evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Inovace studia hydrobiologických disciplín s důrazem na rozšíření možností uplatnění absolventů biologických oborů PřF UP v praxi.
reg. číslo: CZ.1.07/2.2.00/28.0173

Spring research

50 years after the definition of crenobiology

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MUSE Trento
Limnology and Phycology Research Unit- MUSE

universität innsbruck
Adjunct Prof
Univ. Innsbruck
Austria

What should you expect from this lecture?

Goal: To offer an overview of our current understanding of spring habitats, organisms, and systems.

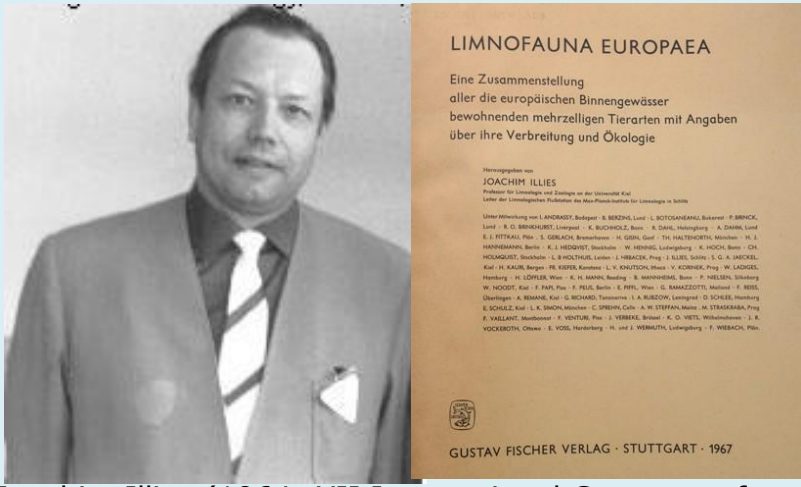
Structure of the talk:

- Crenobiology in present day Limnology.
- Spatial heterogeneity at different scales.
- Springs: Threatened habitats
- Springs as multiple ecotones
- Springs as biodiversity hotspots: species richness, Red List taxa
- Biology and taxonomy of spring organisms. Most relevant environmental determinants of assemblages.
- **Some interesting and promising topics in spring-habitat research**
- Apllied issues & dissemination
- Closing discussion

Development of crenobiology

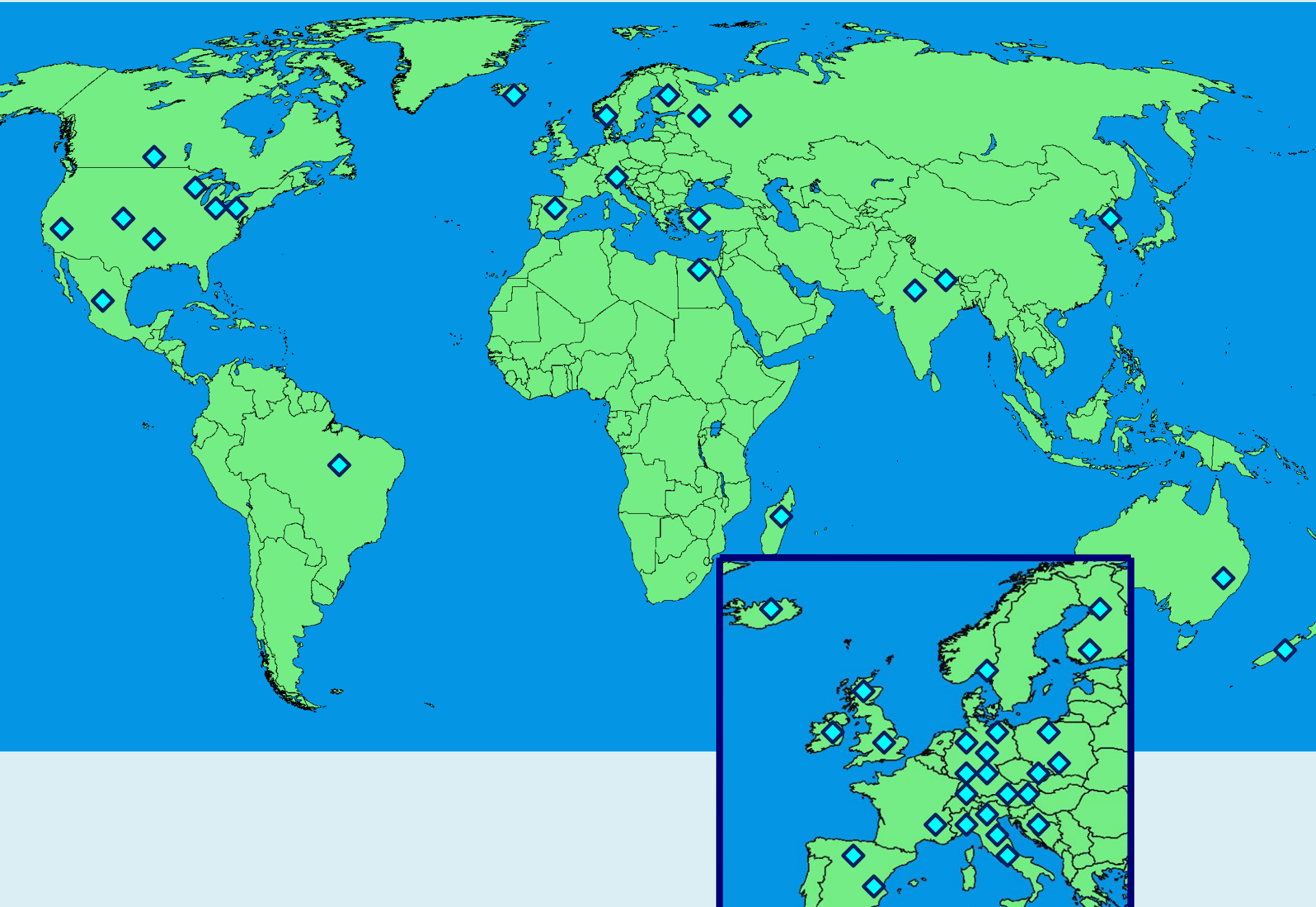
Illies, J., and L. **Botosaneanu**. 1963. **Problèmes et méthodes de la classification et de la zonation écologique des eaux courantes, considérées surtout du point de vue faunistique**. *S.I.L., Mitteilung* **12**: 1-57.

Joachim Illies (1925-1982). Biology Univ. Göttingen and Kiel, student of Prof. August Thienemann. Honorary Prof. Zoology Univ. Gießen. Co-founder (1951) of the „Fuldastation der Limnologischen Fluss-Station Freudenthal" in Schlitz, later leader of the river-station of the Max-Planck-Society (closed in 2006 with the retirement of his successor Prof. P. Zwick). Specialist of Plecoptera and Ephemeroptera, increasing also of general limnology, e.g. river zonation, editor of the „Limnofauna europaea" (1967).

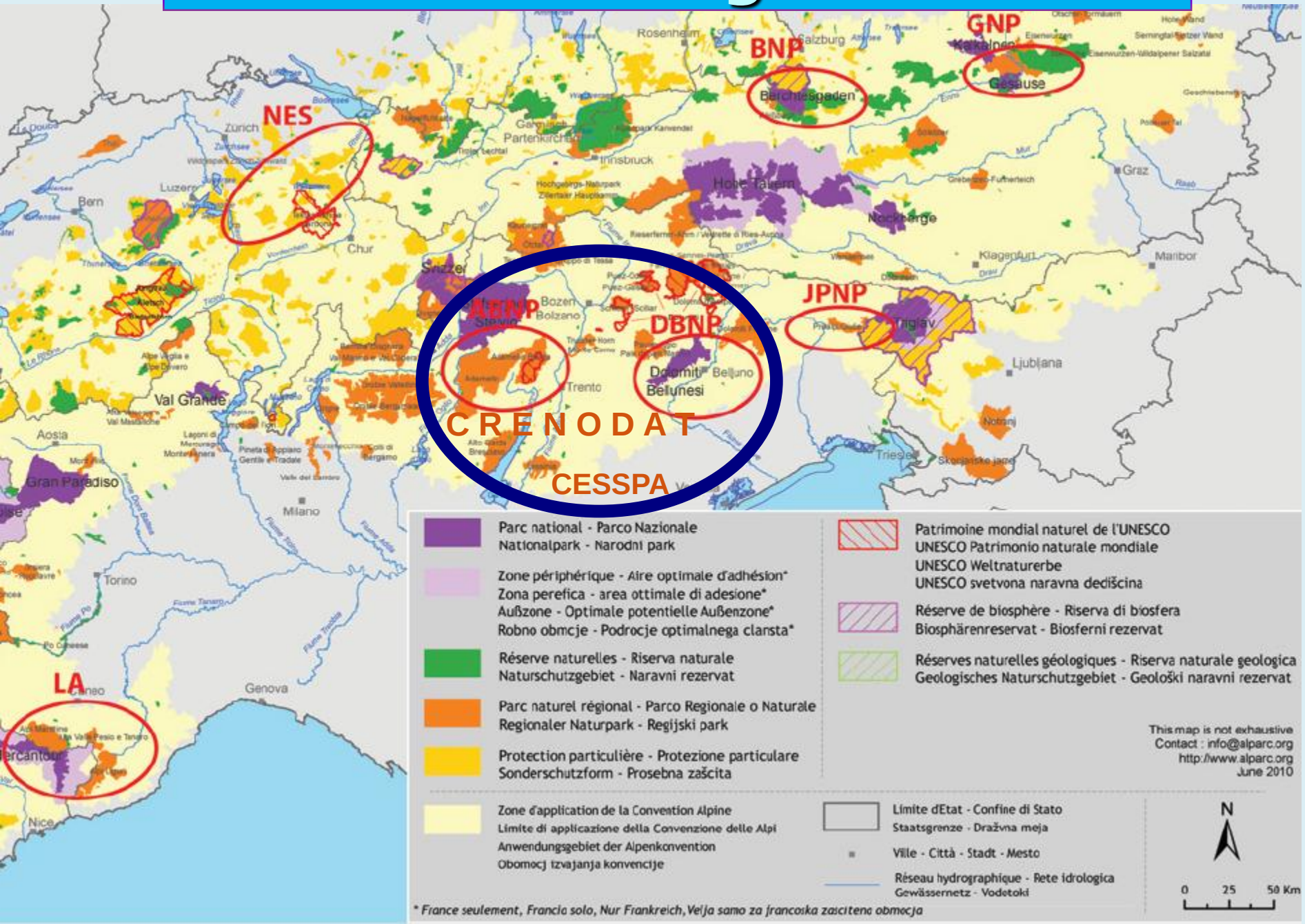


Joachim Illies (1964: XII International Congress of Entomology, London picture presented by nhm.ku.edu "photo album of Entomologists")

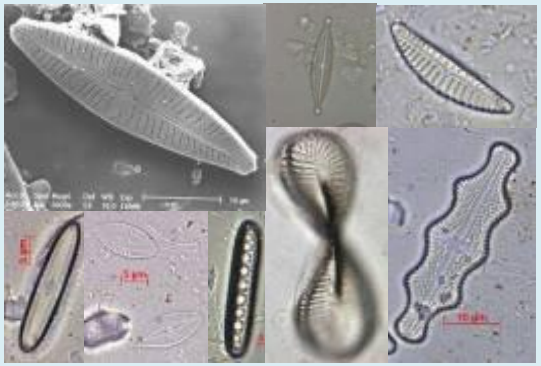
Lazare Botosaneanu (1927-2012). First publication -about a new caddisfly species– at the age of 20. Researcher at the Institute of Speleology of the Rumanian Acad. Sc. As an opponent of the Ceaușescu regime, he was dismissed from the Institute and had to leave Romania in 1978. Prof. J. Stock managed to get him appointed at a position established for political refugees at the Univ. Amsterdam (Zoological Museum).



MC: Crenobiological studies

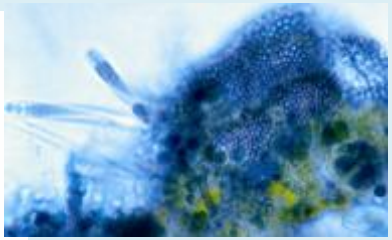


CRENODAT: Broad spring biodiversity study



DIATOMS (M. Cantonati, H. Lange-Bertalot E. Bertuzzi & N. Angeli, Trentino Nature & Science Museum and University of Frankfurt)

OTHER ALGAE (M. Cantonati, E. Rott, N. Angeli & E. Bertuzzi)



CYANOBACTERIA (M. Cantonati, J. Komarek, N. Angeli, E. Bertuzzi & E. Rott)

BRYOPHYTHES AND VASCULAR PLANTS **(D. Spitale, A. Petraglia & M. Tomaselli**, Trentino Nature & Science Museum and University of Parma)

OSTRACODA
G. Rossetti
Univ. Parma

AQUATIC LICHENS (J. Nascimbene, Un. Padua)

COPEPODA
F. Stoch
Univ. L'Aquila

PROTOZOA (M. Lazzara, F. Dini, G. Di Giuseppe) - Univ. Pisa & Trentino Nature & Science Museum

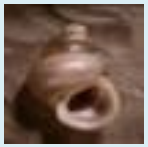
OLIGOCHAETA
B. Sambugar
Museo di St. Nat. Verona

NEMATODA
F. Gatti &. **A. Zullini**
Univ. di Milano Bicocca

VERTEBRATES
M. Menegon
Museo Tridentino di Scienze Naturali - Vertebrate Zoology Section

HYDRACARINA
R. Gerecke
Univ. Tübingen Germany

EPHEMEROPTERA, TRICHOPTERA, PLECOPETERA, COLEOPTERA & DIPTERA
B. Maiolini ,V. Lencioni, L. Marziali
Museo Tridentino di Scienze Naturali – Hydrobiology and Invertebrate Zoology Sect.

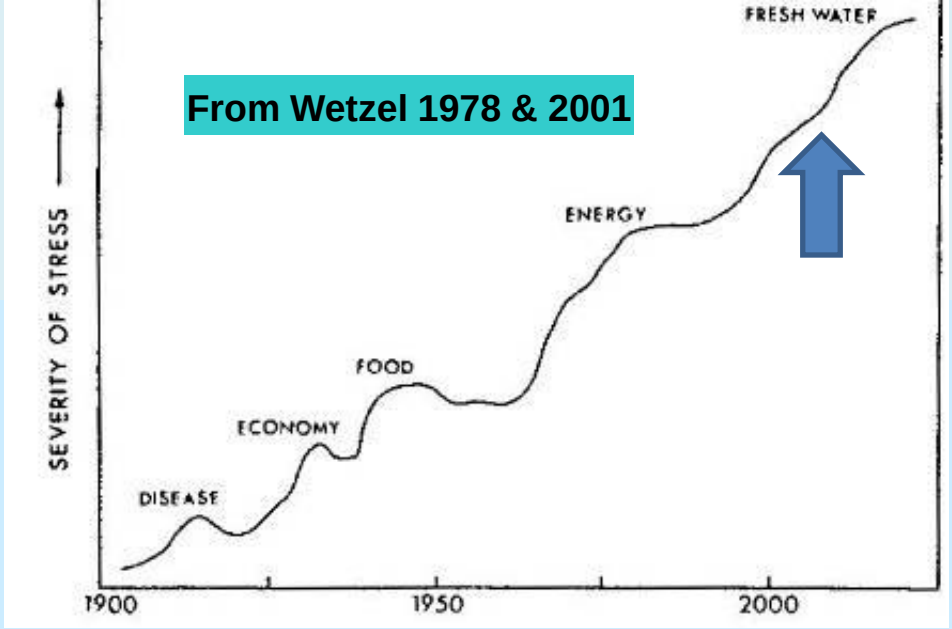


MOLLUSCA
C. Dalfreddo
Feltre

From the Alps to the Apennines…

The EBERs Project - EBERs (*Exploring the Biodiversity of Emilia-Romagna springs*) is a three-years-lasting (2011-2013) Project fostered and funded by the Geological Survey of the Emilia-Romagna Region. Its main goal is an exploratory investigation on the biota of selected springs of the Emilia-Romagna Region with a multidisciplinary approach.

Spring research & Leading topics in Limnology



- The **water crisis**

The water crisis & ecosystem functions,

& **freshwater biodiversity**

- Effects of **climate** and **environmental change** on freshwater ecosystems

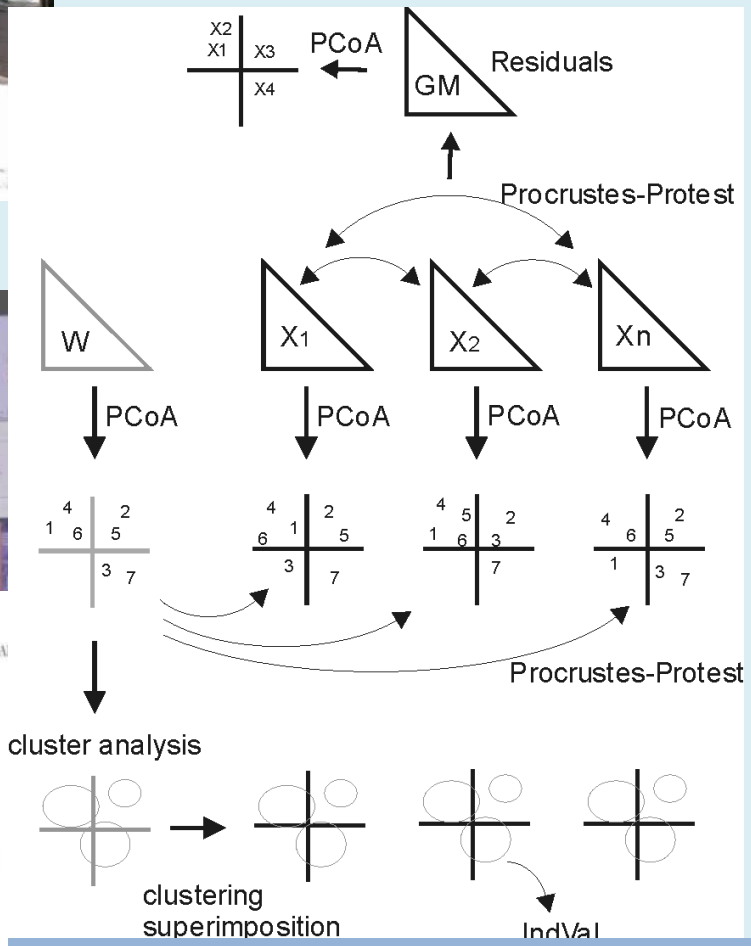
Global warming, eutrophication, acidification, diffuse airborne pollution, increased N deposition, increased incident UV radiation

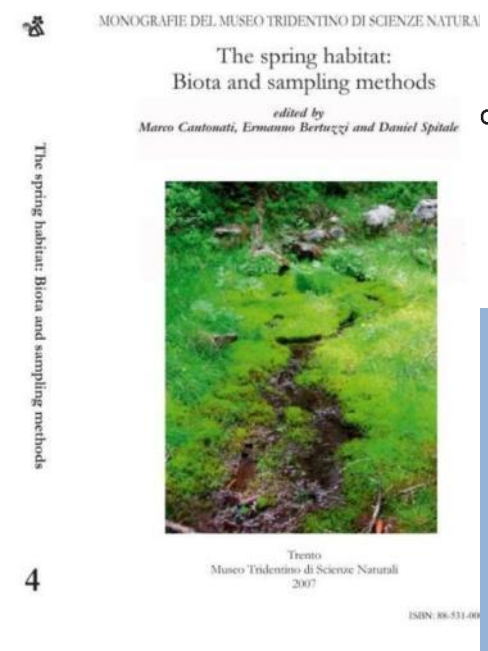
- A "LIMPACS approach" to environmental-change research:

Paleolimnology – long-term data series (ILTER) – present day assessment and surveys – modelling

- Macroecology
- Polyphasic approaches to the characterization of freshwater organisms
- Ecohydrological perspective

METHODS





- In-depth environmental characterization
- Collections & databases
- New taxa: SEM, plastids, TEM, bio org. chem., genetics
- Statistical approaches (e.g., Fuzzy clustering, IndVal, CCA etc.)

From: Spitale D., Leira M., Angeli N. & Cantonati M. 2012. Environmental classification of springs of the Italian Alps and its consistency across multiple taxonomic groups. In: M. Cantonati, L. Füreder, I. Jüttner & E.J. Cox (Eds.), The Ecology of Springs. *Freshwater Science* **31**:563-574.

Springs are unique habitats

Species Richness

Richness of species for each taxonomical group in 84 springs. Presences are calculated as percentage of springs in which that group was present. In brackets is the number of times a group was present on a total of 84 springs.

Environmental classification of springs of the Italian Alps and its consistency across multiple taxonomic groups

Daniel Spitale[1,3], Manel Leira[2,4], Nicola Angeli[1,5], AND Marco Cantonati[1,6]

Freshwater Science, 2012, 31(2):563–574

DOI: 10.1899/10-038.1
Published online: 8 May 2012

	richness	presences
diatoms	208	99% (82)
bryophytes	144	98% (81)
vascular pl.	174	94% (78)
Nematodes	88	88% (73)
molluscs	48	53% (44)
oligochetes	47	66% (55)
water mites	65	76% (65)
copepods	27	94% (78)
ostracods	25	19% (16)
chironomids	103	98% (81)
stoneflies	38	93% (77)
caddisflies	46	87% (72)

High % of threatened Red-List species

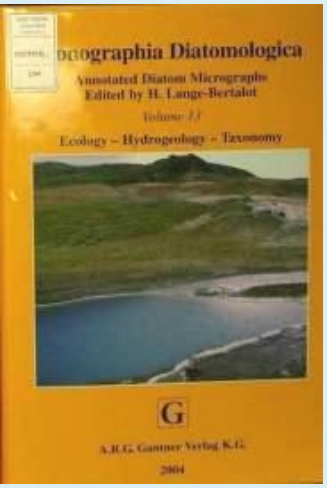
-(Danta-di-Cadore shallow mire pools: **72%**)
-Berchtesgaden National Park: **54%**
- Gesäuse National Park: **52%**
-Adamello-Brenta Natural Park: **48%**

close-to-pristine, high integrity

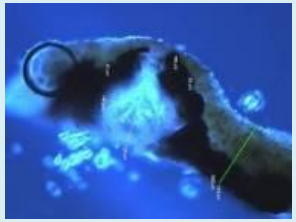
-Dolomiti Bellunesi National Park: **41%**
(incl. streams!)
-CRENODAT: **45%**
-Springs vicinities of Frankfurt (Ger.): **43%**
-Julian Pre-Alps Natural Park: **40%**
-Mountain springs Vorarlberg (Aust.): **38%**
-Western Carpathians Spring fens: **33%**
-Swiss pre-Alpine carb. Springs: **30%**
-CESSPA: **24%**
-French low-altitude carb. springs: **23%**
-Nitrate-affected carb. Spr. Bavaria: **8%**

From: Cantonati M., Füreder L., Gerecke R., Jüttner I. & Cox E.J. 2012. Crenic habitats, hotspots for freshwater biodiversity conservation: toward an understanding of their ecology. In: Cant. Füred., Jütt. & Cox (Eds.), The Ecology of Springs. *Freshwater Science* **31**:463-480.

Spring habitats as refugia



- In springs of mountain areas of central Germany Werum & Lange-Bertalot (2004) could find **52%** of the **total freshwater pennate diatom flora** of **Central Europe** (**646 taxa**).



- Single springs considered in the CRENODAT Project hosted a low number of species, while at **regional level** the **entire pool of investigated springs** hosted a **relevant aquatic lichen flora**.

- Botosaneanu (1995): geographic relicts = in areas heavily impacted by human activities springs can be the last freshwater habitats where species with high environmental requirements can still survive. Replaced by **least-impaired habitat relicts** by Cantonati *et al.* (2012; *Freshwater Science*).

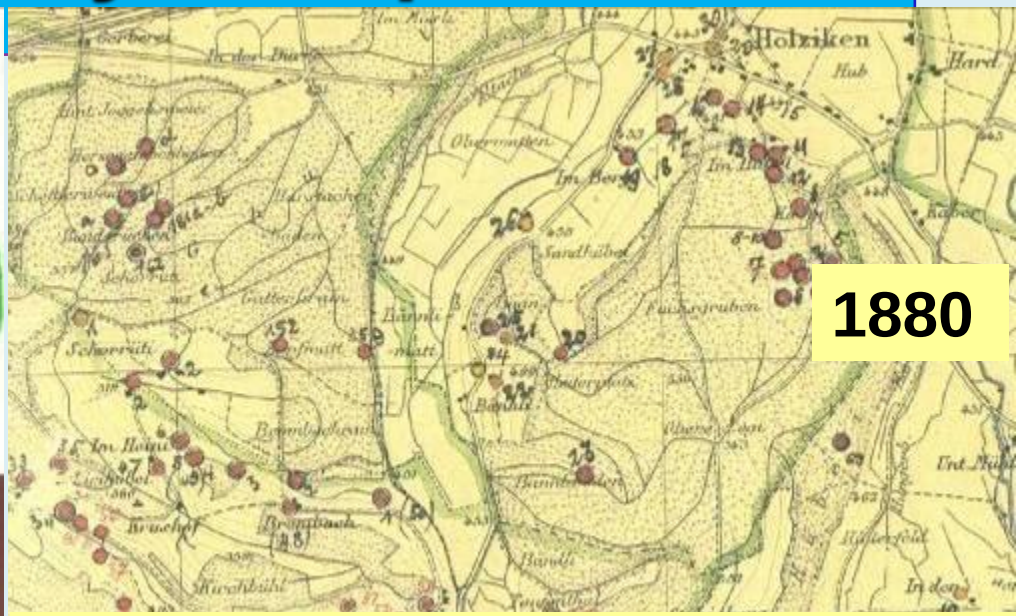
Springs ecosystem services

Springs: A History of exploitation

Quellen
die unbekannten Biotope:
erfassen, bewerten,
schützen

Jens M. Zollhöfer

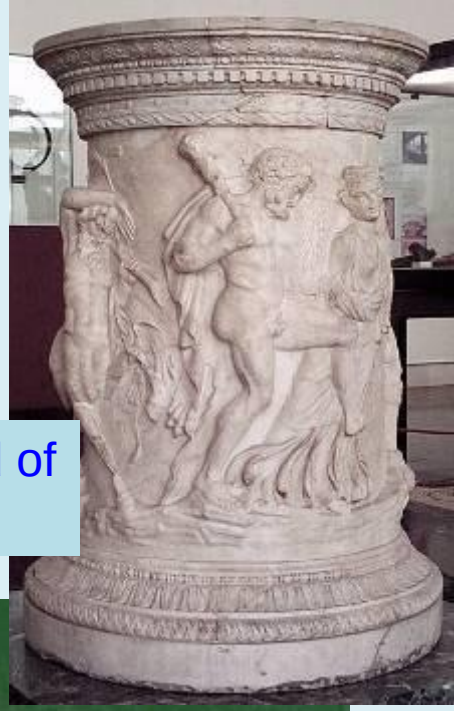
Bristol-Stiftung
Ruth und Herbert Uhl-Forschungsstelle
für Natur- und Umweltschutz



***Quellkataster* Kanton Aargau, Switzeland**

Hydrological maps in the Swiss *Mittelland*. **1880**: more than **75%** of the springs affected by water abstractions and transformation into wells; **1990**: **95%** affected.

Mythology
Biophilia
Environmental psychology



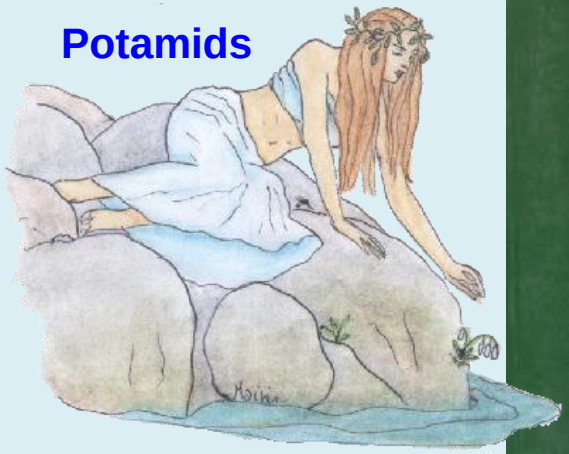
Fons: Roman God of springs and wells

Naiads

Creneids

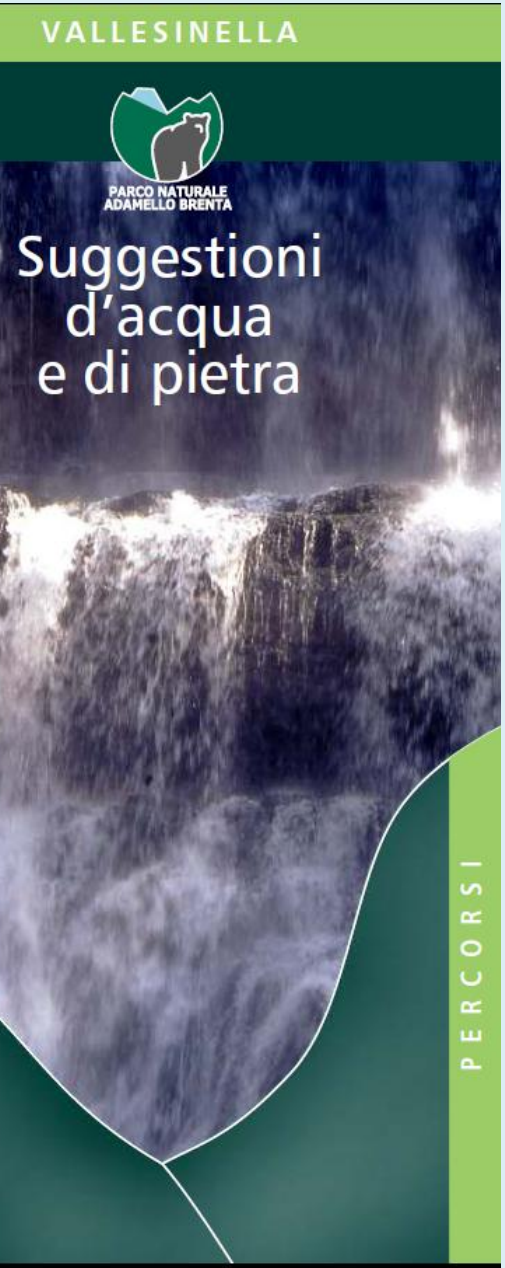
Limniads

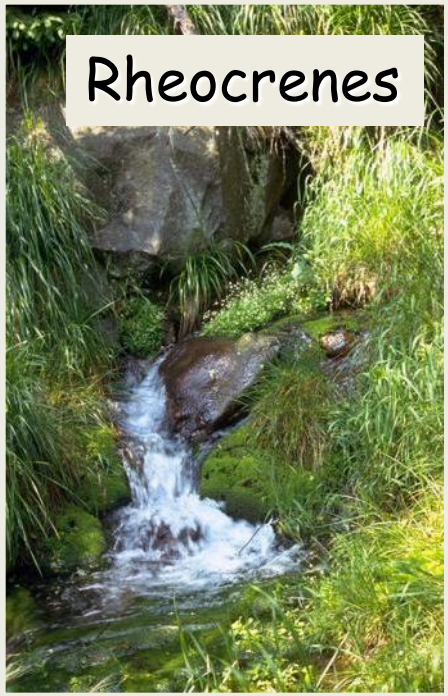
Potamids

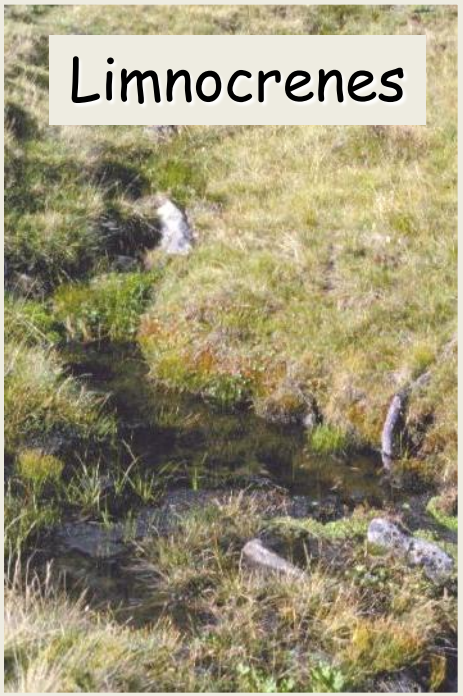


Spatial heterogeneity at different scales

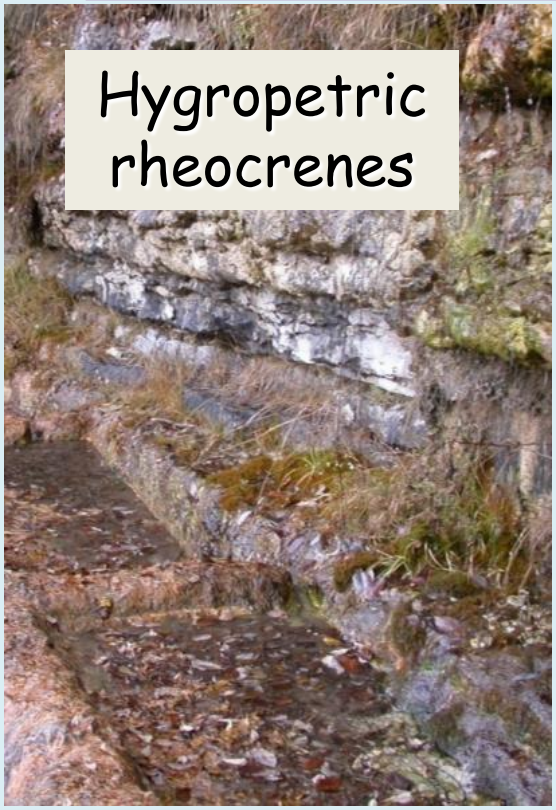
Springs: What do they look like. Types.



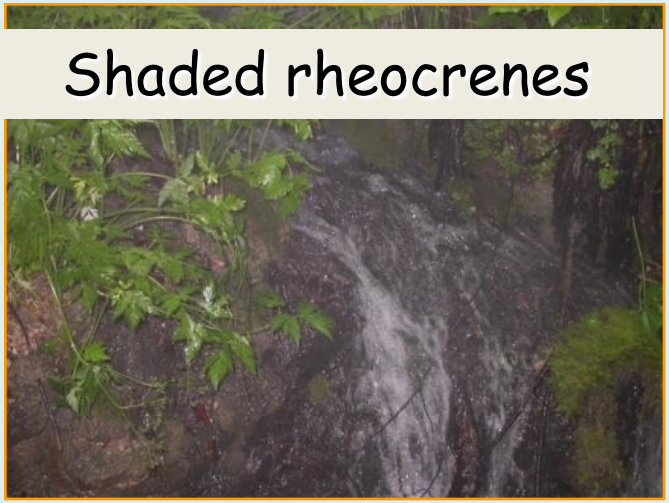




Springs: Types, and variety of situations



Large karstic carbonate rheocrenes



The EBERs springs: Ecomorphology (I)

Low conductivity seepage (1): Elo_L_S

Low cond. flow. spr. (2): Cap_L_S, Font_Ve

Hygropetric (1): Ciap_Li

Shaded flow. spr. with *Hild.* (4): Mt_Nero

Shaded flow. spr., high pH (1): Prinzer

Shaded flow. spr., med. cond. (1): Barigaz

The EBERs springs: Ecomorphology (II)

SAL springs (2 + 1 spring stream):
Labante, Caramet, Tor_Ooc

- small, near-natural:

- large, exploited:

Pool springs (2):
F_VR_Su, F_VR_Sh

- sun-exposed:

- shaded:

Mineral springs (2):
Ges_Rio, PoianoS

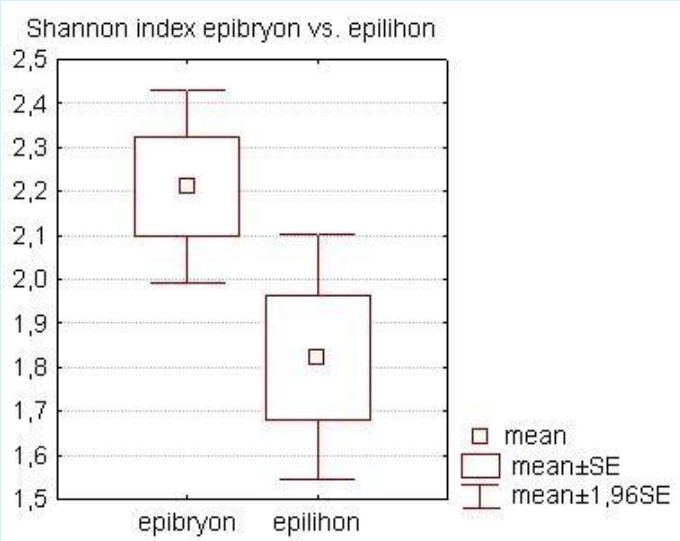
- sodium, chloride:

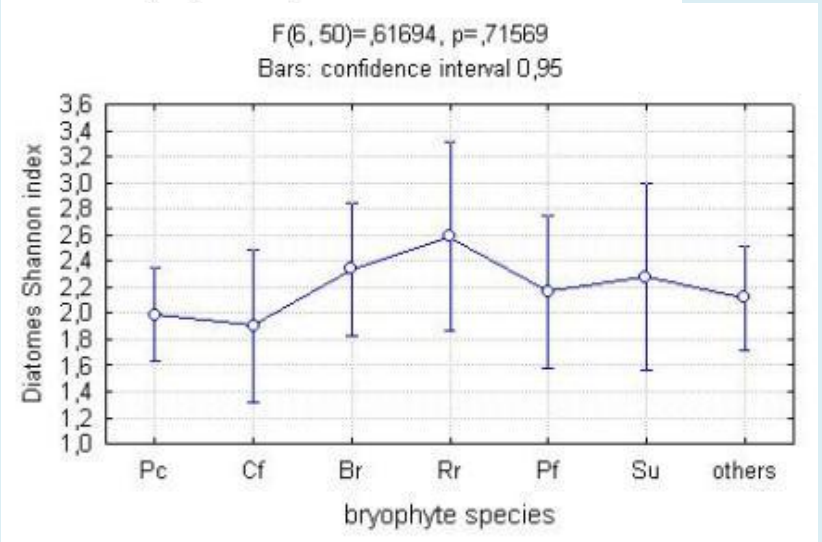
- sulphates:

Diatoms: Substratum preferences (CRENODAT)

bryophythes	P indval
Achnanthidium dolomiticum Cantonati et Lange-Bertalot	0,077
Adlafia bryophila (Petersen) Lange-Bertalot	0,001
Caloneis fontinalis (Grunow) Lange-Bertalot et Reichardt	0,001
Caloneis tenuis (Gregory) Krammer	0,001
Cymbopleura austriaca (Grunow) Krammer	0,012
Diploneis krammeri Lange-Bertalot et Reichardt	0,027
Encyonopsis cesatii (Rabenhorst) Krammer	0,003
Encyonopsis falaisensis (Grunow) Krammer	0,001
Meridion circulare (Greville) C. Agardh	0,020
Navicula cryptotenella Lange-Bertalot	0,010
Navicula leistikowii Lange-Bertalot	0,001
Adlafia minuscula (Grunow) Lange-Bertalot	0,001
Nitzschia hantzschiana Rabenhorst	0,006
Planothidium lanceolatum (Brébisson) Lange-Bertalot	0,005
stones (= cobbles + small boulders)	
Achnanthidium pyrenaicum (Hustedt) Kobayasi	0,011
Achnanthidium pfisteri Lange-Bertalot	0,013
Achnanthidium strictum Reichardt	0,001
Amphora pediculus (Kützing) Grunow	0,032
Cymbopleura naviculiformis (Auerswald) Krammer	0,002
Gomphonema elegantissimum Reichardt et Lange-Bertalot	0,001
Nitzschia fonticola Grunow	0,036
Reimeria sinuata (Gregory) Kociolek et Stoermer	0,007

…but Cantonati & Spitale (2009, *FAL*) showed (variance partitioning) that:
-**environmental vars**: **40%**
-**type of substrata** (st. vs. bryoph.) **3%**).





REISS, M. 2011. Substratpräferenz und Mikrohabitat-Fauna-Beziehung im Eukrenal von Quellgewässern. PhD Dissertation am Fachbereich Geographie der Philipps-Universität Marburg, Marburg, Germany.

Springs as multiple ecotones

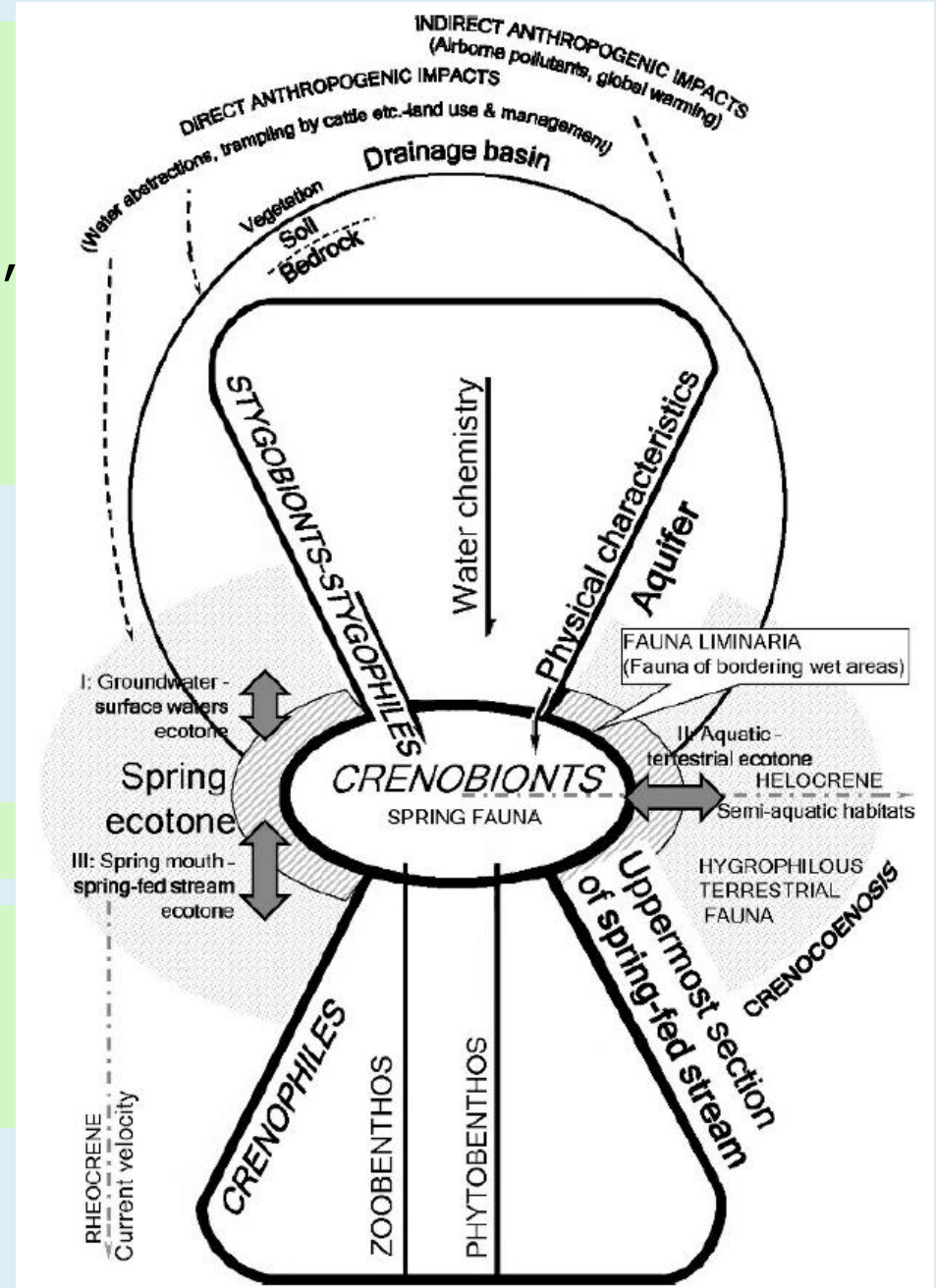
Springs: Some theoretical background

Variety of environmental situations: Flow permanence, shading, nutrient status, presence of humic acids etc.

Main drainage point of a subterranean hydrografic system.

Multiple ecotones

Natural constant temperature laboratories (Odum 1963)



Freshwater Science, 2012, 31(2):463–480
© 2012 by The Society for Freshwater Science
DOI: 10.1899/11-111.1
Published online: 17 April 2012

Crenic habitats, hotspots for freshwater biodiversity conservation: toward an understanding of their ecology

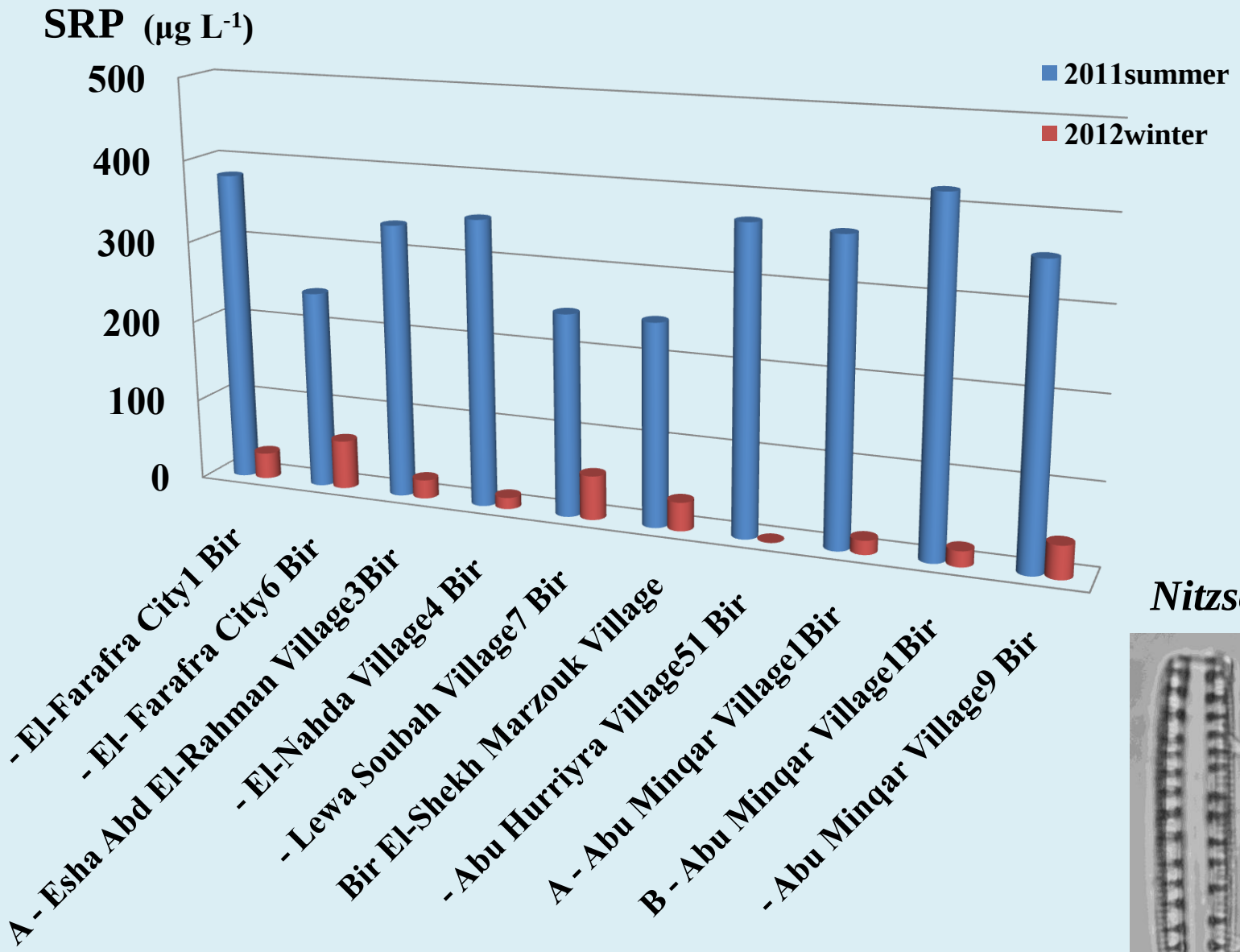
Marco Cantonati[1,6], Leopold Füreder[2,7], Reinhard Gerecke[3,8], Ingrid Jüttner[4,9], AND Eileen J. Cox[5,10]

Spring-habitats: from extremely-isolated to connected

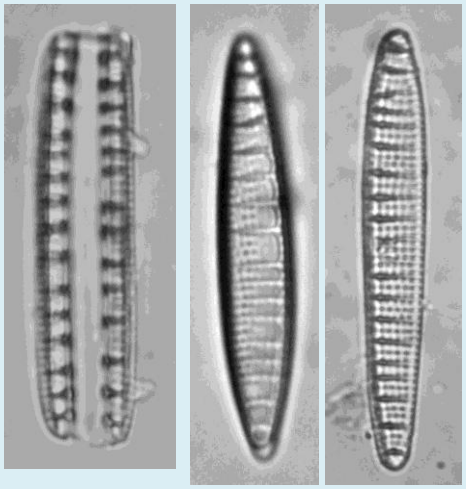
Abdullah A. SABER. Botany Department, Faculty of Science,
Ain Shams University, Cairo, **Egypt**


Bir NO. 1 B
Abu Mungar
7/9/2012

❖ Wells (called in arabic Bir):



Nitzschia denticula



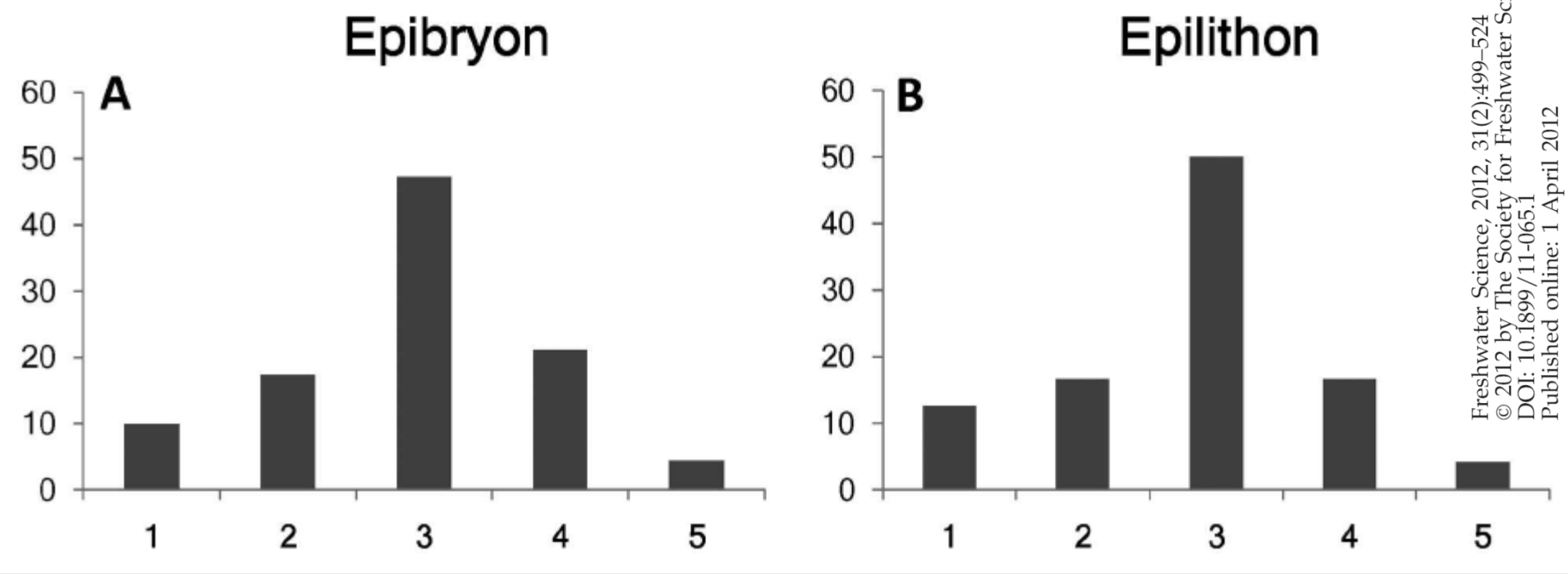
Disturbance in springs: Low or high?

• A study by **Scarsbrook et al. (2007)** supported the hypothesis that **flow permanence and variability** are the **primary determinants of invertebrate community patterns in springs**.

•The **relative importance of contemporary and historical processes** is a fundamental question in understanding patterns of biodiversity. **Rader et al. (2012)** tested the hypothesis that **history would account for the greatest variation in macroinvertebrate diversity in desert artesian springs** of The Bonneville Basin, U.S.A.

The '**expansion' hypothesis** suggests that the **youthful age** of a region (communities in a pre-equilibrial state, maximum carrying capacity not reached & niche space plentiful), combined with slow dispersal by a fauna dominated by generalists, **will maximize the imprint of history**. Consequently, the importance of niche-based processes may increase with time.

Diatoms in springs of the Alps: spring types, environmental determinants, and substratum



Freshwater Science, 2012, 31(2):499–524
© 2012 by The Society for Freshwater Science
DOI: 10.1899/11-065.1
Published online: 1 April 2012

FIG. 4. Percent diatom taxa on bryophytes (A, C, E) and on rocks (B, D, F) with known preference for specific moisture (A, B), pH (C, D), and trophic status (E, F) conditions in springs (van Dam et al. 1994). Moisture: 1 = never or only rarely occurring outside water bodies; 2 = mainly occurring in water bodies, sometimes on wet places; 3 = mainly occurring in water bodies, also on wet and moist places; 4 = mainly occurring on wet and moist or temporarily dry places; 5 = nearly exclusively occurring outside water bodies; 6 = unclassified. pH: acb = acidobiontic (pH < 5.5), acp = acidophilous (pH < 7), cn = circumneutral (pH

Marco Cantonati[1], Nicola Angeli[2], Ermanno Bertuzzi[3], AND Daniel Spitale[4]

Museo delle Scienze, Limnology and Phycology Section, Via Calepina 14, I-38122 Trento, Italy

Horst Lange-Bertalot[5]

Institute for Ecology, Evolution, Diversity, University of Frankfurt, Siesmayerstraße 70, and Senckenberg Research Institute, Senckenberganlage 31-33, D-60054 Frankfurt/M., Germany

Springs: Direct and indirect impacts

Paleolimnology in springs

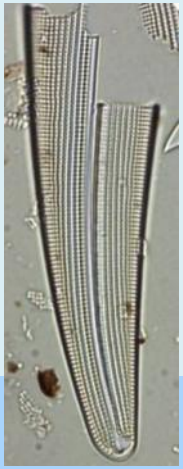
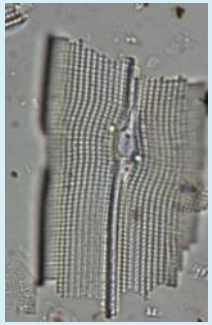
Is it possible to study palaeoenvironmental changes in Alpine spring habitats? A few examples from the south-eastern Alps (NE Italy)

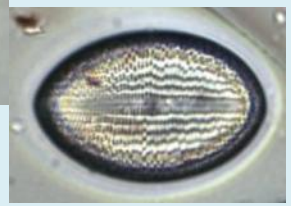
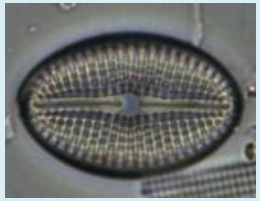
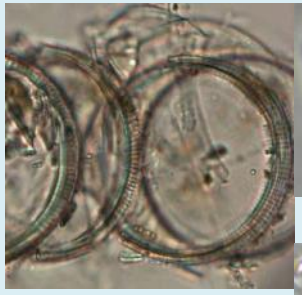
Maria Letizia FILIPPI*, Gayane PILIPOSIAN[1)], Laura MARZIALI[2)], Nicola ANGELI, Valeria LENCIONI and Marco CANTONATI

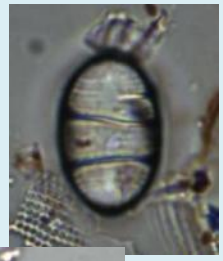
M. Cantonati, R. Gerecke, I. Jüttner and E.J. Cox (Guest Editors)
Springs: neglected key habitats for biodiversity conservation
J. Limnol., 70(Suppl. 1): 155-167, 2011 - DOI: 10.3274/JL11-70-S1-12

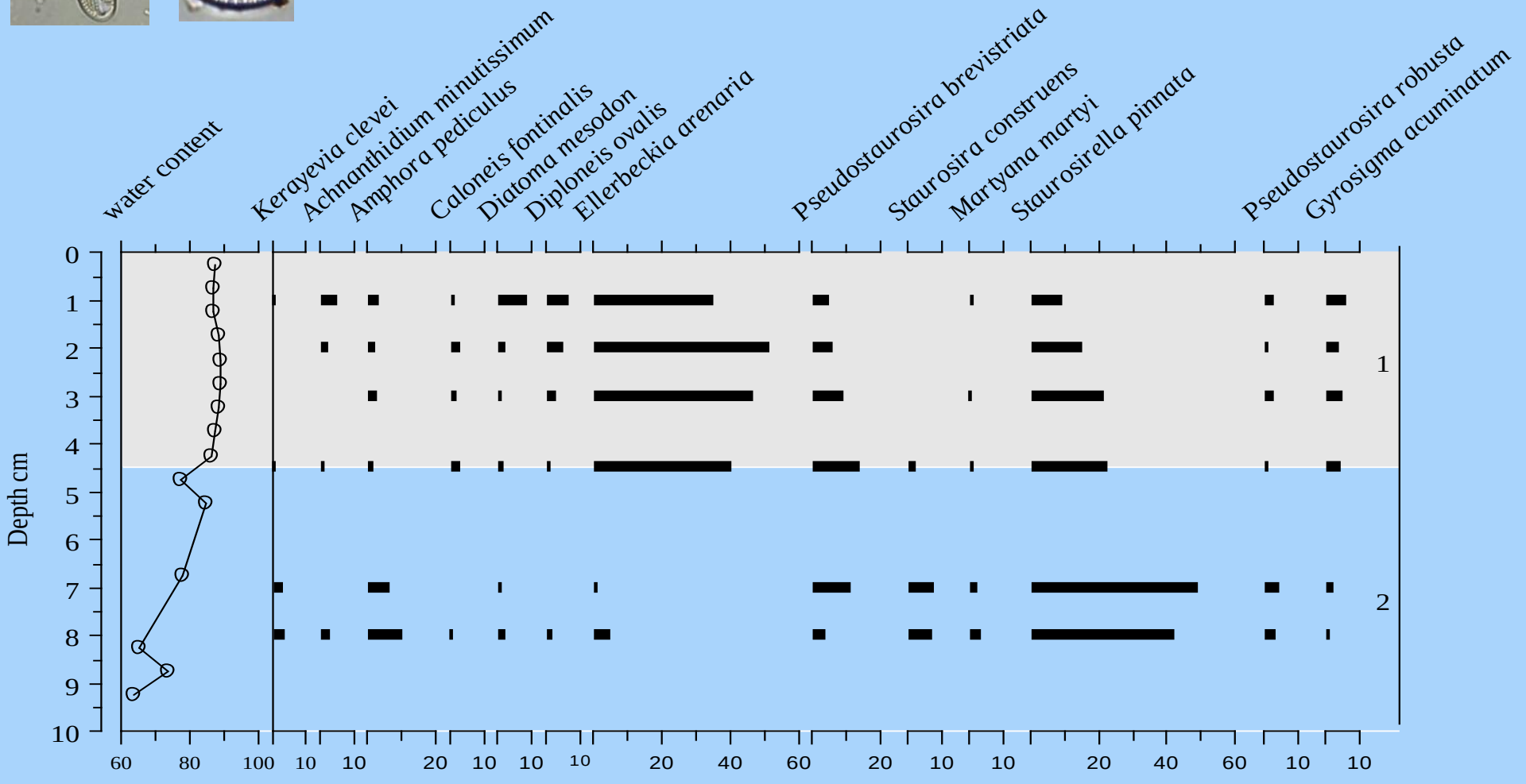
Madonnina Val Lomasona (503 m a.s.l., carbonate)

Diatoms

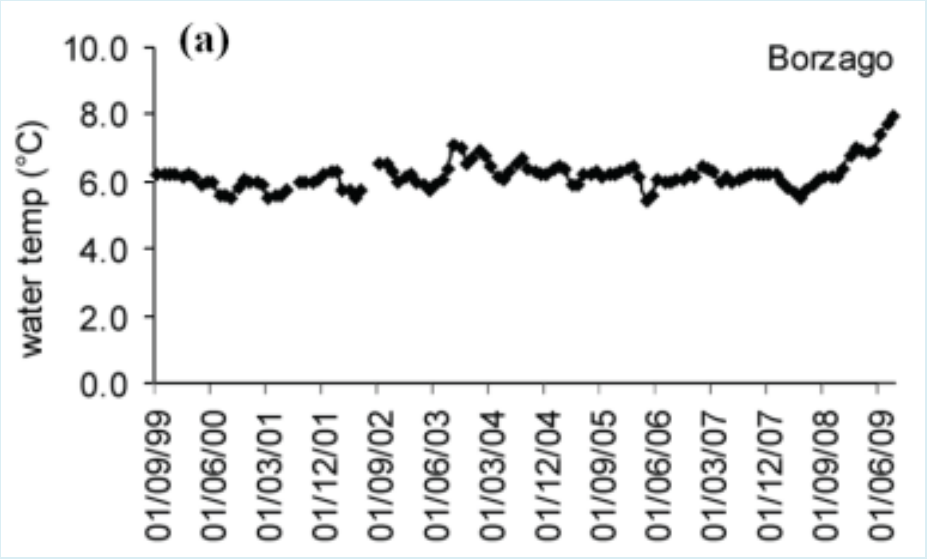



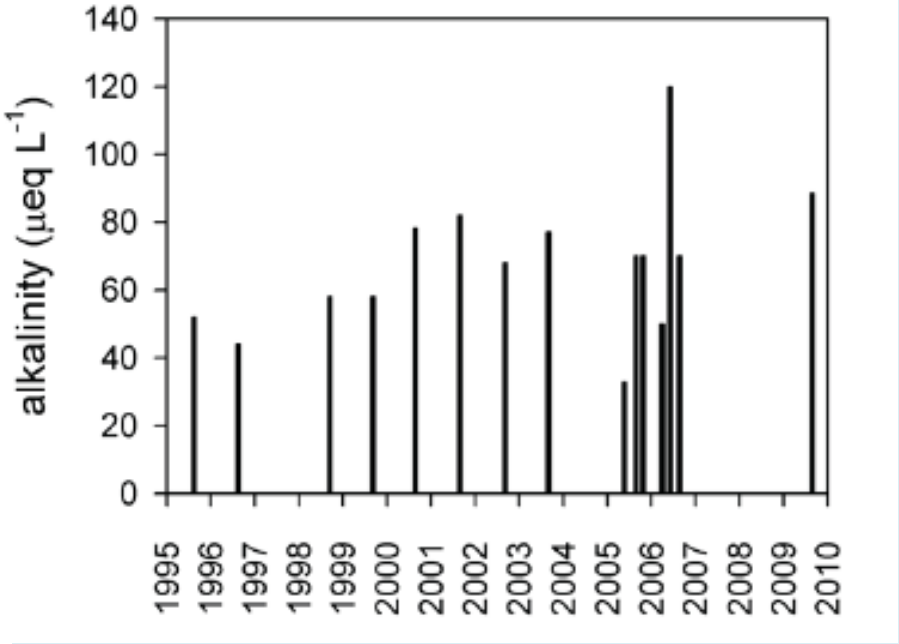




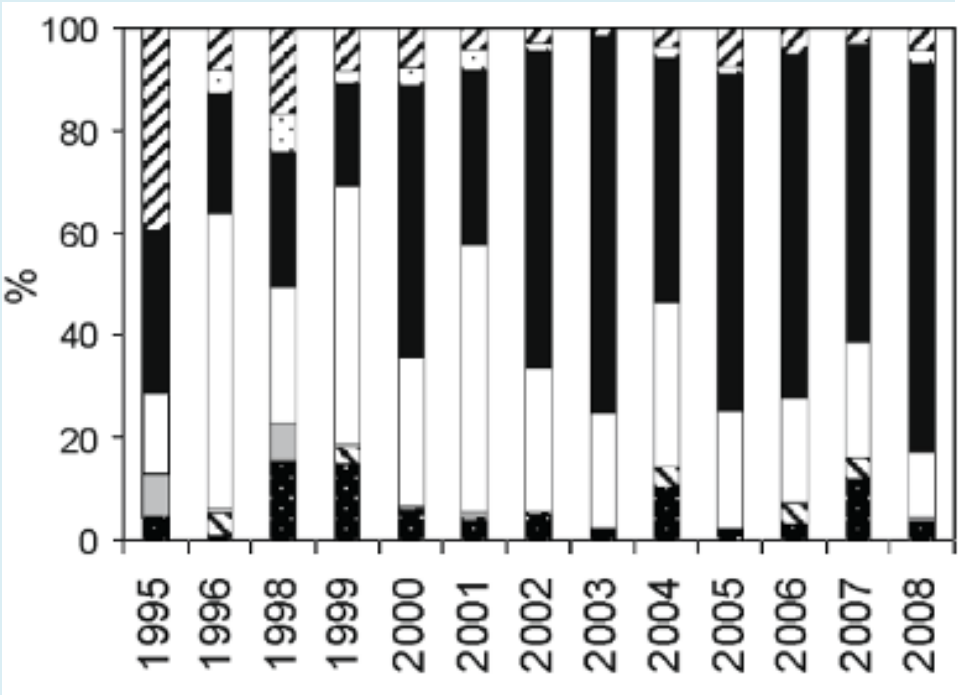



water content
Kerayevia clevei
Achnanthidium minutissimum
Amphora pediculus
Caloneis fontinalis
Diatoma mesodon
Diploneis ovalis
Ellerbeckia arenaria
Pseudostaurosira brevistriata
Staurosira construens
Martyana martyi
Staurosirella pinnata
Pseudostaurosira robusta
Gyrosigma acuminatum
Depth cm
0
1
2
3
4
5
6
7
8
9
10
1
2
60
80
100
10
10
20
10
10
10
20
40
60
20
10
10
20
40
60
10
10

Long-term monitoring of hypersensitive systems





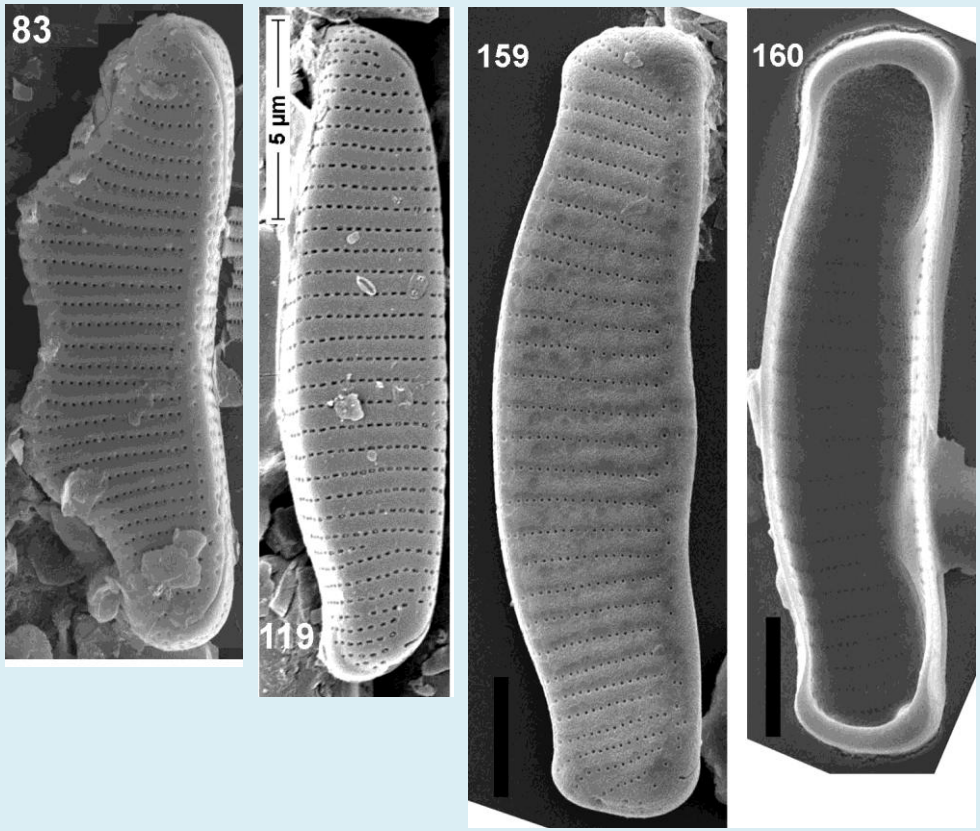


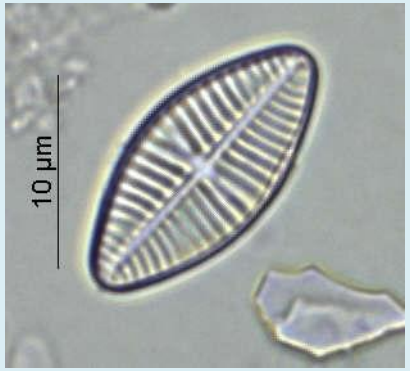
The challenges of long-term ecological research in springs in the northern and southern Alps: indicator groups, habitat diversity, and medium-term change

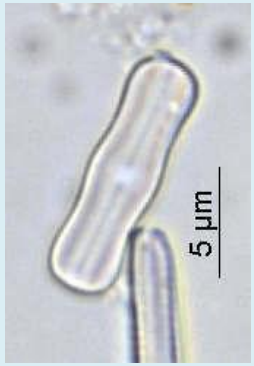
Reinhard GERECKE*, Marco CANTONATI[1)], Daniel SPITALE[1)], Elisabeth STUR[2)] and Sofia WIEDENBRUG[3)]

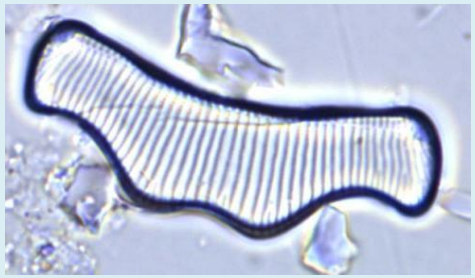
- other species
- *Eunotia subarcuatoides*
- *Eunotia intermedia*
- *Eunotia exigua*
- *Brachysira brebissonii*
- *Psammothidium marginulatum*
- *Psammothidium acidoclinatum*

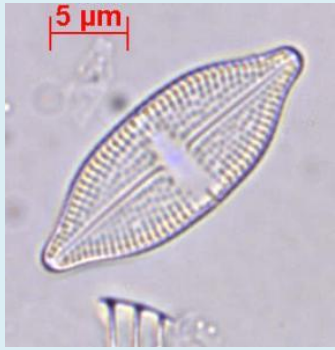
Rich, diverse, and peculiar diatom microflora of naturally very-low-alkalinity springs











Diatom monitors of close-to-pristine, very-low alkalinity habitats: three new *Eunotia* species from springs in Nature Parks of the south-eastern Alps

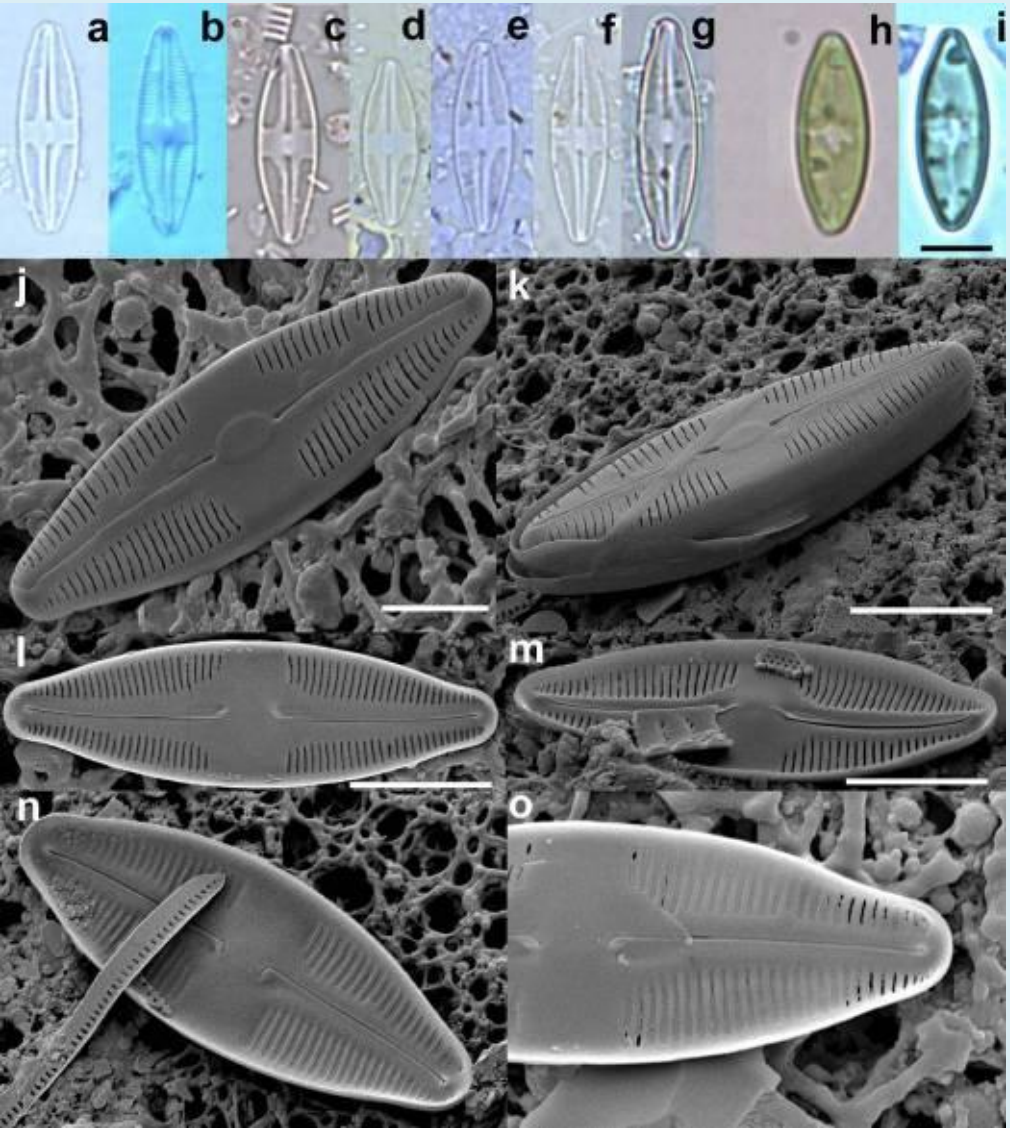
Marco CANTONATI* and Horst LANGE-BERTALOT[1)]

J. Limnol., 70(2): 209-221, 2011
DOI: 10.3274/JL11-70-2-12

Taxonomy of spring organisms

Dystrophic habitats. Terrestrial-Aquatic ecotone in springs

***Microfissurata* gen. nov.** Lange-Bertalot, Cantonati & Van de Vijver



J. Phycol. 45, 732–741 (2009)

DOI: 10.1111/j.1529-8817.2009.00683.x

MICROFISSURATA GEN. NOV. (BACILLARIOPHYTA), A NEW DIATOM GENUS FROM DYSTROPHIC AND INTERMITTENTLY WET TERRESTRIAL HABITATS[1]

Marco Cantonati[2]

Museo Tridentino di Scienze Naturali, Limnology and Phycology Section, Via Calepina 14, I-38100 Trento, Italy

Bart Van de Vijver

National Botanic Garden, Department of Bryophyta and Thallophyta, Domein van Bouchout, B-1860 Meise, Belgium

and Horst Lange-Bertalot

Institute for Ecology, Evolution, Diversity, University of Frankfurt, Siesmayerstraße 70, and Senckenberg Research Institute, Senckenberganlage 31-33, D-60054 Frankfurt/M., Germany

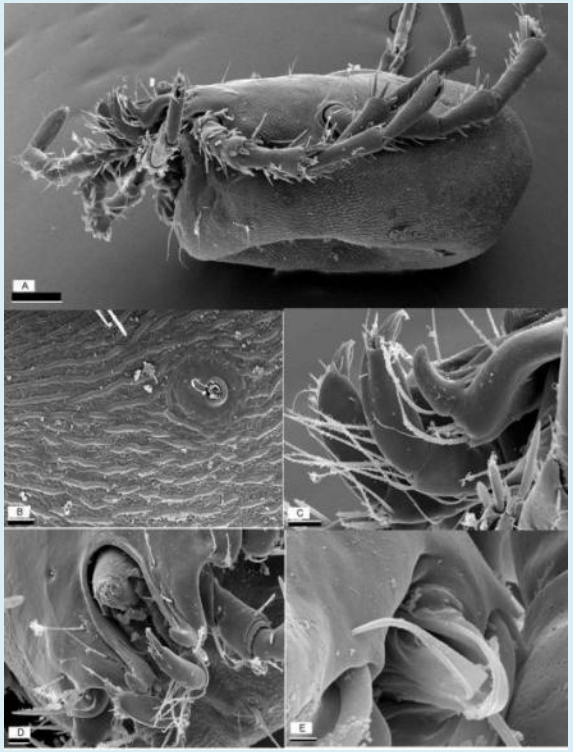
New taxa: Not only algae…

A new species and subgenus of *Lebertia* (Acari: Hydrachnidia: Lebertiidae)

Generitype species": *Lebertia* (*Brentalebertia*) *hygropetrica*.
Locus typicus: Spring at Scala di Brenta Adamello-Brenta Natural Park.

Gerecke R., 2008. A new species and subgenus of *Lebertia* (Acari: Hydrachnidia: Lebertiidae) from the Brenta-Adamello Natural Park (Italian Alps). *Fundamental and Applied Limnology*, **170**/4: 325-332.

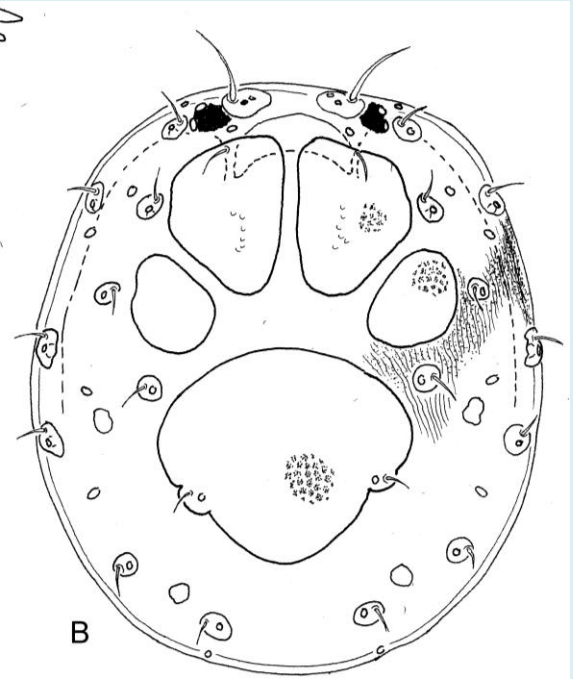
Not only water mites…:



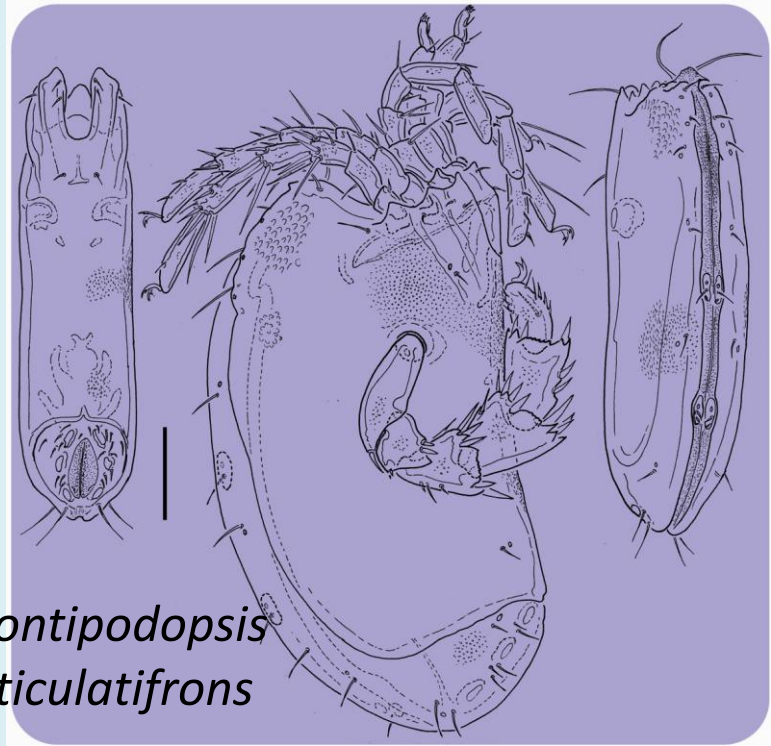
Water mites (EBERs)

Reinhard Gerecke
Univ. Tübingen, Germany

This is the group of organisms that includes the highest number of species exclusive to springs (so-called **crenobionts**). Biodiversity: A **species new-to-science** (*Pseudofeltria aemiliana* sp. nov. Gerecke); relatively-high number of species found (about 25); 2 new records for Italy, and a very-recently described species (*Hygrobates psammocrenicus* Gerecke & Di Sabatino). With reference to **stygobiotic species**, the most striking result was the finding of large population of the typical interstitial, laterally compressed water mite *Frontipodopsis reticulatifrons*. This species in normally strictly bound to interstitial water.

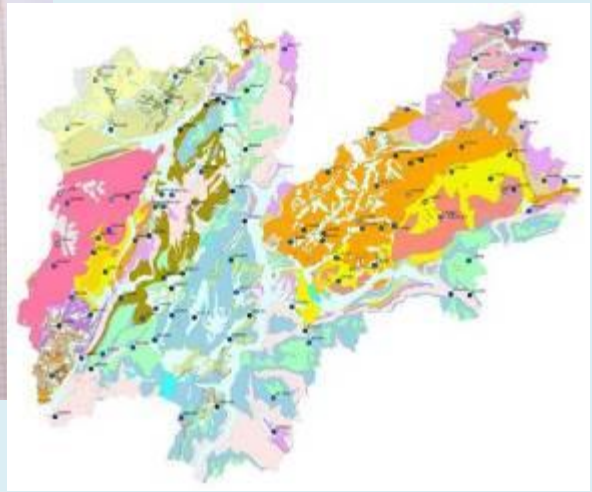


***Pseudofeltria aemiliana* sp. nov.**, this species is more distinct in females (with 5 dorsal plates)



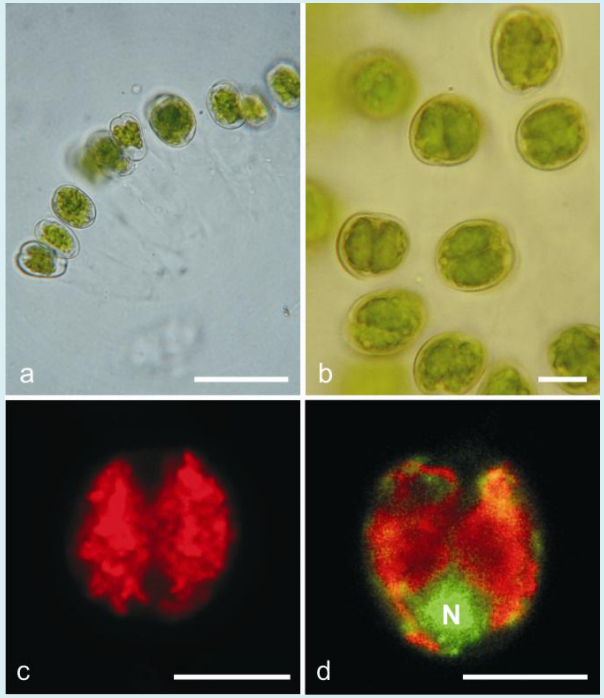
Frontipodopsis reticulatifrons

Springs as natural culture collections?



Biology of spring organisms

Tufa-spring protection status in the Central Eastern Alps, with special reference to the desmid *Oocardium stratum*



Freshwater Science, 2012, 31(2):610–624

DOI: 10.1899/11.084.1
Published online: 8 May 2012

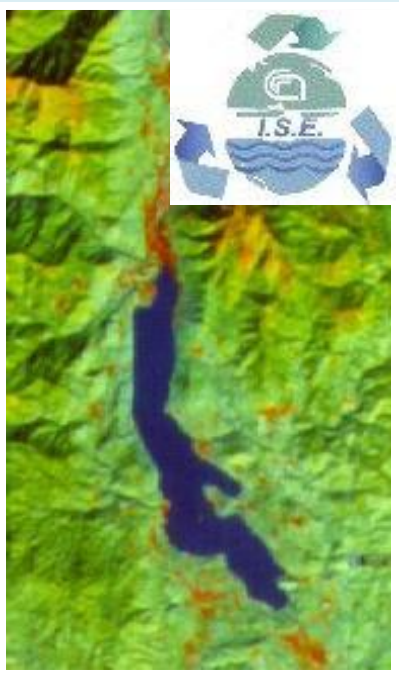
Spiazzi / Pte Arche Trentino Italy

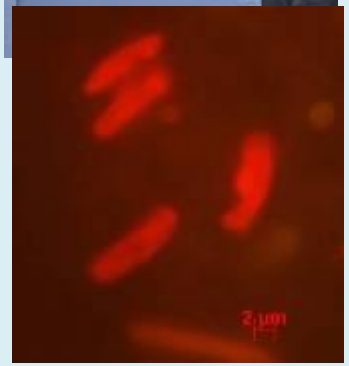
1st record July 2009

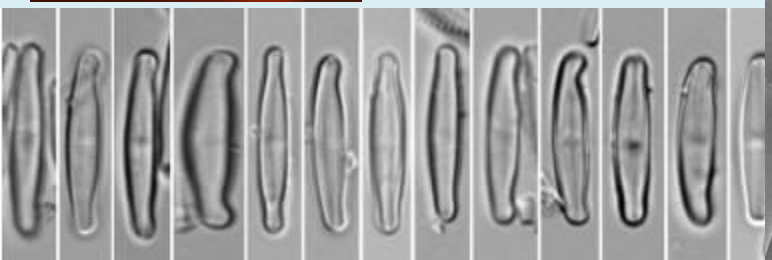
Calcification types of *Oocardium stratum* Nägeli and microhabitat conditions in springs of the Alps

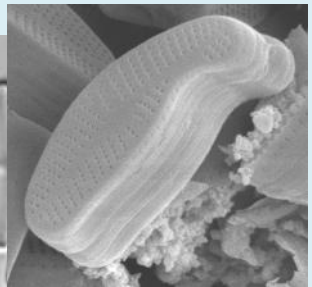
Eugen Rott[1,5], Ralf Hotzy[2,6], Marco Cantonati[3,7], AND Diethard Sanders[4,8]

Achnanthidium deformities & Cu, Zn, Sb









Enrichment factors (Ba)			
	Kraków fountain	Adamello spring	Gromolo stream
Sr88(LR)	276	11	51
Sb121(LR)	747	21	20
U238(LR)	3	539	7
Bi209(LR)	1101	1	4
Cd111(LR)	9	509	475
Fe56(MR)	0	1	4
Ni60(MR)	1	2	116
Cu63(MR)	7	117	2010
Zn64(MR)	9	528	161

Chamaesiphon fuscus & Cu

Spring:	Coel Vigo	Portentosa	Miniera	Tunnel C3831
Cu63(MR) :	300	767	5250	457
EF Cu63(MR):	5	11	114	19
C. fuscus*	3	0	4	1

However in springs 3, 4 significant Efs also for uranium, cadmium, zinc…

*Abundance value according to European Standard scale

EF = enrichment factors with respect to average crustal composition using Ba as a crustal reference. EF > 10 are significant.

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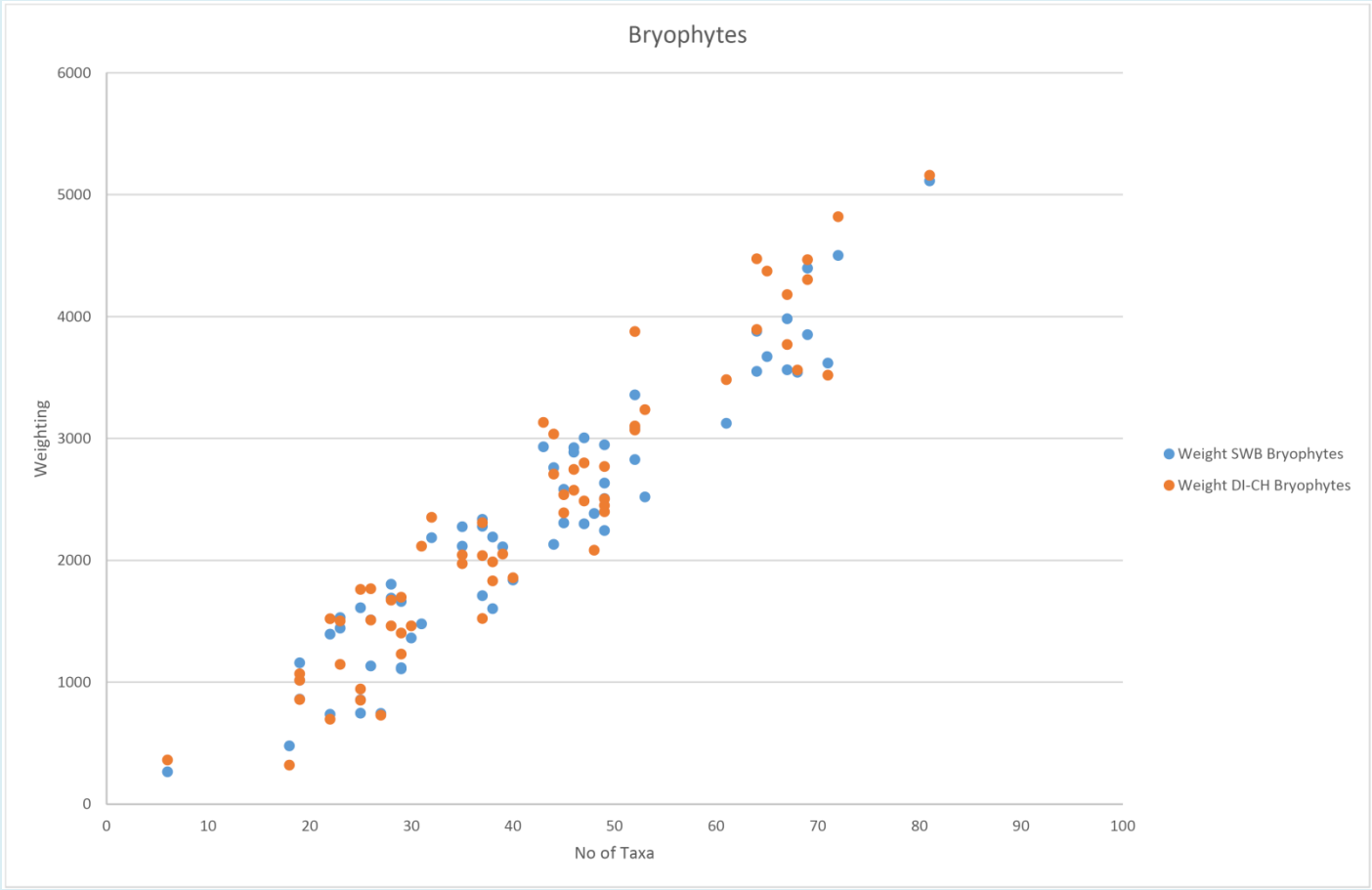
journal homepage: www.elsevier.com/locate/scitotenv

Achnanthidium minutissimum (Bacillariophyta) valve deformities as indicators of metal enrichment in diverse widely-distributed freshwater habitats

Marco Cantonati [a,*], Nicola Angeli [a], Laura Virtanen [b], Agata Z. Wojtal [c,1], Jacopo Gabrieli [d], Elisa Falasco [e], Isabelle Lavoie [f], Soizic Morin [g], Aldo Marchetto [h], Claude Fortin [f], Svetlana Smirnova [i]

Least-impaired habitat relicts

Comparison of spring and stream diatom assemblages in Switzerland (L. Taxböck, Univ. Zürich & AQUAPLUS)



From: Taxböck et al. in prep.

Crenophilous and crenobiontic taxa

More or less marked specialization of organisms to the spring environment

Crenobionts	Crenophyles	Crenoxenes
Water mites Hydrobioidea gasteropods Dipterans	Ostracods Copepods Caddisflies Midges Triclads Bryophytes	Mayflies

Cyanobacteria: *Chamaesiphon amethystinus, Rivularia* spp., *Phormidium favosum, P. fonticolum.*

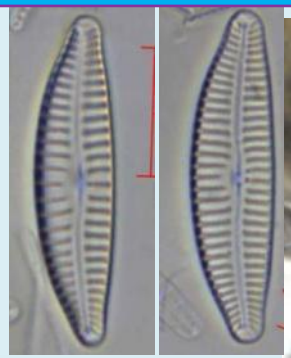
Diatoms: *Diatoma mesodon*, *Caloneis fontinalis*, *Gomphonema elegantissimum*, *Achnanthidium dolomiticum*, *Meridion circulare, Eunotia tenella, Achnanthidium neomicrocephalum, Fallacia lange-bertalotii*

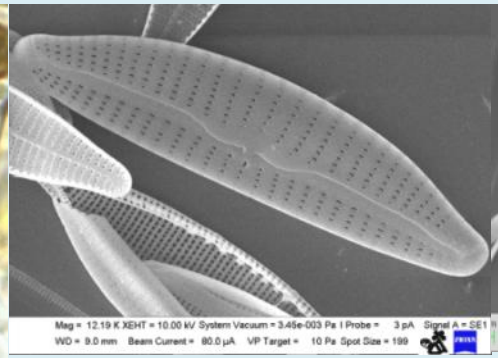
Other algae: *Oocardium stratum (desmid), Batrachospermum* spp. (red algae)

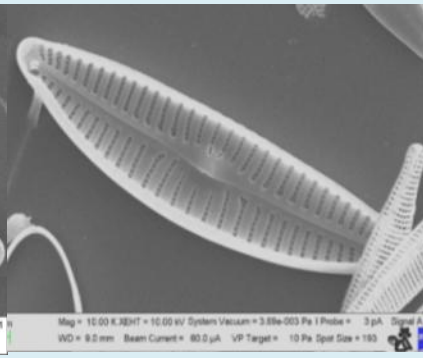
Among photoautotrophs there seem to be **no** species strictly exclusive of spring habitats (**crenobionts**).

Cymbella tridentina Lage-Bertalot, Cantonati et Scalfi

- carbonate oligotrophic rheocrenes (large springs & upper part of spring-streams, or microniches with higher current velocity).
- seasonal development with two peaks, the main one being in late autumn.







TAXA	NI	NII	NIII
Planothidium lanceolatum	■	+	
Amphora inariensis Krammer	■		
Gomphonema pumilum var. *elegans*	■	▪	
Reimeria sinuata	▪	■	+
Amphora pediculus	■	▪	
Achnanthidium minutissimum (+ A. strictum)	■	■	■
Hannea arcus		■	■
Diatoma mesodon	■	▪	▪
Cymbella tridentina nov. spec.	■		
Gomphonema micropus	■	+	
Cocconeis pseudolineata	+	■	
Cocconeis placentula var. *lineata*	■	▪	+
Nitzschia fonticola	■	▪	▪
Gomphonema angustum	■	▪	▪
Achnanthidium pyrenaicum	■	■	■

Cantonati et al. 2010. *J-NABS*

Longitudinal distribution in a spring-fed stream

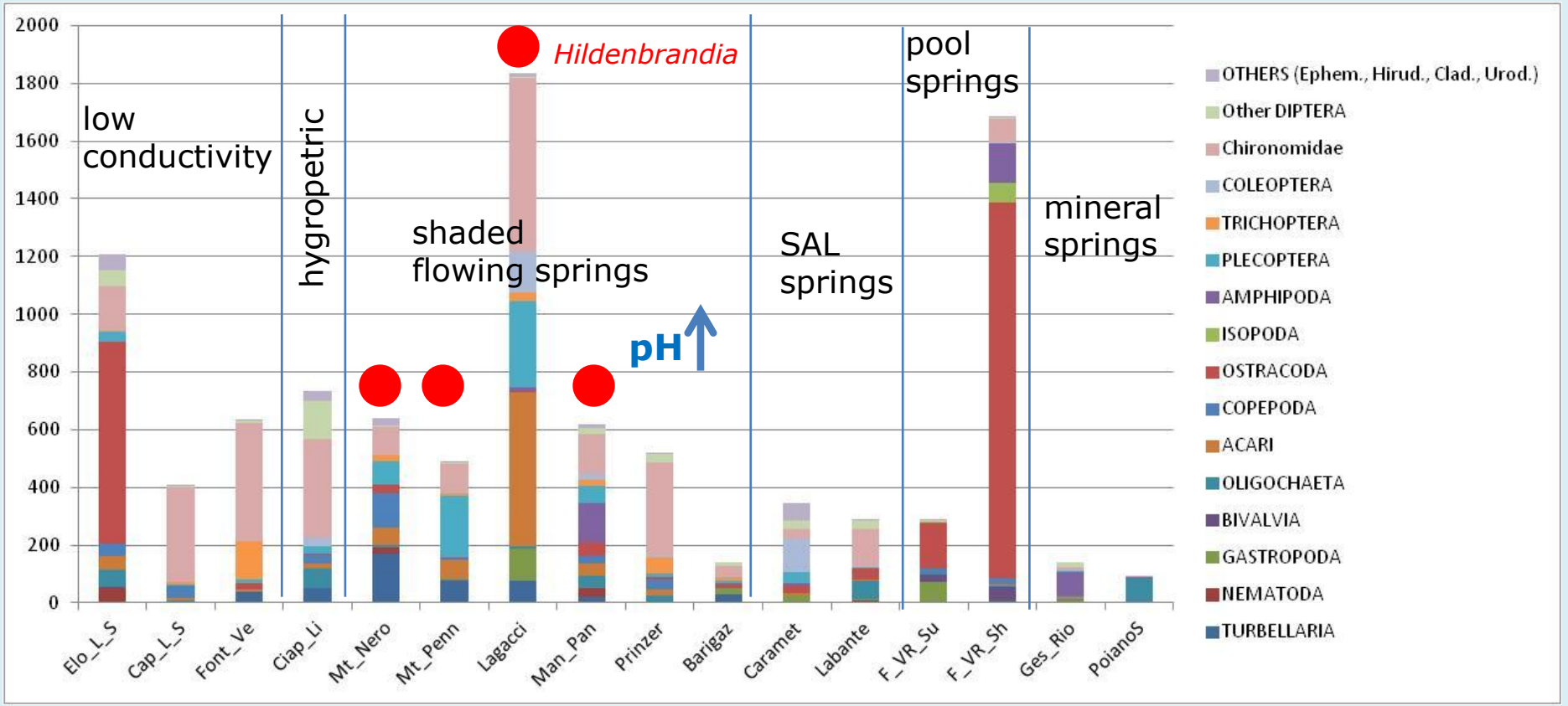
Peculiar features of spring assemblages

Zoobenthos (EBERs)

Reinhard Gerecke
(Univ. Tübingen, Germany)

TURBELLARIA	NEMATODA	GASTROPODA	BIVALVIA	OLIGOCHAETA	HIRUDINEA	ACARI	COPEPODA
473	124	241	70	393	7	827	331
OSTRACODA	CLADOCERA	ISOPODA	AMPHIPODA	EPHEMEROPTERA	PLECOPTERA	TRICHOPTERA	URODELA
2356	58	76	385	150	805	286	1
COLEOPTERA	Dytiscidae	Elmidae	Haliplidae	Hydraenidae	Hydrophilidae	Psephenidae	Scirtidae
41	5	250	3	12	7	1	20
DIPTERA	Athericidae	Ceratopogonidae	Chironomidae	Culicidae	Dixidae	Empididae	Limoniidae
4	14	124	2780	1	9	61	24
	Psychodidae	Ptychopteridae	Stratiomyidae	Tabanidae			
	94	6	19	1			

Decreasing abundance →



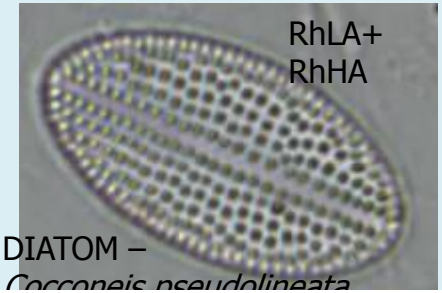
RhLA

RhHA

RhL

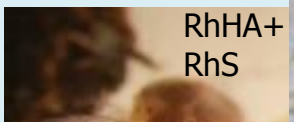
DIATOM – *Tetracyclus rupestris*

Hyg



DIATOM – *Cocconeis pseudolineata*

WATER MITE– *Atractides walterii*



DIATOM – *Nitzschia dissipata*

RhL

Freshwater Science, 2012, 31(2):563–574

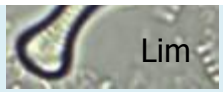
DOI: 10.1899/10-038.1
Published online: 8 May 2012

Environmental classification of springs of the Italian Alps and its consistency across multiple taxonomic groups

Daniel Spitale[1,3], Manel Leira[2,4], Nicola Angeli[1,5], AND Marco Cantonati[1,6]

[1] *Museo delle Scienze, Limnology and Phycology Section, Via Calepina 14, 38122 Trento, Italy*
[2] *Faculty of Sciences, University of A Coruña, Campus da Zapateira, 15071 A Coruña, Spain*

Lim



CHIRONOMID – *Prodiamesa olivacea* Lim

Lim

Hel

VASCULAR PLANT – *Eriophorum* spp.

crassinervia

BRYOPHYTE – *Scapania undulata*

Hel

VASCULAR PLANT – *Saxifraga stellaris*

Hel

RhS

Diatoms in springs of the Alps: spring types, environmental determinants, and substratum

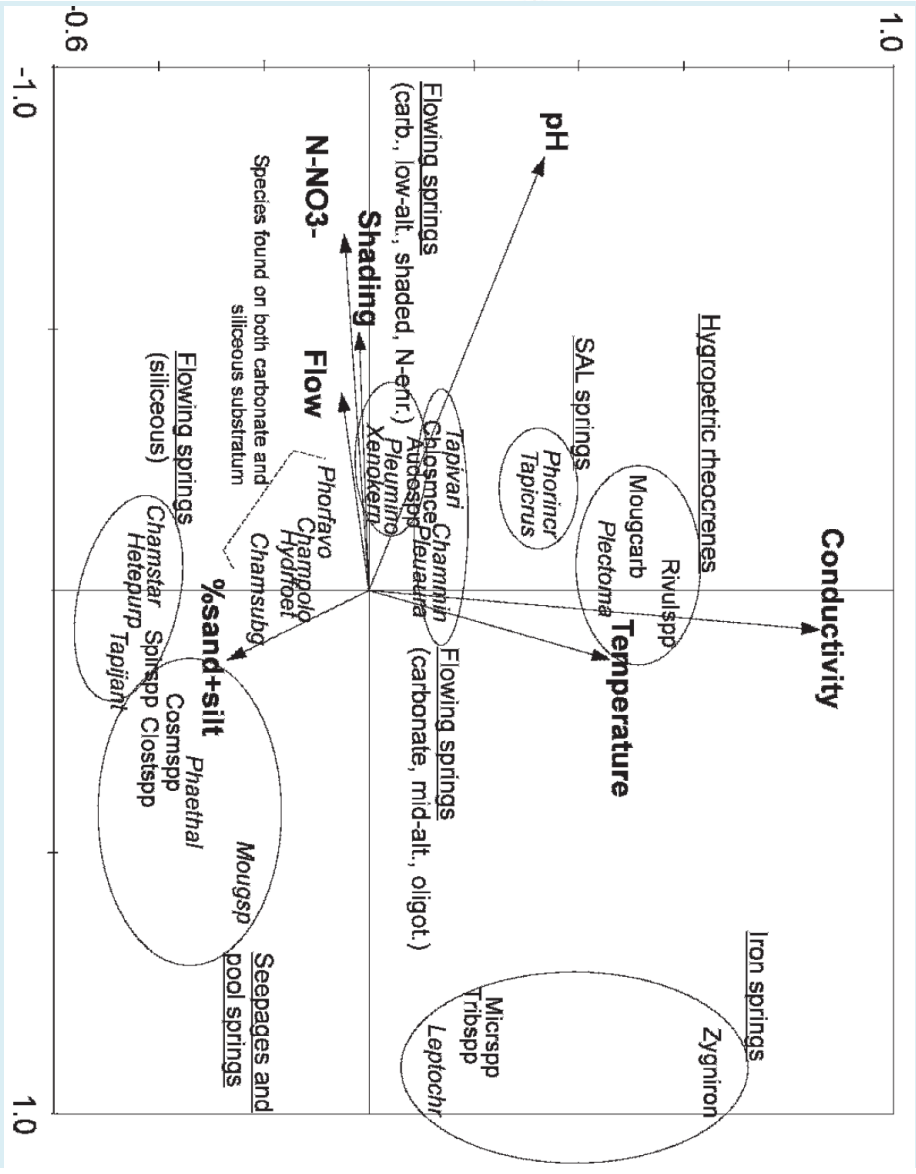
Freshwater Science, 2012, 31(2):499–524

DOI: 10.1899/11-065.1
Published online: 1 April 2012

Marco Cantonati[1], Nicola Angeli[2], Ermanno Bertuzzi[3], AND Daniel Spitale[4]

Museo delle Scienze, Limnology and Phycology Section, Via Calepina 14, I-38122 Trento, Italy

Horst Lange-Bertalot[5]



Main environmental determinants

Are benthic algae related to spring types?

Freshwater Science, 2012, 31(2):481–498

DOI: 10.1899/11-048.1
Published online: 1 April 2012

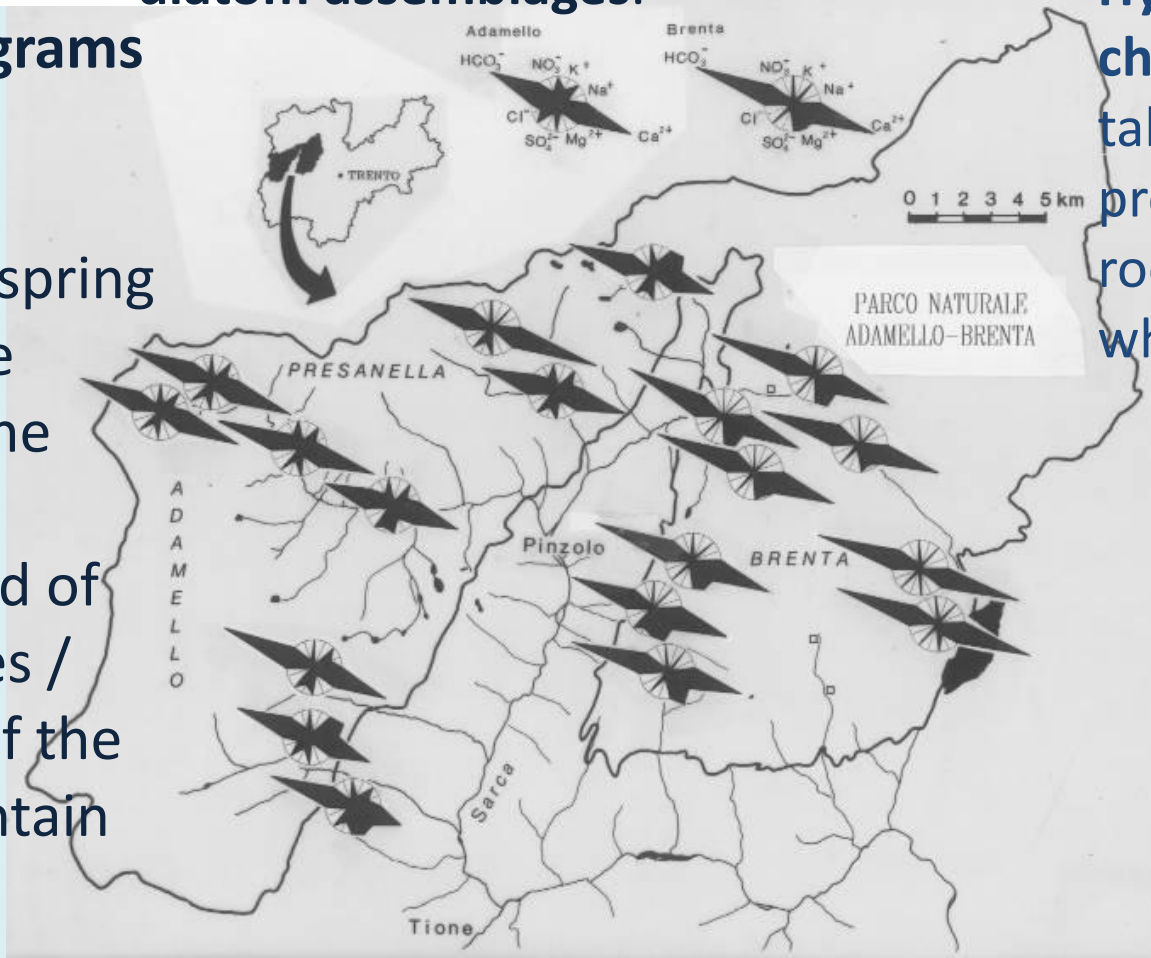
Marco Cantonati[1,4], Eugen Rott[2,5], Daniel Spitale[1,6], Nicola Angeli[1,7], AND Jiří Komárek[3,8]

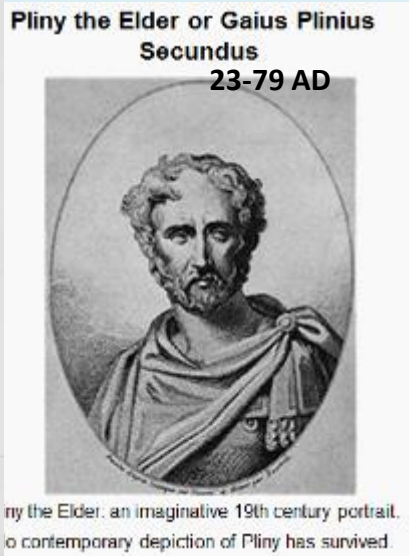
Environmental chemistry

Impressive **lithological variety** of the Autonomous Province of Trento, and its **reflection in the spring waters** and **diatom assemblages**.

"Tales sunt aquae quales terrae per quas fluunt" **Pliny** the**Elder**, *Naturalis historia,* 74 D.C. **First law of Hydrogeo-chemistry**: "Waters take on the properties of the rocks through which they pass".

Maucha diagrams to show differences beween the spring waters of the holocrystalline rocks of the Adamello and of the dolomites / limestones of the Brenta mountain range





ny the Elder: an imaginative 19th century portrait.
o contemporary depiction of Pliny has survived

J. Phycol. **42,** 1184–1188 (2006)

DOI: 10.1111/j.1529-8817.2006.00281.x

ACHNANTHIDIUM DOLOMITICUM SP. NOV. (BACILLARIOPHYTA) FROM OLIGOTROPHIC MOUNTAIN SPRINGS AND LAKES FED BY DOLOMITE AQUIFERS[1]

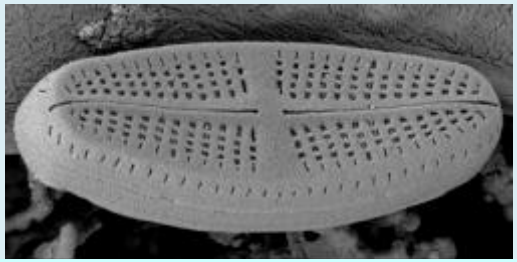
Marco Cantonati[2]

Museo Tridentino di Scienze Naturali, Limnology and Phycology Section, Via Calepina 14, I-38100 Trento, Italy

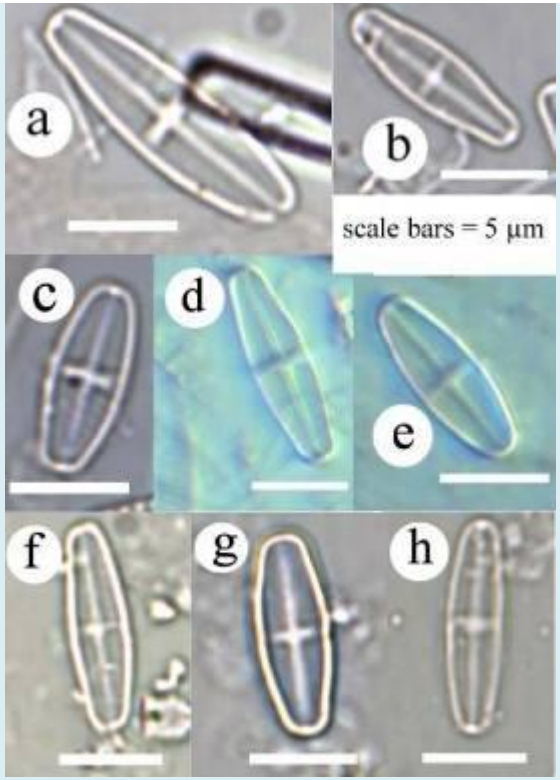
and

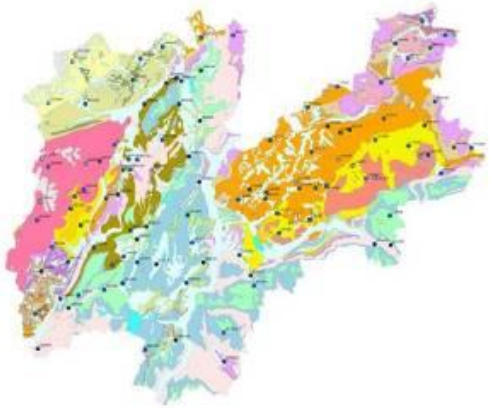
Horst Lange-Bertalot

Botany Institute, University of Frankfurt, Siesmayerstraße 70, D-60323 Frankfurt/M., and Senckenberg Research Institute, Senckenberganlage 31-33, D-60054 Frankfurt/M., Germany



- **Mainly EPIPHYTIC on bryophytes** and aquatic vascular plants in carbonate springs and lakes.
- Freshwater habitats fed by drainage basins dominated by dolomite lithology with medium mineralization, oligotrophic and affected by seasonal desiccation.



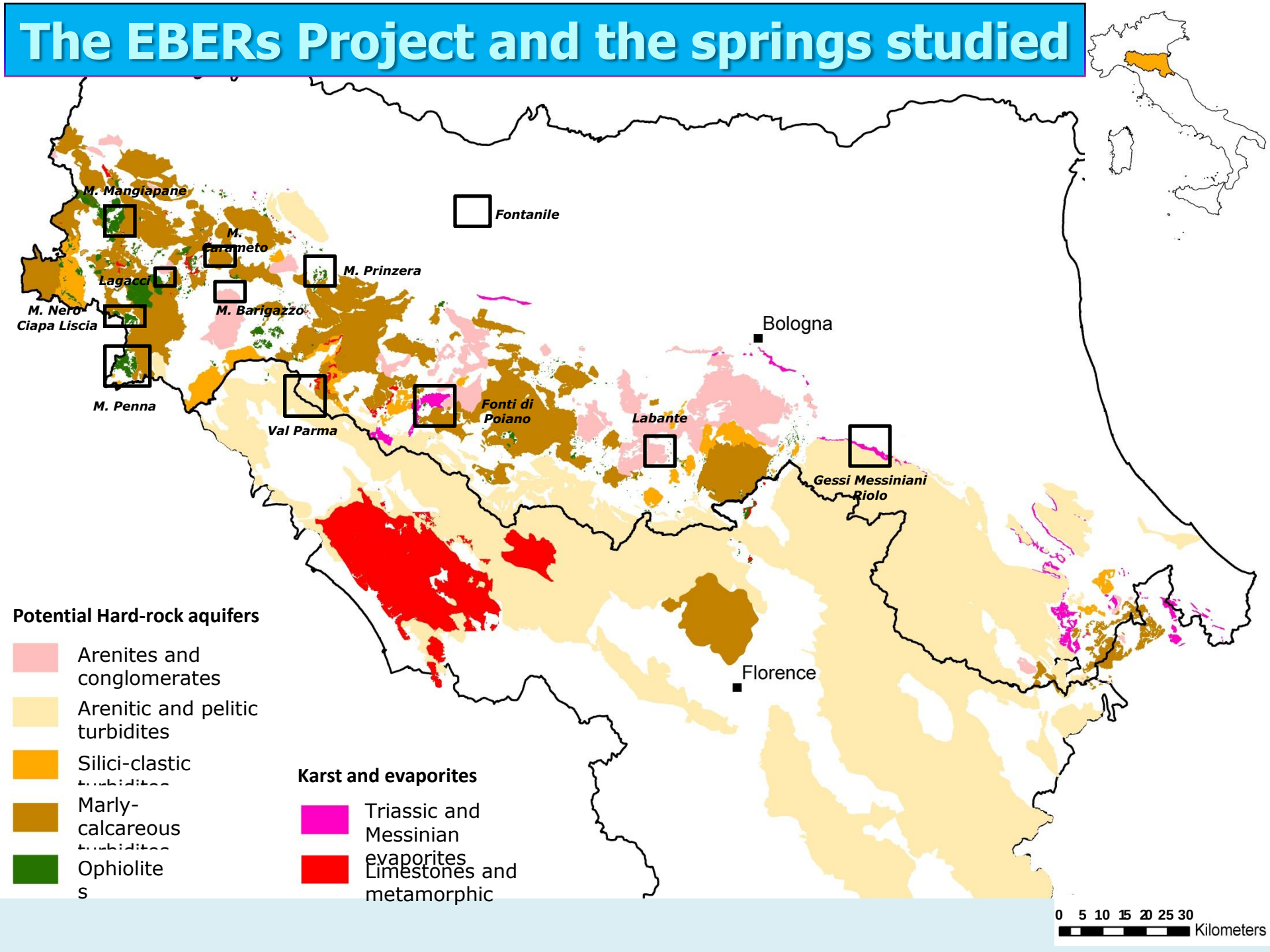


Gentiana brentae
Prosser et Bertolli

"Plants" apparently restricted in their distribution to dolomite substratum

"*the Brenta Group …a mysterious range utterly unlike anything in the central Alps*" (Freshfield 1875)

The EBERs Project and the springs studied



Types of springs: Diatoms

Freshwater Science, 2012, 31(2):499–524
© 2012 by The Society for Freshwater Scie
DOI: 10.1899/11-065.1
Published online: 1 April 2012

1. Rheocrenes on carbonate substratum

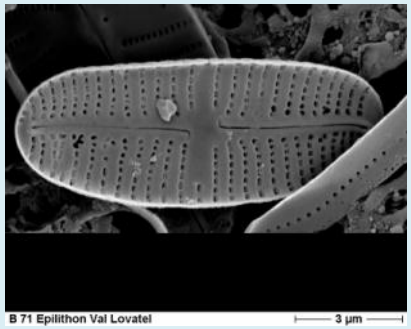
Achnanthidium

1.1 Low current.

	opt	tol	class opt	class tol
GOMPELEG	849.8	576.8	2	3
ACHDLINE	721.2	280.6	2	2

1.2 High current. *A. pyrenaicum*

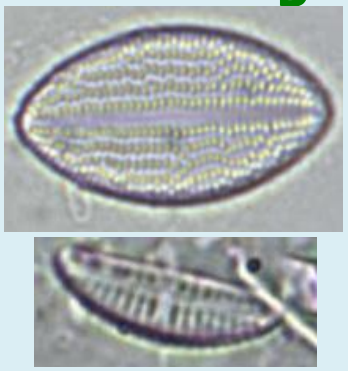
ACHDPYRE	663.4	348.5	2	2



2. Carbonate rheocrenes with nitrate enrich. and/or shading

Cocconeis

AMPHPEDI	1085.9	1092.6	3	4
AMPHINAR	2422.2	2091.8	5	4
CALOFONT	1208.6	1147.7	3	4
EUNOARCB	937.6	1131.6	2	4
REIMSINU	1407.8	1336.8	3	4
SELAJOUB	1300.0	535.0	3	3



3. Carbonate rheoc. with lower cond. and seasonal desiccation

Diadesmis

DIADCONT	1378.4	916.4	3	3
PLANFREQ	955.5	1106.6	2	4
MERICIRC	586.6	347.9	2	2
ACHDDOLO	678.4	657.4	2	3

& T.D.I.Spr.: Autecological data

4. Hygropetric rheocrenes (carbonate substrata)

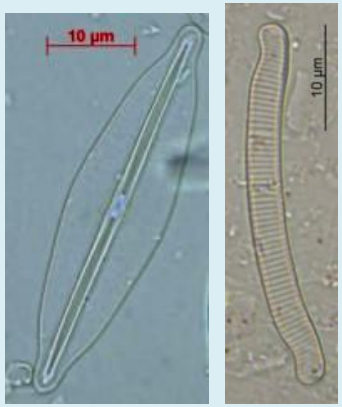
Encyonopsis

ENCSMICR	2889.6	1864.7	5	4
DELIMINU	944.2	71.0	2	1
CYMPAUST	916.6	946.3	2	3
GOMPLATE	548.2	407.5	2	2
BRACCALC	3629.5	1348.2	5	4
DENTTENU	683.2	379.1	2	2

5. Helocrens and limnocrenes on siliceous substratum

Eunotia

PSAMACID	146.2	36.3	0	1
BRACBREB	343.7	146.9	1	1
EUNOEXIG	57.5	93.2	0	1
EUNOCISA	329.6	316.9	1	2
FRUSCRAS	307.3	100.7	1	1
NITZACID	120.4	197.7	0	1
TABEFLOC	321.1	303.3	1	2



6. Rheocrenes on siliceous substrata

Diatoma

DIATMESO	554.4	423.0	2	2
DIATHYEM	572.4	364.4	2	2
EUNOMINO	276.1	219.3	1	1
NAVIEXIL	445.7	209.3	1	1
PLANLANC	613.5	471.8	2	2
MERICONS	414.1	441.7	1	2

Types of springs: Benthic algae

Freshwater Science, 2012, 31(2):481–498

DOI: 10.1899/11-048.1
Published online: 1 April 2012

1. Iron springs

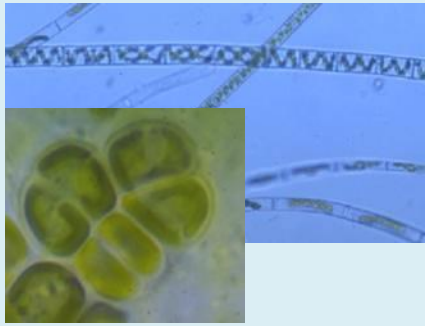
***Zygnema* sp. "iron"**

- ***Tribonema* spp.**
- ***Microspora* spp.**
- ***Klebsormidium* sp.**

- ***Leptothrix ochracea***

2. Helocrenes and limnocrenes

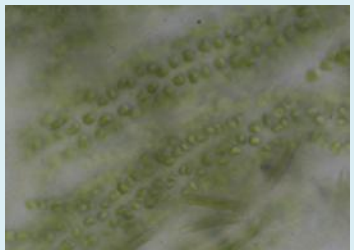
- ***Spirogyra* spp.**
- ***Mougeotia* spp.**
- ***Cosmarium* spp.**
- ***Closterium* spp.**
- ***Phaeoplaca thallosa***



3. Siliceous rheocrenes

Tapinothrix janthina
Heteroleibleinia purpurascens
Chamaesiphon starmachii

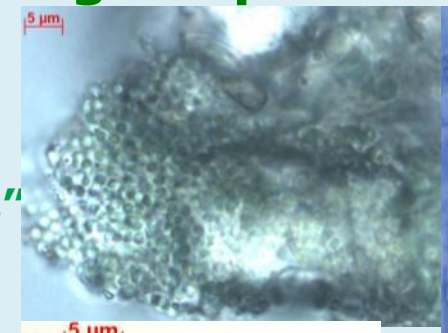
"Accompanying" species:
Chamaesiphon fuscus
Stichosiphon pseudopolymorphus
Chamaesiphon polonicus "violet"
Hydrurus foetidus

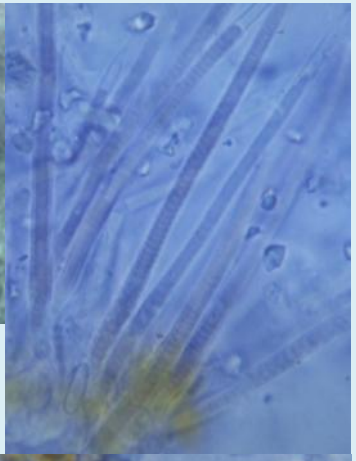


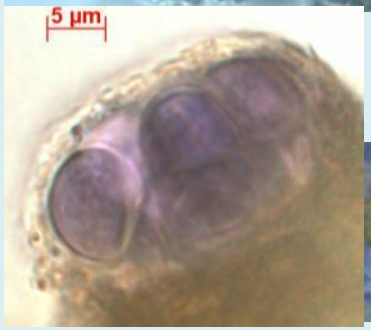
4. Carbonate mid-altitude, N- & P-oligotrophic rheocrenes

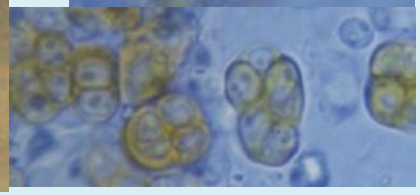
***Chlorogloea* "small cells"**
Xenotholos kerneri

"Accompanying" species:
Tapinothrix varians
Pleurocapsa aurantiaca









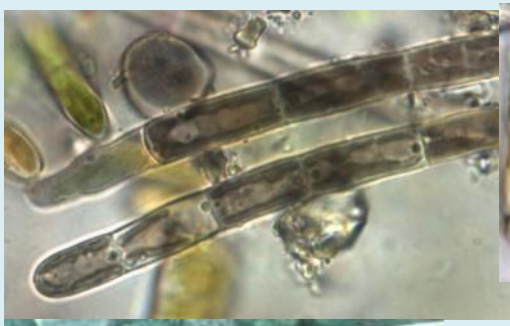
5. Low-altitude, mostly-shaded & N-enriched carbonate rheoc.

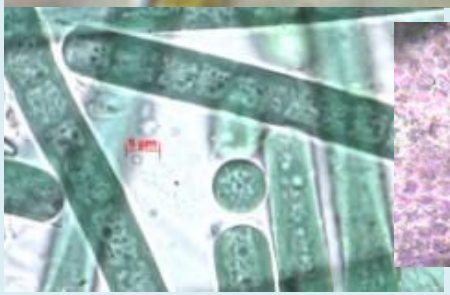
Pleurocapsa minor

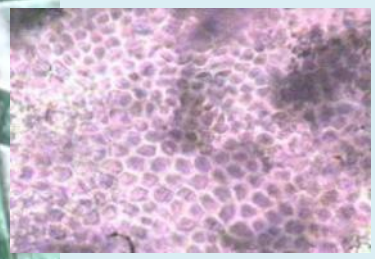
Audouinella spp.

"Accompanying" species:
Chamaesiphon geitleri
Phormidium retzii

Hildenbrandia rivularis





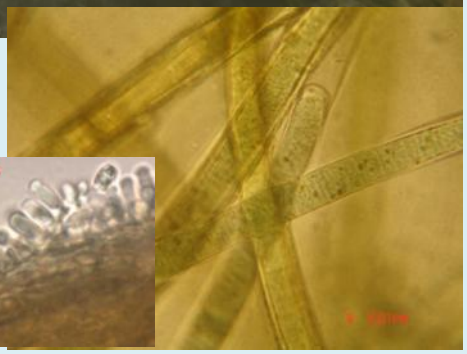


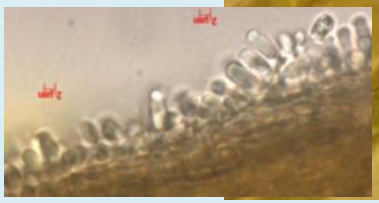
6. Hygropetric rheocrenes

***Rivularia* spp.**
Chamaesiphon minutus
Plectonema tomasinianum

***Mougeotia* sp. carbonate**

"Accompanying" species:
Ammatoidea normanni
Calothrix parietina

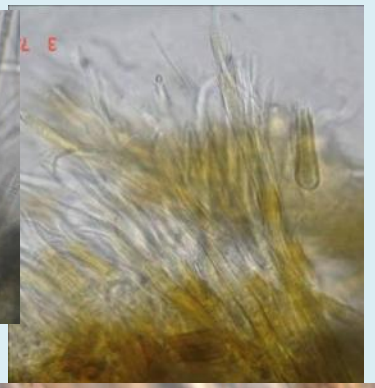


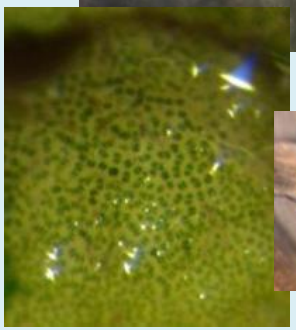


7. SAL (Spring-associated limestones) springs

Phormidium incrustatum
Homoeothrix crustacea

"Accompanying" species:
Scytonema myochrous
Dichothrix gypsophila
Schizothrix tinctoria
Chroococcus sp. "Spiazzi"
Gloeothece sp. "Spiazzi"
Oocardium stratum





Functional studies

• **Odum** (**1957**) considered the chemostatic, steady-state ecosystem of the Silver Springs in Florida (USA) as a natural "giant constant temperature laboratory" in which to investigate **energy flux and function in trophic food webs**.
• **Glazier**, D. S. Application of **metabolic scaling** to different aspects of crenic ecology (e.g., Glazier et al. 2011, Glazier 2012).

The aquifer-spring system or crenoecology meets hydrogeology

Springs as the most-characteristic groundwater dependent ecosystem (GDE)

Review: From multi-scale conceptualization to a classification system for inland groundwater-dependent ecosystems

Guillaume Bertrand · Nico Goldscheider · Jean-Michel Gobat · Daniel Hunkeler

Hydrogeology Journal

DOI 10.1007/s10040-011-0791-5

Published online: 03 November 2011

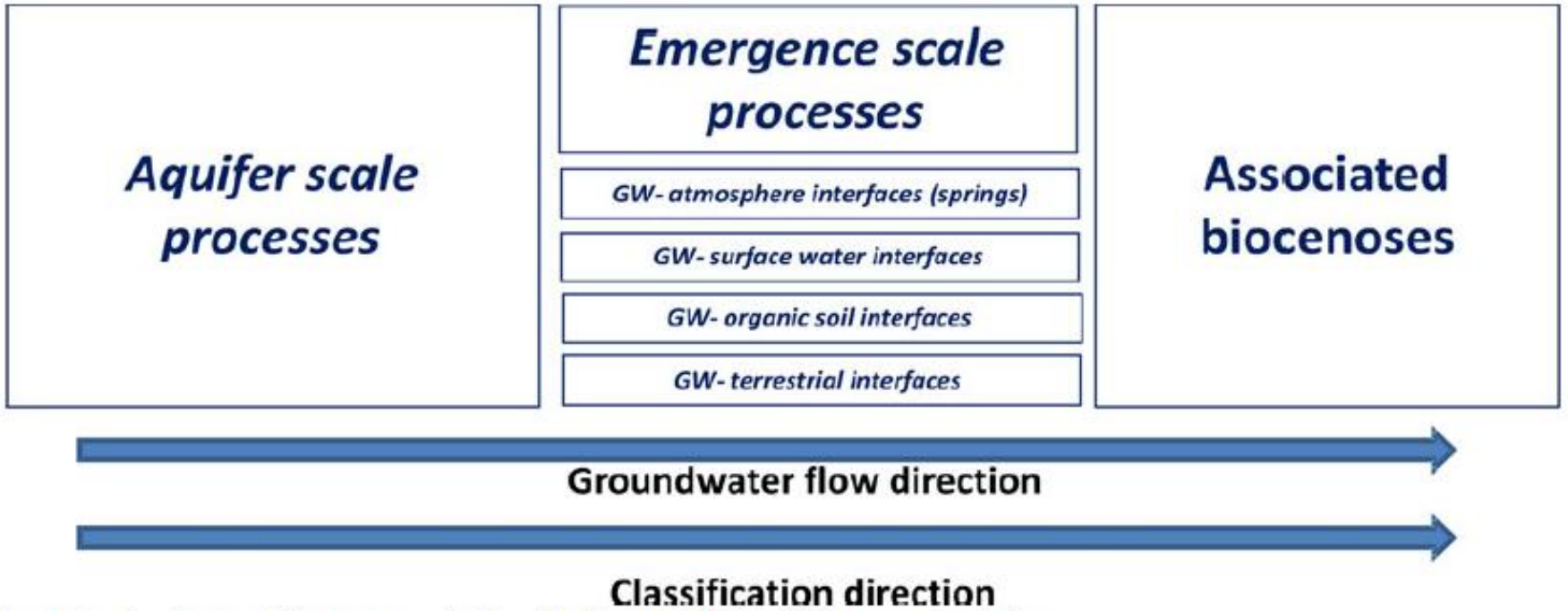


Fig. 8 Conceptual scheme of the proposed classification of GDEs (*GW* groundwater)

Table 3 Classification key of spring ecosystems

Determined by aquifer scale attributes		Determined by emergence scale attributes	GDE's denomination	Ecology		
Hydroperiod	Chemical type	Geomorphological characteristics		Phytosociology	Characteristic species	Biogeographic area
Permanent	Alkaline pH	Helocrene, rheocrene	Permanent alkaline spring ecosystems	*Cratoneurion*	*Cratoneuron filicinum, Saxifraga aizoides*	Atlantic, Continental, Alpine, Mediterranean, Boreal
	Neutral to alkaline pH	Rheocrene	Permanent rheocrene springs	*Ranunculion fluitantis*[a]	*Ranunculus fluitans Potamogeton nodosus,*	Mediterranean, Atlantic, Continental
				Fontinalidion antipyreticae[a]	*Fontanilis antipyretica, Potamogeton nodosus*	Atlantic, Continental, Mediterranean, Boreal
				Scarpanion undulatae[a]	*Brachythecium plumosum, Fontanilis antipyretica*	Atlantic, Continental, Mediterranean, Boreal
				Dermatocarpion rivulorum[a]	*Dermatocarpon rivolurum, Hydrogrimnia mollis*	Atlantic, Continental, Boreal, Alpine
		Helocrene, (limnocrene)	Permanent helocrene springs	*Calthion*[a]	*Caltha palustris, Ranunculus aconitifolius*	Atlantic, Continental, Alpine, Mediterranean, Boreal
		Limnocrene	Permanent limnocrene springs	*Charion*[a]	*Chara fragilis, Chara vulgaris, Nitella batrachosperma*	Atlantic, Continental, Alpine, Mediterranean, Boreal
				Potamion[a]	*Potamogeton crispus, Elodea canadensis*	Atlantic, Continental, Mediterranean, Boreal
				Lemnion[a]	*Lemna minor*	Atlantic, Continental, Mediterranean, Boreal
				Nymphaeion[a]	*Nuphar lutea, Callitriche palustris*	Atlantic, Continental, Mediterranean, Boreal
		On cliffs and hillslopes (colluviosols)	Cliff spring ecosystems	*Adiantion*	*Adiantum capillus-veneris, Eucladium verticillatum*	Mainly Mediterranean
	Acid pH	Helocrene, rheocrene, limnocrene	Acid spring ecosystems	*Cardamino montion*	*Cardamine amara, Montia montana, Sedum villosum*	Atlantic, Continental, Boreal
Periodic	Alkaline pH	Rheocrene	Non permanent alkaline rheocrene springs	*Cratoneurion*	*Cratoneuron filicinum, Saxifraga aizoides*	Atlantic, Continental, Alpine, Mediterranean, Boreal
	Neutral to alkaline pH	Helocrene	Non permanent helocrene springs	*Petasition paradoxi*[a]	*Petasites paradoxus, Adenostyles glabra*	Mainly Alpine
				Calthion[a]	*Caltha palustris, Ranunculus aconitifolius*	Atlantic, Continental, Mediterranean, Alpine

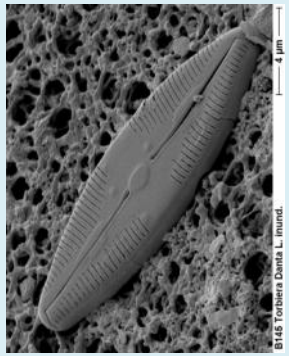
[a] Indicates phytosiociologies that are not necessarily typical of groundwater outflows but are, however, common near springs

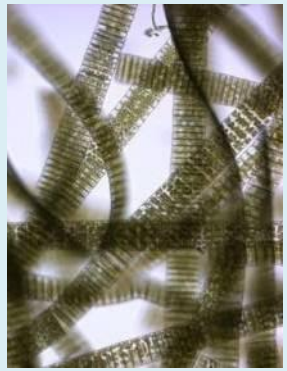
Applied issues

Towards the development of benthic-algae tools for the bioassessment of the quality and ecological integrity of spring habitats

M. Cantonati[1,2,3] N. Angeli[1] & D. Spitale[1]

[1]Museo delle Scienze, Limnology & Phycology Sect., Trento.E-mail: marco.cantonati@mtsn.tn.it; [2]Assoc. Researcher, Inst. for Ecosystem Study (ISE-CNR), Italy; 3Adjunct Prof. Univ. Innsbruck, Botany Inst., Austria





The Trophic Diatom Index for Springs

The **Weigthed-average method** (**w.a.**) was used to generate the diatom autecological data (Birks *et al*. 1990).

The **optimum** (w.a.) is calculated as follows:

$$\hat{u}_k = \sum_{i=1}^{n} y_{ik} x_i \Big/ \sum_{i=1}^{n} y_{ik}$$

where, $\hat{u}_k$ is the N-NO_3^- w.a. for a taxon *k*, x_i is the N-NO_3^- value of at site *i,* and y_{ik} is the abundance of species k at site *i*.

The inferred N-NO_3^- (x_i) can be calculated (Stoermer & Smol 1999) as:

$$\hat{x}_i = \sum_{k=1}^{m} y_{ik} \hat{u}_k \Big/ \sum_{k=1}^{m} y_{ik}$$

Trophic Diatom Index for Springs (T.D.I. Spr.)

$$= \frac{\sum a_k s_k v_k}{\sum a_k s_k}$$

where *a* is the relative abundance, *s* is the sensitivity (tolerance) and *v* is the trophic indicator value of the species *k*. The value of the index varies between 0 and 5.

Based on the algorithm of Zelinka & Marvan (1961)

Towards sustainable spring capturing: A case study

Verh. Internat. Verein. Limnol.
2009, vol. 30, Part 8, p. 1267–1270, Stuttgart, October 2009

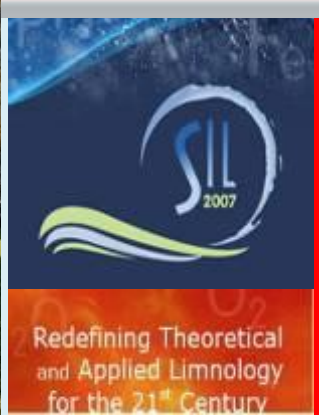
The potential importance for spring conservation of residual habitats after flow capturing: A case study

Marco Cantonati, Ermanno Bertuzzi, Alessia Scalfi and Valentina Campana

Communication and dissemination of information

- Italian Edition of Smith & Smith, ecology textbook

http://www.jlimnol.it/JL_70_sup/JL_70_sup.htm



Special Session N. 47: "Sprigs and small streams: Understudied and under-protected key habitats for biodiversity conservation"

Communication and dissemination of information

Special Session N. 051 at the Joint Aquatic Sciences Meeting (JASM = SFS+ASLO+PSA+SWS, Portland, Oregon, May 2014)

Session title:

Spring-habitats' and spring-fed headwaters' biology fifty years after the definition of crenobiology

Duration: 4h, 15 talks

Co-Chairs:

Marco Cantonati,

Timo Muotka, John Richardson, & Morgan Vis

Acknowledgements:


Daniel Spitale


Nicola Angeli


Erm. Bertuzzi


Alessia Scalfi


Mic. Segnana

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Museo delle Scienze
Science Museum
MUSE
Museum für Wissenschaft

Trentino Nature & Science Museum

Autonomous Province of Trento, University and Scientific Research Dept.


Aloise Poulíčková


Eugen Rott


Horst Lange-Bertalot


Jiří Komárek

Děkuji za pozornost!

PARCO NATURALE ADAMELLO BRENTA


Karin Ortler


Reinhard Gerecke

esf evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ