Boris SKET

Biodiversity of **subterranean** habitats and an **operational approach** to its conservation

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Biotehniška fakulteta
Univerza v Ljubljani
Slovenia

We are sitting now close to one of the global hotspots.

What kind of it?

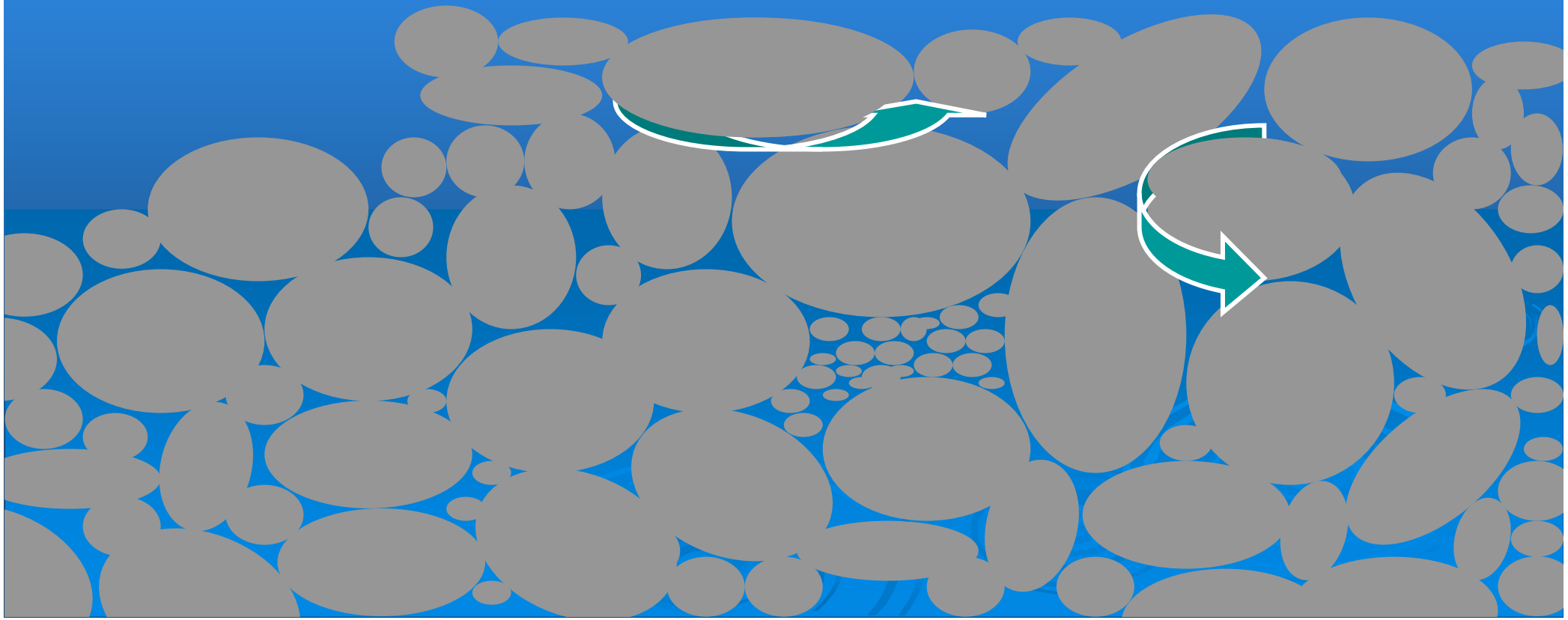
(not very obvious, because)

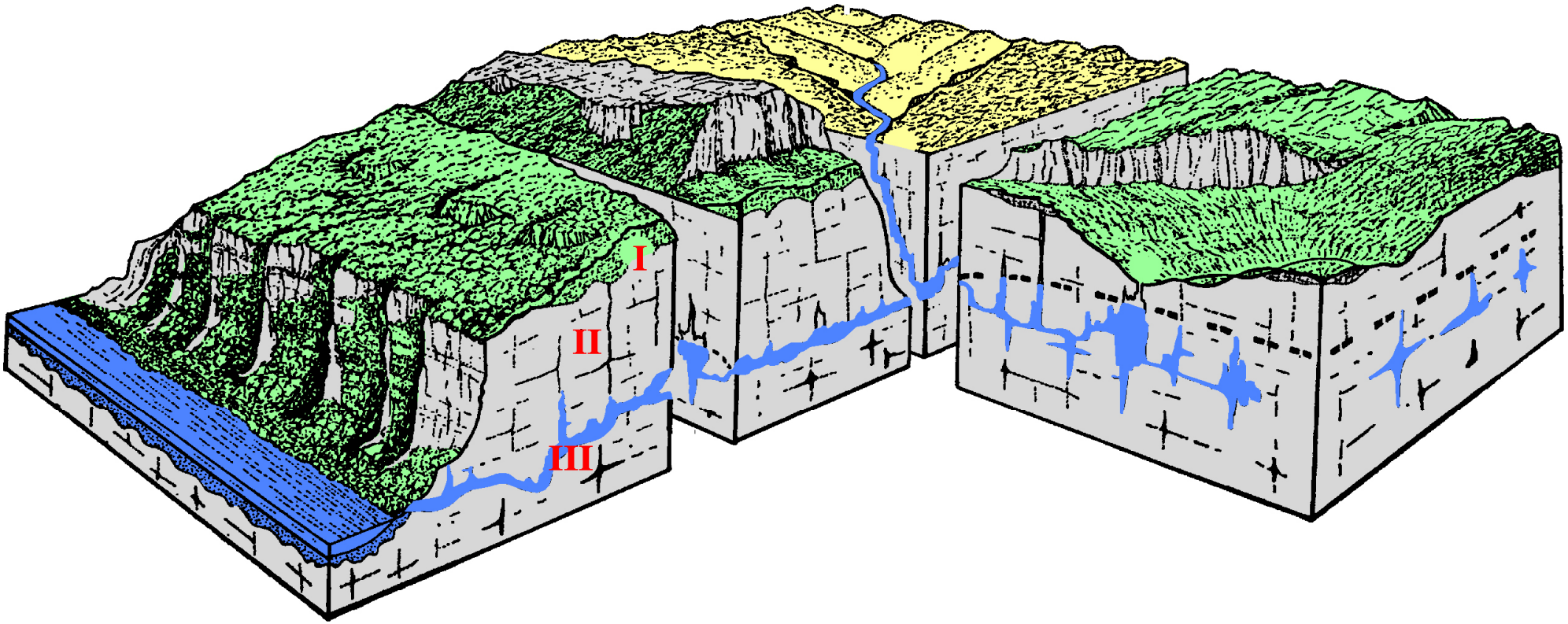
It’s a hotspot of the subterranean biodiversity.

What are subterranean habitats?

- interstitial waters,
- fissures and caves in karst, in lava.

Interstitial waters:
between pebbles or sand grains

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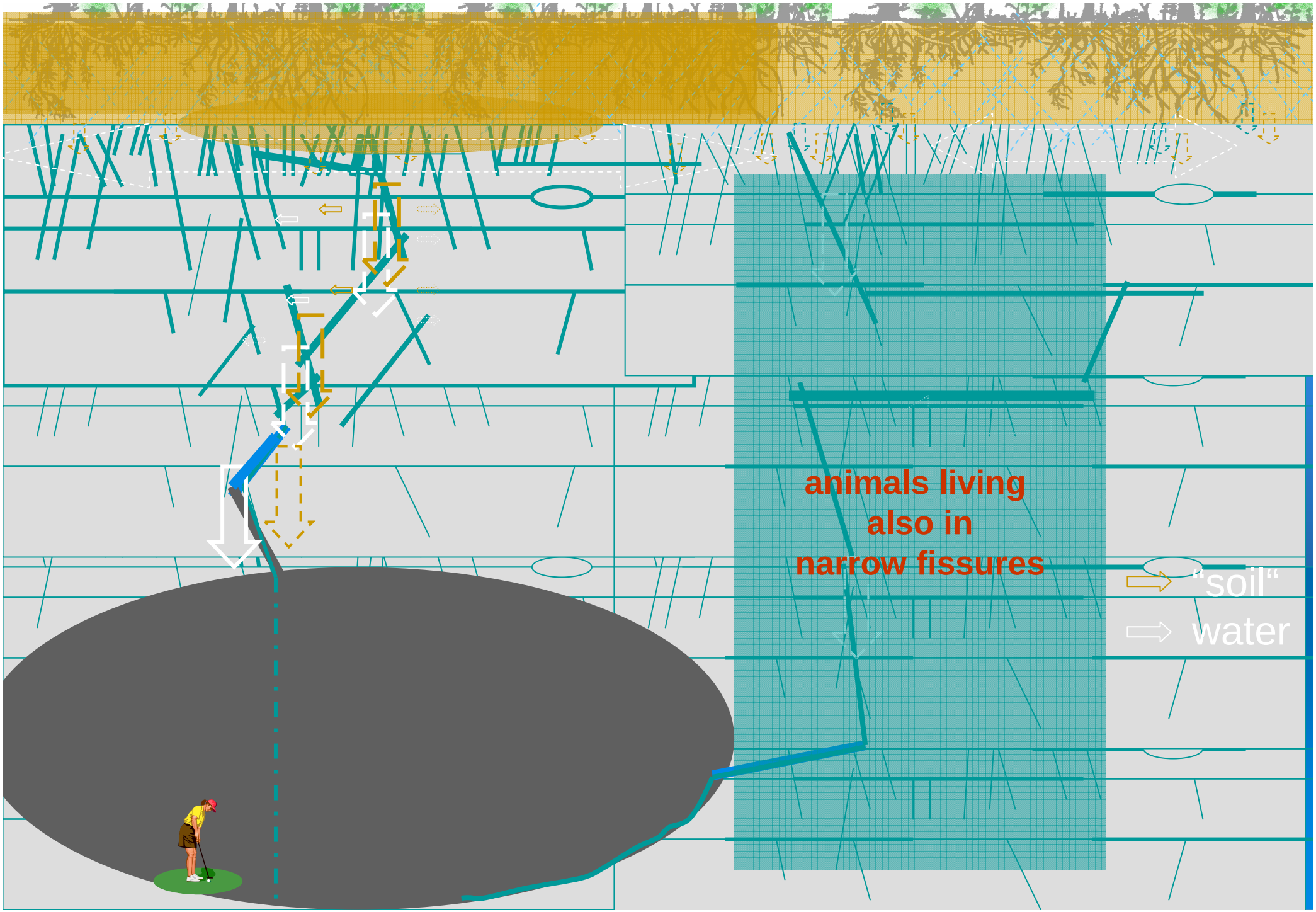
III

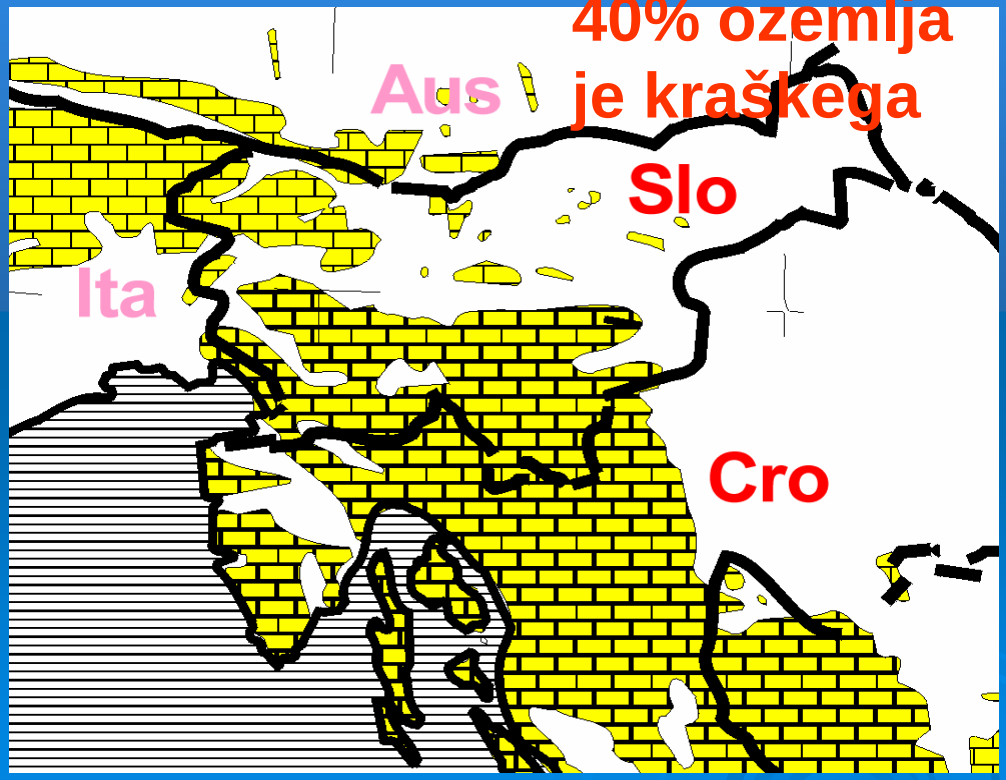

animals living
also in
narrow fissures
"soil"
water

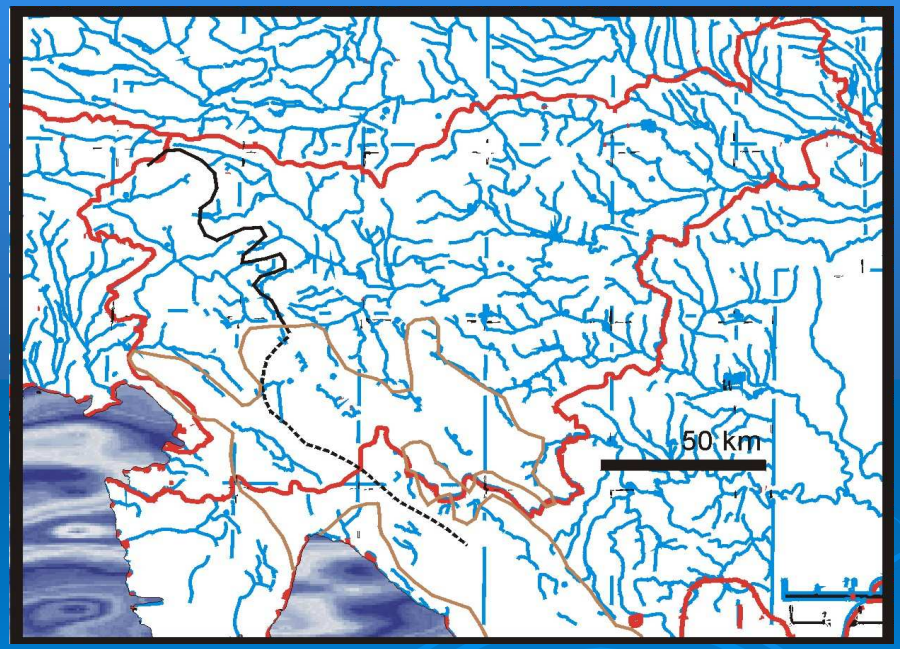
(Slovenia is rich in both:

40% of its area is karst
the rest is rich in streams and gravel-sand deposits)

- vir pitne vode pri nas skoraj izključno intersticialne in jamske kraške vode, zato varstvo podzemeljskih habitatov **praktično pomembno**

zato v Sloveniji pomembna tudi speleobiologija





drugod talna voda v naplavinah

Are subterranean habitats rich in fauna?
Not particularly, but ...

- 8% of European aquatic species are **troglobionts** (i.e. obligate subterranean).

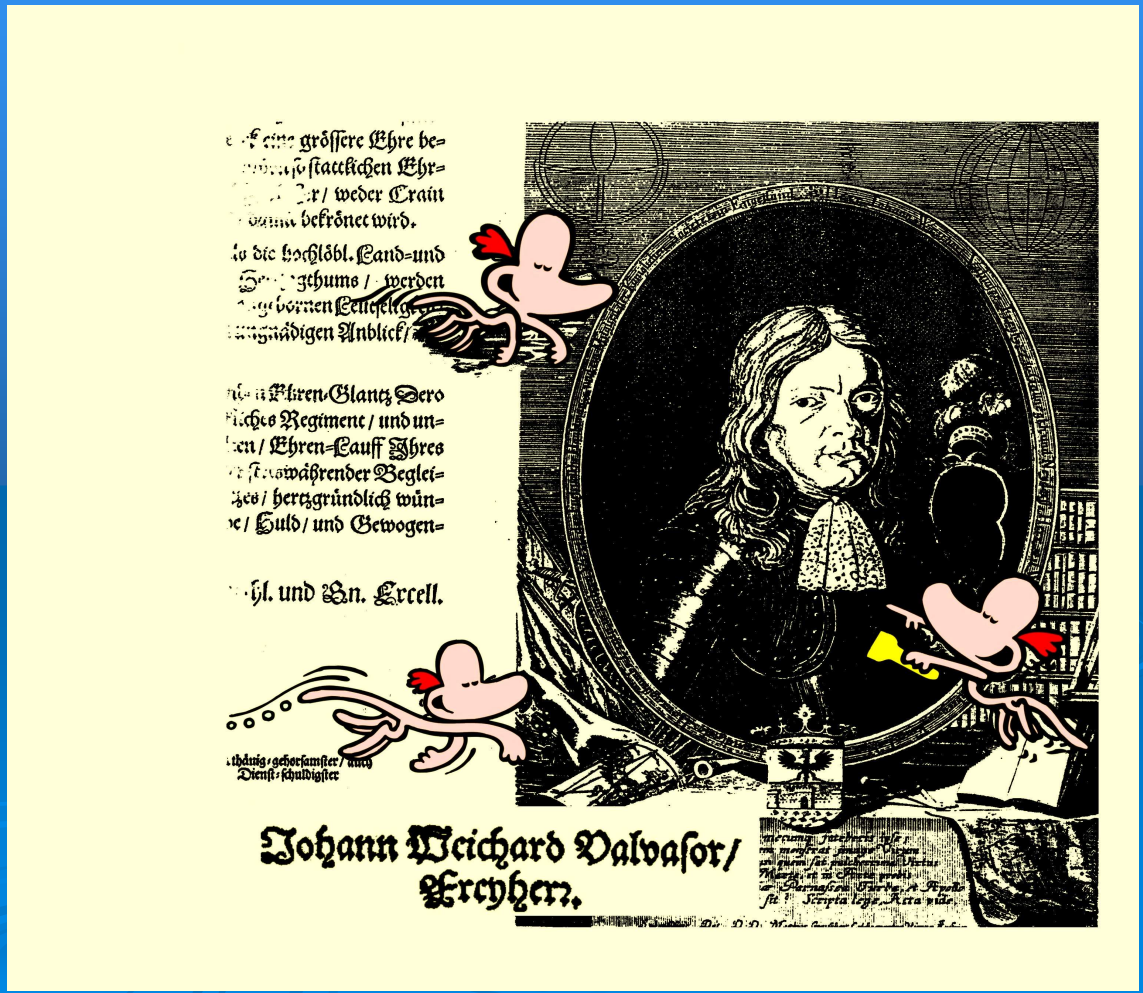
- some crustacean groups are close to 100% troglobiotic.

AQUATIC FAUNA, EUROPE	EUROPE	all aquatic species	stygo-xenes & stygo-philes	stygo-bites	troglobionts - in % of all species
Turbellaria (ex Tricladida)		315	5	8	2
Turbellaria: Tricladida		120	11	60	50
Rotatoria		1440	x	0	0
Gastrotricha		135	x	0	0
Nematoda		595	28	75	13
AMERIA (ex. Mollusca)		**2600**	**44**	**145**	**6**
Gastropoda		450	2	70	15
Bivalvia		46	5	1	2
AMERIA: Mollusca		**500**	**7**	**70**	**14**
ANNELIDA		**210**	**10**	**30**	**13**
CHELICERATA: Acarina		**1065**	**25**	**135**	**13**
Copepoda		525		269	51
Anostr + Notostr + Conchostr.		65	0	0	0
Cladocera		140	10	5	3
Ostracoda		415	20	75	18
Bathynellacea		40	0	40	100
Decapoda		35	2	8	23
Isopoda		170	5	145	85
Amphipoda		348	33	140	40
CRUSTACEA		**1735**	**105**	**685**	**39**
Insecta		**6010**	**?20**	**2**	**~0**
lover INVERTEBRATA		**6,110**	**190**	**1,065**	**17.40**
INSECTA		**6,010**	**x**	**2**	**0.03**
VERTEBRATA Pis+Am+Re		**420**	**x**	**1**	**0.20**
Total		**12,540**	**190+x**	**1,070**	**8.5**

Sket 1999

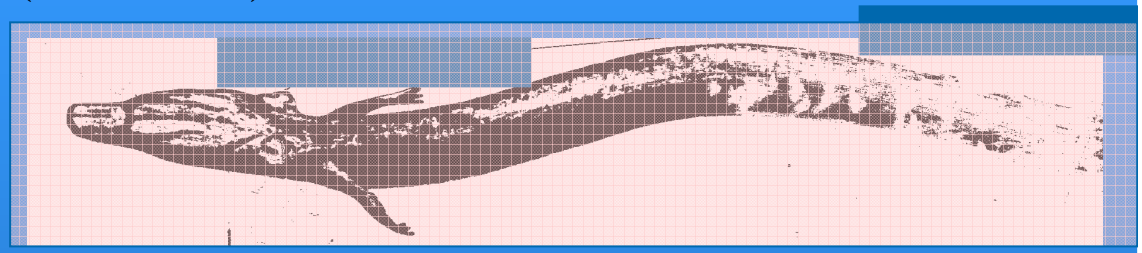
By chance (or not),
first troglobionts were found in Slovenia.

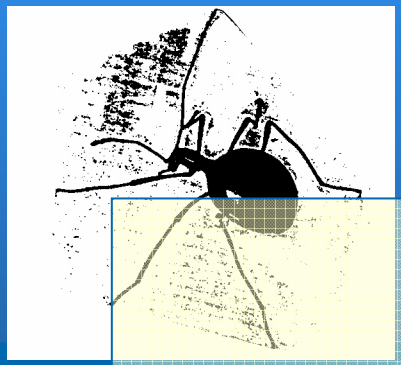
J.W. Valvasor, 1689

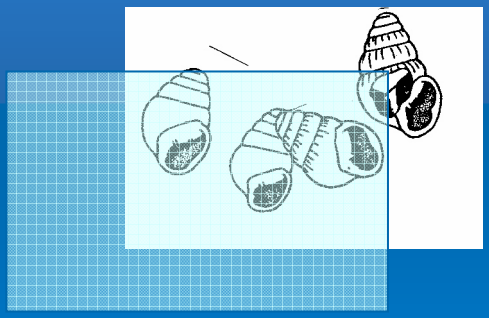


ZGODOVINA SPELEOBIOLOGIJE

TUJI AVTORJI	cit.		"DINARSKI" AVTORJI
KITAJSKA. STEKLASTA RIBA		1541	
		70	
Tauste 1678 (opis gvačara)		80	
		90	Valvasor 1689 (močeril, črne race)
		1700	
		10	
		20	
		30	
		40	
		1750	
		60	
Laurenti 1768 (opis *Proteus*), Scopoli 1772 (Plantae, *Proteus*)		70	
		80	
		90	
Humboldt 1799 (*Steatornis*) Schreibers 1801 (*Proteus*)	2	1800	Jeršinovič vonLoewengreiff 1797 (močeril v jami)
		05	
	2		
		10	
		15	
	3		
		20	
	2		
		25	
	3		Čeč 1831 (našel *Leptodirus*)
		30	Schmidt 1832 (opis *Leptodirus*)
	4		Freyer 1833 (našel *Bathysciotes*)
Rossmaessler 1835 (našel polže)		35	
Rossmaessler 1837 (opis *Zospeum*)	9		
Moèulski 1840 (kavkaški j. hrošči)		40	
deKay, Wyman, Tellkampf 1842-1845 (*Amblyopsis*)	9		
		45	
Schioedte 1848	6		Schmidt 1847 (seznam Mollusca)
		1850	
Schiner 1854 (klasifikacija j. favne)	30		Schmidt 1852 (opisi Coleoptera)
Schioedte 1855		55	Schmidt 1854, 1855 (Gastrop., Coleopt.)
Delarouzee 1857 (Pirinejі)	45		







Sket 1996

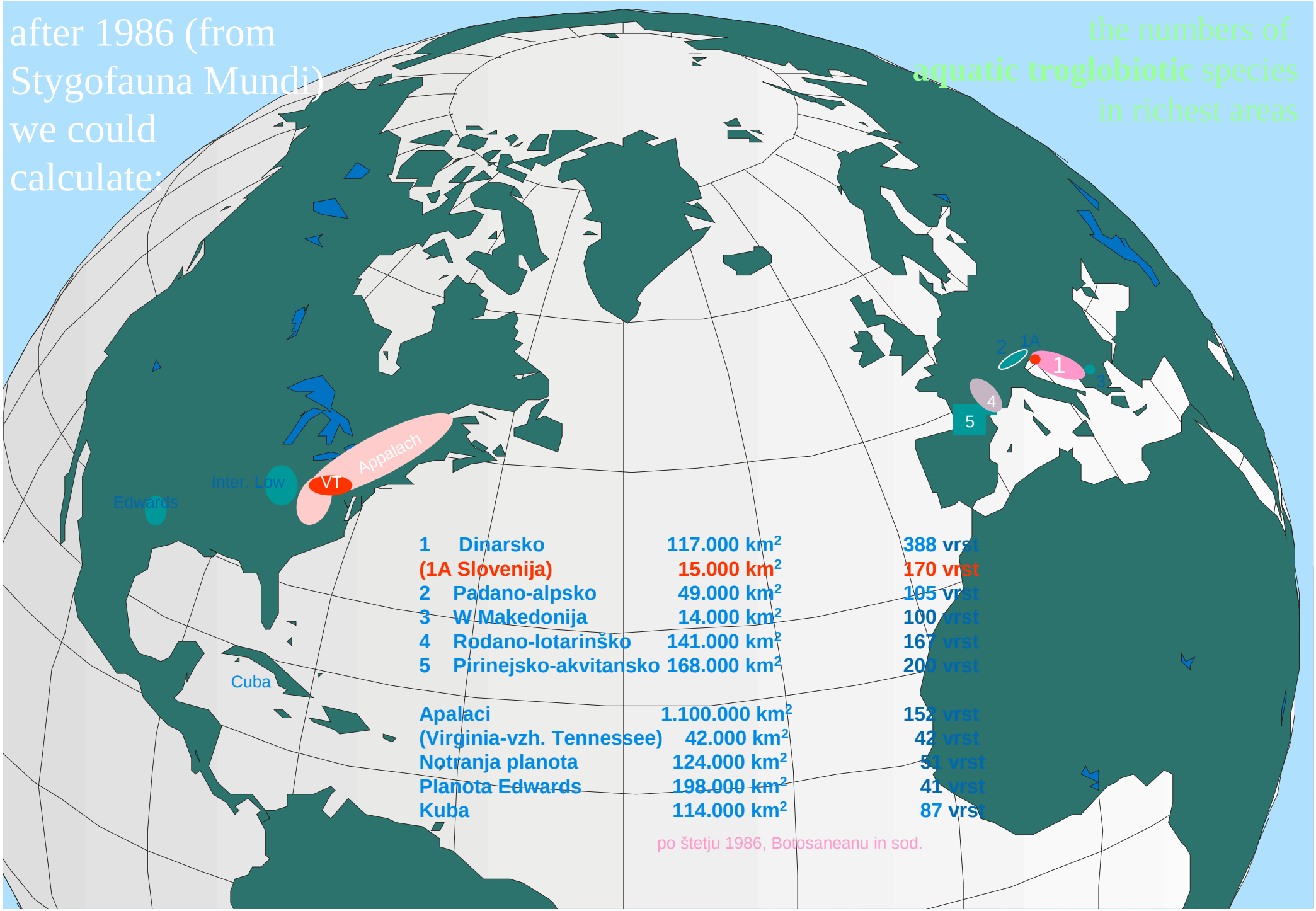

Zospeum
1 mm

By chance, this country is also
the richest in aquatic and nearly so in terrestrial troglobionts.

(In the frame of RAMSAR, both are
formally inhabitants of 'subterranean wetlands'.)

after 1986 (from Stygofauna Mundi) we could calculate:

the numbers of **aquatic troglobiotic** species in richest areas



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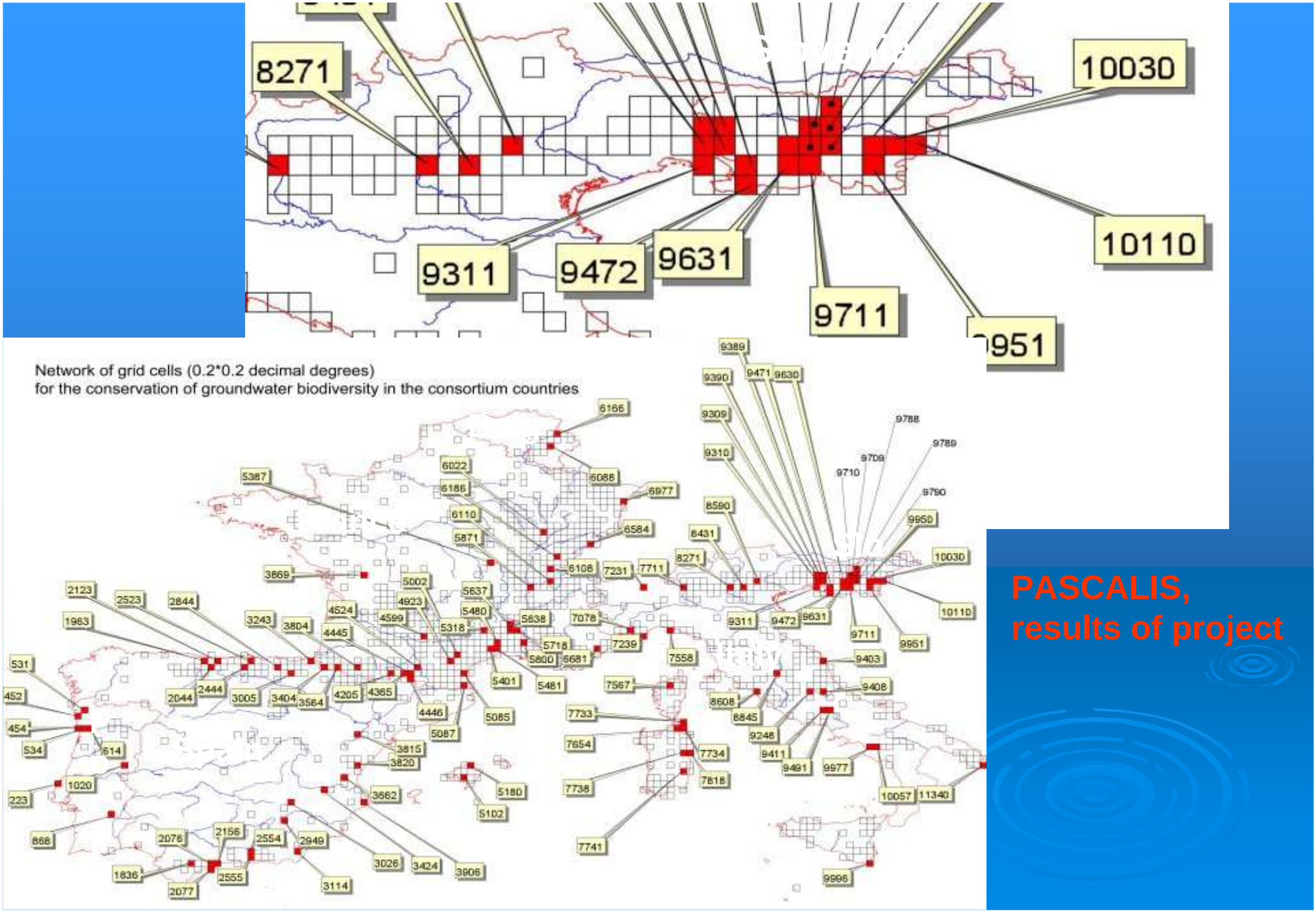
po štetju 1986, Botosaneanu in sod.



PASCALIS, results of project

PPCS is the **richest** system in the **world** by number of species:

	Mammoth **USA**	Shelta **USA**	San Marcos **USA**	Movile **Romania**	Salukkang Kallang **Indonesia**	Bayliss **Australia**	Walsingham **Bermuda**	Triadou **France**	Baget-Peyrere- **France**	Goueil di Her **France**	Sauve-Vidourle, **France**	Cent Fons, **France**	Grotta dell'Arena **Italy**	Buso della Rana **Italy**	Vjetrenica **B&H**	Šica-Krka **SLO**	PPCS **SLO**	Logarček **SLO**	Križna **SLO**	Grad **SLO**
AQUATIC	15	12	27	18	7	0	39	34	17	14	21	22	6	15	40	31	49	28	29	17
TERRESTRIAL	27	12	0	29	21	24	0	0	9	9	0	0	14	5	21	7	33	15	15	3
TOTAL	42	24	27	47	28	24	39	34	26	23	21	22	20	20	61	38	82	43	44	20

Culver & Sket 2000

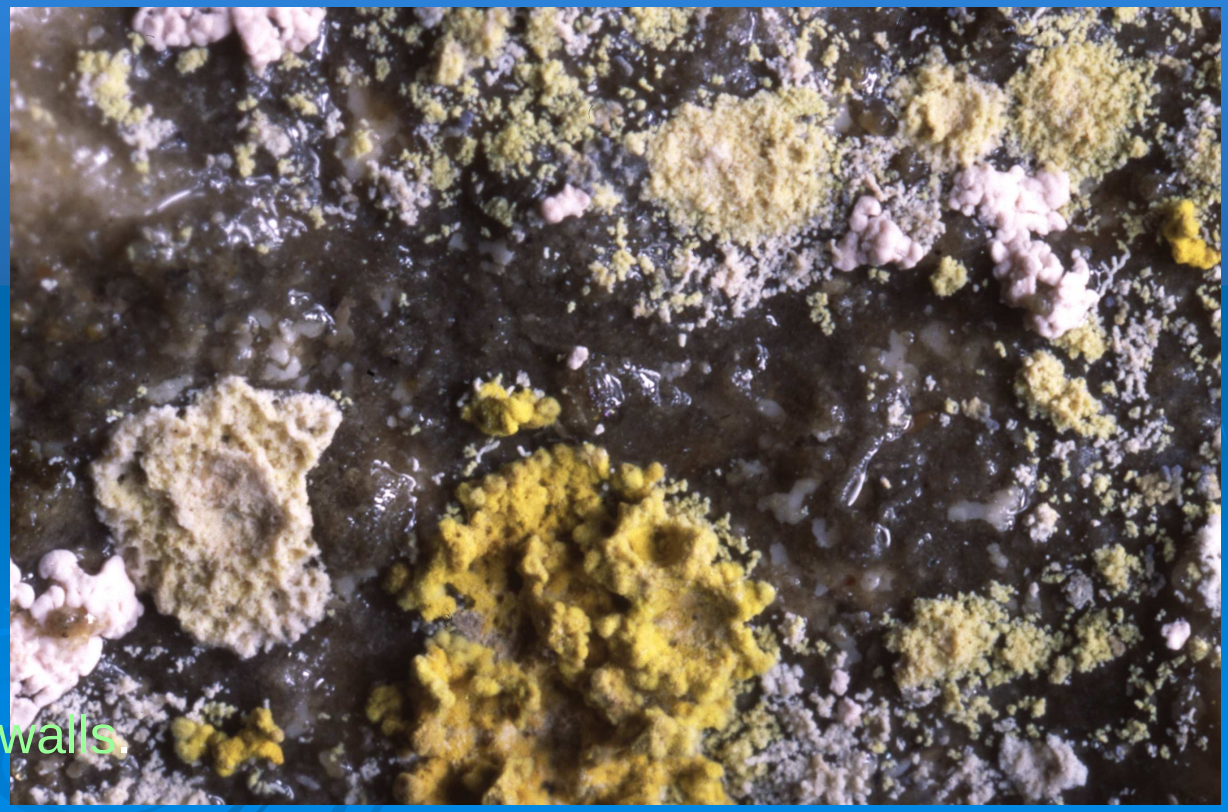
The imposing list of troglobiotic species in PPCS

troglophile species
with troglobiotic races

	AQUATIC TROGLOBIONTS		TERRESTRIAL TROGLOBIONTS
		mol-gas	*Zospeum spelaeum* Rossmaessler 1837
prot-cil	*Spelaeophrya troglocaridis* Stammer		*Zospeum alpestre rossmaesleri* Wagner 1912
tur-tem	*Troglocaridicola capreolaria* Matjašič	ara-pal	*Koenenia austriaca* Hansen
	Bubalocerus pretneri Matjašič	ara-ara	*Stalita taenaria* Schioedte 1848
tur-tri	*Dendrocoelum tubuliferum* Beauchamp	ara-pse	*Neobisium spelaeum* Schioedte 1848
cni-hyd	*Velkovrhia enigmatica* Matjašič & Sket		*Neobisium pusillum* Beier 1939
mol-gas	*Belgrandiella kusceri* A.J.Wagner		*Chthonius cavernarum* Ellington
	Belgrandiella schleschi (Kuščer)		*Roncus stussineri* Simon
	Hadziella ephippiostoma Kuščer	ara-opi	*Hadziana postumicola* Roewer 1935
	Iglica luxurians (Kuščer)	ara-aca	Acarina div.
	Hauffenia michleri Kuščer		*T. spelaeum, T. coecum* Joseph - spp. dubiae
	Neohoratia subpiscinalis (Kuščer)	cru-iso	*Titanethes albus* Schioedte 1848
	Acroloxus tetensi (Kuščer)		*Androniscus cavernarum tschammeri* Strouhal
	Ancylus fluviatilis O.F.Mueller *	myr-chi	*Lithobius stygius* Latzel 1880
	Zospeum exiguum Kuščer		*Monotarsobius zveri* Matic & Stentzer
ann-oli	*Sketodrilus flabellisetosus* (Hrabe)	myr-dip	*Acherosoma troglodytes* Latzel 1884
	Psammoryctides hadzii Sp.Karaman		*Attemsia stygium* Latzel 1884
	Potamothrix postojnae Sp.Karaman	myr-sym	*Scolopendrellopsis pretneri* Juberthieu-Jupeau
	Epirodrilus slovenicus Sp.Karaman	ins-apt	(*Achorutes spelaeus* Joseph 1882 - sp. dubia)
	Rhyacodrilus sketi Sp.Karaman		*Onychiurus boldorii* Denis 1938
	Trichodrilus ptujensis Hrabe		*Onychiurus giganteus* Absolon 1901
	Trichodrilus strandi Hrabe		*Onychiurus postumicus* Bonet 1931
ann-hir	*Dina krasensis* (Sket) *		*Onychiurus stachianus* Bagnall 1939
cru-ost	*Pseudocandona trigonella* (Klie)		*Onychiurus stillicidii* Schioedte 1848
	Typhlocypris schmeili Mueller		*Oncopodura cavernarum* Stach 1934
cru-cop	*Troglodiaptomus sketi postojnae* Brancelj		(*Tomocerus niveus* Joseph 1882 - sp. dubia)
	Acanthocyclops kieferi (Chappuis)		(*Smirthurus coecus* Joseph 1882 - sp. dubia)
	Acanthocyclops venustus stammeri (Kiefer)		*Plusiocampa erebophila* Hamann 1896
	Diacyclops charon (Kiefer)	ins-col	*Anophthalmus schmidti* Sturm
	Diacyclops slovenicus (Petkovski)		*Anophthalmus hirtus confusus* G. Mueller
	Metacyclops postojnae Brancelj		*Anophthalmus pubens*
	Speocyclops infernus (Kiefer)		*Typhlotrechus bilimeki*
	Bryocamptus (L.) dacicus (Chappuis)		*Laemostenes cavicola* (Schaum)
	Bryocamptus (B.) pyrenaicus (Chappuis)		*Bathyscimorphus byssinus* (Schioedte)
	Elaphoidella cvetkae Petkovski		*Bathysciotes khevenhuelleri* (L.Miller)
	Elaphoidella franci Petkovski		*Aphaobius milleri* F.Schmidt
	Elaphoidella jeanneli (Chappuis)		*Leptodirus hochenwarti* F.Schmidt
	Elaphoidella stammeri (Chappuis)		*Machaerites ravasinii* (G.Mueller)
	Elaphoidella elaphoides (Chappuis)	cru-amp	*Synurella ambulans* Mueller *
	Morariopsis scotenophila (Kiefer)		*Niphargus stygius* Schioedte
cru-dec	*Troglocaris anophthalmus* (Kollar)		*Niphargus wolfi* Schellenberg
cru-iso	*Asellus aquaticus* (Linne)*		*Niphargus aquilex* ssp.
	Monolistra racovitzai Stammer		*Niphargus orcinus* ssp.

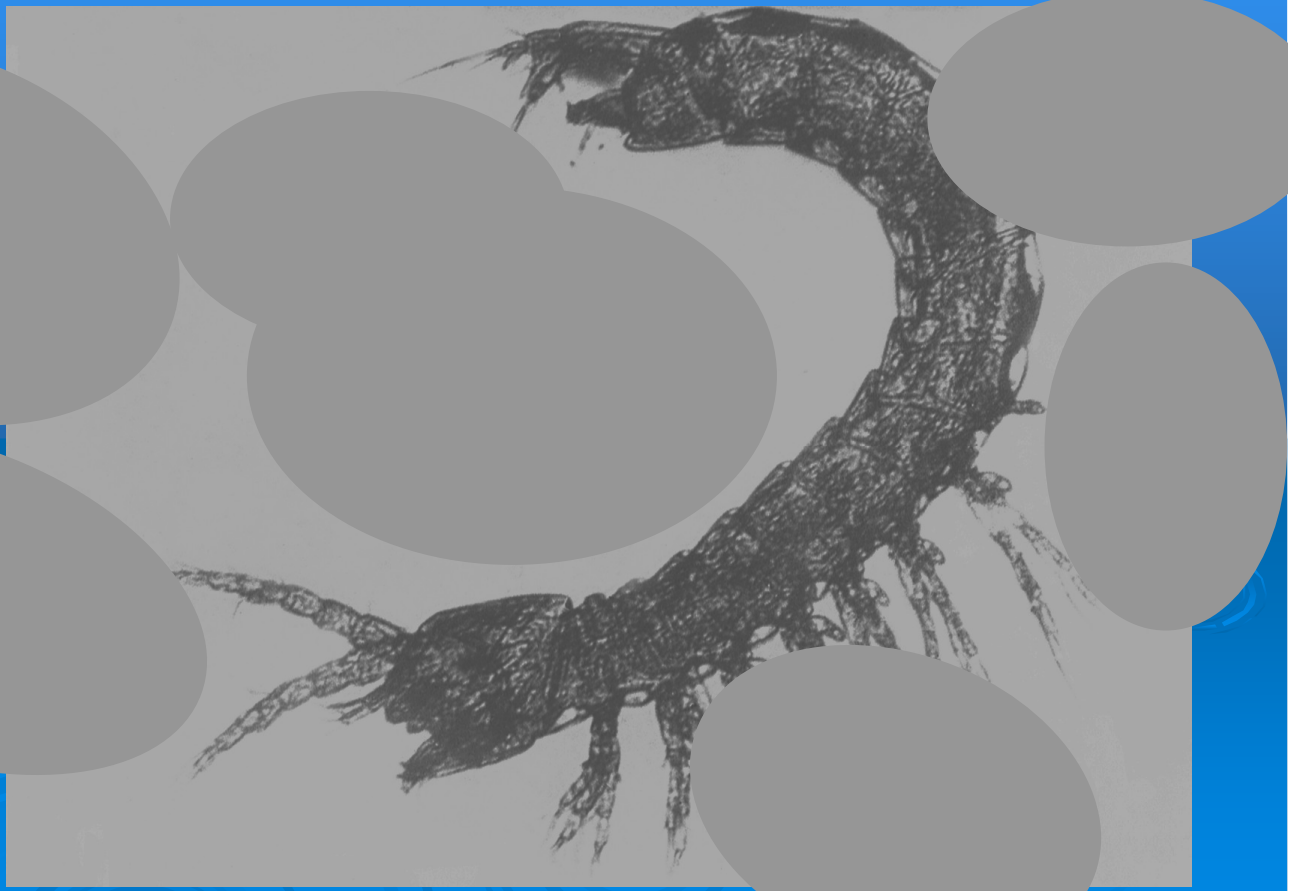
Do you know subterranean animals?

What about Bacteria?

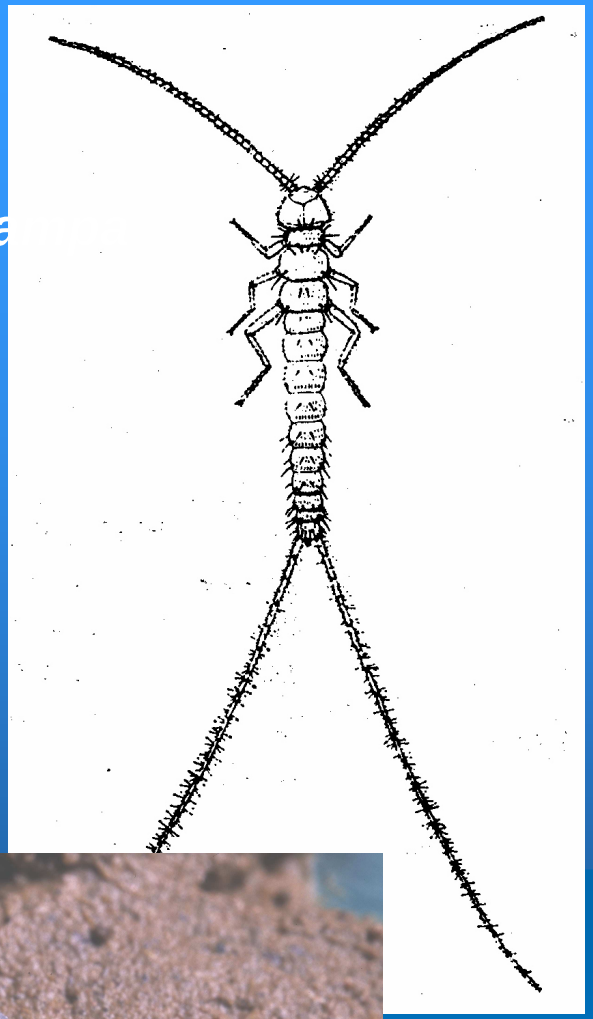


For **Bacteria** only these beautiful Actinomycetales from damp cave walls.

Parabathynella sp., tipičen intersticialni rakec **peščinar**;
tel. dolžina 1 mm



Diplura:
Plusioca



Collembola: cf
Tomocerus scutellatus

Crustacea: Isopoda
Titanethes albus

Diplopoda:

Glomeris

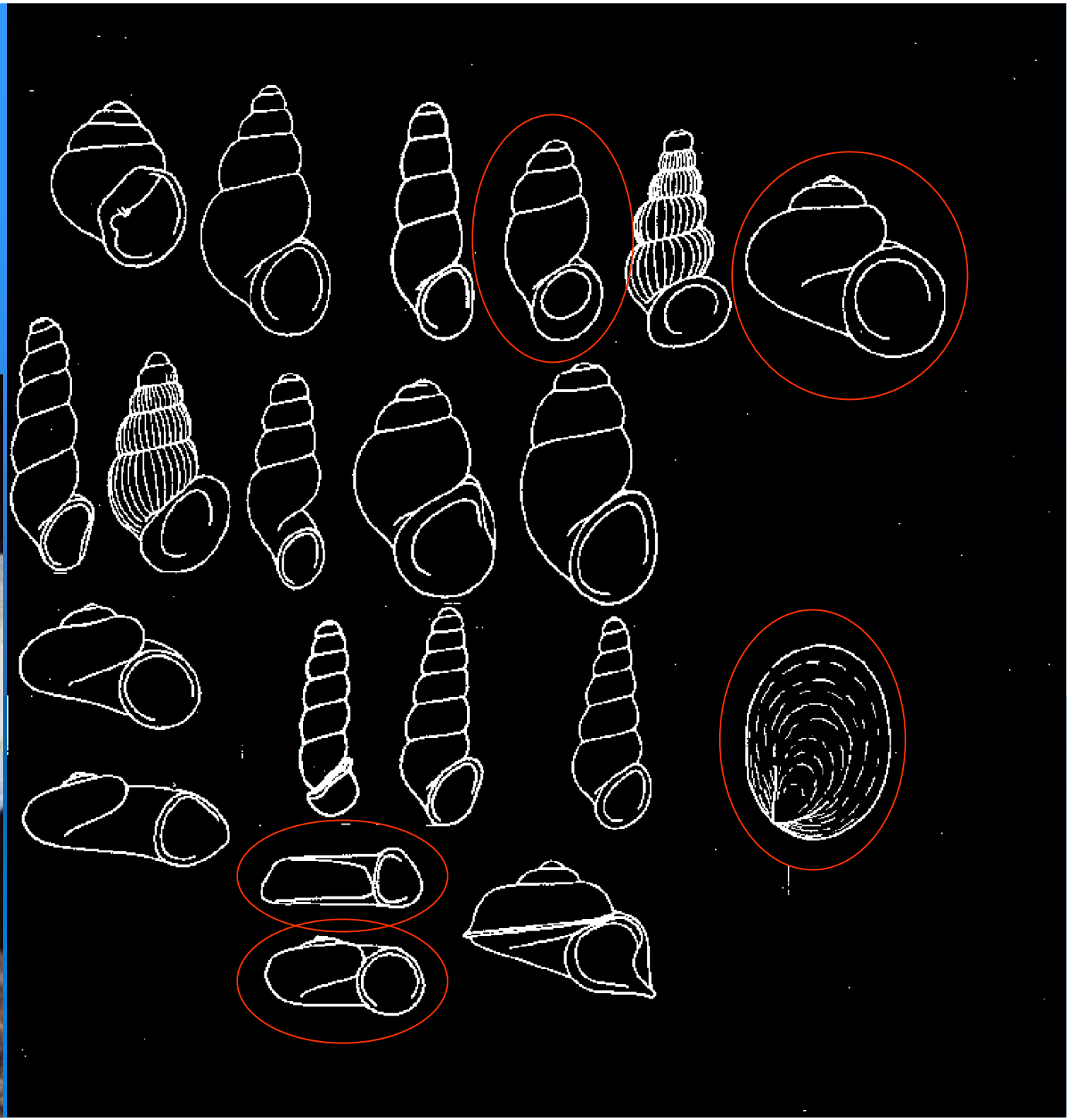
Typhloglomeris

Stalita taenaria

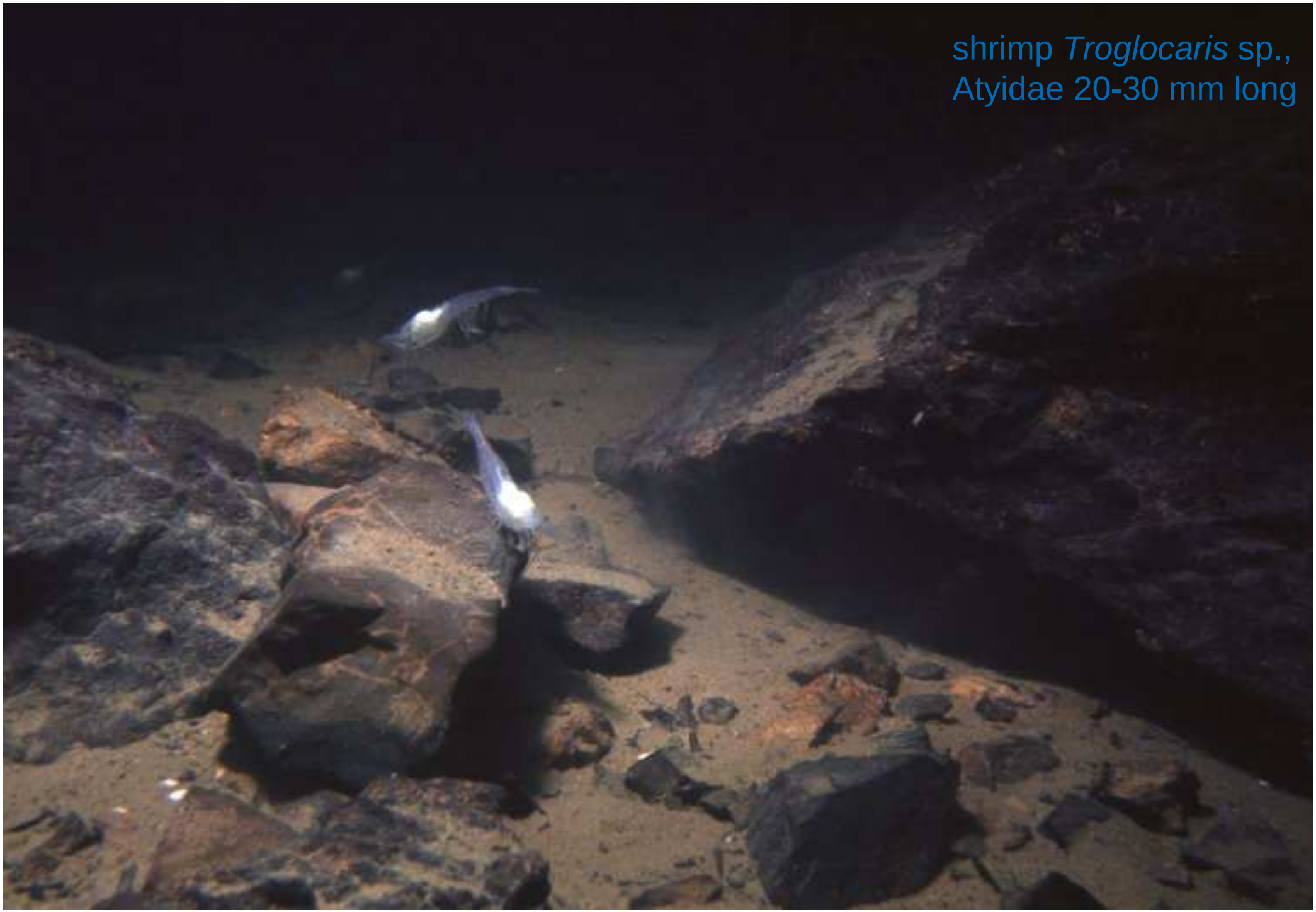
Chilopoda:
Polybothrus obrovensis

Zospeum amoenum – Duboki do

a rich assortment of snails Gastropoda



opalworm *Delaya bureschi*


shrimp *Troglocaris* sp.,
Atyidae 20-30 mm long

Crustacea: Amphipoda
Niphargus stygius

Crustacea: Amphipoda
Niphargus* gr *orcinus

Monolistra (Microlistra)

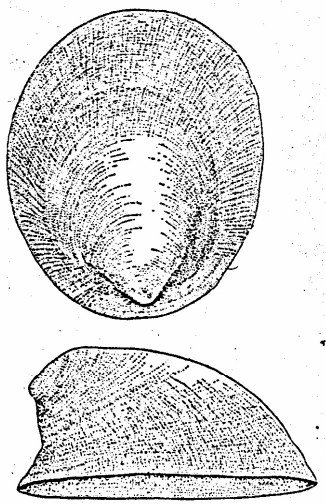
dinarsko podzemlje ni le bogato z vrstami,
v njem najdemo tudi zelo nenavadne oblike

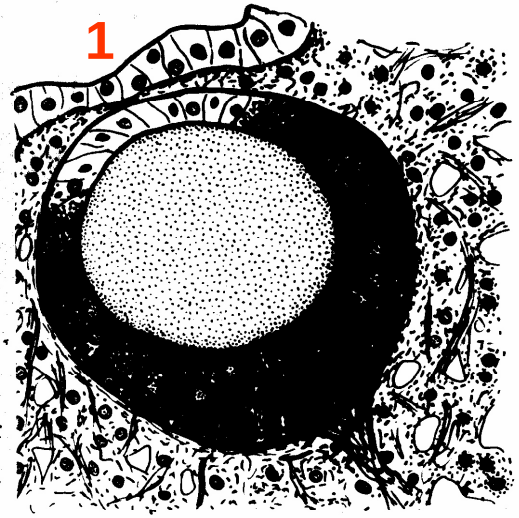
Monolistra (Microlistra) spinosa

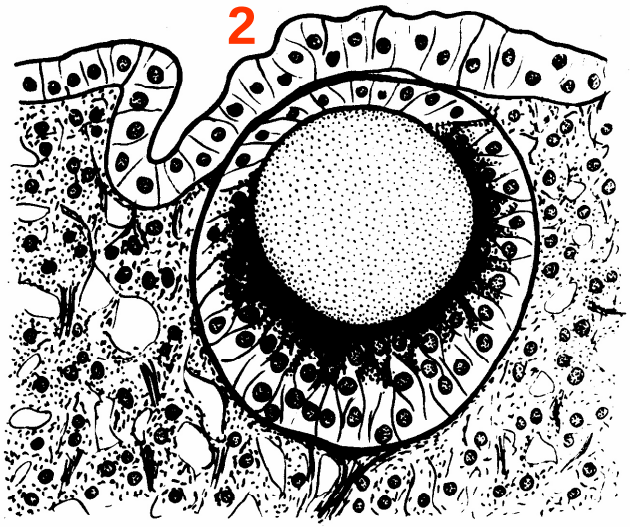
tubeworm *Marifugia*

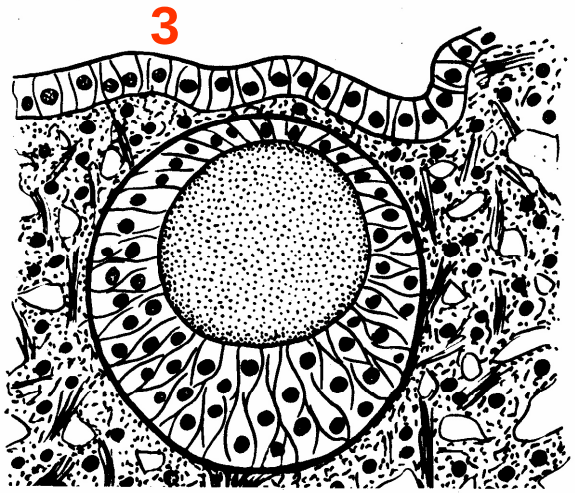
morphological changes

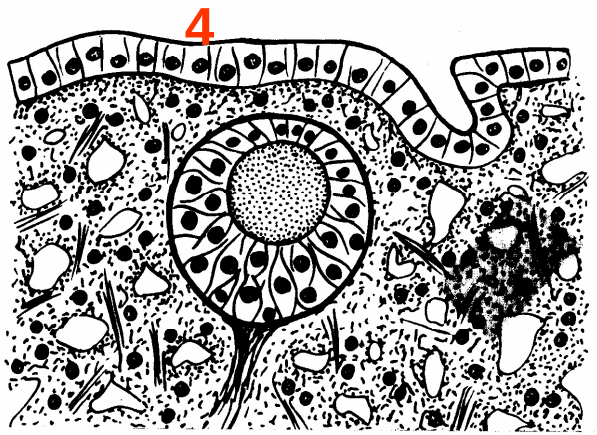
troglomorphisms











aquatic snail
Ancylus fluviatilis
in subterranean Pivka:

gradual eye reduction

Crustacea: Isopoda

Asellus aquaticus

complex morphological changes:
depigmentation and eye reduction,
elongation of appendages
changes in shape and spinulation
etc

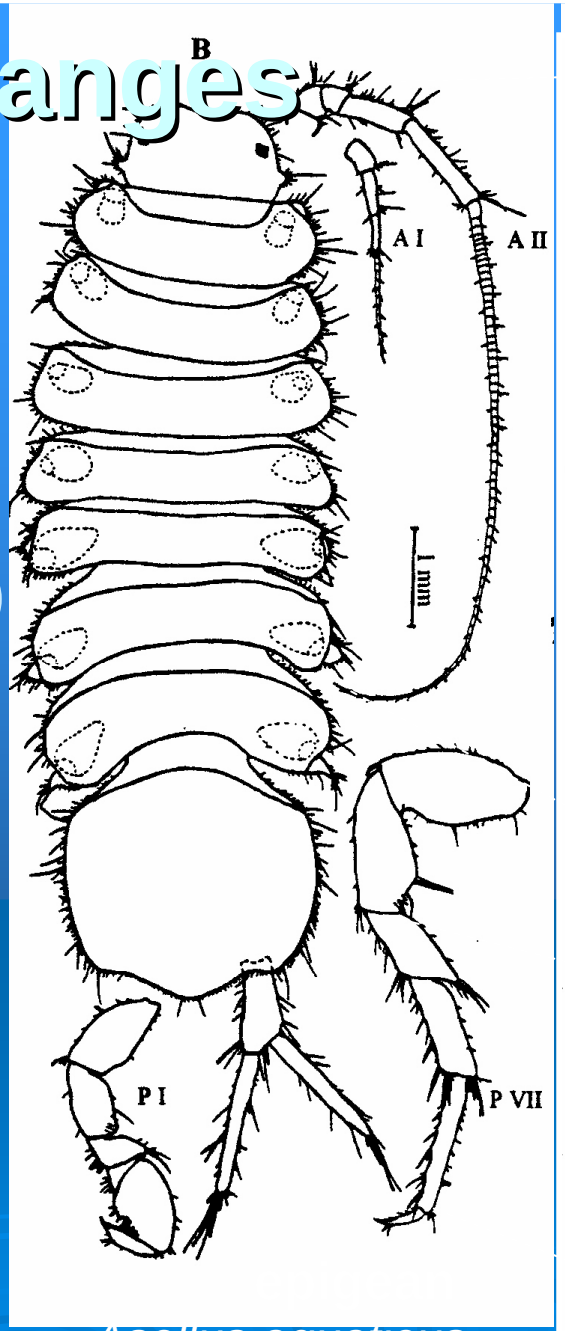
morphological changes

troglomorphisms

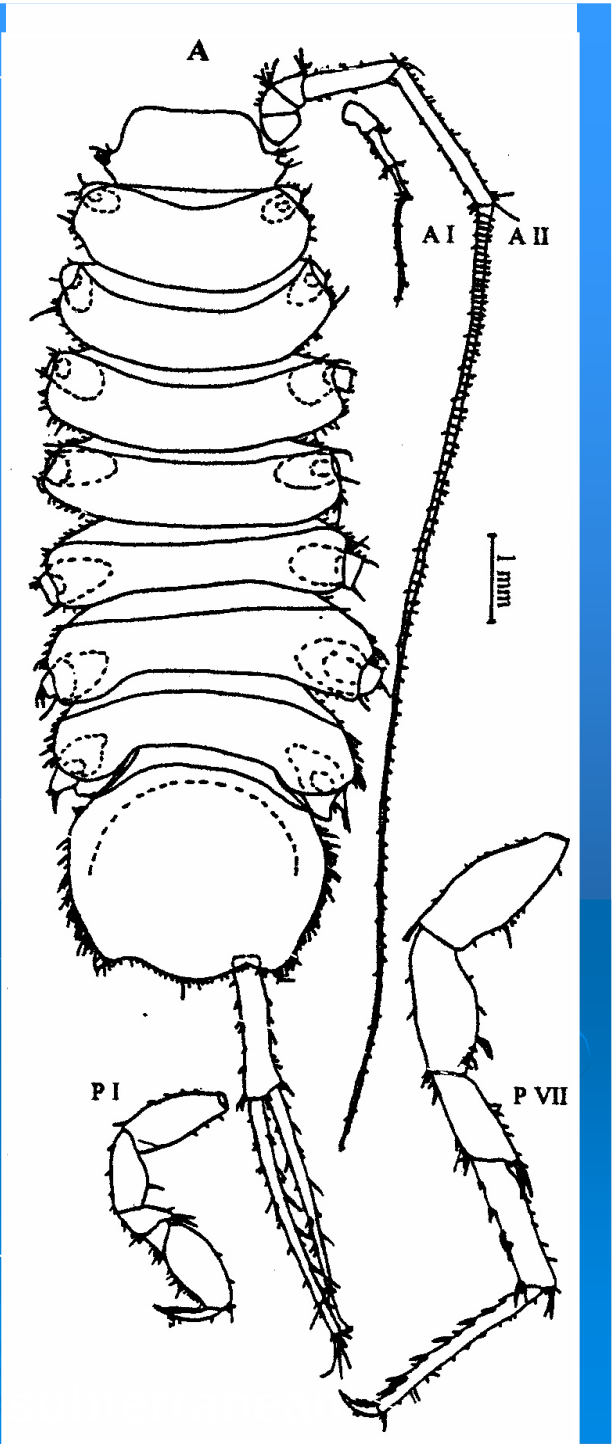
reductive adaptations
(eye reduction, depigmentation)

constructive adaptations
(elongation of appendages)

Prevorčnik et al 2004



Asellus aquaticus



In subterranean biodiversity,
the world hot-zone is in
northern moderate climates,

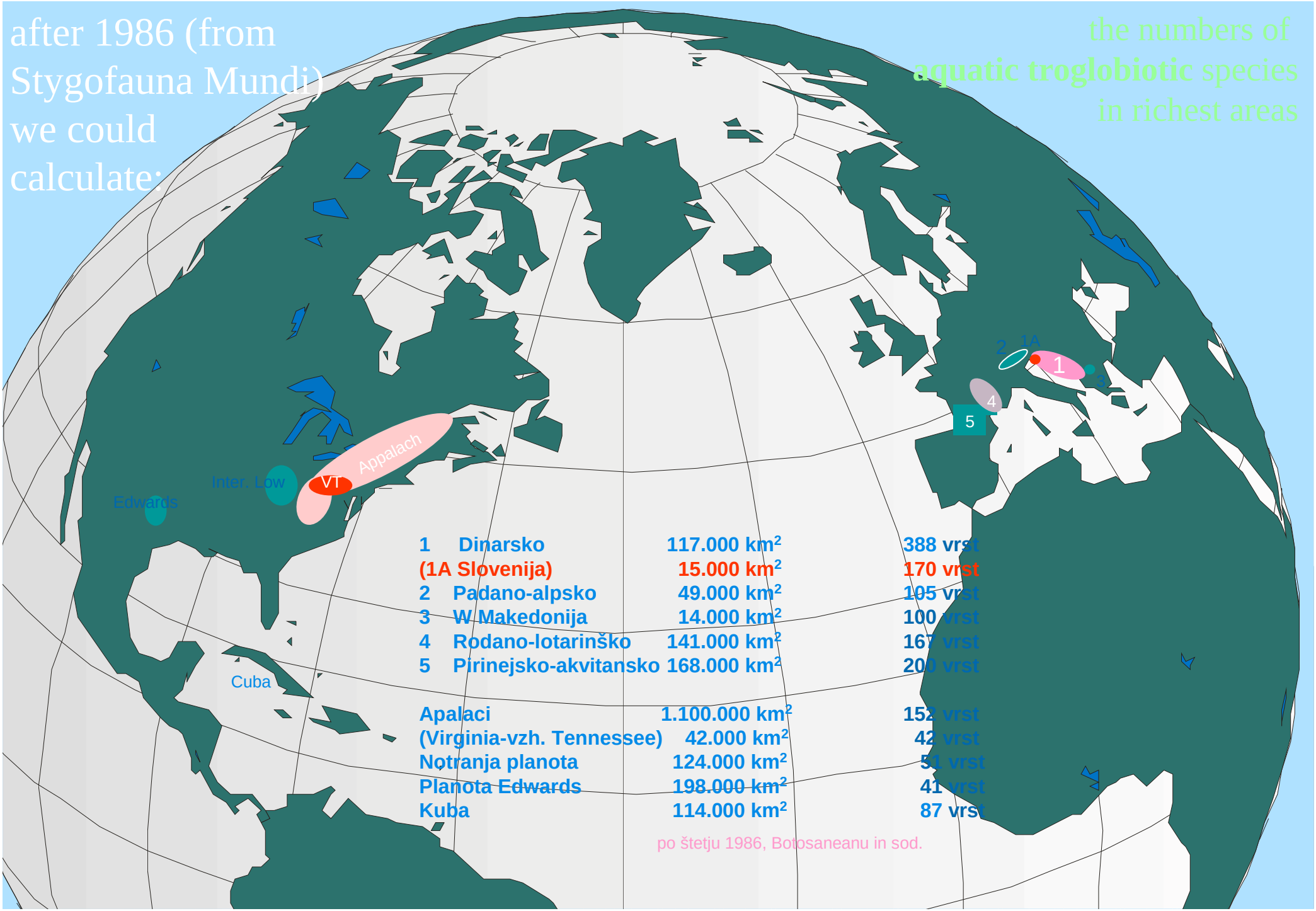
their hottest segment is in **southern Europe**,

the European hot-area is **Balkan peninsula**,

the real global hot-spot is **Dinaric area**
(karst and attached valleys).

after 1986 (from Stygofauna Mundi) we could calculate:

the numbers of **aquatic troglobiotic** species in richest areas



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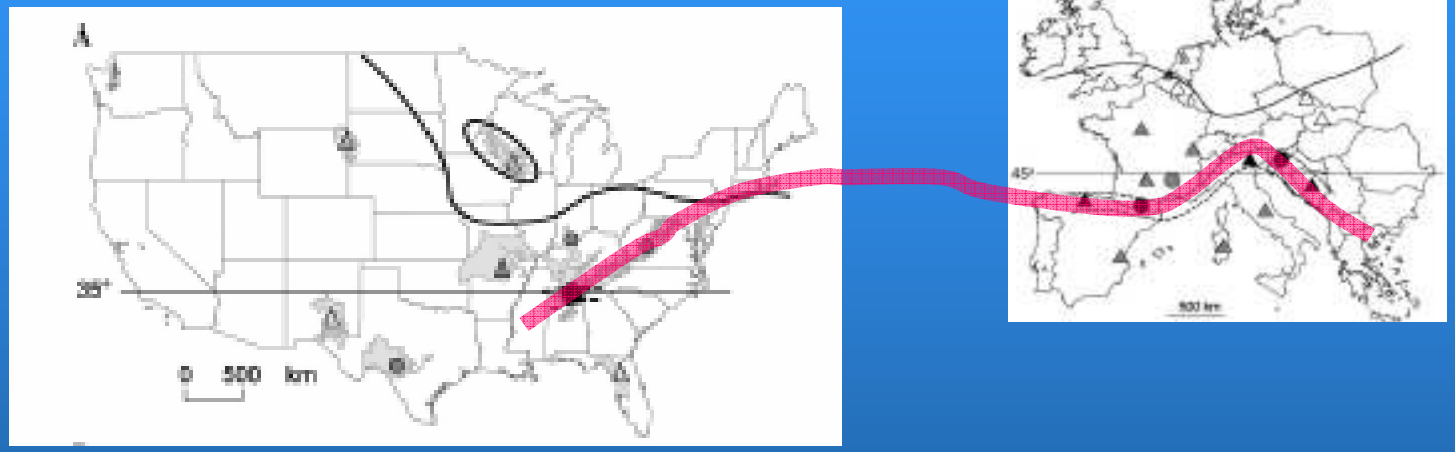


Culver et al 2006

Europa is a global hotspot of subterranean biodiversity …

USA & Canada	spp	spp	Balkan Peninsula
		1	Porifera
		13	Tur: Temnocephalida
Tur: Tricladida	27	12	Tur: Tricladida
		1	Cnidaria
Moll: Gastropoda	27	162	Moll: **Gastropoda**
		1	Moll: Bivalvia
		x	Nematoda
		1	Nemertini
Ann: Polychaeta		3	Ann: Polychaeta
Ann: Oligochaeta	6	22	Ann: Oligochaeta
		5	Ann: Hirudinea
		x	Ara: Acarina
		4	Cru: Cladocera
Cru:Copepoda	8	175	Cru: **Copepoda**
Cru: Ostracoda	10	45	Cru: Ostracoda
Cru: Bathynellacea	1	8	Cru: Bathynellacea
Cru: **Decapoda**	28	4	Cru: Decapoda
Cru: Thermosbaenacea	1	2	Cru: Thermosbaenacea
		1	Cru: Mysidacea
Cru: **Isopoda**	71	65	Cru: **Isopoda**
Cru: **Amphipoda**	221	135	Cru: **Amphipoda**
Ins: Coleoptera	3		
Ver: **Pisces**	6		
Ver: **Amphibia**	12	1	Ver: Amphibia
N America: STGB …	**421**	**661**	**STGB: Balkans s. str.**

Balkan Peninsula is a hotspot within Europe …

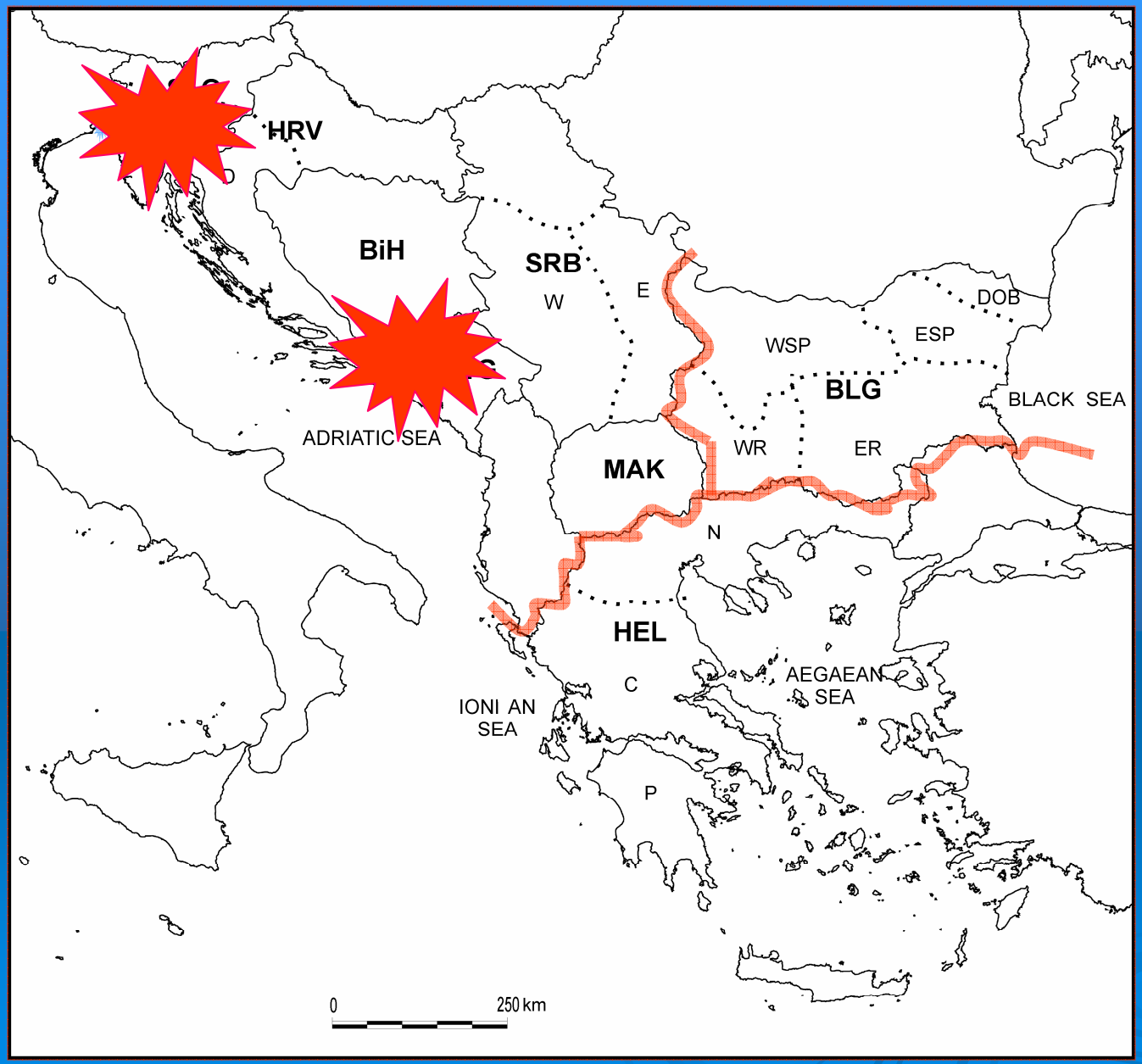
numbers of aquatic troglobiotic species

NOT Slovakia
SLOVENIA
NOT Slavonia
45oN
North Sea
Mediterranean Sea

45oN
PACIFIC OCEAN
ATLANTIC OCEAN

Balkan Peninsula

internal hotspots



Sket, Paragamian, Trontelj 2004

Subterranean fauna **is endangered**, because:

- **out of sight, out of mind** – **society does not care about,**

- most species are strict endemics,
therefore the **extinction** (of a population)
may be forever (for the species).

Distribution of Copepoda-**Cyclopoida** spp.
through regions in Limnofauna Europaea, 1978

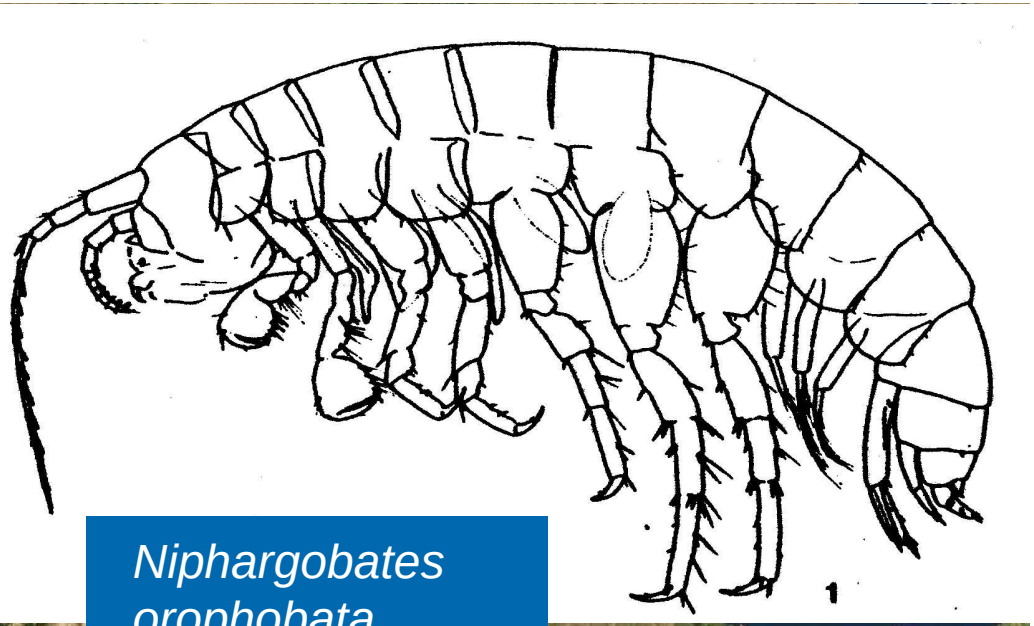
in **1** region	in **2 - 5** regions	**6 or more** regions	**also outside** Europe	
50*	**10**	**2**	**0**	troglobionts
6	**6**	**27**	**18**	non-troglobionts

(* numerous with only one locality)

Sket 1999

N. orohobata

an endemic



Niphargobates orophobata

and its closest relative

N. lefkodemonaki

What endangers subterranean species?
Any **changes of habitats**:

- directly: hydrotechnical measures,
industry with inorganic pollution, agriculture,
husbandry with heavy organic pollution;

- indirectly: slight organic pollution
(abused by surface immigrants-competitors);

Only **exceptionally**: collecting
for commercial purposes.

POLYSAPROBIEN

(Leitorganismen für außergewöhnlich stark

A

(Vergrößerung 10000:6fac

1. Zoogloea ramigera (Bäumchenbakterie)
2. Sarcina paludosa (Bakterie in Paketform)
3. Streptococcus margaritaceus (Kettenbakter
4. Beggiatoa alba (weiße Schwefelbakterie)
5. Chlorobacterium aggregatum (grüne Schwef
6. Sphaerotilus natans (Fadenstück d. „Abwa
7. Achromatium oxaliferum (weiße Schwefelb
8. Chromatium Okenii (rote Schwefelbakterie)
9. Oscillatoria putrida (Blaualge)
10. Trigonomonas compressa (Geißeltierchen)
11. Spirulina Jenneri (Blaualge)
12. Euglena viridis (Geißeltierchen)
13. Bodo putrinus (Geißeltierchen)
14. Tetramitus pyriformis (Geißeltierchen)

B

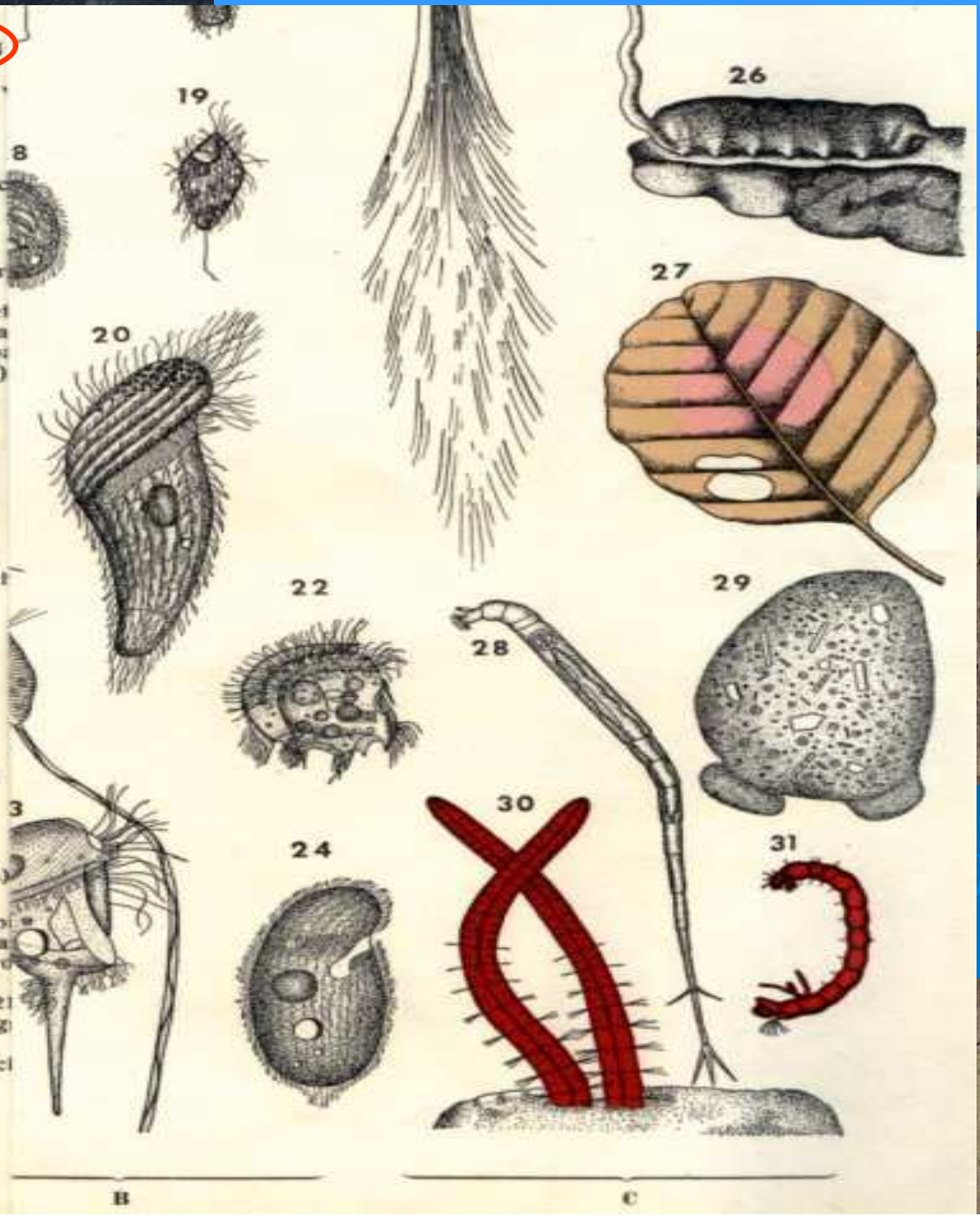
(Vergrößerung 2000:6fac

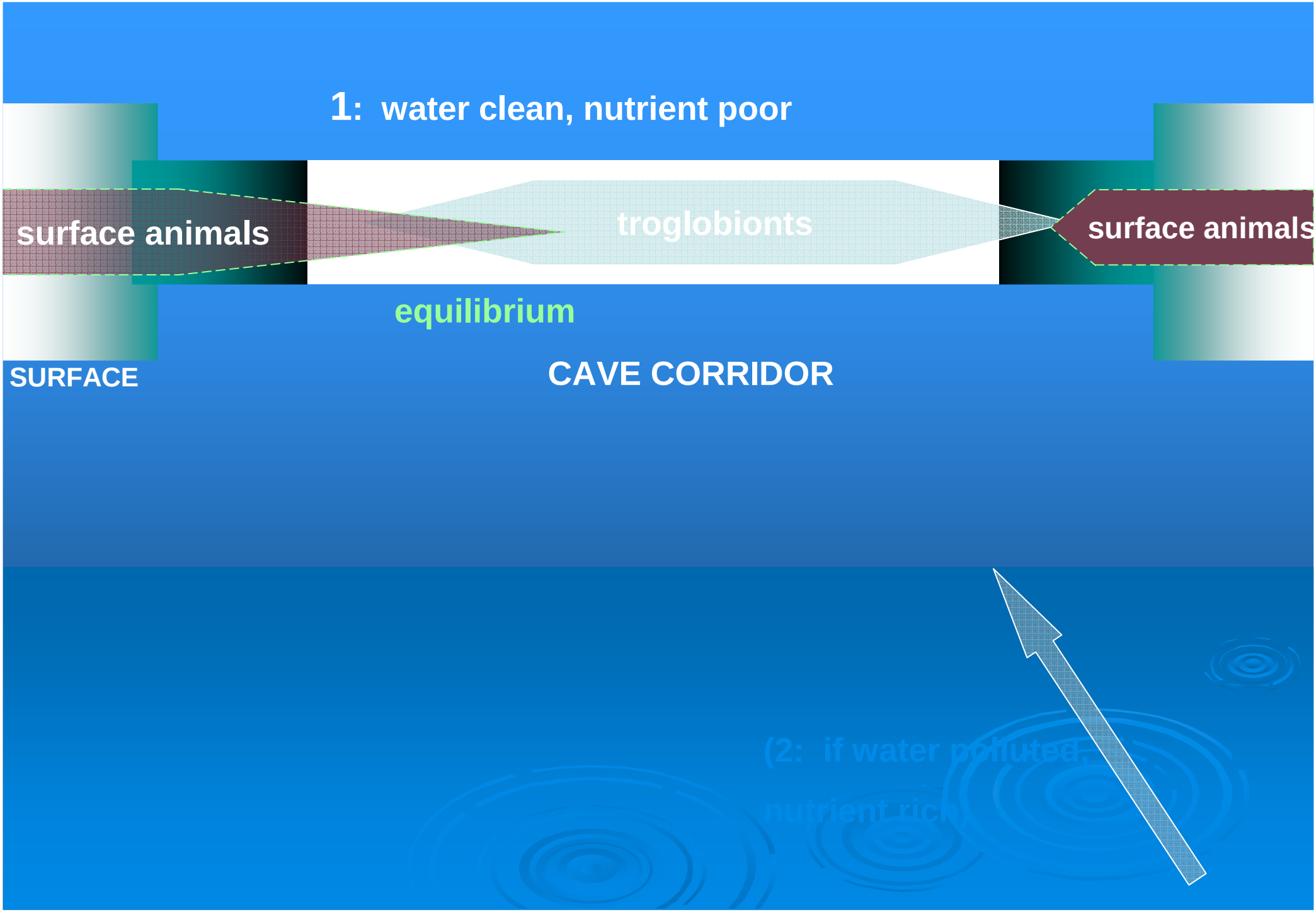
15. Hexotricha caudata (Wimpertierchen)
17. Enchelys vermicularis (Wimpertierchen)
18. Glaucoma scintillans (Wimpertierchen)
19. Trimyema compressa (Wimpertierchen)
20. Metopus es (Wimpertierchen)
21. Vorticella microstoma (Glockentierchen)
22. Saprodinium dentatum (Wimpertierchen)
23. Caenomorpha medusula (Wimpertierchen)
24. Colpidium colpoda (Wimpertierchen)

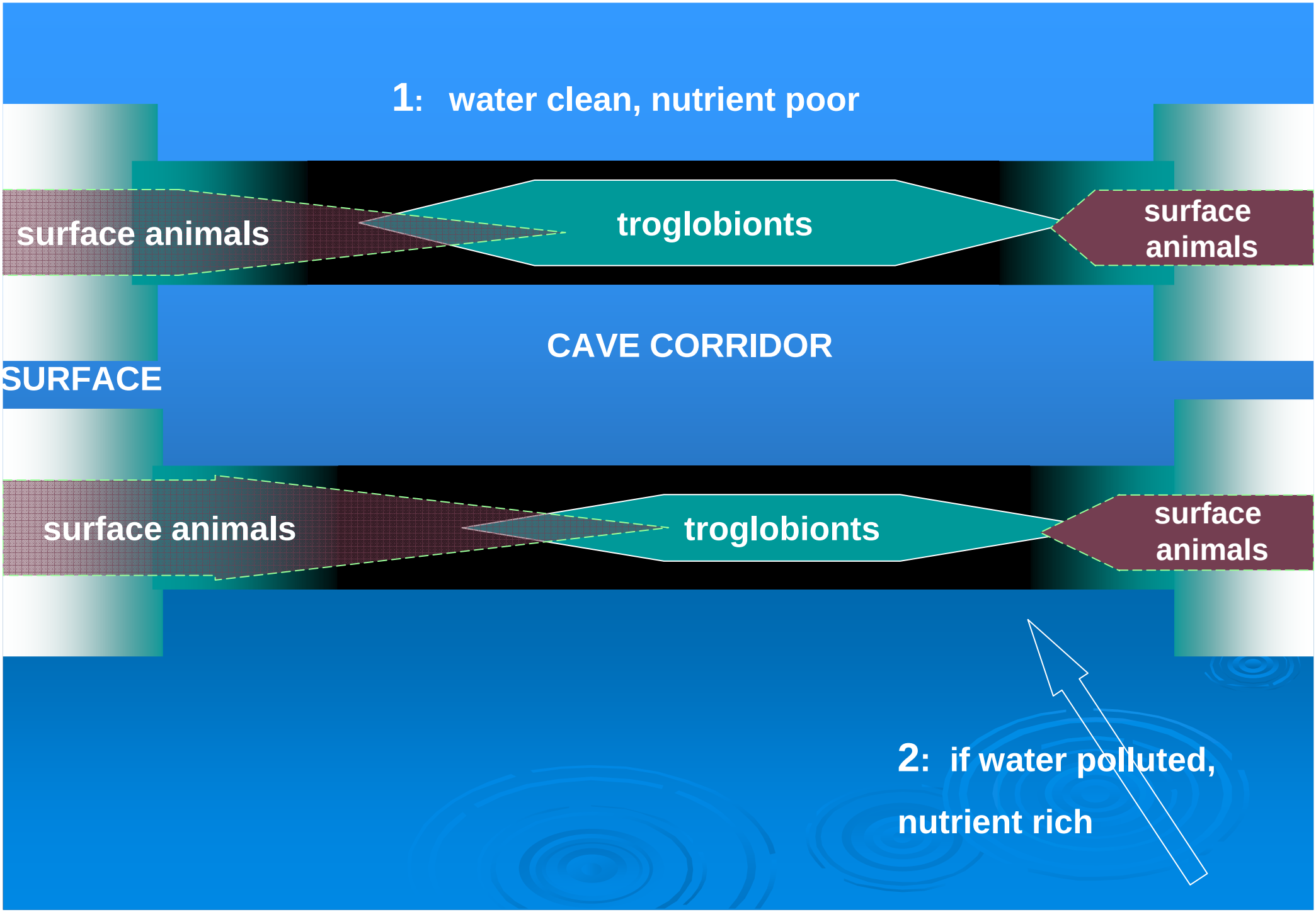
C

(Vergrößerung 100:6fach)

25. Sphaerotilus natans (Zotte des „Abwasserp
26. Larve von Eristalis tenax (Rattenschwanzla
27. Lamprocystis roseo-persicina (Kolonien r
    auf einem Laubblatt)
28. Rotaria neptunia (Rädertierchen), Vergr. 2
29. Pelomyxa palustris (Wechseltierchen), Verg
30. Tubifex rivulorum (roter Schlammwurm)
31. Chironomus thummi (Larve der roten Zuc




1: water clean, nutrient poor
surface animals
troglobionts
surface animals
equilibrium
SURFACE
CAVE CORRIDOR
(2: if water polluted,
nutrient rich


1: water clean, nutrient poor
surface animals
troglobionts
surface animals
CAVE CORRIDOR
SURFACE
surface animals
troglobionts
surface animals
2: if water polluted,
nutrient rich

Our **Research Group for Zoology and Speleobiology** in	
Oddelek za biologijo Biotehniška fakulteta Univerza v Ljubljani	Biology Department Biotechnical Faculty University of Ljubljana

Boris SKET
speaking here

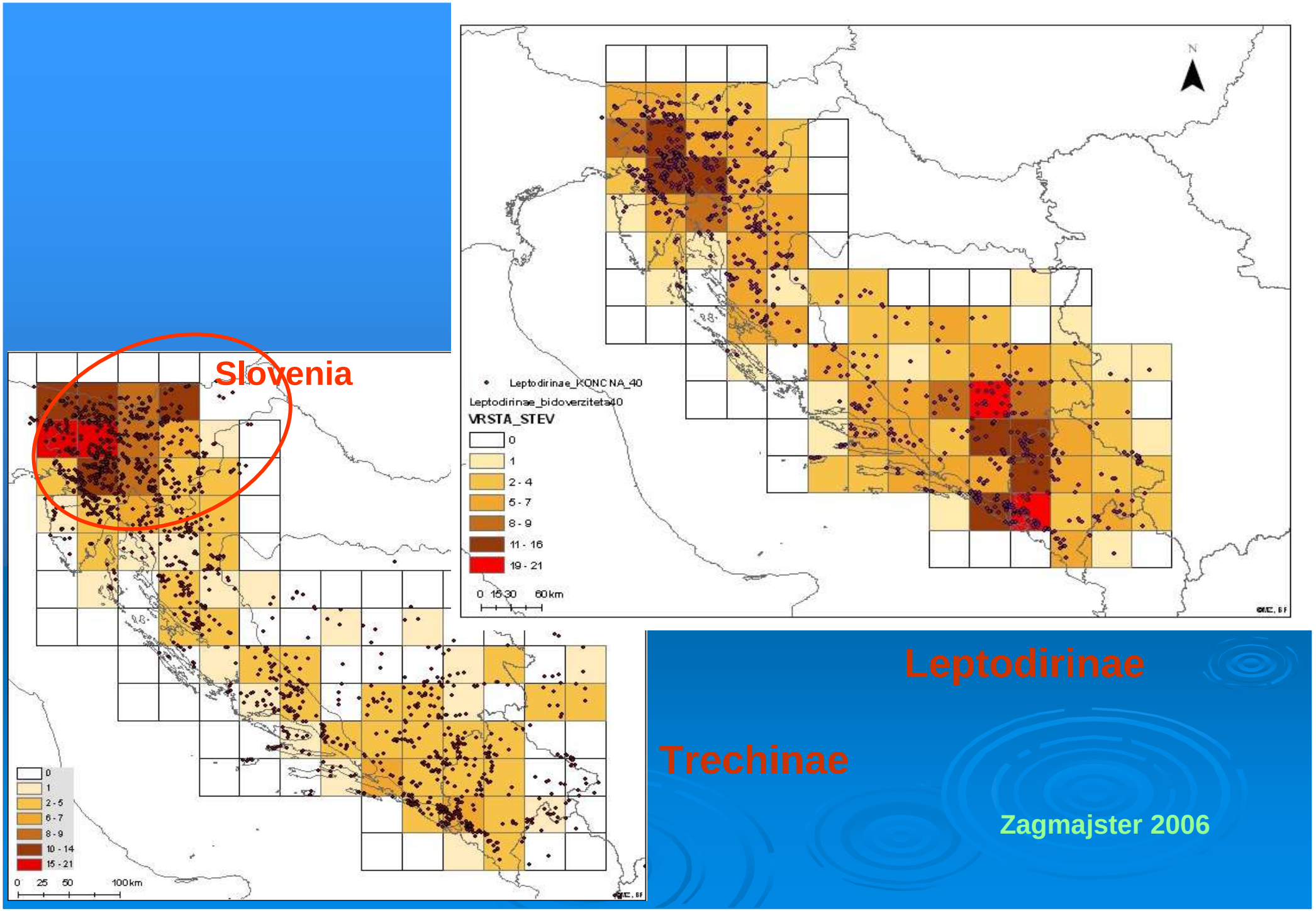
is cataloging the subterranean fauna – mainly (but not only) of Slovenia and Dinarides (W Balkans)

- studying patterns of its biodiversity

- studying its distribution patterns (biogeography)

- discovering also its molecular diversity

- and performing some ecological investigations


Slovenia
Leptodirinae_KONCNA_40
Leptodirinae_bidoverziteta40
VRSTA_STEV
0
1
2 - 4
5 - 7
8 - 9
11 - 16
19 - 21
0 15 30 60 km
0
1
2 - 5
6 - 7
8 - 9
10 - 14
15 - 21
0 25 50 100 km
Leptodirinae
Trechinae
Zagmajster 2006

because:

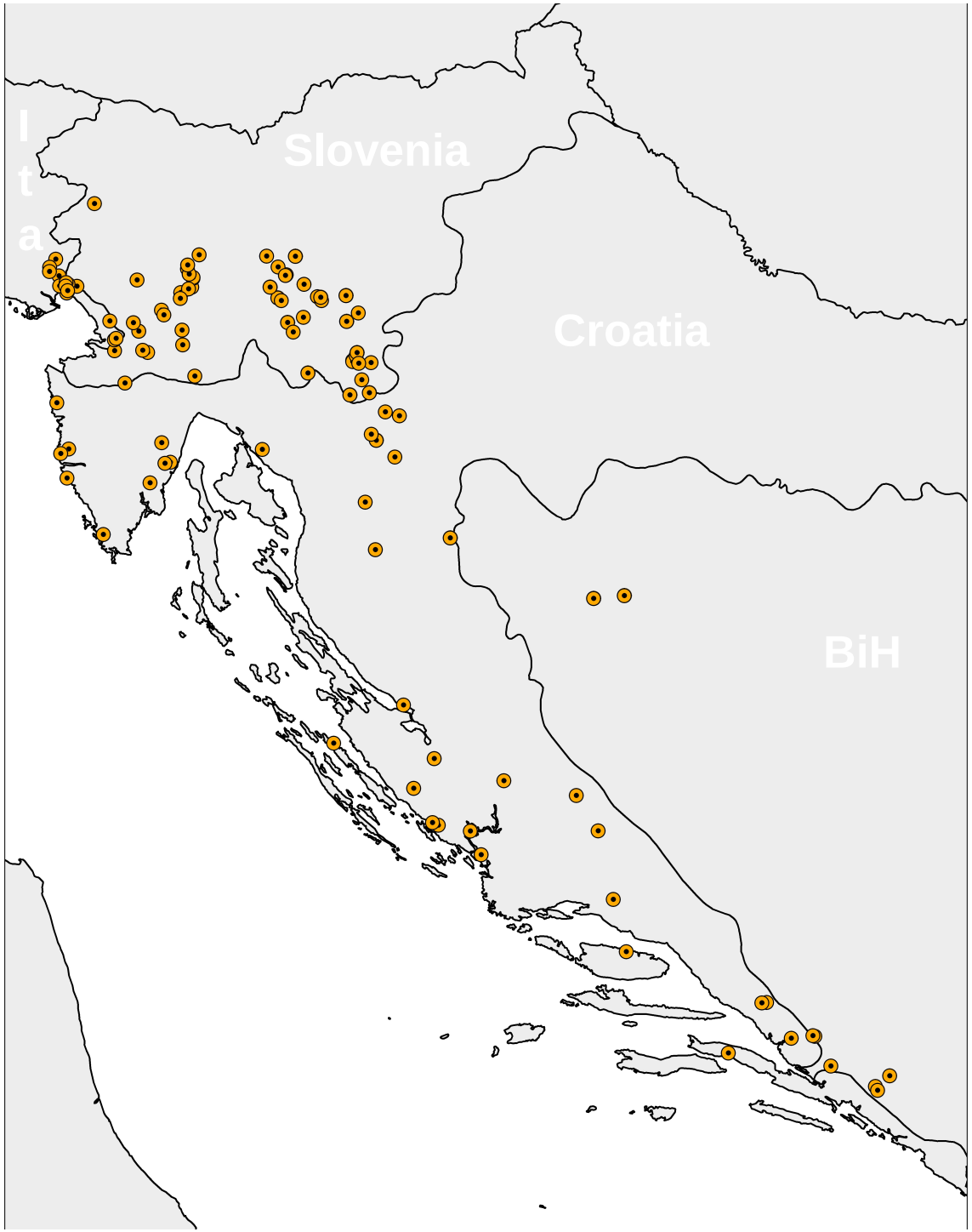
- local investigations may be useful
  for administrative purposes

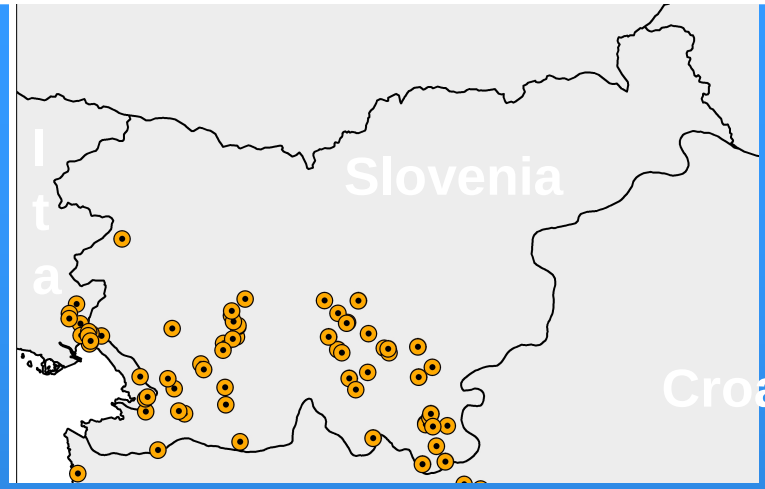
- but regional or global investigations are often necessary to make findings scientifically important, predictable-predicting, and globally useful.

C (1986) Stygofauna:	1.7a	1.7b	1.7c	1.7d	1.7e	1.7f	1.7
	Slovenia S+W	Istria	Croatia SW+S	BiH	Serbia W	Mtg+Kos	
area km²	14,900	3,600	25,500	51,100	33,800	24,500	153,400
taxa:							
total (endemic)	169 (113)	24 (9)	102 (60)	99 (55)	15 (6)	55 (36)	396 (309)

a result of
faunistic sampling
and …

these are
localities of
Troglocaris ‘anophthalmus’

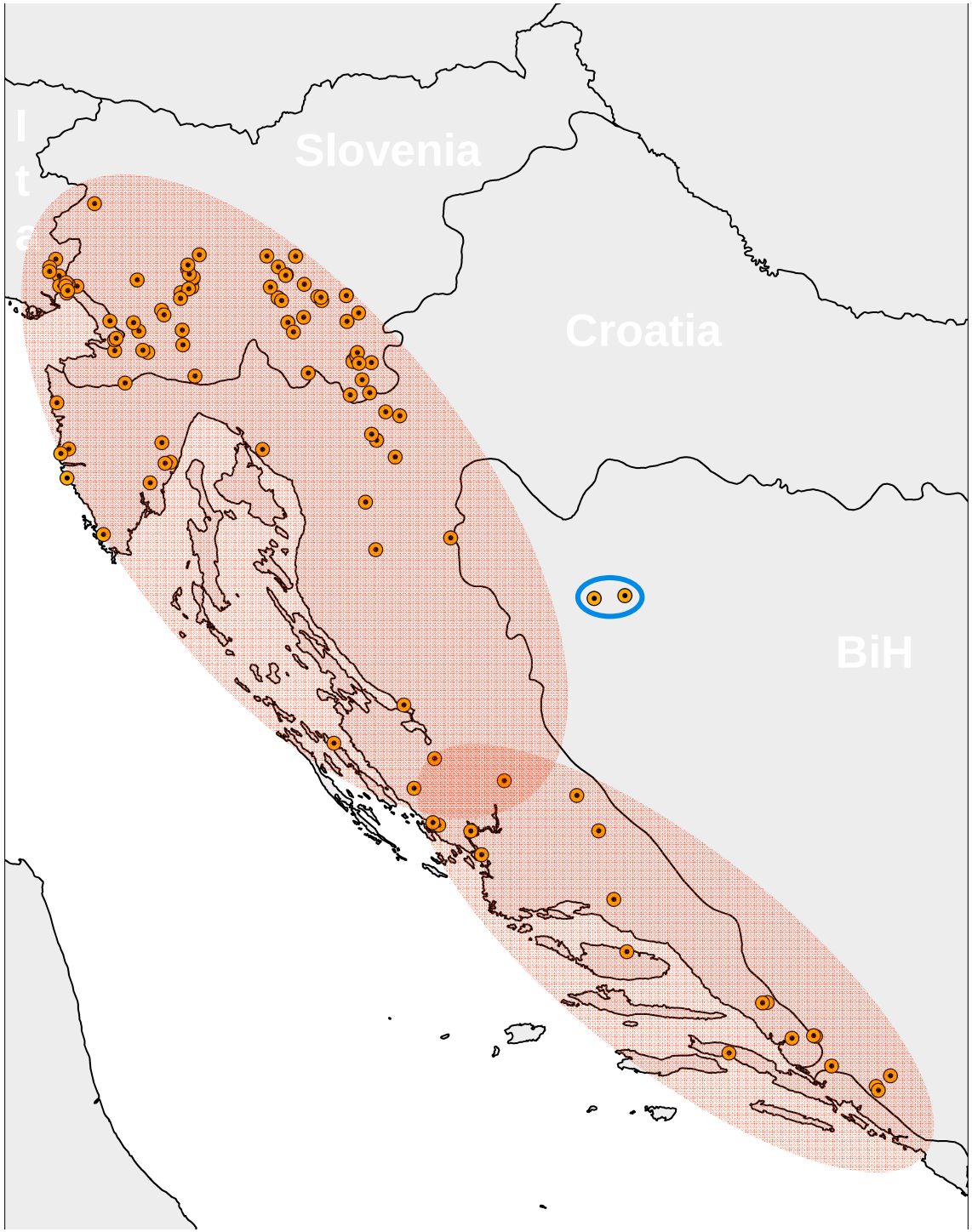




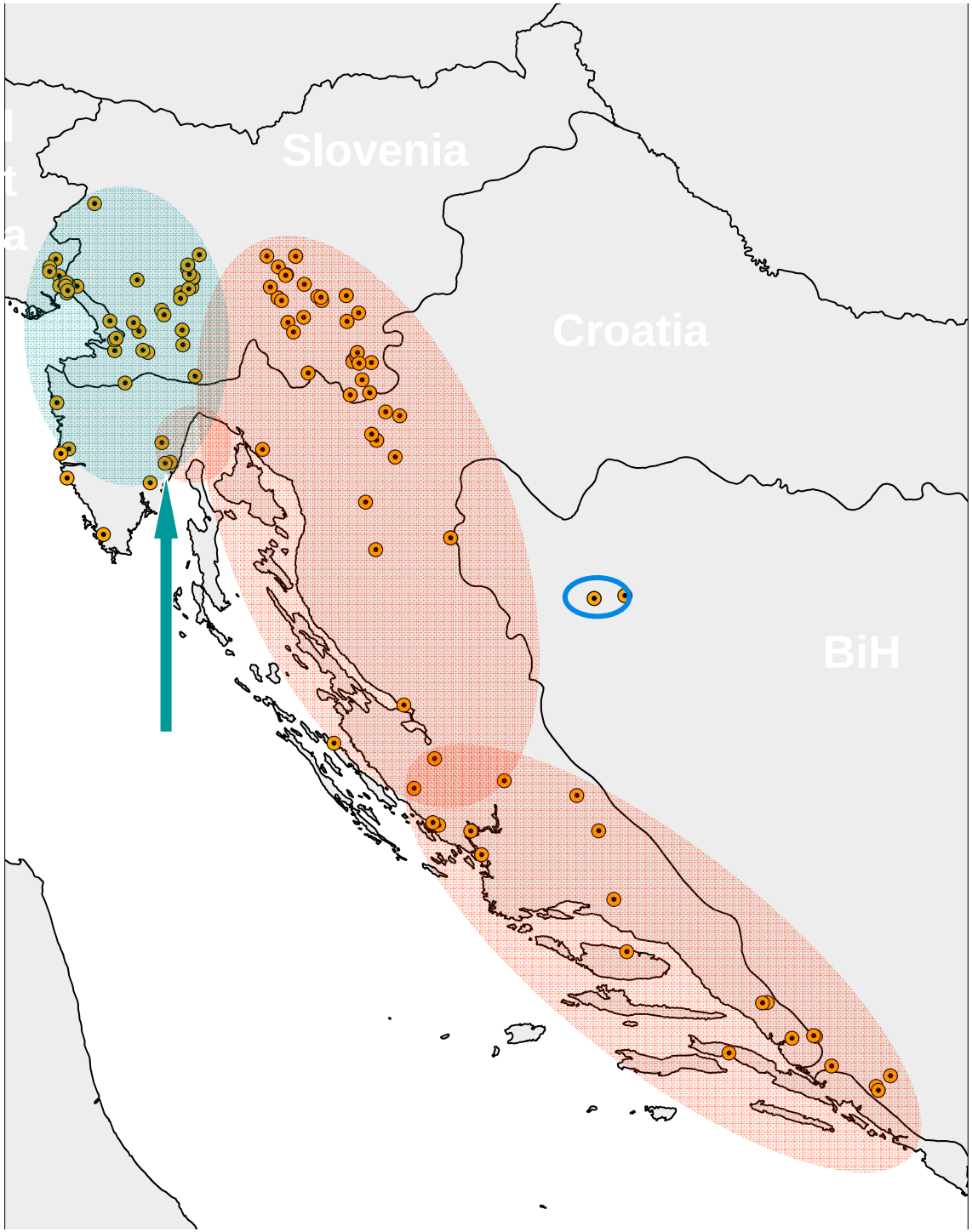
… morphological study of only Slovenian populations says nothing

(they all look the same)

these are localities of *Troglocaris 'anophthalmus'*

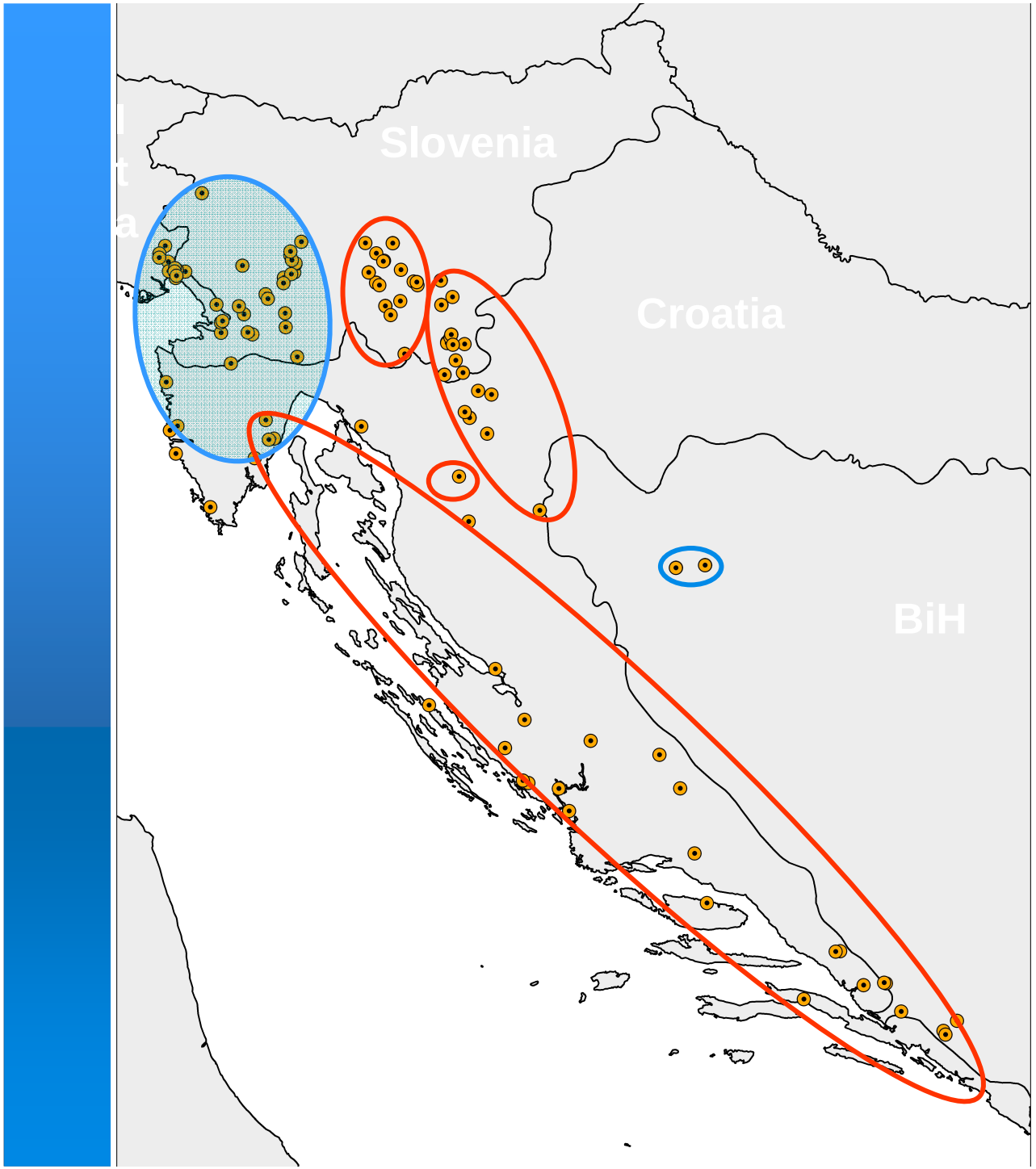


by a detailed morphology
in a wider area,
we may
distinguish 2 species



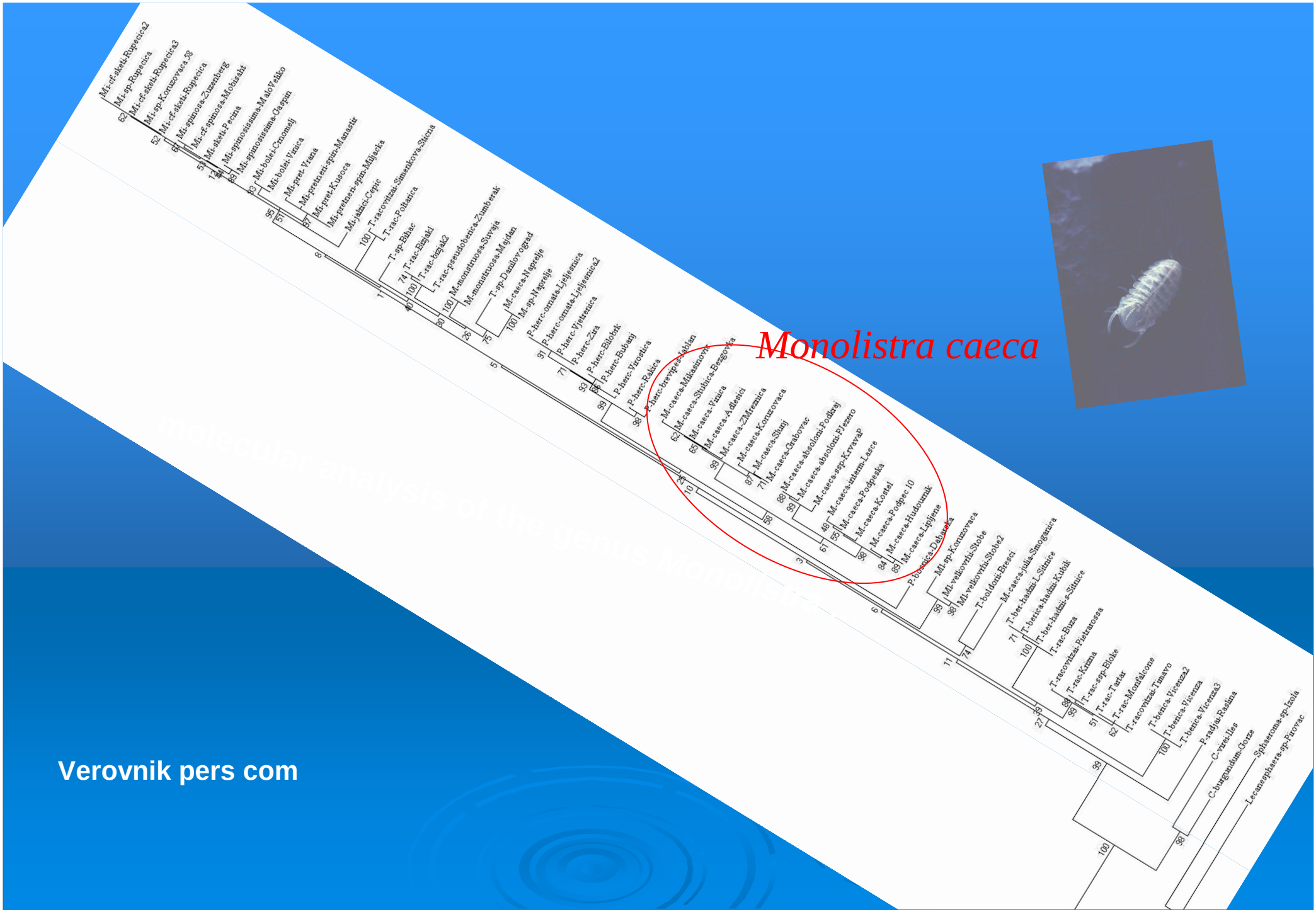
molecular analysis
reveals a further split

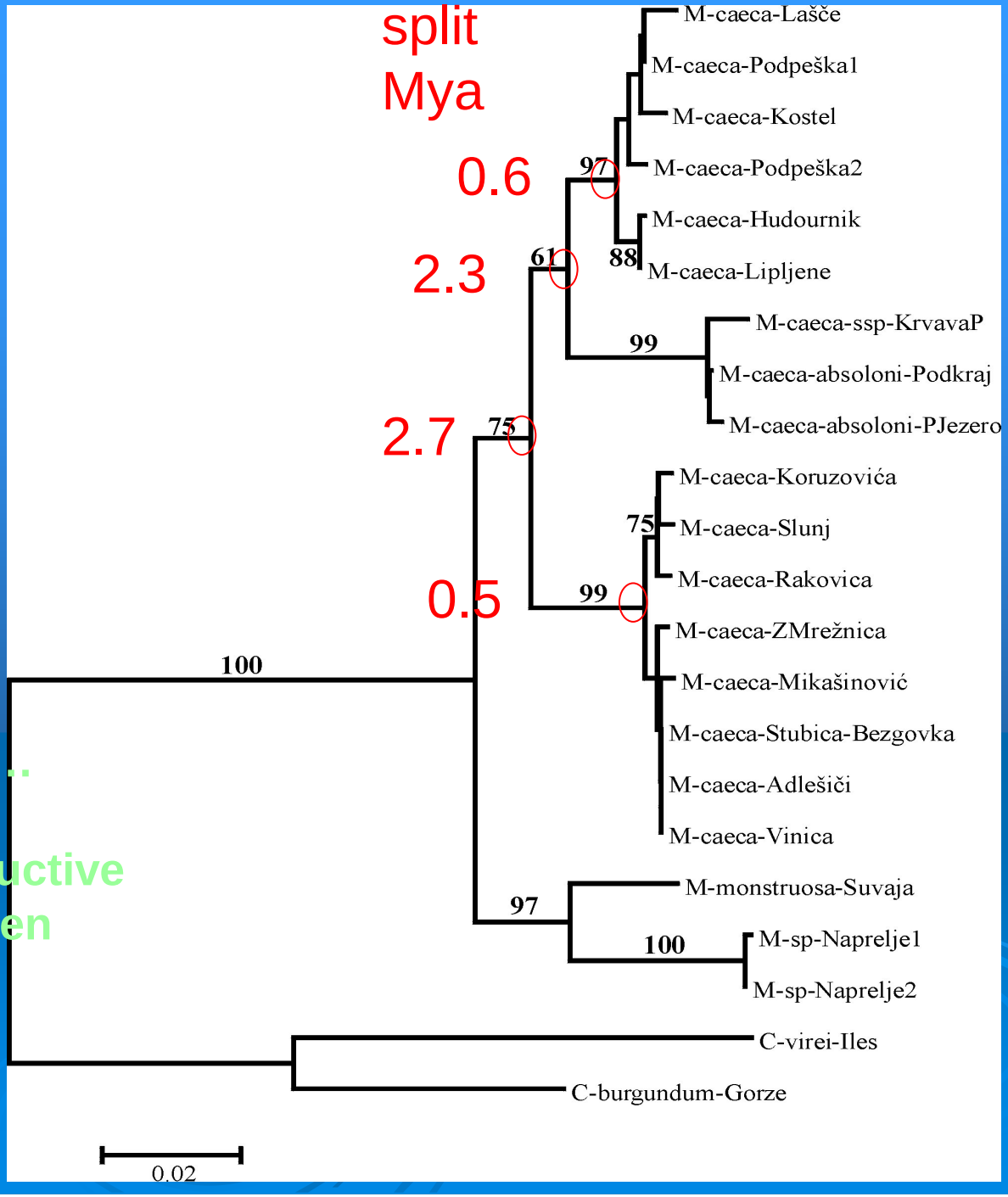
even to two species ...



... and some additional splits on subsequently lower levels

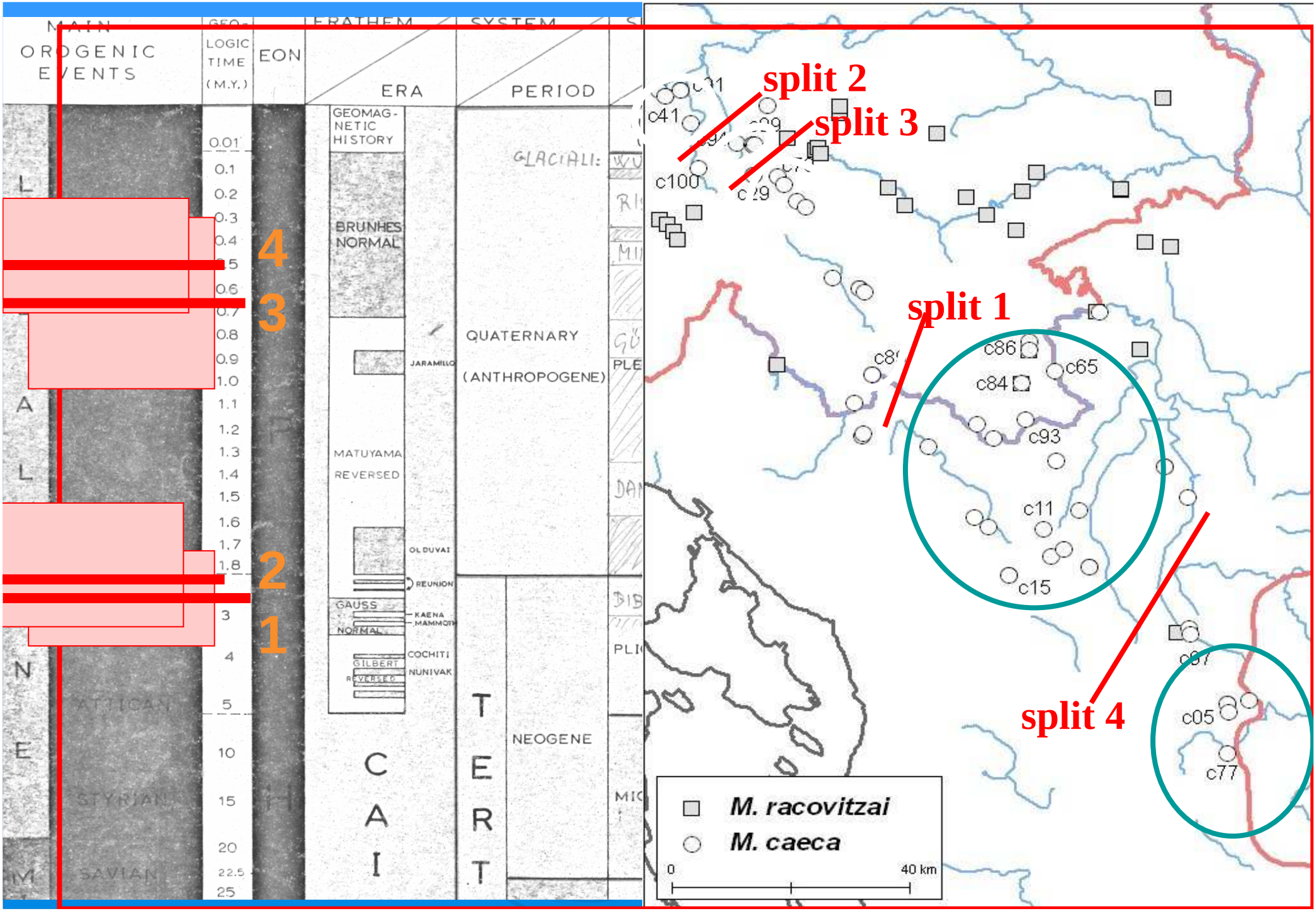
Zakšek et al 2007

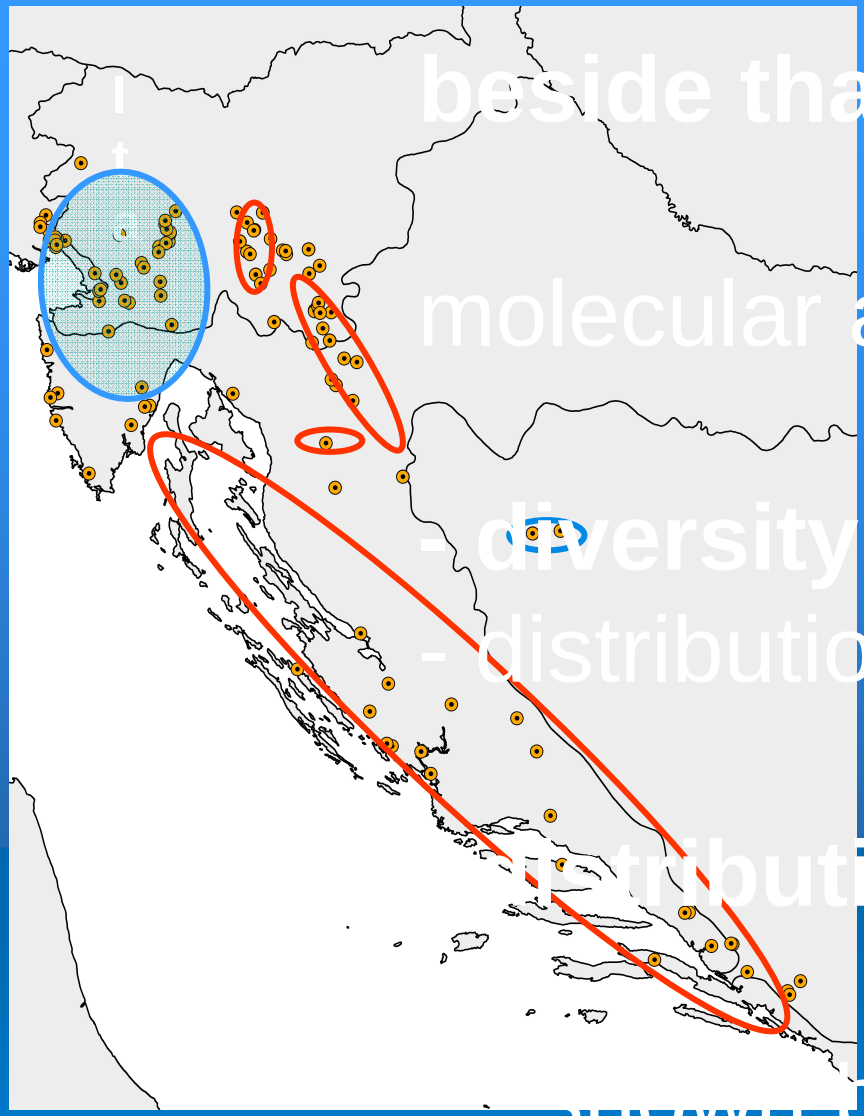

Monolistra caeca
molecular analysis of the genus Monolistra
Verovnik pers com



or its species (*M. caeca*) …

appeared to be very instructive biogeographically and even paleogeographically


MAIN OROGENIC EVENTS
GEOLOGIC TIME (M.Y.)
EON
ERATHEM
ERA
SYSTEM
PERIOD
GEOMAGNETIC HISTORY
BRUNHES NORMAL
MATUYAMA REVERSED
JARAMILLO
OL DUVAI
REUNION
GAUSS NORMAL
KAENA
MAMMOTH
GILBERT REVERSED
COCHITI
NUNIVAK
QUATERNARY
(ANTHROPOGENE)
NEOGENE
CAI
TERT
ATTICAN
STYRIAN
SAVIAN
split 1
split 2
split 3
split 4
c41
c100
c86
c65
c84
c93
c11
c15
c05
c77
M. racovitzai
M. caeca
0
40 km



beside that,

molecular analyses show
that
- **diversity is even higher,**
- distribution patterns are more
regular than ...
... distribution areas of taxa are even smaller than ...
... shown by morphology.

(> new data for conservation activities)

Anyway,
intense faunistic, biogeographic, phylogenetic etc **investigations are still needed** to support **an operational strategy of biodiversity conservation**.

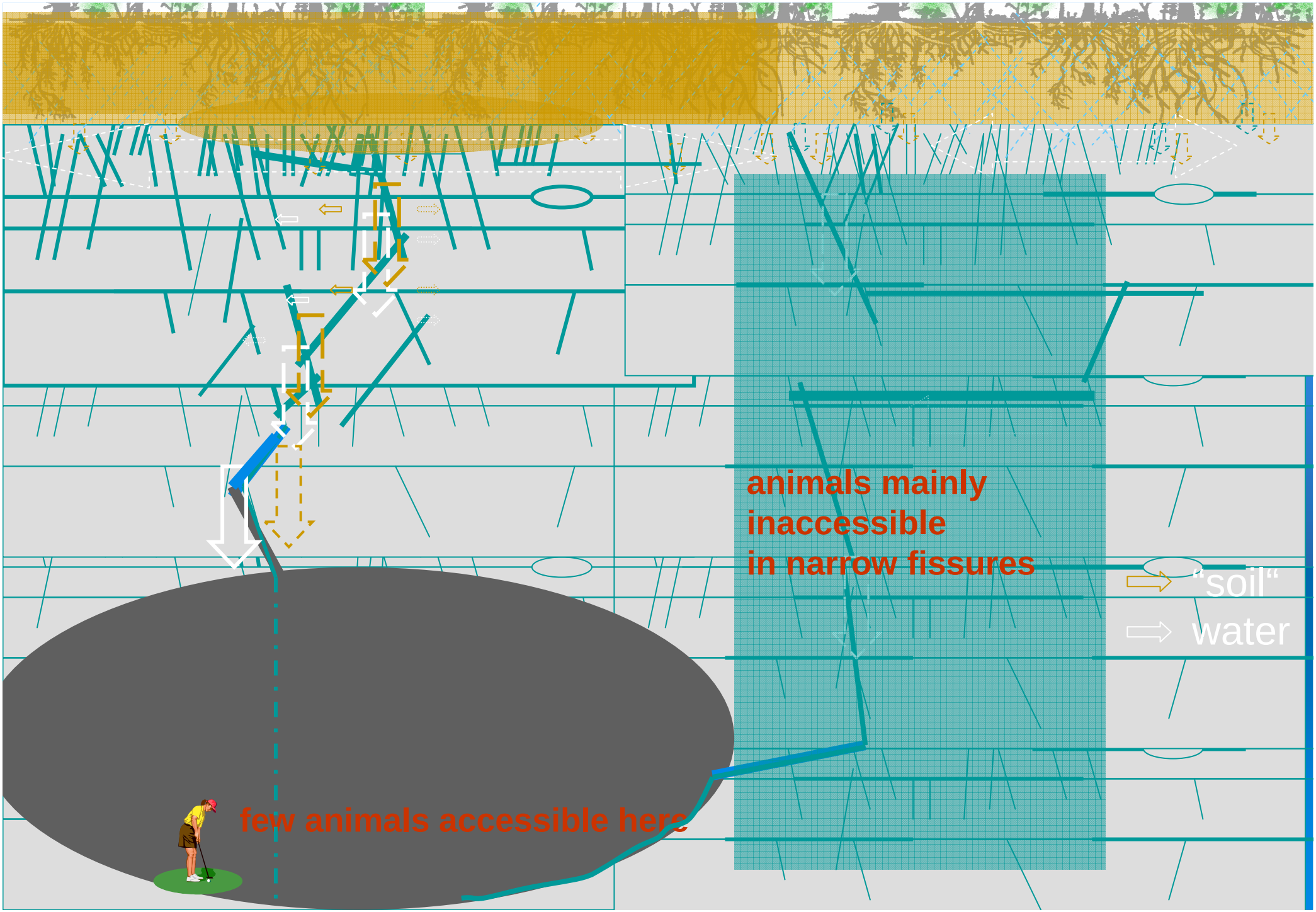
Therefore, any conservational, protectional, act **should stimulate investigations**.

In Slovenia, a fruitful
dialogue between researchers and authorities
resulted in a very reasonable solution.

In Slovenia, a fruitful **dialogue** between researchers and authorities resulted in a very **reasonable solution**.

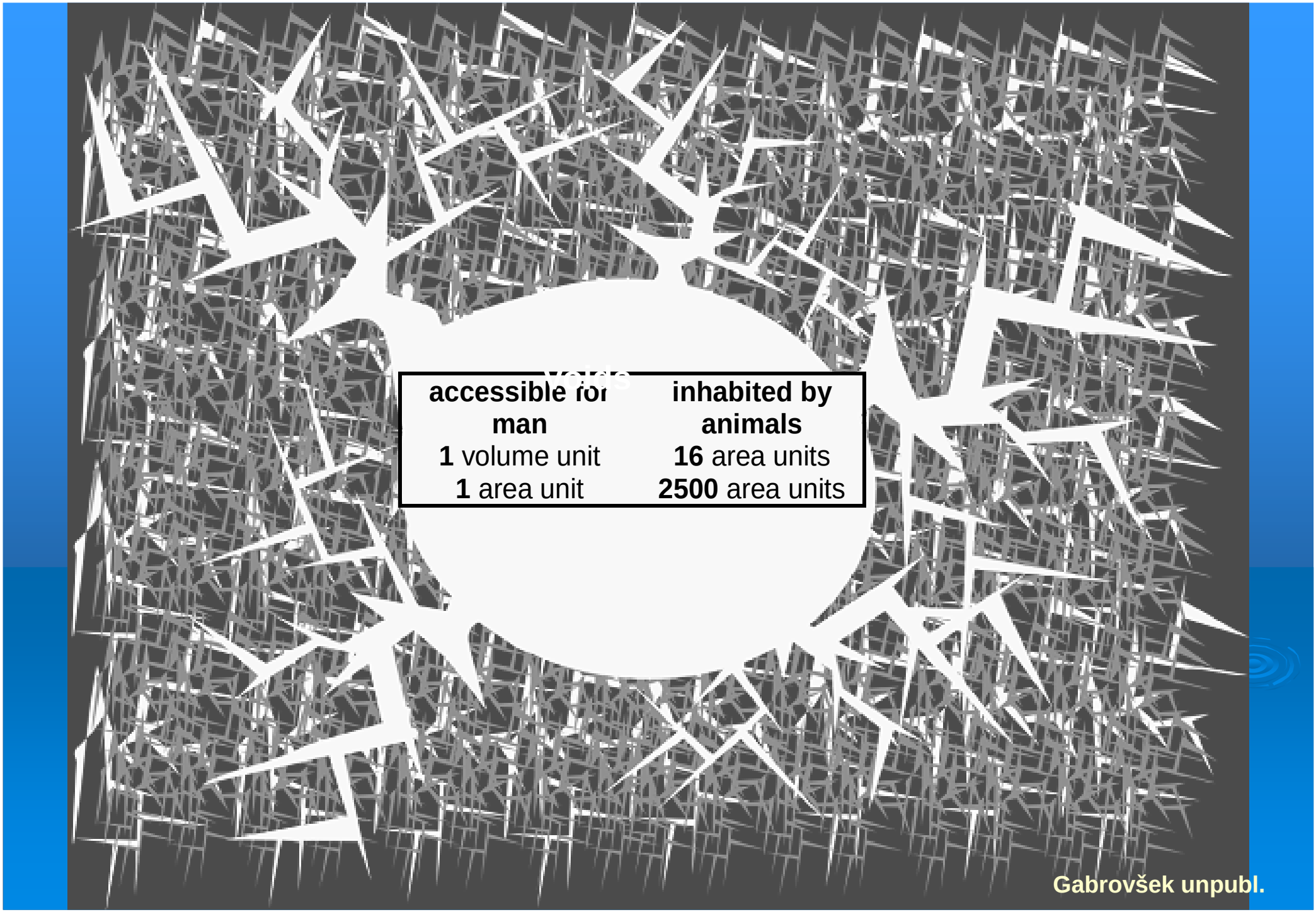
- Only commercially interesting animals are protected as species in the Law on caves (1976).

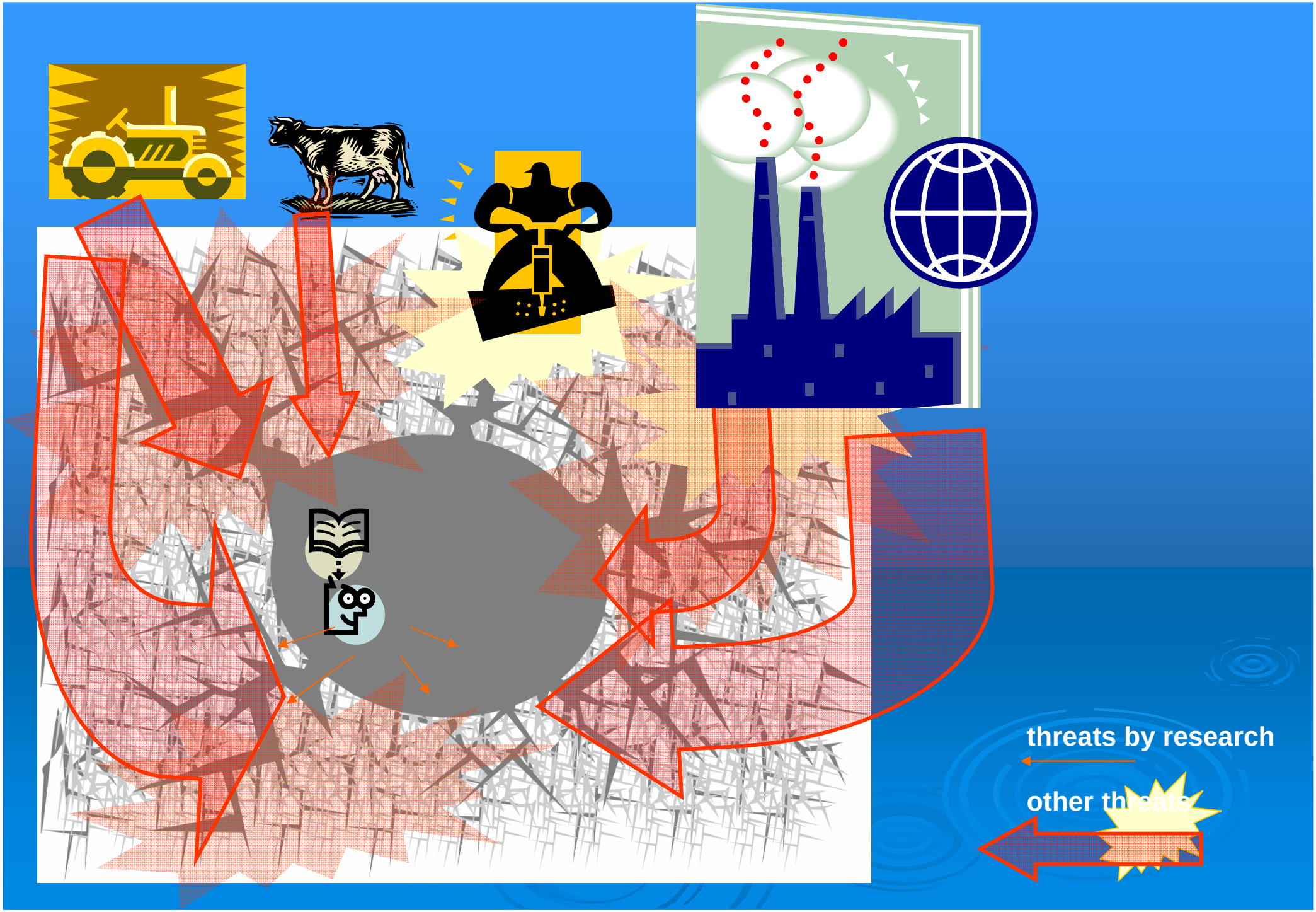
- All the others are more efficiently protected by protection of subterranean habitat(s).


animals mainly
inaccessible
in narrow fissures
"soil"
water
few animals accessible here

within **Slovenia**	20.000 km^2 its karst 8.000 km^2	**volume** in **m^3**	**surface** (= water bottom + 'cave' walls) in **m^2**	
voids **for man** (sizes 1m – 100m) **known entrance**		6 x 10^6	10^6	**accessible to researcher**
voids for man (sizes 1m – 100m) **without entrance**		6 x 10^7	10^7	potentially **inhabited** by animals **but inaccessible** to reseracher
additional voids **for animals** 1mm – 1m		3 x 10^7	2.5 x 10^9	
ratio		**volume 1 : 16**	**area 1 : 2500**	

‘endangered’ by research : endangered as habitat


Voids
accessible for man
1 volume unit
1 area unit
inhabited by animals
16 area units
2500 area units
Gabrovšek unpubl.


threats by research
other threats

This is not a general practice.

(1) - In some countries, all **'rare'**, endemic, (subterranean **species in general may be legally ‘protected’**.
Researchers are obliged to ask for special permissions, wait for inefficient bureaucracy, obey sometimes irrational rules ...

(example: Croatian authorities issued a license for collecting in some caves, but only under supervision of Croatian researchers – doubled expenses, multiplied organisational difficulties.)

(2) – Convention on Biological Diversity (1992) triggered an absolutely counter-productive **exaggeration of 'provisions** on access to genetic resources'.

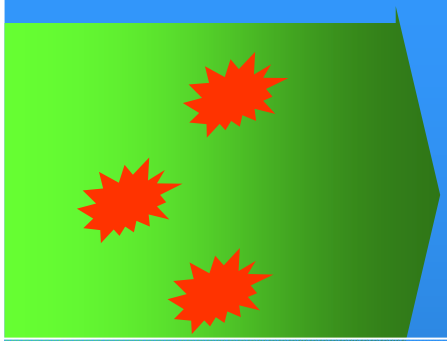
(example: Philippino authorities
handled in 9 years 17 applications and
granted only 1 (one) 'Academic Research Agreement‘.)

Protecting habitats is indispensable.
It is also **complementary with protection of** precious ground **water resources**.

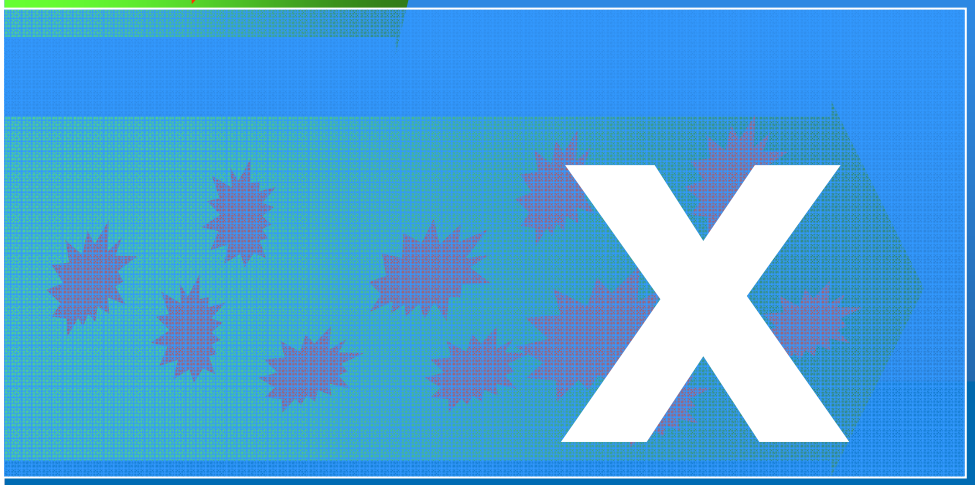
Preventing collections is counterproductive for three reasons:

- it is useless
- it is even an **obstacle** to investigations,

- it causes a **misleading impression** of an effective protection-conservation.

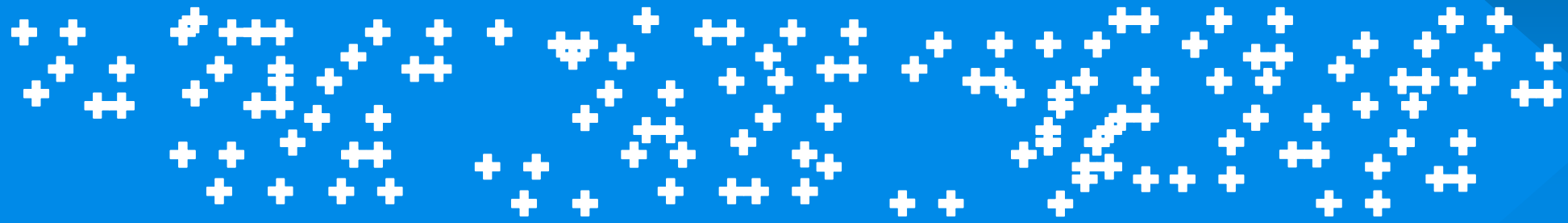


discovery & research
additionally FRUSTRATED
by administrative obstacles



discovery & research
SLOW for
lack of funding

during the FAST
progressive **extermination**
decreasing accessibility



Again:

biodiversity is disappearing,
we are losing time in lack of money and
in administrative obstacles.

If administrative actions
can not **support investigations,**
they should at least stimulate them.

Palaearktische Koleopteren - Sammlung zu verkaufen.

6000 Arten, 15.000 Exemplare, die Höhlentiere in 200 Arten und mehrere Typen. In 120 Schachteln wissenschaftlich geordnet, erstklassig präpariert, vorzüglich erhalten, meist von Spezialisten determiniert. — Preis samt Doubletten und Literatur 6000 Dinar.

Anfragen an Ing. O. Scheibel, Vardište Bosnien, S. H. S.

"- collection on sale cave animals in 200 species …"

(in 1921)

"Cave coleopterans including rare species and novelties"

Höhlencoleopteren

darunter seltene Arten und

Neuheiten.

Ergebnisse meiner ausgedehnten Forschungen der Balkanhöhlen, gibt preiswert ab

T. WEIRATHER

k. k. Postbeamter

TREBINJE, HERZEGOWINA.

Höhlen - Coleopteren

darunter seltene Arten und

Neuheiten.

Ergebnisse meiner ausgedehnten Forschungen der Balkanhöhlen gibt preiswert ab

T. WEIRATHER,

k. k. Postbeamter,

Trebinje, Herzegowina.

Sl. 51.

Weirather-ovi oglasi o prodaji

(described 1768)

(described recently)

troglomorfna človeška ribica in netroglomorfni črni močeril