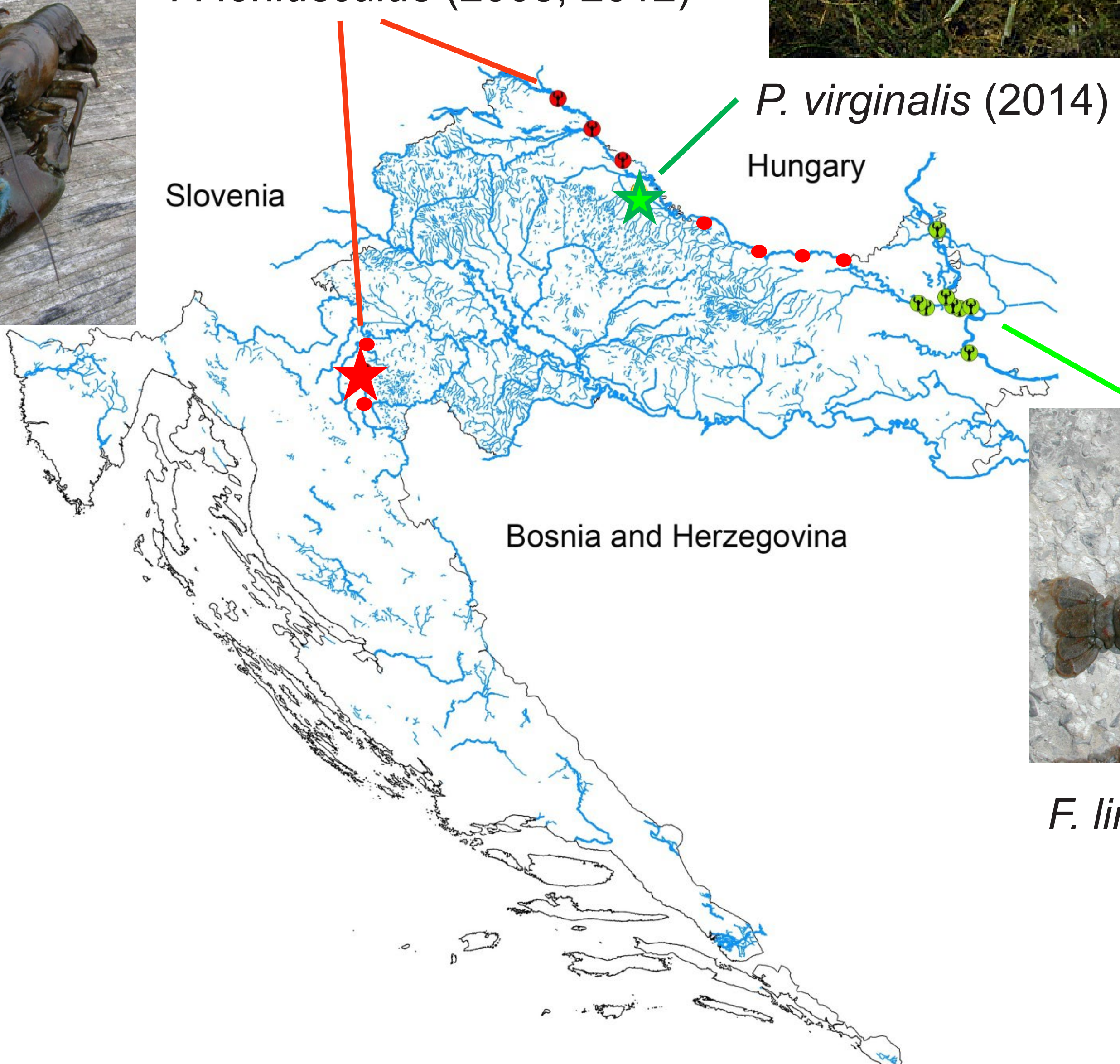
MALAKOLOGIJA I ASTAKOLOGIJA U NASTAVI BIOLOGIJE (208676)

2P+1V+0S 4 ECTS

Hrvatska - 3 strane invazivne vrste



The first record of the signal crayfish in Croatia dates from 2008 (Maguire *et al., 2008).* Until now, signal crayfish records in Croatia have been found in the Mura River and the the Drava River.

18-24.4 km/god. (najbrže u Europi)

O. limosus was first recorded in Croatia in 2003 (Maguire and Klobucar, 2003; Maguire and Gottstein-Matocec, 2004) in the Nature Park Kopacki rit, where it spread from the Hungarian section of the Danube River

> 2.5 km/god.

S. Hudina et al.: Knowl. Managt. Aquatic Ecosyst. (2010) 394-395, 09

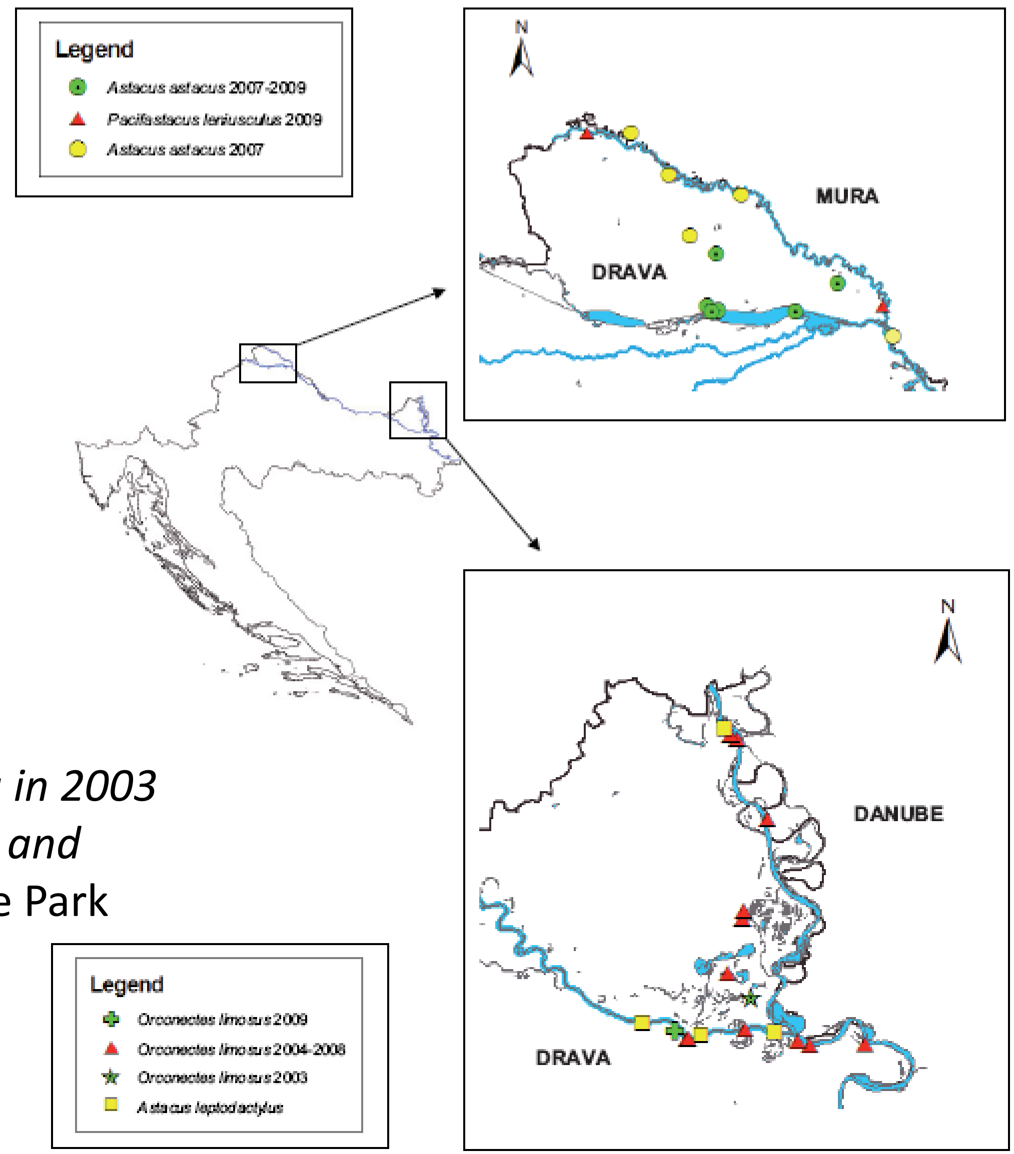


Figure 1
Distribution of the invasive signal crayfish and the native noble crayfish in the Drava and the Mura rivers, and distribution of the invasive spiny-cheek crayfish and the native narrow-clawed crayfish in the Drava and the Danube rivers.

Fig. 1. The position of examined sites in the lower section of the Mura River, Croatia. M1 represents the most upstream examined s (source population), M3 invasion front, while M2 represents the intermediate point between these two sites. G1 and G2 represent t two gauging stations from which continuous measurements of water temperature and discharge were obtained.

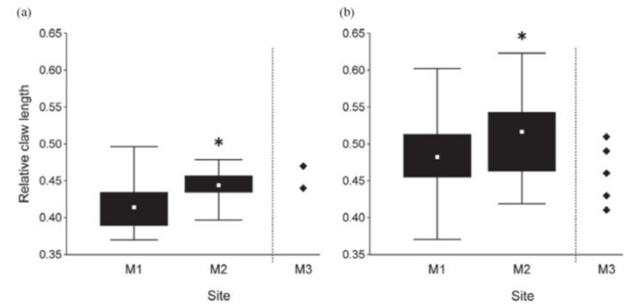


Fig. 4. Relative claw length (CLL) at two segments of signal crayfish invasive range for size class 1 (a) and size class 2 (b) males. Data for the third site (M3) were added for reference only and were not included in the quantitative analyses. The boxes show medians and quartiles, whiskers show minimum and maximum. *Indicates significantly higher relative CLL.

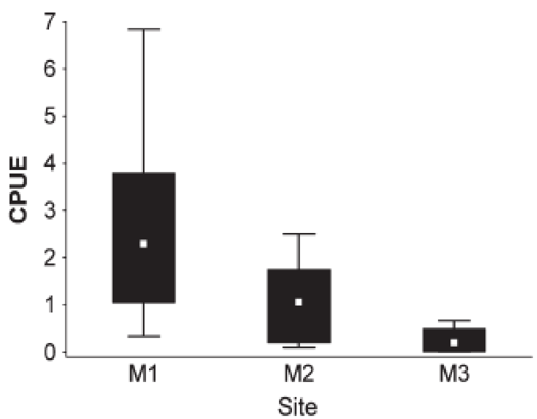


Fig. 2. Differences in catch per unit effort (CPUE; equal to the number of caught crayfish per trap per number of trapping nights) between examined sites during same trapping periods (August, October and November 2009). The boxes show medians and quartiles, whiskers show minimum and maximum.

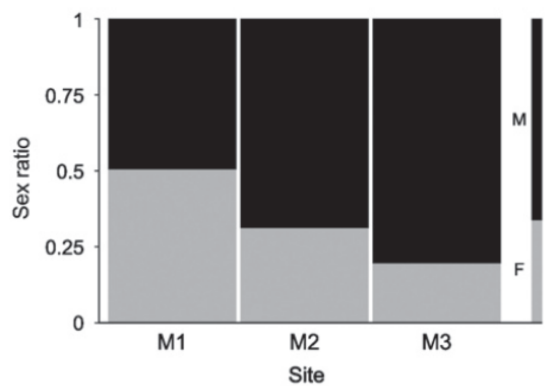


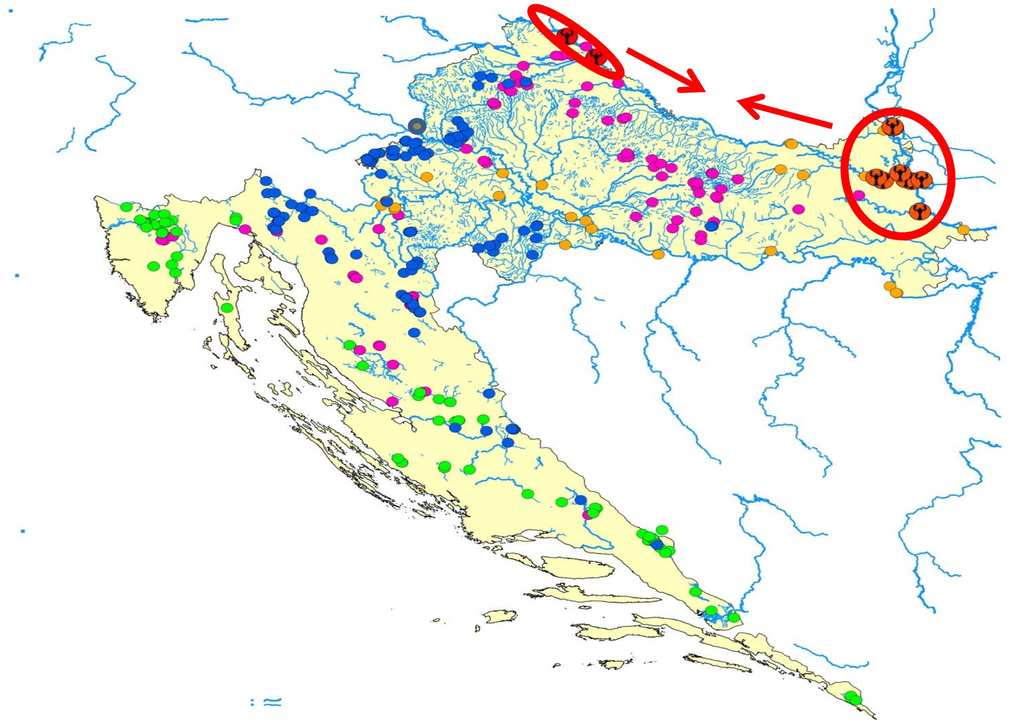
Fig. 3. Sex ratio (M = males; F = females) at three examined sites during the same trapping periods (August, October and November 2009). The bar on the right shows the sex ratio for a composite sample of all three sites.

Biol Invasions
DOI 10.1007/s10530-010-9933-2

ORIGINAL PAPER

Competitive interactions between co-occurring invaders: identifying asymmetries between two invasive crayfish species

Sandra Hudina · Nika Galić · Ivo Roessink · Karlo Hock



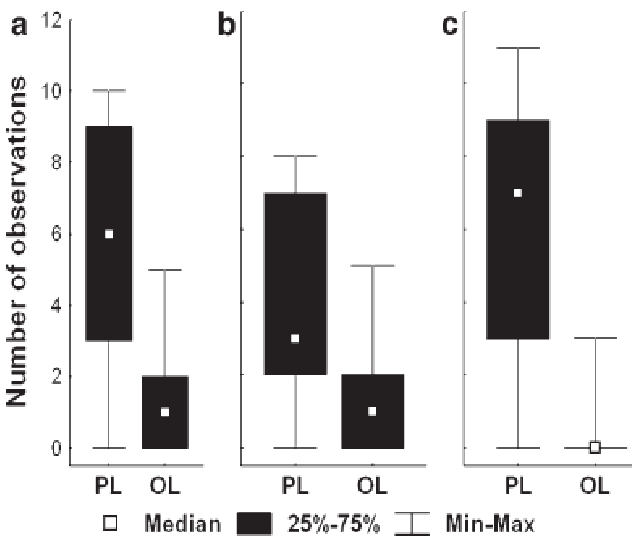
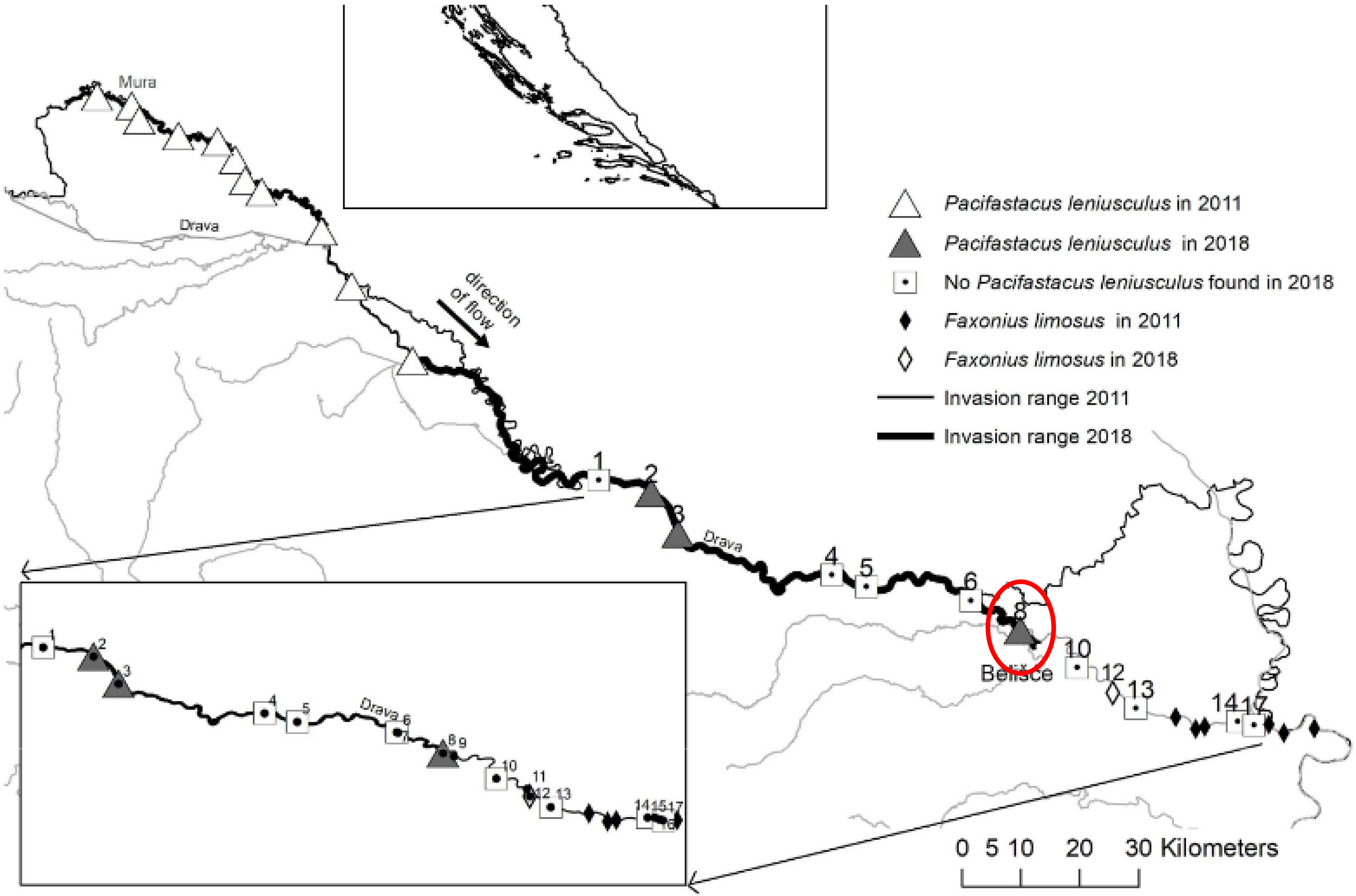


Fig. 1 Counts and identity of **a** initiator of agonistic interaction, **b** initiator of physical contact and **c** interaction winner, in 25 heterospecific dyads of *P. leniusculus* (PL) and *O. limosus* (OL). PL initiated significantly more interactions and physical contacts than OL and was identified as interaction winner significantly more frequently



Mura
Drava
direction of flow
Pacifastacus leniusculus in 2011
Pacifastacus leniusculus in 2018
No Pacifastacus leniusculus found in 2018
Faxonius limosus in 2011
Faxonius limosus in 2018
Invasion range 2011
Invasion range 2018
Belišće
0 5 10 20 30 Kilometers

MARINE AND FRESHWATER BEHAVIOUR AND PHYSIOLOGY, 2016
http://dx.doi.org/10.1080/10236244.2016.1146448

Taylor & Francis
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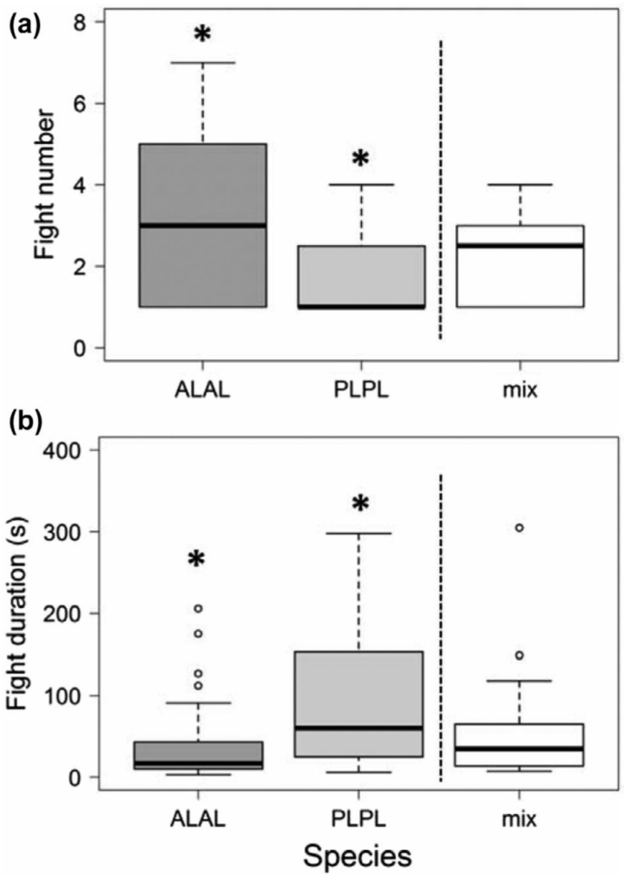
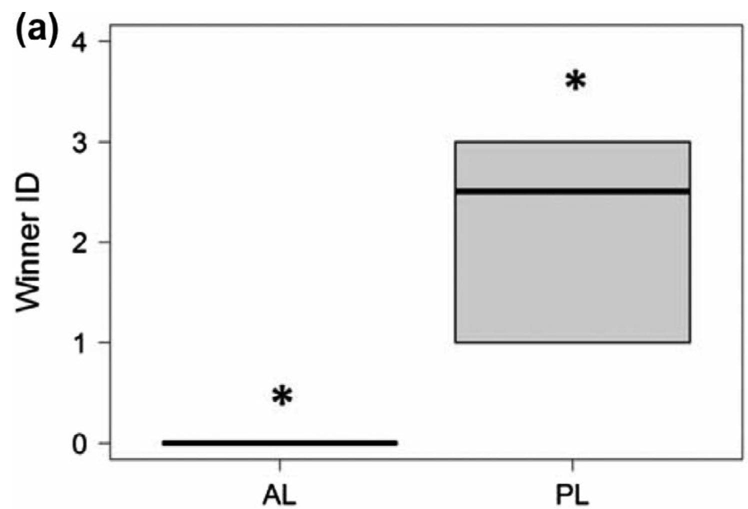
Species-specific differences in dynamics of agonistic interactions may contribute to the competitive advantage of the invasive signal crayfish (*Pacifastacus leniusculus*) over the native narrow-clawed crayfish (*Astacus leptodactylus*)

Sandra Hudina[a], Karlo Hock[b], Andreja Radović[c], Goran Klobučar[a], Jelena Petković[a], Mišel Jelić[a] and Ivana Maguire[a]

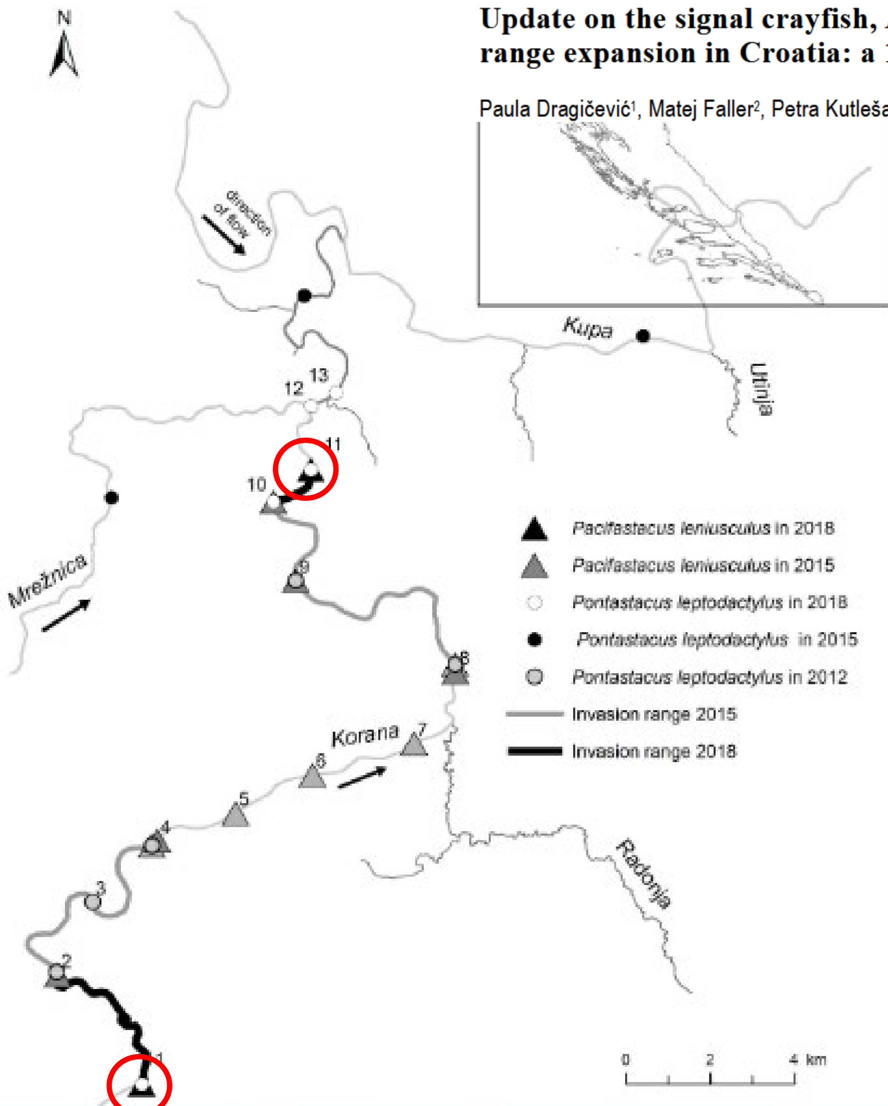




Research Article

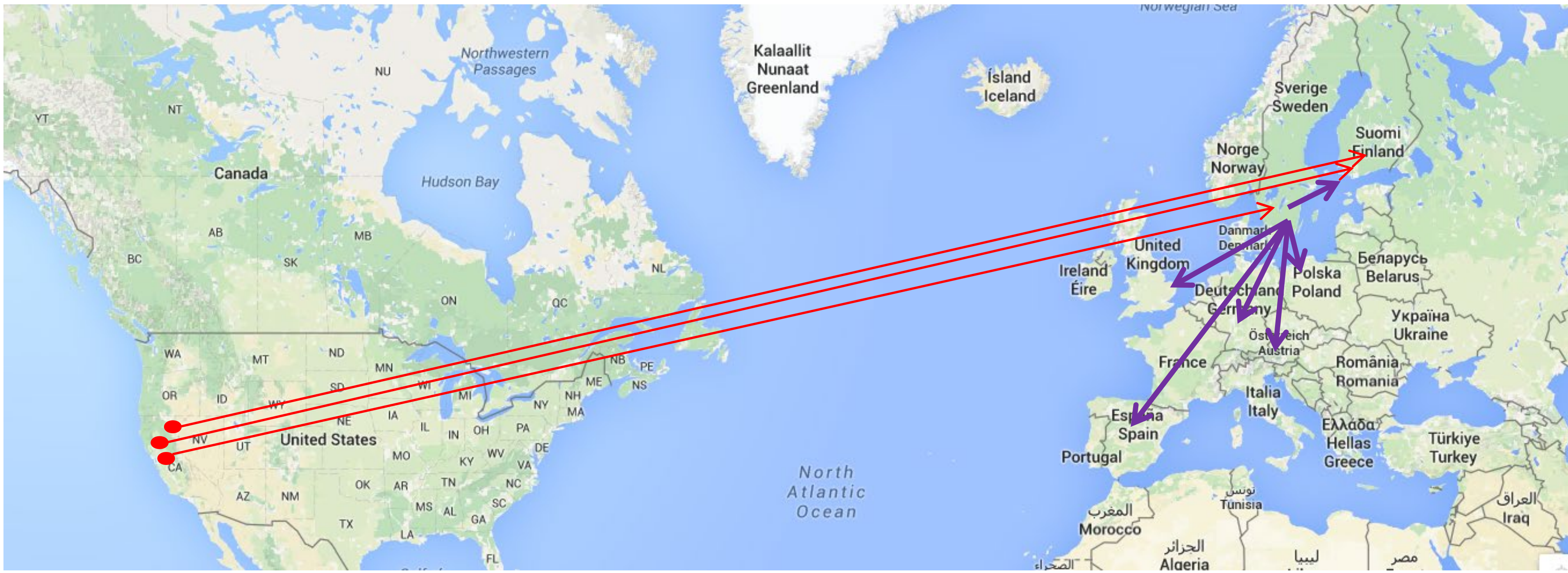
Update on the signal crayfish, *Pacifastacus leniusculus* (Dana, 1852) range expansion in Croatia: a 10-year report

Paula Dragičević[1], Matej Faller[2], Petra Kutleša[3] and Sandra Hudina[1,*]



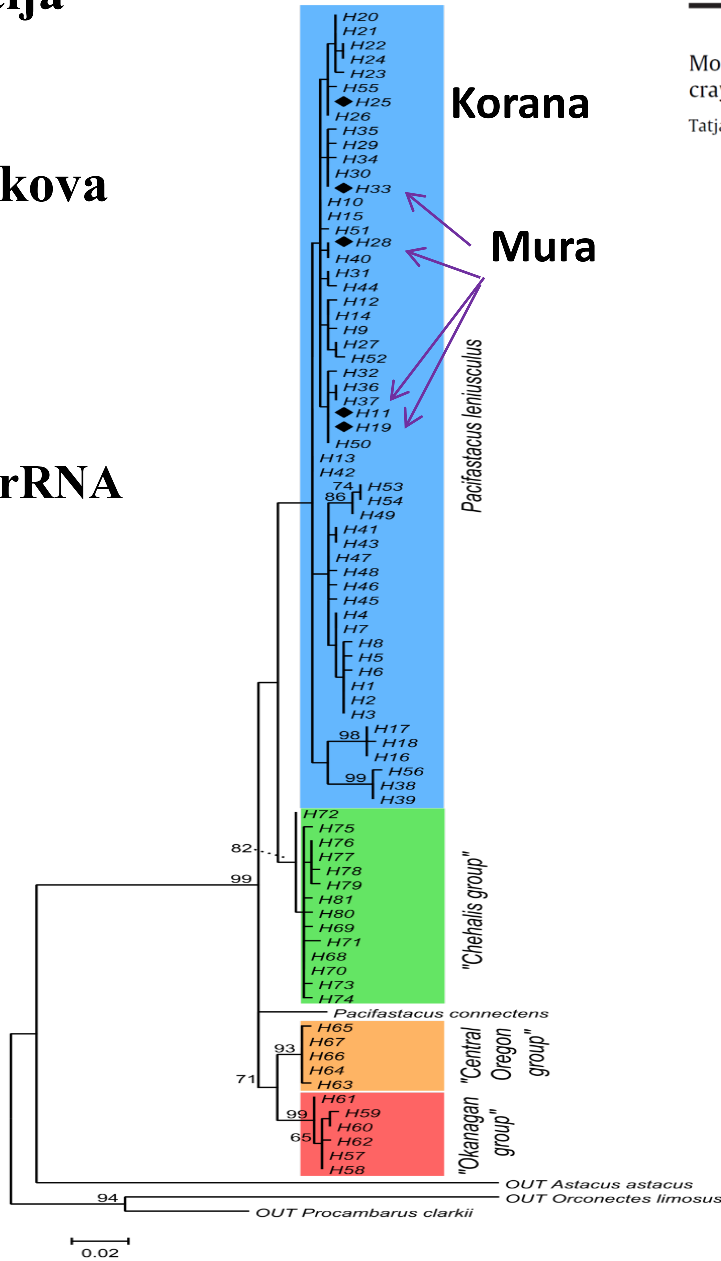
Lake Natoma (Kalifornija) - Švedska

Lake Tahoe, Lake Hennessey (Kalifornija) - Finska



Austrija – unos iz Kalifornije (Lake Tahoe + Švedske) – pritoke Drave i Mure – Slovenija - Hrvatska

Filogenetska rekonstrukcija – pozicija hrvatskih signalnih rakova



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Molecular and morphometric characterisation of the invasive signal crayfish populations in Croatia

Tatjana Mijošek[a], Mišel Jelić[b], Vedrana Mijošek[c], Ivana Maguire[b,*]

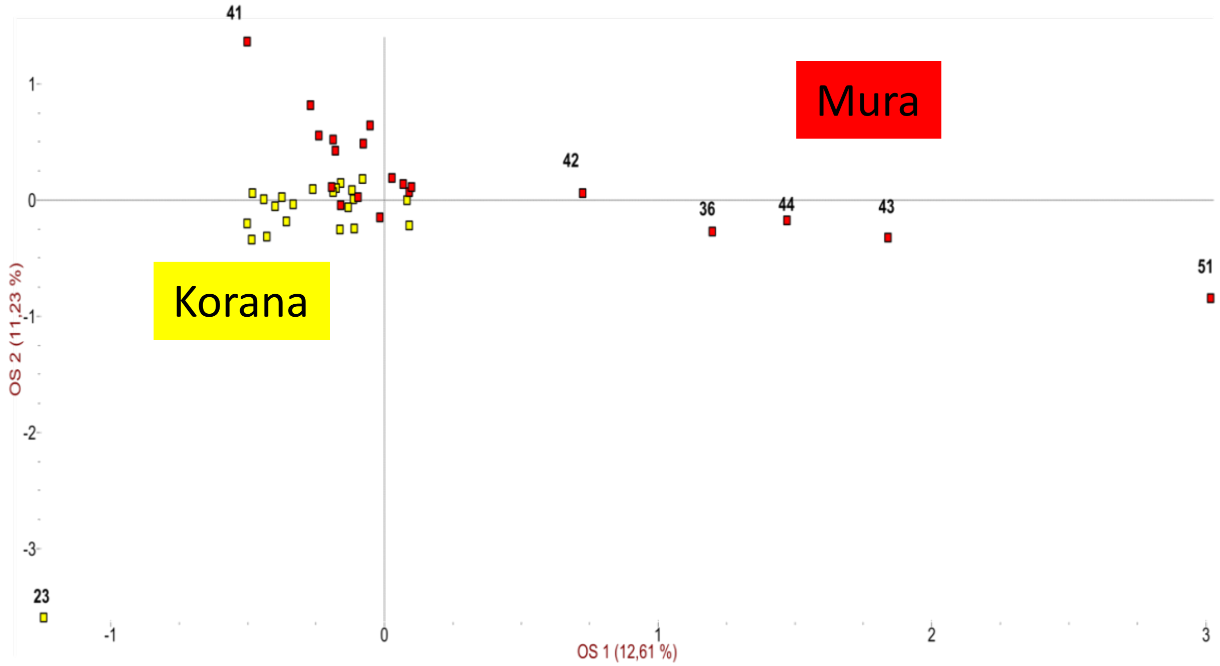
MtDNA – 16S rRNA

Srednje vrijednosti genetskih parametara
N_a – alelno bogatstvo, H_E – očekivana heterozigotnost, H_O – uočena heterozigotnost, F_{IS} – koeficijent križanja u bliskom srodstvu, F_{ST} – fiksacijski indeks; GB – Great Britain, PT – Portugal, FI – Finland, SW- Sweden

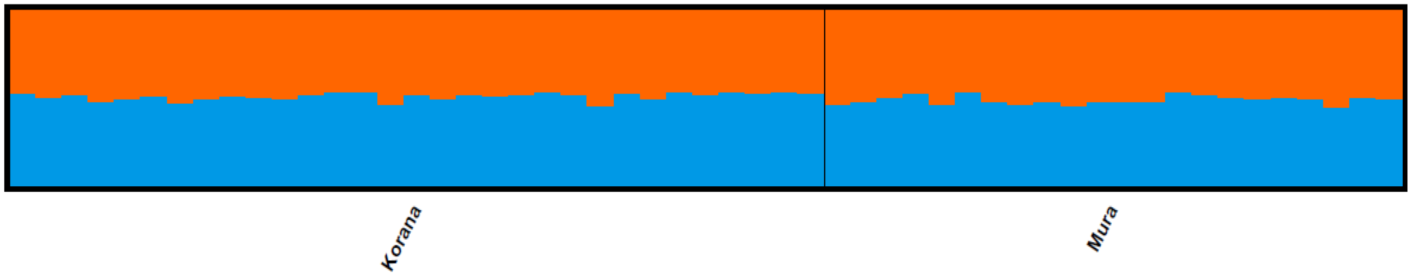
Locality	N_a	H_E	H_O	F_{IS}	F_{ST}
Korana	4.13	0.526	0.496	0.003	0.026
Mura	6.00	0.577	0.530	0.117	
GB	4.36	0.530	0.622	-0.154	0.127
PT	3.83	0.572	0.611	-0.056	
FI	4.16	0.529	0.432	0.240	
SW	3.63	0.500	0.507	0.108	

- Broj Alela (Na) najveći u Muri
- Uočena heterozigotnost (Ho) nešto manja u Hrvatskoj – Mura veća od Korane (duže etablirane populacije, opetovane introdukcije – veća raznolikost),
  -Niže vrijednosti Ho indicira srođivanje – gubitak raznolikosti i porast homozigota
- Indeks križanja u bliskom srodstvu (Fis)- pozitivan kad postoji manje heterozigota (opet indicira srođivanje)
- Fiksacijski indeks (Fst) – što je manji – veći protok gena (povezanost kroz parenje) – Kod nas manji nego u EU – ali populacije geo odvojene – indicira nedavnu povezanost – antropogeni utjecaj – možebit **uneseni u Koranu iz Mure**

Faktorijalna analiza korespondencije – vizualizira genetske odnose između jedinki – grupiraju se zajedno, ali je raznolikost Mure ipak veća



STRUCTURE analiza – 1 populacija



Ecology and Evolution

Open Access

Phylogeographic insights into the invasion history and secondary spread of the signal crayfish in Japan

Nisikawa Usio[1], Noriko Azuma[2], Eric R. Larson[3,4], Cathryn L. Abbott[5], Julian D. Olden[4], Hiromi Akanuma[6], Kenzi Takamura[7] & Noriko Takamura[7]

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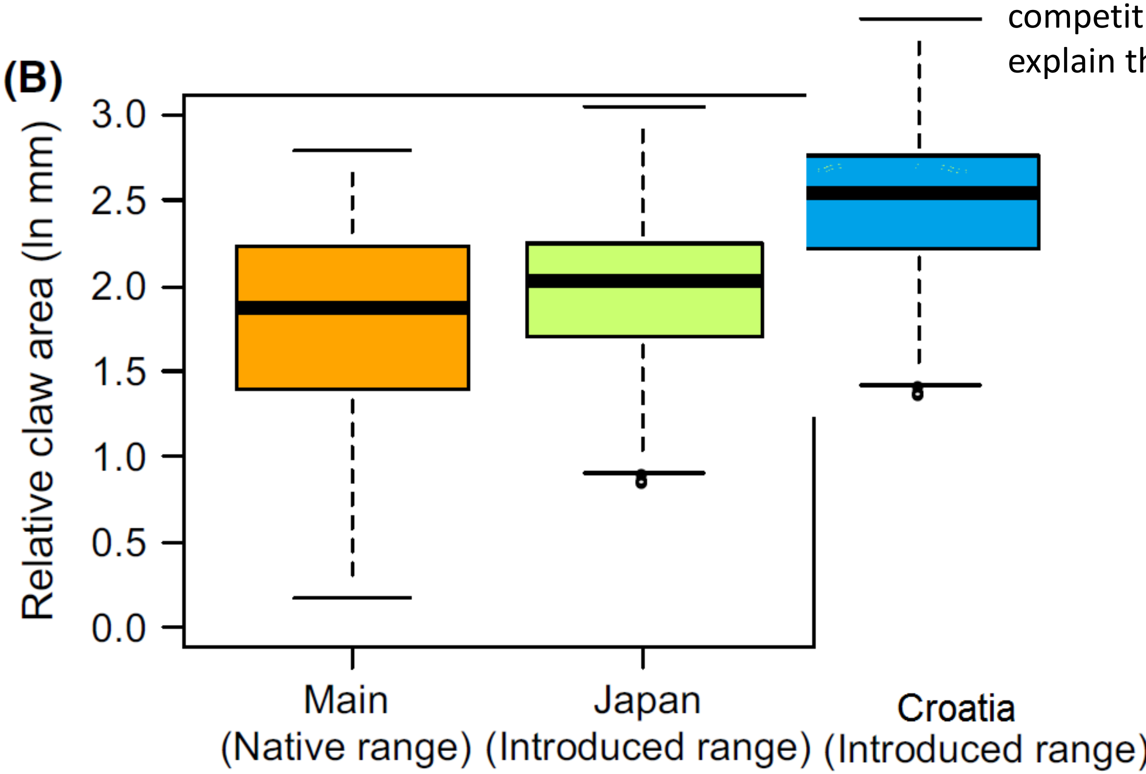
Molecular and morphometric characterisation of the invasive signal crayfish populations in Croatia

Tatjana Mijošek[a], Mišel Jelić[b], Vedrana Mijošek[c], Ivana Maguire[b,*]

Veličina kliješta – agresivno ponašanje – bolje invazivni uspjeh

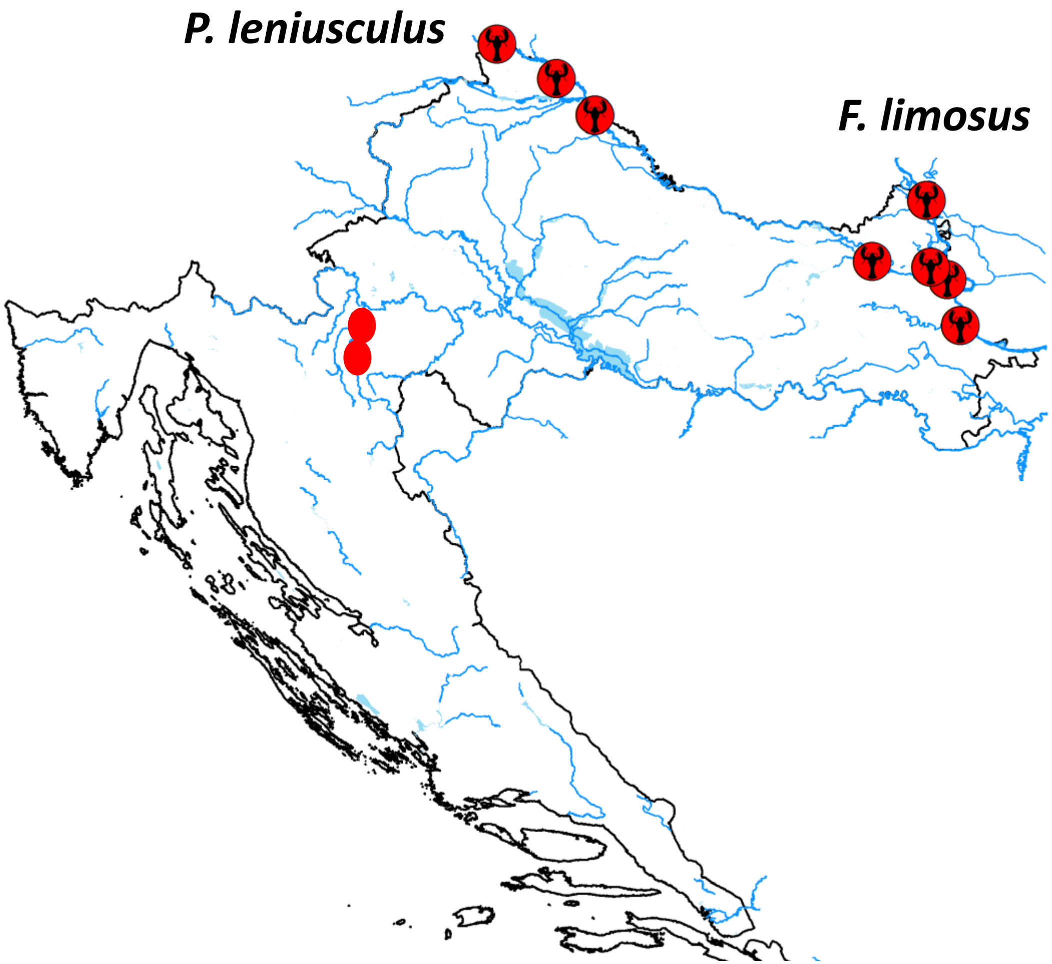
- claws are larger compared to signal crayfish from the native range, what is one of the features that gives them competitive advantage over other species, and could explain their invasive success

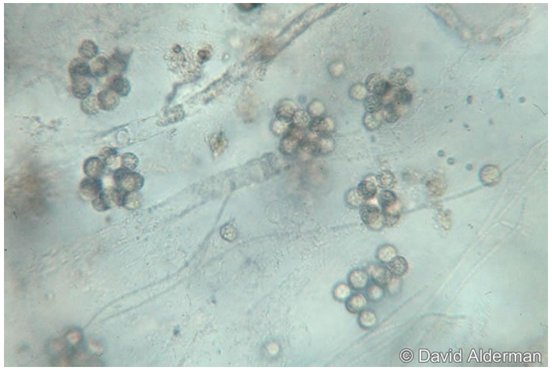


Kolbe et al. (2004) showed that substantial increases in genetic diversity of invasive populations can occur and can be explained by multiple introductions, especially when source populations are genetically divergent. Both interspecific hybridization and **intraspecific admixture** seem to be possible stimuli of invasion success in those cases.

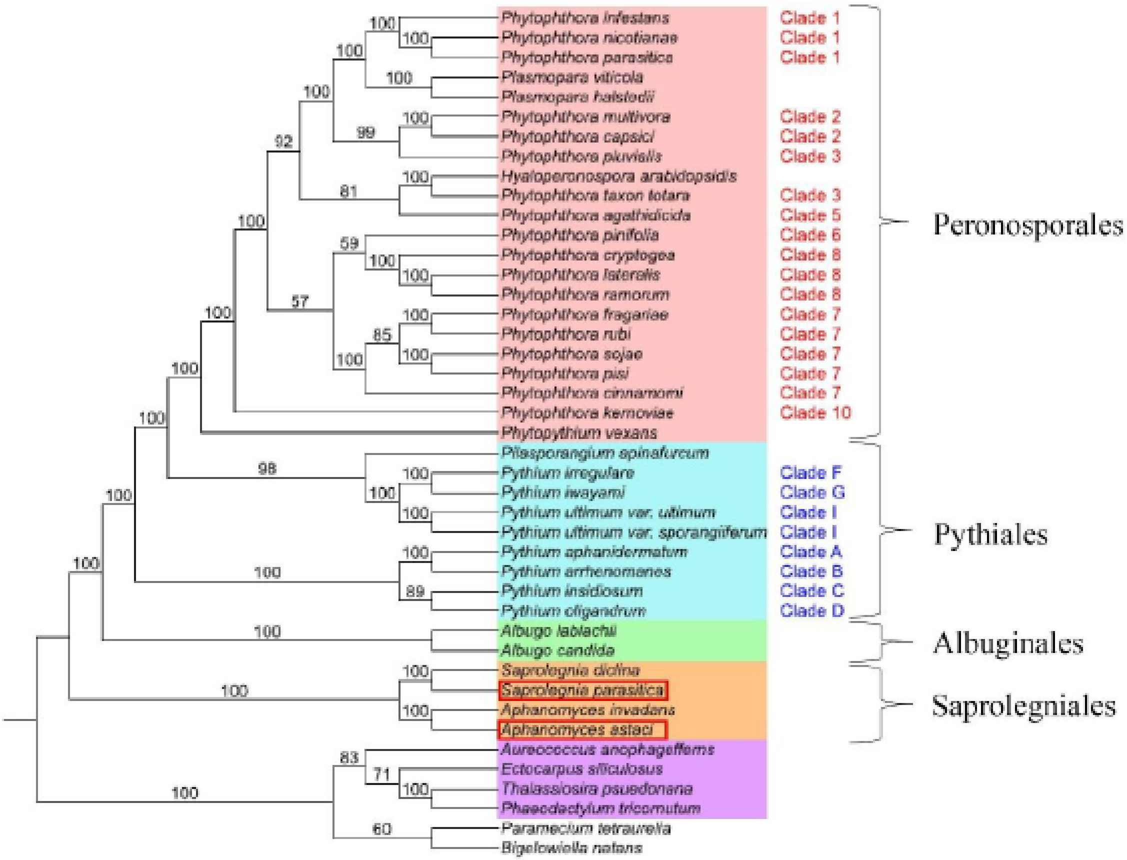
Strane vrste prenosioci patogena *Aphanomyces astaci* **RAČJA KUGA**

- Letalna po nativne vrste
- *Aphanomyces astaci* – jedna od 100 najinvazivnijih vrsta na svijetu

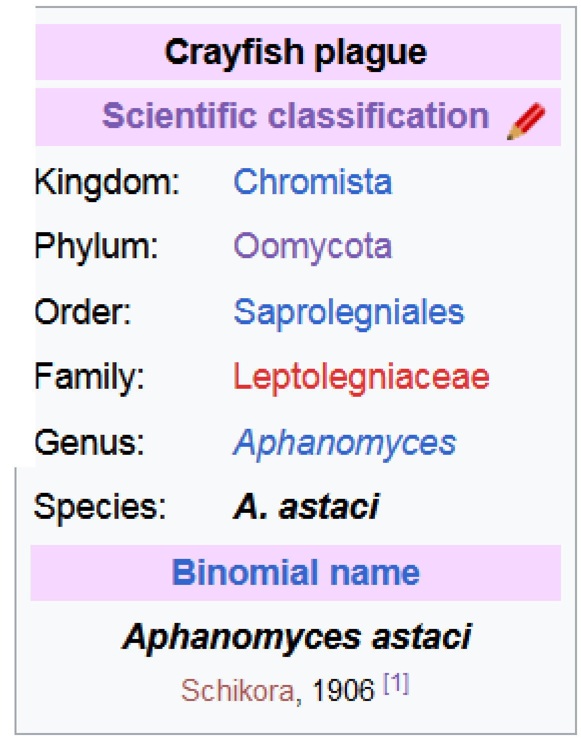


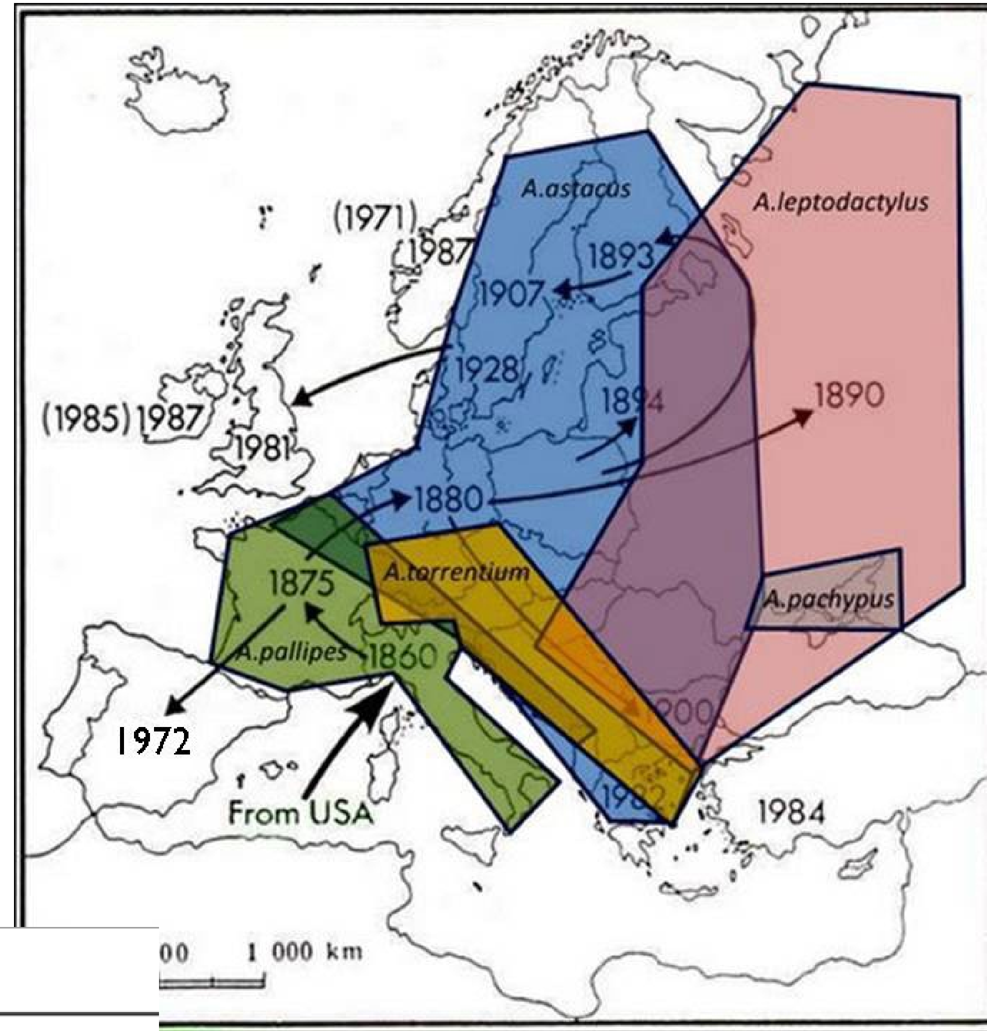


Što je *A. astaci* i kud spada?



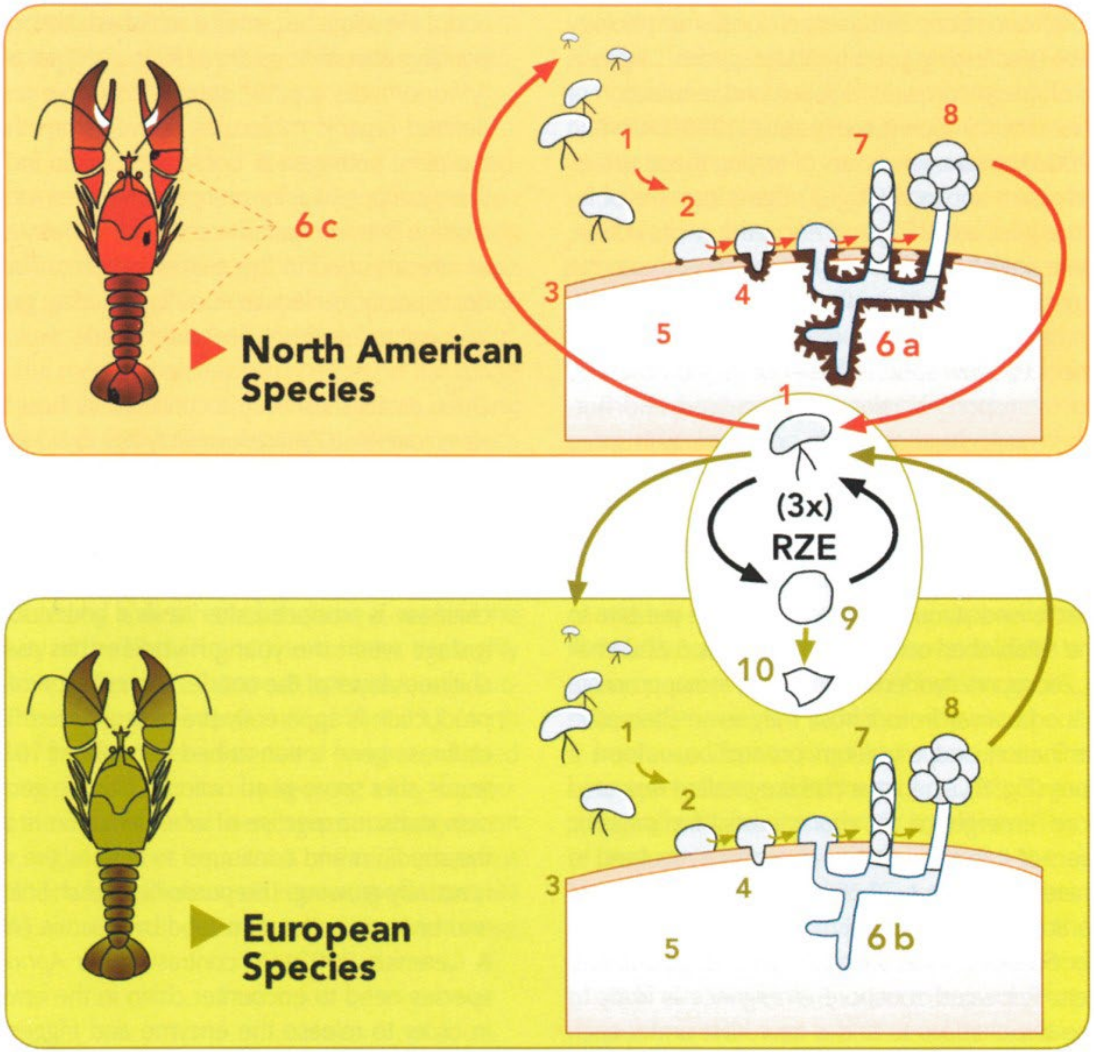
McCarthy and Fitzpatrick, 2017 (Pavić, 2023)





	Genotype	Original host
A	As	unknown
B	PsI	*P. leniusculus* (Lake Tahoe)
C	PsII	*P. leniusculus* (Lake Pitt)
D	Pc	*P. clarkii*
E	Or	*O. limosus*

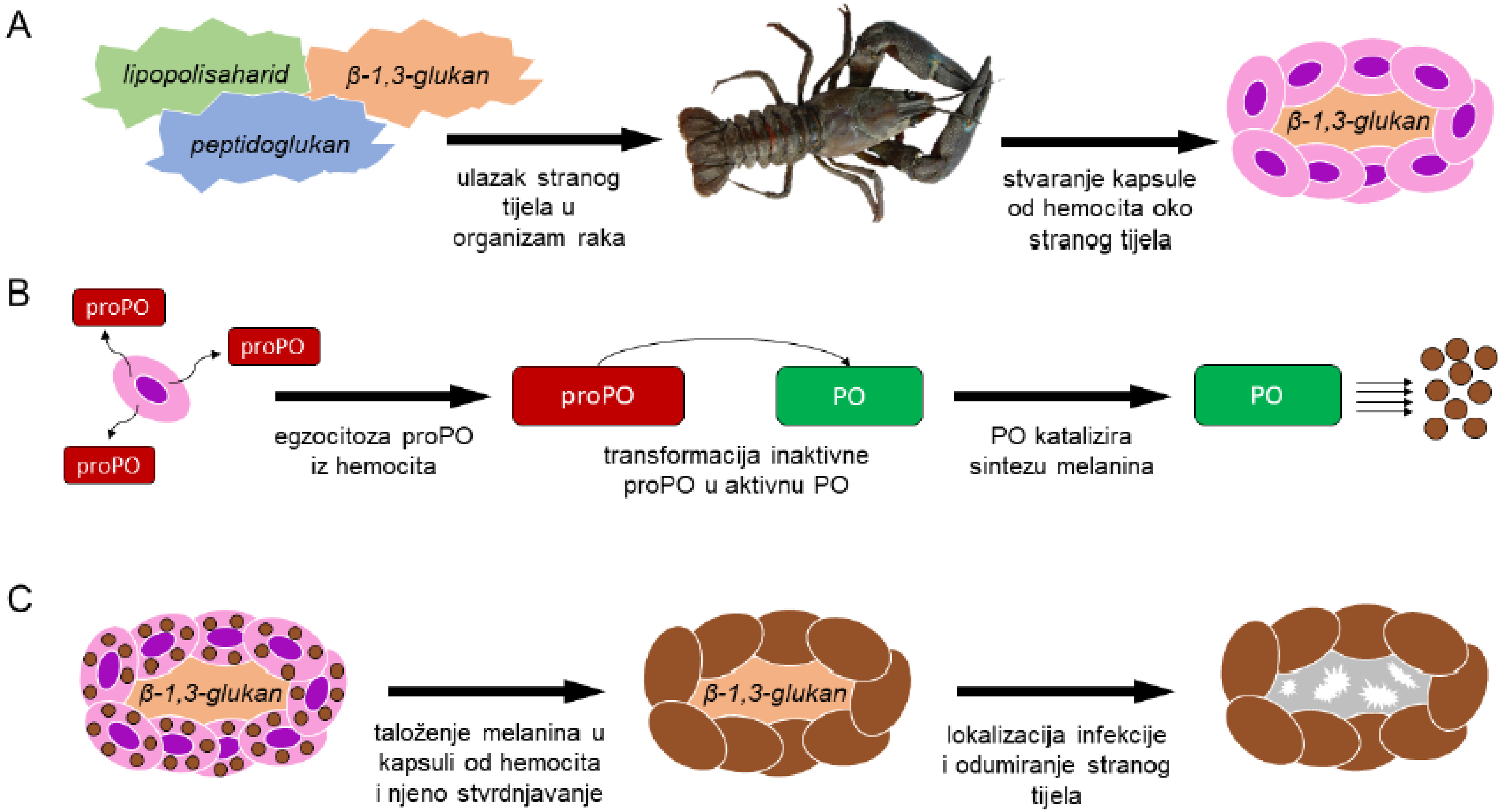
- Zašto nativni obolijevaju i ugibaju?



Diéguez-Uribeondo et al. (2006)

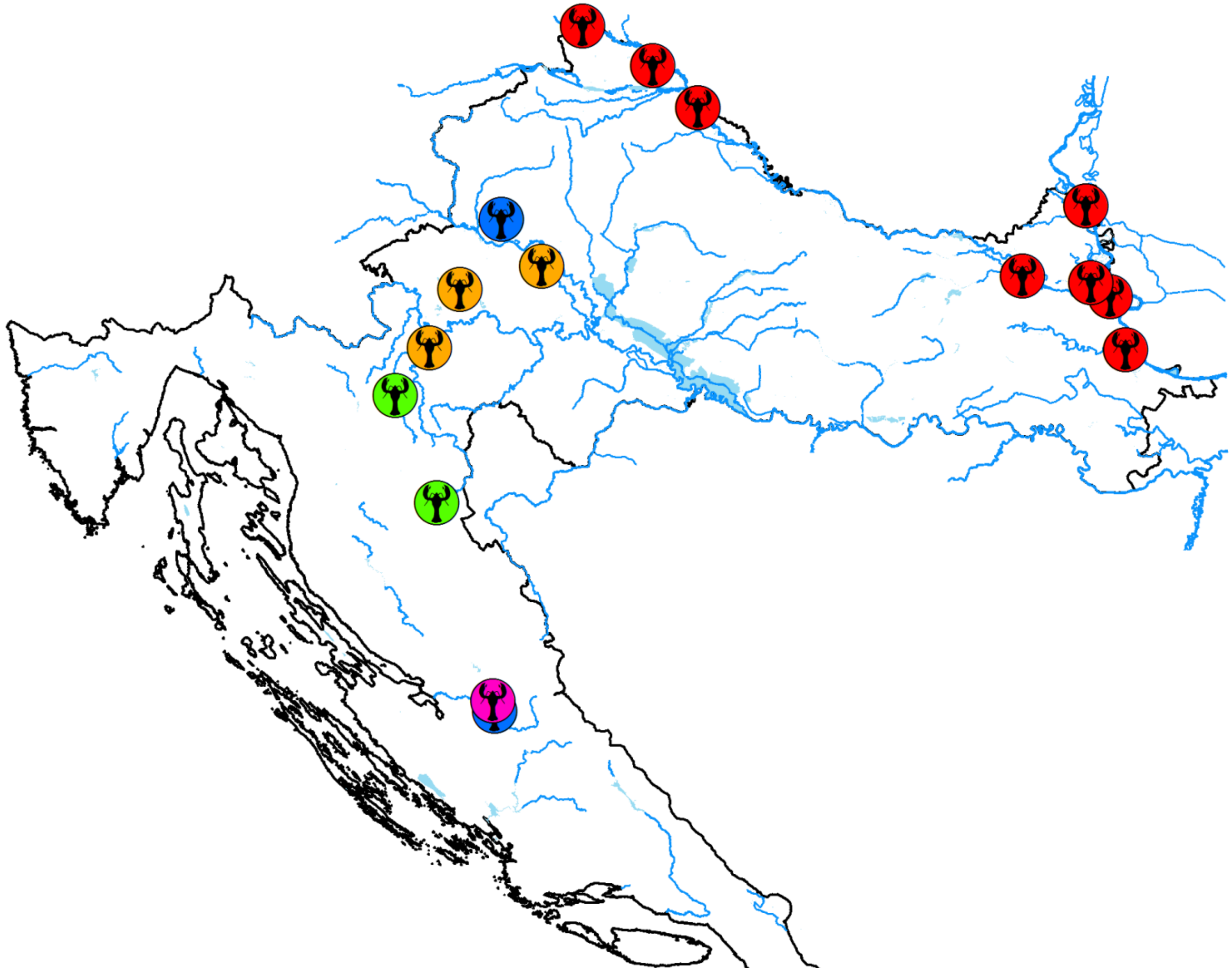
Američke vrste imaju stalno aktivirani proPO sistem (melanizacija patogena)

Life cycle of A. astac
1) secondary zoospore (the infective unit),
2) encysting zoospore,
3) crayfish epicuticle,
4) germinating cyst,
5) cuticle penetration,
6a) melanized hyphae (chronic infection in the North-American crayfish),
6b) unmelanized hyphae (acute infection in the native European crayfish species or in the immune stressed North-American crayfish),
6c) melanized spots in the crayfish cuticle as a macroscopic sign of an infection of A. astaci,
7) sporangium of A. astaci,
8) clusters of primary cysts,
9) secondary cyst - form a new zoospore
10) Non-viable cyst



Dragičević, 2022

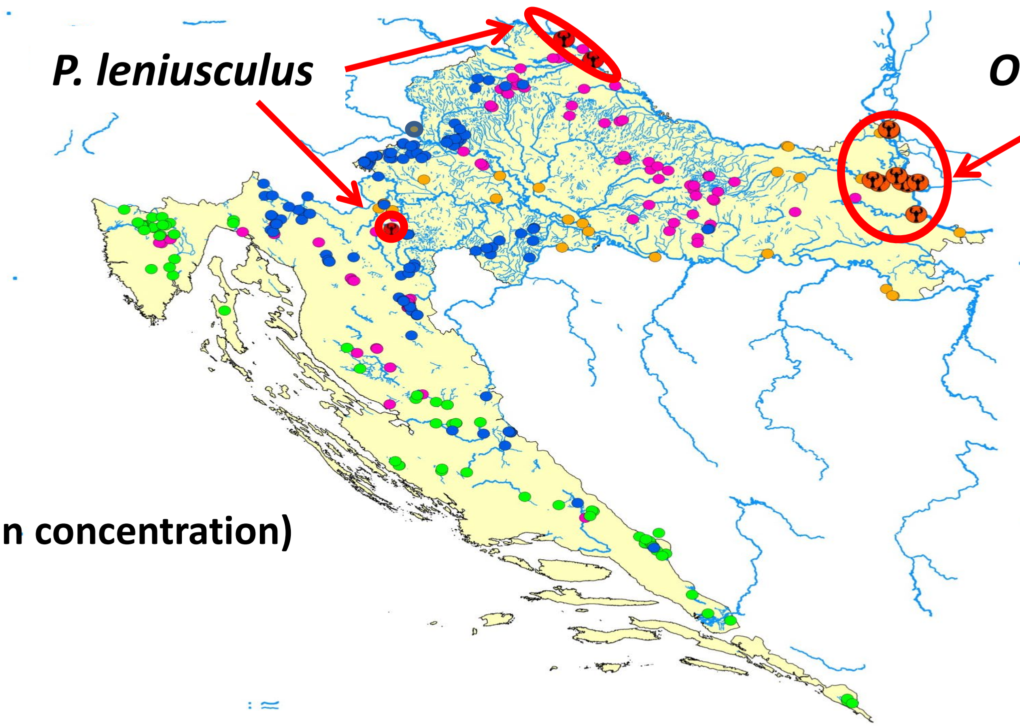
Pojavnost *Aphanomyces astaci* u Hrvatskoj



vrsta	*A. pallipes*	*A. torrentium*	*A.astacus*	*P. leptodactylus*	*F. limosus*	*P. leniusculus*	*P. virginalis*
zaraza	+	+	+	+	+	+	-

Maguire et al., 2016

Prisutnost patogena *Aphanomyces astaci* u invazivnih vrsta



Infection level (pathogen concentration)

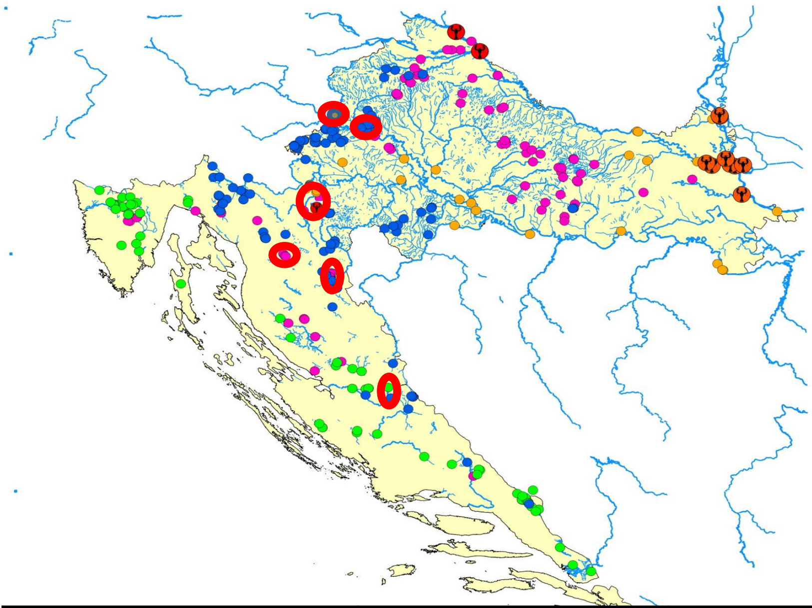
A0 – no infection

A1-A2 – low infection

> A3 – strong infection

vrsta	*O. limosus*	*P. leniusculus*
Br.infic./br.testiranih	**14 / 24**	**7 / 26**
% zaraženih	**58%**	**27%**
Nivo zaraze	**A0(10), A1(1), A2(2), A3(11)**	**A0(19), A2(4), A3(1), A4(1), A5(1)**
Soj /genotip/haplogrupa	**?**	**B (Ps)**

Prisutnost patogena *Aphanomyces astaci* u nativnim vrstama



Zaključak

- Patogen prisutan i u nativnih
- Nivo zaraze invazivnih niži (samo 1 jedinka A5 - Ps genotip)
- Nivo zaraze nativnih (ako pozitivan) viši – moguća genotipizacija – ako u kontaktu s invazivnim Ps genotip, ako ne As genotip (stari europski nepoznatog podrijetla)

vrsta	***A. pallipes***	***A. torrentium***	***A.astacus***	***A. leptodactylus***
Br zaraženih/Br tesiranih	**1 / 1**	**2 / 5**	**7 / 9**	**12 / 52**
% zaraženosti	**100%**	**40%**	**77%**	**23%**
Soj/genotip/hapologrupa	**A3(1)**	**A0(3), A3(1), A6(1)**	**A0(2), A1(1), A2(1), A3(3), A4(1), A6(1)**	**A0(40), A1(1), A3(4), A4(7)**
Nivo zaraze	**?**	**A (As)***	**A (As)**	**B (Ps)**

Metode detekcije

Invazivna metoda

Foto: Ljubej L.

Žrtvovanje rakova – izrezivanje komadića kutikule

Neinvazivna metoda

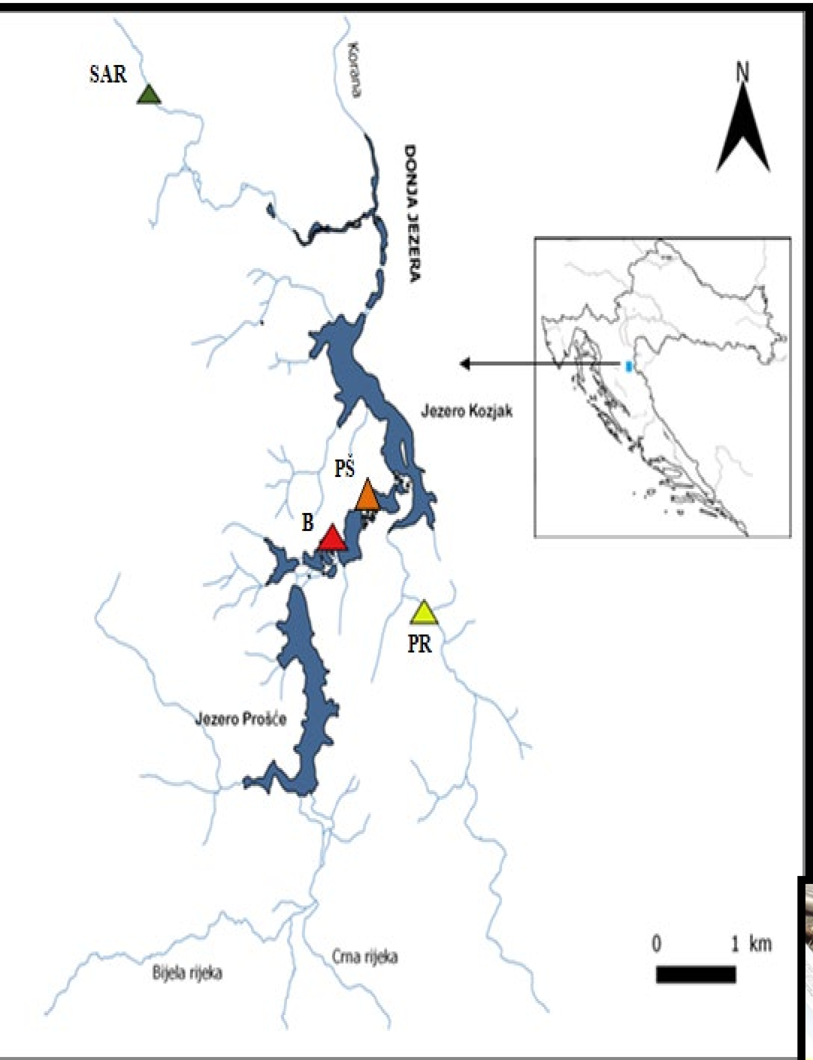
Foto: Hudina S.

Uzimanje brisa kutikule živog raka

- izolacija DNA
- PCR – utvrđivanje prisutnosti patogena
- qPCR – informacije o intezitetu infekcije (A0-A7)
- genotipizacija

PRAĆENJE STANJA BOLESTI RAČJE KUGE U NACIONALNOM PARKU PLITVIČKA JEZERA
Dora Pavić (2018)

Metoda testirana na populacijama *A. astacus* i *A. torrentium* u NP Plitvička jezera



Astacus astacus

Austropotamobius torrentium

PCR- test

- proveden za sve uzorke
- patogen utvrđen kod 9/115 jedinki
- samo na vrsti *A. astacus*
- usporedba metoda – 7/9

Oznaka	Vrsta	Lokacija	PCR
B5	*A. astacus*	Burgeti	-(B), +(K)
B9	*A. astacus*	Burgeti	+ (B)
B10	*A. astacus*	Burgeti	-(B), +(K)
B21	*A. astacus*	Burgeti	+(B)
B24	*A. astacus*	Burgeti	+ (B), + (K)
B37	*A. astacus*	Burgeti	+(B)
B60	*A. astacus*	Burgeti	+(B)
B67	*A. astacus*	Burgeti	+(B)
PŠ1	*A. astacus*	Slap Prštavac	+(B)

qPCR

- tri para uzorka – određen intezitet infekcije

Oznaka	Vrsta	Lokacija	PCR	qPCR
B5	*A. astacus*	Burgeti	-(B), +(K)	A0(B), A3(K)
B9	*A. astacus*	Burgeti	+ (B)	N.T.
B10	*A. astacus*	Burgeti	-(B), +(K)	A1(B), A3(K)
B21	*A. astacus*	Burgeti	+(B)	N.T.
B24	*A. astacus*	Burgeti	+ (B), + (K)	A4(B), A5(K)
B37	*A. astacus*	Burgeti	+(B)	N.T.
B60	*A. astacus*	Burgeti	+(B)	N.T.
B67	*A. astacus*	Burgeti	+(B)	N.T.
PŠ1	*A. astacus*	Slap Prštavac	+(B)	N.T.

Genotipizacija

- analizom dužine mikrosatelitnih biljega – određen genotip
- A4 ili više
- soj A

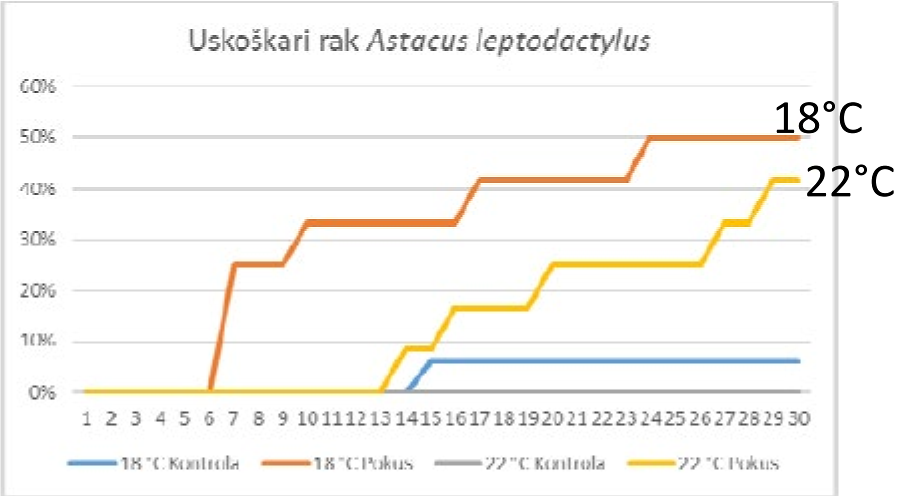
- niska razina virulencije soja A
- adaptacija imunog sustava
- dugi boravak soja A

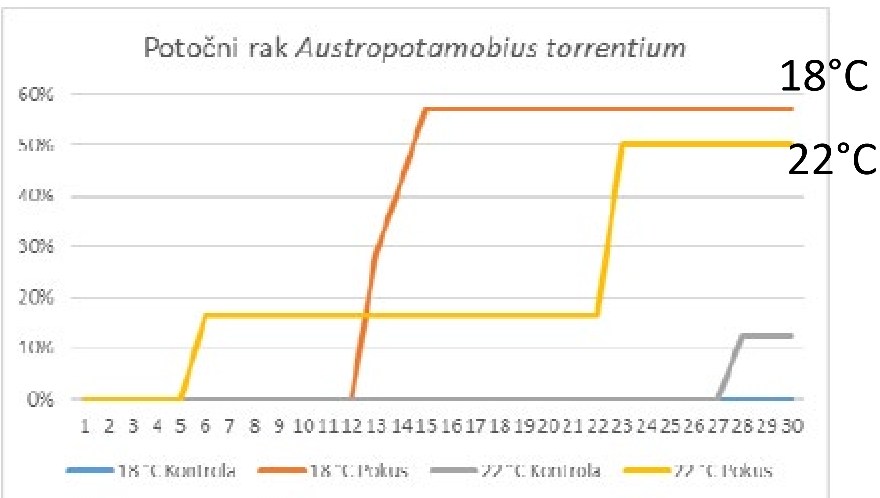
Oznaka	Vrsta	Lokacija	PCR	qPCR	Soj (genotip)
B5	*A. astacus*	Burgeti	-(B), +(K)	A0(B), A3(K)	N.T.
B9	*A. astacus*	Burgeti	+ (B)	N.T.	N.T.
B10	*A. astacus*	Burgeti	-(B), +(K)	A1(B), A3(K)	N.T.
B21	*A. astacus*	Burgeti	+(B)	N.T.	N.T.
B24	*A. astacus*	Burgeti	+ (B), + (K)	A4(B), A5(K)	A(B), A(K)
B37	*A. astacus*	Burgeti	+(B)	N.T.	N.T.
B60	*A. astacus*	Burgeti	+(B)	N.T.	N.T.
B67	*A. astacus*	Burgeti	+(B)	N.T.	N.T.
PŠ1	*A. astacus*	Slap Prštavac	+(B)	N.T.	N.T.

Populacije zavičajnih rakova kronično zaražene, ali vijabilne.

PRAĆENJE STANJA BOLESTI RAČJE KUGE U NACIONALNOM PARKU PLITVIČKA JEZERA
Dora Pavić (2018)

Klimatske promjene i račja kuga

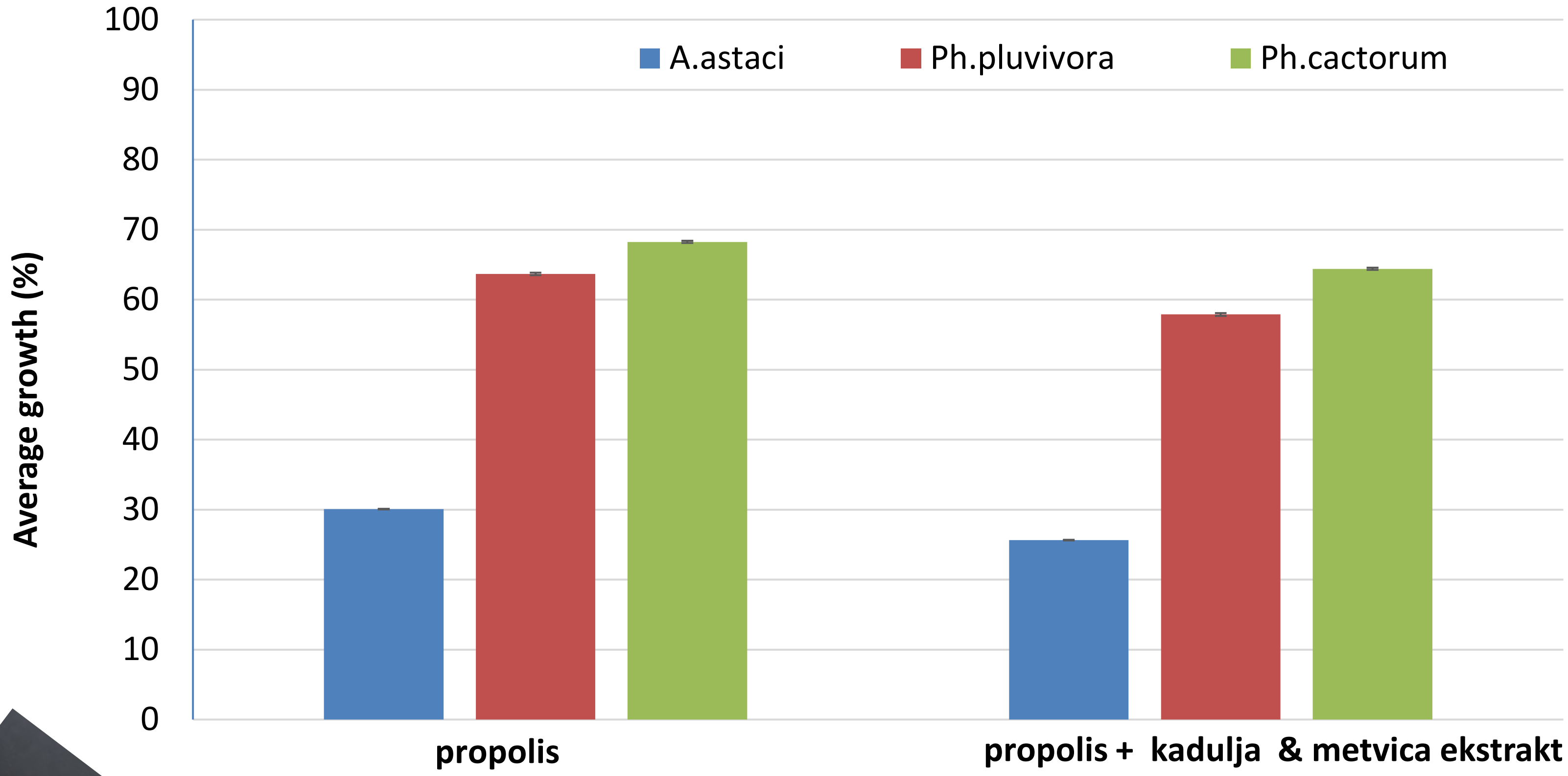


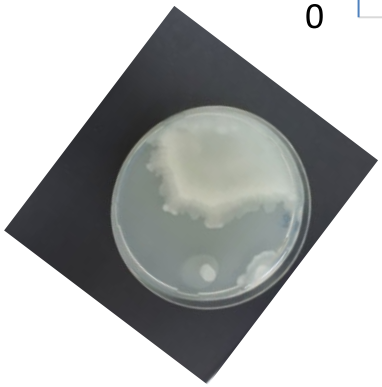


- *A. astaci* (B ili PsII soj) osjetljiv na porast temperature iznad 22°C
- treba testirati ostale sojeve

Interactions of freshwater pathogenic oomycetes and their environment

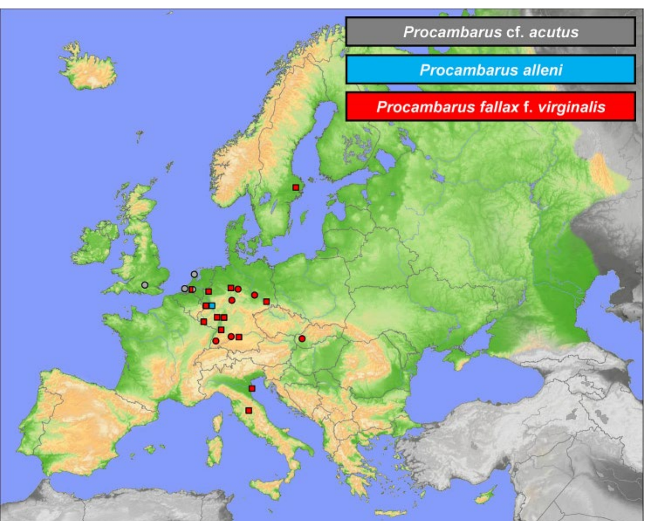
- Mogućnot prevencije kuge





3. invazivna vrsta - *Procambarus virginalis*

- Akvaristika
- Poplave



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Short Articles

The First Record of the Marbled Crayfish (*Procambarus fallax* (Hagen, 1870) f. *virginalis*) in Croatia

Here we report the first record of the non-indigenous parthenogenetic species, the marble crayfish in the wild from Croatia. It is the third non-indigenous crayfish (NICS) recorded in Croatia – with four indigenous crayfish, Croatian astacofauna now contains 7 crayfish species. The marble crayfish were discovered in the Šoderica gravel pit lake, located at far northwest of Croatia, close to the Drava River and Hungarian border (Figure 1).

Previous studies recorded presence of the native *Astacus astacus* in the Šoderica, and invasive *Pacifastacus leniusculus* in the nearby Drava River (Hudina et al, 2009; Maguire et al, 2011). In the autumn 2013, during scuba-diving in the Šoderica gravel pit lake numerous crayfish were observed under submerged boat. Some juvenile specimens were taken to the school laboratory under presumption that they are juvenile specimens of *A. astacus*. However, after their close examination they were identified as the marble crayfish, *Procambarus fallax* (Hagen, 1870) f. *virginalis* (Figure 2) (Chucholl et al, 2012; Martin et al, 2010; Souty-Grosset et al, 2006). We assume that the widespread and lively on-line marble crayfish pet trade, and its release to the gravel pit lake, was the introduction pathway of this species to Croatia.

The nearest recorded marble crayfish locations in the wild

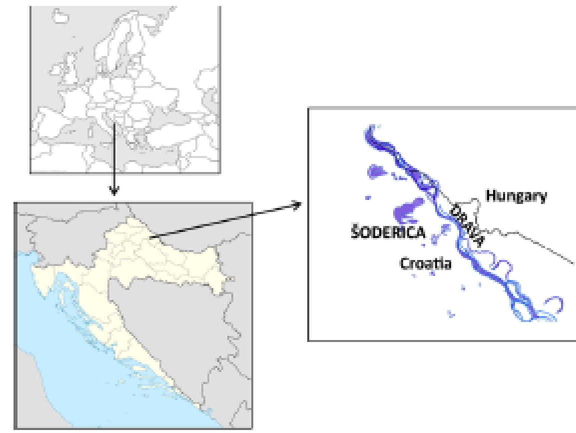

Figure 1. Position of the Šoderica gravel pit lake (coordinates 46.175; 17.025) where the marble crayfish were caught in autumn 2013.

Procambarus fallax

Procambarus (fallax f.) virginalis

- akvaristika sredina 1990ih Njemačka
- jedina vrsta za koju se zna da je partenogenetska

Elizabeth Pennisi
(26 August 2015) *Science*| DOI: 10.1126/science.aad1673

- researchers show that the *Procambarus fallax* males can't fertilize marbled crayfish eggs, a hallmark of a species split, and that the clones contain enough genetic differences to justify designating them a separate species

- researchers are now analyzing these so-called epigenetic differences in more detail and are proposing this new species be called *Procambarus virginalis*—the virgin form of the genus *Procambarus*

The marbled crayfish (Decapoda: Cambaridae) represents an independent new species

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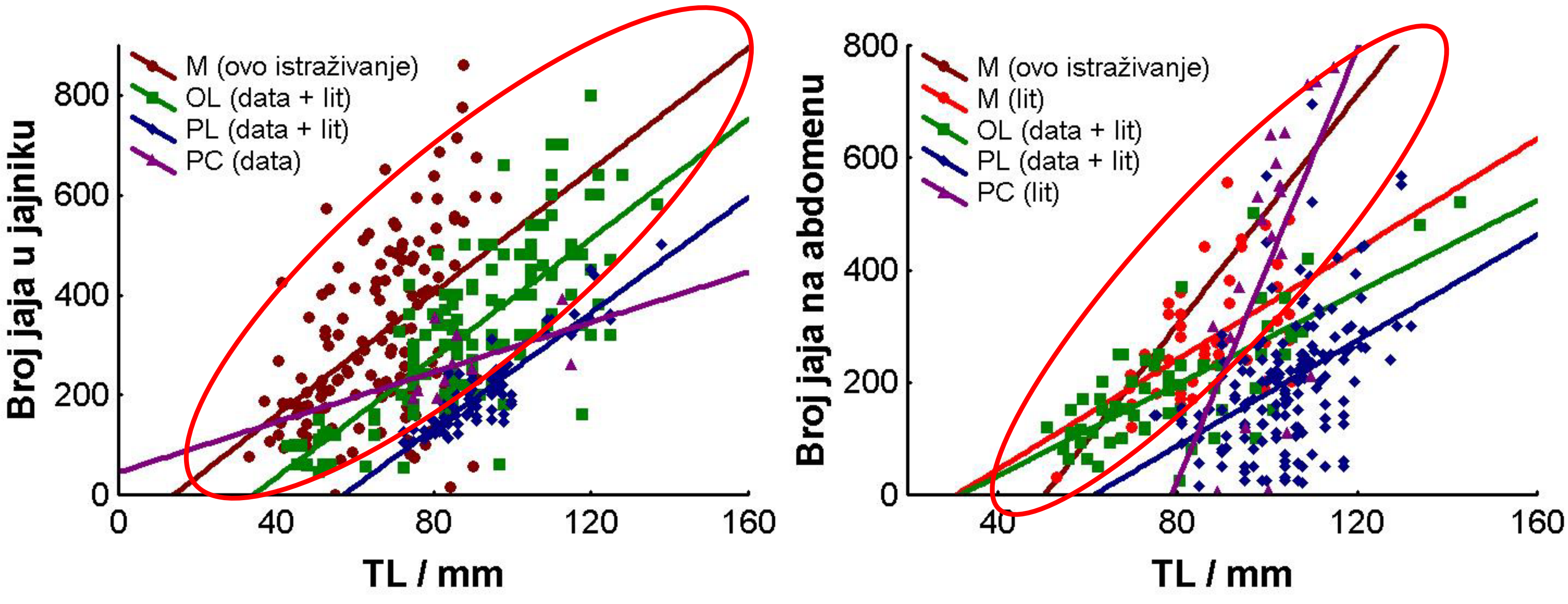

M – mramorni rak, **OL** – bodljobradi rak, **PL** – signalni rak, **PC** – *P. clarkii*


…will live happily ever after