Změny sladkovodních ekosystémů v prostoru a čase

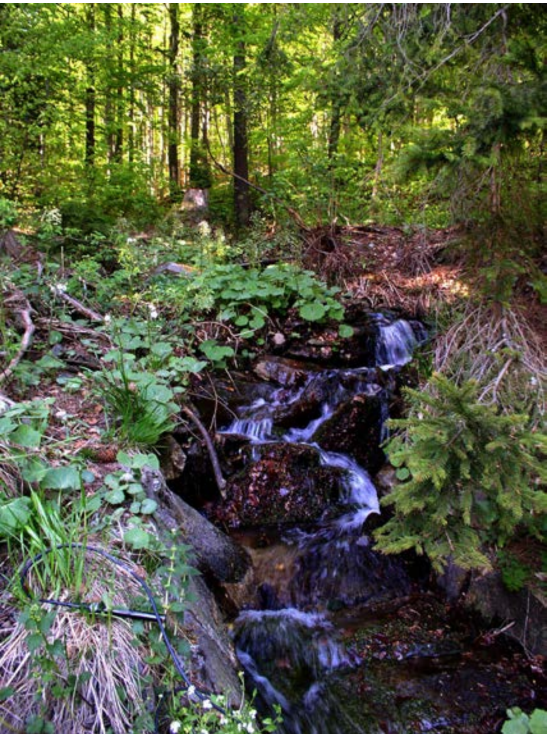
Z8025 (učebna Z2, pondělí 14.00-15.50)

3. Změny vodních toků v podélném profilu

GEOGRAFICKÝ ÚSTAV
PŘÍRODOVĚDECKÁ FAKULTA MU

Mgr. Karel Brabec, Ph.D.

brabec@sci.muni.cz




SYLABUS

1. Úvod – teoretické koncepty
2. Prostorové škály říční krajiny
3. **Změny vodních toků v podélném profilu**
4. Laterální a vertikální interakce vodních toků s okolním prostředím
5. Stojaté vody – vztahy k povodí, procesy ve vazbě na prostorové členění
6. Dlouhodobé trendy ve vývoji vodních ekosystémů
7. Sezonní dynamika faktorů prostředí a biologických společenstev
8. Teplotní režim povrchových vod
9. Ekologické aspekty průtokového režimu a hydraulických podmínek
10. Antropogenní modifikace vodních ekosystémů (se zřetelem na časoprostorové aspekty)
11. Potenciální dopady změn klimatu ve sladkovodních ekosystémech
12. Časo-prostorové aspekty adaptačních opatření a revitalizací degradovaných ekosystémů
13. Případové studie

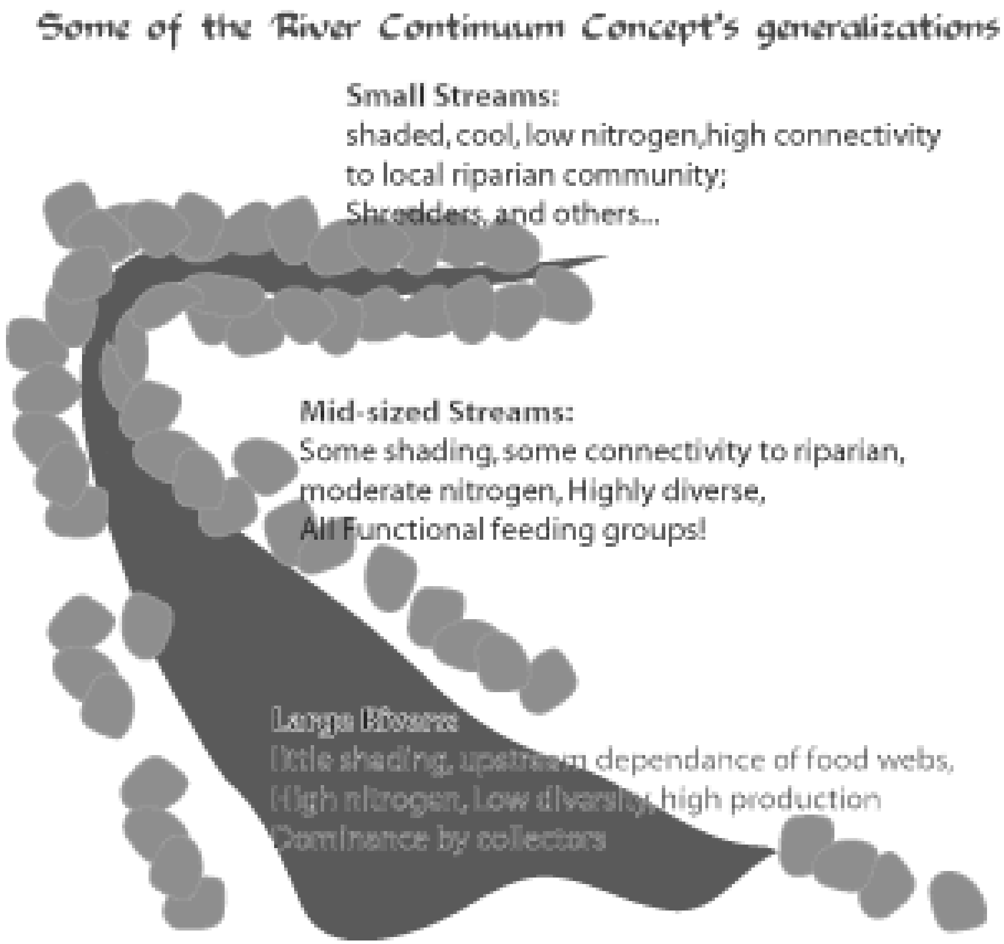
PODÉLNÝ PROFIL TOKŮ

- toky energie

- toky látek

- biota

- experimenty ukazující roli kouskovačů (odstranění hmyzu – role při rozkladu a transportu detritu)



http://www.rivercontinuum.org/about.php

TEORIE ŘÍČNÍHO KONTINUA

- struktura a funkce říčních společenstev
- predikovatelný průběh
- geomorfologické a hydrologické změny
- dynamická rovnováha

River Continuum Concept

(Vannote et al. 1980)

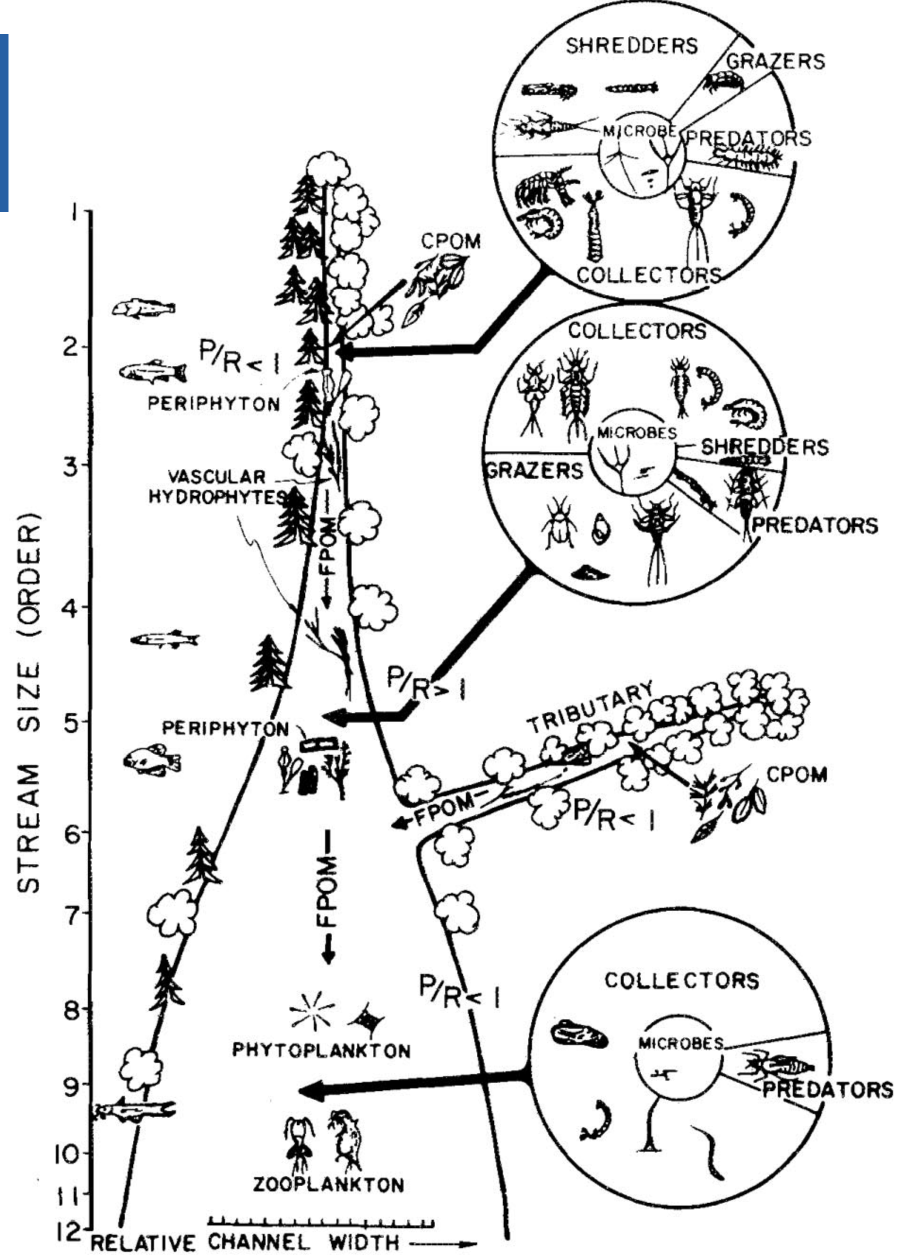
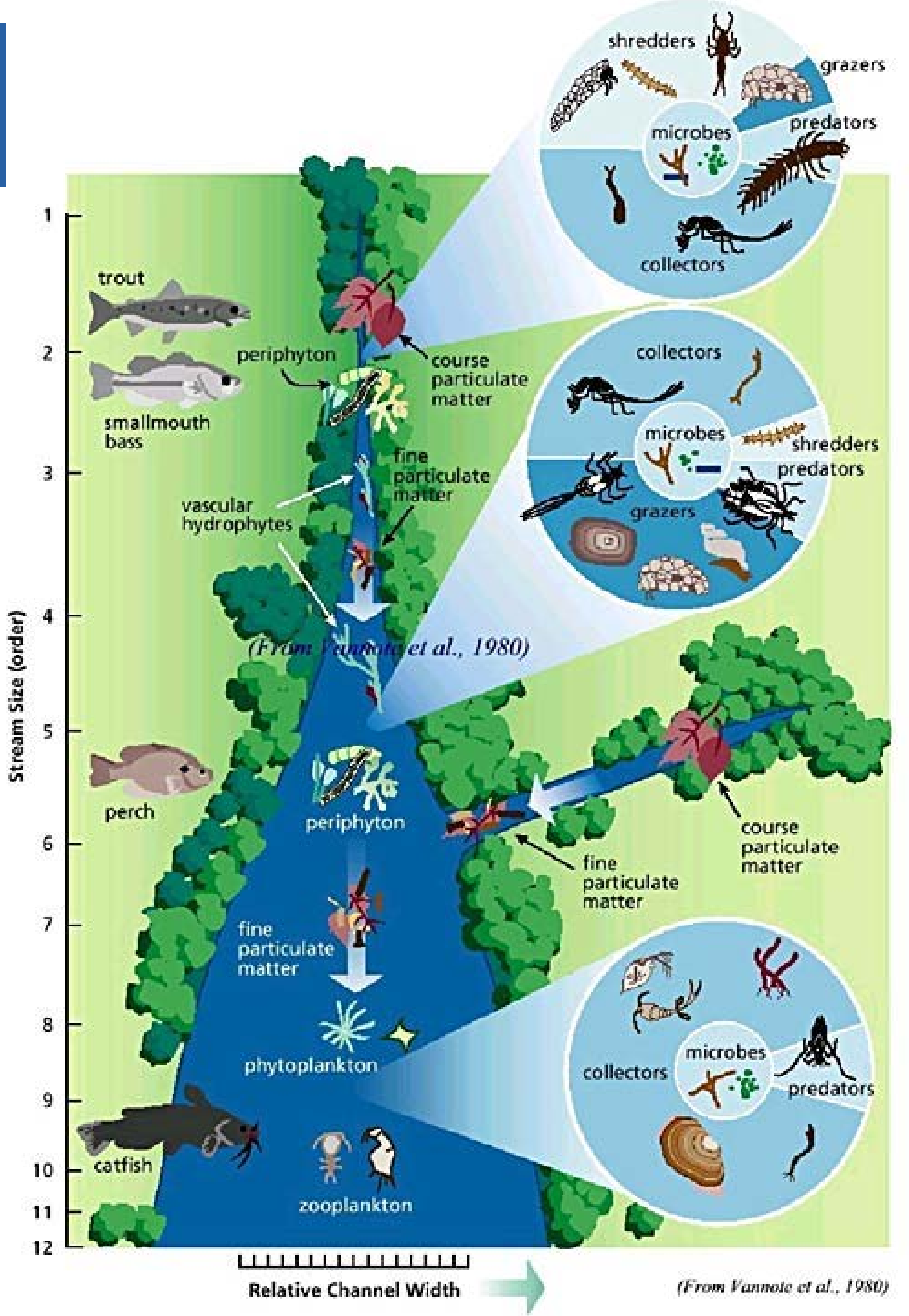


FIG. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

FLUVIAL ECOSYSTEMS

changes of channel slope, shading, origin of organic matter, ratio of production and respiration, thermal regime, substrate characteristics

River Continuum Concept (Vannote et al. 1980)



ORGANICKÁ HMOTA – VELIKOST ČÁSTIC

Table 3.2 Nature and size categories of non-living particulate organic matter. (Modified from Cummins, 1974).

	Detritus Categories and Subcategories	Approximate Size Ranges
HRUBÁ	Coarse particulate organic matter (CPOM)	>1 mm
	Large woody debris	>64 mm
	Terrestrial leaves forming leaf packs	>16 to <64 mm
	Leaf, twig & bark fragments, needles, fruits, buds and flowers	>4 to <16 mm
	Plant and animal detritus, faeces	>1 to < 4 mm
JEMNÁ	Fine particulate organic matter (FPOM)	>0.5 μm to <1 mm
	Ultrafine particulate organic matter (includ. microbes)	>0.45 μm to <75 μm
ROZPUŠTĚNÁ	Dissolved organic matter (DOM)	<0.45 μm

ORGANICKÁ HMOTA

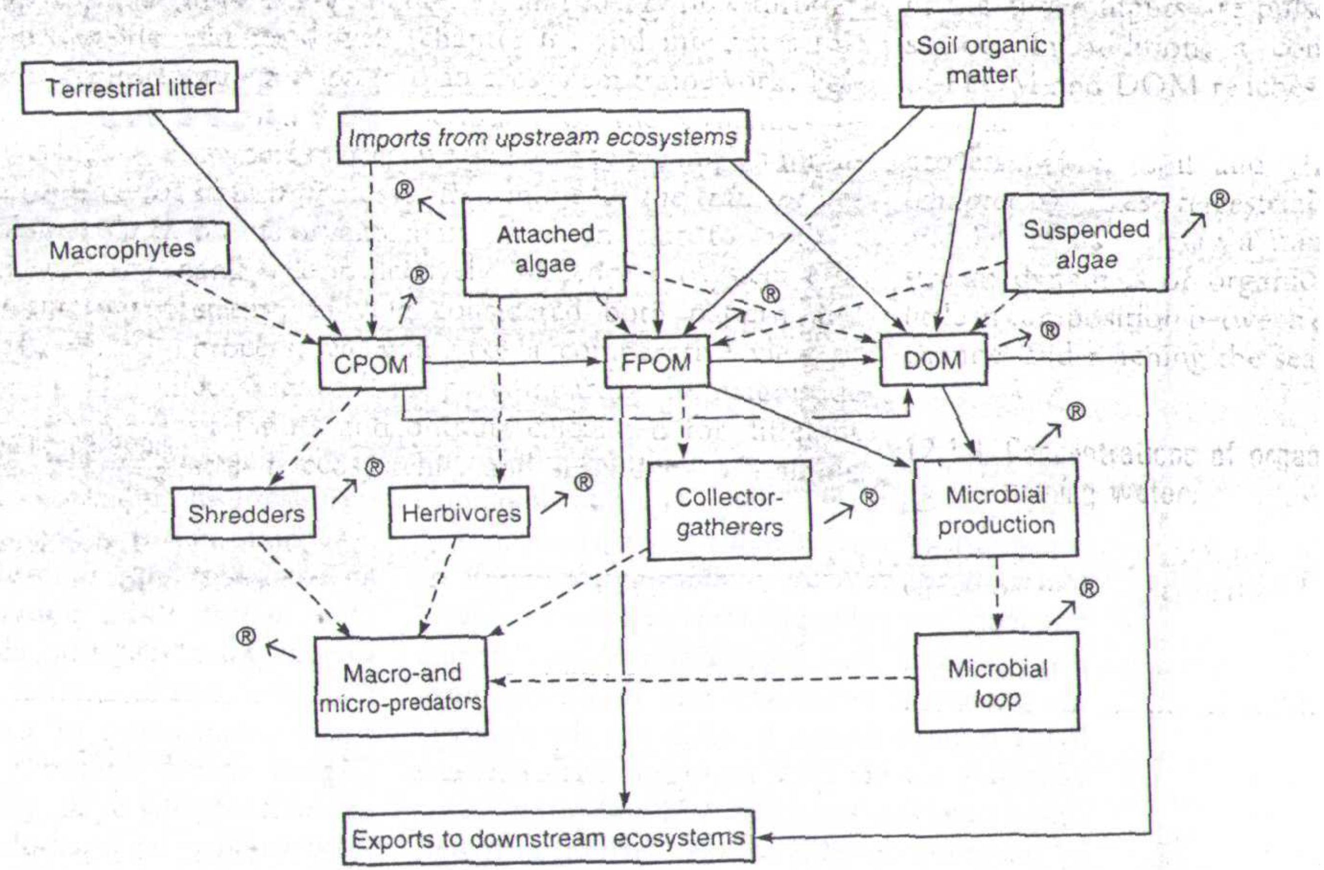
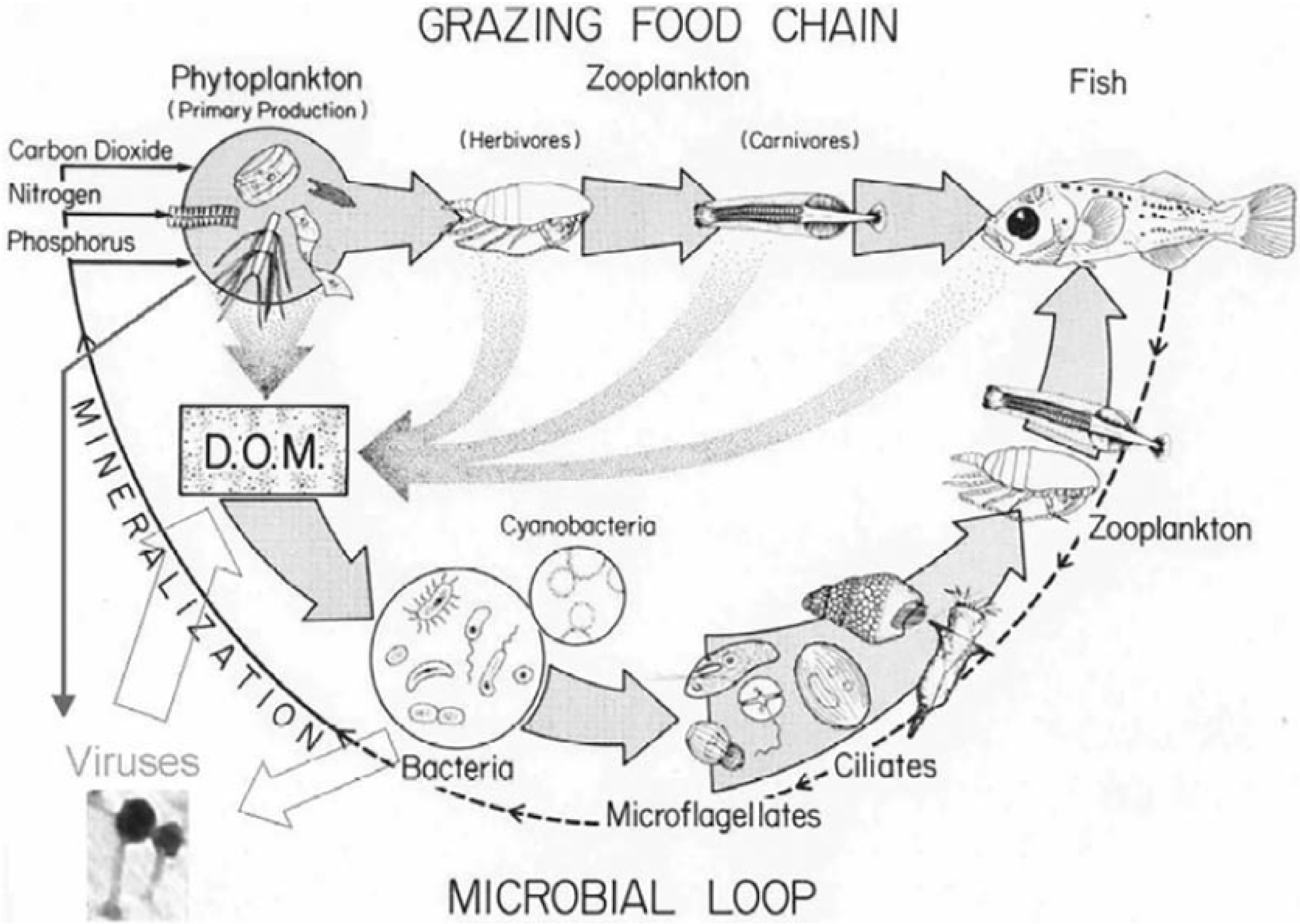


FIGURE 12.1 Simplified model of principal carbon fluxes in a stream ecosystem. Solid lines indicate dominant pathways of transport or metabolism of organic matter in a woodland stream. ® denotes mineralization of organic carbon to carbon dioxide by respiration. See Figure 12.7 for a depiction of how energy inputs change with increasing river size. Note that storage is omitted. CPOM, coarse particulate organic matter; FPOM, fine particulate organic matter; DOM, dissolved organic matter. (Modified from Wetzel, 1983.)

MIKROBIÁLNÍ SMYČKA



TEORIE ŘÍČNÍHO KONTINUA

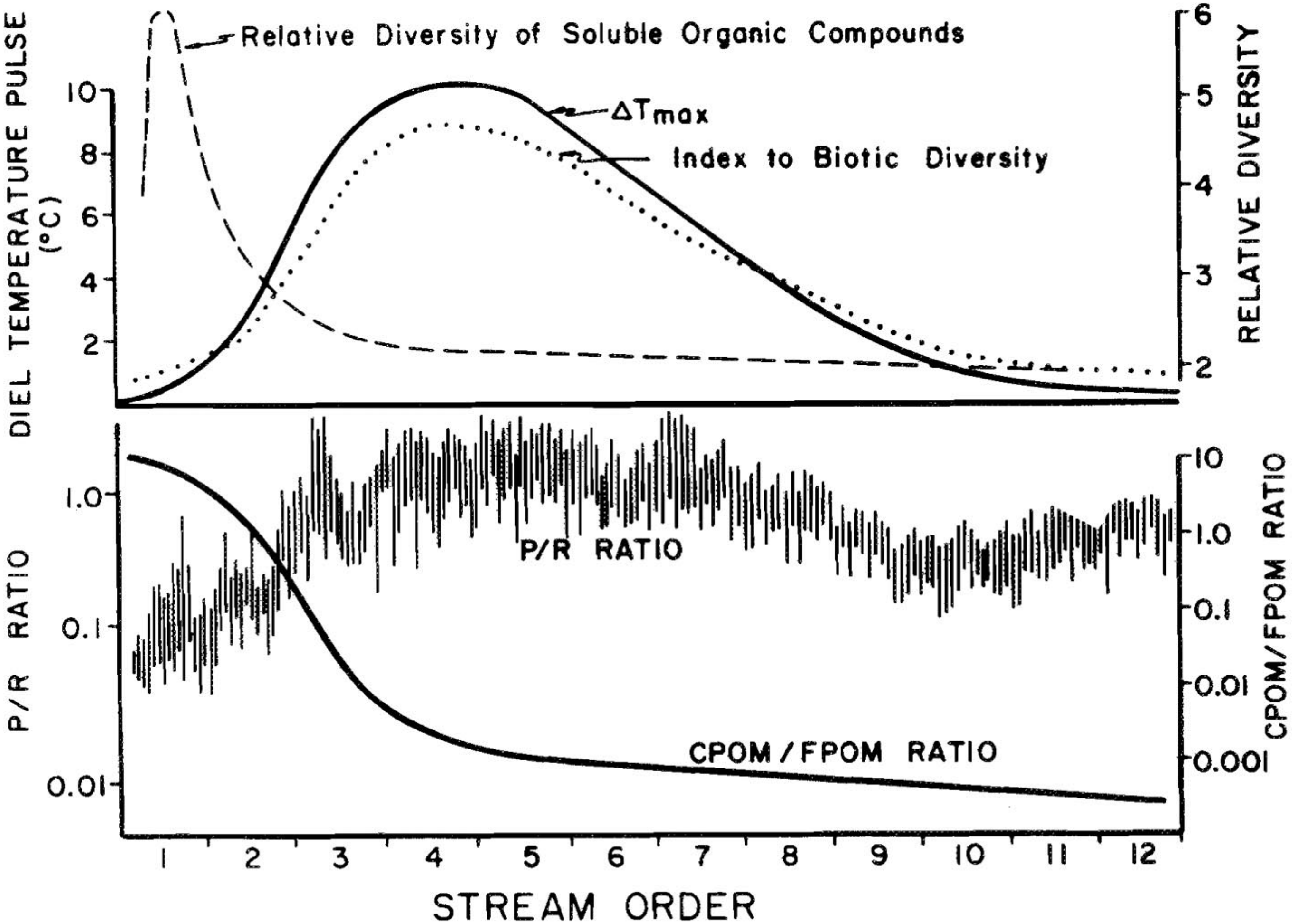


FIG. 2. Hypothetical distribution of selected parameters through the river continuum from headwater seeps to a twelfth order river. Parameters include heterogeneity of soluble organic matter, maximum diel temperature pulse, total biotic diversity within the river channel, coarse to fine particulate organic matter ratio, and the gross photosynthesis/respiration ratio.

limity TEORIE ŘÍČNÍHO KONTINUA

- antropogenní vlivy (využití krajiny)

- formulována pro povodí s listnatými lesy (mírné pásmo Severní Ameriky)

- např. novozélandské toky – málo kouskovačů – nižší hranice lesa – malá retence CPOM – nepravidelné povodně

- nezohledňuje vliv přítoků, jezer a dalších lokálních nebo regionálních faktorů (např. rozsáhlé záplavové území)

River Continuum Concept

(Vannote et al. 1980)

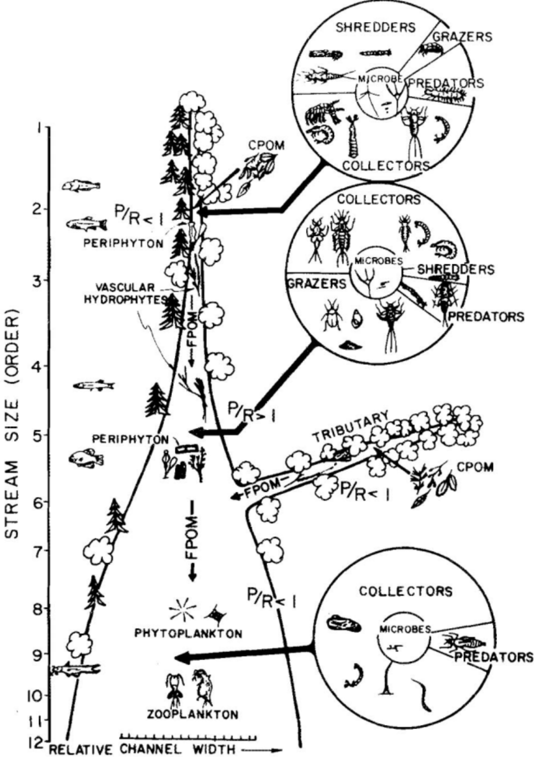


FIG. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

limity TEORIE ŘÍČNÍHO KONTINUA

- maximální diverzita je vázána na střední toky kde se vyskytuje největší variabilita abiotických podmínek (teplota)
- ale: diverzita ryb a planktonu je největší v tocích vyššího řádu
- ale: v tropech mají největší teplotní variabilitu toky nízkého řádu

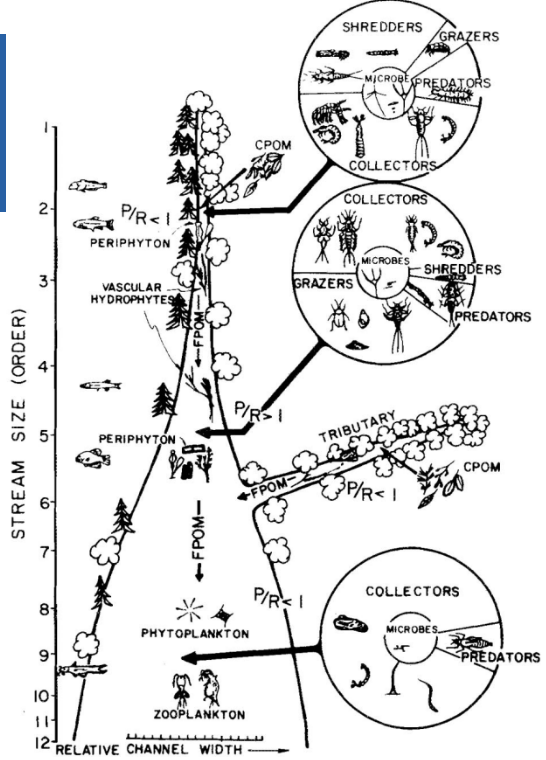


FIG. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

River Continuum Concept
(Vannote et al. 1980)

Questions and Comments on the River Continuum Concept
(Statzner & Higler, 1985)

limity TEORIE ŘÍČNÍHO KONTINUA

- předpoklad, že toky nízkého řádu jsou charakteristické velkým přísunem CPOM a mají vysoký podíl kouskovačů (shredders) – heterotrofní systém
- ale: mnohé říční systémy postrádají v pramenné oblasti lesy (např. suché a vysokohorské oblasti)

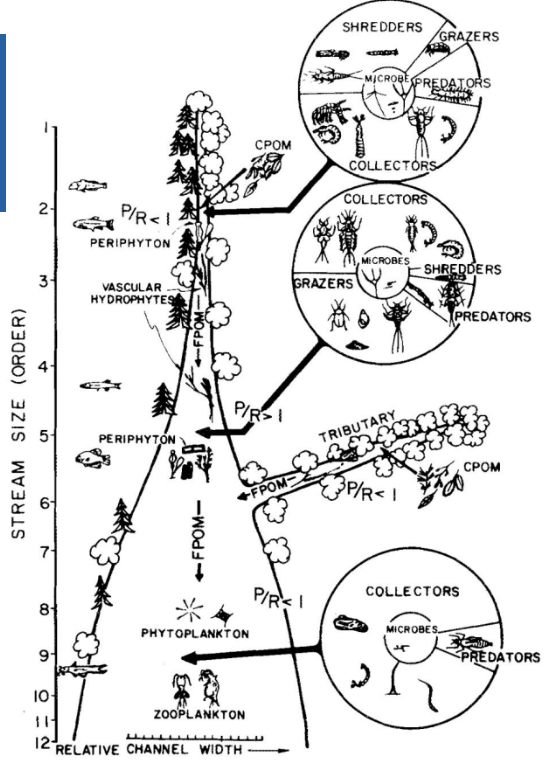


FIG. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

River Continuum Concept
(Vannote et al. 1980)

Questions and Comments on the River Continuum Concept
(Statzner & Higler, 1985)

obhajoba TEORIE ŘÍČNÍHO KONTINUA

- rozpory pocházejí z výzkumu zaměřeného na jednotlivé typy habitatů (kamenité peřeje)
- kvantita organismů vyjádřena biomasou (namísto relativní abundance)
- vyvolání diskuze, vznik dalších konceptů

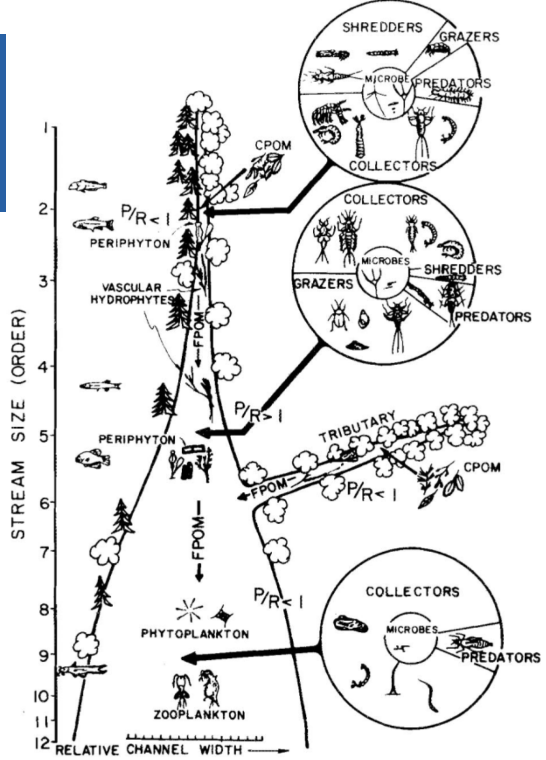


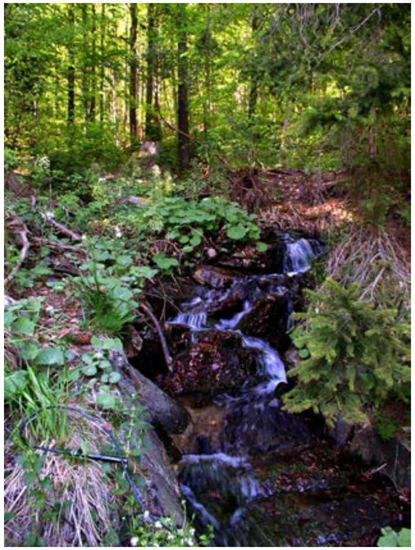
Fig. 1. A proposed relationship between stream size and the progressive shift in structural and functional attributes of lotic communities. See text for fuller explanation.

River Continuum Concept
(Vannote et al. 1980)

(Grubaugh et al., 1996)
(Giller & Malmquist, 1998)

Zones according Frič

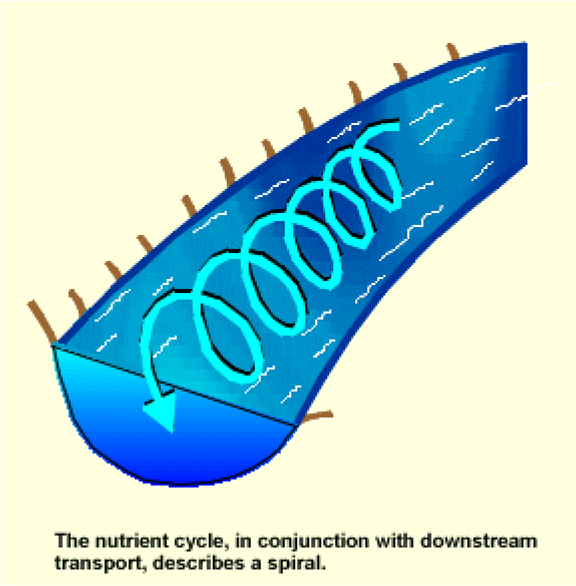
- trout
- grayling
- barbel
- bream
- delta

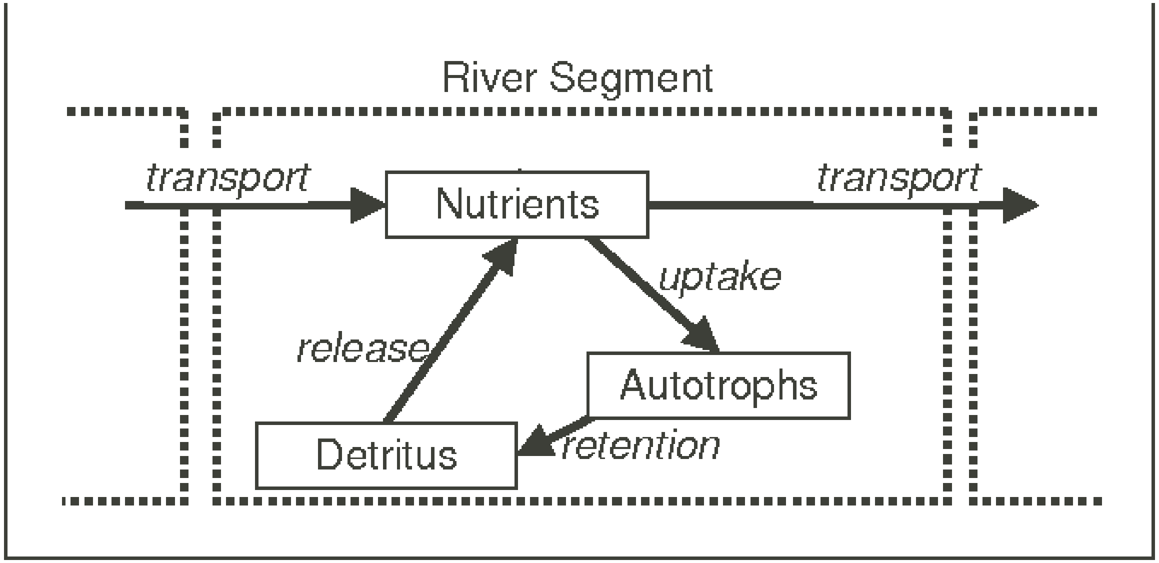


stream zonation concept (ILLIES & BOTOSANEANU 1963)

- crenal
- rhithral
- potamal

Teorie spirálního koloběhu látek (Nutrient Spiralling Concept)





Teorie spirálního koloběhu látek (Nutrient Spiralling Concept)

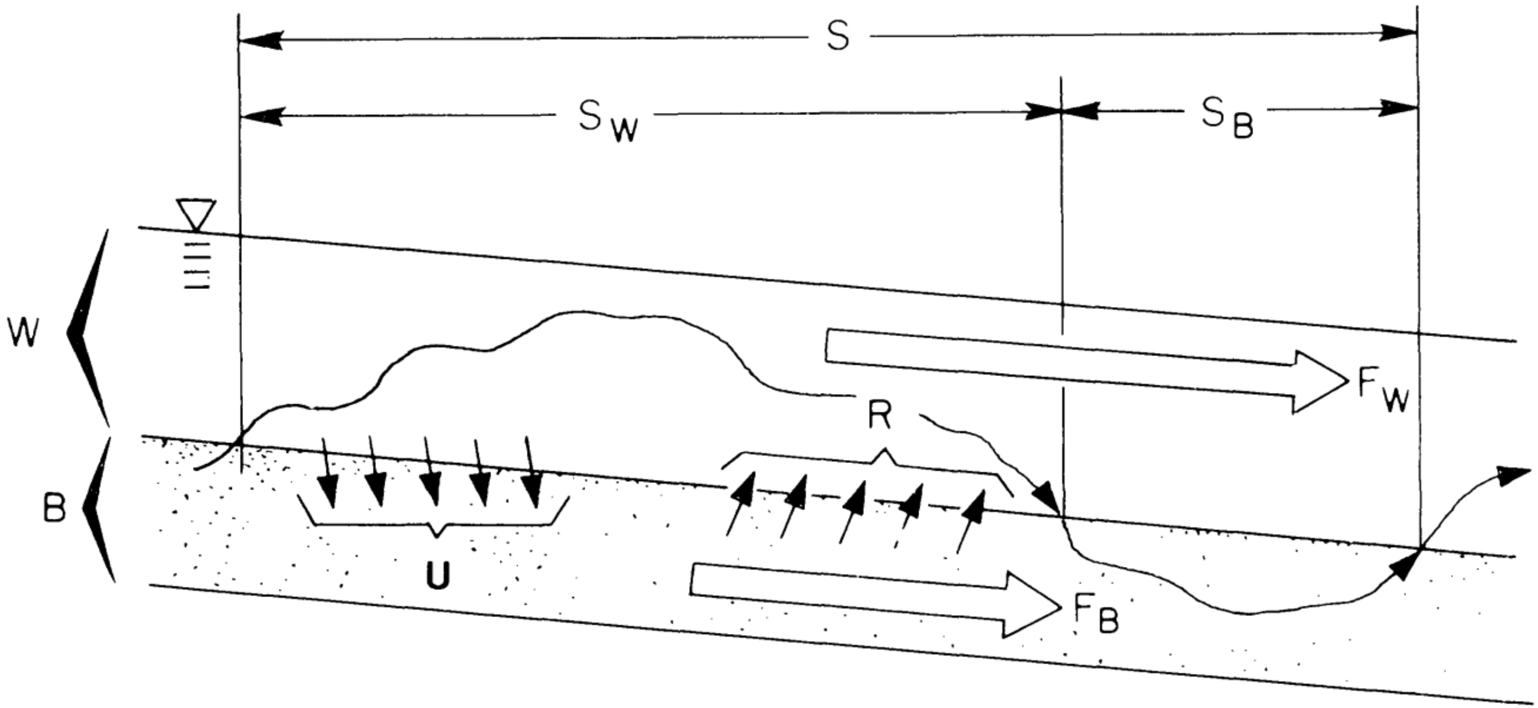


FIG. 1.—Nutrient spiralling in a two-compartment stream. The spiralling length, S (m), is the sum of the uptake length, S_W (m), and the turnover length, S_B (m). F_W (g s^{-1}) is the downstream flux of dissolved nutrient in the water compartment, W, and F_B (g s^{-1}) is the downstream flux of nutrient in the particulate compartment, B. R and U (g m^{-2} s^{-1}) are exchange rates of dissolved nutrient between the water compartment and a unit surface area of the particulate compartment.

Nutrient Spiralling in Streams: Implications for Nutrient Limitation and Invertebrate Activity (Newbold et al., 1982)

TEORIE OPAKOVANÉHO DISKONTINUA

serial discontinuity

The serial discontinuity concept of lotic ecosystems

- délka diskontinua (discontinuity distance)– posun parametru v rámci podélného profilu toku (pozitivní/negativní) vlivem regulace
- intenzita – rozdíl v hodnotách parametru
- vliv mají vlastnosti nádrže a její poloha na toku

WARD, J. V., AND J. A. STANFORD. 1983. The serial discontinuity concept of lotic ecosystems, pp. 29-42 in T. D. Fontaine and S. M. Bartell (editors). Dynamics of lotic ecosystems. Ann Arbor Science Publishers, Ann Arbor, Michigan

TEORIE OPAKOVANÉHO DISKONTINUA

serial discontinuity

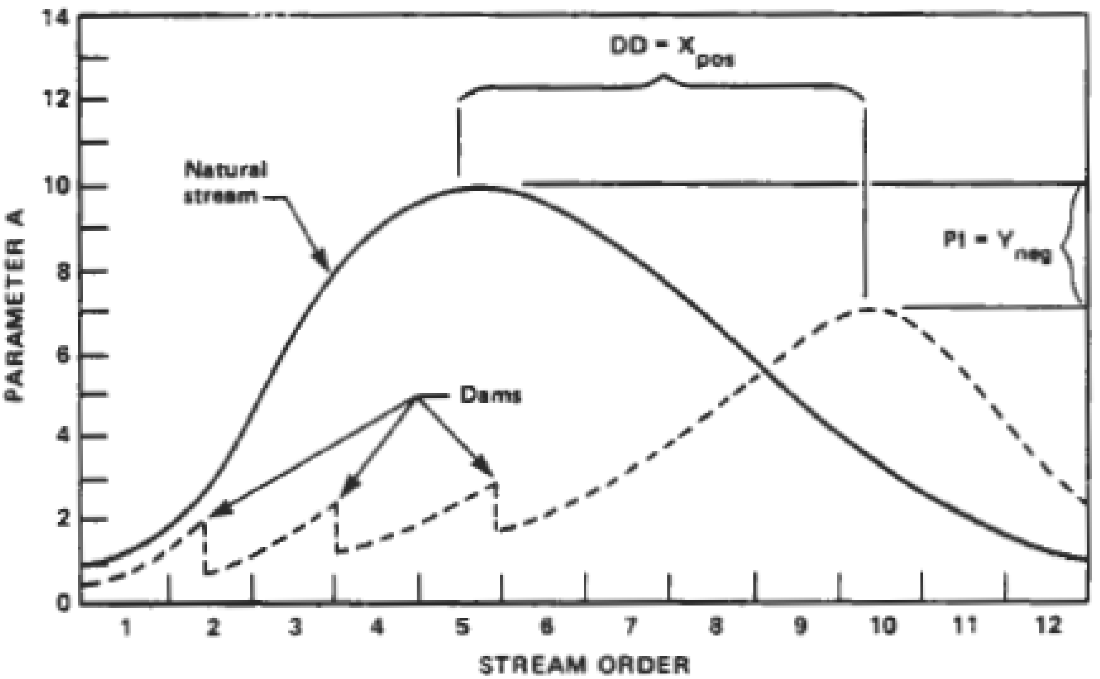


Figure 3. Theoretical framework for conceptualizing the influence of impoundment on ecological parameters in a river system. Discontinuity distance (DD) is the downstream (positive) or upstream (negative) shift of a parameter a given distance (X) due to stream regulation. PI is a measure of the difference in the parameter intensity attributed to stream regulation. See text for further explanation.

WARD, J. V., AND J. A. STANFORD. 1983. The serial discontinuity concept of lotic ecosystems, pp. 29-42 in T. D. Fontaine and S. M. Bartell (editors). Dynamics of lotic ecosystems. Ann Arbor Science Publishers, Ann Arbor, Michigan

TEORIE OPAKOVANÉHO DISKONTINUA

serial discontinuity

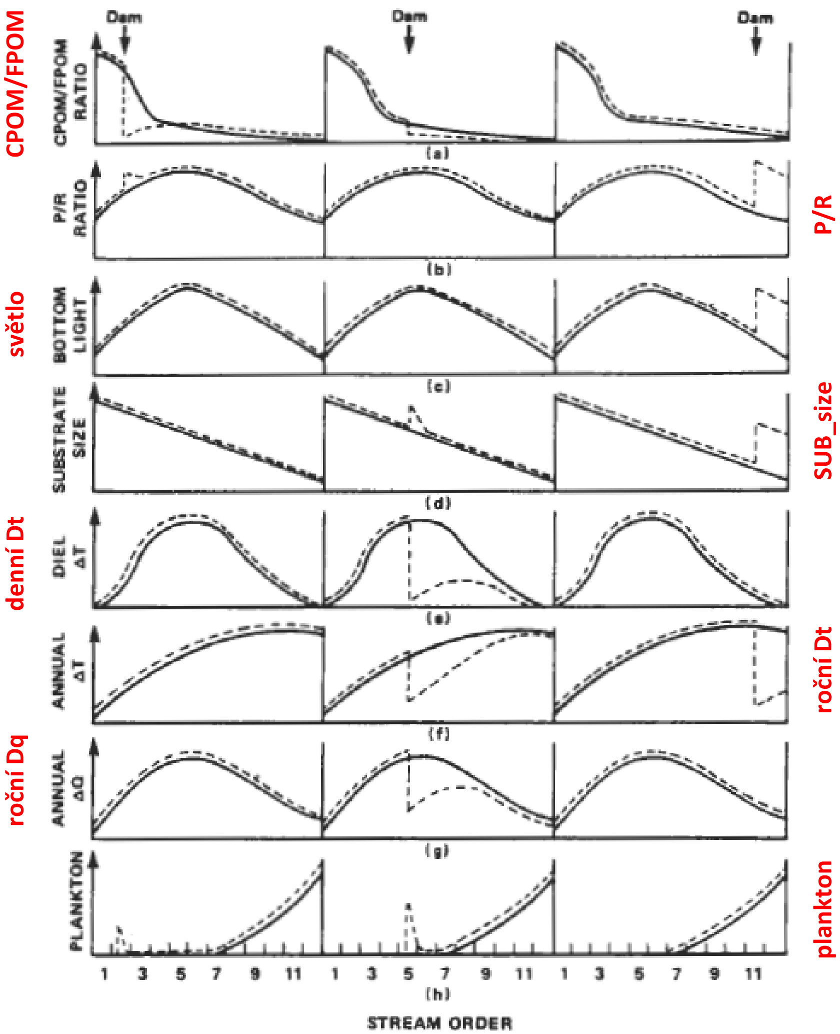


Figure 1. Relative changes in various parameters as a function of stream order, based on our interpretation of natural stream continua theory (solid lines) and postulated effects (dashed lines) of damming headwaters (left column), middle reaches (center column), and lower reaches (right column) of a river system. See text for further explanation.

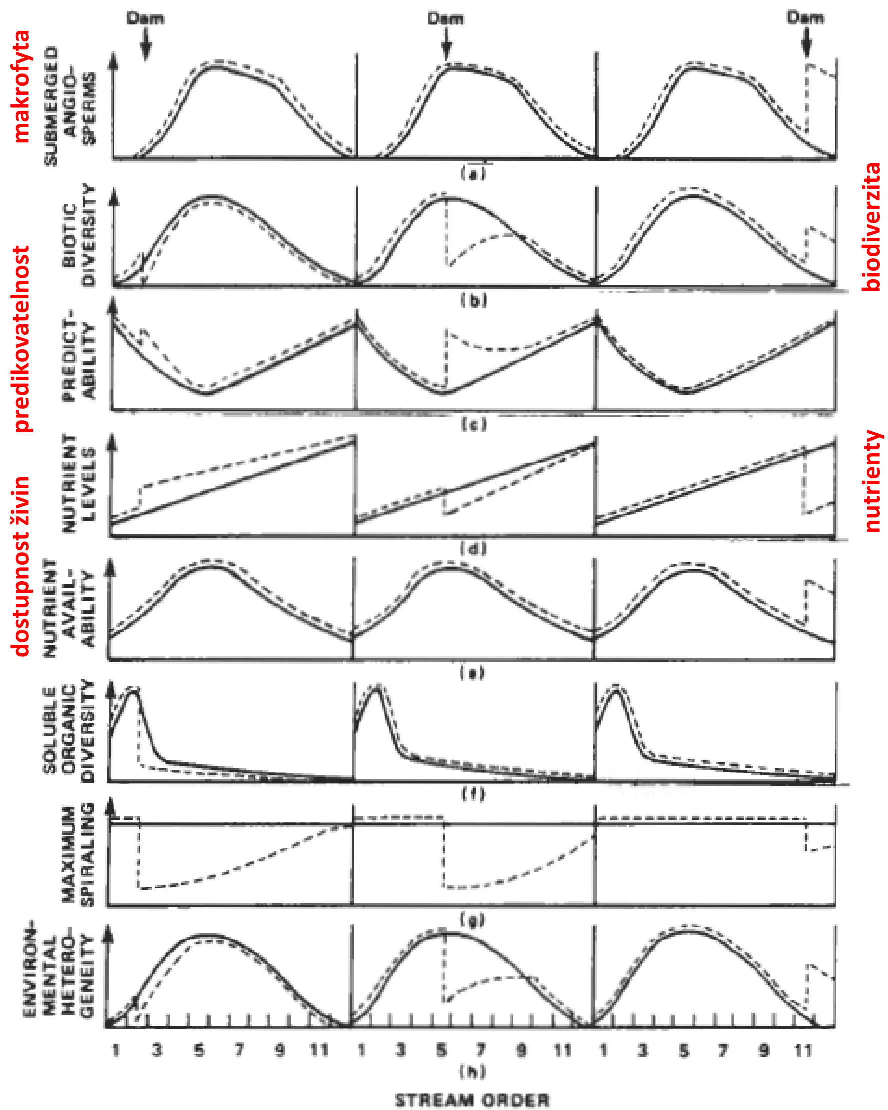


Figure 2. Relative changes in additional parameters (see Fig. 1 legend).

WARD, J. V., AND J. A. STANFORD. 1983

TEORIE OPAKOVANÉHO DISKONTINUA

serial discontinuity

REGULATED RIVERS: RESEARCH & MANAGEMENT
Regul. Rivers: Res. Mgmt. **17**: 303–310 (2001)
DOI: 10.1002/rrr.659

ARENA

REVISITING THE SERIAL DISCONTINUITY CONCEPT

JACK A. STANFORD[a,*] AND J.V. WARD[b,1]

Table I. Regulated rivers where the serial discontinuity concept has been empirically evaluated with respect to responses to a suite of biophysical parameters, including flow, temperature and some measure of species distribution

River (country)	Basin area (km^2)	Reach length (km)	Mode	Discontinuity orders	Distance (km)	Parameter intensity	References
Flathead (USA)*							
Upper	22 349	185	H	+1.5	+30	Moderate	(Stanford *et al.*, 1988)
Lower	25 220	82	E	−1	> −82	Minor	(Stanford *et al.*, 1988)
Kootenai (USA)	27 250	75	S	+1	+75	Severe	(Perry *et al.*, 1986)
Clearwater (USA)	24 960	225	H	+1	+40	Moderate	(Munn and Brusven, 1991)
Colorado (USA)							
Gunnison*	20 533	239	H	+2	+80	Moderate	(Ward and Stanford, 1991)
Green	18 149	339	S	+2?	+150	Severe	(Stanford, 1994; Vinson, 2001)
Grand Canyon	210 000	472	H	NA	> +472	Severe	(Stevens *et al.*, 1997)
Buffalo (South Africa)	1230	137	S, H	NA	±0–30	Moderate	(Palmer and O'Keefe, 1990)
Caning (Australia)	804	6	E	−1	−5	Moderate	(Storey *et al.*, 1991)
Tees (UK)	NA	1	H	0	+0.5	Minor	(Armitage and Blackburn, 1990)
Ter (Spain)	3010	208*	H	+1?	+32	Moderate	(Sabater *et al.*, 1989)
Loire (France)	117 000	1012*	H	0	0	NA	(Guinand *et al.*, 1996)

Mode refers to hypolimnial (H), epilimnial (E), or selective (S) release of water from the dam(s). Non-regulated tributaries in every case significantly influenced discontinuities.
* Entire length of river system included in study.

TEORIE OPAKOVANÉHO DISKONTINUA

serial discontinuity

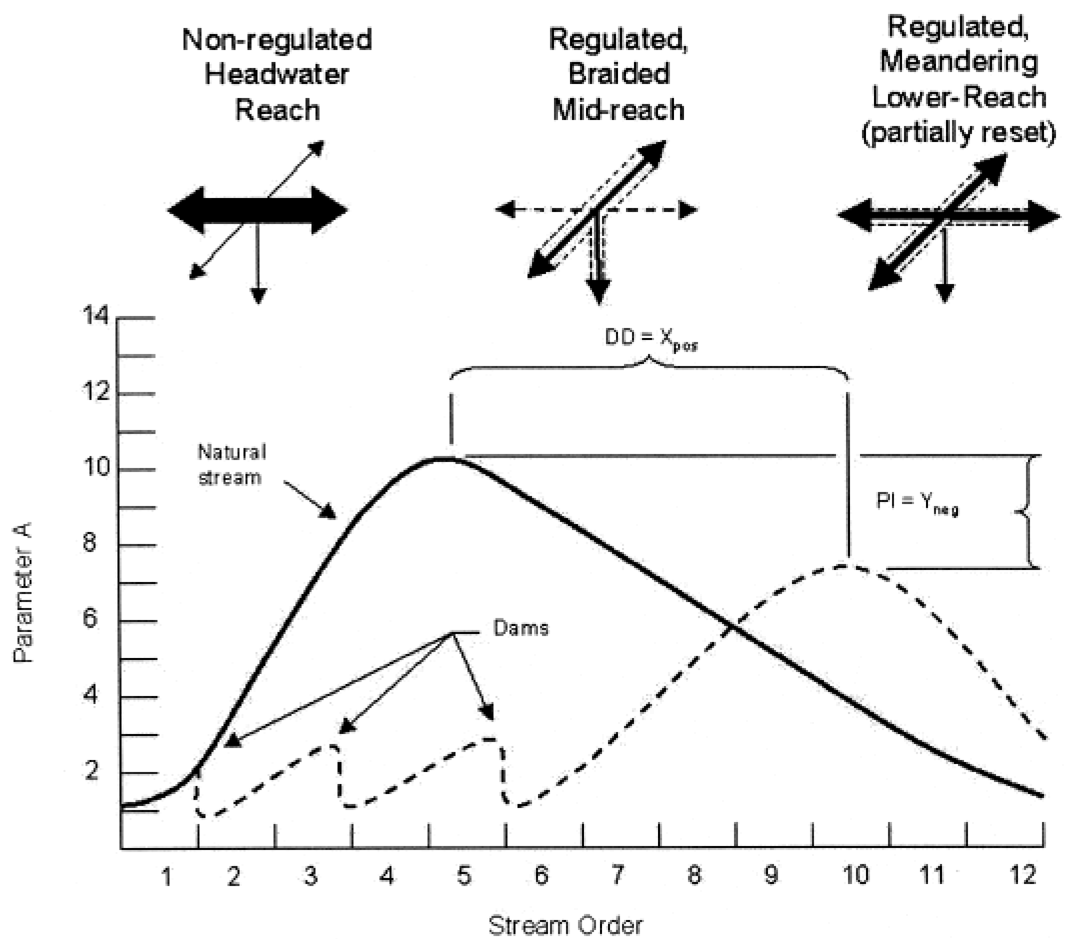
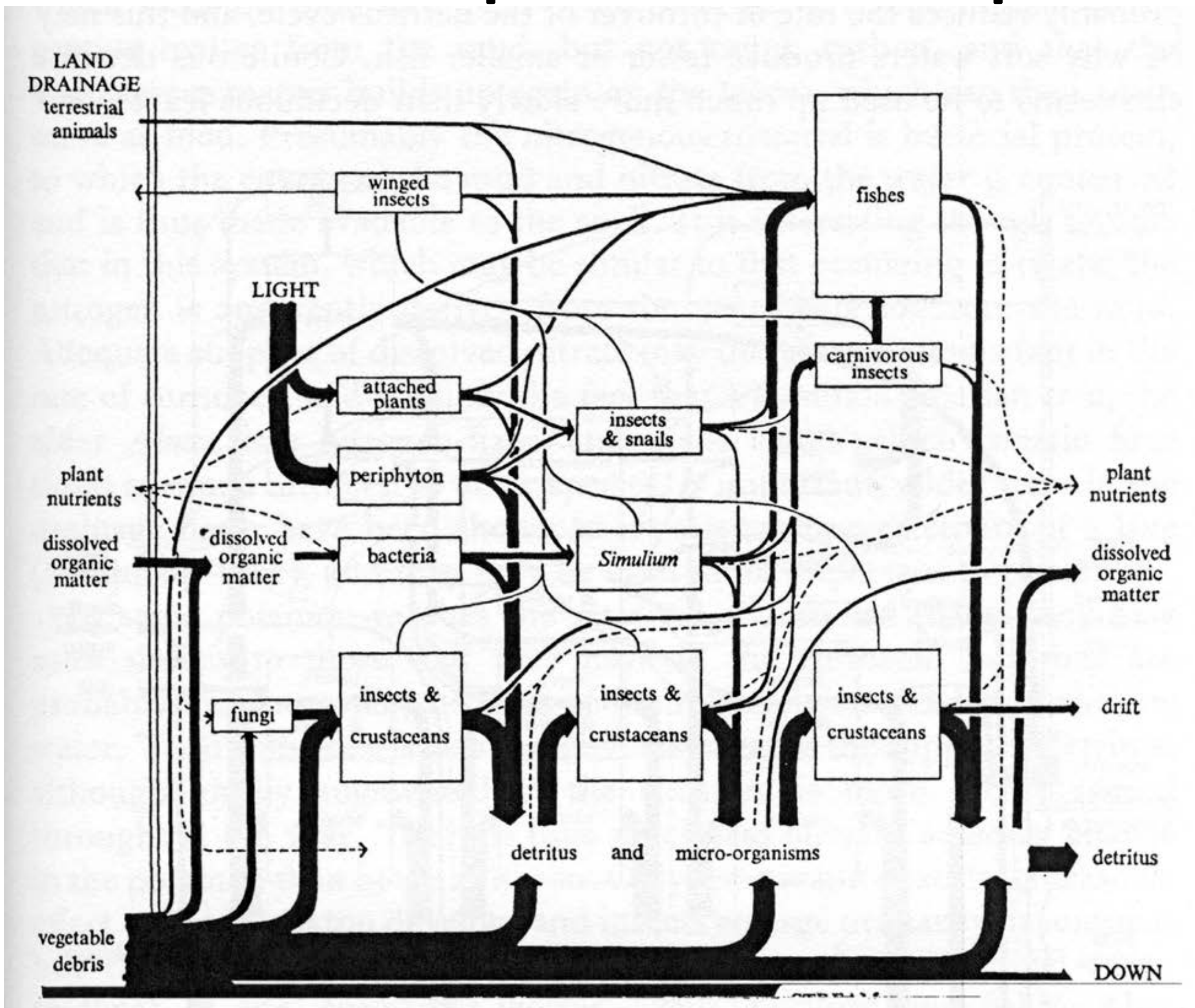


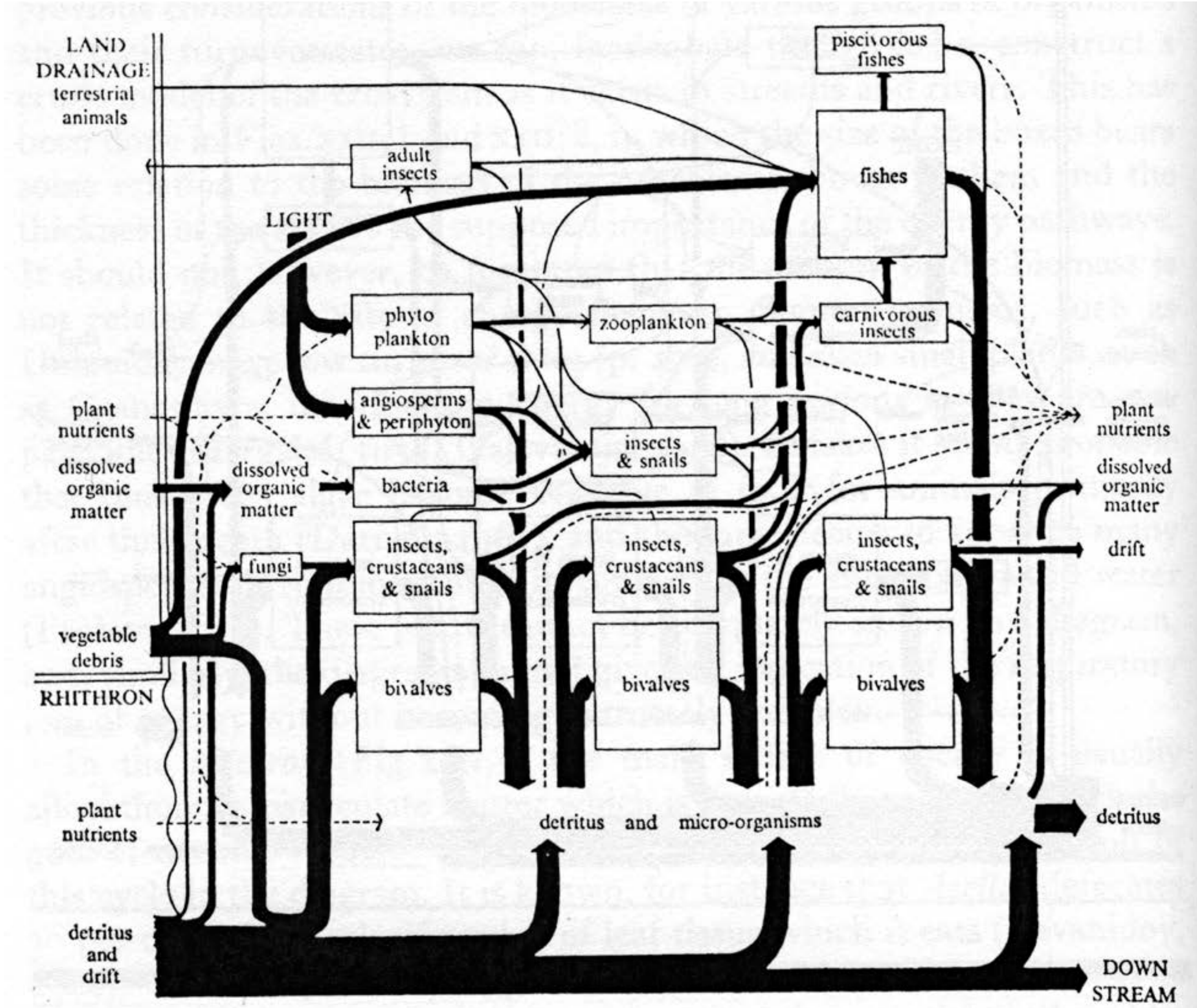
Figure 1. The theoretical framework of the SDC within a stream corridor from headwaters to mouth. Discontinuity distance (DD) is the downstream (positive) or upstream (negative) shift of a given parameter at a given distance (*X*, measured in steam orders or Euclidean distance) because of the regulation scheme. Parameter intensity (PI) is the strength (*Y*, which may also be positive or negative) of the regulation effect on biophysical parameter *A*. Interactive arrows that expand or contract show influences on longitudinal, lateral and vertical connectivity in direct relation to the position and mode of regulation (after Ward and Stanford, 1983a,b, 1995)

Rhithron – podhorské potoky

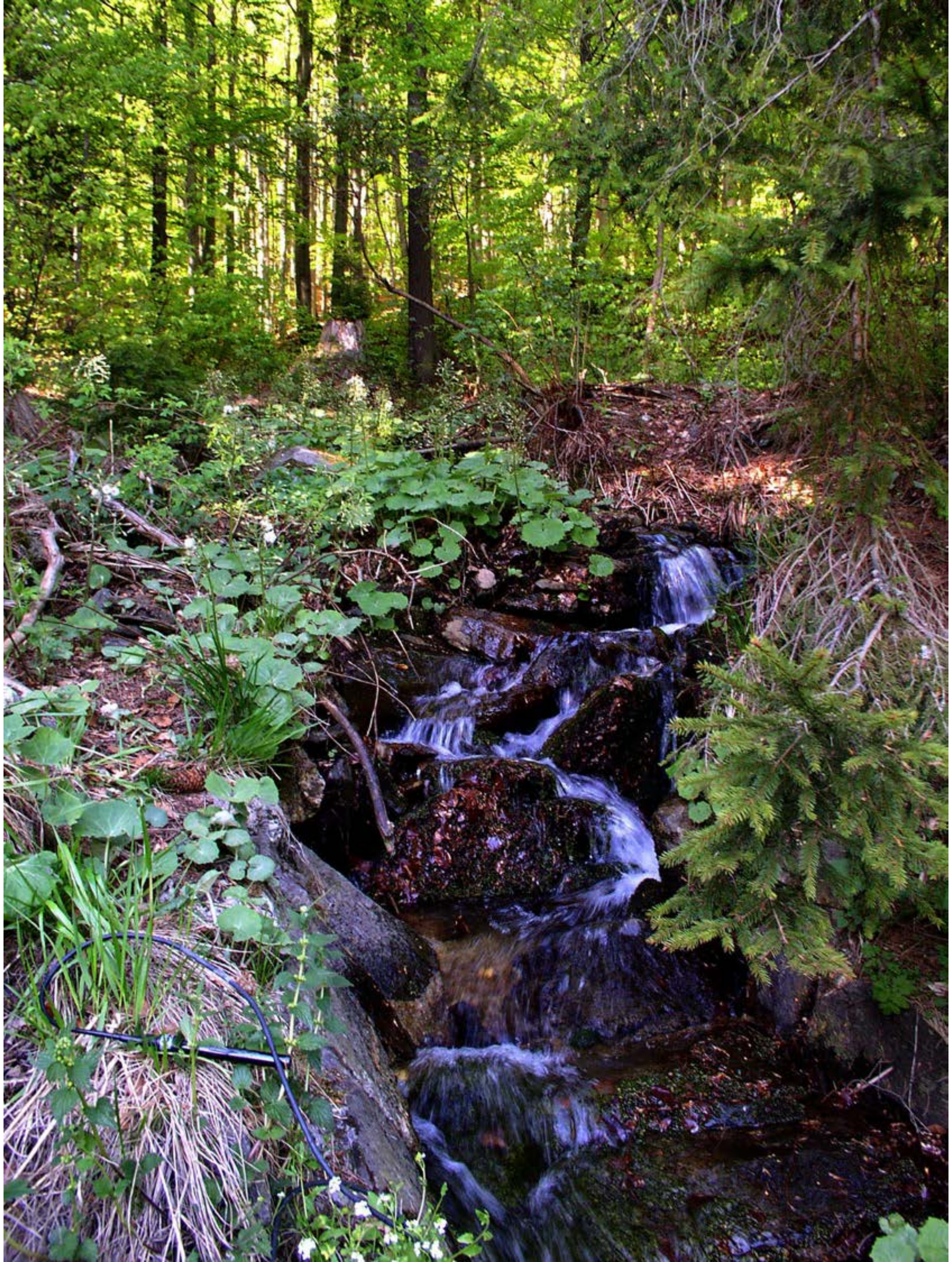


Hynes, 1970: The Ecology of Running Waters

Potamon – nížinné řeky



Hynes, 1970: The Ecology of Running Waters




Morava


Labe

Seasonal dynamics of chironomids in impounded river: taxa composition and life cycles

Department of Geography
Faculty of Science
Masaryk University

Karel Brabec, Ph.D.

brabec@sci.muni.cz

STUDY AIMS

Effects of dams

- disruption of river continuum
- altered discharge and thermal regimes
- sedimentation regime (transparency)
- nutrients

Study aims

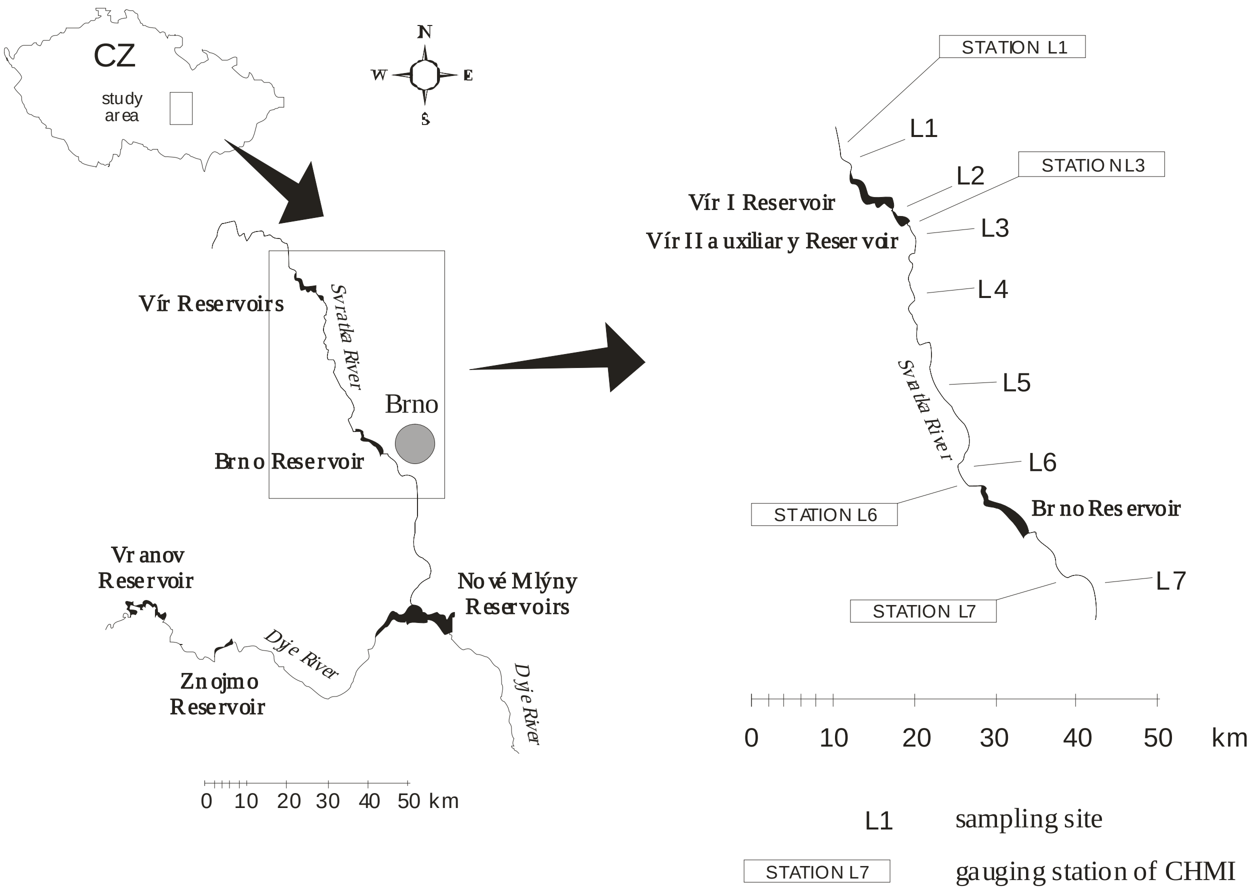
- to analyze chironomid response to altered conditions below dams
- to apply both seasonaly sumarised characteristics and seasonal pattern

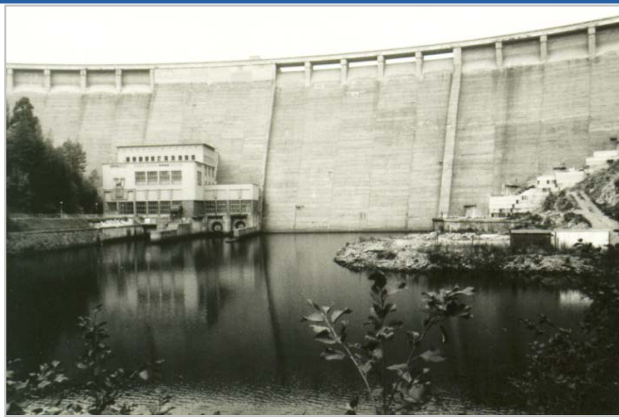
CHIRONOMIDS AS INDICATORS

- **thermal preference/plasticity**
- **feeding strategies and hydraulic preferences**
- **growth, voltinism, seasonal dynamics of instars abundances**

- **taxonomic structure of community/taxocoenoses**
- **trait-based characteristics**
- **life-cycle (instar composition, morphometric characteristics)**

STUDY AREA


CZ
study area
N
W
E
S
Vír Reservoirs
Svratka River
Brno
Brno Reservoir
Vranov Reservoir
Znojmo Reservoir
Dyje River
Nové Mlýny Reservoirs
Dyje River
0 10 20 30 40 50 km
STATION L1
L1
L2
STATION L3
Vír I Reservoir
Vír II auxiliary Reservoir
L3
L4
L5
Svratka River
L6
STATION L6
Brno Reservoir
L7
STATION L7
0 10 20 30 40 50 km
L1 sampling site
STATION L7 gauging station of CHMI



METHODS

Biota

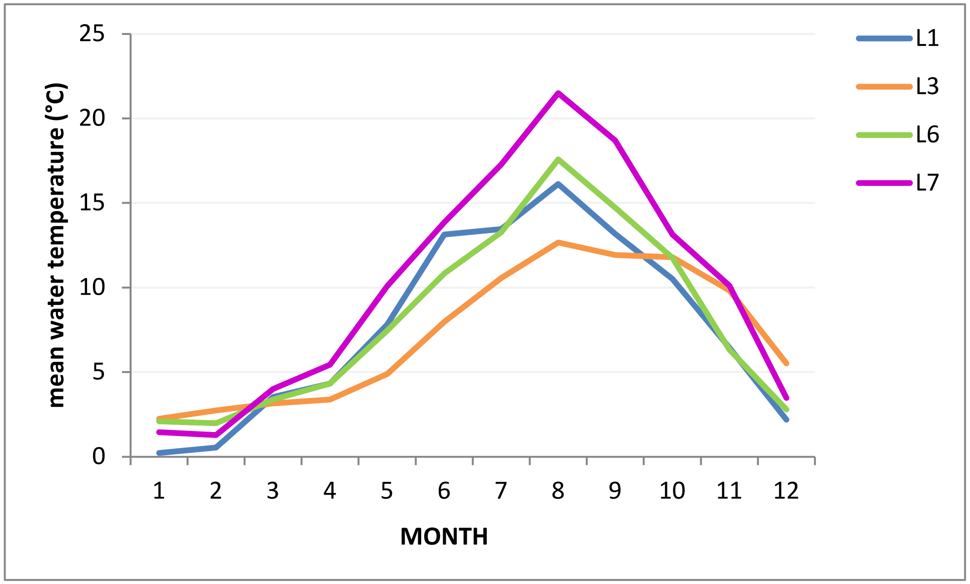
- single habitat type – riffle in central part of river channel
- 7 sites x 12 montly dates in 1992
- net with mesh 500 µm, sampling area 25x25 cm,
- sorting in laboratory (stereomicroscope)
- measurements of head length (in some cases also head width and body length were obtained)
- identification (taxa + instar), linking to ecological traits

Environmental characteristics

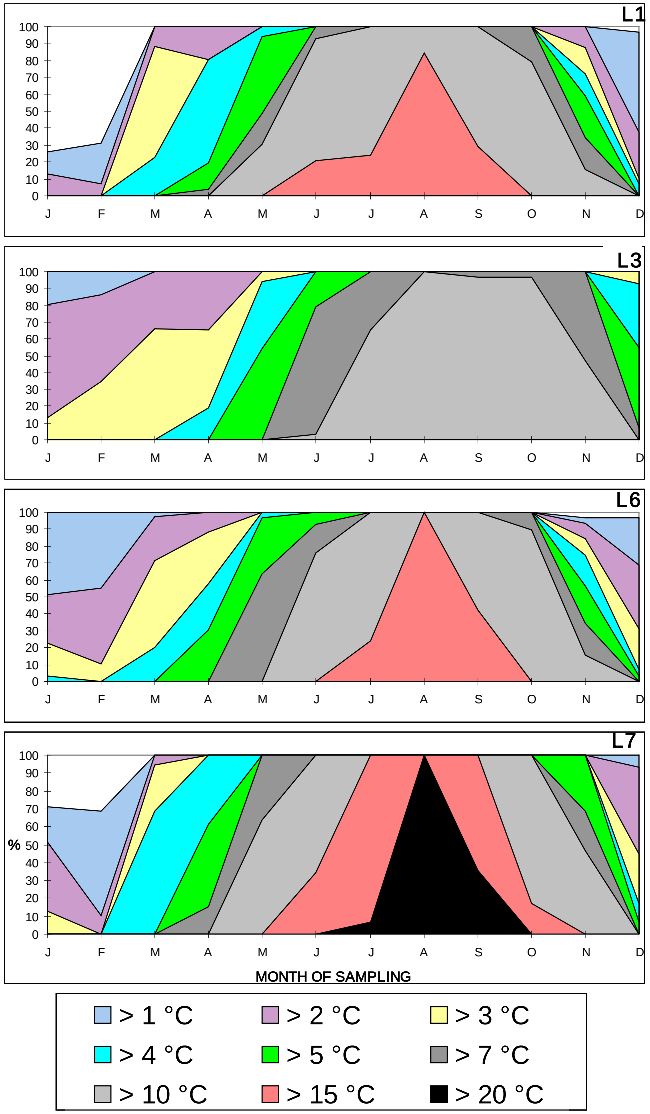
- temperature and flow regime from 4 gauging stations (located close to L1, L3, L6 and L7)

THERMAL REGIME

sampling site	L1	L2	L3	L4	L5	L6	L7
distance from the source	49.7	59.9	65.1	76.4	92.9	103.1	128.5
distance from Vír Reservoir I (km)	-1.0	0.9	6.1	17.4	33.9	44.1	69.5
altitude	467.0	395.0	361.0	324.5	257.7	235.0	194.0
channel width (m)	20.0	19.0	27.0	20.0	19.0	14.5	27.0
slope at site (‰)	2.30	7.50	5.70	2.75	2.85	1.60	1.00
conductivity (µS.cm^{-1})	180	190	211	238	265	303	324
pH	7.69	7.65	7.79	7.76	7.93	7.75	7.87
mean annual water temperature (°C)	7.70	7.33	7.36	7.41	7.78	8.18	9.41
degree days	2783	2628	2602	2687	2833	2904	3647
mean annual discharge (m^3.s^{-1})	3.319	-	3.741	-	-	7.808	7.114
mean diurnal range of water level (cm)	6	-	26	-	-	18	36



temporal percentage
of temperature exceeded



FLOW REGIME – DAM OPERATION

Vír

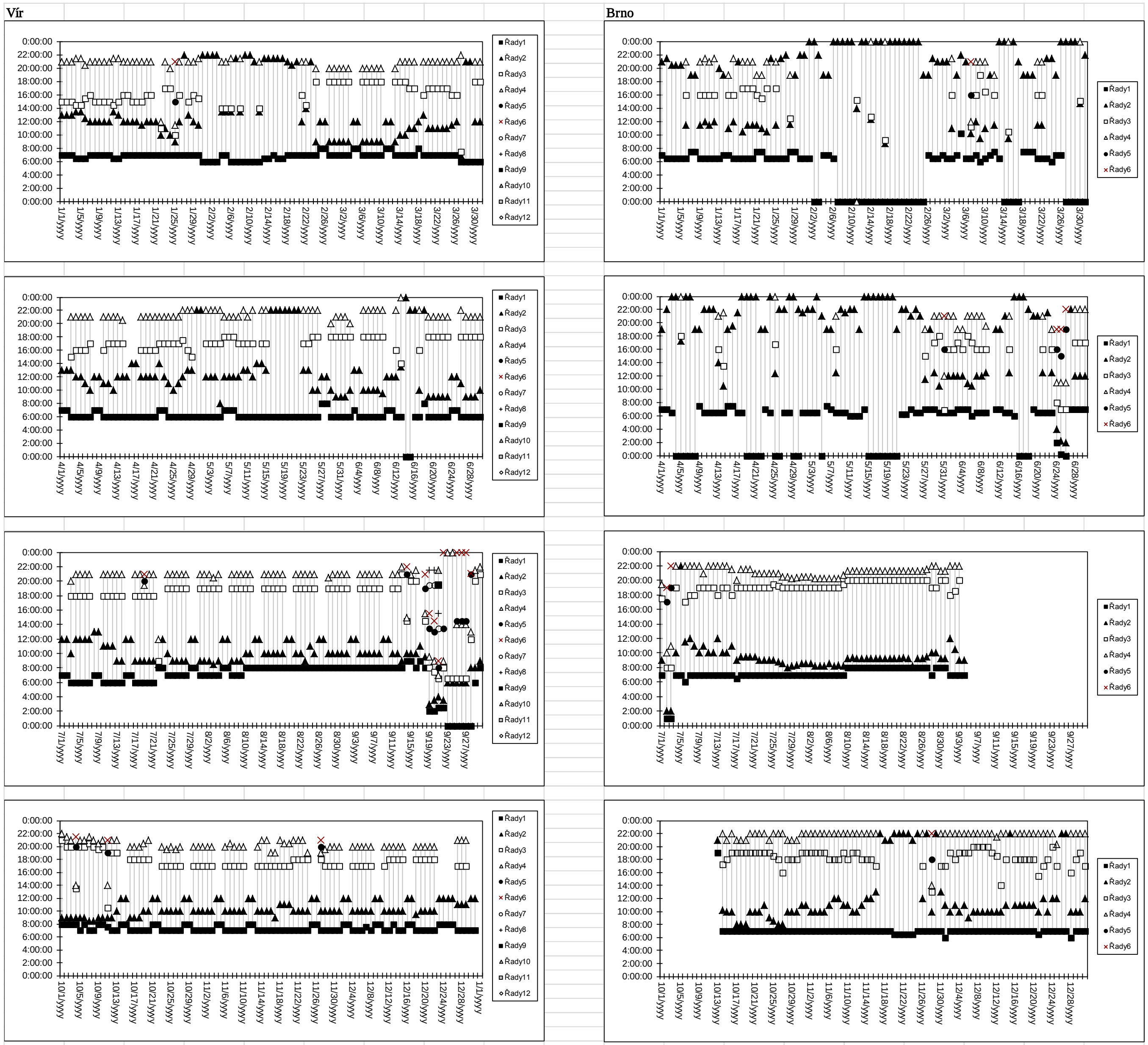
Brno

I-III

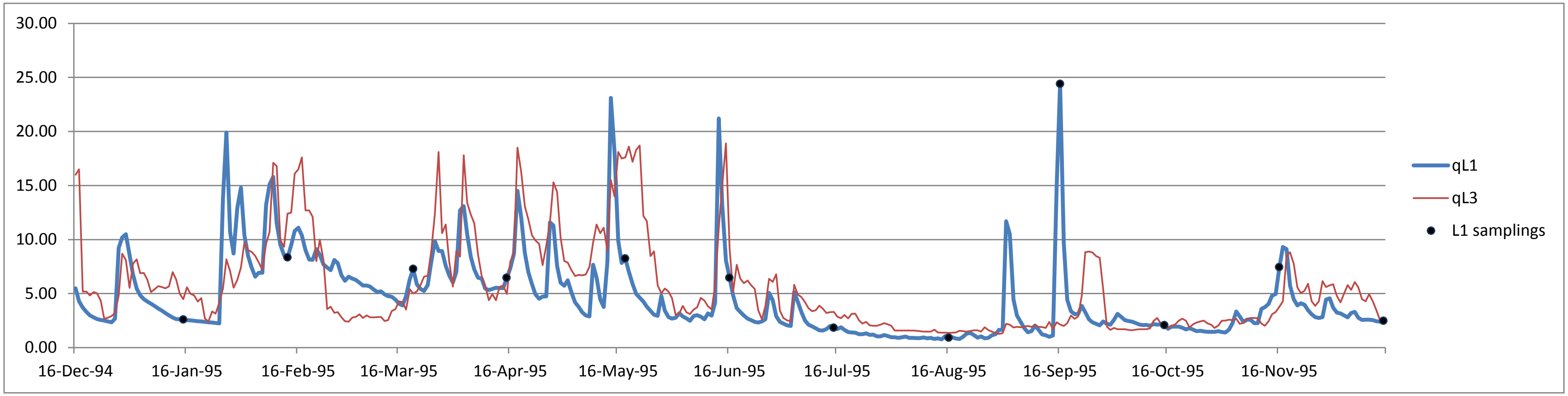
IV-VI

VI-IX

IX-XII



FLOW REGIME


30.00
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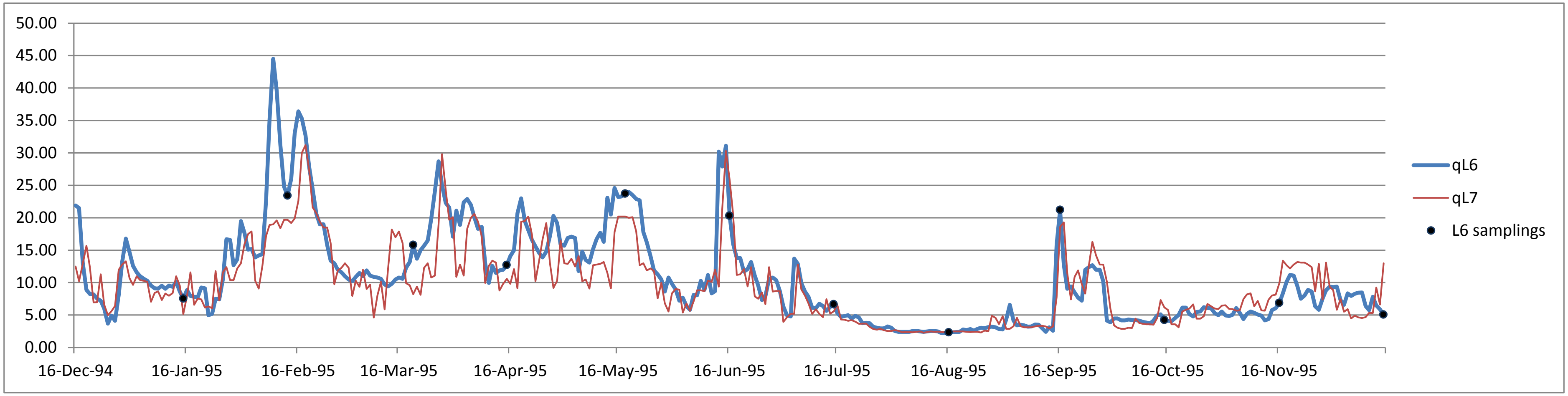
16-Dec-94
16-Jan-95
16-Feb-95
16-Mar-95
16-Apr-95
16-May-95
16-Jun-95
16-Jul-95
16-Aug-95
16-Sep-95
16-Oct-95
16-Nov-95
qL1
qL3
L1 samplings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45.00
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35.00
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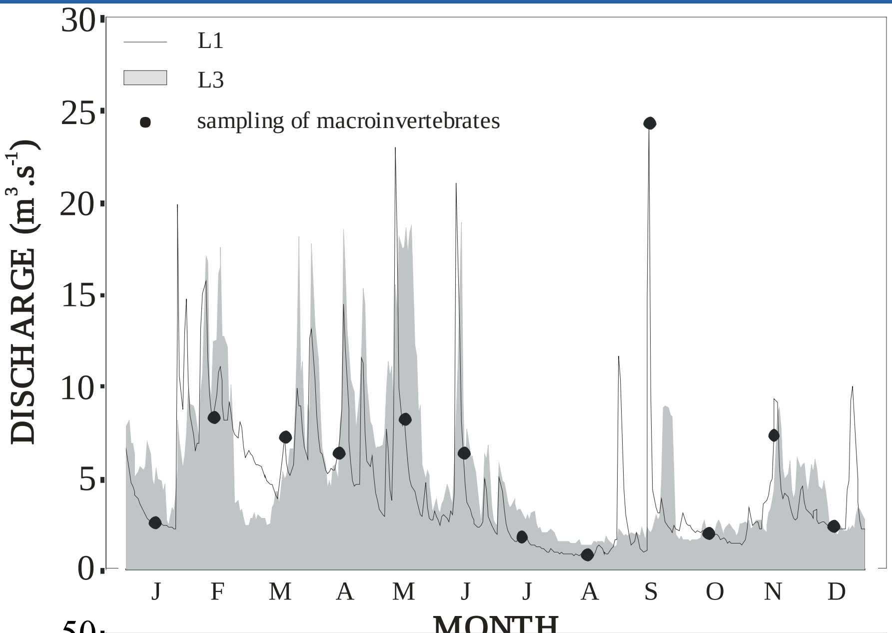
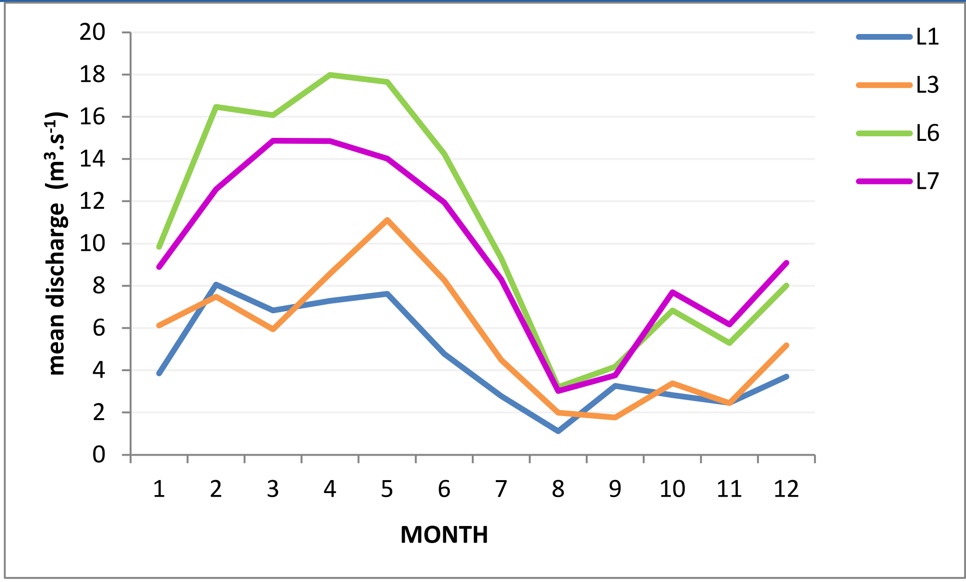
16-Dec-94
16-Jan-95
16-Feb-95
16-Mar-95
16-Apr-95
16-May-95
16-Jun-95
16-Jul-95
16-Aug-95
16-Sep-95
16-Oct-95
16-Nov-95
qL6
qL7
L6 samplings

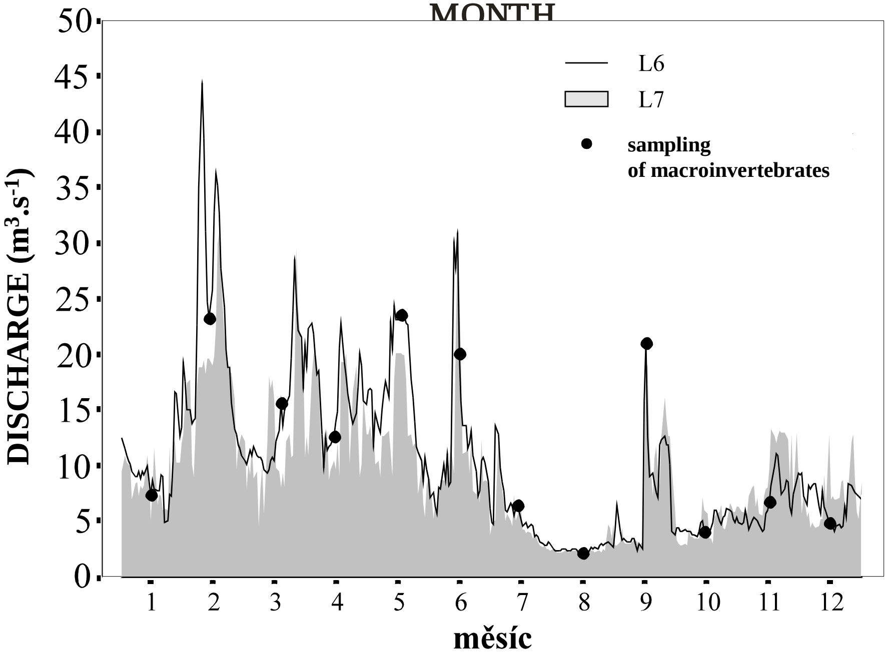
FLOW REGIME



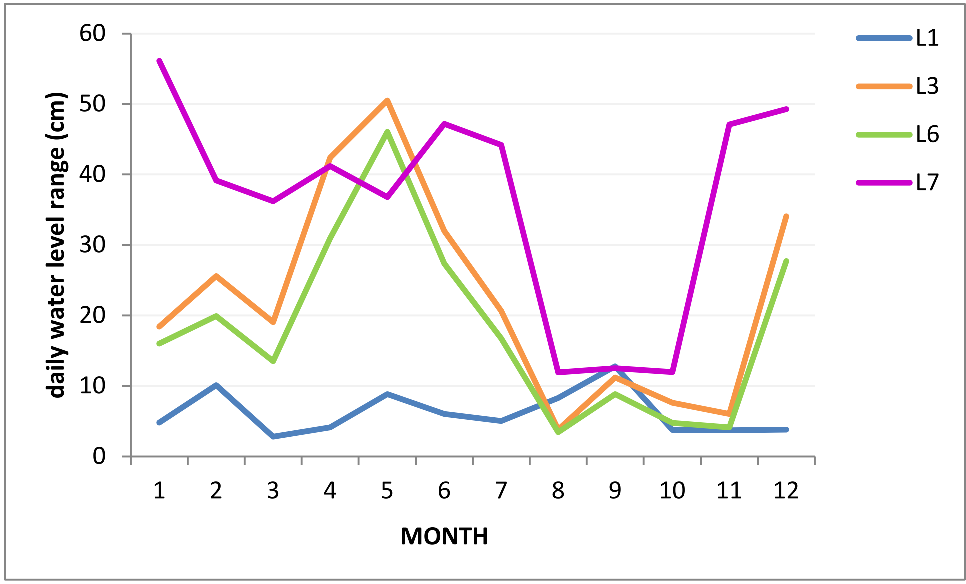
L1
L3
sampling of macroinvertebrates
DISCHARGE ($m^3.s^{-1}$)
30
25
20
15
10
5
0
J F M A M J J A S O N D
MONTH



L1
L3
L6
L7
mean discharge ($m^3.s^{-1}$)
MONTH

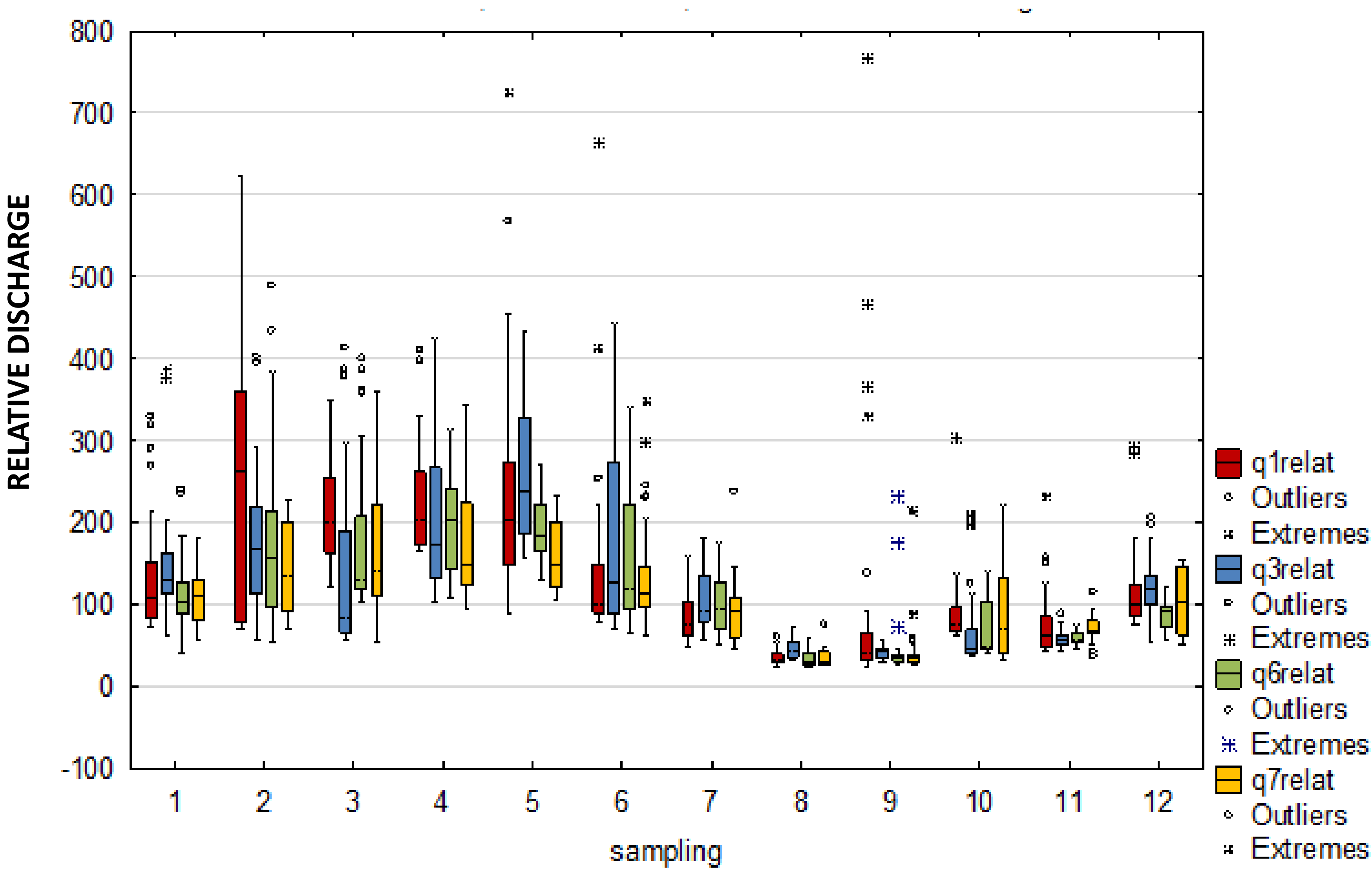


L6
L7
sampling
of macroinvertebrates
DISCHARGE ($m^3.s^{-1}$)
1 2 3 4 5 6 7 8 9 10 11 12
měsíc



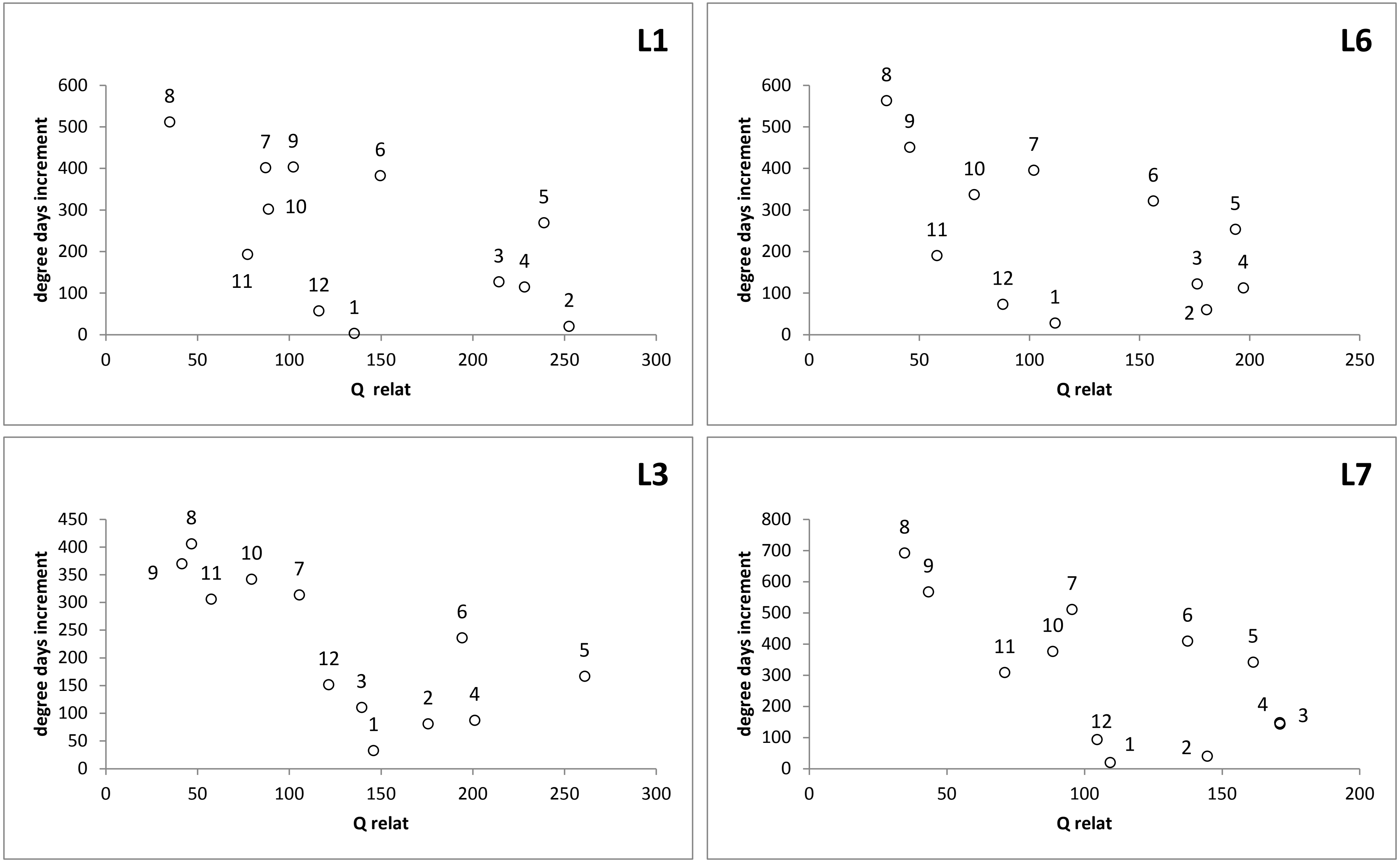
L1
L3
L6
L7
daily water level range (cm)
MONTH

FLOW REGIME



RELATIVE DISCHARGE
800
700
600
500
400
300
200
100
0
-100
1
2
3
4
5
6
7
8
9
10
11
12
sampling
q1relat
Outliers
Extremes
q3relat
Outliers
Extremes
q6relat
Outliers
Extremes
q7relat
Outliers
Extremes

FLOW REGIME


L1
degree days increment
600
500
400
300
200
100
0
0
50
100
150
200
250
300
Q relat
8
7
9
6
10
5
11
12
3
4
1
2
L6
degree days increment
600
500
400
300
200
100
0
0
50
100
150
200
250
Q relat
8
9
10
7
6
11
5
3
4
12
1
2
L3
degree days increment
450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
Q relat
8
9
11
10
7
6
5
12
3
2
4
1
L7
degree days increment
800
700
600
500
400
300
200
100
0
0
50
100
150
200
Q relat
8
9
7
10
6
11
5
4
3
12
1
2

FLOW REGIME – WATER LEVEL VARIATION

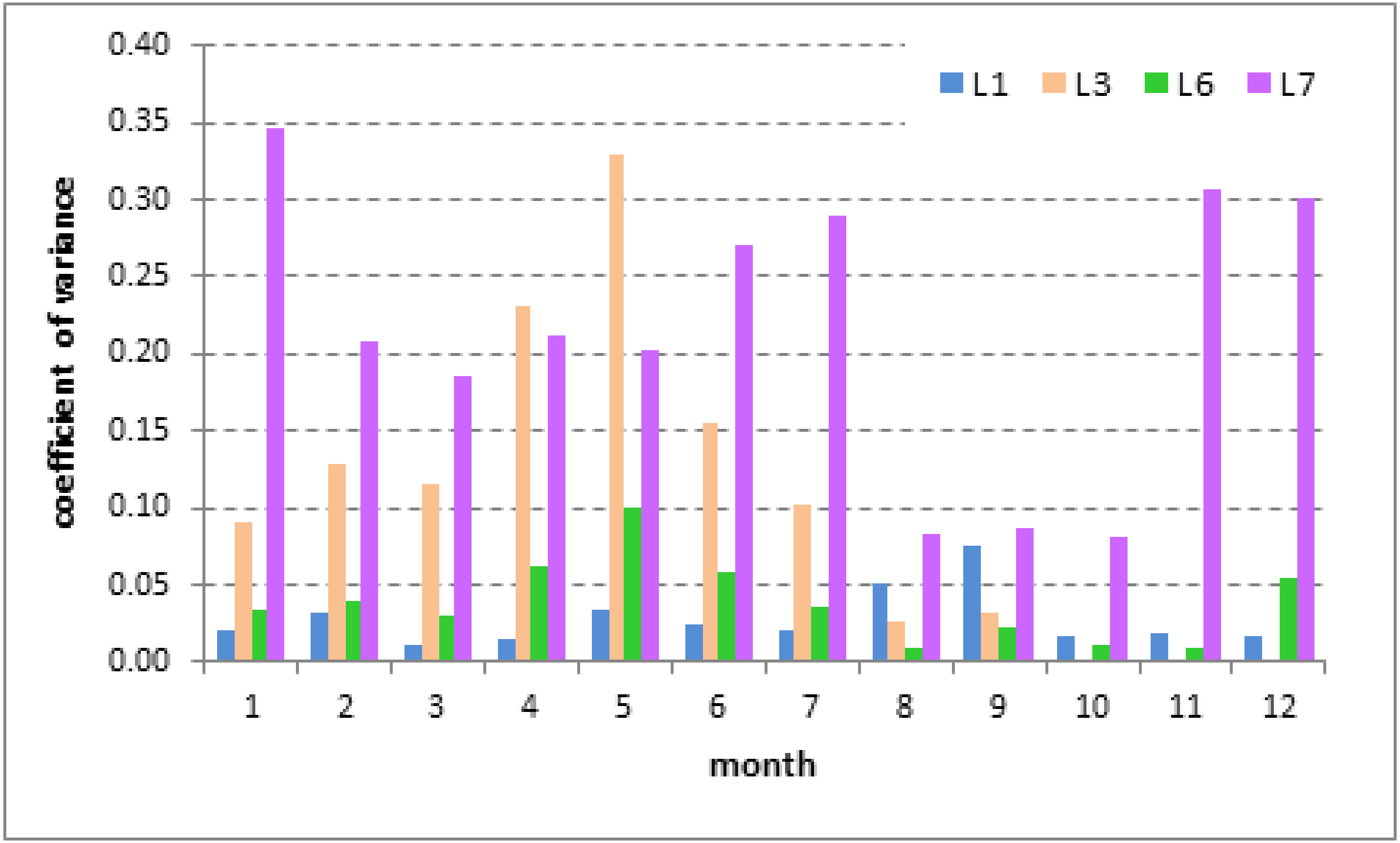
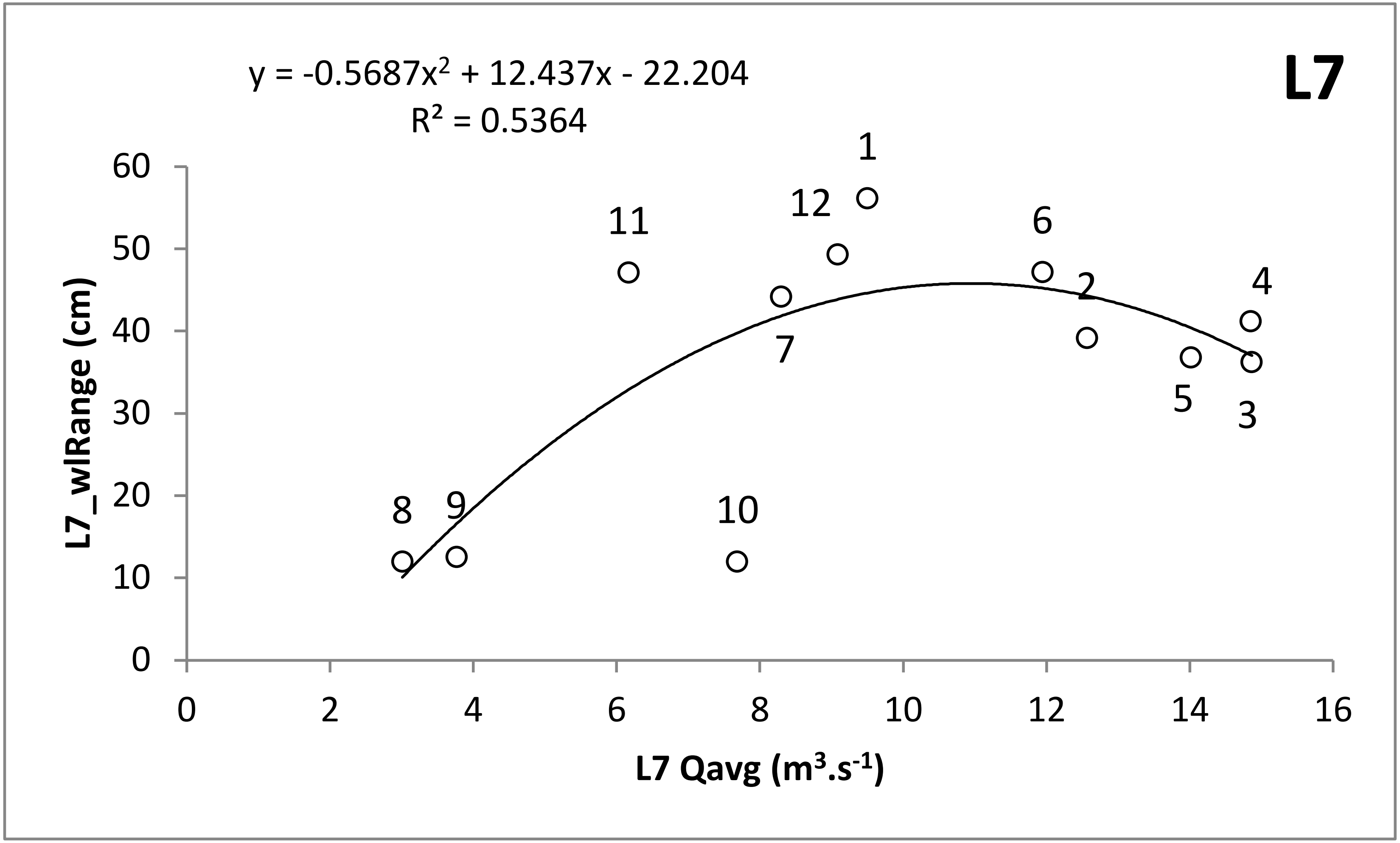
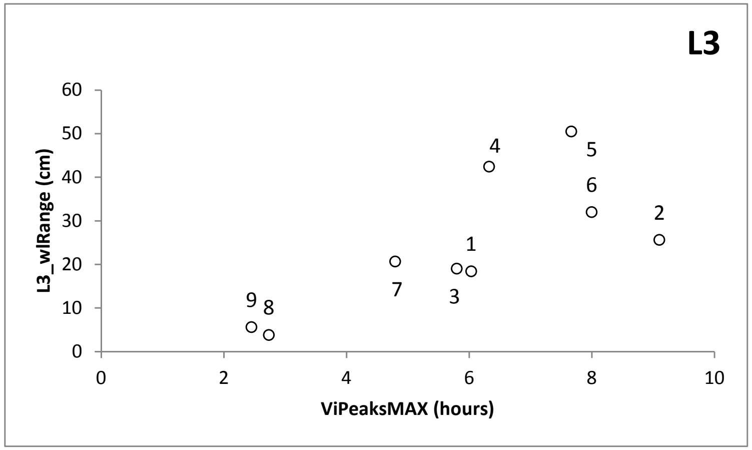


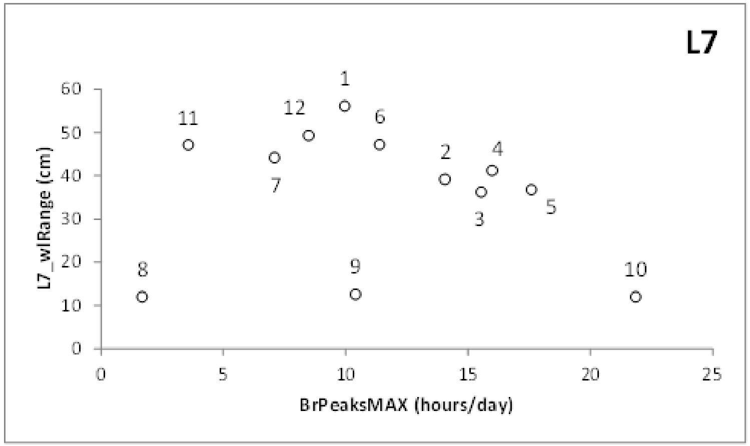
Fig. 1. water level CV (missing data for L3 S10-S12)

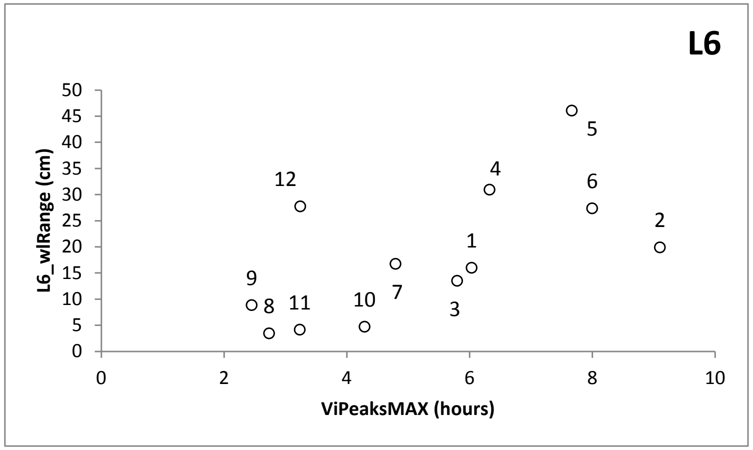
FLOW REGIME – WATER LEVEL VARIATION



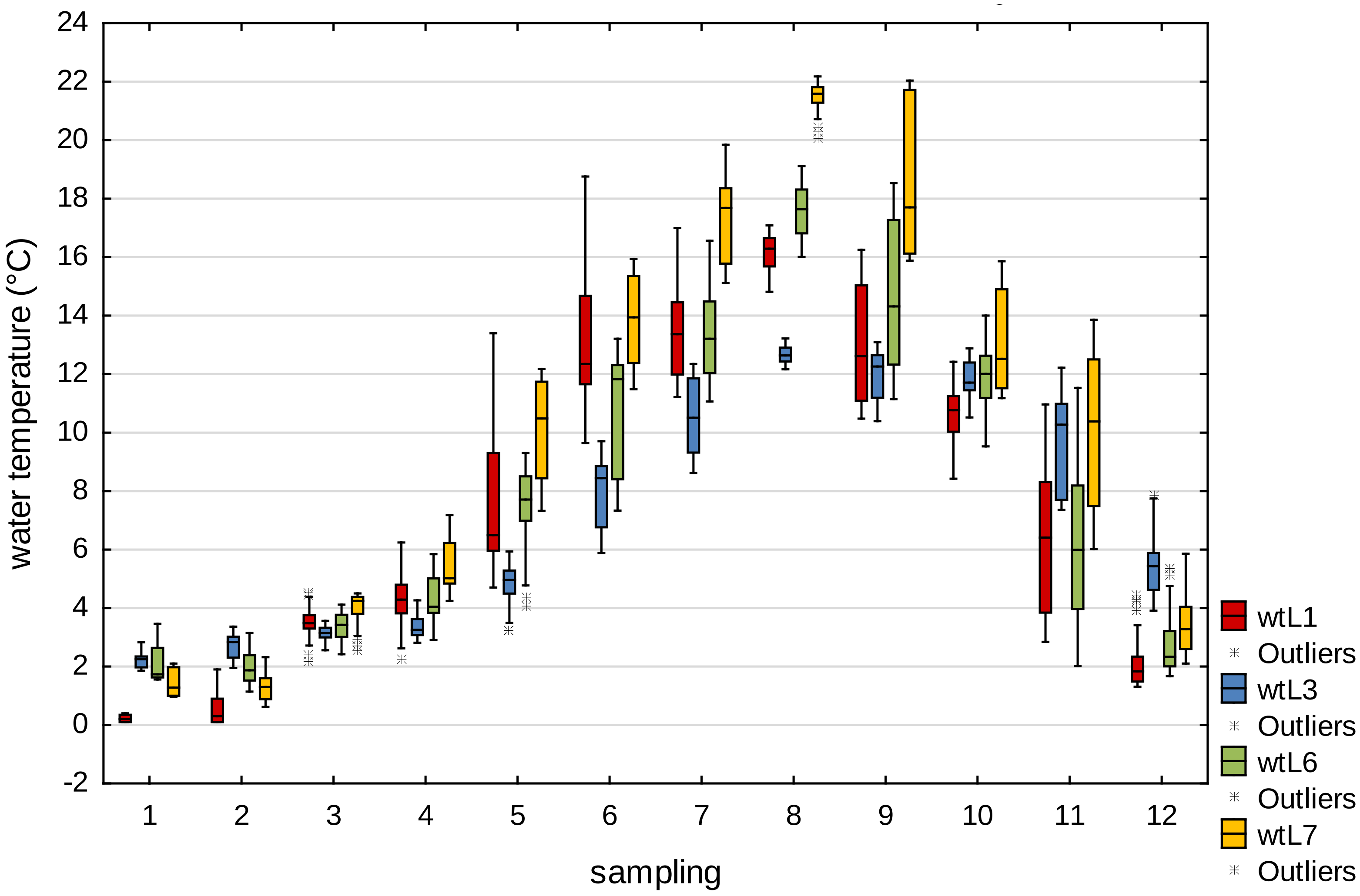
FLOW REGIME – WATER LEVEL VARIATION



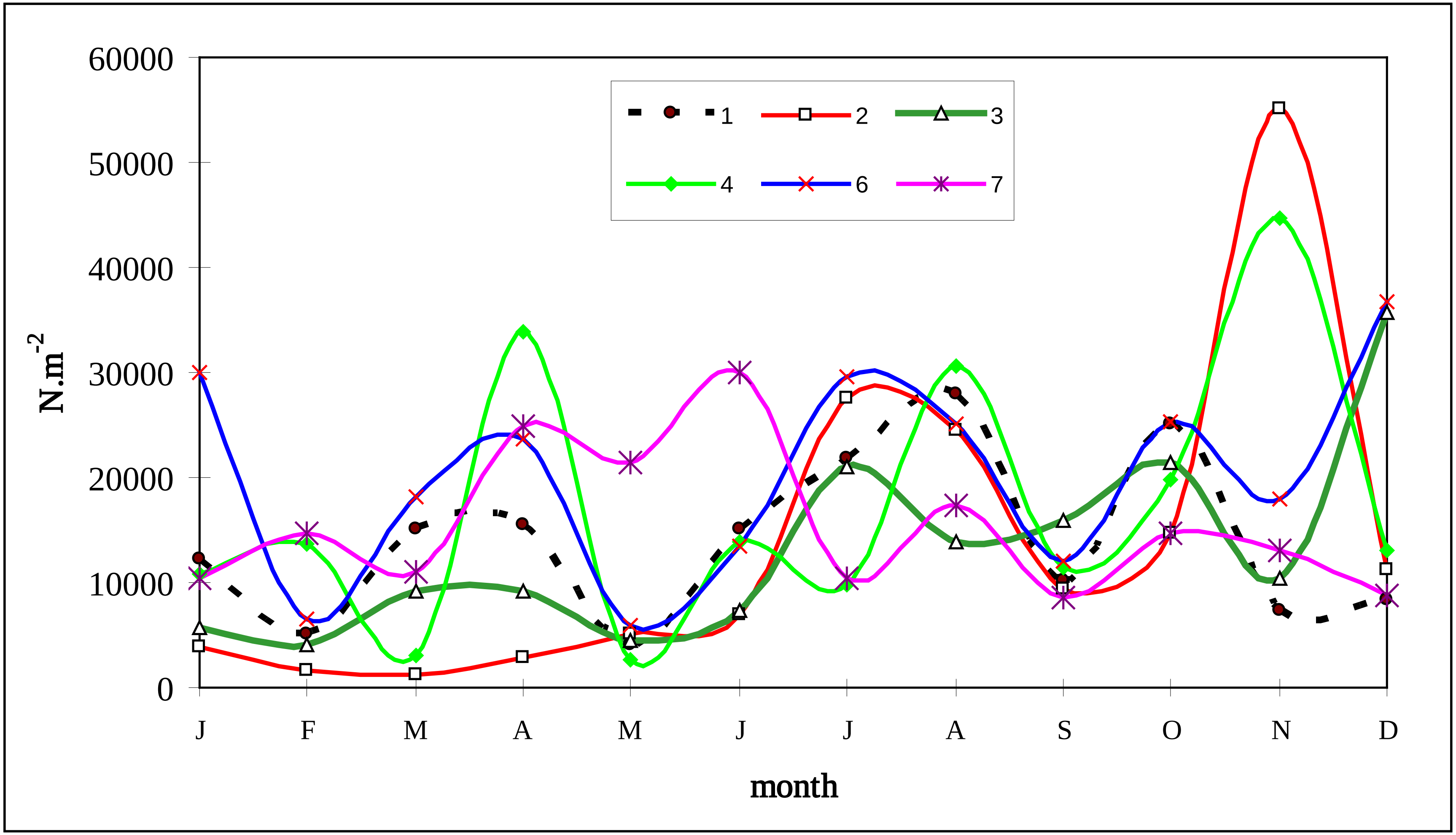




TEMPERATURE REGIME

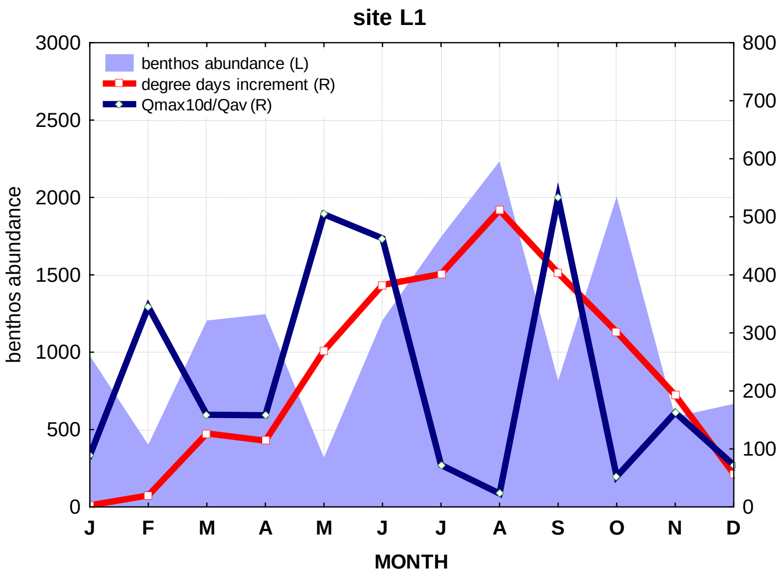


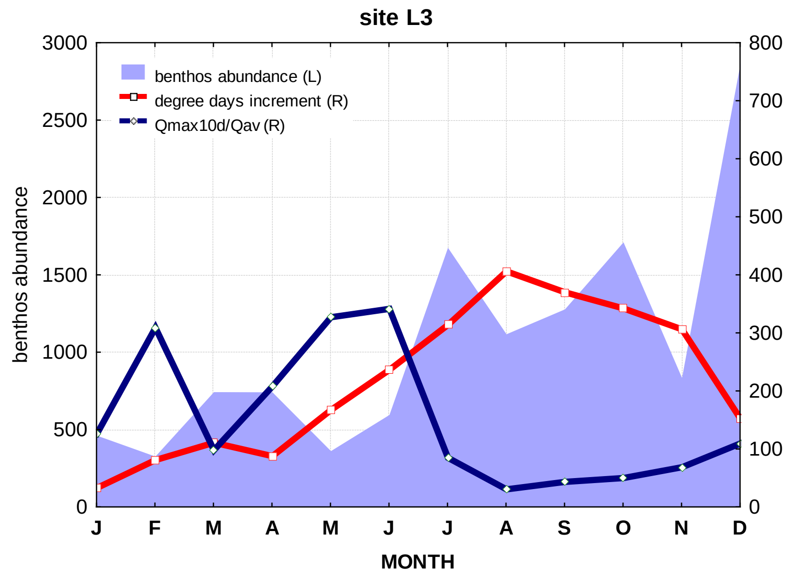
ABUNDANCE

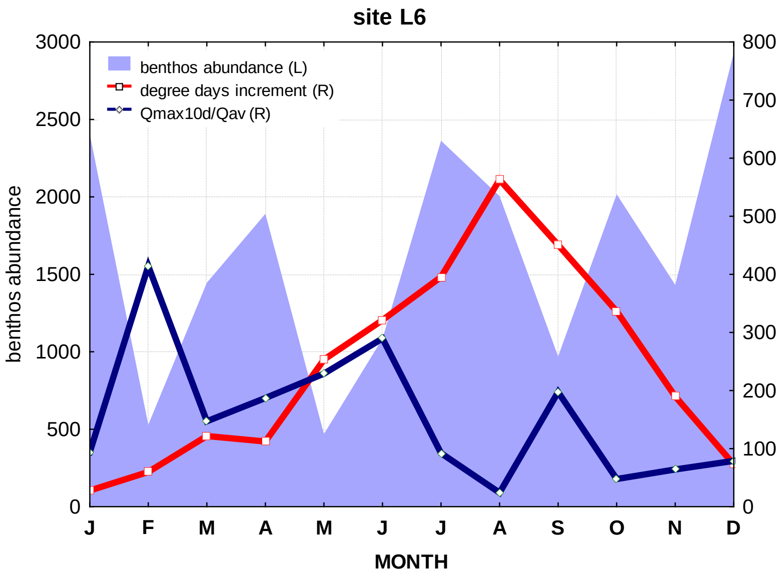


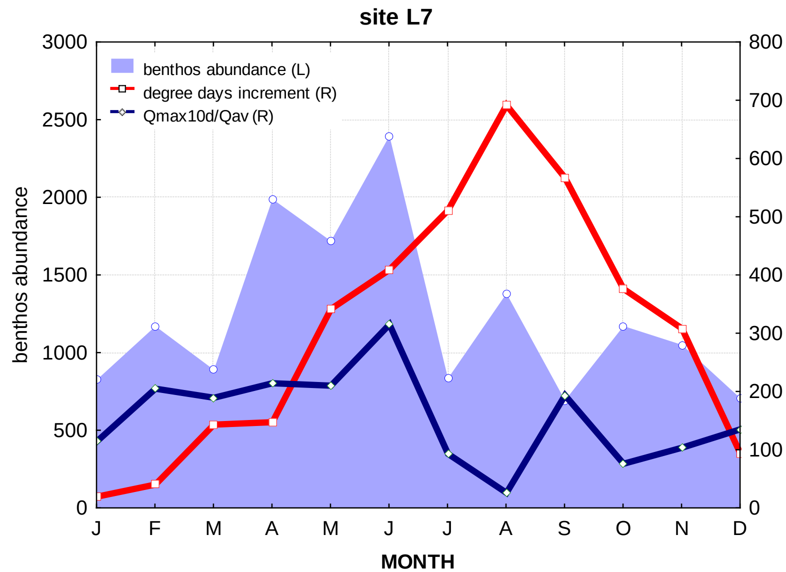
60000
50000
40000
30000
20000
10000
0
N.m-2
1
2
3
4
6
7
J
F
M
A
M
J
J
A
S
O
N
D
month

TEMPERATURE REGIME X ABUNDANCE



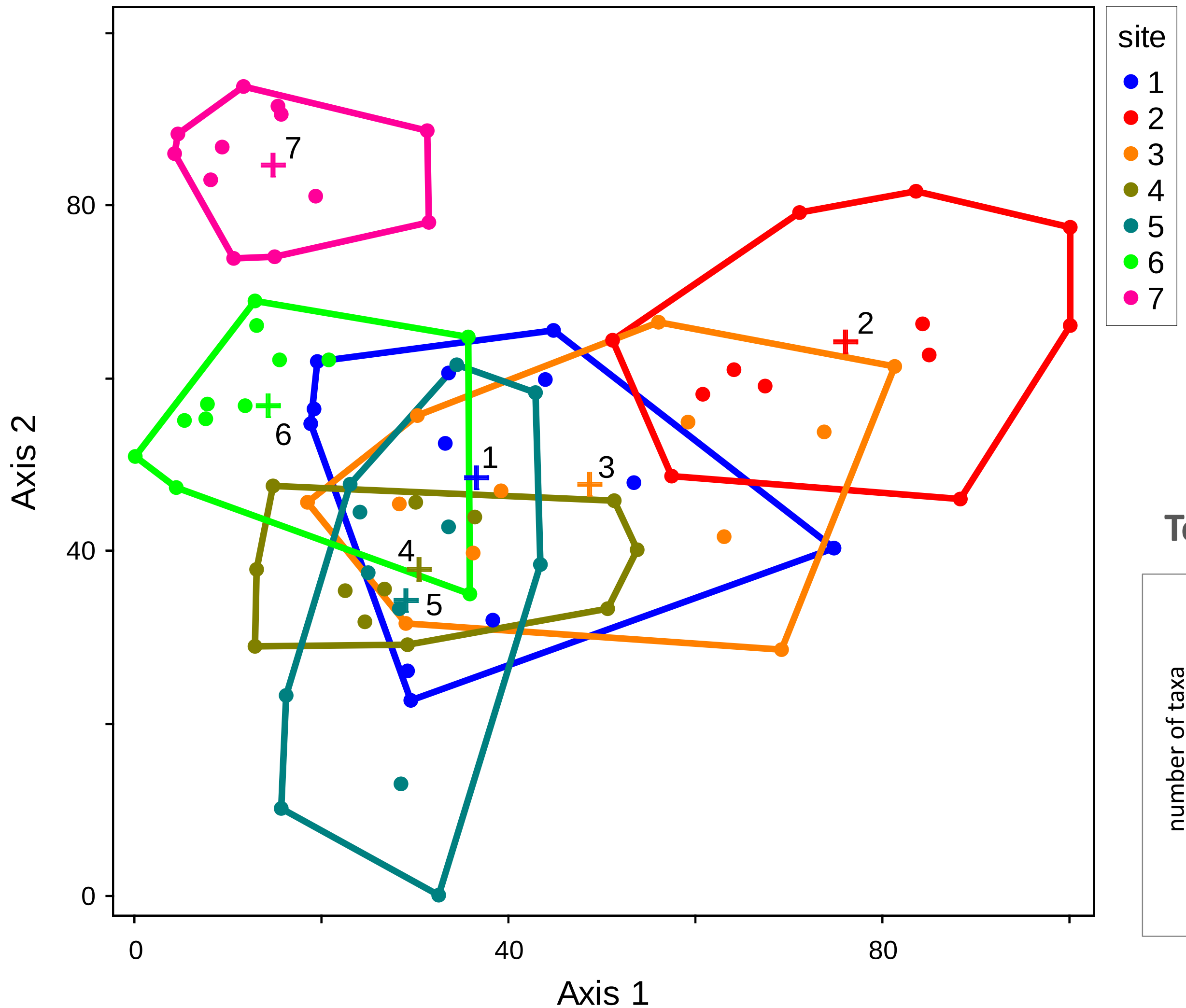




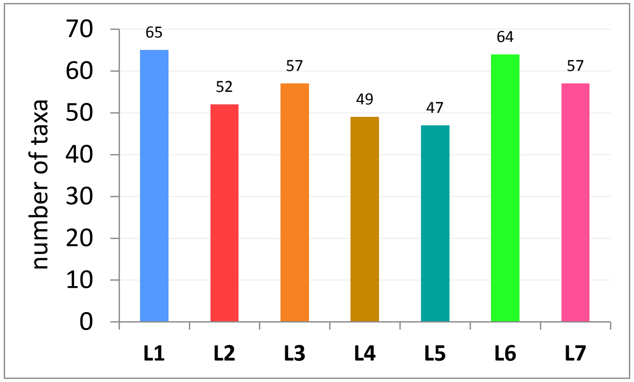


TAXONOMIC STRUCTURE AT SITES

Principal Coordinate Analysis (PCoA) based on Bray-Curtis dissimilarity

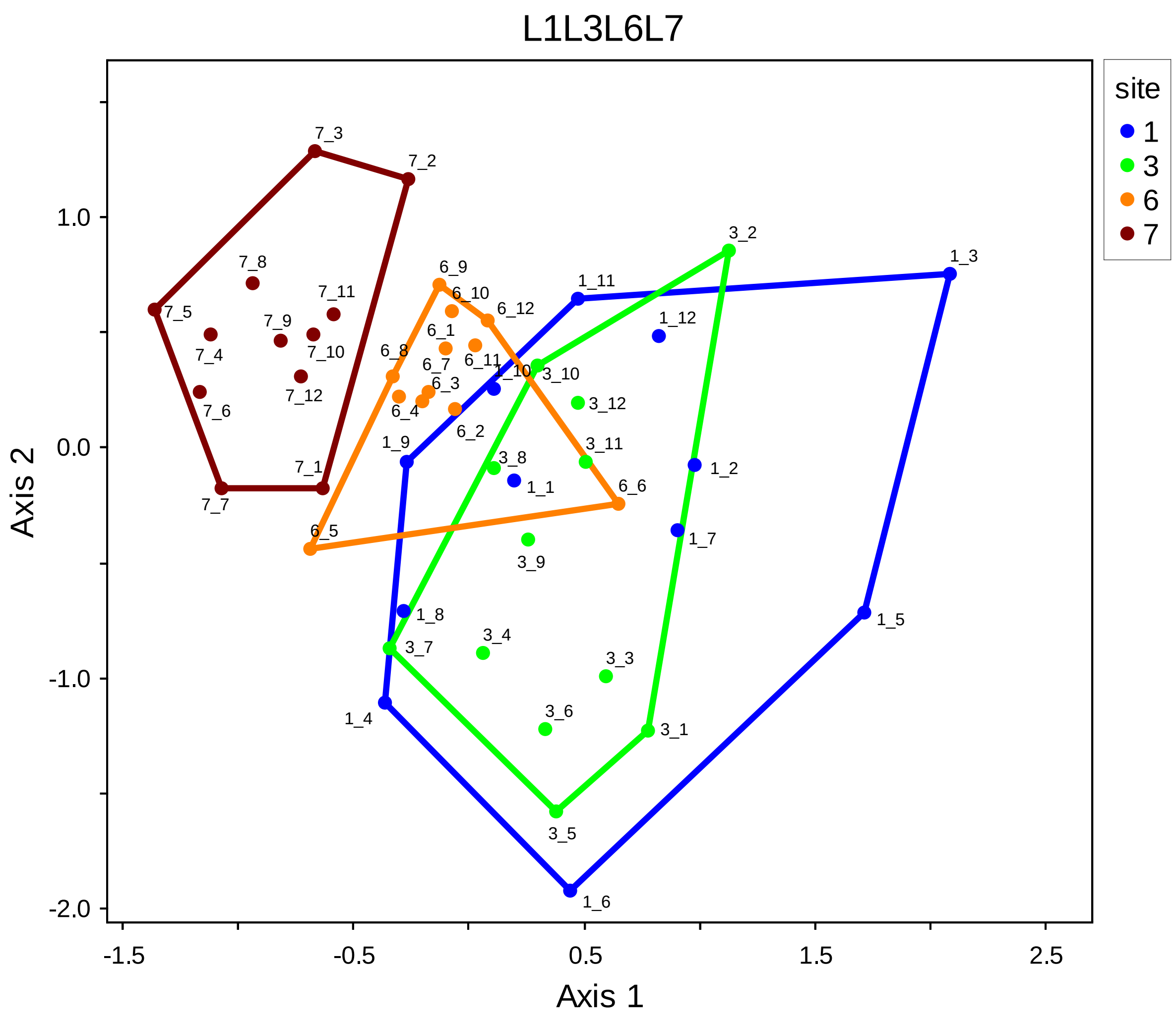


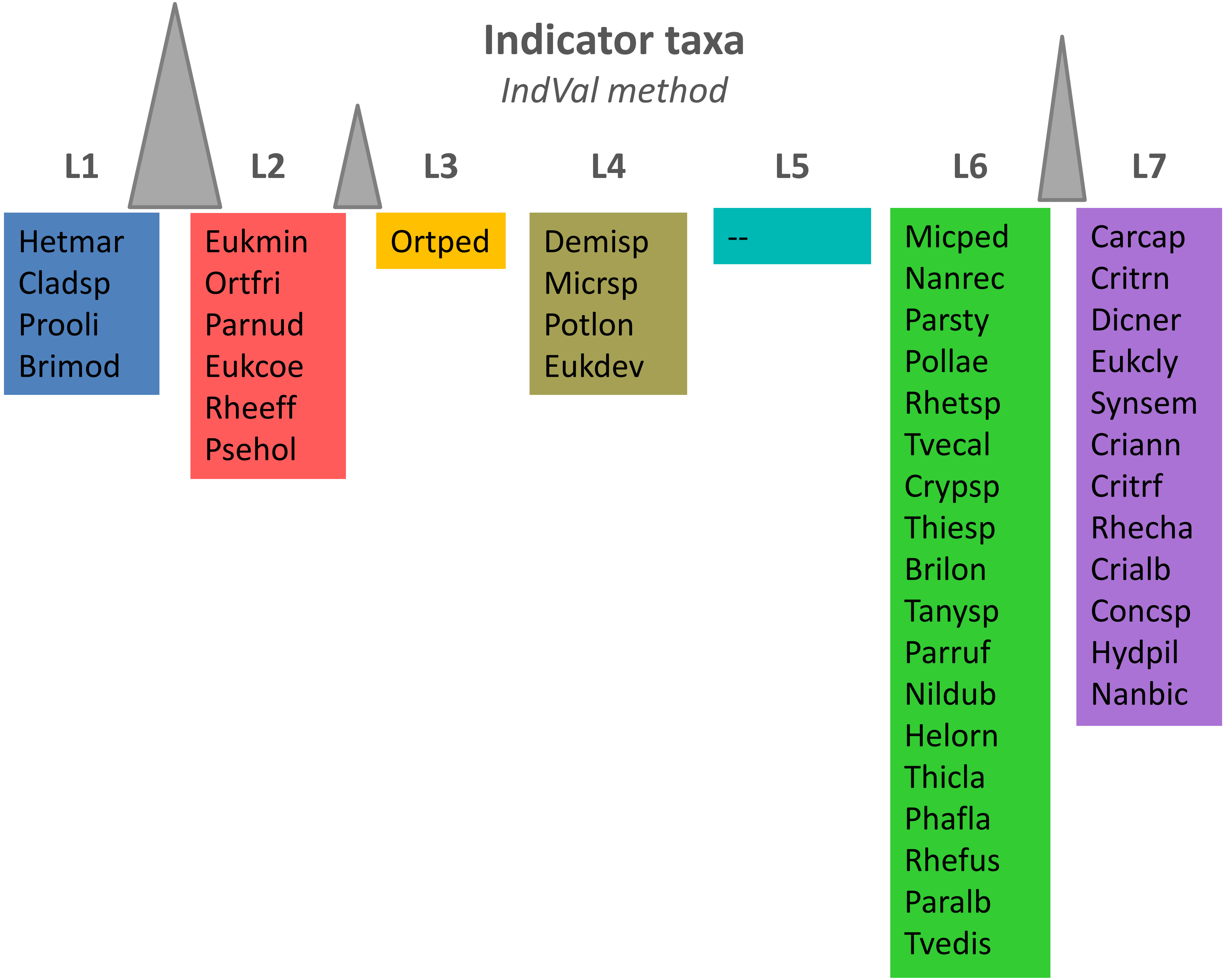
Total number of chironomid taxa



TAXONOMIC STRUCTURE AT SITES

Multidimensional Scaling based on Bray-Curtis dissimilarity

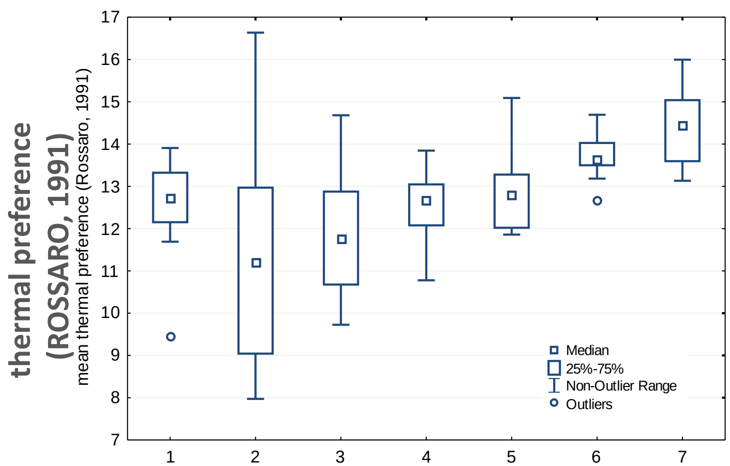



Indicator taxa
IndVal method
L1
Hetmar
Cladsp
Prooli
Brimod
L2
Eukmin
Ortfri
Parnud
Eukcoe
Rheeff
Psehol
L3
Ortped
L4
Demisp
Micrsp
Potlon
Eukdev
L5
--
L6
Micped
Nanrec
Parsty
Pollae
Rhetsp
Tvecal
Crypsp
Thiesp
Brilon
Tanysp
Parruf
Nildub
Helorn
Thicla
Phafla
Rhefus
Paralb
Tvedis
L7
Carcap
Critrn
Dicner
Eukcly
Synsem
Criann
Critrf
Rhecha
Crialb
Concsp
Hydpil
Nanbic

CHIRONOMID TRAITS

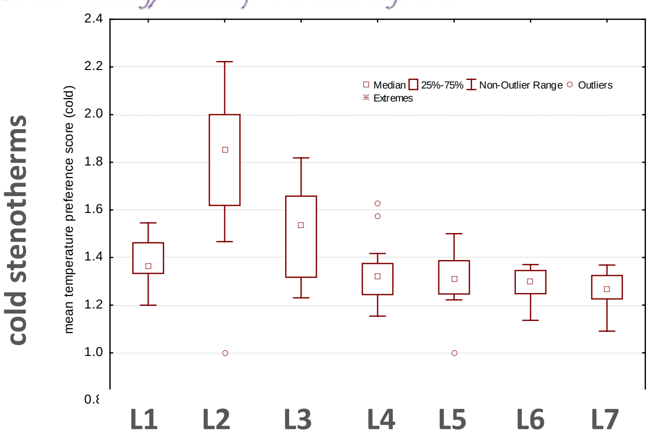
Thermal preferences from:

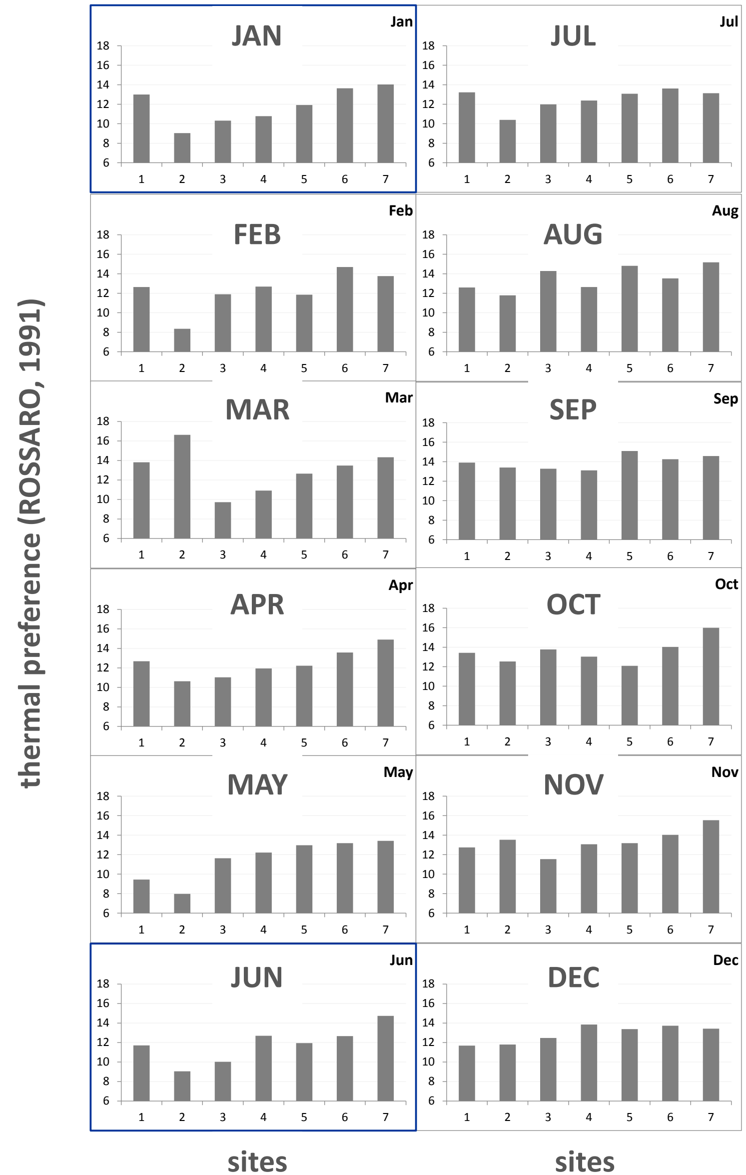
Rossaro B., 1991: Chironomids and water temperature. Aquat. Insect. 13: 87-98.



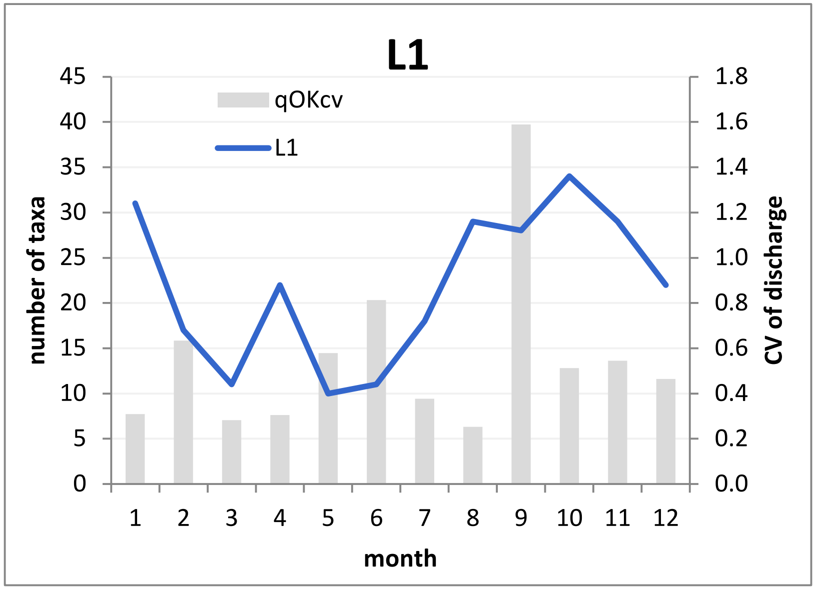
www.freshwaterecology.info

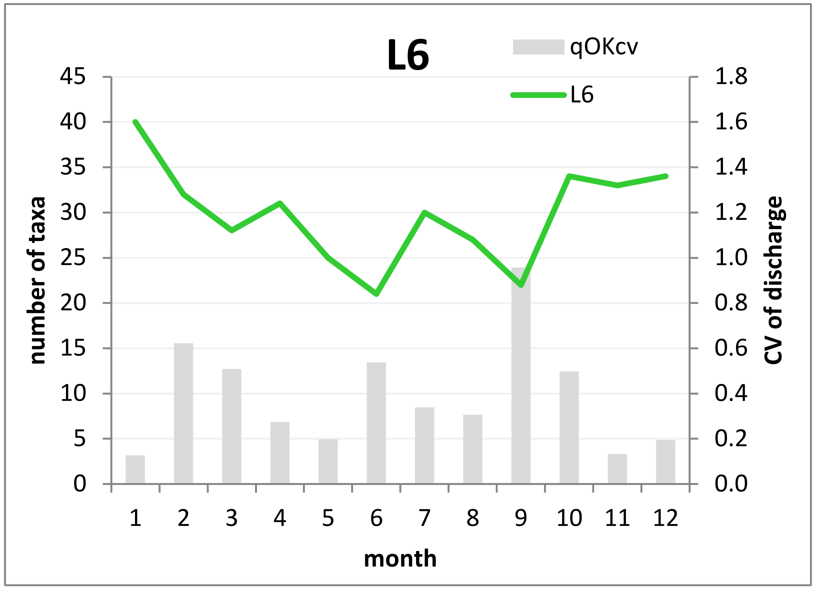
The Taxa and Autecology Database for Freshwater Organisms

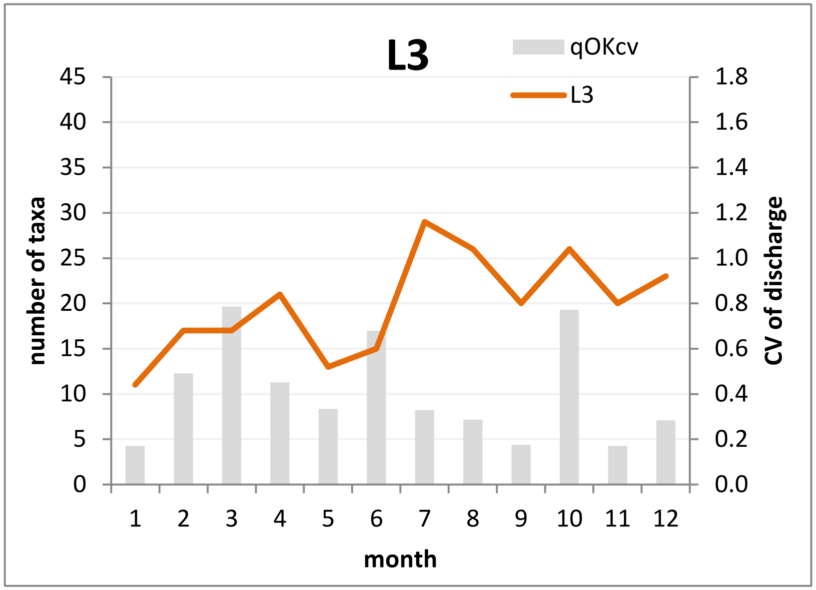


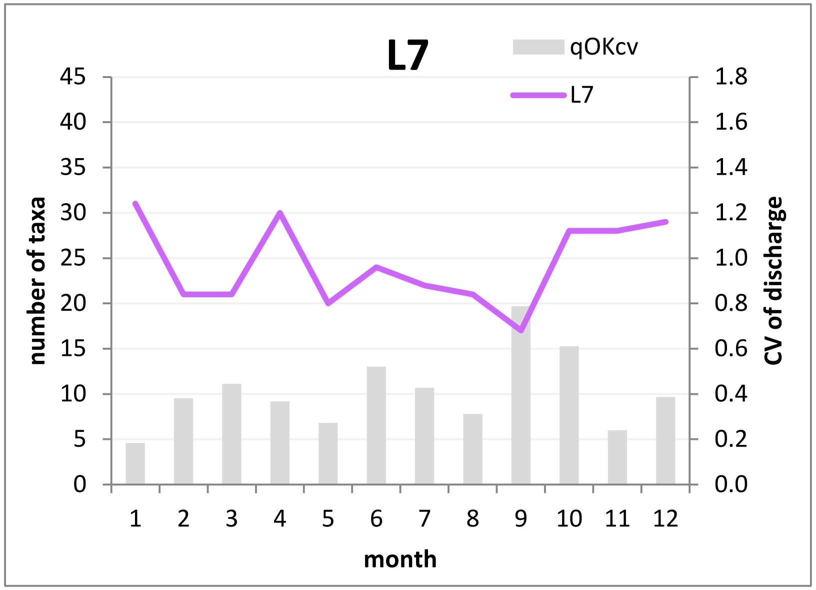


SEASONAL PATTERNS - DIVERSITY





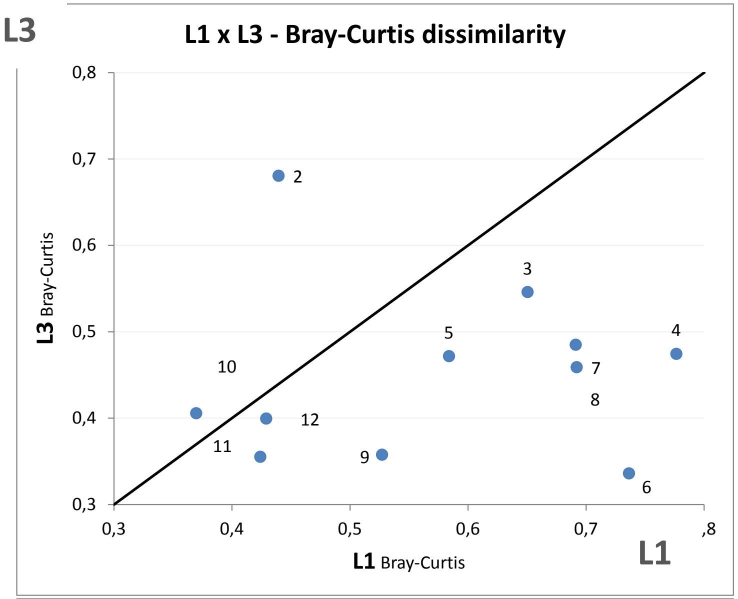


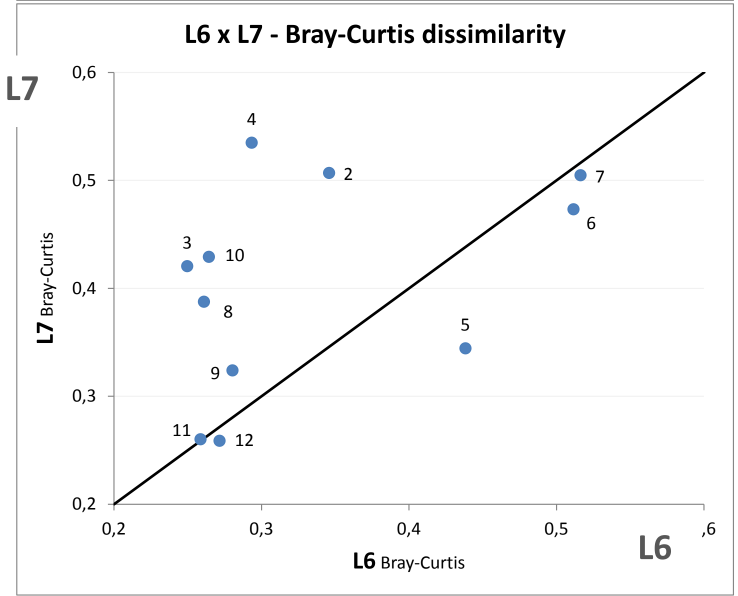


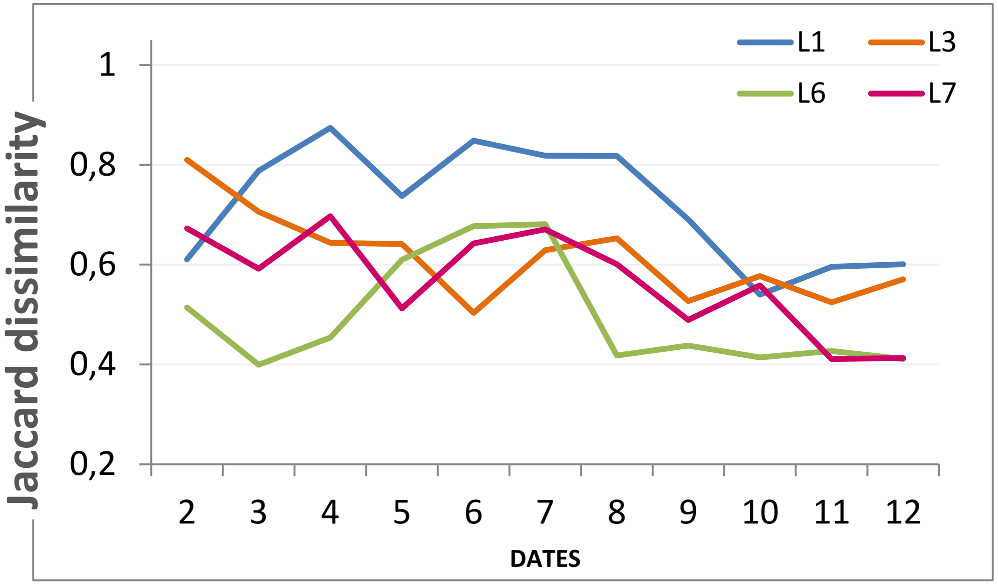
SEASONAL PATTERNS

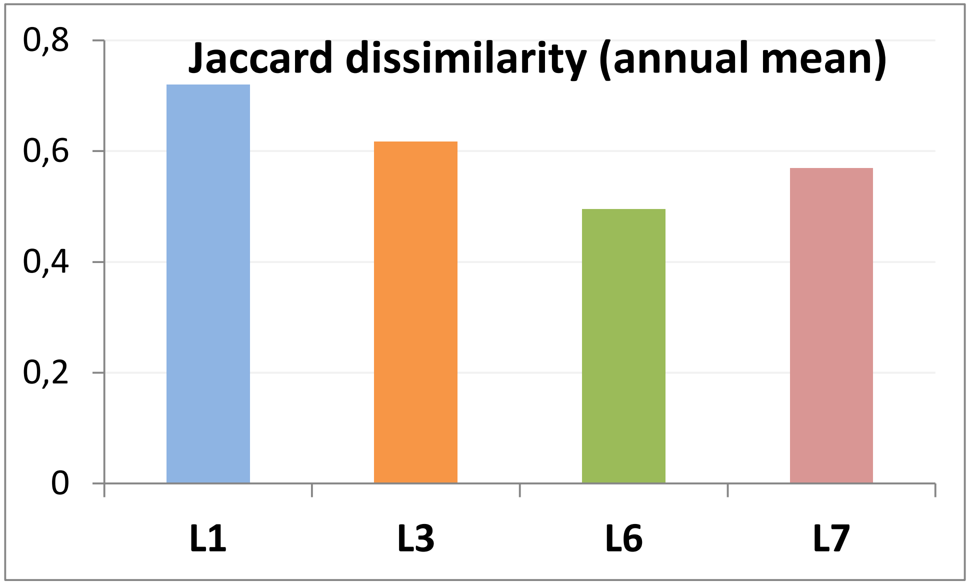
TAXONOMIC DISTANCE AMONG DATES

Bray-Curtis dissimilarity



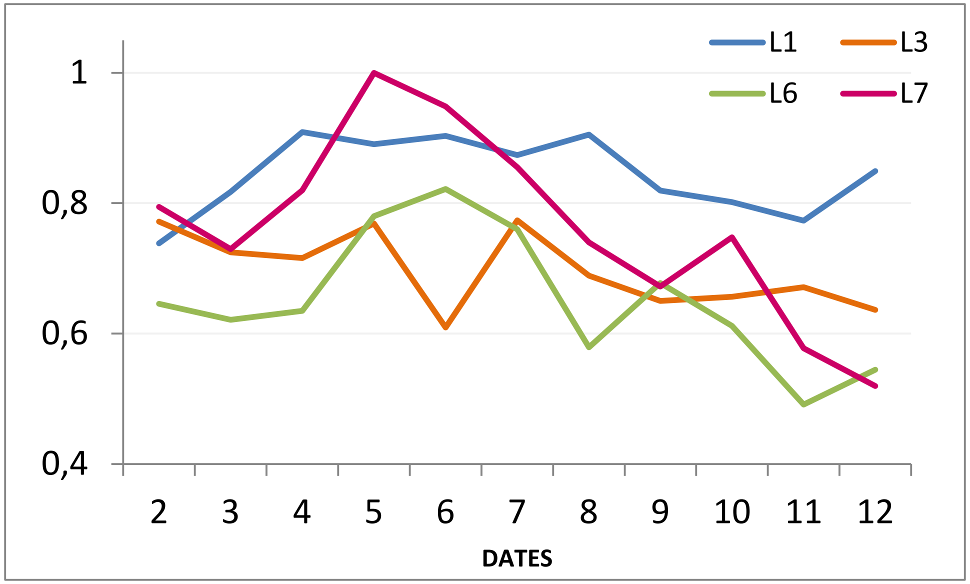




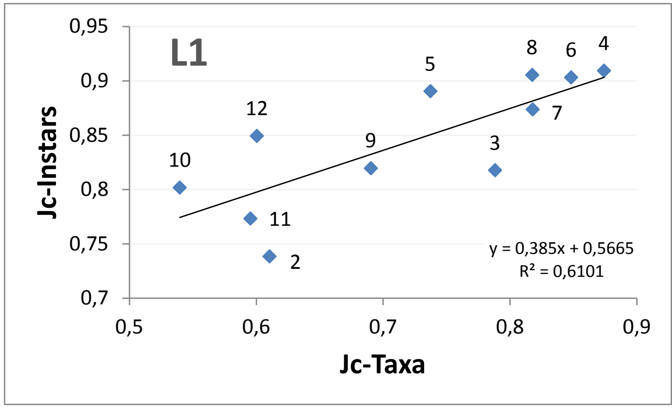


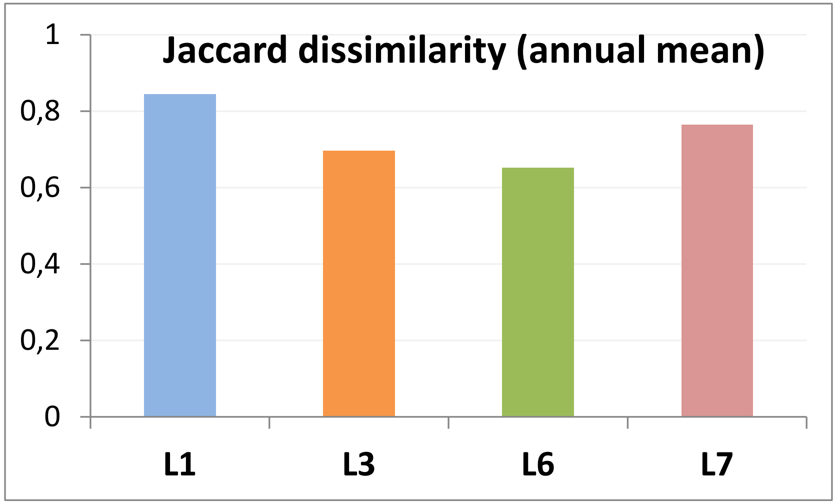
SEASONAL PATTERNS

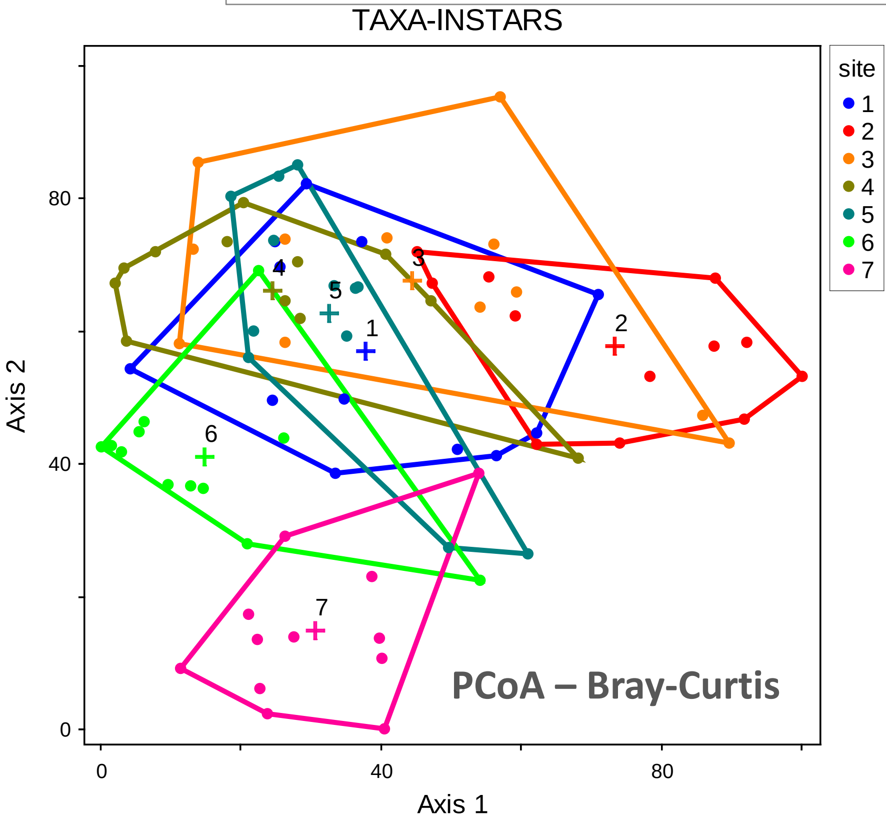
TAXONOMIC AND INSTAR DISTANCE AMONG DATES



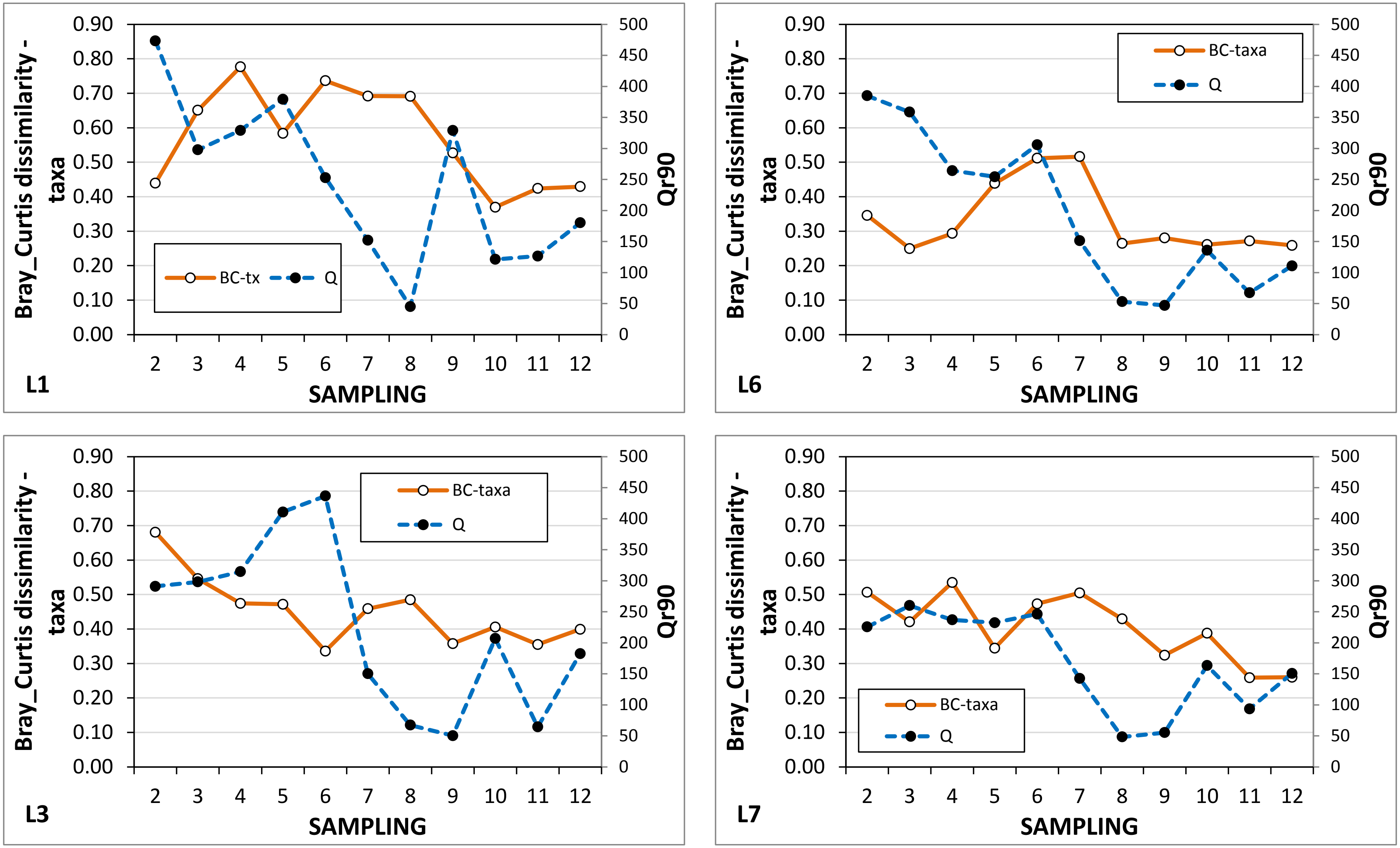
Temporal beta diversity



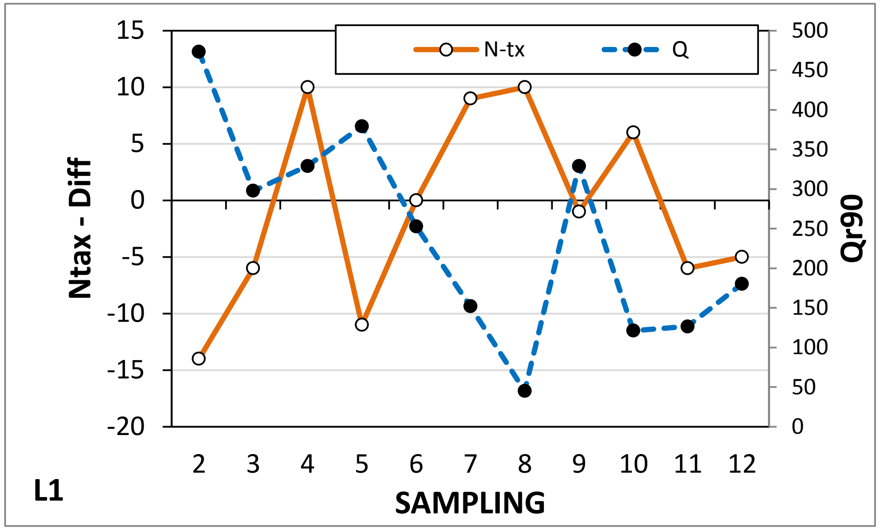


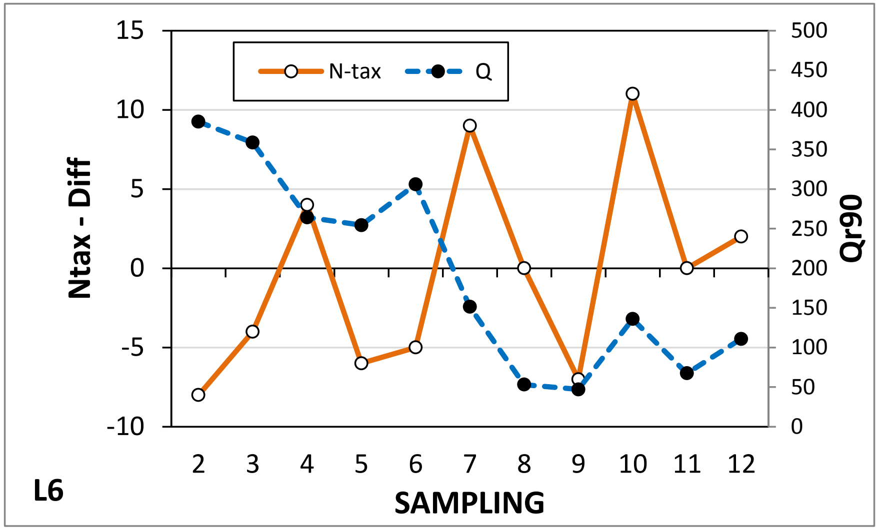


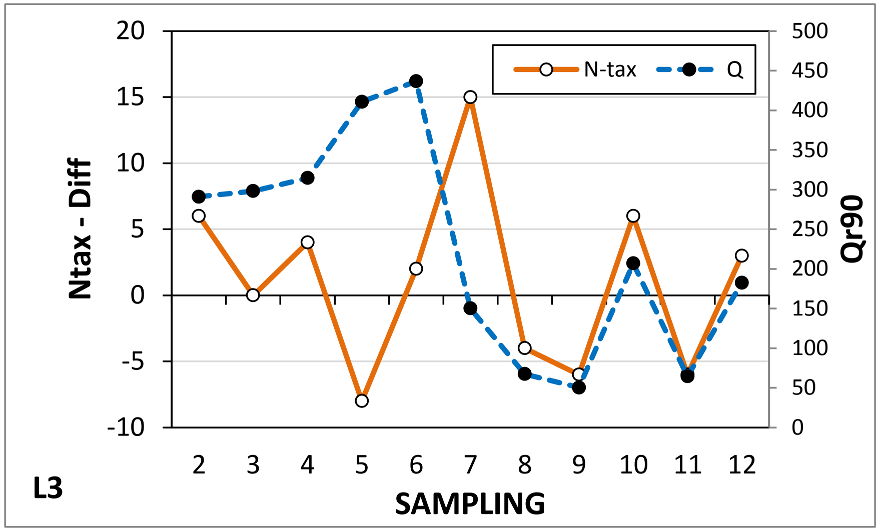
TEMPORAL DYNAMICS

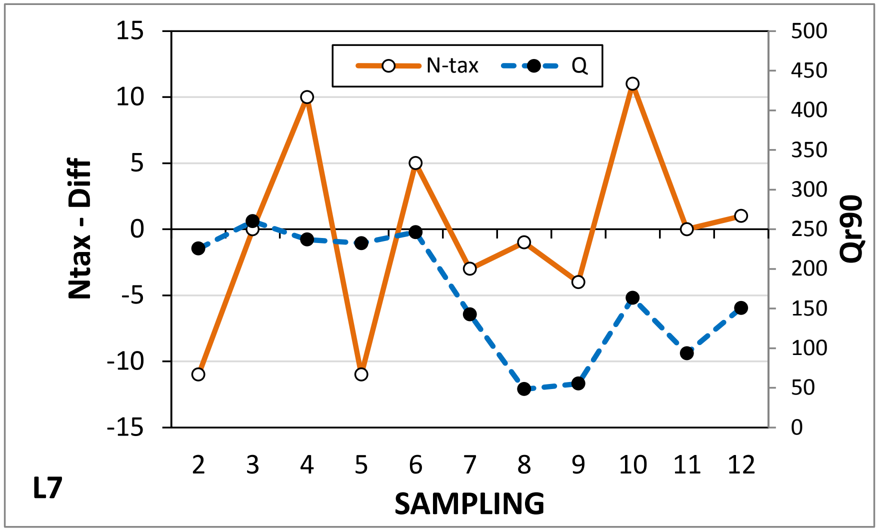


TEMPORAL DYNAMICS

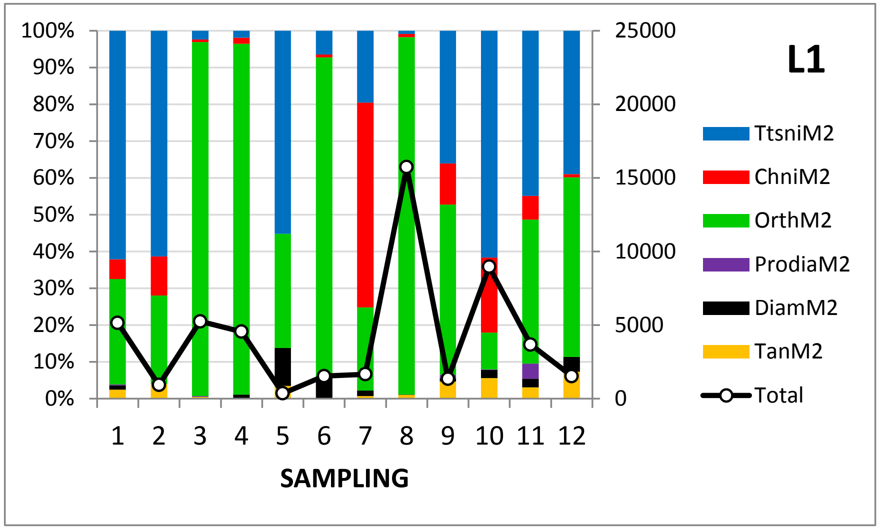


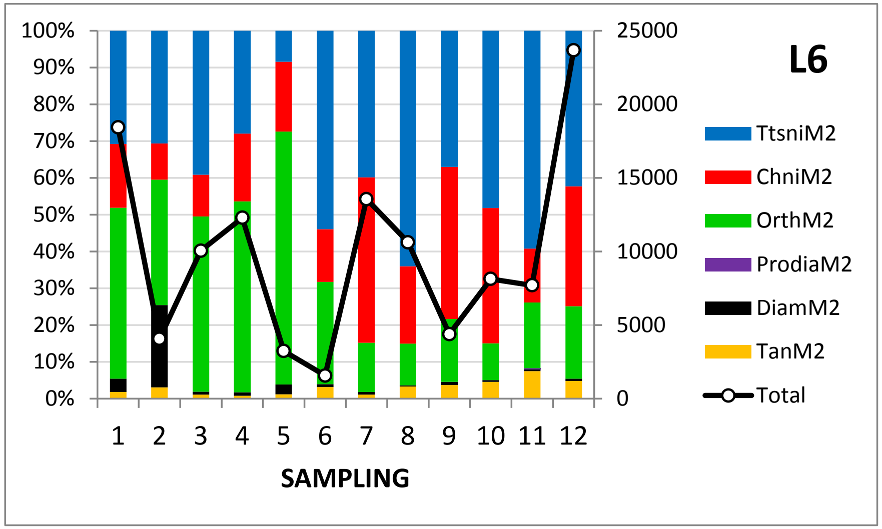


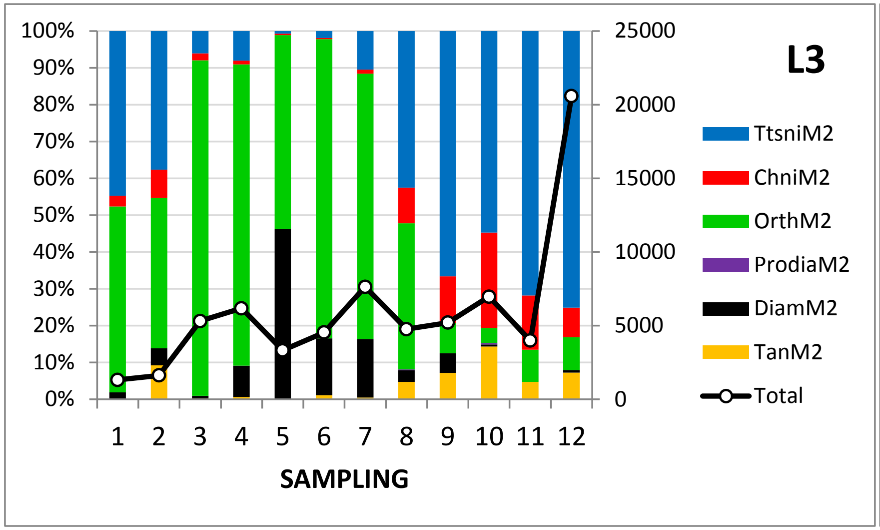


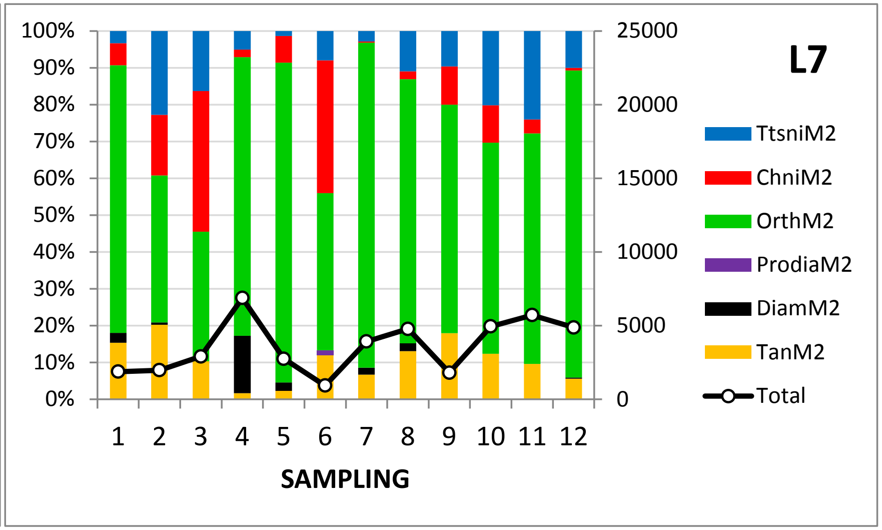


SUBFAMILIES

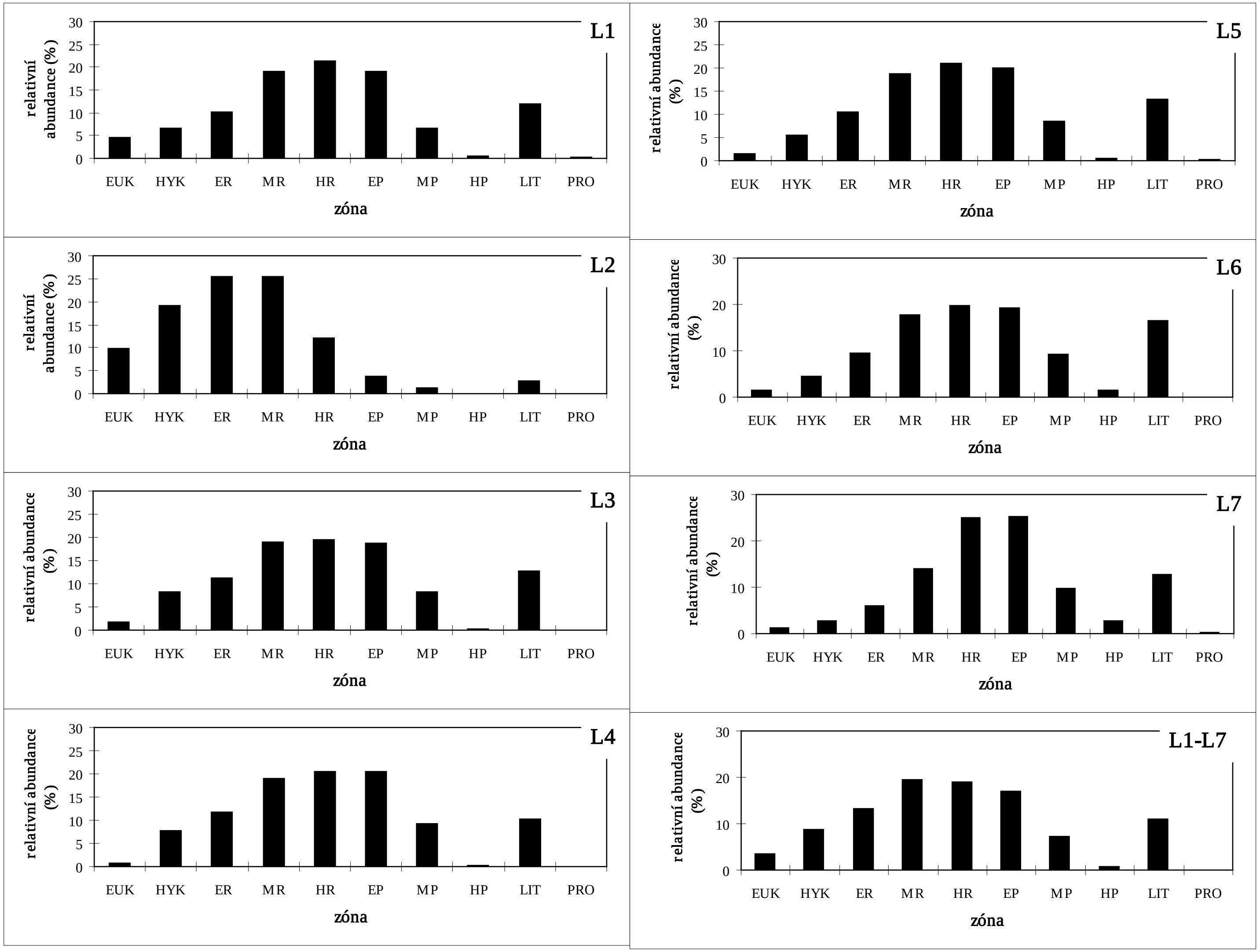




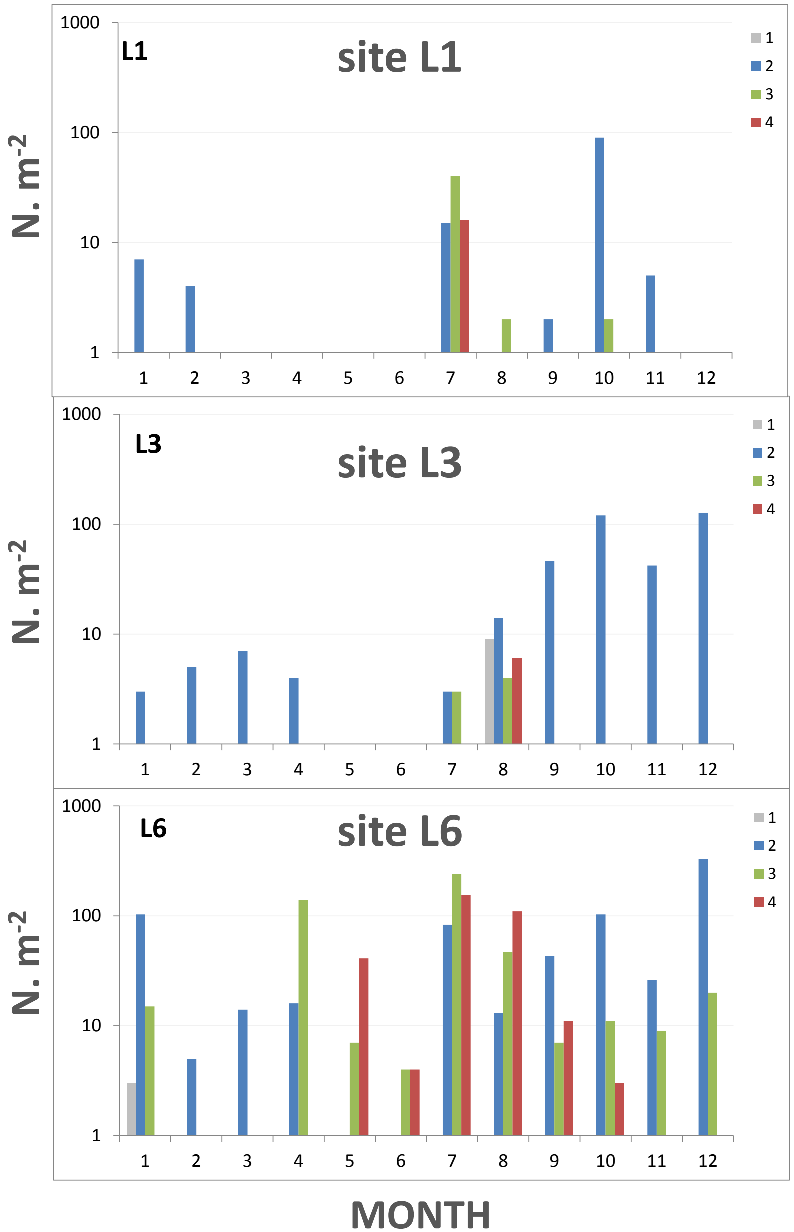




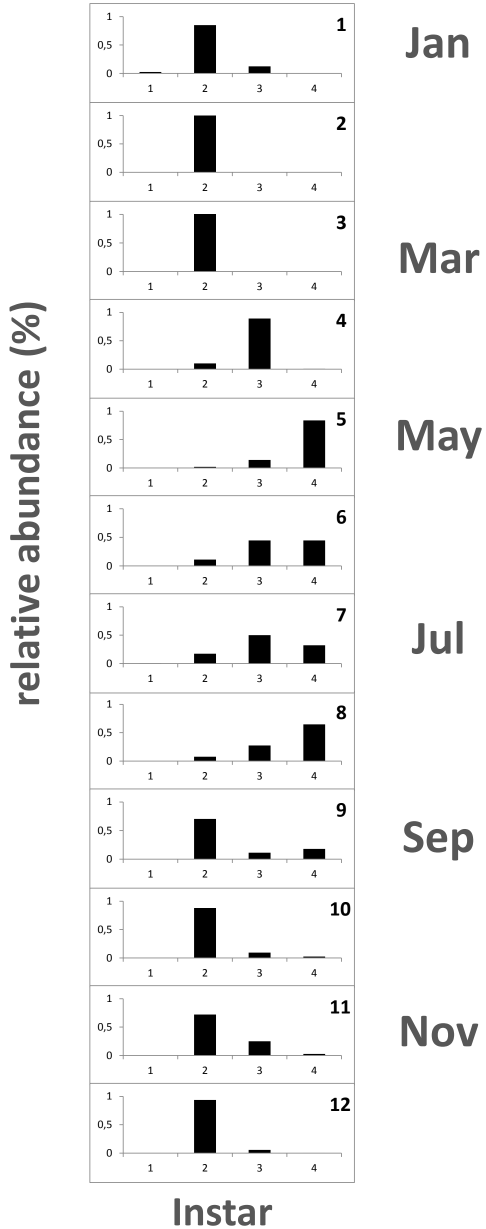
ZONAL CHARACTERISTICS OF CHIRONOMIDS



LIFE CYCLES – INSTARS (*Polypedilum gr. laetum*)



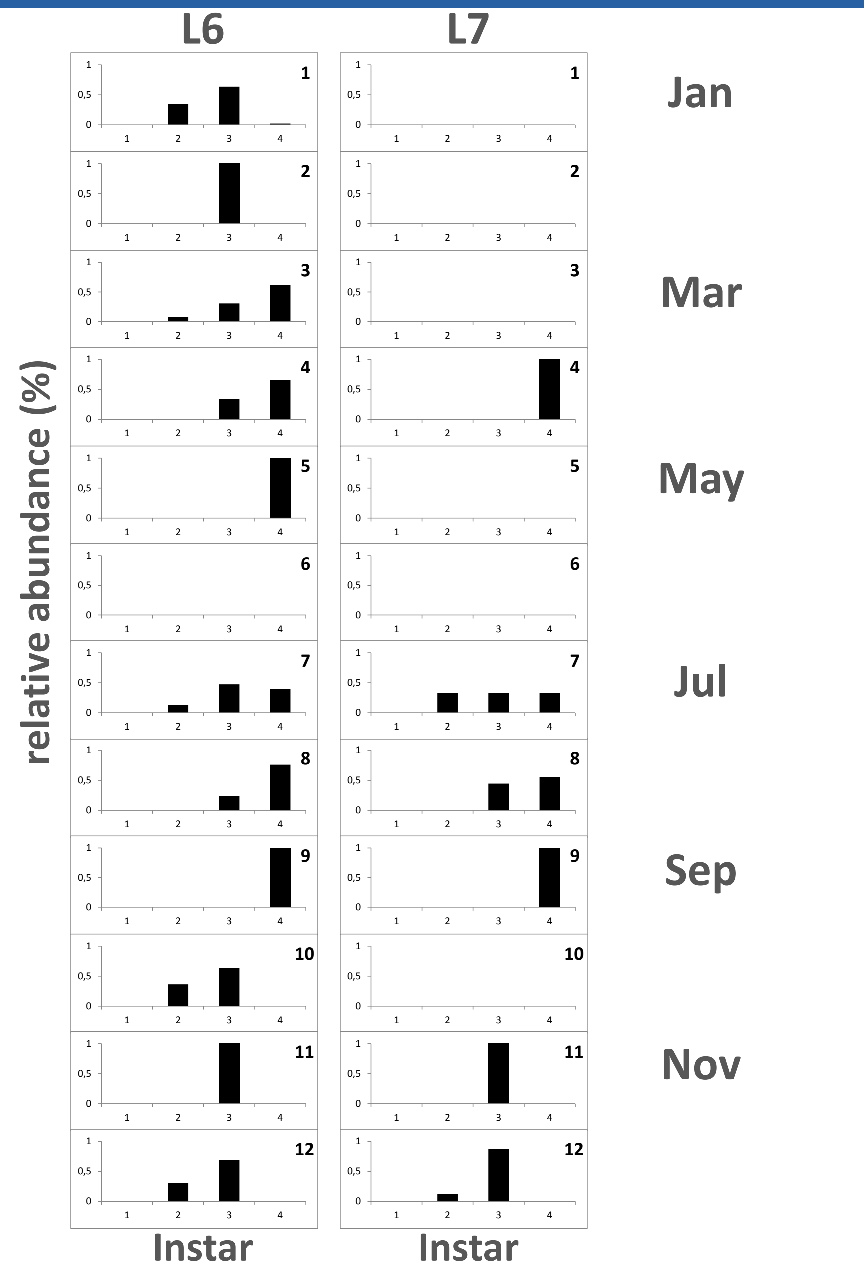
1 month delayed occurrence of 4th instar



LIFE CYCLES – INSTARS (*Parametriocnemus stylatus*)

Parametriocnemus stylatus

month/site	1	2	3	4	5	6	7	Sum
1				1	1	99		101
2			3			3		6
3					11	39		50
4		1	1	6	4	76	1	89
5					12	22		34
6				2				2
7			1		4	38	3	46
8				2		25	9	36
9				1	8	21	8	38
10	2					11		13
11	3			1	1	5	4	14
12			1	4		151	8	164
Sum	5	1	6	17	41	490	33	593



SUMMARY

- both reservoirs caused **deviation** in downstream chironomid taxa composition
- **thermal preferences**: decrease and higher variation below Vir Reservoir
- sites with **seasonally adjusted flow** regime (L3, L6) exhibited lower **temporal beta-diversity** (lower dissimilarity among dates)
- even though mesh size and monthly sampling **life cycles** of selected taxa were observed
- analyses of taxa with **distinguished instars** may provide tool for evaluation of thermally-oriented changes
- distinguishing of instars allows better linkages to stage-dependend **ecological traits and estimation of biomass**