups in particular localities. The different is between up to the tributary and under the tributary. We can see great amount of green algae in MT, UN and UT, but not in UP. On the other side, there was a decrease of red algae assemblage under the tributary. We used Student's t-test for comparing the abundance (N.cm²) and number of species of algal community in localities (Tab. 3). We can see the significant difference in number of species and in abundance between up to the tributary and under the tributary. (Fig. 15,16) The number of species and the abundance of algal community were lower in UP than UN. The thermal tributary probably caused the higher abundance and the number of algal species under the tributary.

p<0.05	UP-UN	UN_UT	UT-UP
Number of species	**0.00539**	0.1959	**0.1233**
Abundance	**0.00736**	**0.00048**	0.1233

Tab. 3 Results of t.test between localities, p value < 0.05





Figs 15-16. Boxplots showed the difference among particular localities.

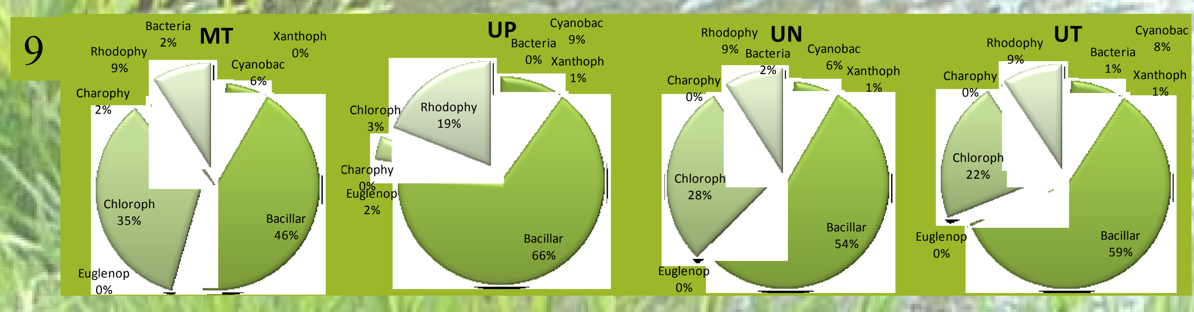


Fig. 9. The circle graphs of algal communities

Results

We used a redundancy analysis RDA of species abundance data (invertebrate and algal assemblages) and environmental parameters, where we can find the main direction of variability. The significant parameters shown in Tab 4. From graphical output it is clear that localities are divided according to gradient of changed parameters, which was influenced by thermal tributary. On the surface it seems that the thermal tributary had very good quality of water (it's very clear), but these parameters like warmer water, high conductivity and SO_4^{-2} significantly changed the quality of water under the tributary and changed the plant and animal communities.

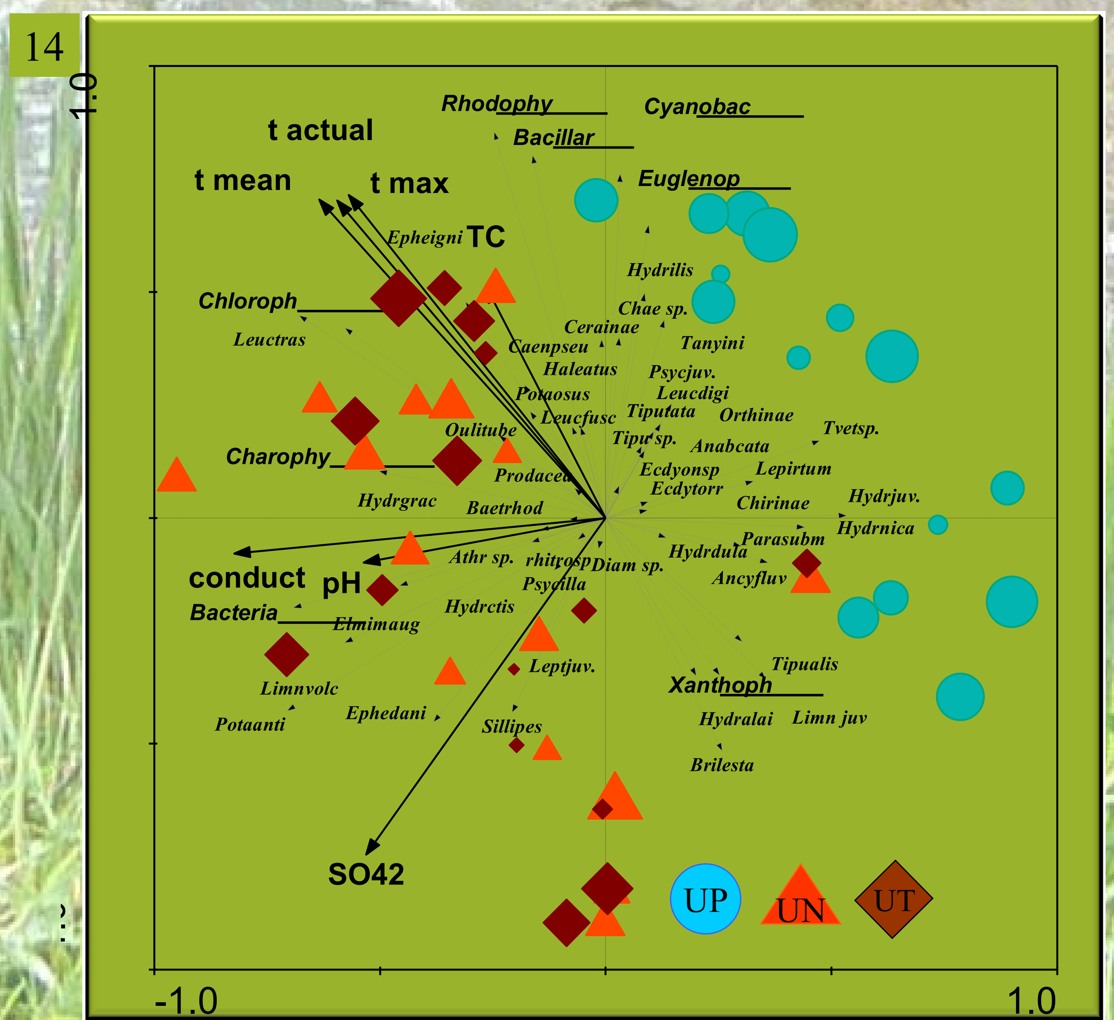


Fig. 14. The result of redundant analysis, used restricted permutation with split plot design, factor season like covariate, used Monte Carlo permutation test, first axis = 17,5% , second axis = 31,2,%.

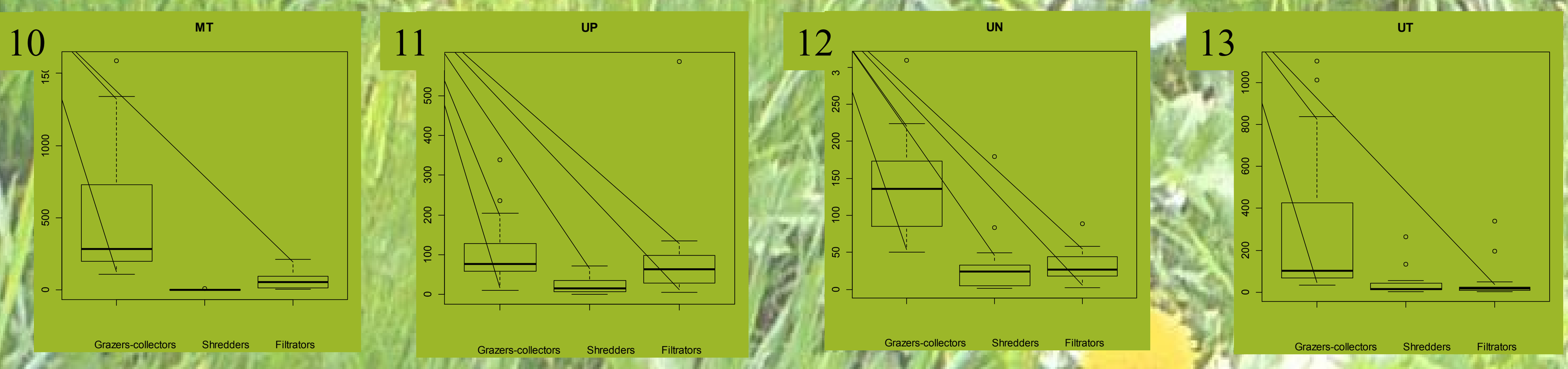
Our photos from sampling.

Tab 4. Significant parametres

Code	Significant factors	p value
t actual	actual temperature measured during sampling	0
SO42	phosphates	0
t max	maximal temperature during month	0,001
conduct	conductivity	0,002
t mean	mean temperature during month	0,002
TC	total carbon	0,021
pH	pH	0,03

Functional feeding group

Invertebrate taxa were assigned to functional groups by reference to Moog (1995). We divided herbivores to 3 functional group: Grazer-collectors (GC), Shredders (S) and Filtrators (F) and we wanted to find the difference of groups among localities. We tested the difference by Student's t-test again, but we found no statistically significant difference, but we can see some differences. (Figs 10-13) The almost balanced assemblages were up to the tributary (UP). We can see the difference among other localities under the tributary. The grazers collectors predominated in all localities, but the mostly predominated in thermal tributary. The higher amount of GC than S and F was find under the tributary. The higher abundance of algal assemblage in MT and under the tributary could due to more GC under the tributary.



Figs 10-13. Boxplots show the difference of abundance in feeding groups among localities.

Acknowledgement: Financial support for this study was provided by the Funding of Ministry of Education of Czech Republic; project No. MSM0021622416.