SPELEOBIOLOGIJA – evolucioni aspekti

Rudi Verovnik

Niš, 25.10.2018

SPELEOBIOLOGIJA – terminologija

spḗlaion (gr.) = rupa, pećina + **bios** + **logos**

SPELEOBIOLOGIJA proučava:

- **ekologiju** podzemnih organizma i staništa
- **fiziologiju/etologiju/taksonomiju,...** podzemnih organizma,
- **biogeografiju** podzemnih organizma,
- **evolucione mehanizme** u podzemlju, …

ŠTA JE PODZEMLJE?

- u širem smislu (*s. lat.* = *sensu lato*) → sve izpod površine zemlje
- u užem smislu (*s. str.* = *sensu stricto*) → potpuna tama,
  ± zatvorena celina,
  ± ograničen unos hrane,
  ± manja pristupačnost,
  ± stabilni ekološki uslovi

TIPOVI podzemnih staništa (klasifikacija)

- KRAŠKI
- NEKRAŠKI

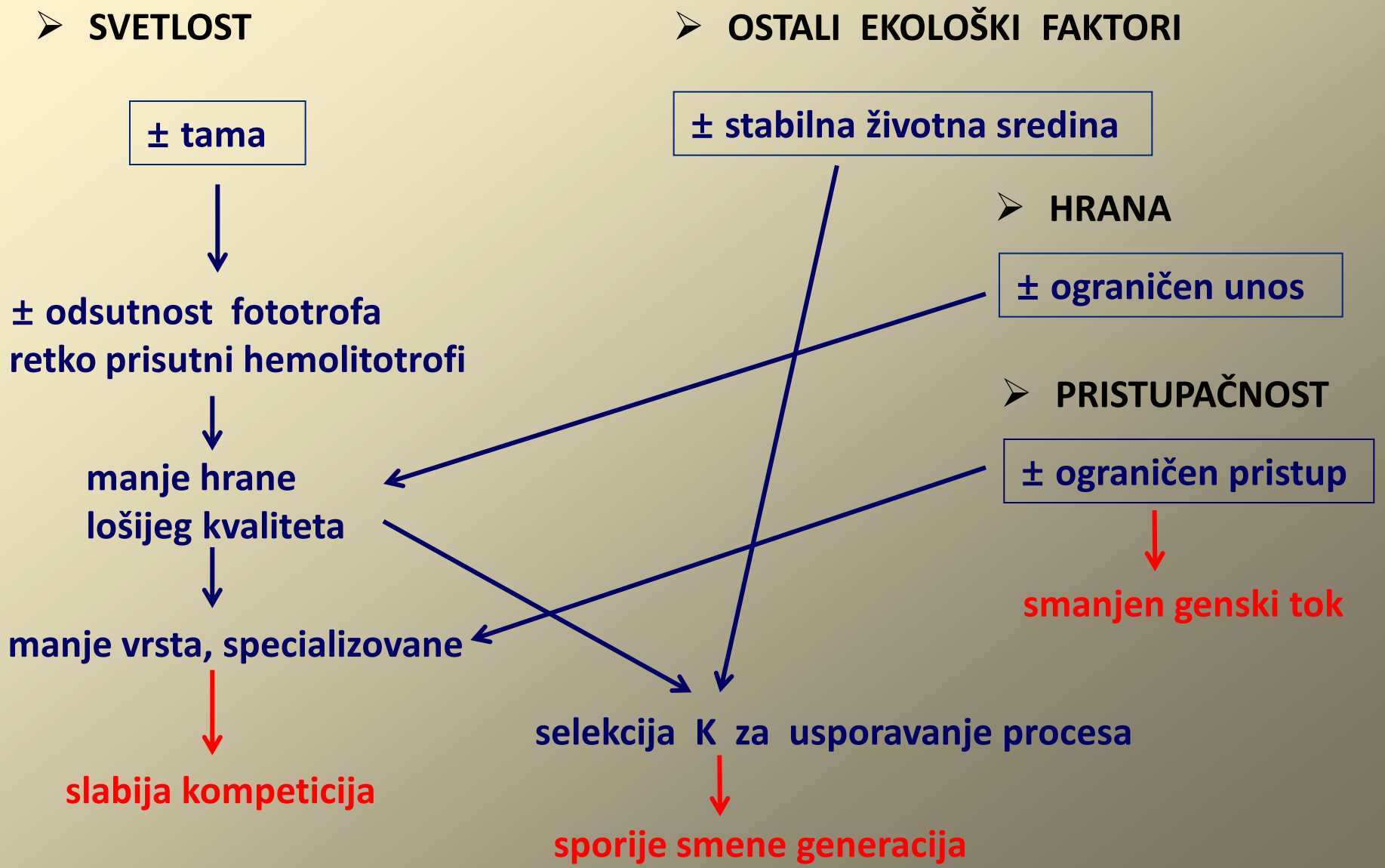
- VODNI
- KOPNENI

- PRIRODNI
- VEŠTAČKI

- VELIKI PROSTORI (>20 cm)
- SREDNJE VELIKI PROSTORI
- MANJI PROSTORI (<0,1 cm)

- PLITKI
- DUBOKI

EKOLOŠKA KARAKTERIZACIJA - PEĆINE



SPELEOBIOLOGIJA – terminologija

Ekološka klasifikacija pećinskih životinja - poređenje, Sket 2008

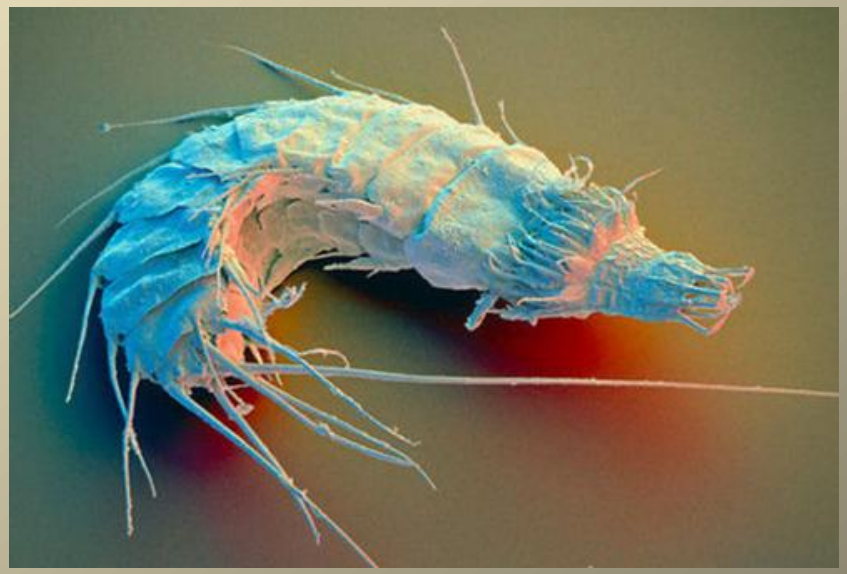
Schiner-Racovitza Used by speleobiologists worldwide	Ruffo Used primarily by Italian speleobiologists	Barr Used by some American speleobiologists
troglobiont	**troglobiont**	troglobiont (troglobite)
troglophile	**eutroglophile**	troglophile
troglophile	**subtroglophile**	trogloxene
trogloxene	**trogloxene**	accidental

Ekološka klasifikacija pećinskih životinja - poređenje, Sket 2008

Predloženi termin	Definicija
Troglobiont (vrsta, populacija ili rasa)	Obligatni stanovnik podzemlja (»strongly bound to hypogean habitats«).
Eutroglophil	Površinska vrsta, koja može imati stalne podzemne populacije (može da postane troglobiotska).
Subtroglophil	Vrsta, koja redovno ili povremeno naseljava podzemelje, ali joj jeza okončanje životnog ciklusa neophodna i površinska sredina (zbog prehrane ili reprodukcije).
Trogloksen	Vrsta, koja samo povremeno ulazi u podzemna staništa i ne može imati stalne podzemne populacije.

Evoluciona pitanja

- **Da li je naseljavanje podzemlja aktivan proces?**
- **Da li su podzemni orgnizmi klimatski relikti?**
- **Da li su degenerativne troglomorfoze rezultat neutralne selekcije?**



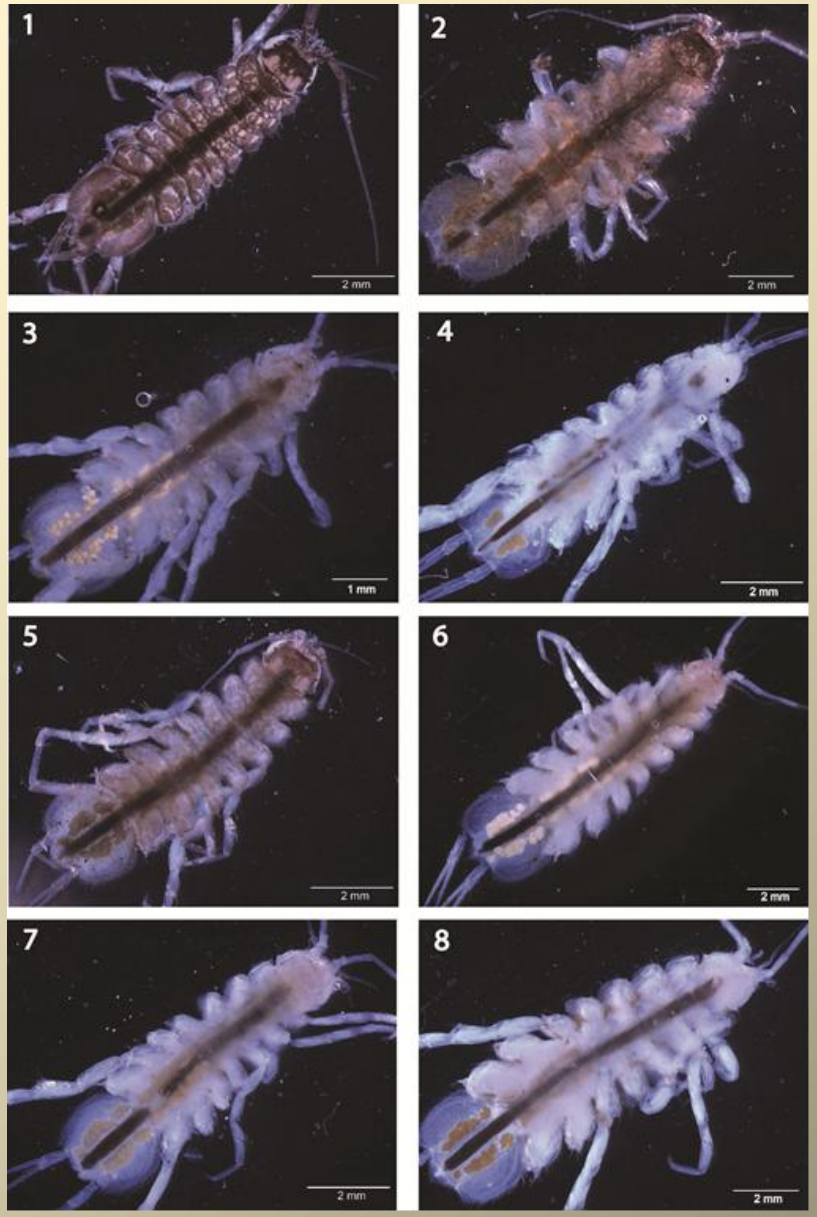
Darwin (1859): cave animals are '**wrecks of ancient life**'

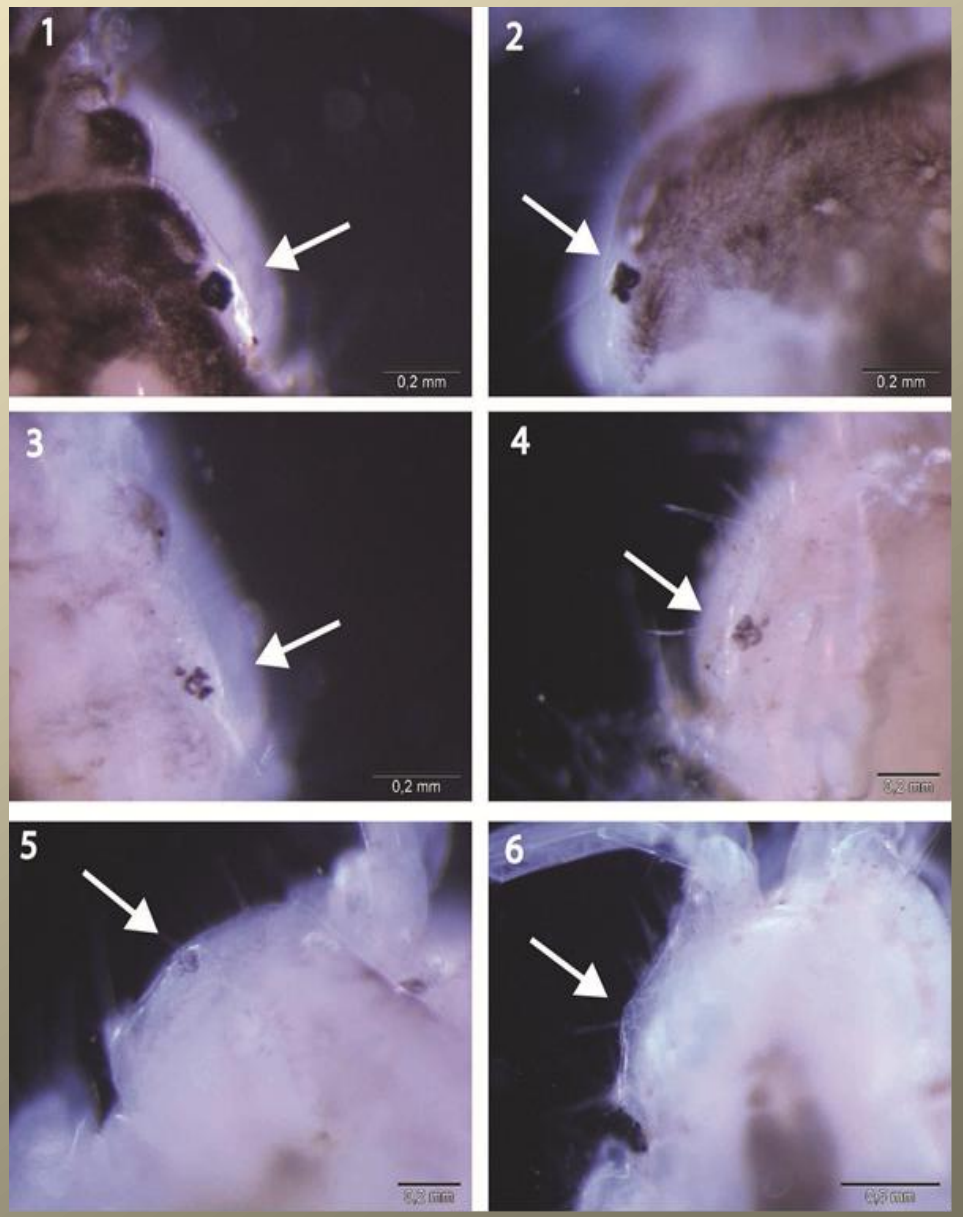
MODEL ORGANZAM: *Asellus aquaticus*

- Eurivalentna slatkovodna vrsta Evrope
- Stalne populacije u podzemnim vodama
- Prisutne simpatrijske podzemne i nadzemne populacije
- Prisutne troglomorfoze:
  - degenerativne (redukcija pigmenta i očiju)
  - progresivne (produženje antenna, ekstremiteta)

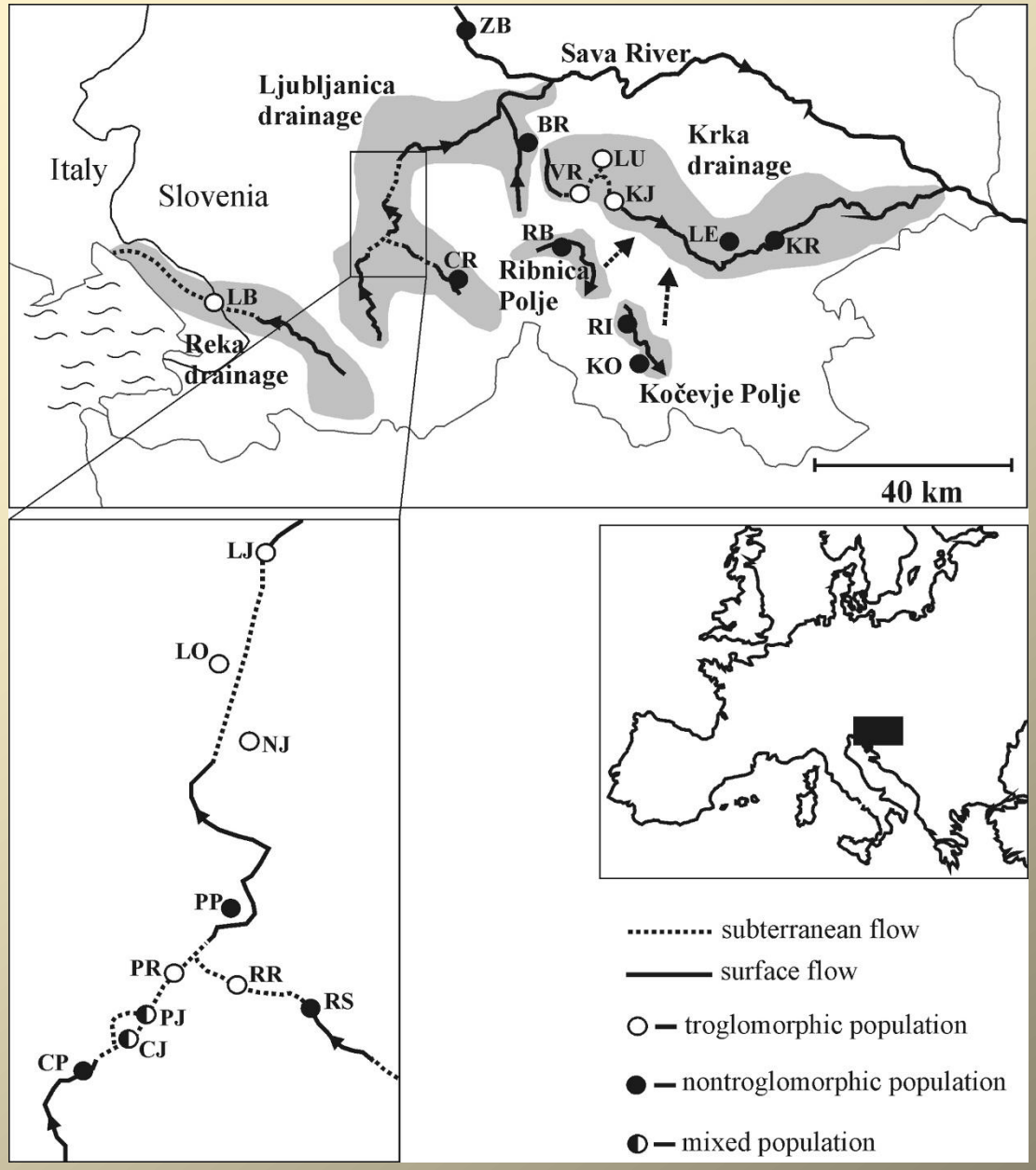
MODEL ORGANIZAM: *Asellus aquaticus*

Gubitak pigmenta kože i očiju.



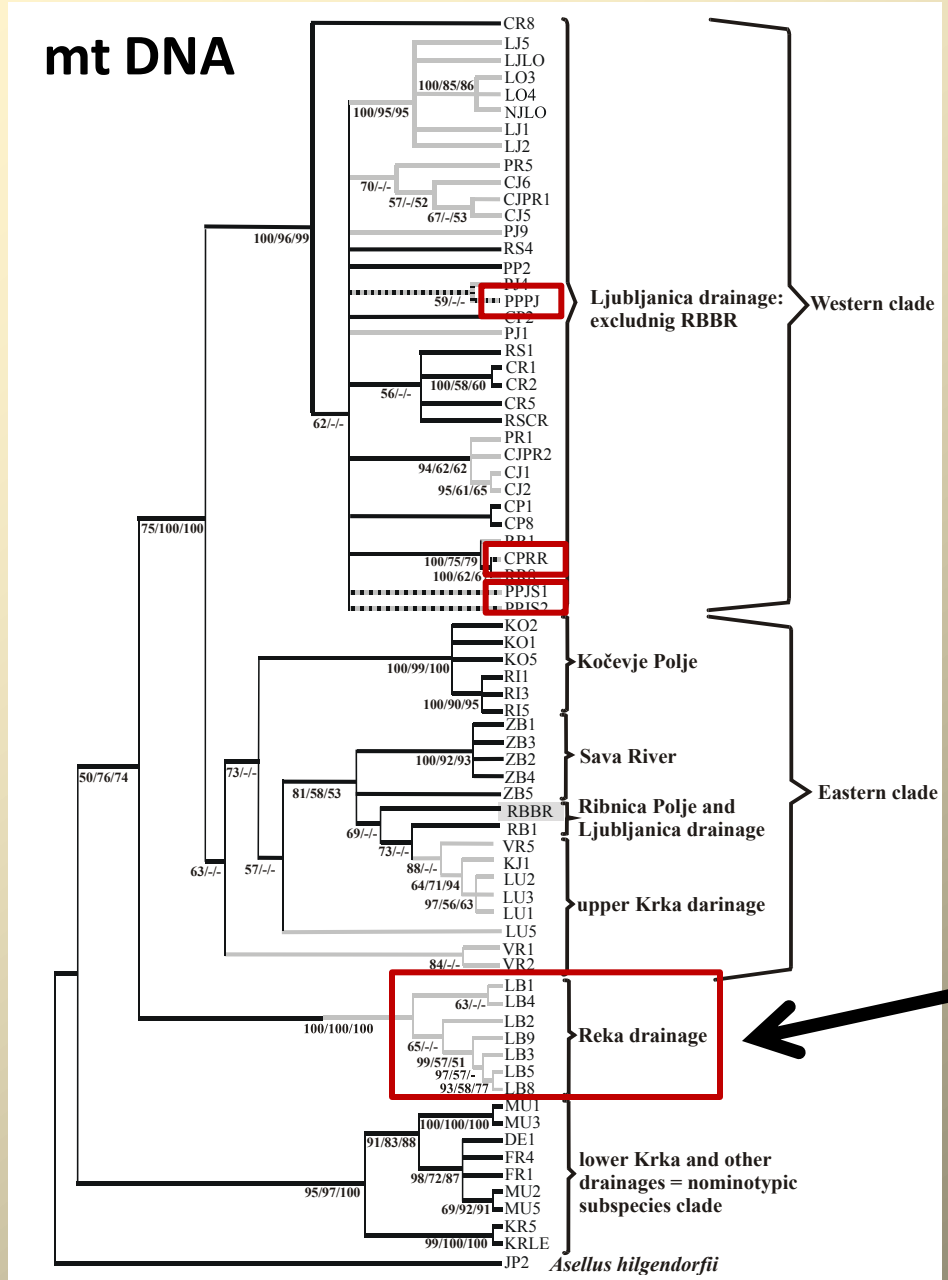


PRVA STUDIJA U SLOVENIJI



- Prostrani kraški region
- Karstifikacija započela pre 5 My.
- Pristune izolovane površinske i podzemne populacije

PRVA STUDIJA U SLOVENIJI

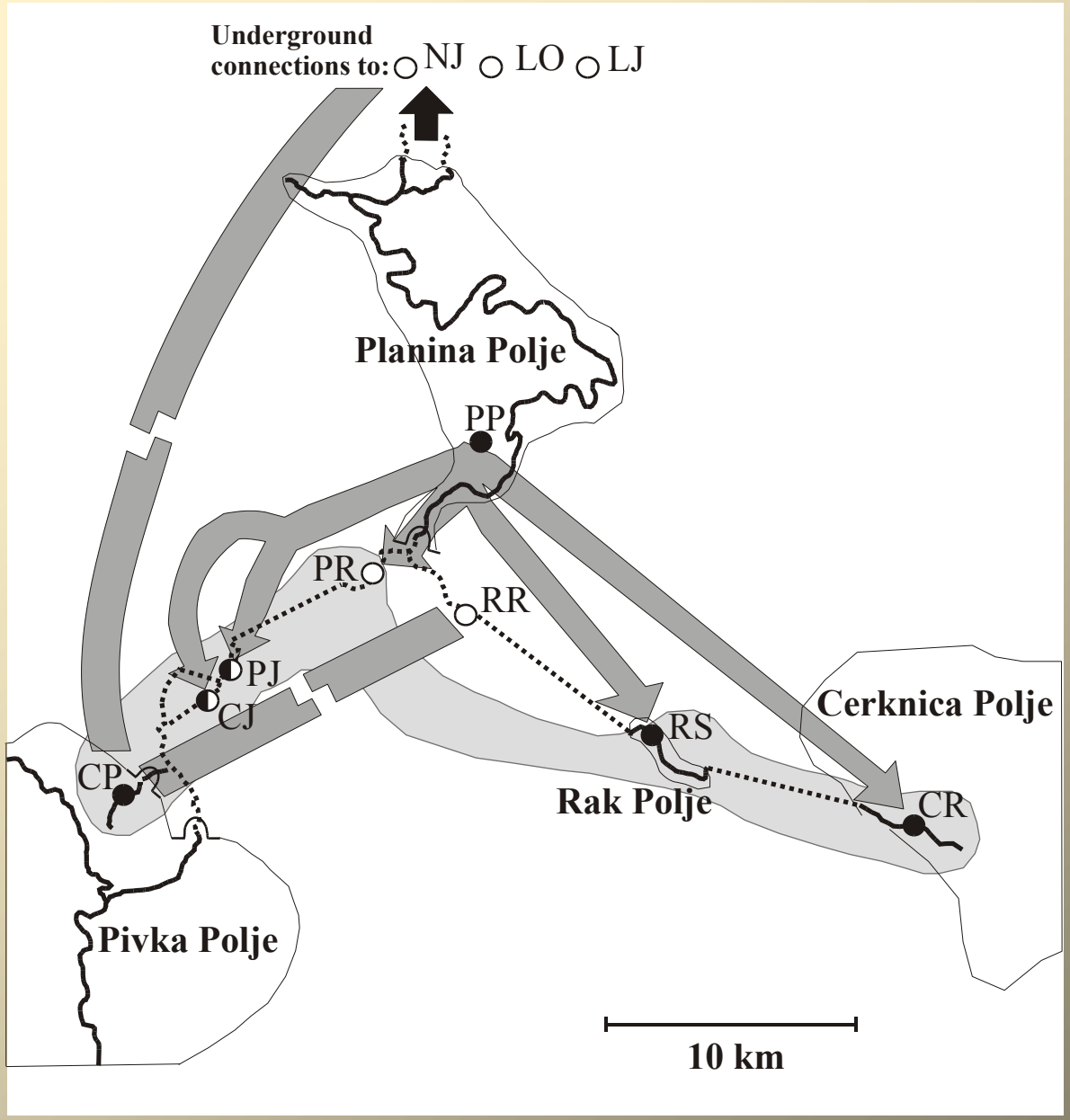


- Dobro poduprte klade po rečnim slivovima
- Neki od haplotipova u površinskim i podzemnim populacijama
- Tri odvojena naseljavanja podzemlja

Asellus kosswigi

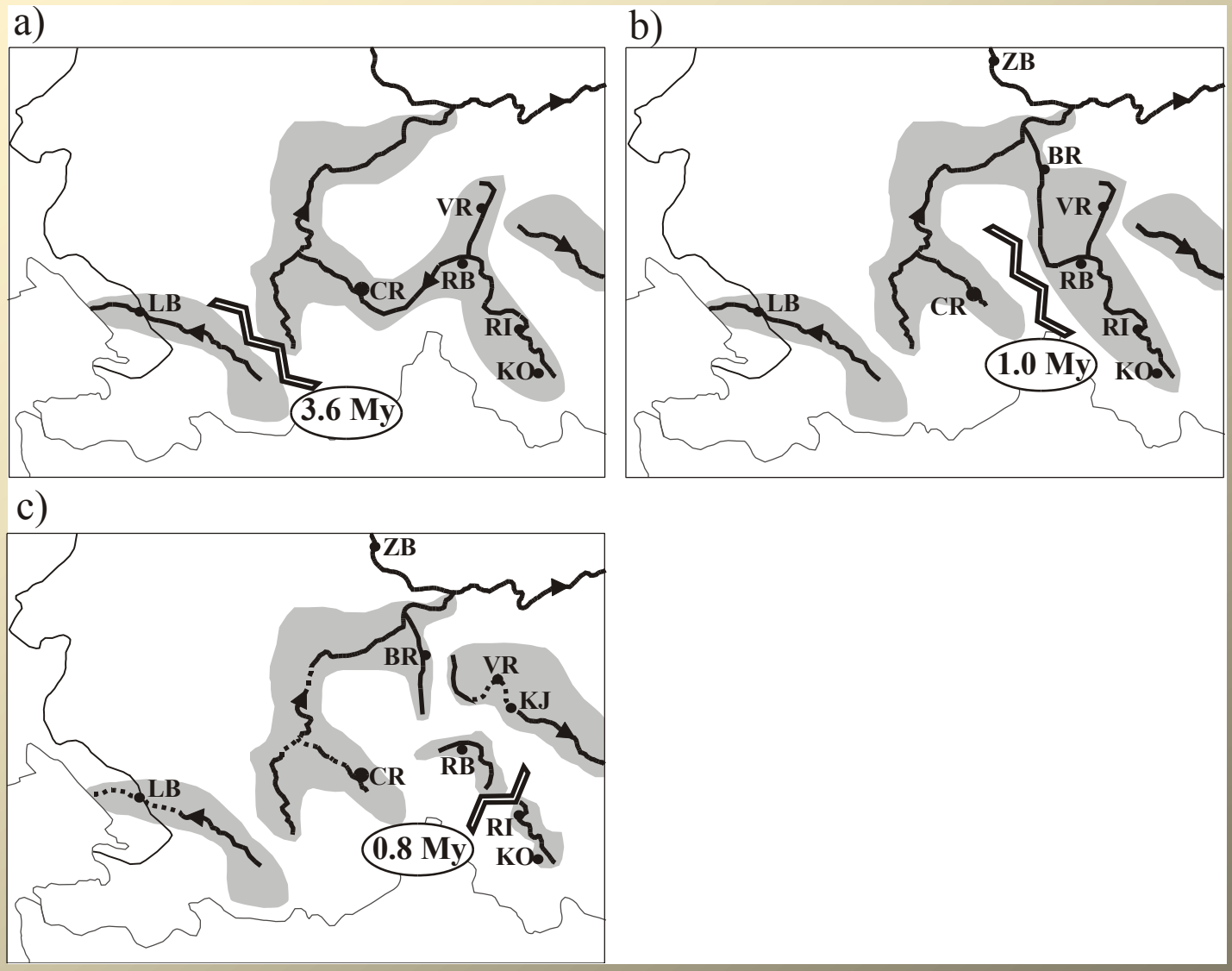
PRVA STUDIJA U SLOVENIJI

Analiza ugnežđenih klada

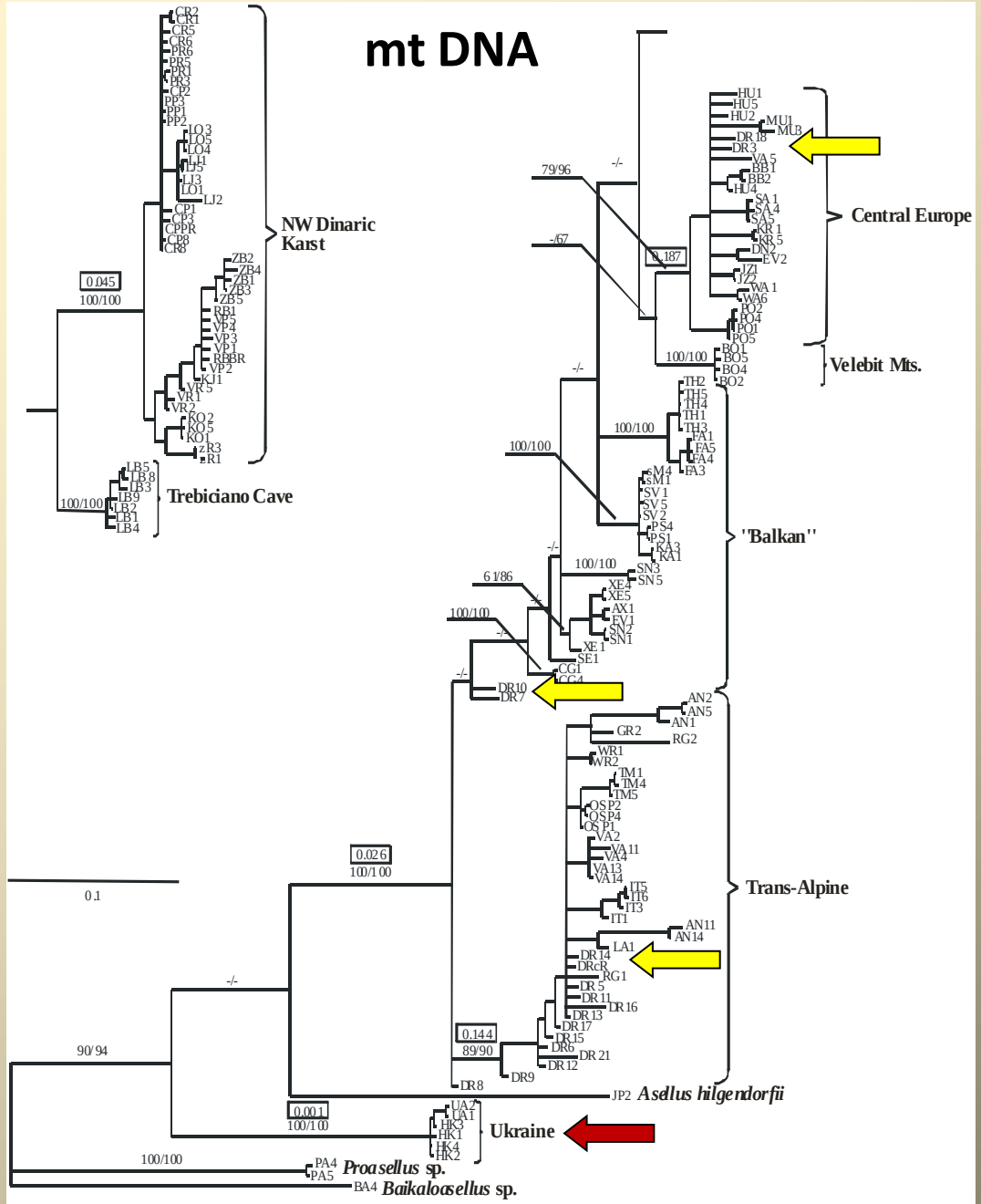


PRVA STUDIJA U SLOVENIJI

Hipotetički lanac događaja

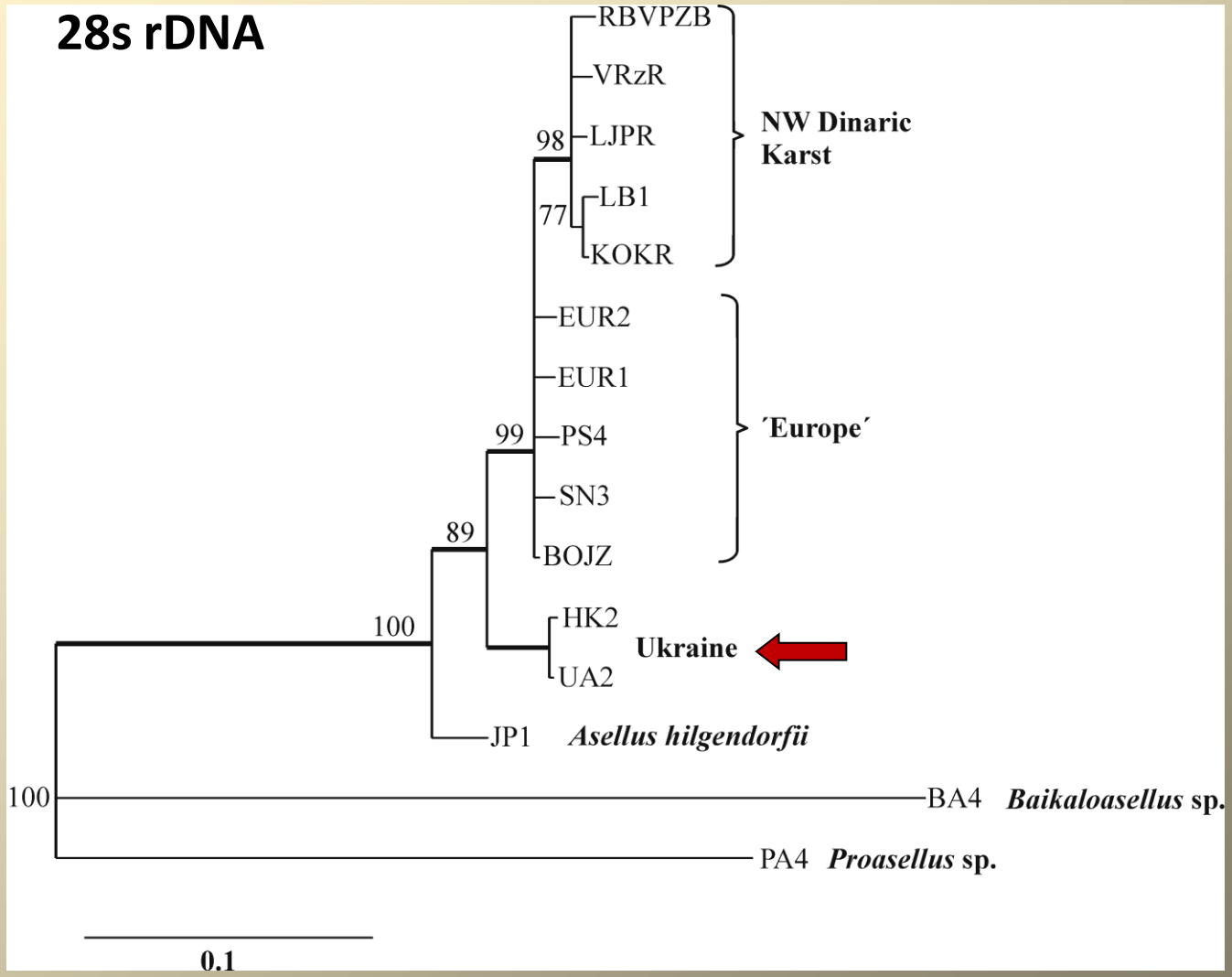


FILOGEOGRAFIJA NA KONITNENTALNOM NIVOU



- Dobro puduprte geografski definisane klade
- DR populacija sa haplotipima u 3 klade
- Kriptična vrsta u Ukrajini

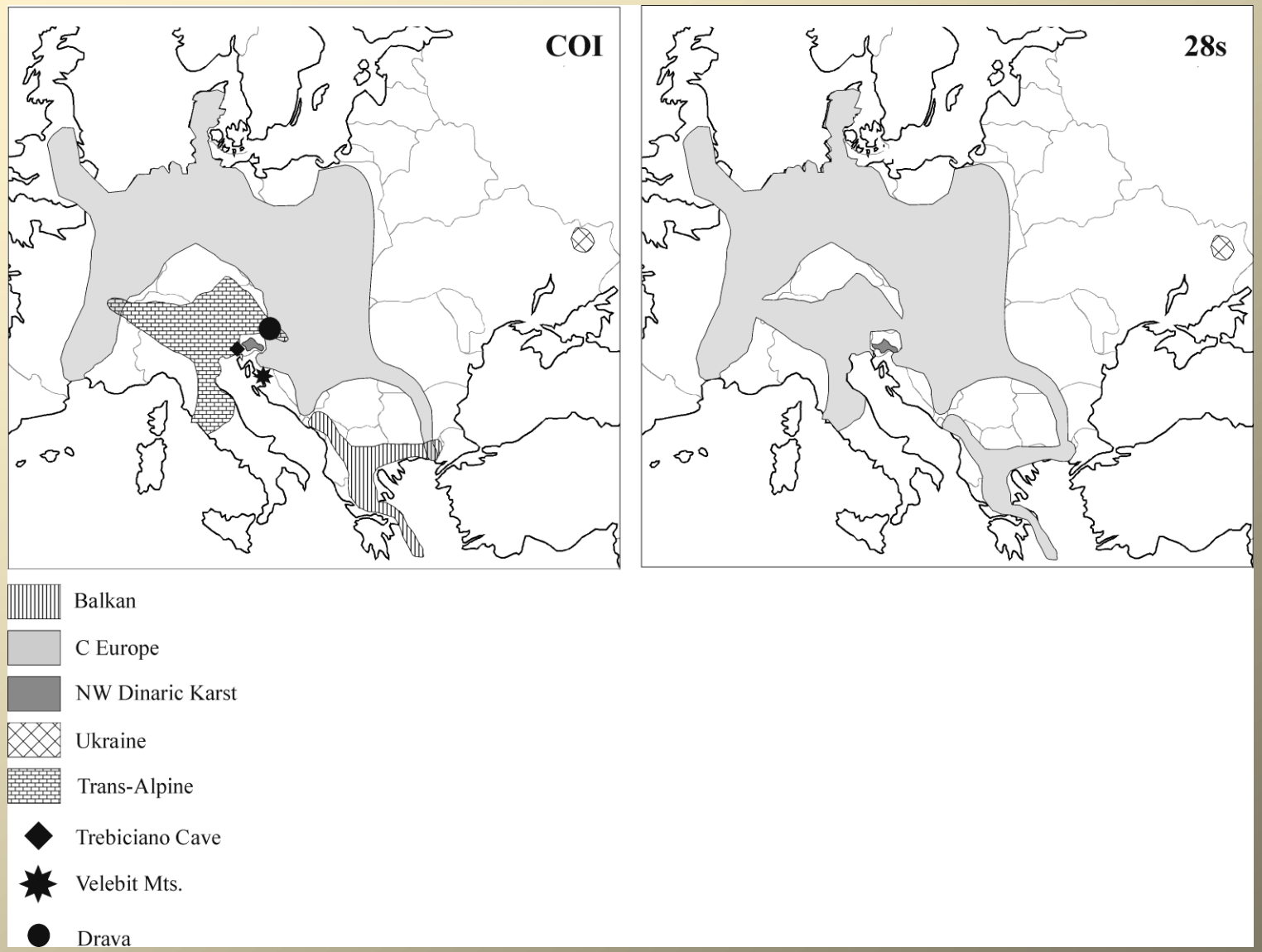
FILOGEOGRAFIJA NA KONITNENTALNOM NIVOU



- Bez variacije u većem delu Evrope
- Kriptična vrsta u Ukrajini

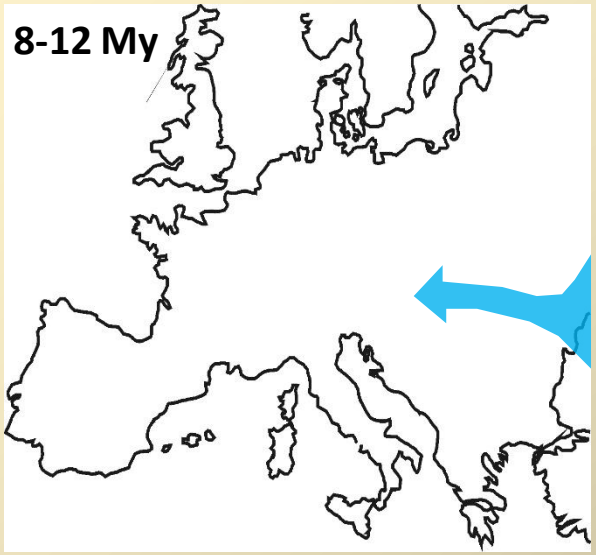
FILOGEOGRAFIJA NA KONITNENTALNOM NIVOU

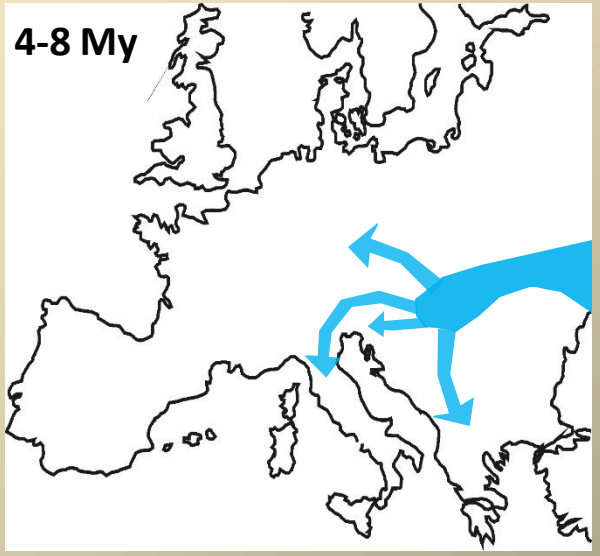
Distribucija klada

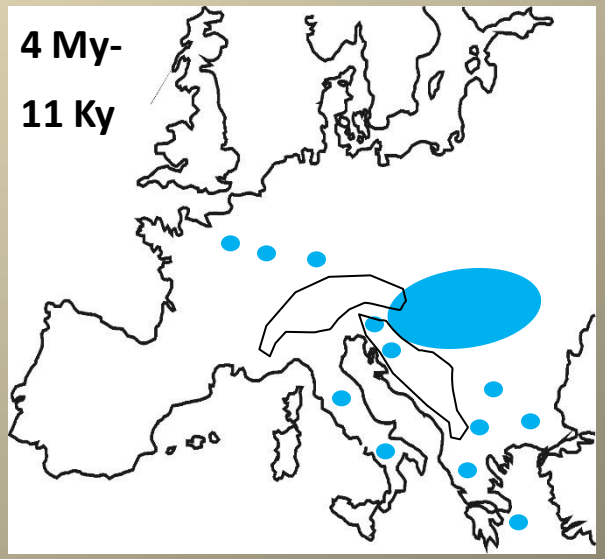


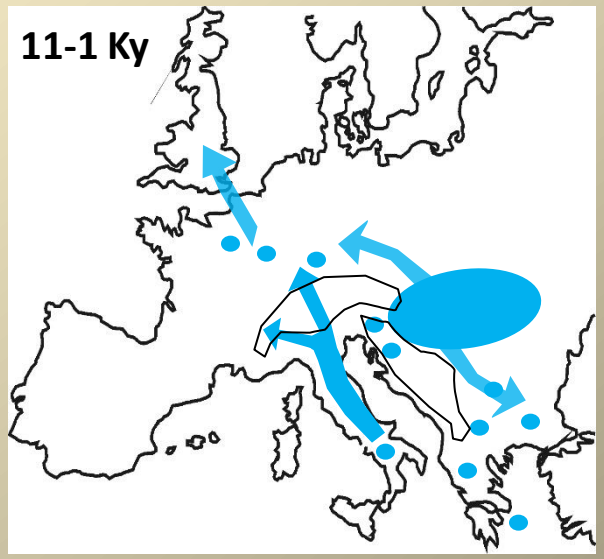
FILOGEOGRAFIJA NA KONITNENTALNOM NIVOU

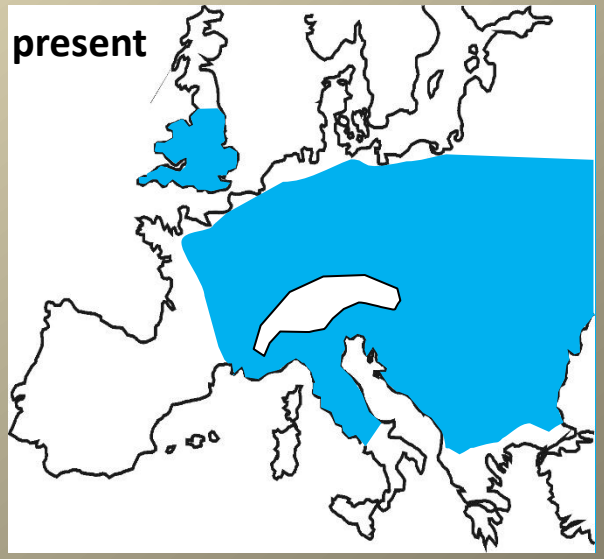
Hipotetički lanac događaja





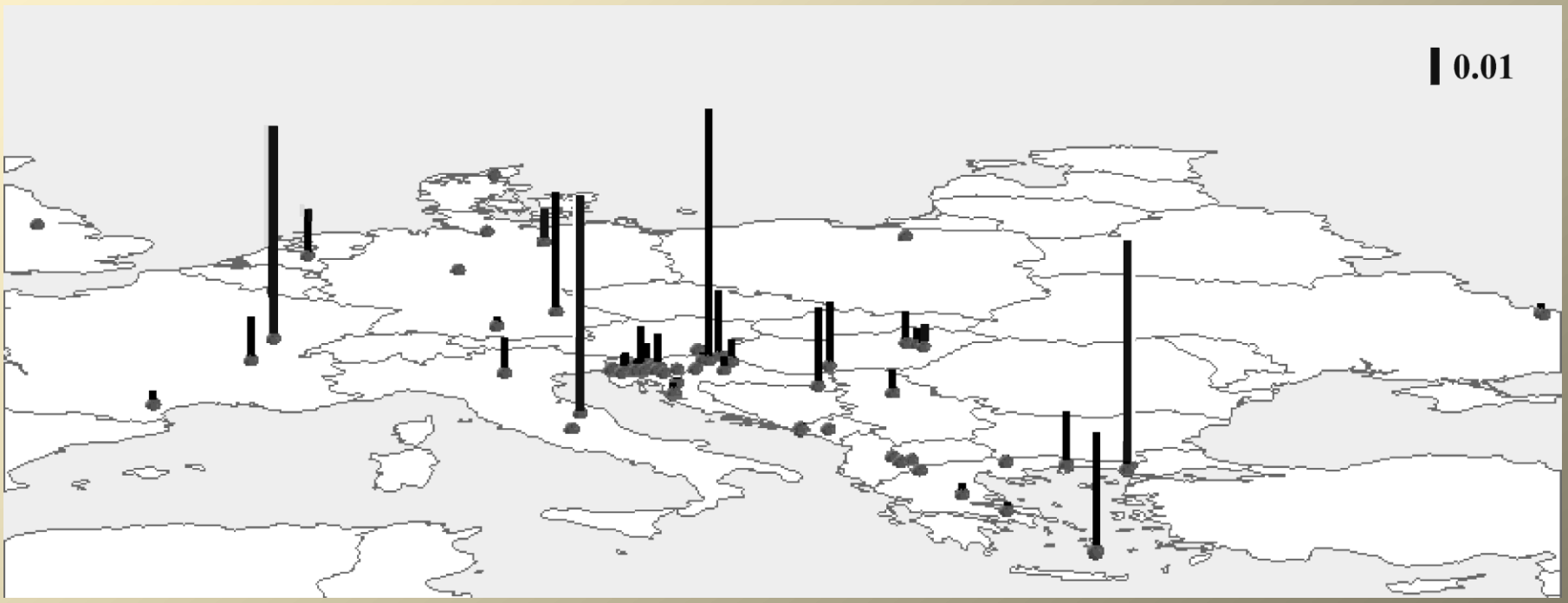






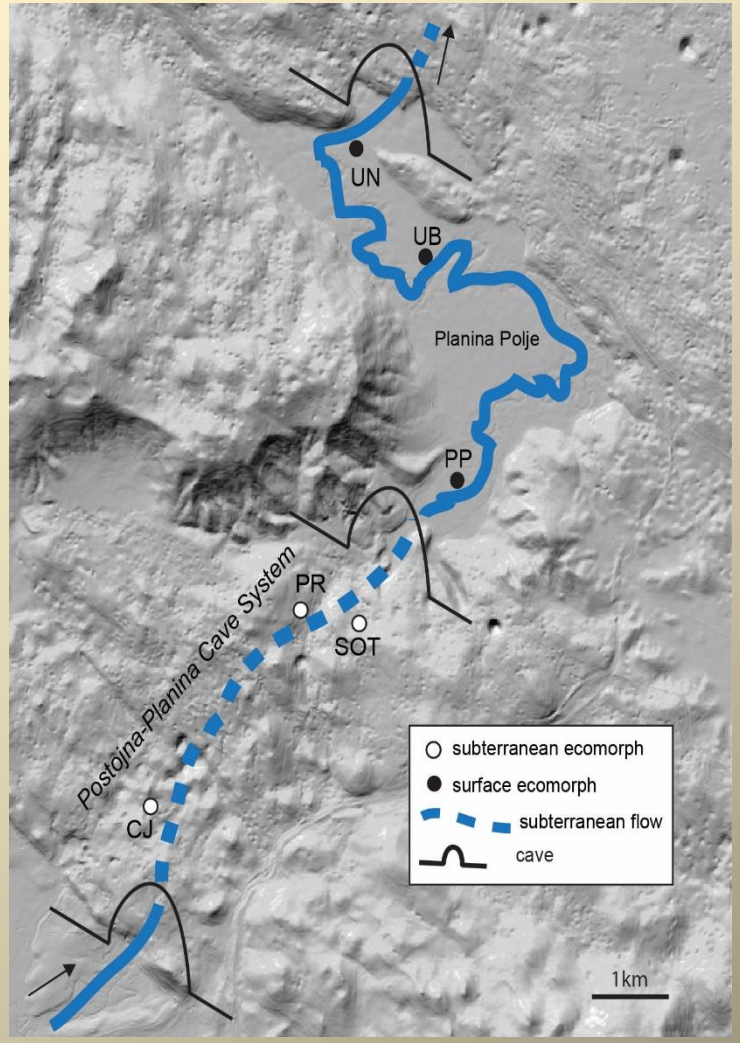
FILOGEOGRAFIJA NA KONITNENTALNOM NIVOU

Distribucija nukleotidnog diverziteta u Evropi

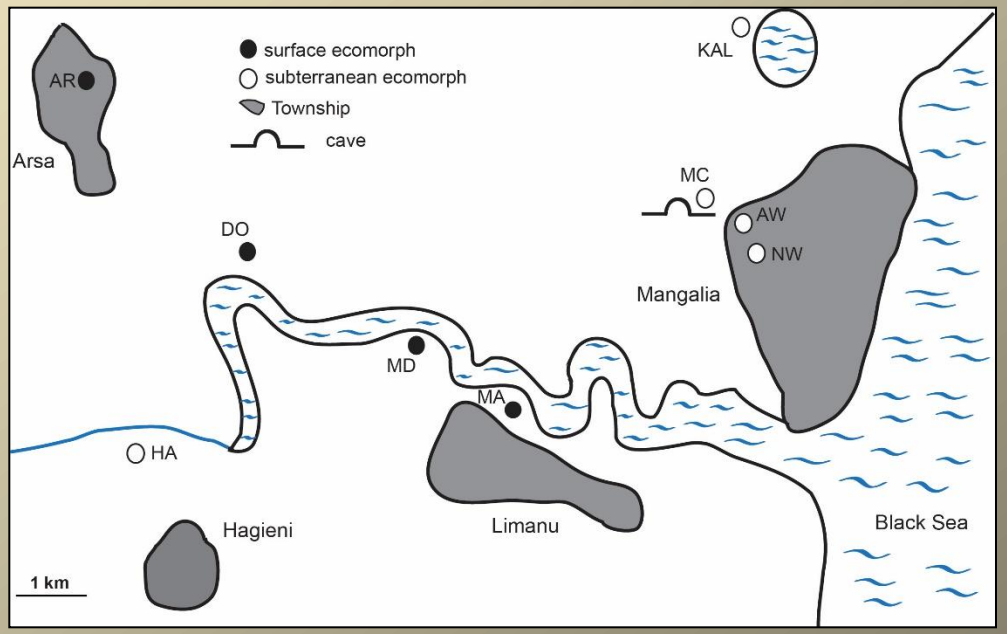


PARALELNA EVOLUCIJA

Dnarski Kras (SLO)



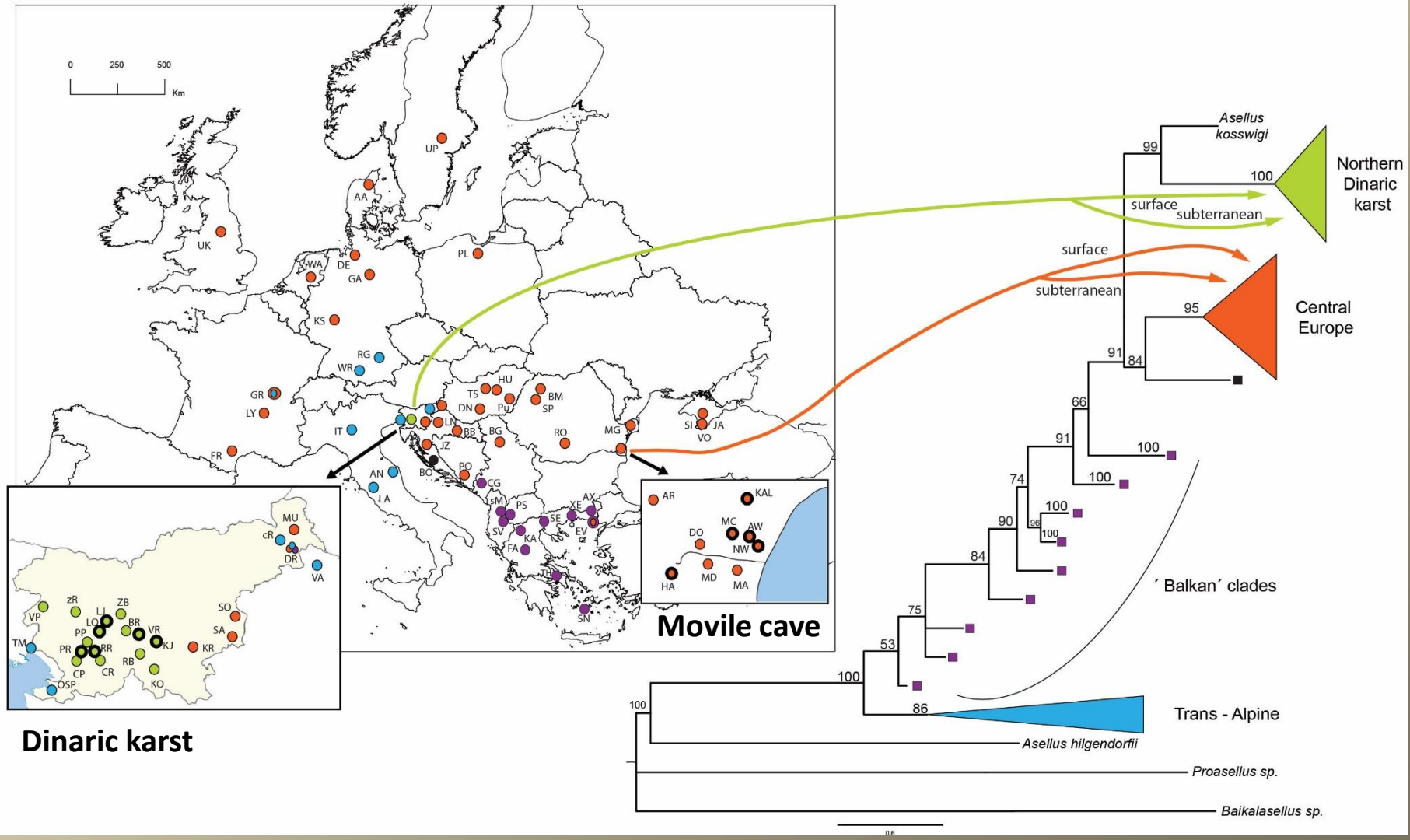
Pećina Movile (RO)



- Pećine sa sulfidnom termalnom vodom
- Prisutna primarna produkcija – nema nedostataka hrane

PARALELNA EVOLUCIJA

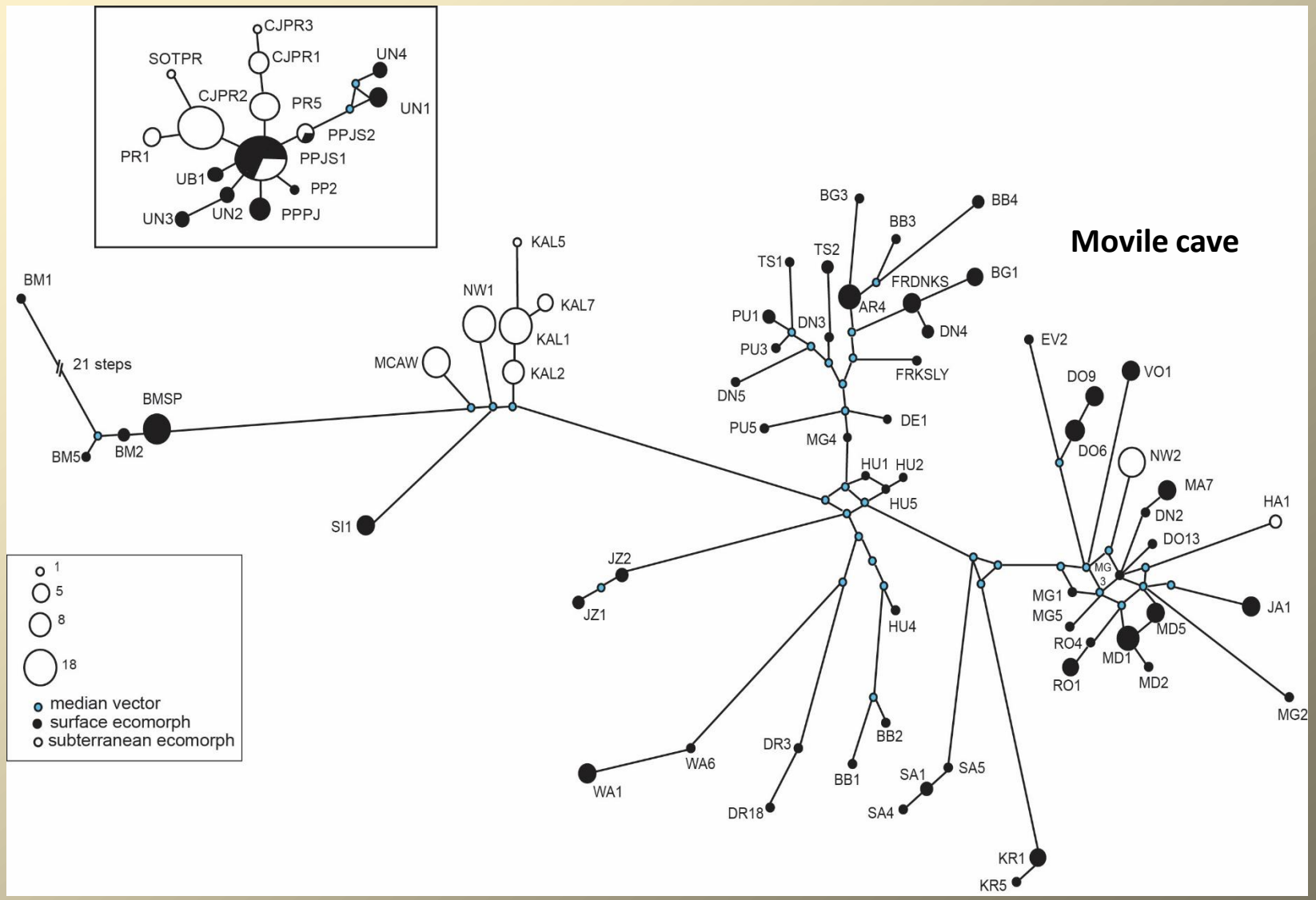
Dva odvojena naseljavanja pećina sa izraženo troglomorfnim populacijama.



PARALELNA EVOLUCIJA

Dva odvojena naseljavanja podzemlja u Movile.

Dinaric karst



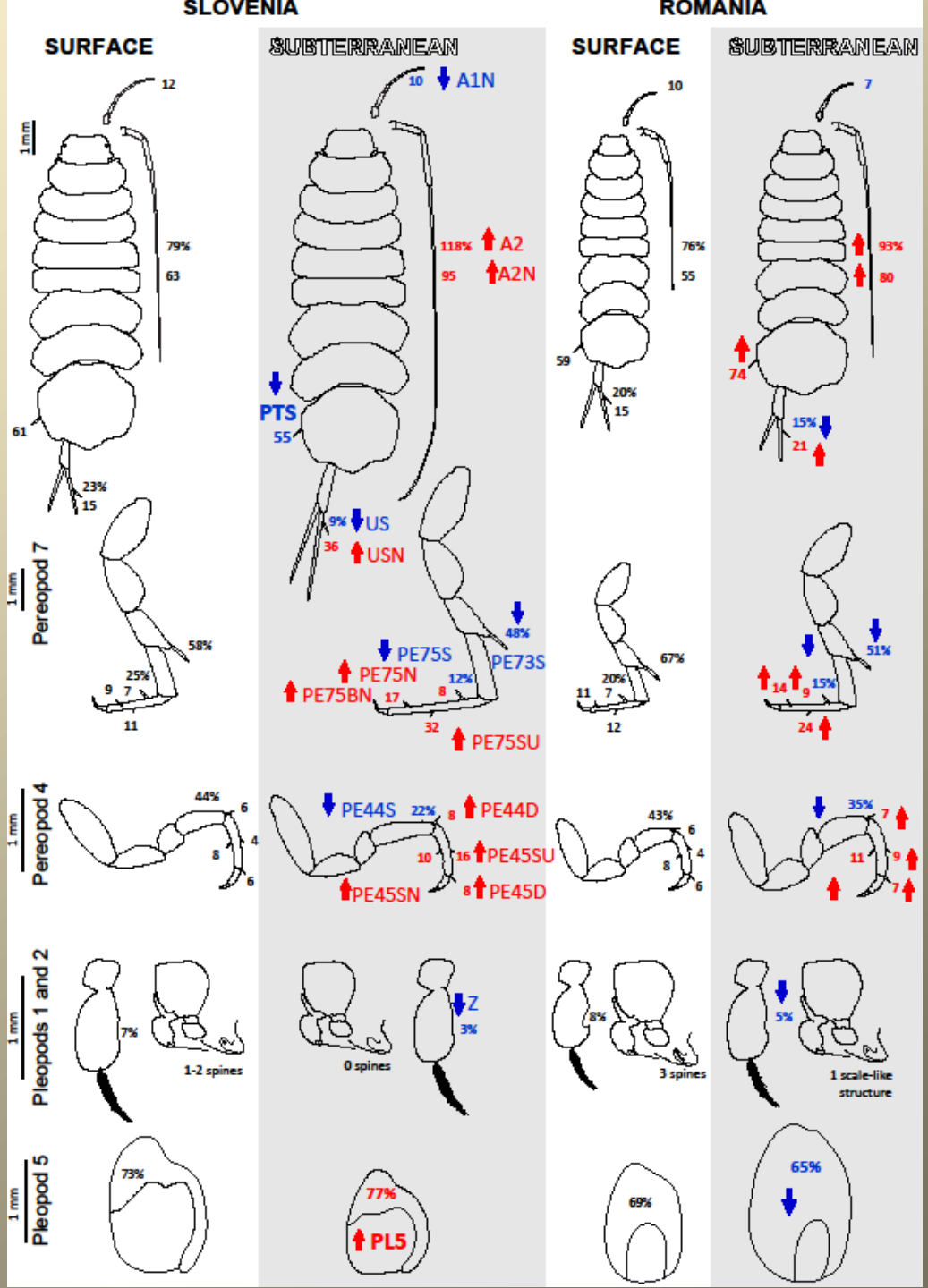
PARALELNA EVOLUCIJA

Poređenje signifikantnih promena morfometrijskih znakova između parova podzemnih i nadzemnih ekomorfa.

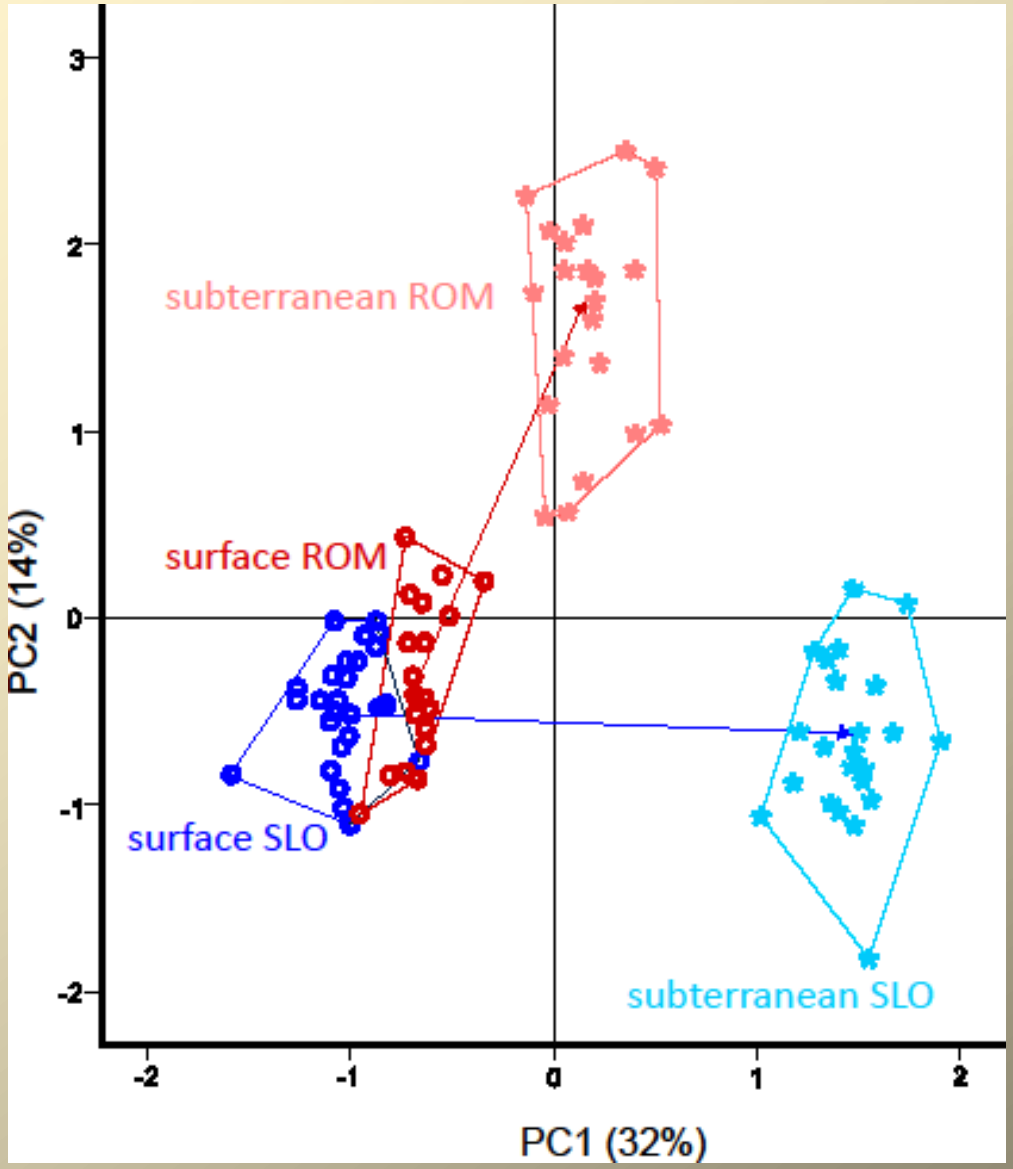
62 upoređena znaka

18 znakova pokazuje signifikantnu jednosmernu promenu u obe ekomorfe (moguće troglomorfoze)

2 znaka pokazuju singinifikantne promene u suprotnom pravcu (moguće lokalne adaptacije na specifiku ekosistema)



PARALELNA EVOLUCIJA



PCA- principal component analysis morfometrijskih znakova.

Površinske populacije su udružene, ali podzemne divergiraju u morfoprostoru.

MONOLISTRA - subgenera

	Uropods	Male pereopod II
Pseudomonolistra	developed	slightly thickened
Monolistra	developed	with subchela
Microlistra	rudimentary, on sockle	slightly thickened
Typhlosphaeroma	rudimentary or absent	with subchela
Monolistrella	rudimentary	strongly thickened

Microlistra jalzici

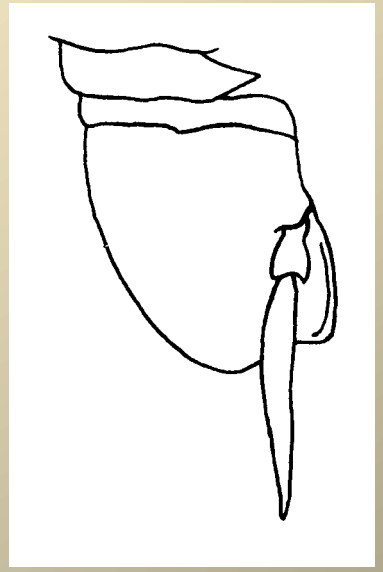
Monolistra monstruosa

Typhlosphaeroma karamani

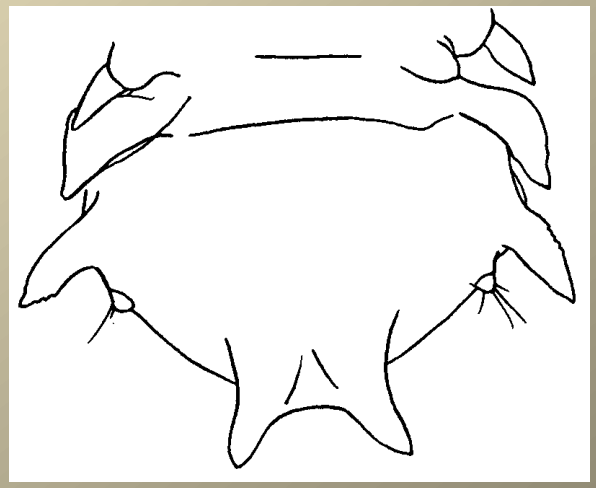
MONOLISTRA - subgenera

	Uropods	Male pereopod II
Pseudomonolistra	**developed**	slightly thickened
Monolistra	**developed**	with subchela
Microlistra	**rudimentary, on sockle**	slightly thickened
Typhlosphaeroma	**rudimentary or absent**	with subchela
Monolistrella	**rudimentary**	strongly thickened

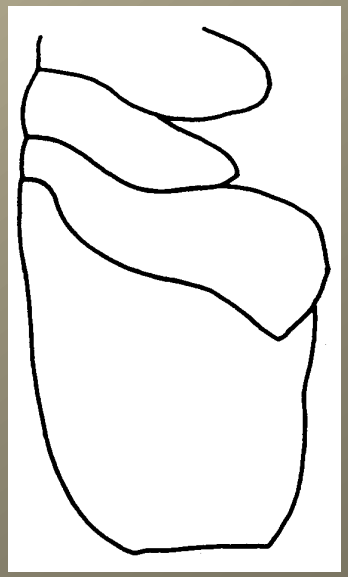
Monolistra
Pseudomonolistra



Microlistra



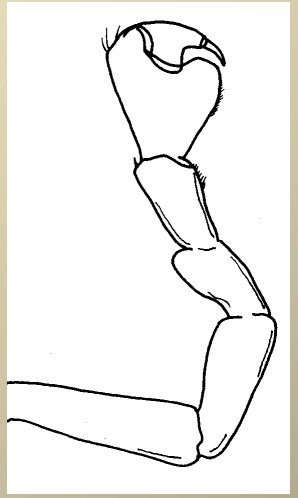
Typhlosphaeroma



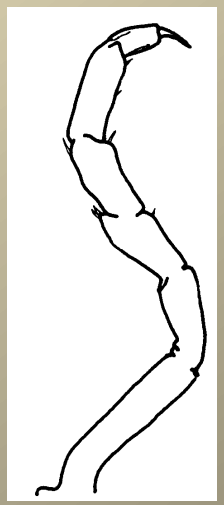
MONOLISTRA - subgenera

	Uropods	Male pereopod II
Pseudomonolistra	developed	**slightly thickened**
Monolistra	developed	**with subchela**
Microlistra	rudimentary, on sockle	**slightly thickened**
Typhlosphaeroma	rudimentary or absent	**with subchela**
Monolistrella	rudimentary	**strongly thickened**

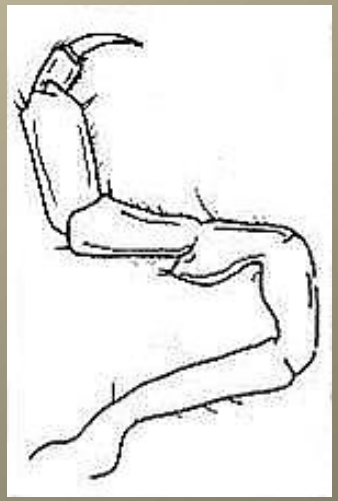
Monolistra
Typhlosphaeroma



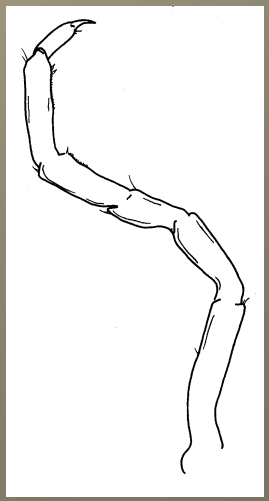
Pseudomonolistra
Microlistra



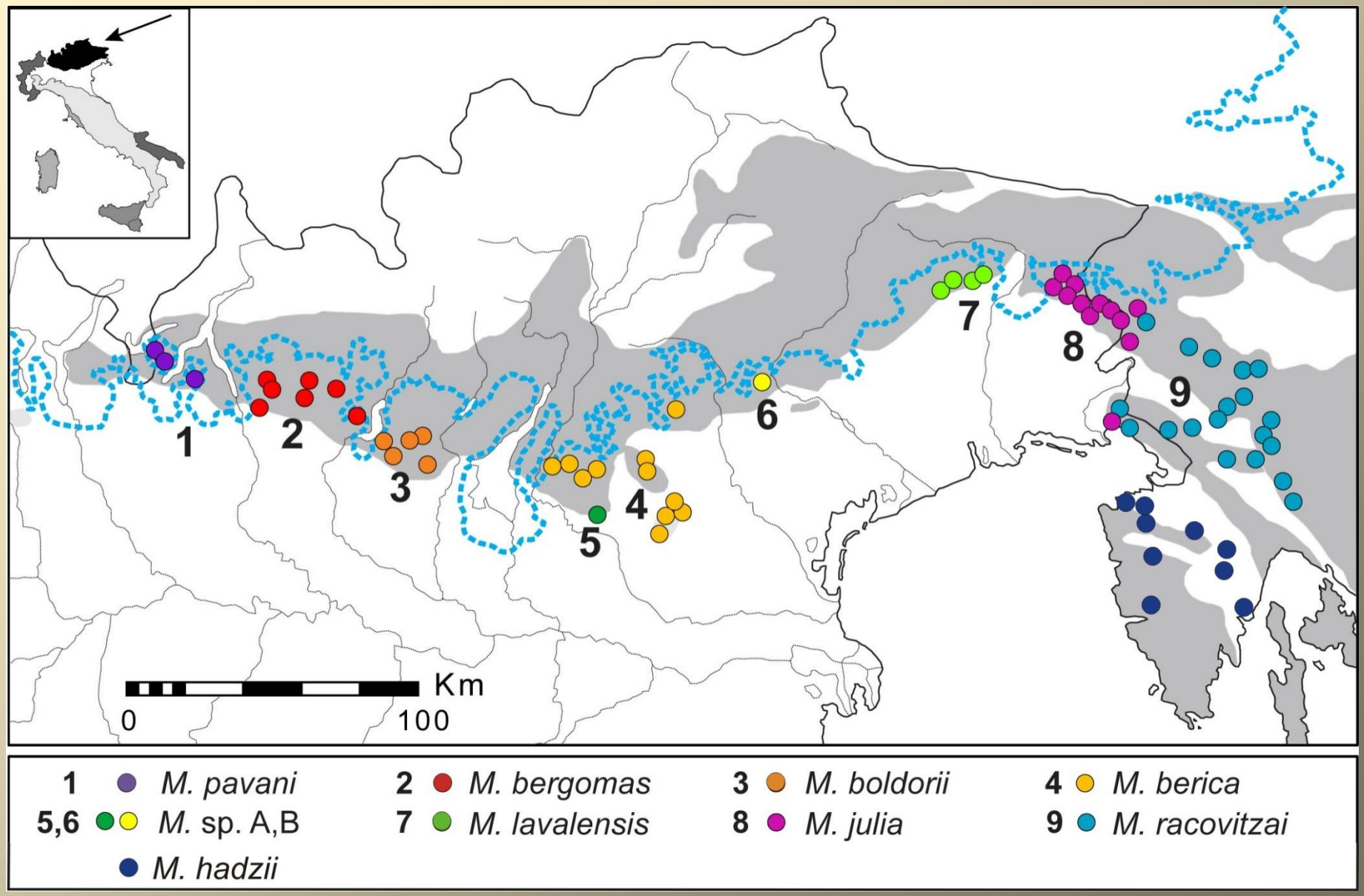
Monolistrella

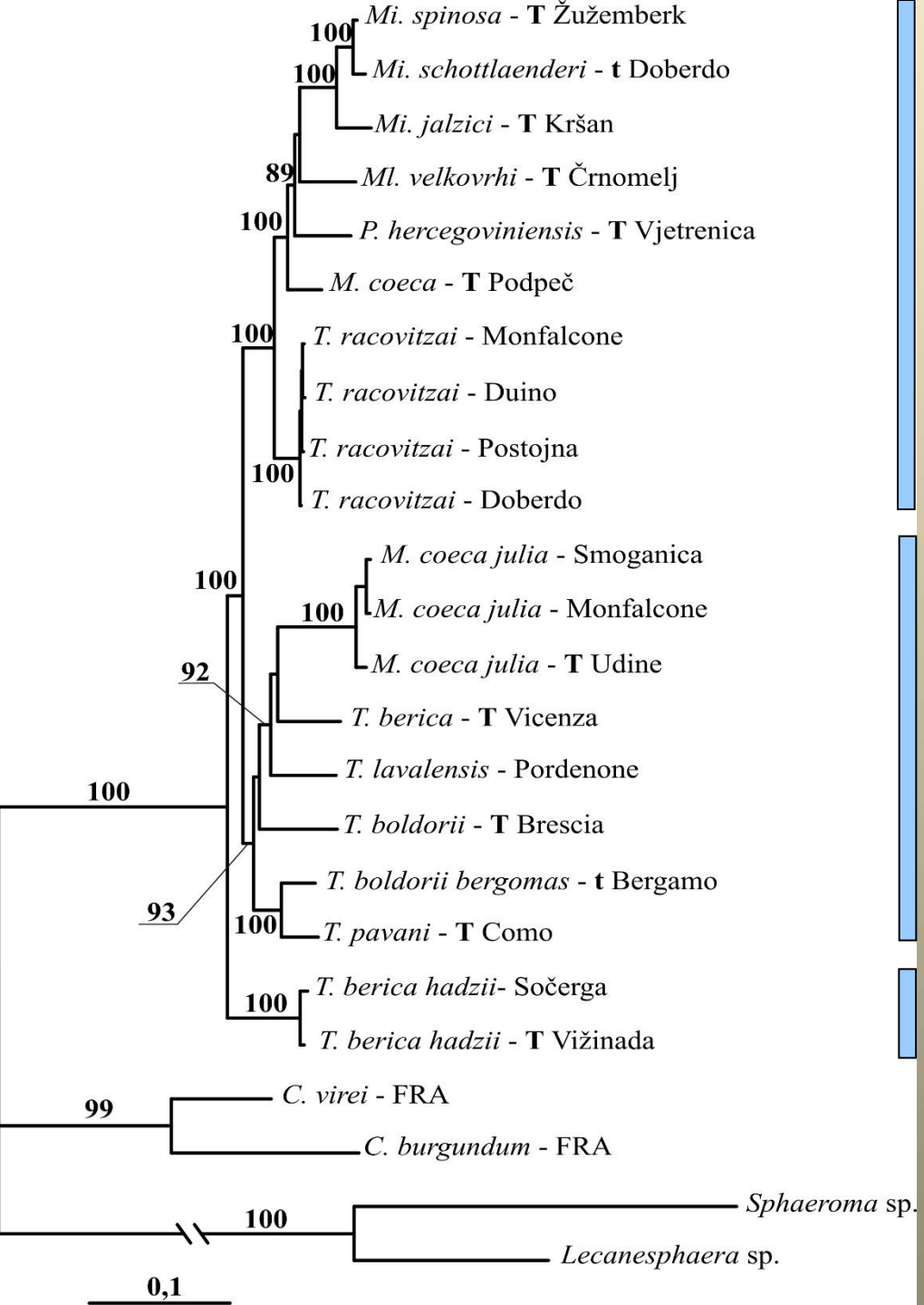


ženka pp II



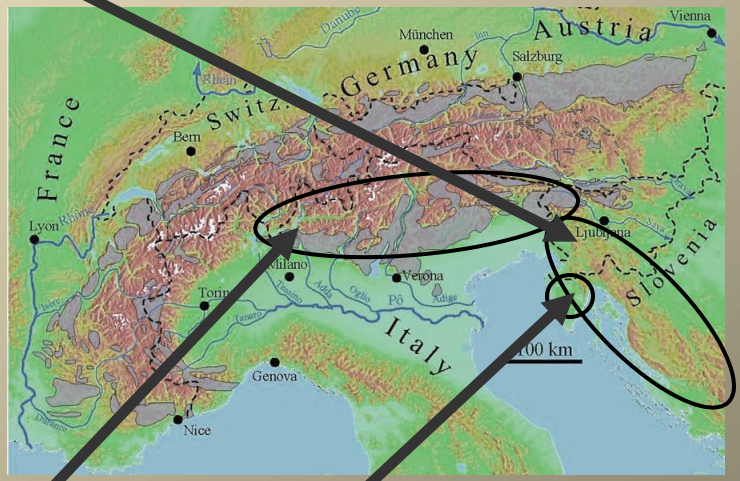
Raširenost zapadnih taksona genusa *Monolistra*





Filogenija zapadnih taksona *Monolistra*

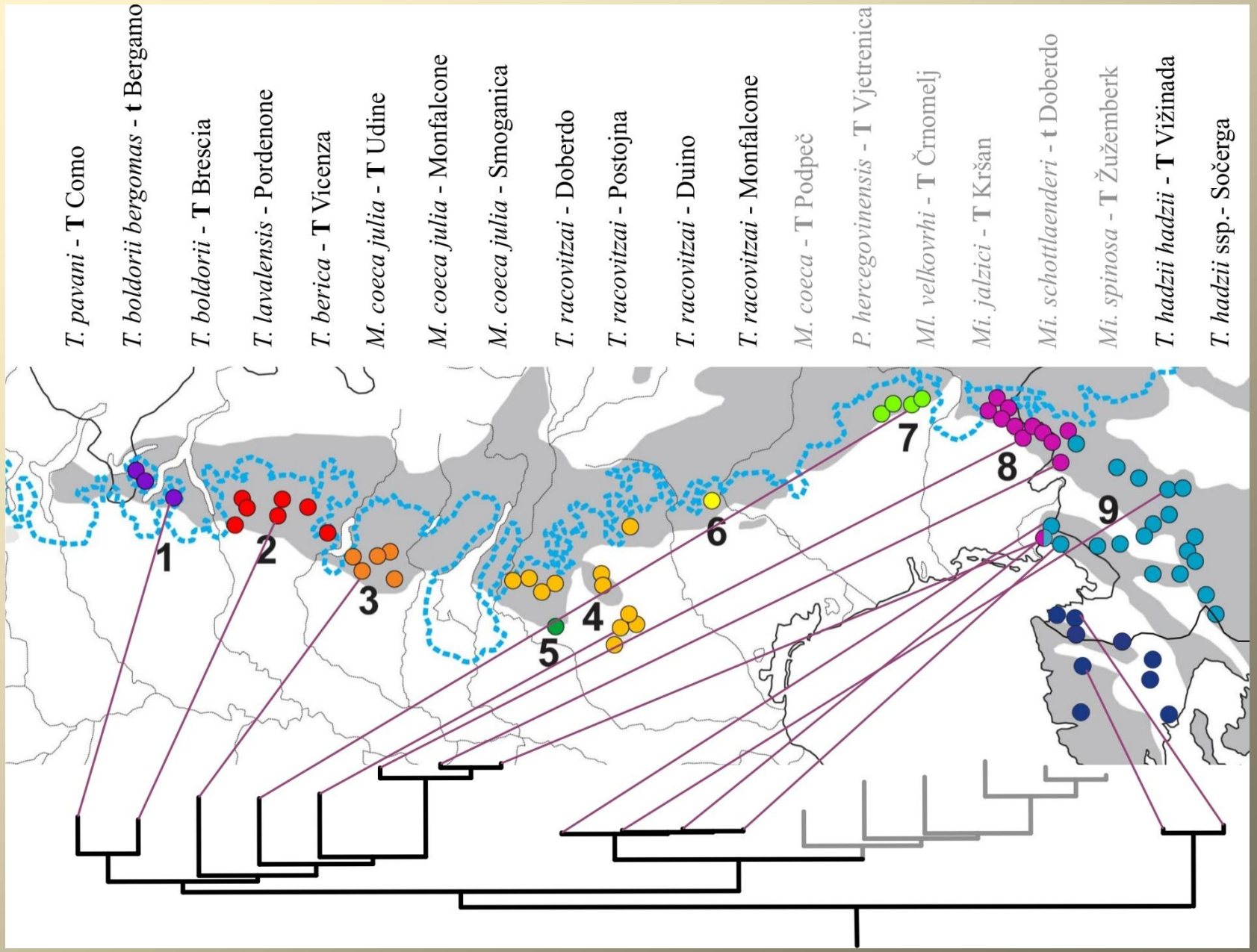
Dinaridi

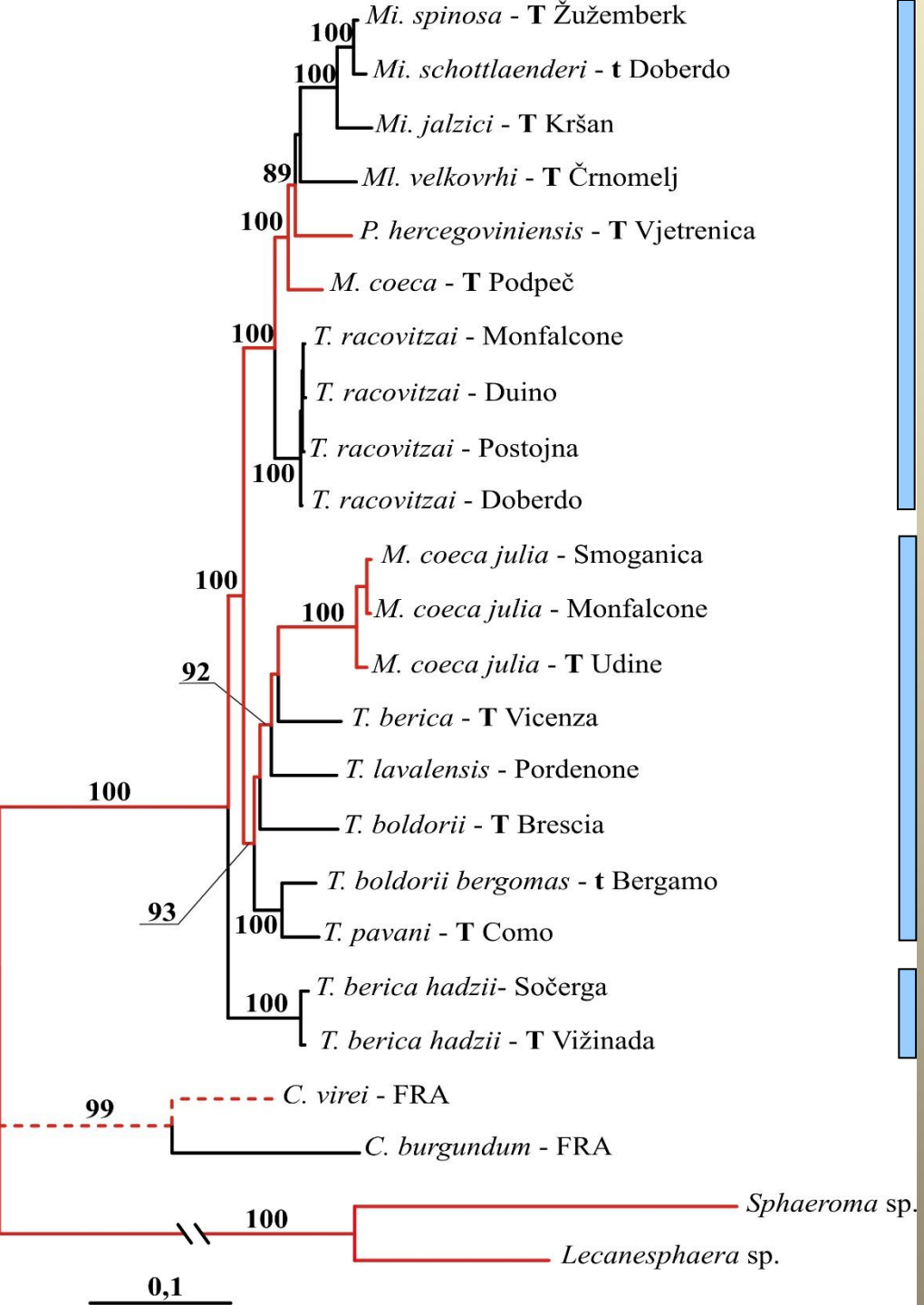


Južni Alpi

Istra

Raspored klada sub-genusa *Typhlosphaeroma*



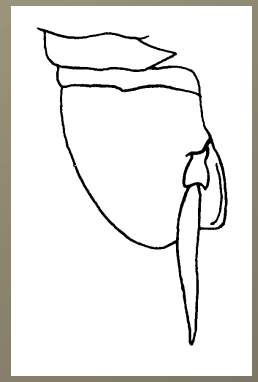


Filogenija zapadnih taksona *Monolistra*

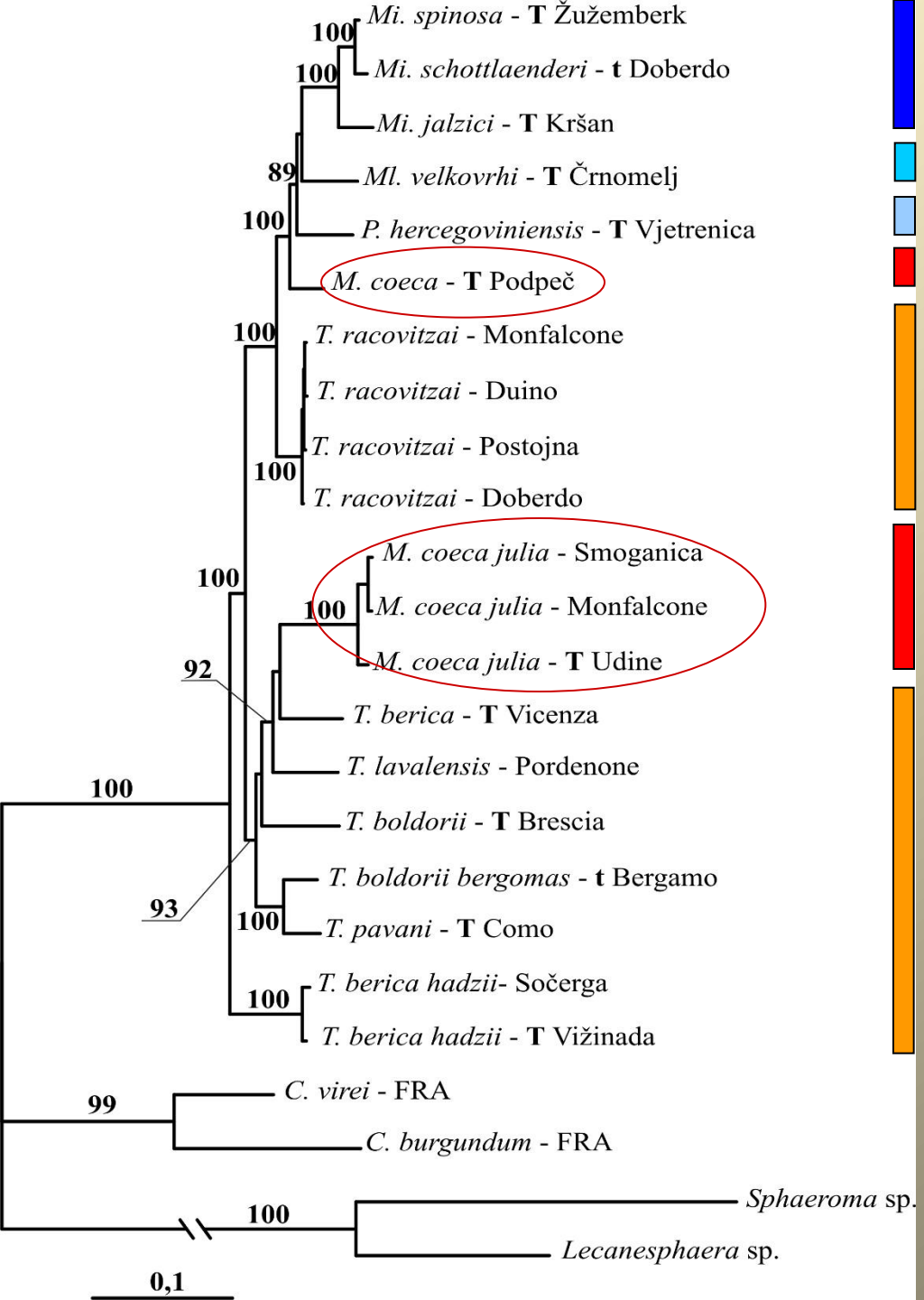
Dinaridi

Južni Alpi

Istra

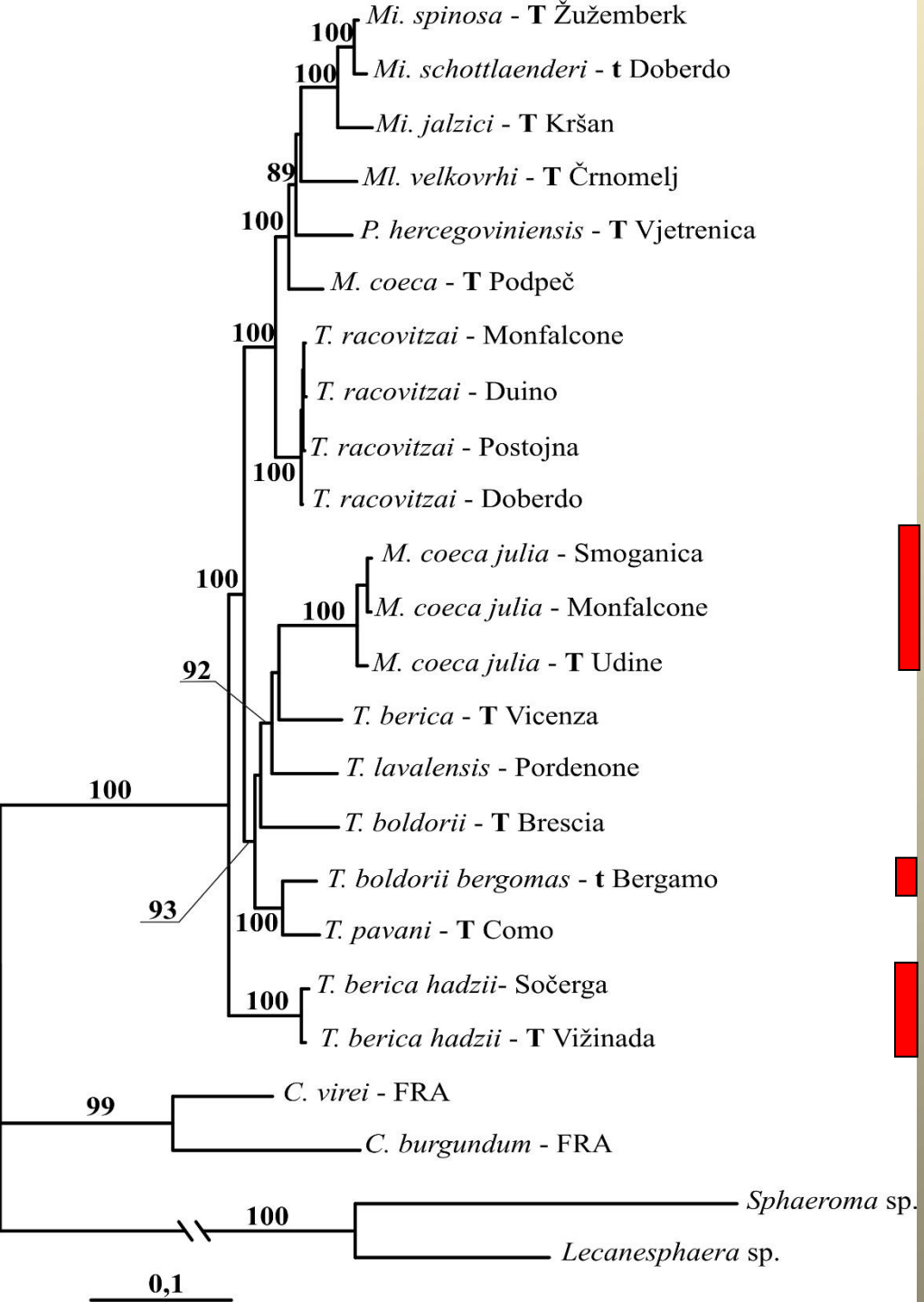


uropodi razvijeni



Monofilija subgenusa

Nove vrste



Monolistra julia

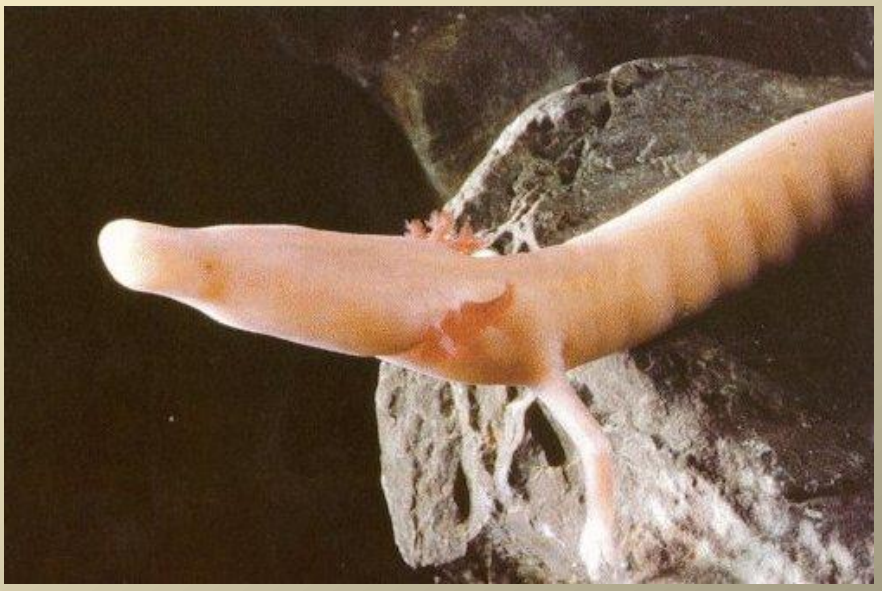
Monolistra bergomas

Monolistra hadzii

PROTEUS – koliko vrsta?

Fitzinger je 1850 godine opisao sedam (7) vrsta čovečje ribice. Danas su opšte prihvaćene samo dve podvrste:

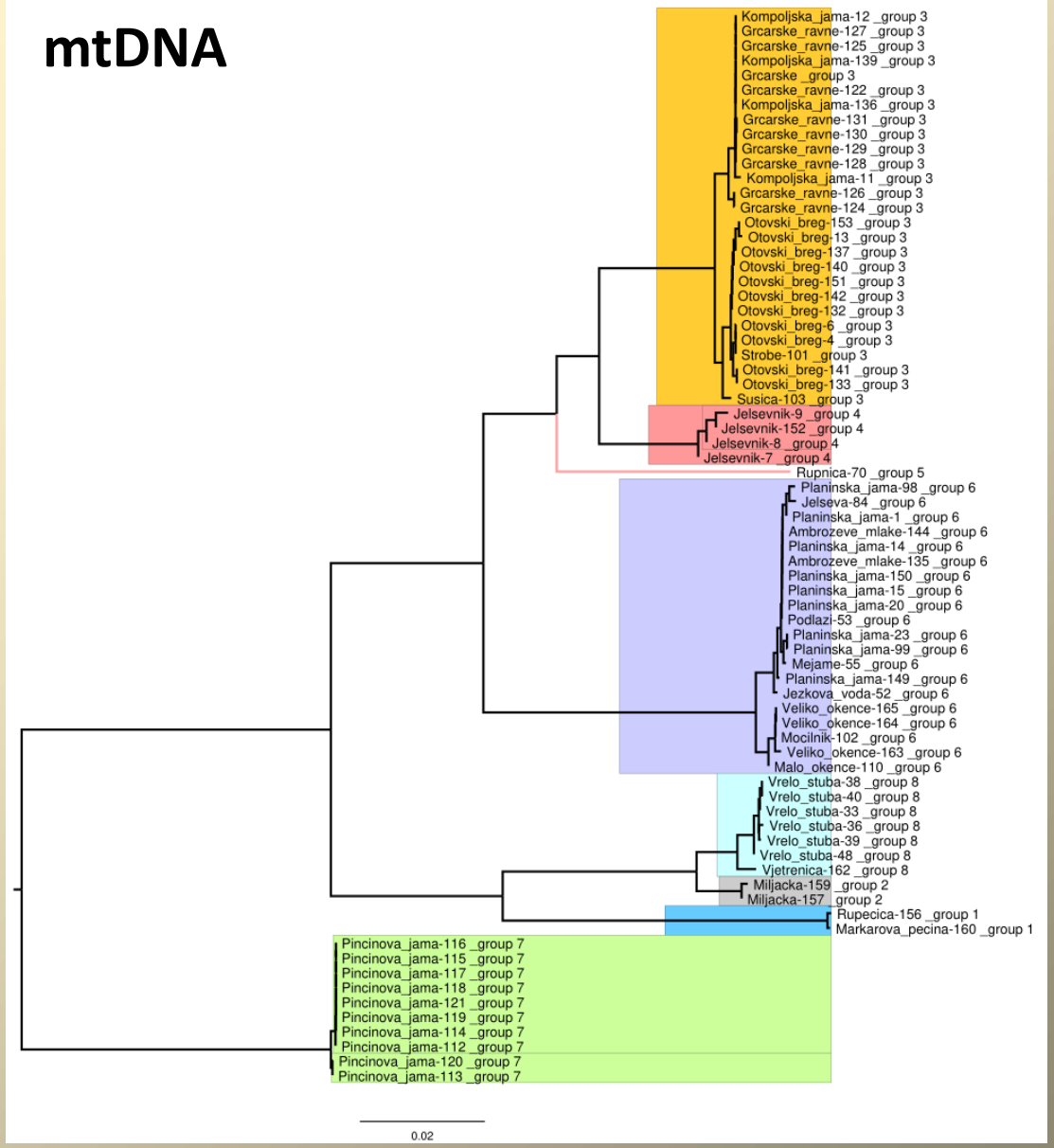
Proteus a. anguinus

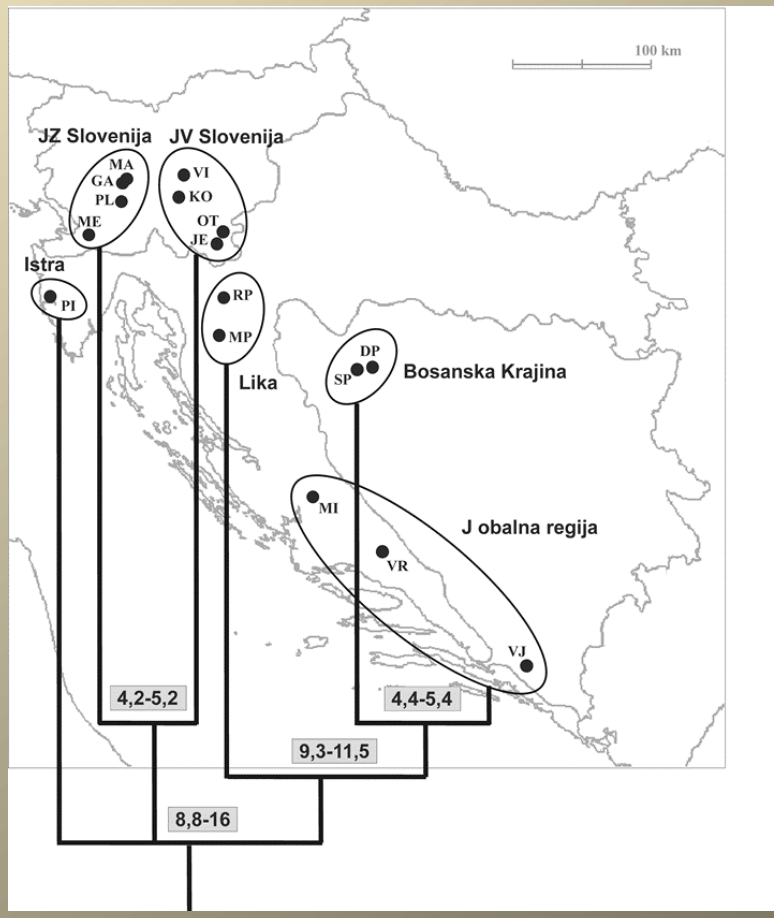


Proteus a. parkelj

PROTEUS – koliko vrsta?

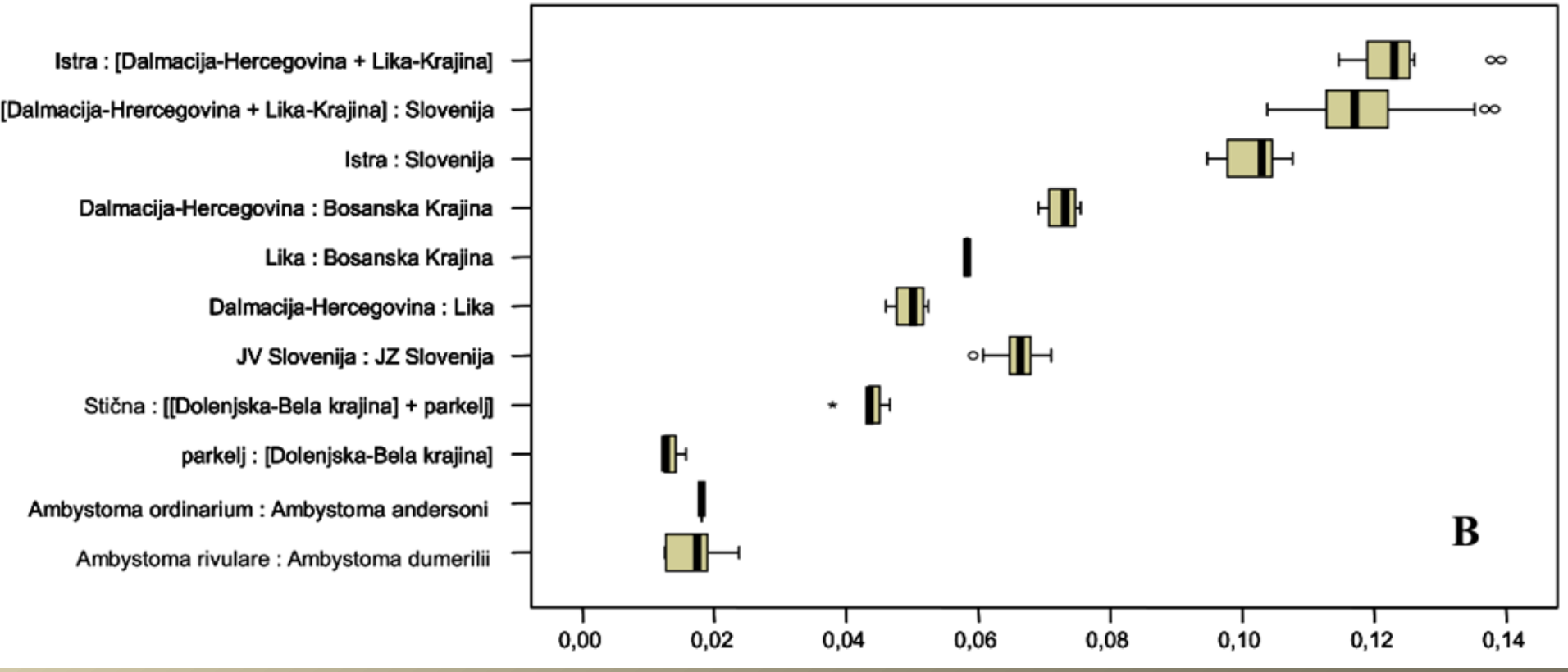
mtDNA



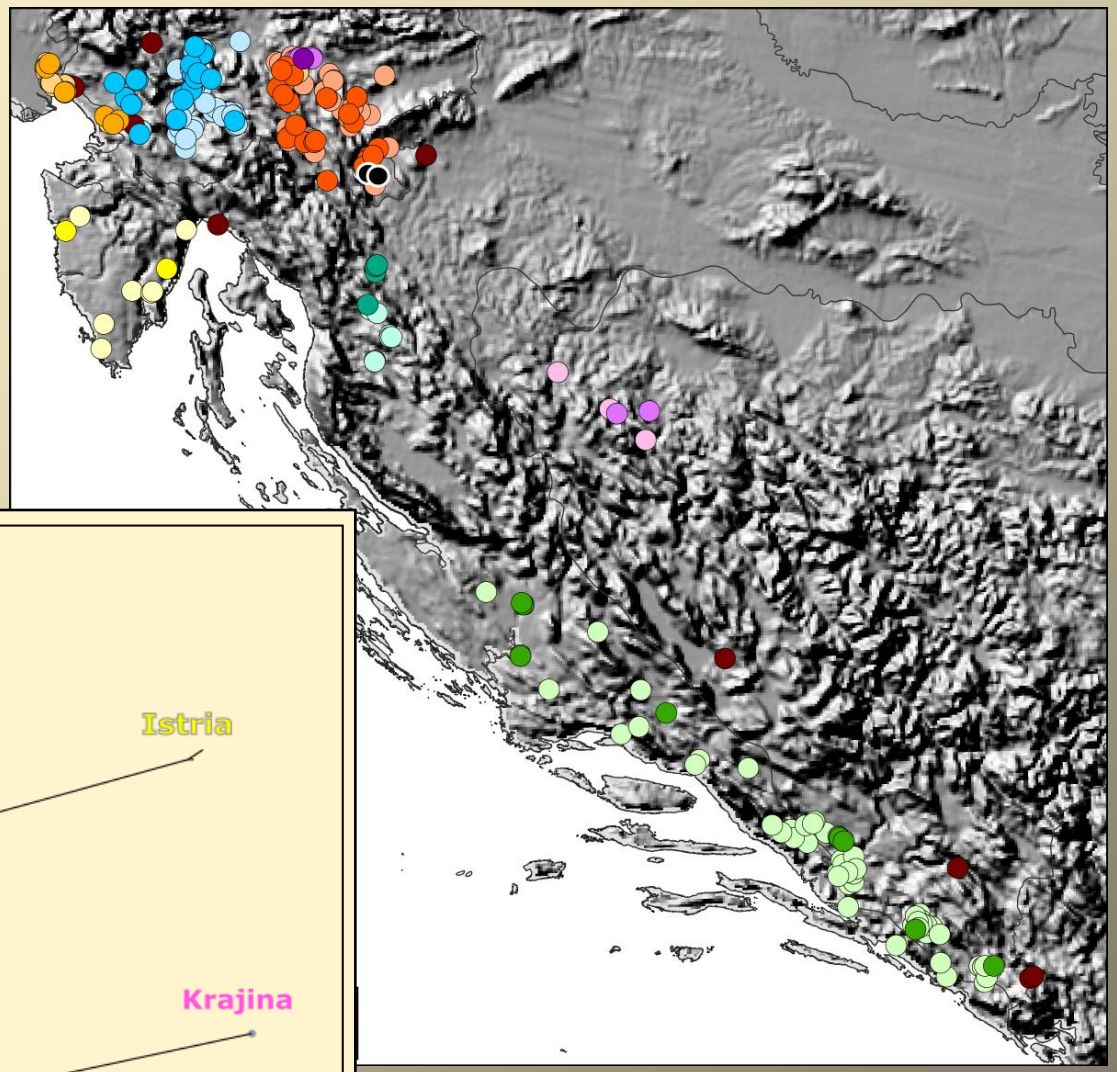


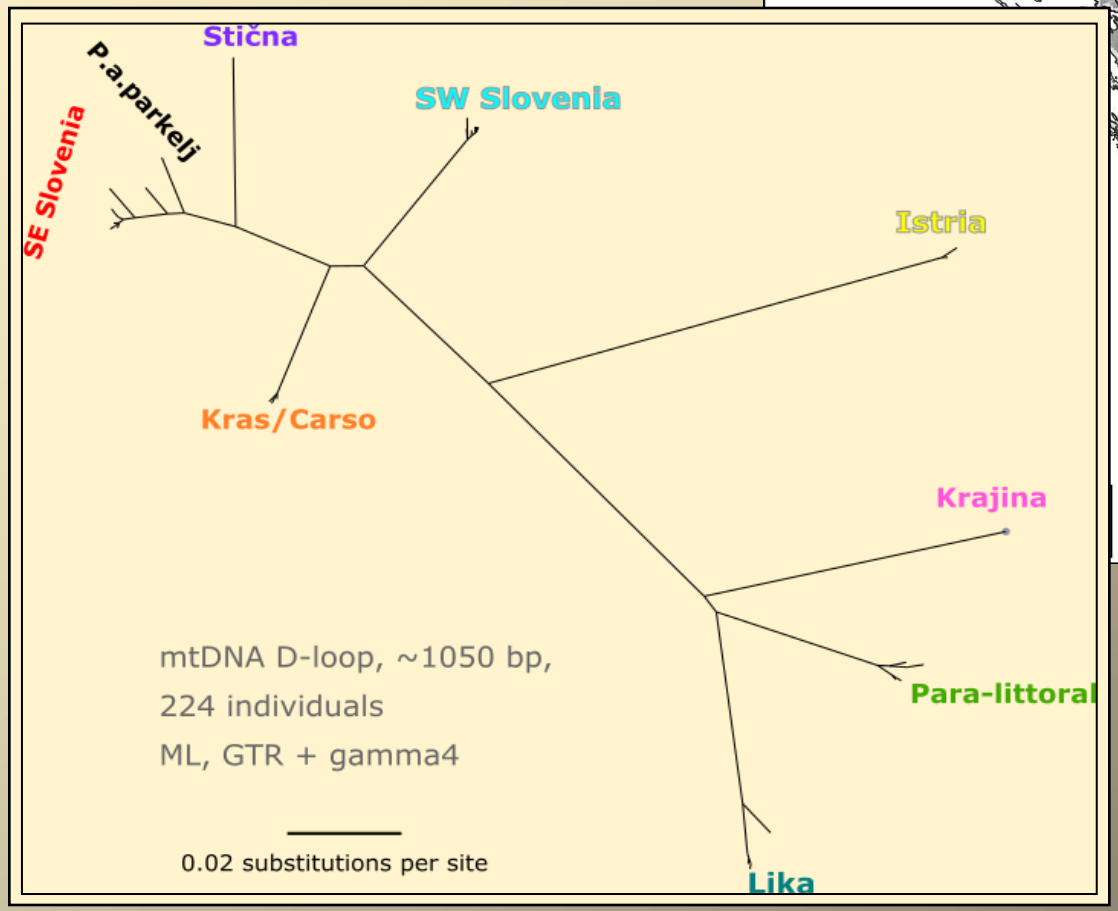
PROTEUS – koliko vrsta?

Poređenje patrističnih genetskih rastojanja (mtDNA) između sestrijskih klada proteusa in sestrijskih vrsta iz genusa *Ambystoma*.

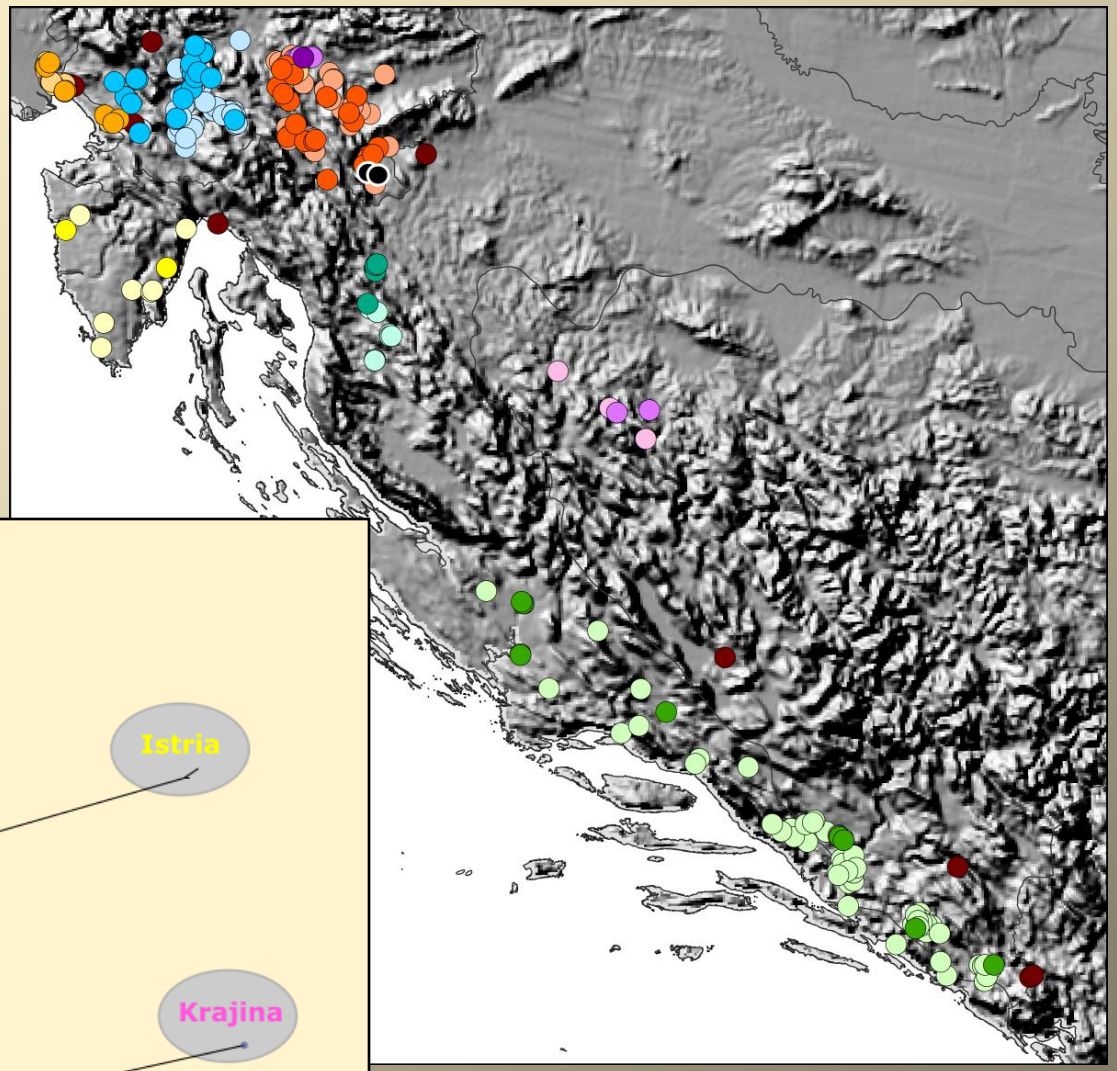


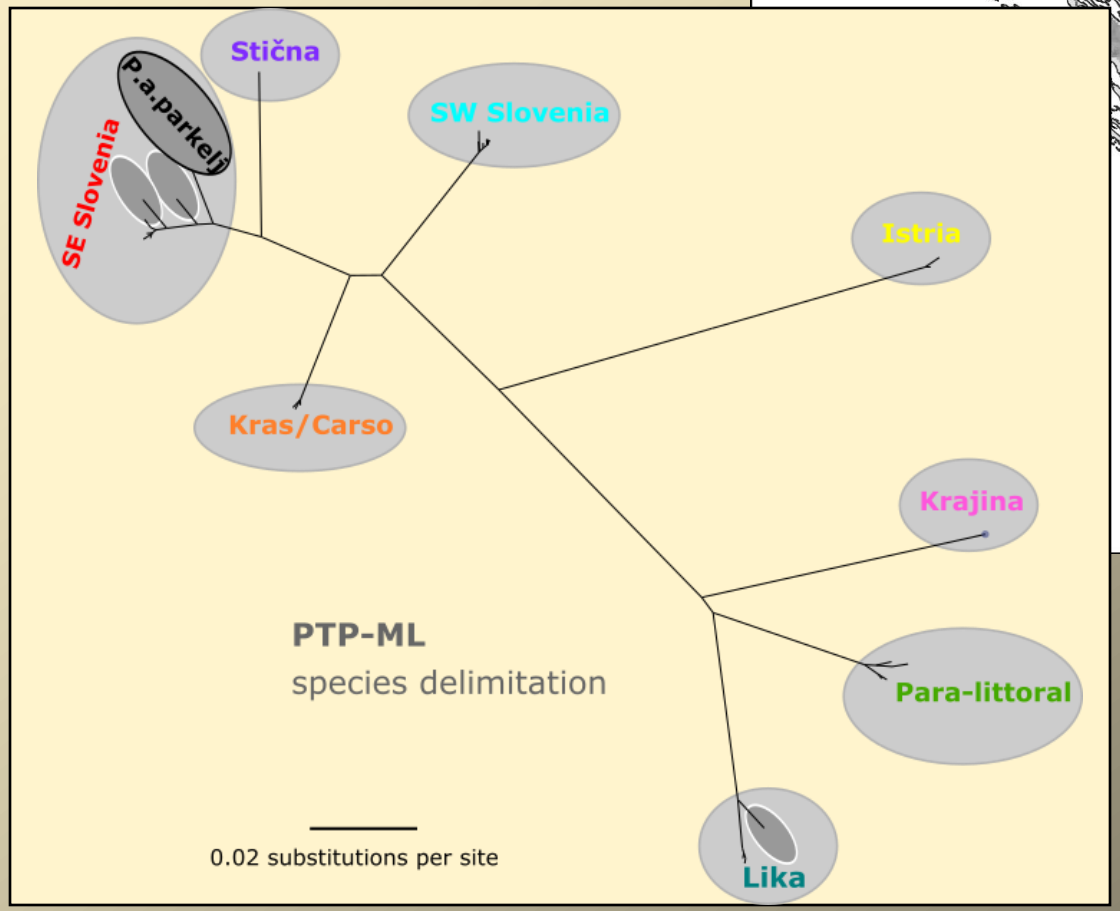
PROTEUS – koliko vrsta?





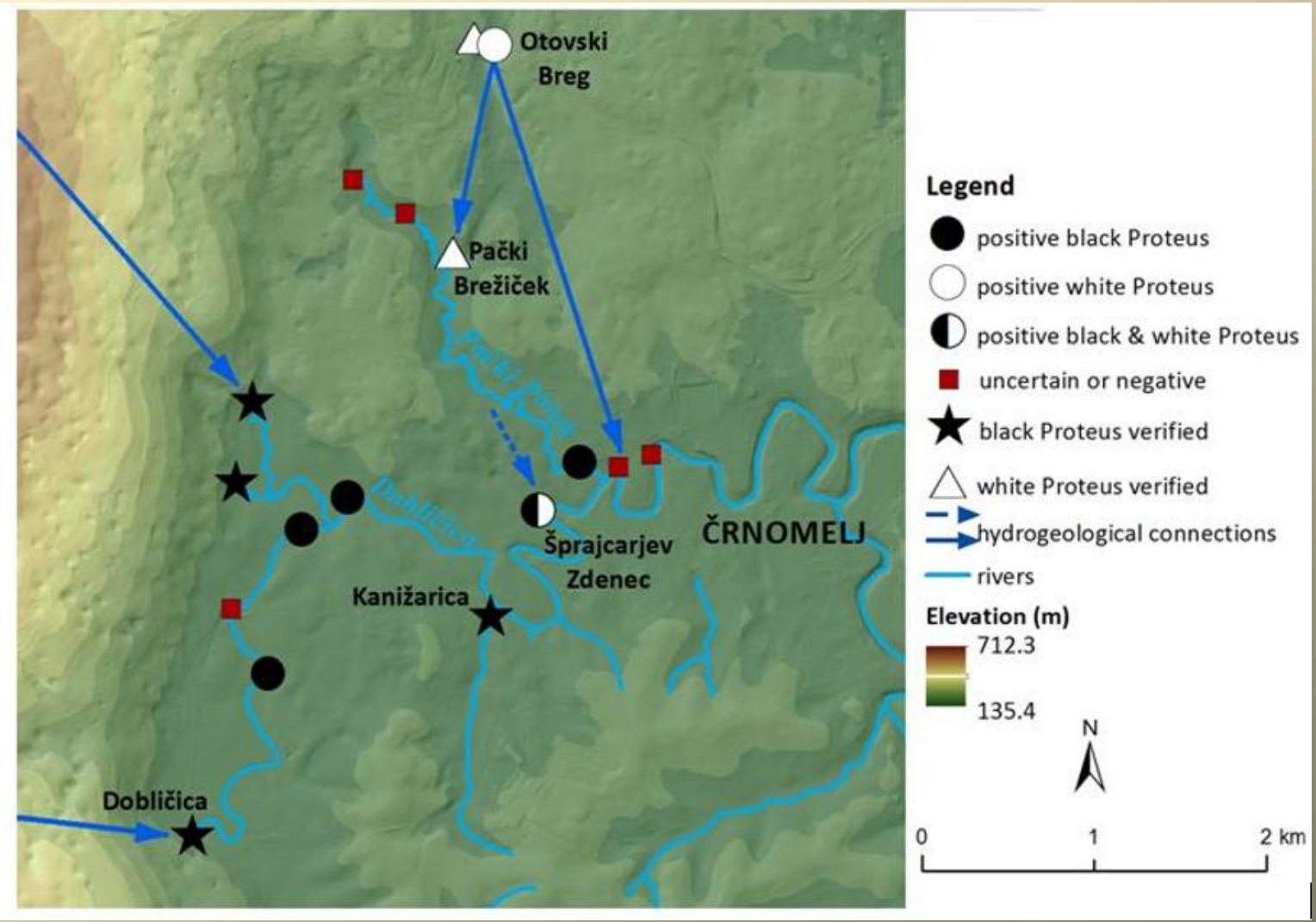
PROTEUS – koliko vrsta?





8 kriptičnih vrsta

Dokaz sintopije *P. a. parkelj/anguinus* sa eDNA



Proteus kamionus

ParkirišČe za tovornjake ogroŽa posebno vrsto Človeške ribice

Izvor kod Stične

SubBioLab

Boris Sket

Peter Trontelj

Cene Fišer

Simona Prevorčnik

Maja Zagmajster

Valerija Zakšek

Marjeta Konec

http://subbio.net/

HVALA!