Zavlečení nepůvodních organismů a jejich dopady

Princip, teoretické modely a příklady hodnocení impaktu IAS

Souvislost s definicí IAS

KAREL DOUDA

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DOPAD / IMPAKT
Přímá souvislost s definicí invazních druhů
Co je invazní nepůvodní druh?

zavlečený > zdomácnělý > invazní

- Klíčové kritérium je, že invazní druh se rychle šíří a obsadí rozsáhlé území
- Některé definice přímo zahrnují jako nezbytné kritérium negativní vliv – impakt, dopad
- Definice IUCN považuje za invazní druhy pouze druhy invadující na přirozených a polopřirozených stanovištích

DOPAD / IMPAKT
Co je invazní nepůvodní druh?

- Neustálená definice generuje nedorozumění při diskusi o řešení problematiky invazních druhů

DOPAD / IMPAKT
klíčové kritérium pro prioritizaci managementu

- Impakt: každá signifikantní změna (zvýšení/snížení) nějakého ekologického stavu nebo procesu, bez ohledu na hodnotu vnímanou člověkem

- dopad na:

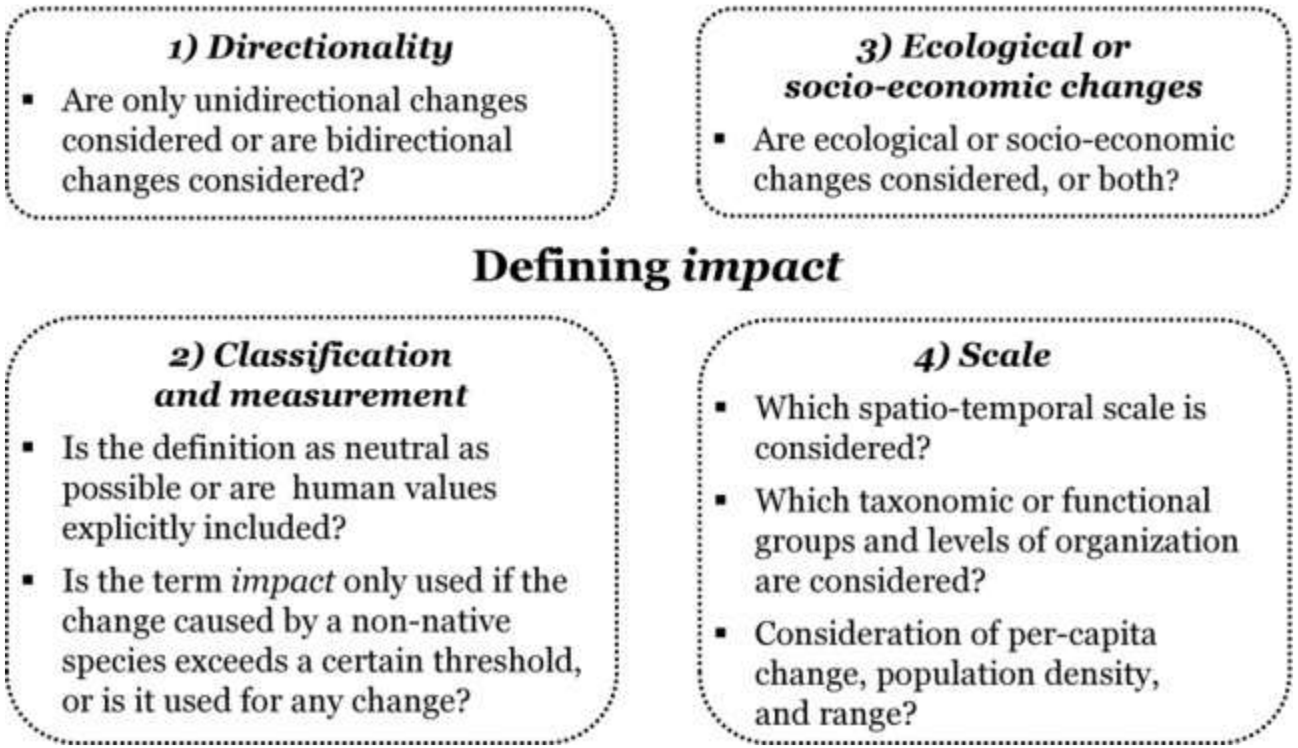
EKOSYSTÉMY

EKONOMIKU

ZDRAVÍ

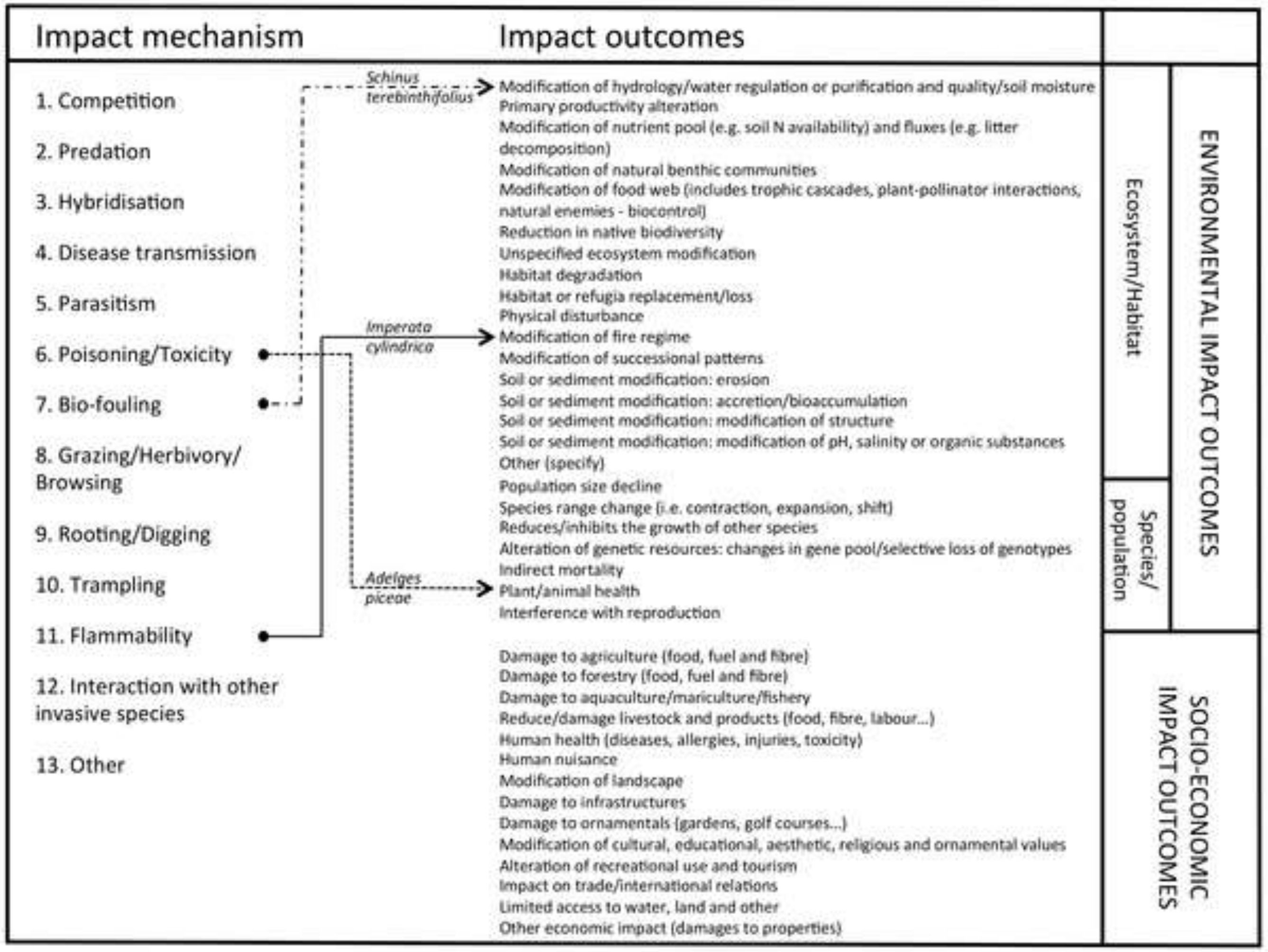
- Většina nepůvodních druhů nemá žádný prokazatelně negativní dopad v žádné z těchto oblastí
- Mnoho druhů má neznámý vliv
- Nejistota: bez vlivu x neznámý vliv

Otázky důležité pro určení vlivu nepůvodních druhů:



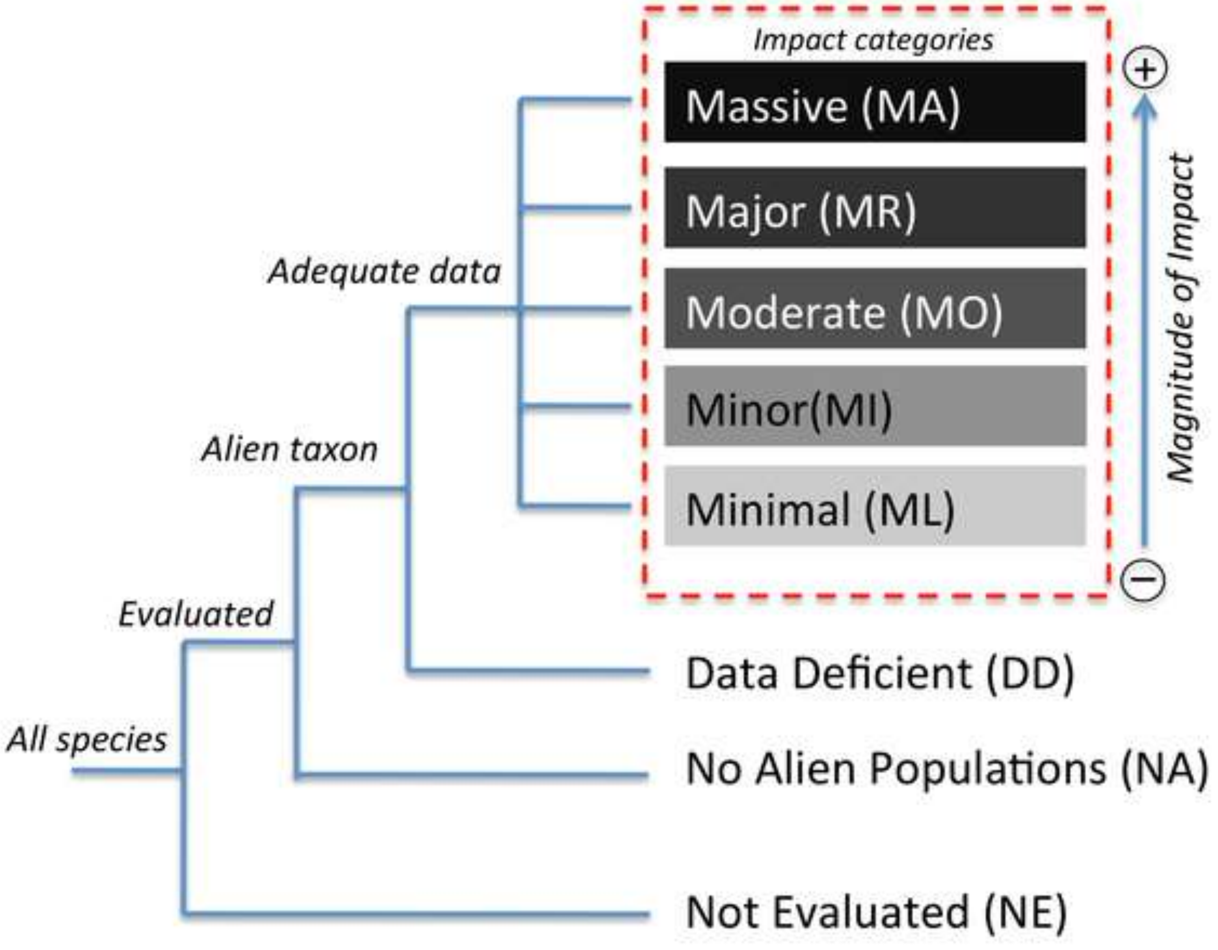
Conserv Biol. 2014 Oct; 28(5): 1188–1194.

Figure 1. Impact scheme of the Global Invasive Species Database, implemented by the IUCN Species Survival Commission (SSC) Invasive Species Specialist Group.



Blackburn TM, Essl F, Evans T, Hulme PE, Jeschke JM, et al. (2014) A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts. PLOS Biology 12(5): e1001850. https://doi.org/10.1371/journal.pbio.1001850
https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1001850

Figure 2. The different categories in the alien species impact scheme, and the relationship between them.



Blackburn TM, Essl F, Evans T, Hulme PE, Jeschke JM, et al. (2014) A Unified Classification of Alien Species Based on the Magnitude of their Environmental Impacts. PLOS Biology 12(5): e1001850. https://doi.org/10.1371/journal.pbio.1001850
https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1001850

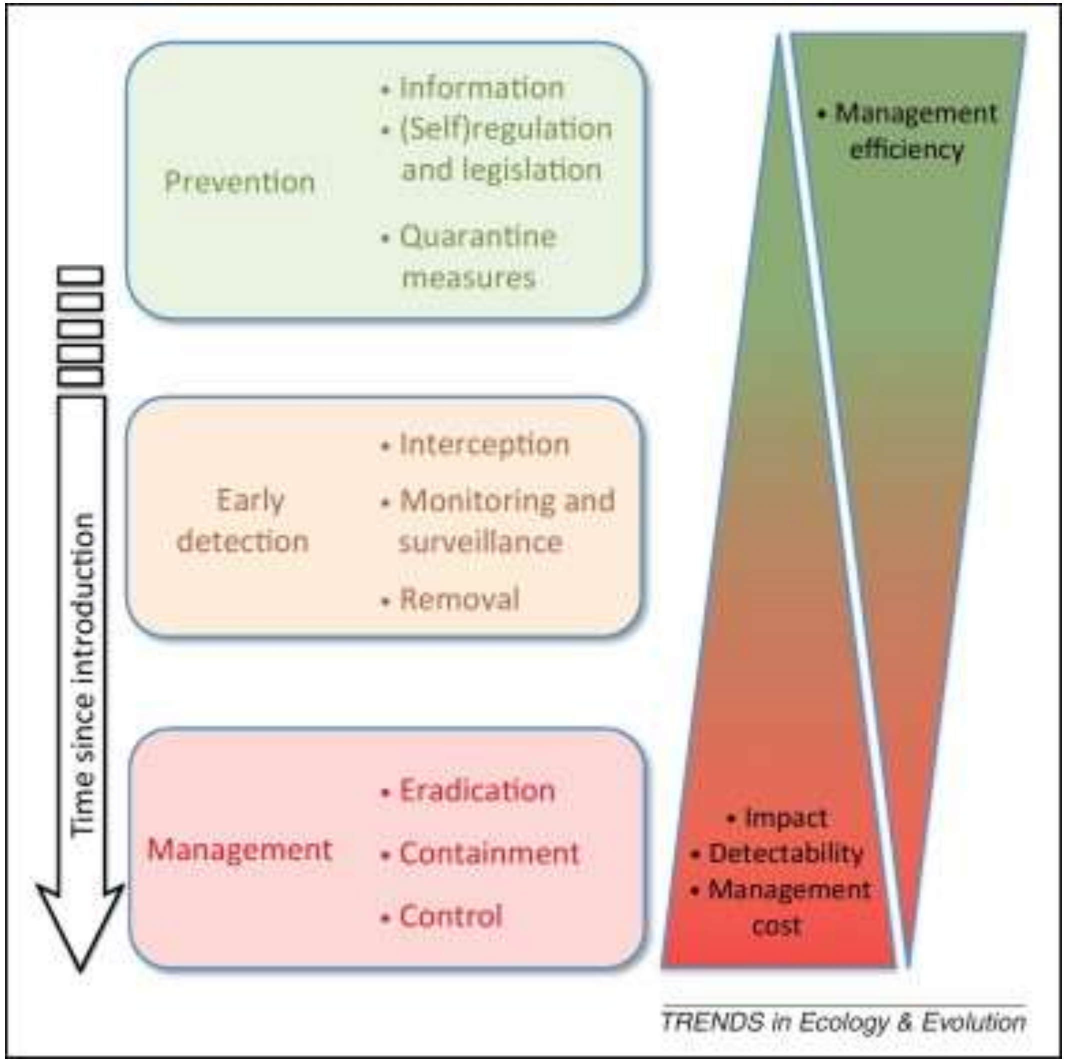
Table 1. Impact criteria for assigning alien species to different categories in the classification

Impact Class	Massive (MA)	Major (MR)	Moderate (MO)	Minor (MI)	Minimal (ML)
Categories should adhere to the following general meaning	*Causes at least local extinction of species, and irreversible changes in community composition; even if the alien species is removed the system does not recover its original state*	*Causes changes in community composition, which are reversible if the alien species is removed*	*Causes declines in population densities, but no changes in community composition*	*Causes reductions in individual fitness, but no declines in native population densities*	*No effect on fitness of individuals of native species*
Competition (1)	Competition resulting in replacement or local extinction of one or several native species; changes in community composition are irreversible	Competition resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien species is removed	Competition resulting in a decline of population size of at least one native species, but no changes in community composition	Competition affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	Negligible level of competition with native species; reduction of fitness of native individuals is not detectable
Predation (2)	Predators directly or indirectly (e.g., via mesopredator release) resulting in replacement or local extinction of one or several native species (i.e., species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible	Predators directly or indirectly (e.g., via mesopredator release) resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien species is removed	Predators directly or indirectly (e.g., via mesopredator release) resulting in a decline of population size of at least one native species but no changes in community composition	Predators directly or indirectly (e.g., via mesopredator release) affecting fitness (e.g., growth, reproduction) of native individuals without decline of their populations	Negligible level of predation on native species
Hybridisation (3)	Hybridisation between the alien species and native species is common in the wild; hybrids are fully vigorous and fertile; pure native species cannot be recovered by removing the alien, resulting in replacement or local extinction of native species by introgressive hybridisation (genomic extinction)	Hybridisation between alien species and native species is common in the wild; F1 hybrids are vigorous and fertile, however offspring of F1 hybrids are weak and sterile (hybrid breakdown), thus limited gene flow between alien and natives; individuals of alien species and hybrids discernible from pure natives, pure native populations can be recovered by removing the alien and hybrids.	Hybridisation between alien species and native species is regularly observed in the wild; hybrids are vigorous, but sterile (reduced hybrid fertility),limited gene flow between alien and natives, local decline of populations of pure native species, but pure native species persists	Hybridisation between alien species and native species is observed in the wild, but rare; hybrids are weak and never reach maturity (reduced hybrid viability), no decline of pure native populations	No hybridisation between alien species and native species observed in the wild (prezygotic barriers), hybridisation with a native species might be possible in captivity
Transmission of diseases to native species (4)	Transmission of diseases to native species resulting in replacement or local extinction of native species (i.e., species vanish from communities at sites where they occurred	Transmission of diseases to native species resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes	Transmission of diseases to native species resulting in a decline of population size of at least one native species, but no changes in community composition	Transmission of diseases to native species affects fitness (e.g., growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	The alien species is not a host of diseases transmissible to native species or very low level of transmission of

Blackburn T ... ne
Magnitude ... 50
https://jou

S | BIOLOGY
NNIVERSARY

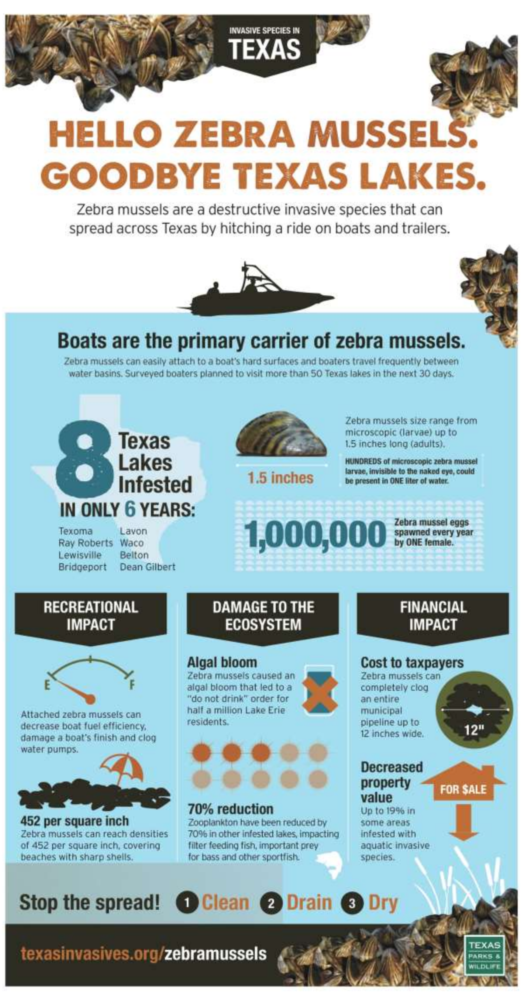
Dopad biologické invaze je závislý na hustotě populace



Simberloff, Daniel, et al. "Impacts of biological invasions: what's what and the way forward." Trends in ecology & evolution 28.1 (2013): 58-66.

Souhrnný efekt invazních druhů?

- Druhé nejčastější riziko spojené s druhy které vyhynuly
- Odhadované škody působené invazními druhy přesahují $1.4 bilionů (10 12) ročně –5% světové ekonomiky (Pimentel, David, et al. "Economic and environmental threats of alien plant, animal, and microbe invasions." Agriculture, Ecosystems & Environment 84.1 (2001): 1-20.)
- Riziko pro zdraví člověka



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Opinion TRENDS in Ecology and Evolution Vol.19 No.9 September 2004

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SCIENCE DIRECT

Are invasive species a major cause of extinctions?

Jessica Gurevitch and Dianna K. Padilla

Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY 11794-5245, USA

The link between species invasions and the extinction of natives is widely accepted by scientists as well as conservationists, but available data supporting invasion as a cause of extinctions are, in many cases, anecdotal, speculative and based upon limited observation. We pose the question, are aliens generally responsible for widespread extinctions? Our goal is to prompt a more critical synthesis and evaluation of the available data, and to suggest ways to take a more scientific, evidence-based approach to understanding the impact of invasive species on extinctions. Greater clarity in our understanding of these patterns will help us to focus on the most effective ways to reduce or mitigate extinction threats from invasive species.

Ecologists, conservation biologists and managers widely believe that invasions by non-native species are a leading cause of recent species extinctions [1,2]. The introduction and spread of non-native species has become a global ecological and conservation crisis as invasive organisms are increasingly altering terrestrial and aquatic communities worldwide. The loss of biodiversity and species

correlation is too often assumed to imply causation. For example, severe habitat alteration (e.g. deforestation), decline or extinction of native plants, and the proliferation of exotic plant species commonly co-occur. Are non-native plants causing the decline of natives, or are the decline of the natives and the proliferation of the exotics both a result of habitat alteration? It is important to distinguish between these alternatives: is removing exotics essential to prevent the extinction of endemic natives, or is it largely a waste of managers' time and effort? Multiple threats can also act synergistically to cause declines or extinctions. However, if invasives are not a primary cause of extinction or major contributors to declines of species (locally or globally) but are instead merely correlated with other problems, the resources and efforts devoted to removing exotics might be better focused on more effective means to preserve threatened species.

The overarching category 'threatened by aliens' might also be misleading, for two reasons: we must distinguish the relative importance of different functional groups in causing extinctions, and also examine whether broad groups of invasives, or merely particular species, are

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110 Update TRENDS in Ecology and Evolution Vol.20 No.3 March 2005

Invasive species are a leading cause of animal extinctions

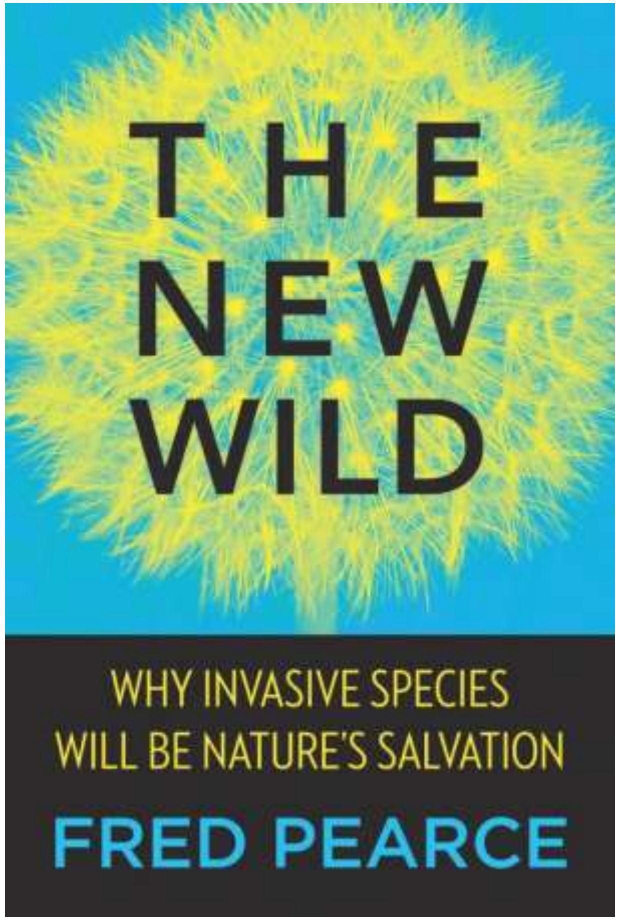
Miguel Clavero and Emili García-Berthou

Institute of Aquatic Ecology, University of Girona, E-17071 Girona, Spain

In a recent Opinion article in *TREE* [1], Gurevitch and

several reviews of particular taxa by expert groups that

Denialismus invazní biologie
- podobný proces, který ovlivnil vědu o klimatu minulou dekádu



Trends in Ecology & Evolution

Science & Society

The Rise of Invasive Species Denialism

James C. Russell[1,2,@,*] and Tim M. Blackburn[3,4,@]

Scientific consensus on the negative impacts of invasive alien species (IAS) is increasingly being challenged. Whereas informed scepticism of impacts is important, science denialism is counterproductive. Such denialism arises when uncertainty on impacts is confounded by differences in values. Debates on impacts must take into account both the evidence presented and motivations.

„It is a mistake to misdirect valuable and increasingly scarce conservation funds into unwinnable wars, especially when the enemy is not especially damaging.“

“Trying to control Himalayan balsam throughout England, just because it is alien, is a waste of effort.“

Thomas (2013) The Anthropocene could raise biological diversity. Nature 502, 7.

- „We are still ill-equipped to predict the biological effects of climate change. **It would therefore be foolish from the standpoint of both ecology and evolution to stop protecting pre-Anthropocene ecosystems** and species from the onslaught of climate-driven newcomers.“

Caro (2013) Anthropocene: keep the guard up. Nature, 502, p. 624

Komunikace negativních dopadů invazních druhů veřejnosti

- Vojenské metafory ve vědecké i ochranářské komunikaci (nepřítel, zbraně, boj, vetřelec) umožňují přitáhnout pozornost k invazním druhů v krátkodobém horizontu, ale z dlouhodobého hlediska ochrany přírody to může být kontraproduktivní

Asijský vetřelec hubí v Česku ryby. Přivezli si ho sami rybáři

15. února 2012 12:41

Do českých řek se dostal "vetřelec z východu" a vážně v nich ohrožuje přirozenou rovnováhu. Jmenuje se škeble asijská. Dovezli ho lidé spolu s rybami určenými k chovu.

Škeble asijská (Sinanodonta woodiana) je u nás invazivním druhem. | foto: Tenki.jp

"Neustále roste počet exotických druhů, které se na nová místa dostávají s pomocí lidí, ohrožují původní společenstva živočichů a rostlin i celé ekosystémy," varuje Martin Reichard z brněnského Ústavu biologie obratlovců Akademie věd

Existují alternativní cesty jak komunikovat problematiku invazních druhů, více konzistentní s hodnotami ochrany přírody

- analogie se zdravotním stavem ekosystému
- narušení rovnováhy, stability ekosystému

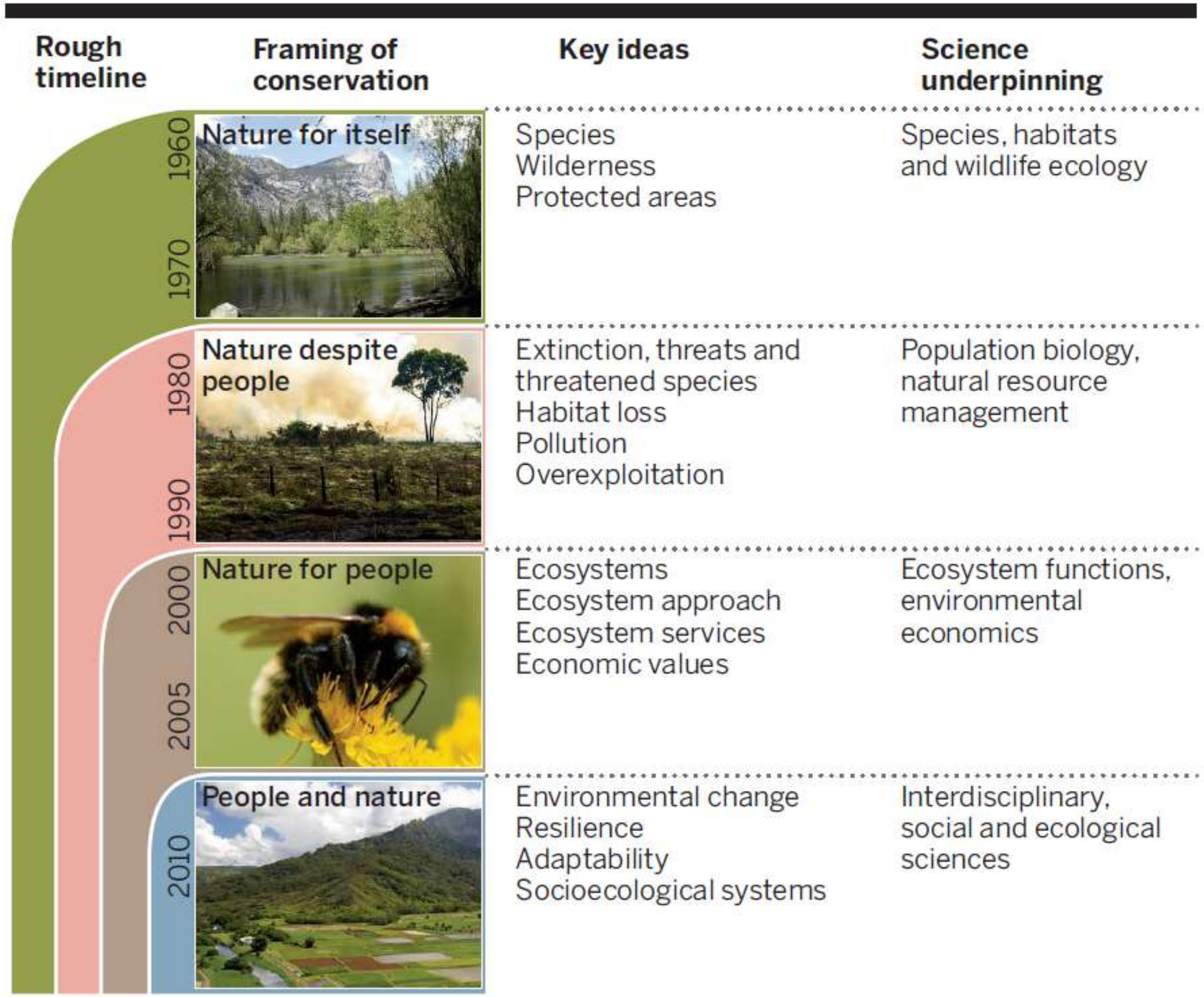
CONCEPTS AND QUESTIONS

495

The war of the roses: demilitarizing invasion biology

Brendon MH Larson

Biologické invaze a ochrana přírody



Changing views of nature and conservation. Over the past 50 years, the prevailing view of conservation has changed several times, resulting, for example, in a shift in emphasis from species to ecosystems. None of the framings has been eclipsed as new ones have emerged, resulting in multiple framings in use today.

Mace, Georgina M. "Whose conservation?." Science 345.6204 (2014): 1558-1560.

Potenciální hodnota nepůvodních druhů pro ochranu přírody

Conservation Biology

Review

The Potential Conservation Value of Non-Native Species

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Table 1. Examples of positive (+) and negative (−) roles of non-native species that were not intentionally introduced for conservation purposes.*

Purpose	*Example*	*Reference*
Habitat, shelter, and food for native species	+non-native tamarisk (*Tamarix* spp.) provides nesting habitat for Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	Sogge et al. 2008; Stromberg et al. 2009
	+ native butterflies oviposit or feed on non-native plants in California, U.S.A.	Graves & Shapiro 2003
Catalysts for restoration	+ non-native guava trees (*Psidium guajava*) support native frugivorous birds and promote forest regeneration via seed dispersal in Kenya	Berens et al. 2008
	+ non-native trees established on abandoned pastures facilitate restoration of native tree species in Puerto Rico	Lugo 2004
	+ non-native zebra mussel (*Dreissena polymorpha*) filters water and control toxic cyanobacteria in shallow eutrophic lakes	Elliot et al. 2008; Dionisio Pires et al. 2009
Ecosystem engineers	+ non-native birds in Hawaii disperse native plant seeds	Foster & Robinson 2007
	+ non-native Pacific oyster (*Crassostrea gigas*) colonizes unvegetated tideflats and forms hard reefs thereby increasing densities of native invertebrate species relative to native oyster beds	Ruesink et al. 2005
	+ non-native ascidian in intertidal waters in Chile creates dense three-dimensional structural matrix that increases local and regional species richness	Castilla et al. 2004
Ecosystem services	+ non-native African honey bees (*Apis mellifera*) pollinate native plants in fragmented forest landscapes in Brazil and Australia	Dick 2001; Gross 2001
	+ pollination of the ieie vine (*Freycinetia arborea*) in Hawaii by non-native Japanese White-eye	Cox 1983
Catal		

Potenciální hodnota nepůvodních druhů pro ochranu přírody

Conservation Biology

Review

The Potential Cons

Species

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†INRA, Ecologie et Santé des Ecosystèmes, 35
‡Department of Ecology and Evolutionary Biol
§School of Aquatic and Fishery Sciences, Unive

Conservation Biology

Comment

Revisiting the Potential Conservation Value of Non-Native Species

JEAN RICARDO SIMÕES VITULE,* CAROLINA A. FREIRE,† DIEGO P. VAZQUEZ,‡
MARTIN A. NUÑEZ,§ AND DANIEL SIMBERLOFF§**

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†Departamento de Fisiologia, Setor de Ciências Biológicas, Centro Politécnico, Universidade Federal do Paraná, 81531, 980, Curitiba, Paraná, Brazil
‡Instituto Argentino de Investigaciones de las Zonas Áridas, CONICET; Instituto de Ciencias Básicas, Universidad Nacional de Cuyo, Mendoza, Argentina
§Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, 1610, U.S.A.

Human travel and transportation of goods are increas-

fects of non-native species (e.g., gorse [*Ulex europaeus*],

Situace v ČR: klasifikace vlivu invazních druhů

NeoBiota 28: 1–37 (2016)
doi: 10.3897/neobiota.28.4824
http://neobiota.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
NeoBiota
Advancing research on alien species and biological invasions

Black, Grey and Watch Lists of alien species in the Czech Republic based on environmental impacts and management strategy

Jan Pergl[1], Jiří Sádlo[1], Adam Petrusek[2], Zdeněk Laštůvka[3], Jiří Musil[4], Irena Perglová[1], Radek Šanda[5], Hana Šefrová[6], Jan Šíma[7], Vladimír Vohralík[8], Petr Pyšek[1,2]

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Corresponding author: *Jan Pergl* (pergl@ibot.cas.cz)

AGENTURA OCHRANY PŘÍRODY A KRAJINY ČESKÉ REPUBLIKY

Tomáš Görner

INVAZNÍ NEPŮVODNÍ DRUHY S VÝZNAMNÝM DOPADEM NA EVROPSKOU UNII

jejich charakteristiky, výskyt a možnosti regulace

METODIKA AOPK ČR

PRAHA 2018

Situace v ČR: klasifikace vlivu invazních druhů

NeoBiota 28: 1–37 (2016)
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RESEARCH ARTICLE

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Advancing research on alien species and biological invasions

Black, Grey and Watch Lists of alien species in the

Taxon group	List categ.	Species (scientific name)	Czech name	Family	Environ-ment	Life history/ taxon group	Note	Mode of current spread	Distribution	Environ-mental impact	Human (socio-economic) impact	Management strategy
animal	BL3	*Corbicula fluminea* (O. F. Müller, 1774)	korbikula asijská	Cyrenidae	aquatic	invertebrate		Spontaneous	Regional	Moderate	Limited	Stratified approach
animal	BL3	*Diaspidiotus perniciosus* (Comstock, 1881)	štítenka zhoubná	Diaspididae	terrestrial	invertebrate		Spontaneous	Regional	Limited	Moderate	Stratified approach
animal	BL3	*Dikerogammarus villosus* (Sowinsky, 1894)	blešivec ježatý	Gammaridae	aquatic	invertebrate		Spontaneous	Regional	Massive	Limited	Stratified approach
animal	BL3	*Dreissena polymorpha* (Pallas, 1771)	slávička mno-hotvárná	Dreissenidae	aquatic	invertebrate		Spontaneous	Regional	Massive	Moderate	Stratified approach
animal	BL3	*Eriosoma lanigerum* (Hausmann, 1802)	vlnatka krvavá	Aphididae	terrestrial	invertebrate		Spontaneous	Regional	Limited	Moderate	Stratified approach
animal	BL3	*Harmonia axyridis* (Pallas, 1773)	slunéčko východní	Coccinellidae	terrestrial	invertebrate		Spontaneous	Regional	Moderate	Moderate	Stratified approach

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AGENTURA OCHRANY PŘÍRODY A KRAJINY ČESKÉ REPUBLIKY

PRAHA 2018

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http://neobiota.pensoft.net

Table 2. Categories of Black and Grey Lists with indication of recommended management, handling restrictions, species examples and classifying criteria that are derived from environmental and socio-economic impact, population status and distribution of the target species. See Table 1 for details of the categories of recommended management.

Lists category	Grouping criteria	Population status, dynamics and distribution of target species	Recommended local management	Handling and release restrictions	No. of plant species	Plant examples	No. of animal species	Animal examples
BL1	High environmental and socio-economic impact.	Abundant, distributed in a wide range of habitats, throughout the country. Species showing high population growth rate and colonization potential.	Complete eradication; eradications or containment everywhere, disposal of abandoned plantations.	No release; application of trade regulations.	2	*Ambrosia artemisiifolia*, *Heracleum mantegazzianum*	3	*Neovison vison*, *Procyon lotor*, *Varroa destructor*
BL2	Moderate to massive environmental impact. Species depending highly on human actions that promote their spread.	Species often found as remnants of planting in gardens and plantations, or in case of animals introduced for hunting and fishing (released or escaped). Usually species with wide distribution, occurring in urban as well as in (semi-)natural habitats.	Stratified approach; instead of economically important species, alternative native species should be promoted. If necessary for economic activities in areas with low conservation value, keeping in capture could be permitted, with prerequisite of prevention escape, and removal of the captive population once the economic activity has ceased. In case of plants disposal of the remnants of abandoned plantations is needed.	No release, legislative regulations of trade and handling, regulation for planting in suburban and rural landscape, some of the economically important species (marked by *) can be planted outside areas of high natural value.	49	*Acer negundo*, *Ailanthus altissima*, *Robinia pseudoacacia*, *Asclepias syriaca*, *Helianthus tuberosus*, *Solidago* sp. *Symphyotrichum* sp., *Telekia speciosa*, *Pinus strobus*, *Quercus rubra*	8	*Cervus nippon*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Oncorhynchus mykiss*, *Ovis musimon*, *Salvelinus fontinalis*
BL3	Moderate to massive environmental impact. Current distribution results from spontaneous spread and unintentional introductions.	Species usually with wide distribution which results mainly from spontaneous spread. Species occur in urban as well as in (semi-)natural habitats.	Stratified approach; due to spontaneous distribution there is no need to tolerate in any area.	No release.	27	*Abutilon theophrasti*, *Bunias orientalis*, *Conyza canadensis*, *Echinochloa crus-galli*, *Iva xanthiifolia*, *Rumex alpinus*, *Senecio inaequidens*	28	*Ameiurus melas*, *Arion vulgaris*, *Cameraria ohridella*, *Dikerogammarus villosus*, *Harmonia axyridis*, *Myocastor coypus*, *Ondatra zibethicus*, *Trachemys scripta*

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RESEARCH ARTICLE

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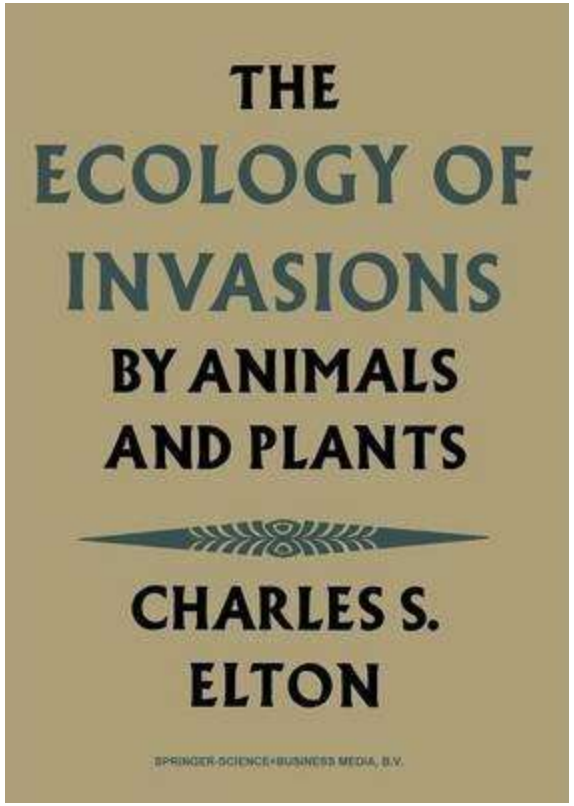
Lists category	Grouping criteria	Population status, dynamics and distribution of target species	Recommended local management	Handling and release restrictions	No. of plant species	Plant examples	No. of animal species	Animal examples
GL	Currently with limited environmental impact.	Scattered distribution throughout the country, resulting from spontaneous spread and escape from planting or captivity. Can be regionally or locally distributed.	Tolerance; outside areas of a high conservation value no need to take direct actions.	Where appropriate, change in management can be employed to reduce their distribution.	47	*Bidens frondosus*, *Erigeron annuus*, *Impatiens parviflora*, *Juglans regia*, *Lonicera caprifolium*, *Rubrivena polystachya*, *Sedum hispanicum*	16	*Ameiurus nebulosus*, *Astacus leptodactylus*, *Eriocheir sinensis*, *Fascioloides magna*, *Gyrodactylus cyprini*, *Rupicapra rupicapra*

Princip předběžné opatrnosti – predikce, vědecký výzkum

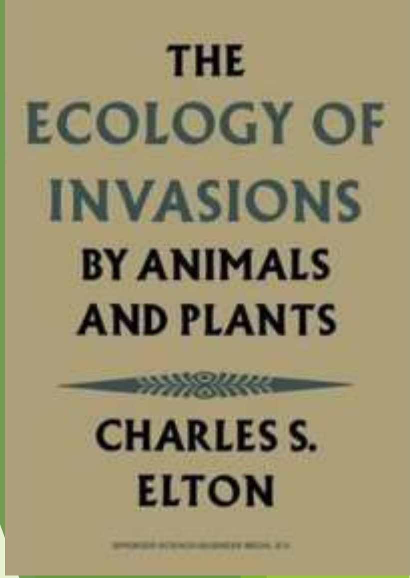
- „The ecology of invasions by animals and plants“ (Elton 1958)

2018: sixtieth anniversary



1958

- Elton předpověděl výrazný nárůst počtu invazí s masivním dopadem
- Zejména zdůrazňoval rizika související s organismy způsobujícími „biofouling“ a význam balastní vody v lodní dopravě jako cestu šíření invazních druhů
- Upozornil na to, že druhy které mají nějak odlišný způsob života od domácích druhů mají největší šanci stát se invazními a mít negativní dopady



1958

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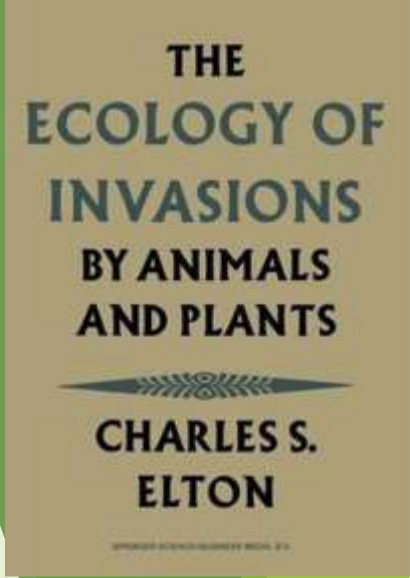


80. léta – slávička mnohotvárná se poprvé objevila v severní Americe a stala se miliardovým ekonomickým problémem a hrozbou pro biodiverzitu

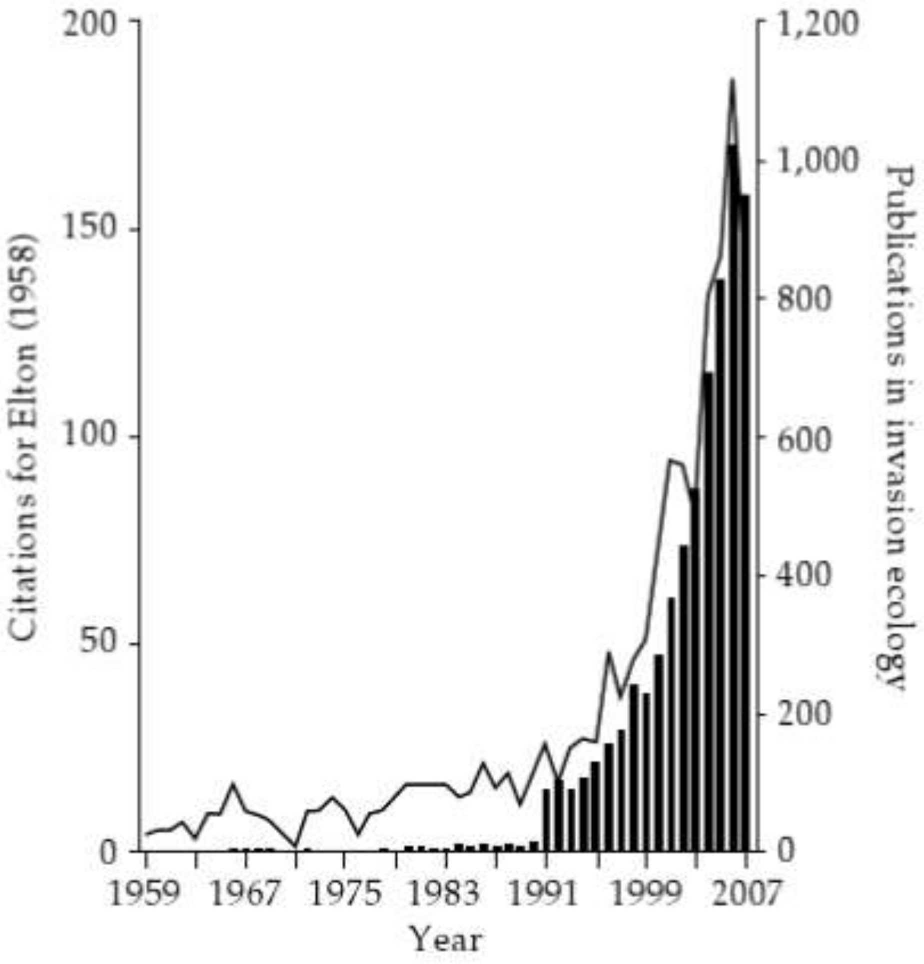
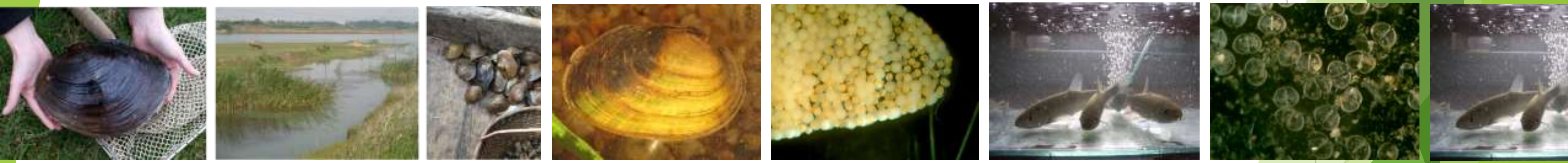


Fig. 1.1 The number of biological invasion publications since Elton published *The ecology of invasions by animals and plants* in 1958 (columns). Also shown are the number of publications that cited Elton's 1958 book during this time period (linegraph). Redrawn and printed, with permission, from Ricciardi and MacIsaac (2008), copyright Nature Publishing Group.

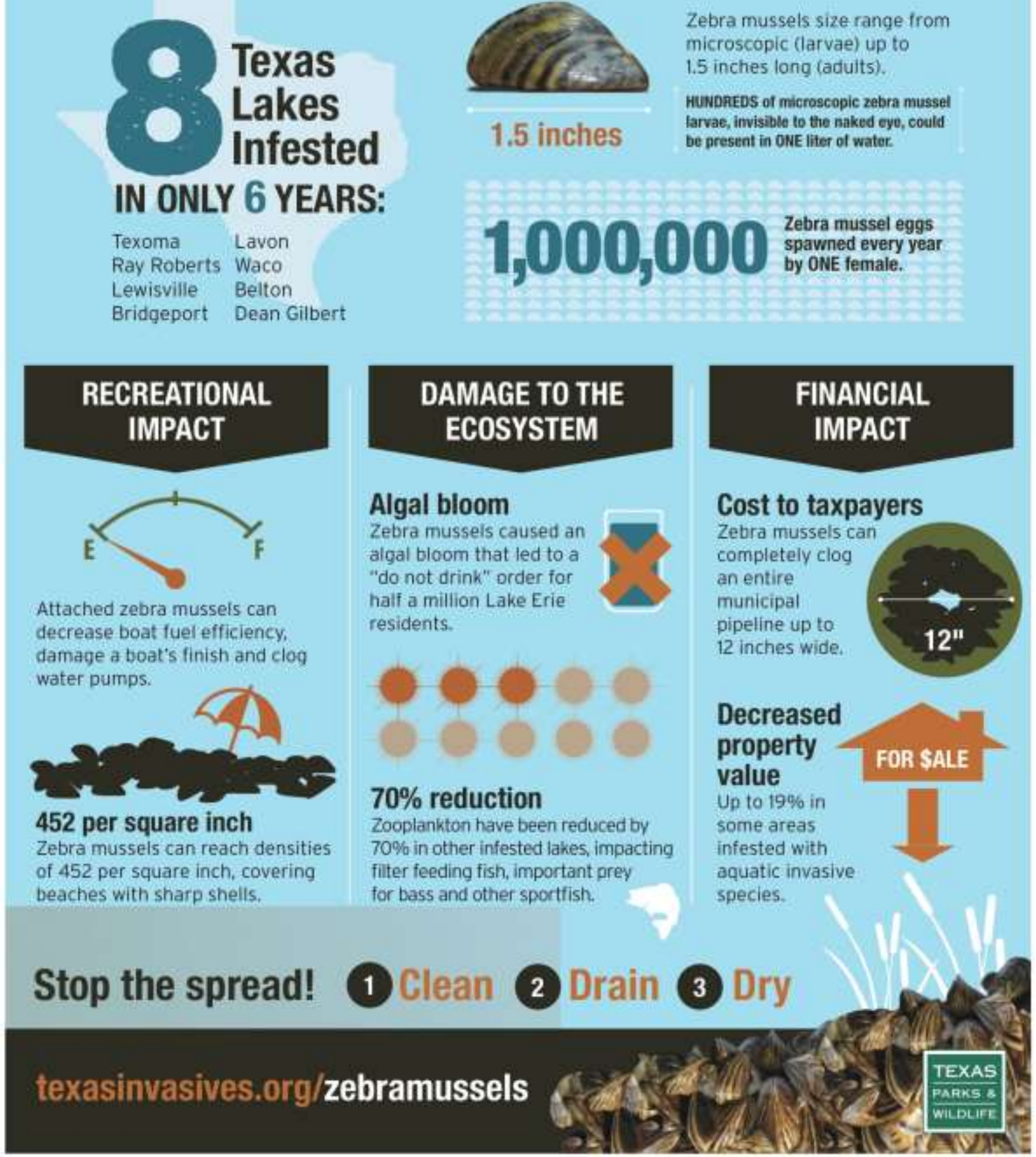
Zavlečení nepůvodních organismů a jejich dopady

VELCÍ MLŽI



k.douda@gmail.com


INVASIVE SPECIES IN
TEXAS
HELLO ZEBRA MUSSELS.
GOODBYE TEXAS LAKES.
Zebra mussels are a destructive invasive species that can spread across Texas by hitching a ride on boats and trailers.
Boats are the primary carrier of zebra mussels.
Zebra mussels can easily attach to a boat's hard surfaces and boaters travel frequently between water basins. Surveyed boaters planned to visit more than 50 Texas lakes in the next 30 days.
8 Texas Lakes Infested
IN ONLY 6 YEARS:
Texoma
Ray Roberts
Lewisville
Bridgeport
Lavon
Waco
Belton
Dean Gilbert
1.5 inches
Zebra mussels size range from microscopic (larvae) up to 1.5 inches long (adults).
HUNDREDS of microscopic zebra mussel larvae, invisible to the naked eye, could be present in ONE liter of water.
1,000,000
Zebra mussel eggs spawned every year by ONE female.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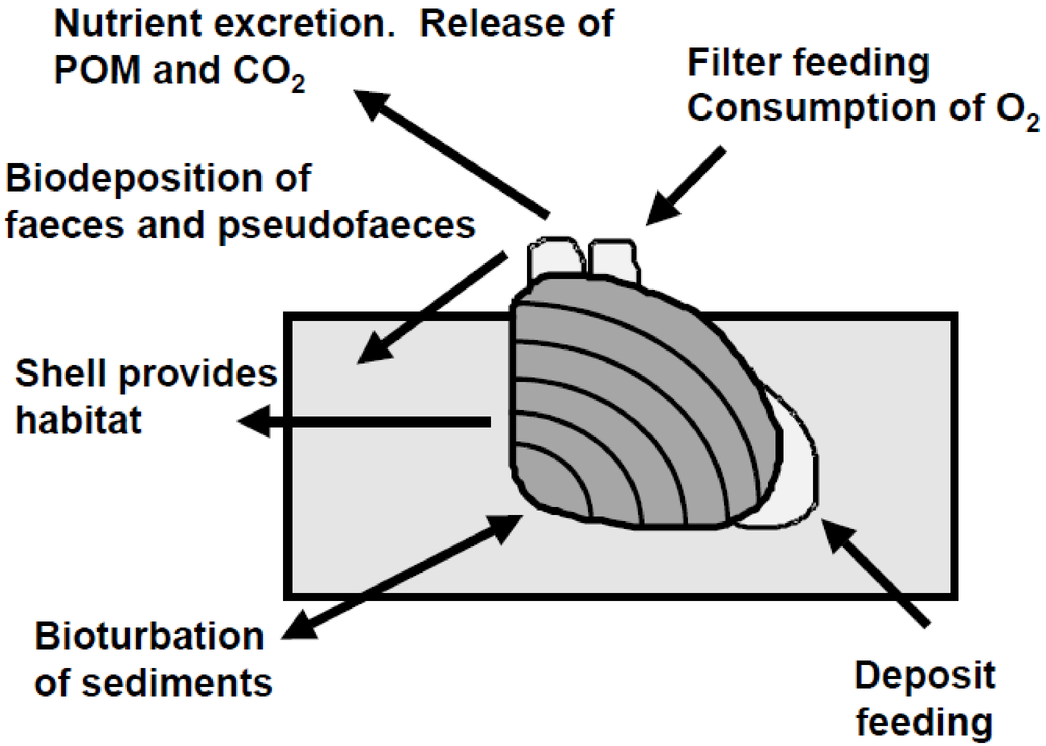
1,000,000
Zebra mussel eggs spawned every year by ONE female.
RECREATIONAL IMPACT
E
F
Attached zebra mussels can decrease boat fuel efficiency, damage a boat's finish and clog water pumps.
452 per square inch
Zebra mussels can reach densities of 452 per square inch, covering beaches with sharp shells.
DAMAGE TO THE ECOSYSTEM
Algal bloom
Zebra mussels caused an algal bloom that led to a "do not drink" order for half a million Lake Erie residents.
70% reduction
Zooplankton have been reduced by 70% in other infested lakes, impacting filter feeding fish, important prey for bass and other sportfish.
FINANCIAL IMPACT
Cost to taxpayers
Zebra mussels can completely clog an entire municipal pipeline up to 12 inches wide.
12"
Decreased property value
Up to 19% in some areas infested with aquatic invasive species.
FOR $ALE
Stop the spread!
1 Clean
2 Drain
3 Dry
texasinvasives.org/zebramussels
TEXAS PARKS & WILDLIFE



Freshwater Biology (2001) **46**, 1431–1446

FRESHWATER BIOLOGY SPECIAL REVIEW

The functional role of burrowing bivalves in freshwater ecosystems

CARYN C. VAUGHN* and CHRISTINE C. HAKENKAMP†
*Oklahoma Biological Survey and Department of Zoology, University of Oklahoma, Norman, OK, U.S.A.
†Department of Biology, James Madison University, Harrisonburg, VA, U.S.A.

Hydrobiologia **527**: 35–47, 2004.

Ecosystem processes performed by unionid mussels in stream mesocosms: species roles and effects of abundance

Caryn C. Vaughn[1,*], Keith B. Gido[1,2] & Daniel E. Spooner[1]

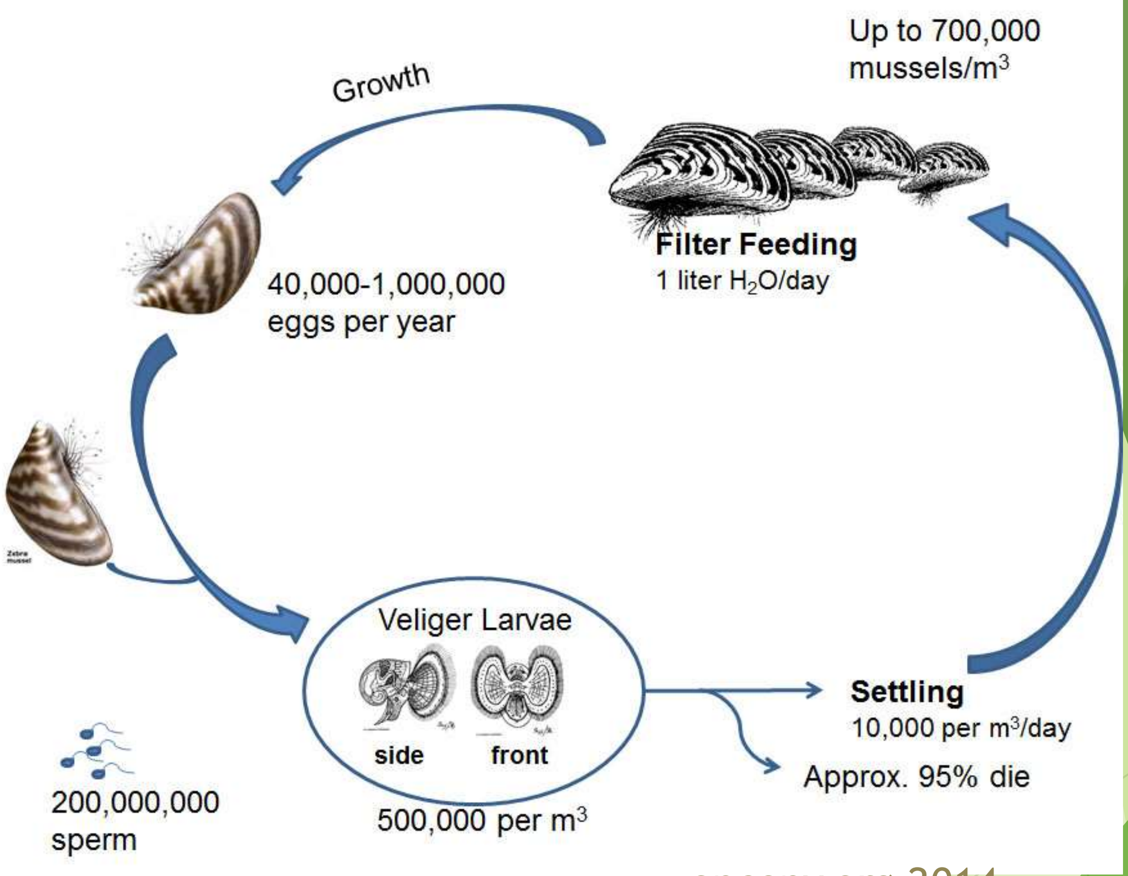
Freshwater Biology (2006) **51**, 460–474 doi:10.1111/j.1365-2427.2005.01507.x

The functional role of native freshwater mussels in the fluvial benthic environment

JEANETTE K. HOWARD AND KURT M. CUFFEY
Department of Geography, University of California, Berkeley, CA, U.S.A.

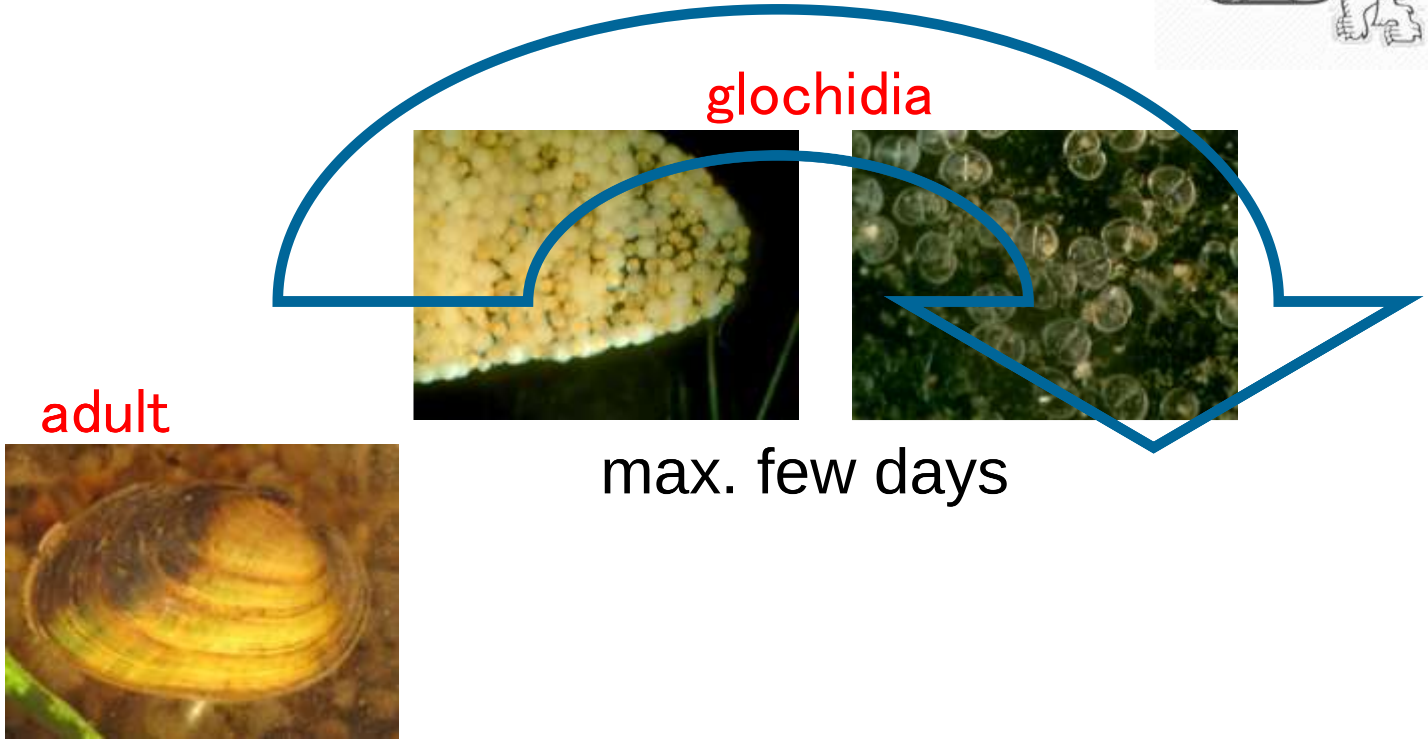
- The most invasive freshwater bivalve species - simple life cycles

  (directly release juveniles, free living dispersal larvae)

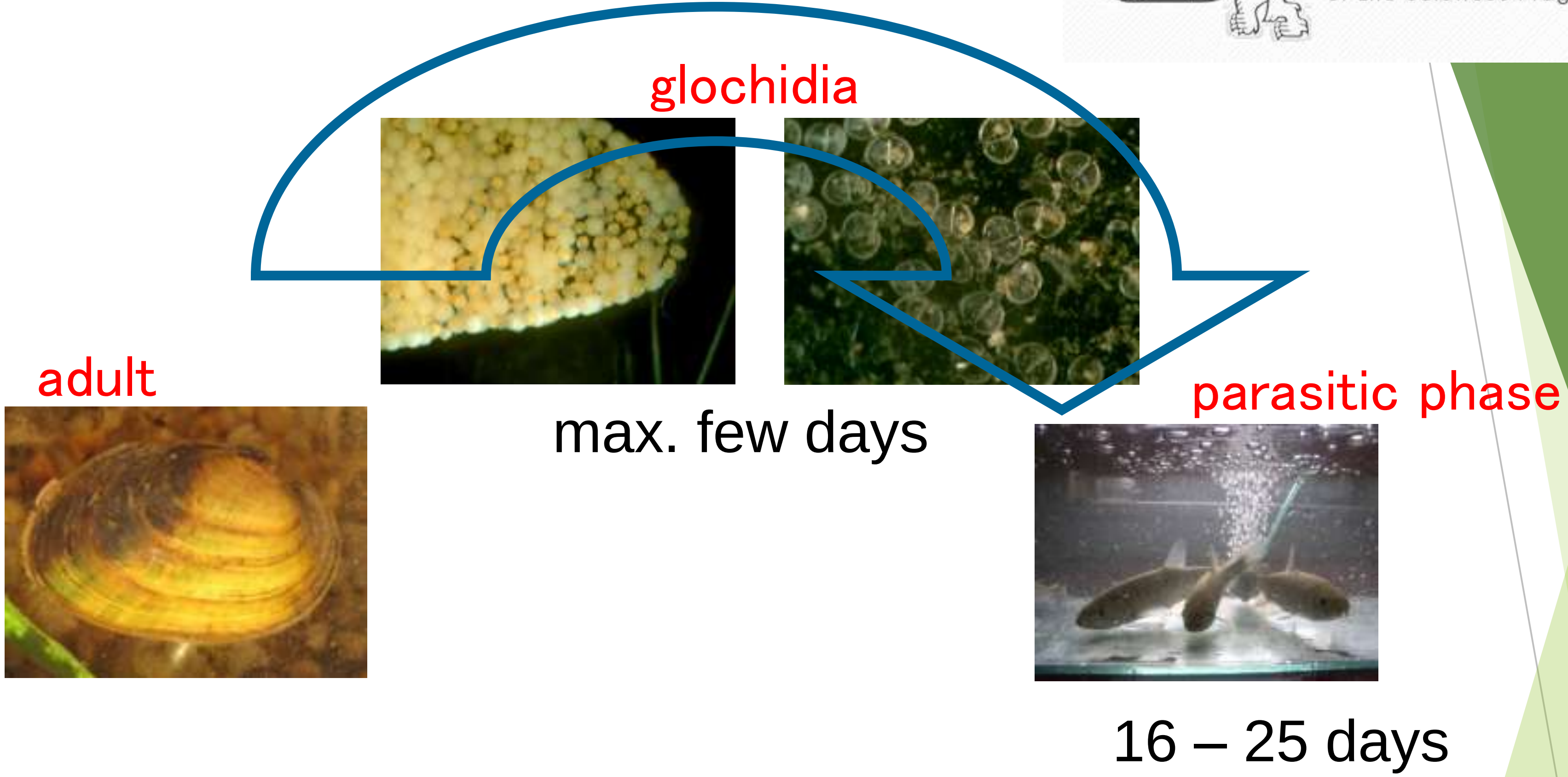


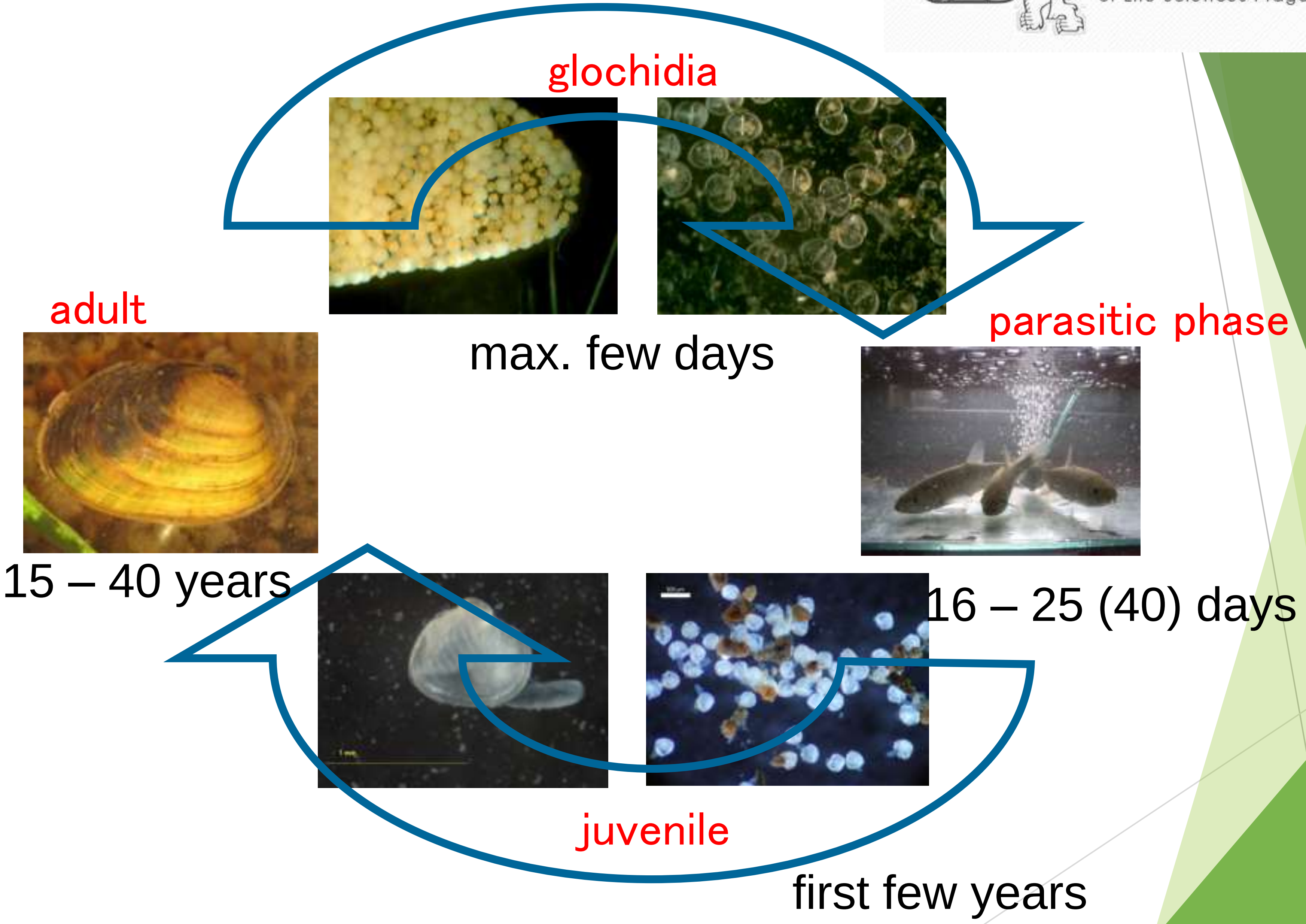
enconv.org 2014

adult

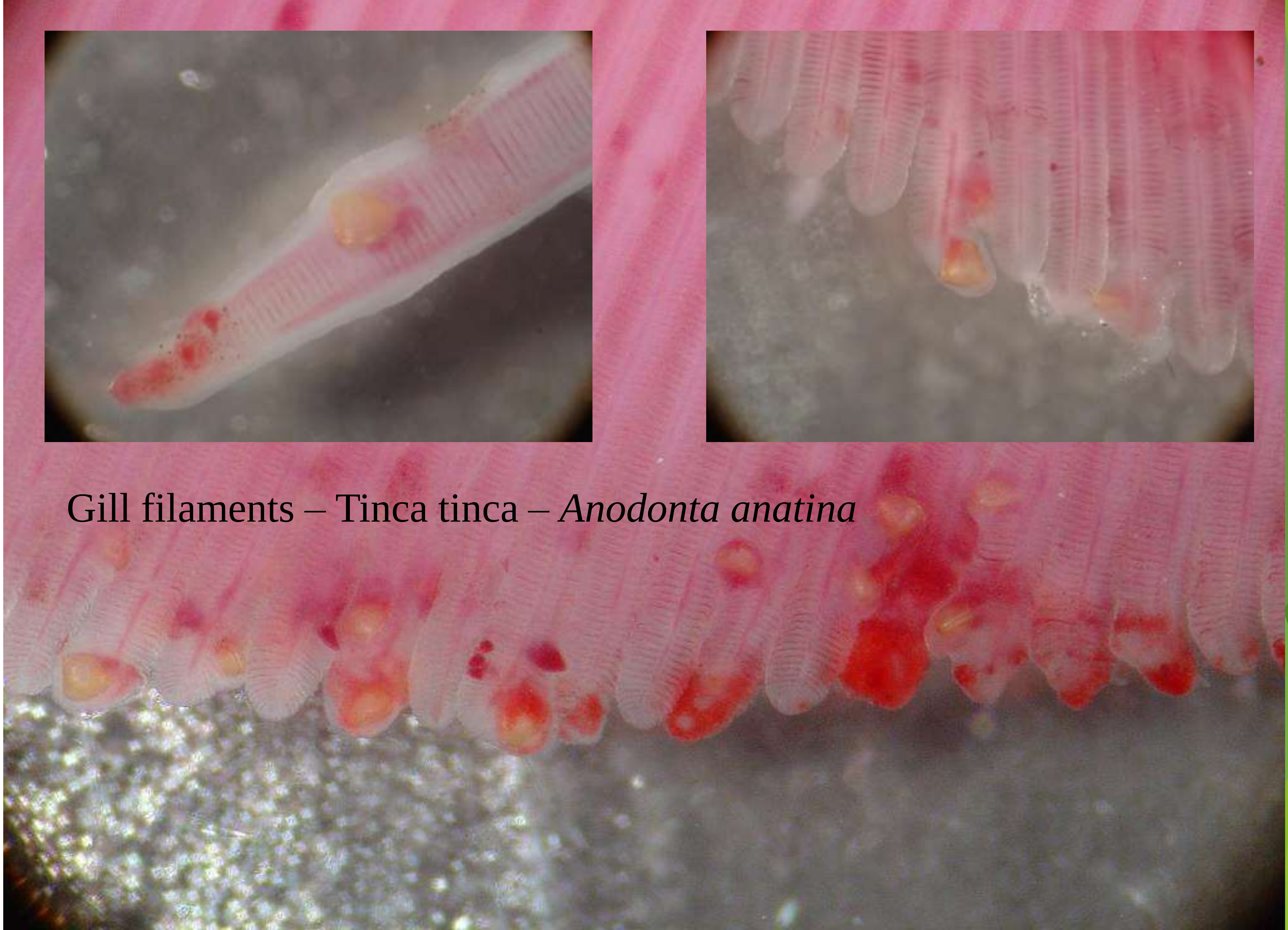

glochidia
adult
max. few days

Czech University of Life Sciences Prague

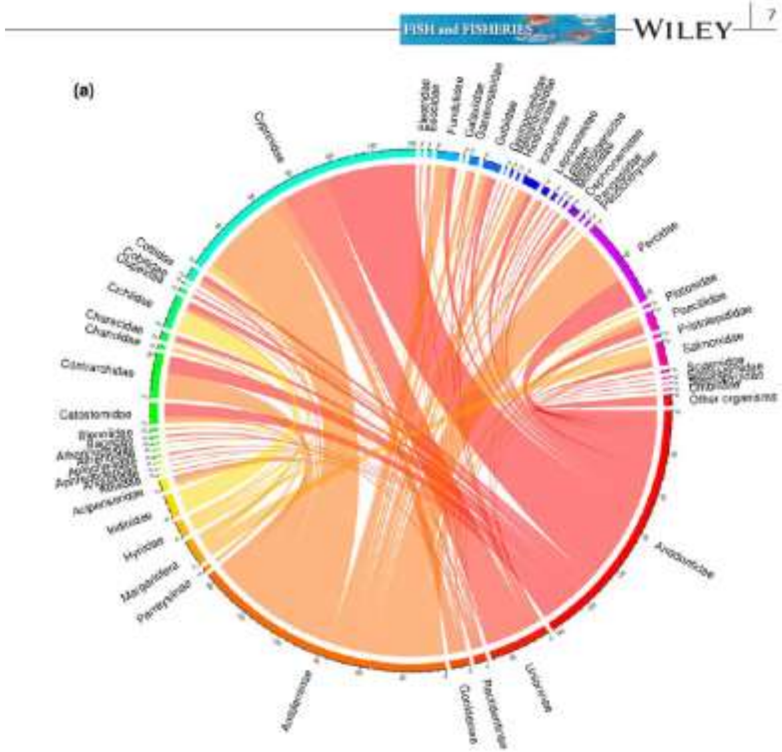



glochidia
adult
max. few days
parasitic phase
15 – 40 years
16 – 25 (40) days
juvenile
first few years



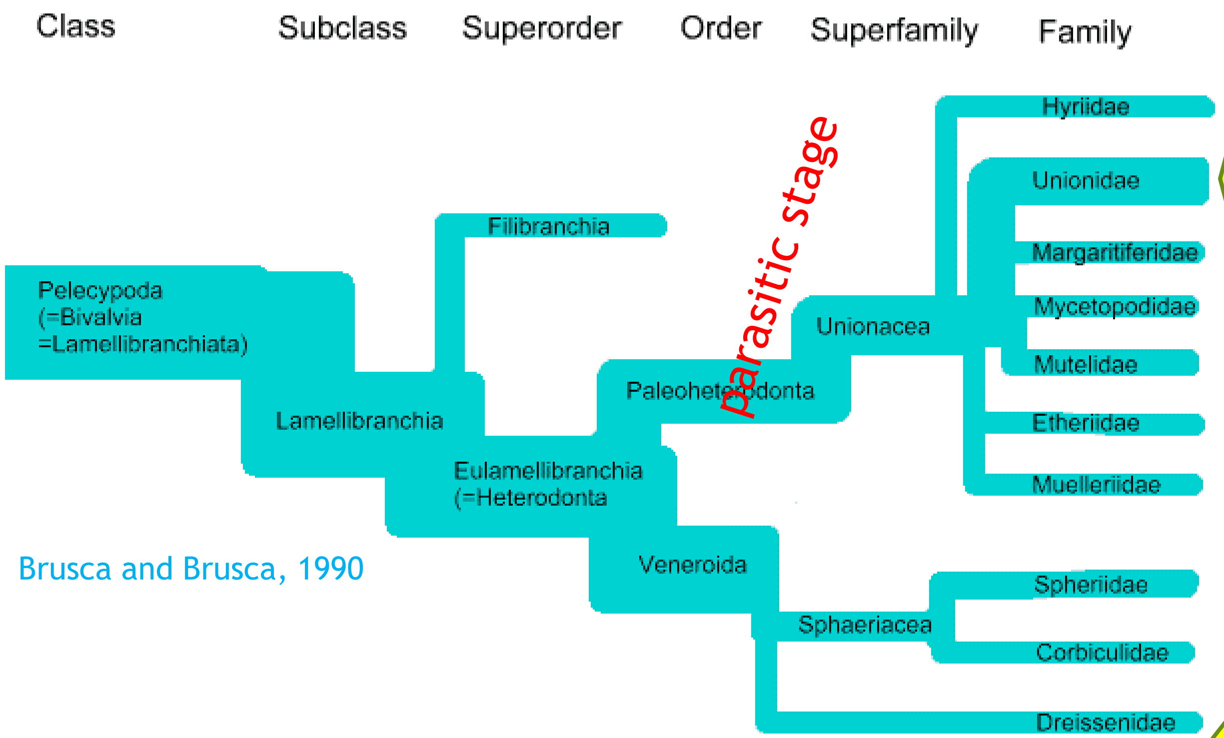



Gill filaments – Tinca tinca – *Anodonta anatina*


FISH and FISHERIES
WILEY
7
(a)
Cyprinidae
Percidae
Catostomidae
Centrarchidae
Salmonidae
Other organisms
Anodontinae
Unioninae
Ambleminae


Margaritiferidae
Unionini
Anodontini
Gonideinae

- Diverse life histories

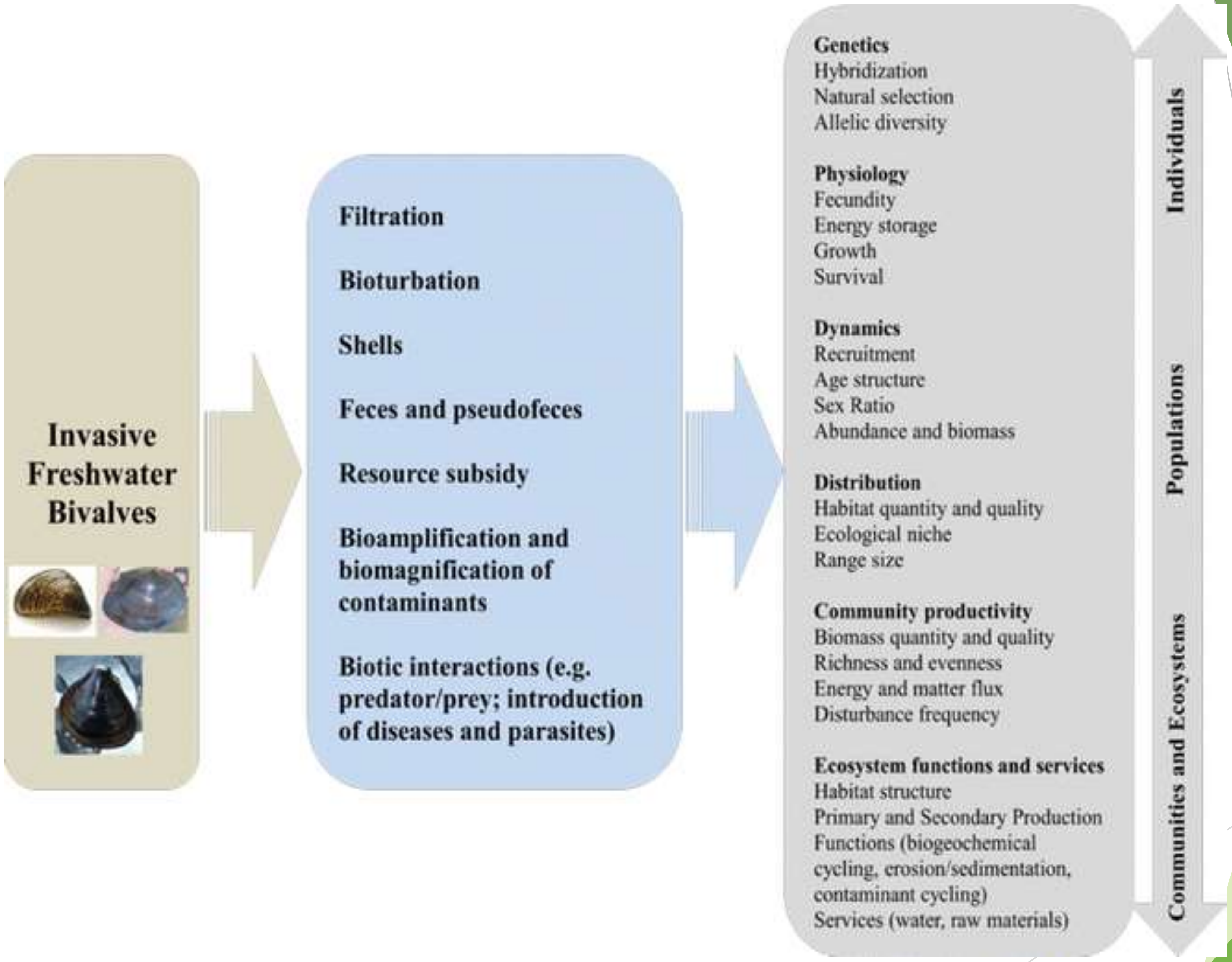


Brusca and Brusca, 1990

Chinese pond mussel *Anodonta woodiana*

Corbicula fluminea

Dreissena polymorpha



Sousa et al. 2014

JAKÉ JSOU DOPADY BIOLOGICKÝCH INVAZÍ V PŘÍPADĚ VELKÝCH MLŽŮ?

PŘÍKLADY VLIVŮ:

1. Biotická homogenizace a hostitelské zdroje

2. Lokální adaptace a interakce s hostiteli

3. Přímé dopady invazních druhů

1. ZMĚNA VE SPOLEČENSTVECH HOSTITELSKÝCH RYB

Biotic homogenization

- gradual increase in biological similarity of regions as a result of combined effects of species invasions and extinctions (Olden, Rooney 2006)

- former co-evolutionarily balanced inter-specific relationships are lost

- many parasites and host species begin interact with novel partners

Unio crassus

high degree of host specificity

Anodonta anatina

low level of host specificity

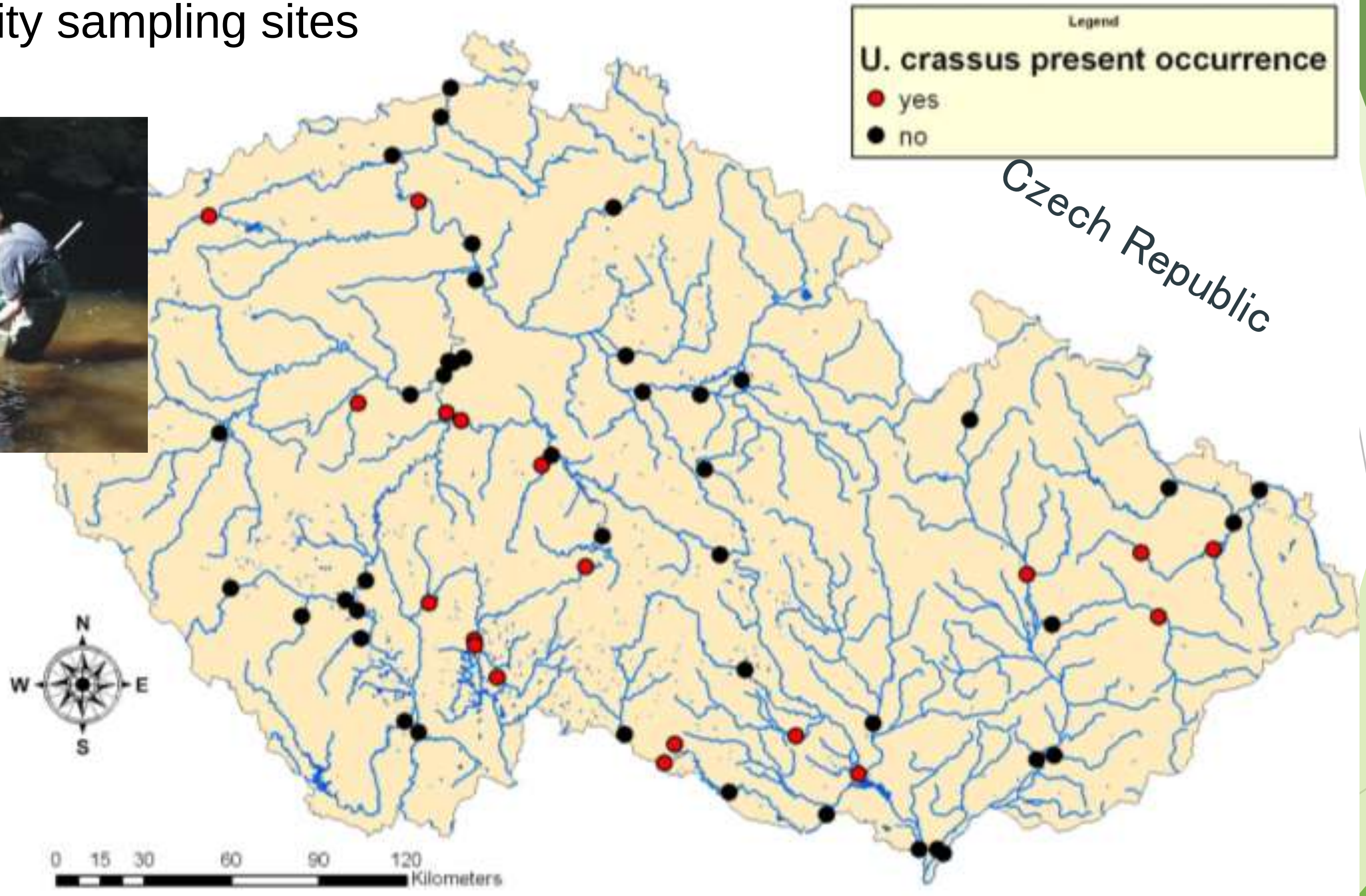
Metody:

(1) Analýza hostitelské kompatibility na druhové úrovni

(2) Analýza životaschopnosti populací na lokalitách s různým druhovým složením

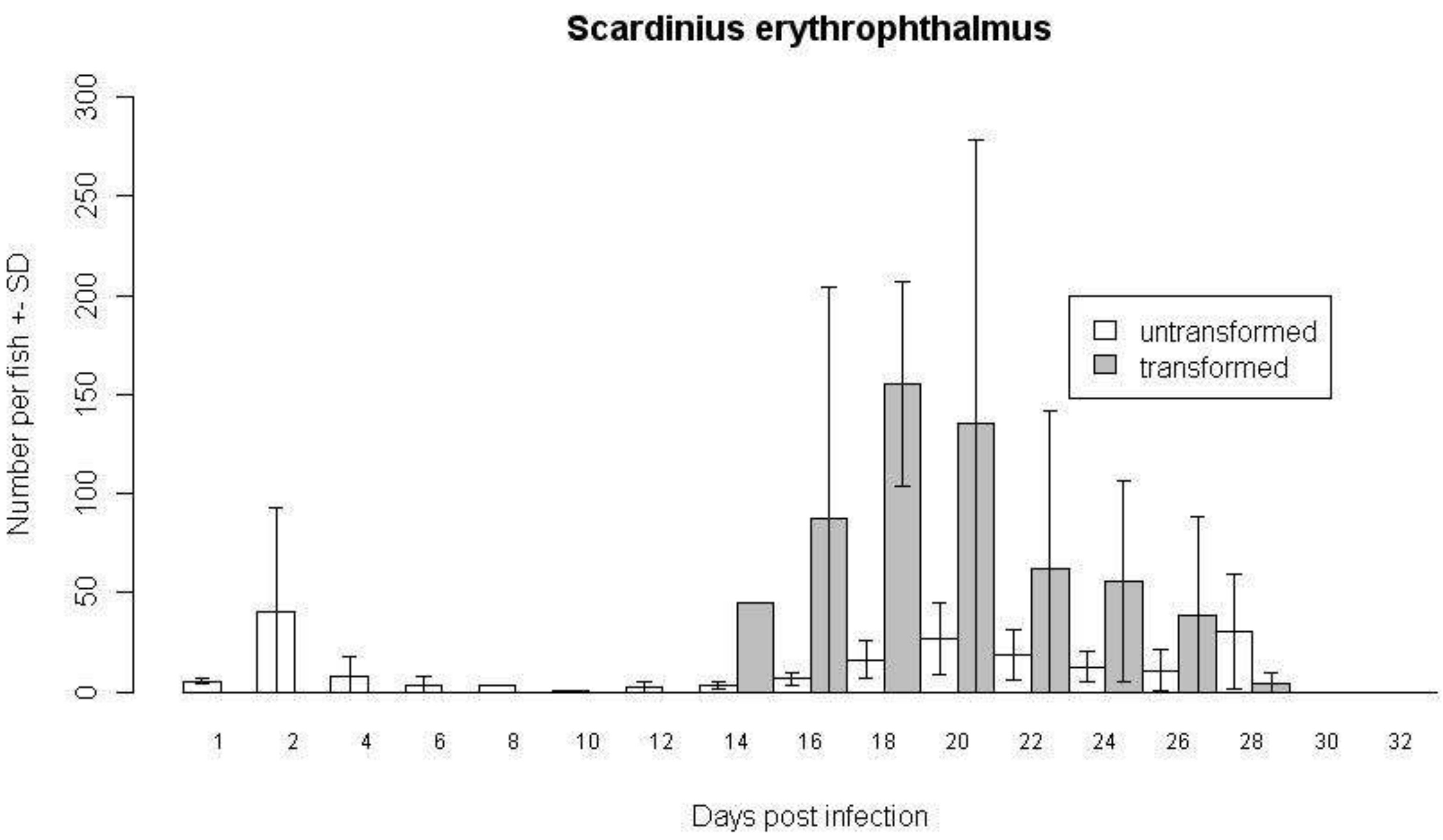
Analýza kompatibility

Fish community sampling sites

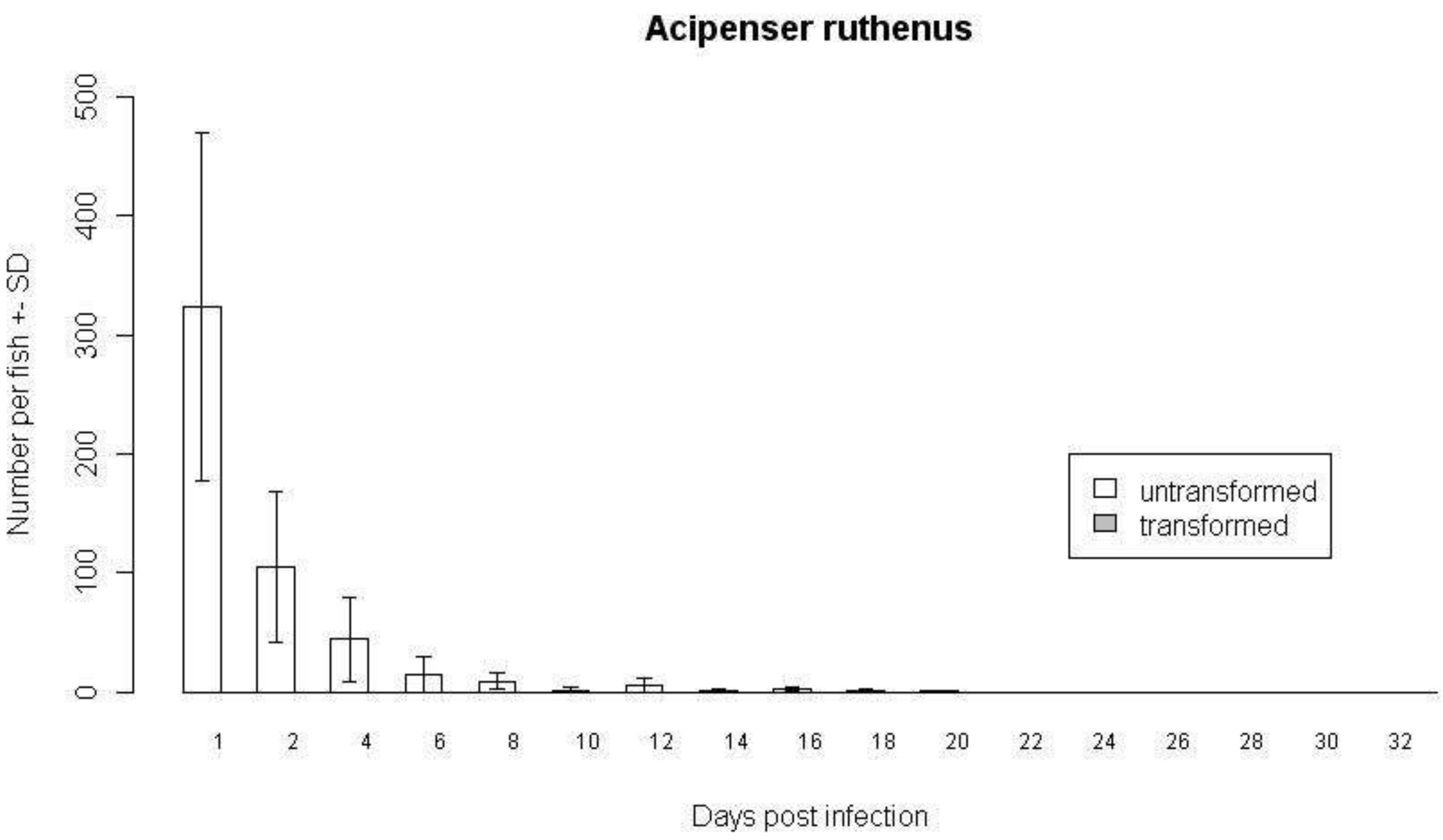


Douda, K., Horký, P., Bílý, M. (2012), Host limitation of the thick-shelled river mussel: identifying the threats to declining affiliate species. Animal Conservation, 15: 536–544.

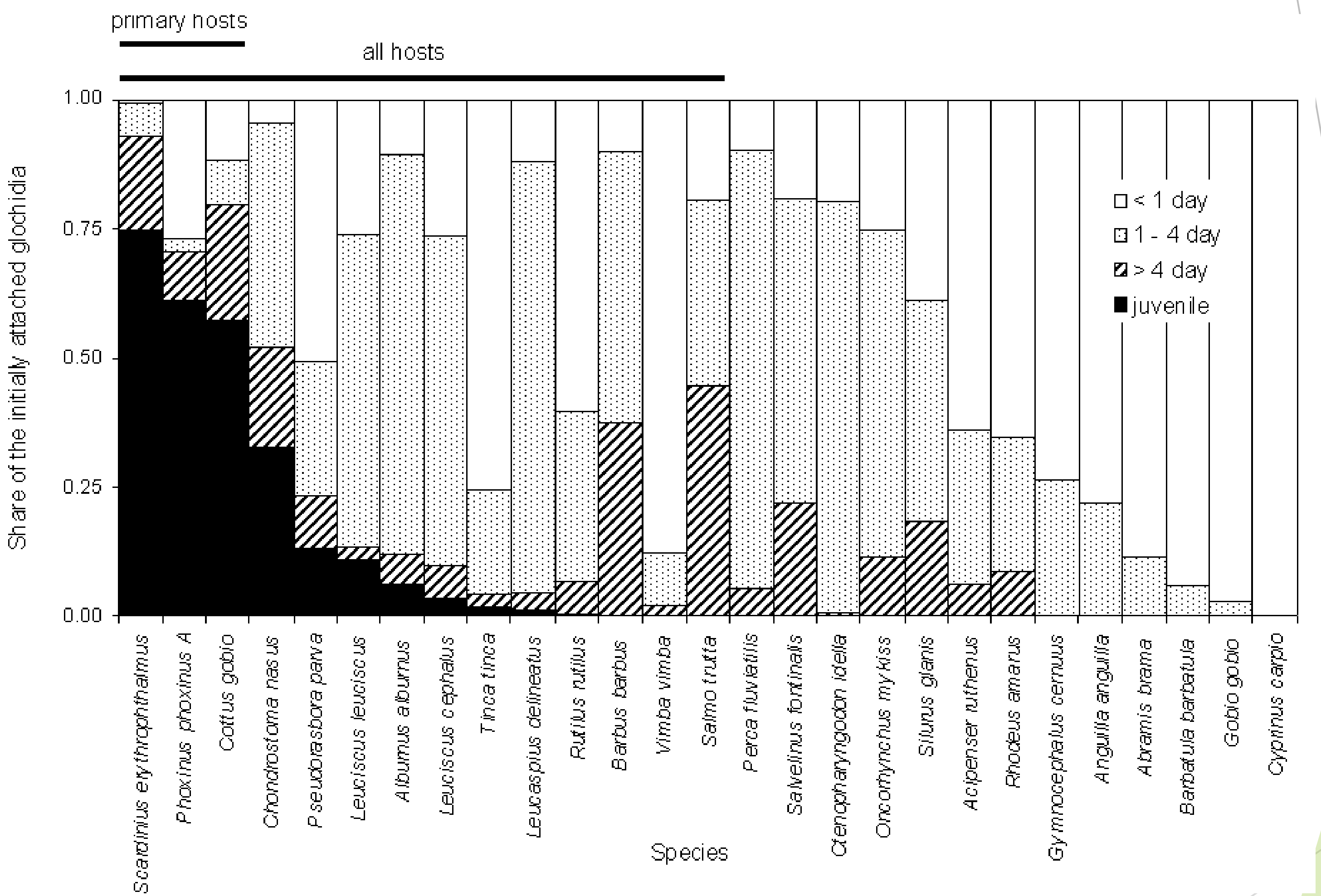
RESULTS


Scardinius erythrophthalmus
Number per fish +- SD
0
50
100
150
200
250
300
untransformed
transformed
1
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Days post infection

RESULTS

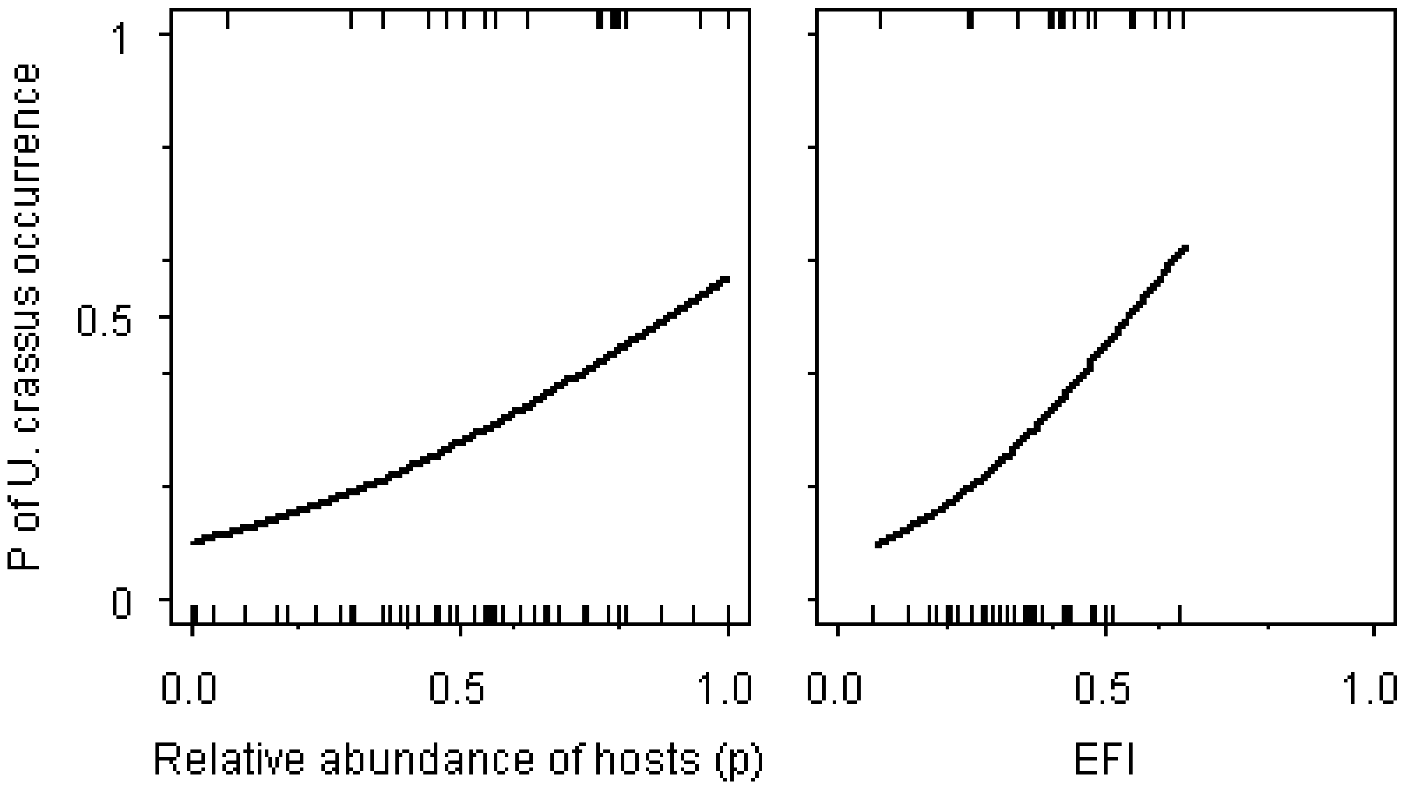


Acipenser ruthenus
Number per fish +- SD
0
100
200
300
400
500
1
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Days post infection
untransformed
transformed



Douda, K., Horký, P., Bílý, M. (2012), Host limitation of the thick-shelled river mussel: identifying the threats to declining affiliate species. Animal Conservation, 15: 536–544.

RESULTS



Probability of recent occurrence of *U. crassus* in relation to the relative abundance of all suitable hosts (a) and in relation to European Fish Index (b) fitted by logistic regression ($p<0.05$). *Unio crassus* presence (symbols at upper axis) and absence (symbols at lower axis) are also shown.

Přežívání populací velevruba tupého souvisí s přítomností nepůvodních a invazních druhů ryb na lokalitách.

Douda, K., Horký, P., Bílý, M. (2012), Host limitation of the thick-shelled river mussel: identifying the threats to declining affiliate species. Animal Conservation, 15: 536–544.

Animal Conservation. Print ISSN 1367-9430

Host limitation of the thick-shelled river mussel: identifying the threats to declining affiliate species

K. Douda, P. Horký & M. Bílý

Department of Applied Ecology, Water Research Institute TGM, Prague, Czech Republic

Keywords
Bivalvia; Europe; experimental infestation; freshwaters; glochidia; host spectrum; *Unio crassus*; Unionidae.

Correspondence
Karel Douda, Department of Applied

Abstract

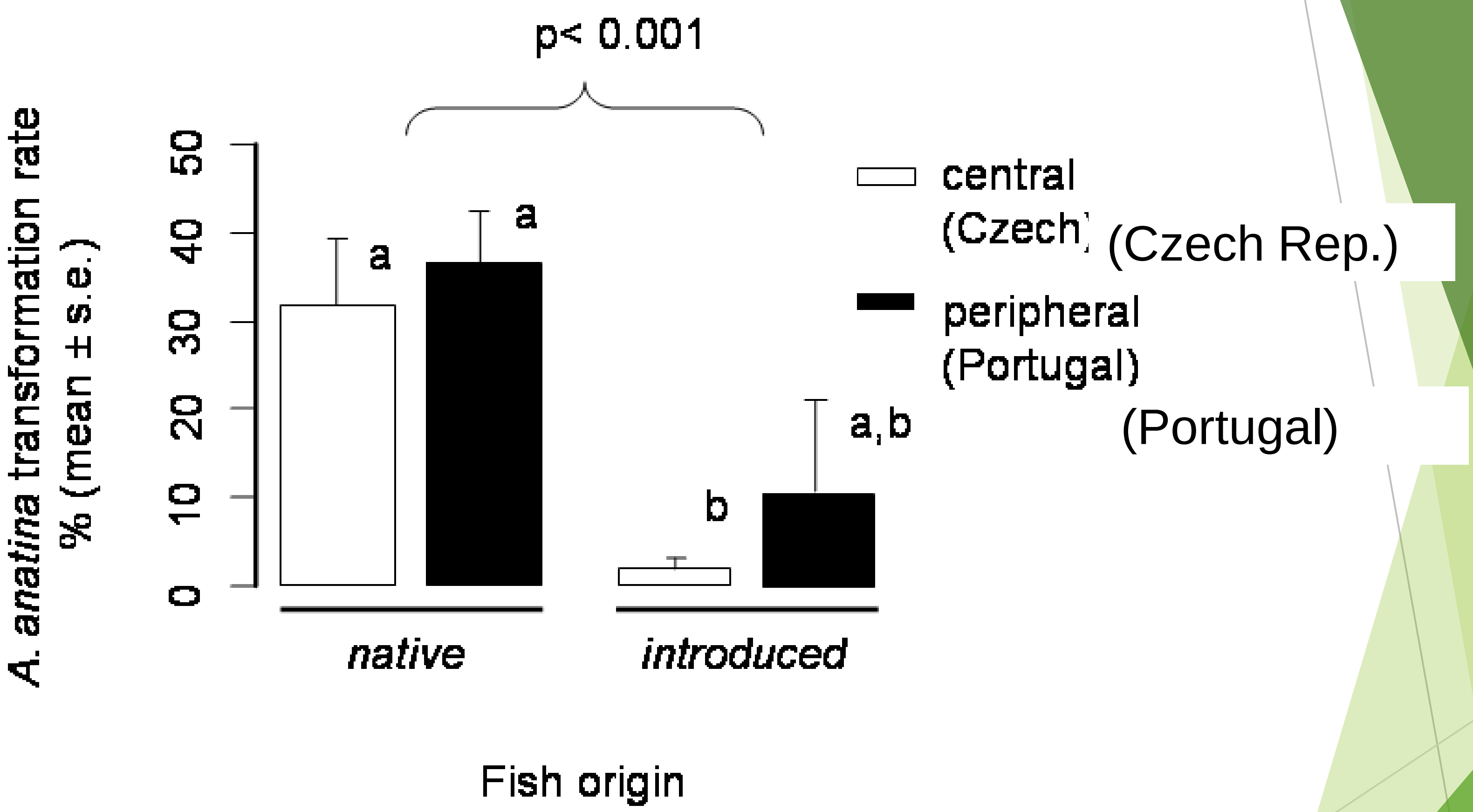
The conservation of endangered affiliate species, which are critically dependent on the presence of another species, is often hindered by a poor understanding of the relationships between the interacting partners. The parasitic stage of endangered unionid bivalves constitutes a tight host–affiliate linkage between the mussels and their host fishes. However, the threats resulting from potential shortages of the

Douda, K., Horký, P., Bílý, M. (2012), Host limitation of the thick-shelled river mussel: identifying the threats to declining affiliate species. Animal Conservation, 15: 536–544.

Anodonta anatina

Douda, K., Lopes-Lima, M., Hinzmann, M. et al. (2013): Biotic homogenization as a threat to native affiliate species: fish introductions dilute freshwater mussel's host resources. Diversity and Distributions, 19: 933–942.

		Fish Species	Trial	Number of fish (N)	Fish length (mm)	Mean (juveniles per fish)	Mean attached glochidia/fish *	Transformation rate (%)
Native	Portugal	*Achondrostoma oligolepis*		9	82.2 ± 40.1	7.9	23.9	33.1
		Cobitis paludica		6	78.8 ± 9.3	0.5	4.9	10.2
		Luciobarbus bocagei		8	140.3 ± 56.2	4	19.0	21
		Pseudochondrostoma duriense		9	110.8 ± 49.3	10.3	18.3	56.4
		Salmo trutta fario		6	170.1 ± 10.7	16.5	39.0	42.3
		Squalius alburnoides		16	86.9 ± 38.2	12.8	27.0	47.4
		Squalius carolitertii		7	100.1 ± 47.2	16.4	37.2	44.1
	Czech Republic	*Scardinius erythrophthalm*	*B*	5	67.2 ± 16.9	154.9	211.0	73.4
		Perca fluviatilis	*A*	10	54.3±3.2	126.2	220.9	57.1
		Barbus barbus	*B*	8	90.4 ± 10.6	413.3	729.0	56.7
		Vimba vimba	*B*	6	44.3 ± 4.4	23.0	103.0	22.3
		Leuciscus cephalus	*B*	8	56.3 ± 7.9	34.3	216.0	15.9
		Rutilus rutilus	*A*	5	100±3.4	17.8	566.6	3.1
		Tinca tinca	*A*	7	45±5.4	0.1	101.6	0.1
		Gobio gobio	*C*	5	51.8±7.2	12.8	53.8	25.3
		Abramis brama	*C*	6	69.3±20.2	33.8	142.5	22.2
		Leuciscus leuciscus	*C*	6	60.2±2.8	27.8	73.0	39.8
Introduced	Portugal	*Cyprinus carpio*		4	150.2 ± 58.1	0	33.2	0
		Gobio Lozanoi		16	100.2 ± 24.3	0	47.1	0
		Lepomis gibbosus		18	98.2 ± 45.9	0	0	0
		Micropterus salmoides		4	145.2 ± 66.7	0	12.1	0
		Oncorhynchus mykiss		6	165.2 ± 9.2	12.5	24.2	51.7
	Czech Repul	*Cyprinus carpio* *	*A*	6	63±8.3	0.5	312.2	0.2
		Rhodeus amarus *	*B*	12	30.7 ± 2.4	1.5	20.0	7.6
		Pseudorasbora parva	*B*	8	62.4 ± 5.7	0.8	209.0	0.4
		Carassius gibelio	*B*	8	82.3 ± 4.7	0.5	463.0	0.1
		Carassius auratus	*C*	15	79.5±6.4	0.1	82.9	0.001



Douda, K., Lopes-Lima, M., Hinzmann, M. et al. (2013): Biotic homogenization as a threat to native affiliate species: fish introductions dilute freshwater mussel's host resources. Diversity and Distributions, 19: 933–942.

- Výrazné rozdíly ve schopnosti využívat nepůvodní druhy - riziko pro reprodukční úspěšnost i u hostitelských generalistů jako je škeble říční

Douda, K., Lopes-Lima, M., Hinzmann, M. et al. (2013): Biotic homogenization as a threat to native affiliate species: fish introductions dilute freshwater mussel's host resources. Diversity and Distributions, 19: 933–942.

Diversity and Distributions, (Diversity Distrib.) (2013) 19, 933–942

A Journal of Conservation Biogeography

BIODIVERSITY RESEARCH

Biotic homogenization as a threat to native affiliate species: fish introductions dilute freshwater mussel's host resources

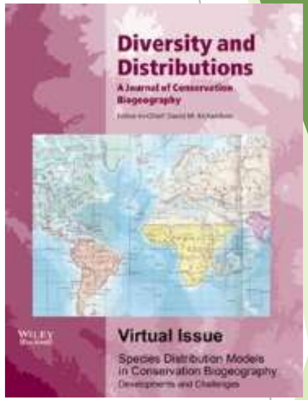
Karel Douda[1]*, Manuel Lopes-Lima[2,3], Mariana Hinzmann[2,3], Jorge Machado[2,3], Simone Varandas[4], Amílcar Teixeira[5] and Ronaldo Sousa[2,6]

[1]Department of Zoology and Fisheries, Faculty of Agrobiology Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, Prague, CZ 165 21, Czech Republic, [2]CIMAR-LA/CIIMAR – Centre of Marine and Environmental Research, University of Porto, Rua dos Bragas 289, 4050-123 Porto, Portugal, [3]ICBAS – Instituto de Ciências Biomédicas de Abel Salazar, Universidade do Porto, Largo Prof. Abel Salazar, 2, 4099-003 Porto

ABSTRACT

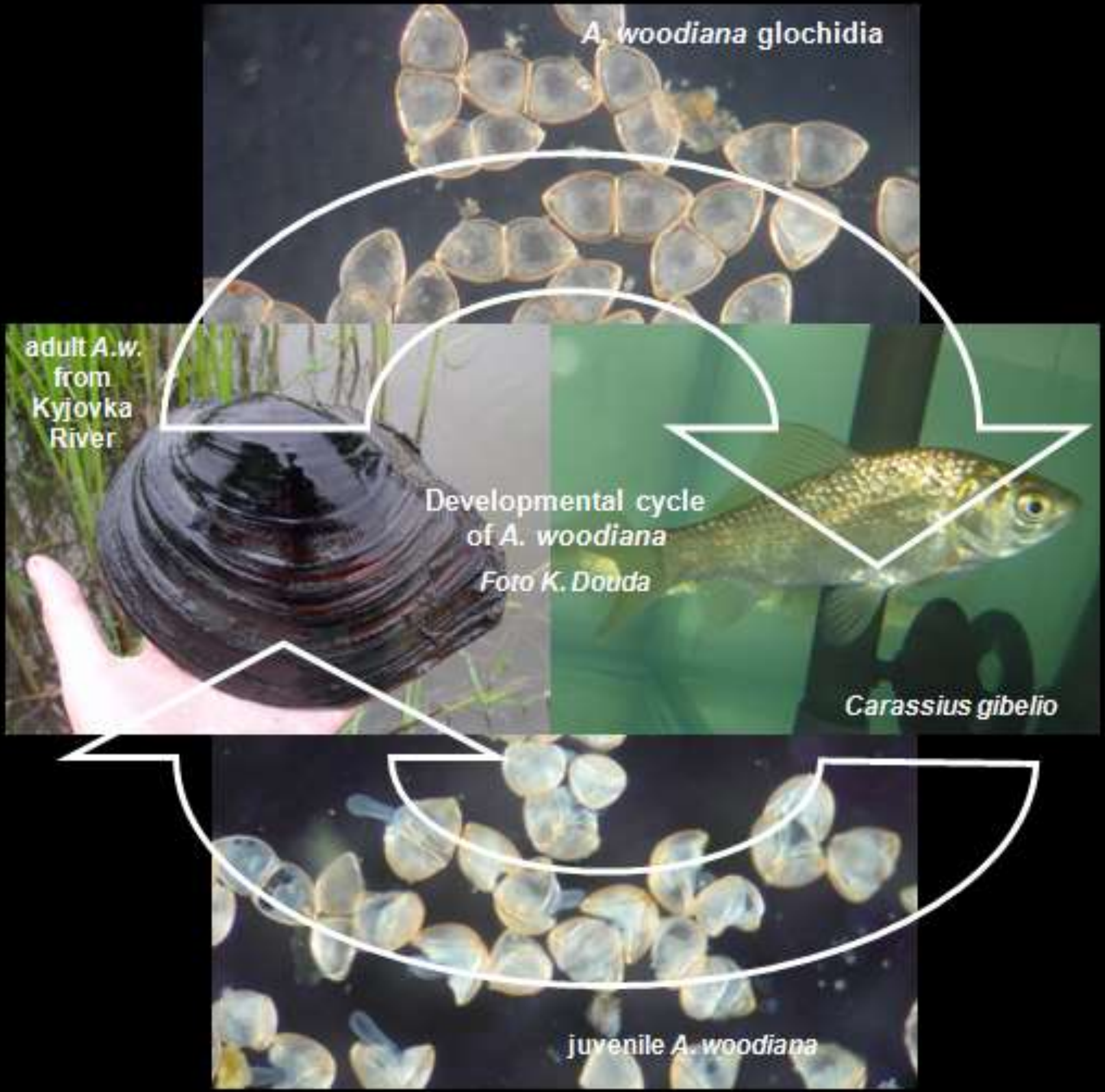
Aim The indirect consequences of biotic homogenization, the process of a gradual increase in the similarity of regional biotas driven by the combined effects of species invasions and extinctions, are still poorly understood. In this study, we aimed to assess the ability of a native affiliate species to maintain its host resources under the condition of biotic homogenization of host communities.

Location Central (Vltava River Basin, Czech Republic) and western (Douro River Basin, Portugal) Europe.

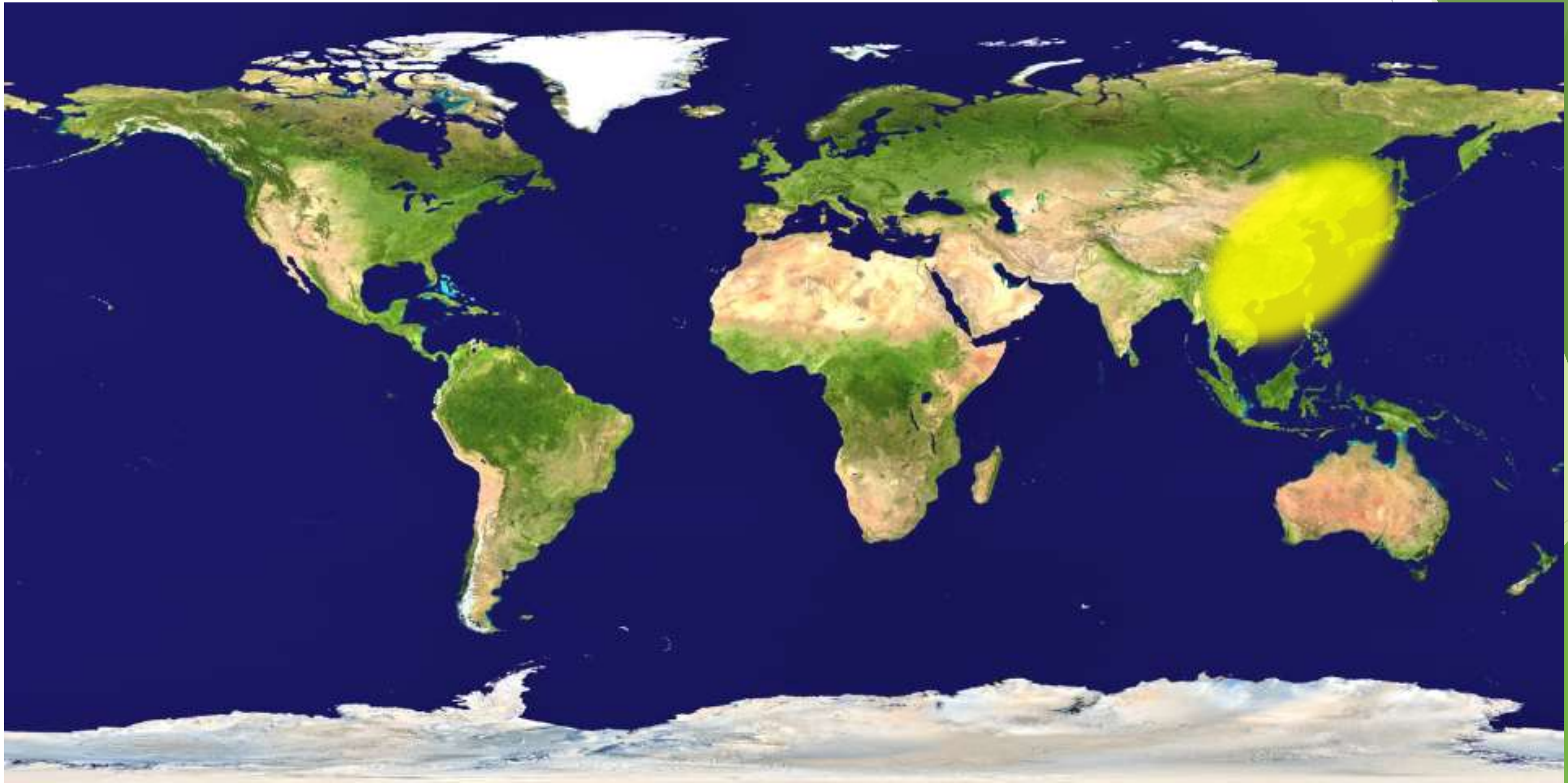


Douda, K., Lopes-Lima, M., Hinzmann, M. et al. (2013): Biotic homogenization as a threat to native affiliate species: fish introductions dilute freshwater mussel's host resources. Diversity and Distributions, 19: 933–942.

1. Vlivy na populační úrovni a invazní druhy velkých mlžů

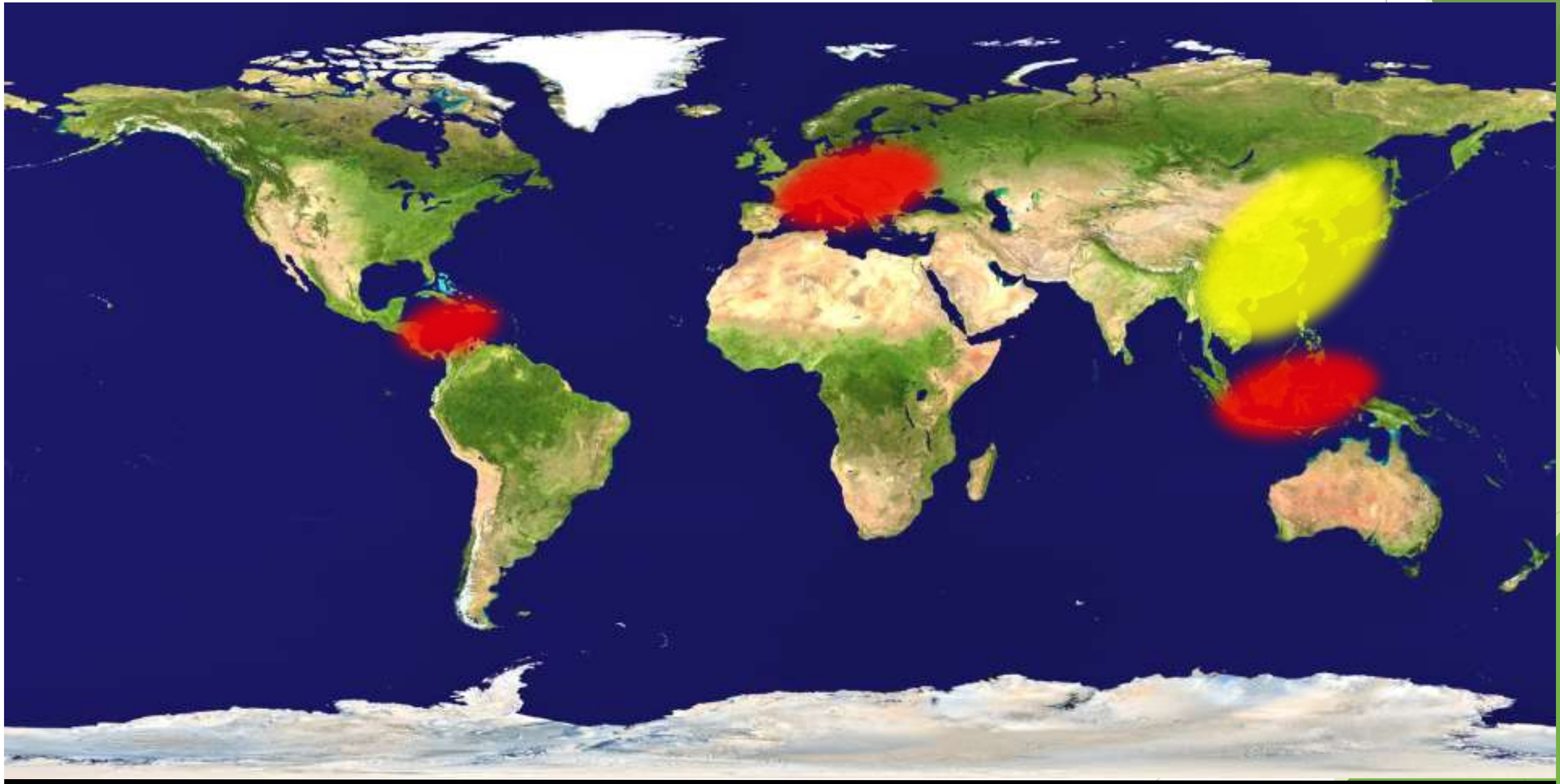

A. woodiana glochidia
adult A.w. from Kyjovka River
Developmental cycle of A. woodiana
Foto K. Douda
Carassius gibelio
juvenile A. woodiana

- *Anodonta woodiana* is native to south eastern Asia, specifically Indochina and southern China to Korea, Japan, Taiwan, Primorye and the Amur Basin in eastern Russia (Graf 2007; Watters 1997).



- *Anodonta woodiana* range expansion has been attributed to its parasitic stage and the notion that infected host fishes serve as a vector for spreading.

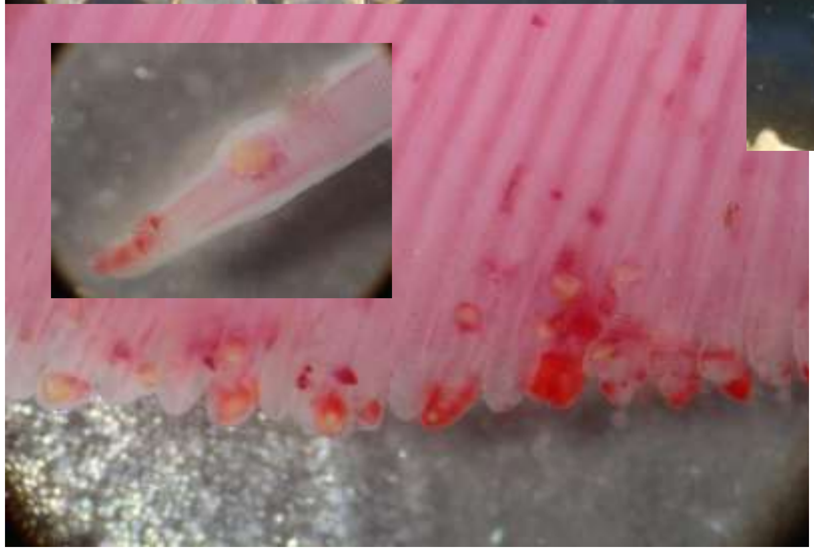
- The expansion of *A. woodiana's* range began in the second half of the 20th century; today, *A. woodiana* can be found in the Indonesian islands (Djajasasmita 1982), Central America (Watters 1997), Europe (Kraszewski 2007; Sárkány-Kiss et al. 2000), the Asian part of Turkey (M. Reichard, unpublished data) and North America (Benson 2011).

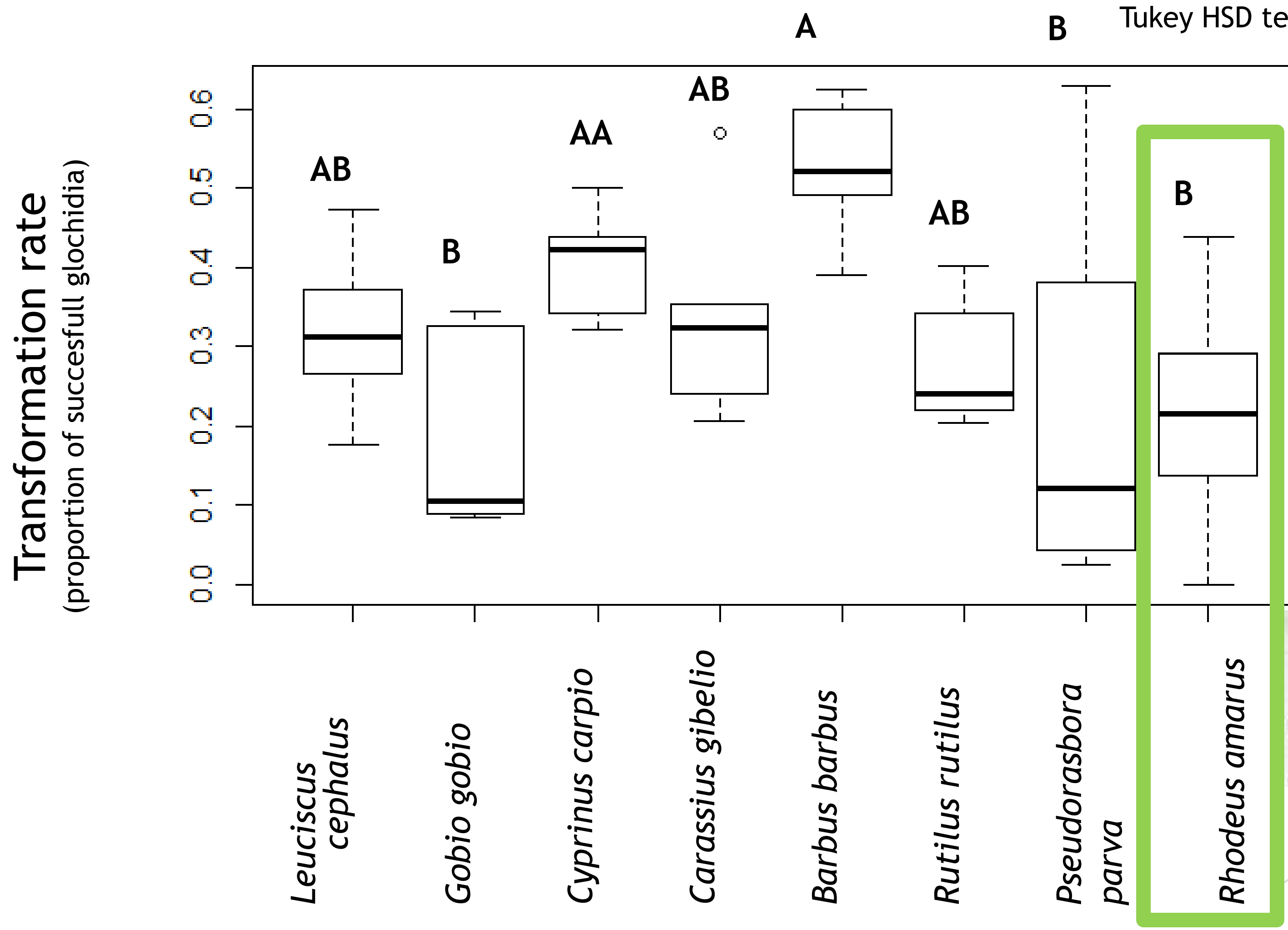


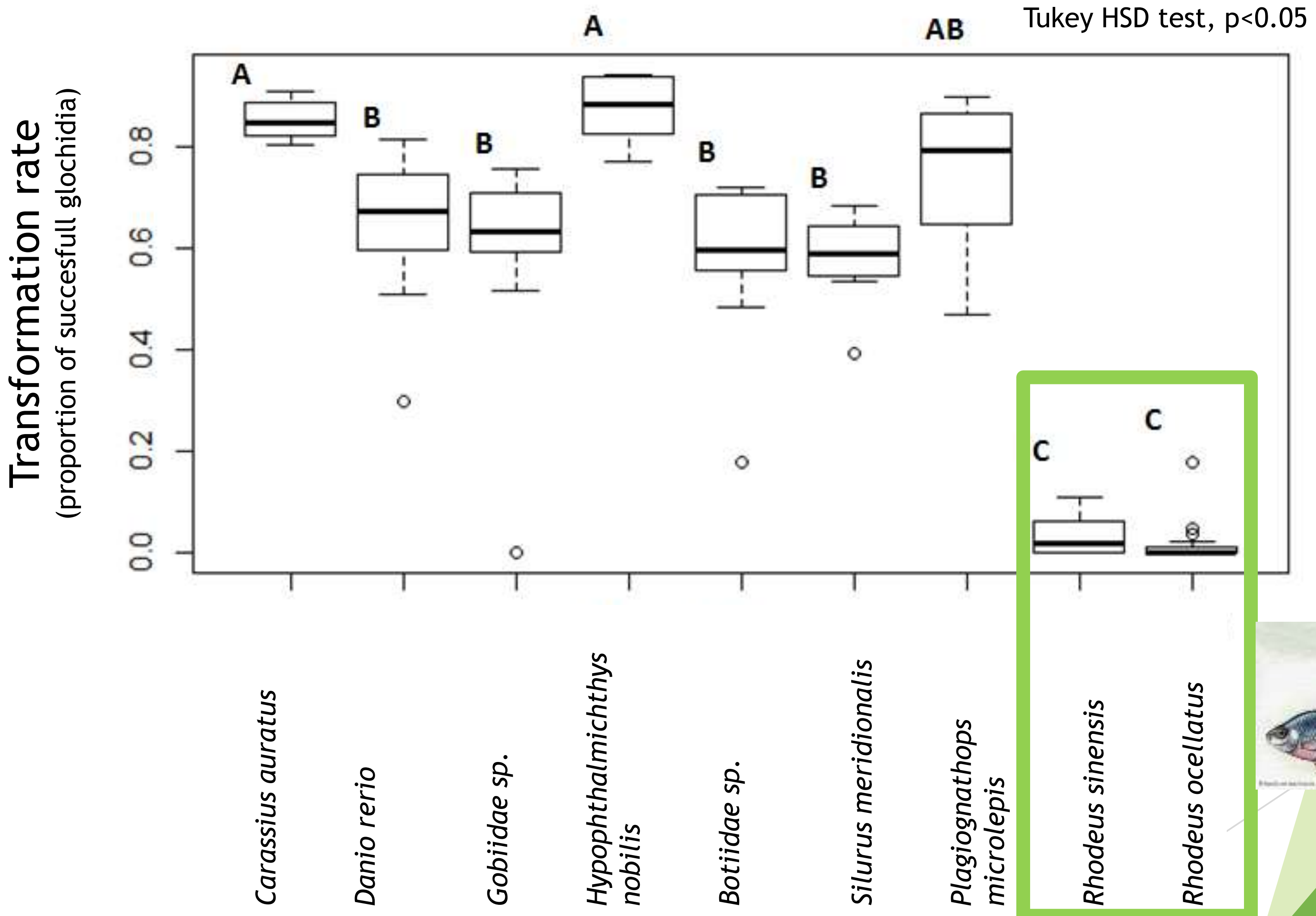
Central China (Hubei province)




methods

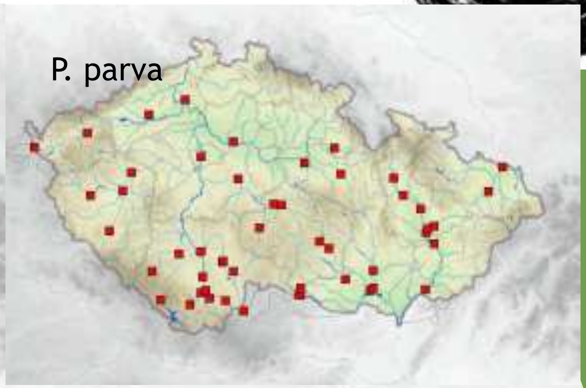


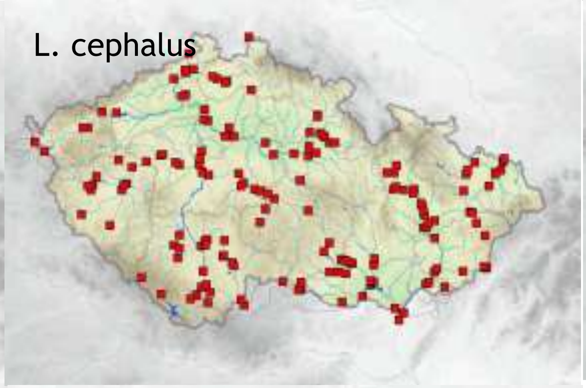

Tukey HSD test, p<0.05
Transformation rate
(proportion of succesfull glochidia)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
AB
B
AA
AB
A
AB
B
B
Leuciscus cephalus
Gobio gobio
Cyprinus carpio
Carassius gibelio
Barbus barbus
Rutilus rutilus
Pseudorasbora parva
Rhodeus amarus

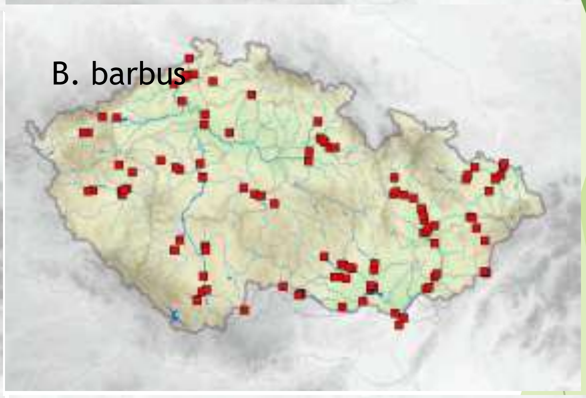

Tukey HSD test, p<0.05
Transformation rate
(proportion of succesfull glochidia)
0.0
0.2
0.4
0.6
0.8
A
B
B
A
B
B
AB
C
C
Carassius auratus
Danio rerio
Gobiidae sp.
Hypophthalmichthys nobilis
Botiidae sp.
Silurus meridionalis
Plagiognathops microlepis
Rhodeus sinensis
Rhodeus ocellatus

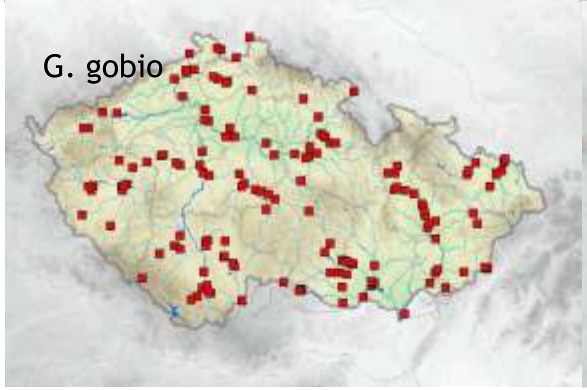
Results

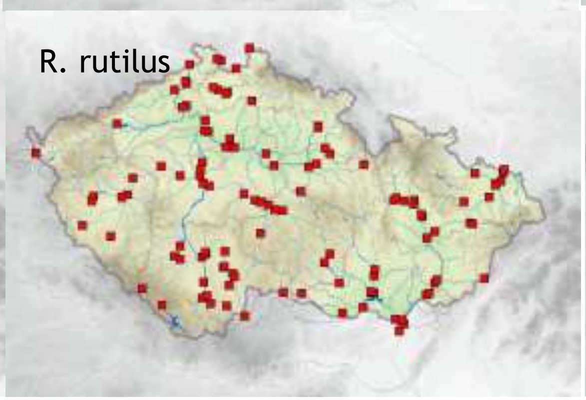
- Host availability

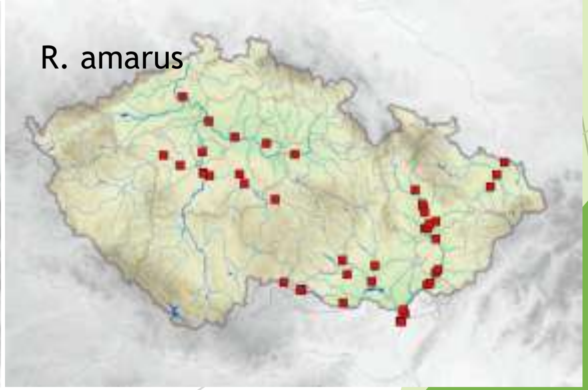






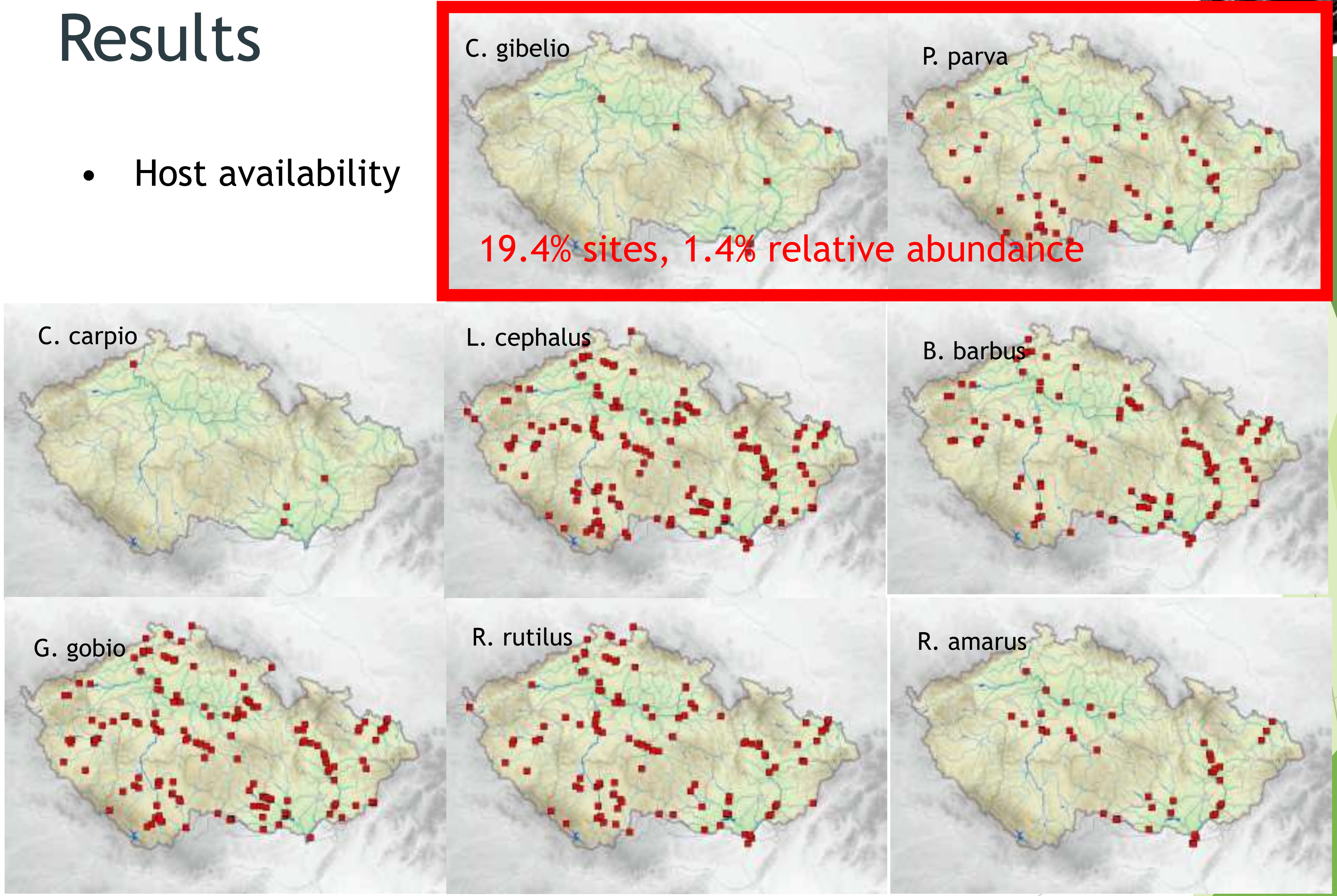






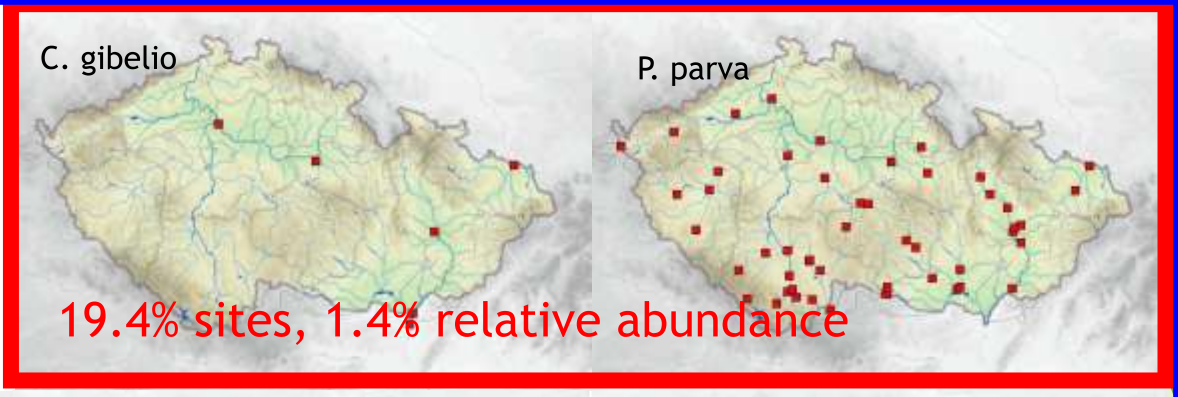
Results

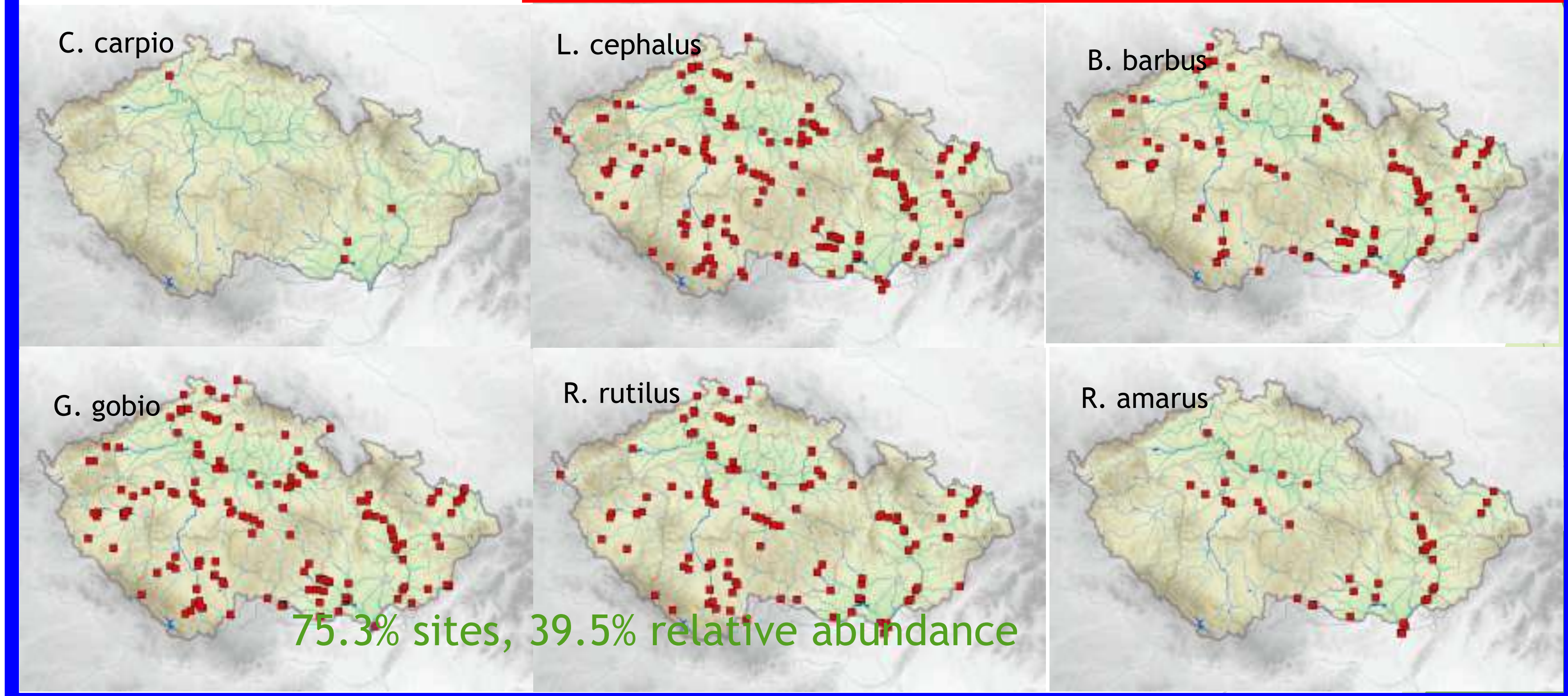
- Host availability



Results

- Host availability





- Rezistence hostitelů vůči globálně generalistickému druhu je nízká napříč oblastmi i populacemi
- Malá šance na omezení šíření druhu vlivem koevoluce

Biol Invasions (2012) 14:127–137
DOI 10.1007/s10530-011-9989-7

ORIGINAL PAPER

The role of host specificity in explaining the invasion success of the freshwater mussel *Anodonta woodiana* in Europe

K. Douda · M. Vrtílek · O. Slavík · M. Reichard

Douda, K., Liu, H. Z., Yu, D., Rouchet, R., Liu, F., Tang, Q. Y., ... & Reichard, M. The role of local adaptation in shaping fish-mussel coevolution. Freshwater Biology.

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WILEY Freshwater Biology

ORIGINAL ARTICLE

The role of local adaptation in shaping fish-mussel coevolution

Karel Douda[1] | Huan-Zhang Liu[2] | Dan Yu[2] | Romain Rouchet[3] | Fei Liu[2] | Qiong-Ying Tang[2] | Caroline Methling[3,4] | Carl Smith[3,5,6] | Martin Reichard[3]

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Abstract

1. The survival of affiliate (dependent) species in a changing environment is determined by the interactions between the affiliate species and their available hosts. However, the patterns of spatial and temporal changes in host compatibility are often unknown despite host shifts having direct impact on the persistence of local populations. Bivalves of the order Unionida (freshwater mussels) are a functionally important but declining group of affiliate species, which are dependent on freshwater fish to host their parasitic larvae. The role of local adaptations and host fish resistance in shaping freshwater mussel host relationships remains poorly understood.
2. We used an invasive East Asian unionid bivalve, *Sinanodonta woodiana*, and its

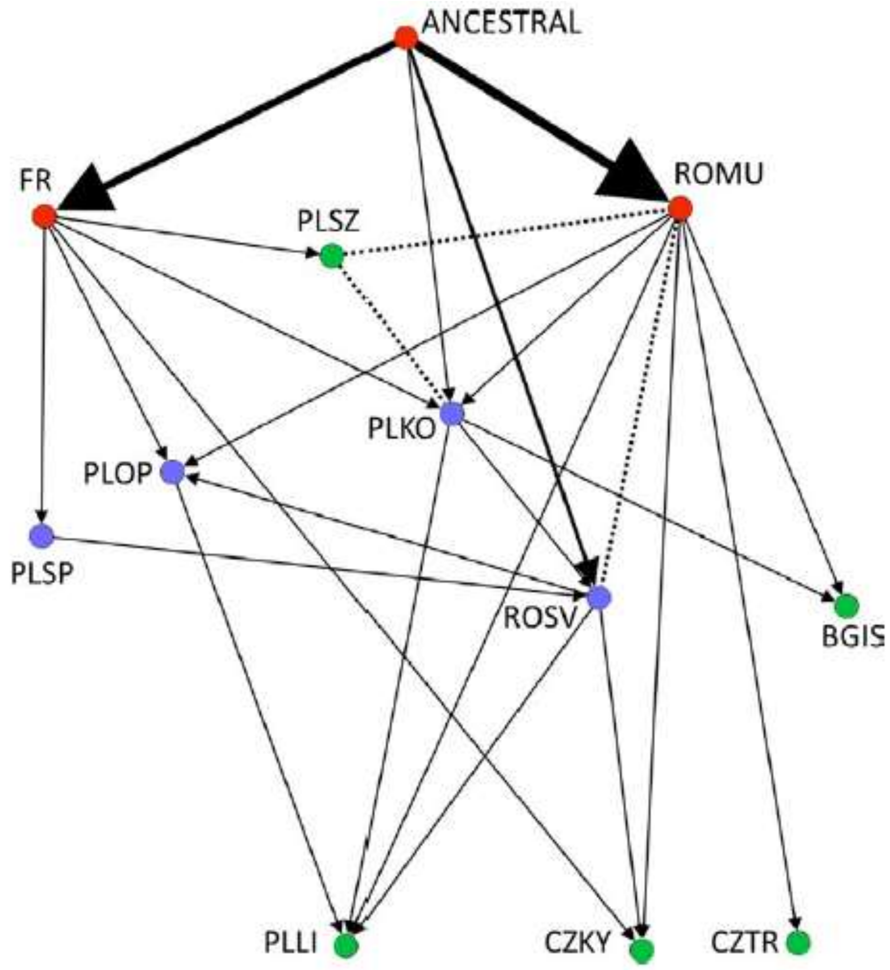

FIGURE 4 The most likely colonization pathways (indicated by arrows) of *S. woodiana* in Europe inferred by ABC pairwise comparisons between 11 populations and a putative ancestral source. The relationships are derived from the single-winner

Evolutionary Applications
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Evolutionary approaches to environmental, biomedical and socio-economic issues

ORIGINAL ARTICLE

WILEY Evolutionary Applications

Modelling the invasion history of *Sinanodonta woodiana* in Europe: Tracking the routes of a sedentary aquatic invader with mobile parasitic larvae

Adam Konečný[1,2] | Oana P. Popa[3] | Veronika Bartáková[1,2] | Karel Douda[4] | Josef Bryja[1,2] | Carl Smith[1,5,6] | Luis O. Popa[3] | Martin Reichard[1]

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[5]Department of Ecology & Vertebrate Zoology, University of Łódź, Łódź, Poland
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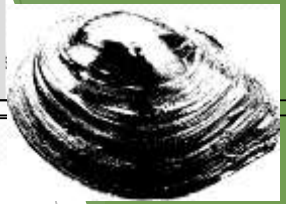
Correspondence
Martin Reichard, The Czech Academy of Sciences, Institute of Vertebrate Biology

Abstract

Understanding the invasive potential of species outside their native range is one of the most pressing questions in applied evolutionary and ecological research. Admixture of genotypes of invasive species from multiple sources has been implicated in successful invasions, by generating novel genetic combinations that facilitate rapid adaptation to new environments. Alternatively, adaptive evolution on standing genetic variation, exposed by phenotypic plasticity and selected by genetic accommodation, can facilitate invasion success. We investigated the population genetic structure of an Asian freshwater mussel with a parasitic dispersal stage, *Sinanodonta woodiana*, which has been present in Europe since 1979 but which has expanded rapidly in the last decade. Data from a mitochondrial marker and nuclear microsatellites have suggested that all European populations of *S. woodiana* originate from the River Yangtze basin in China. Only a single haplotype was detected in Europe, in



Results

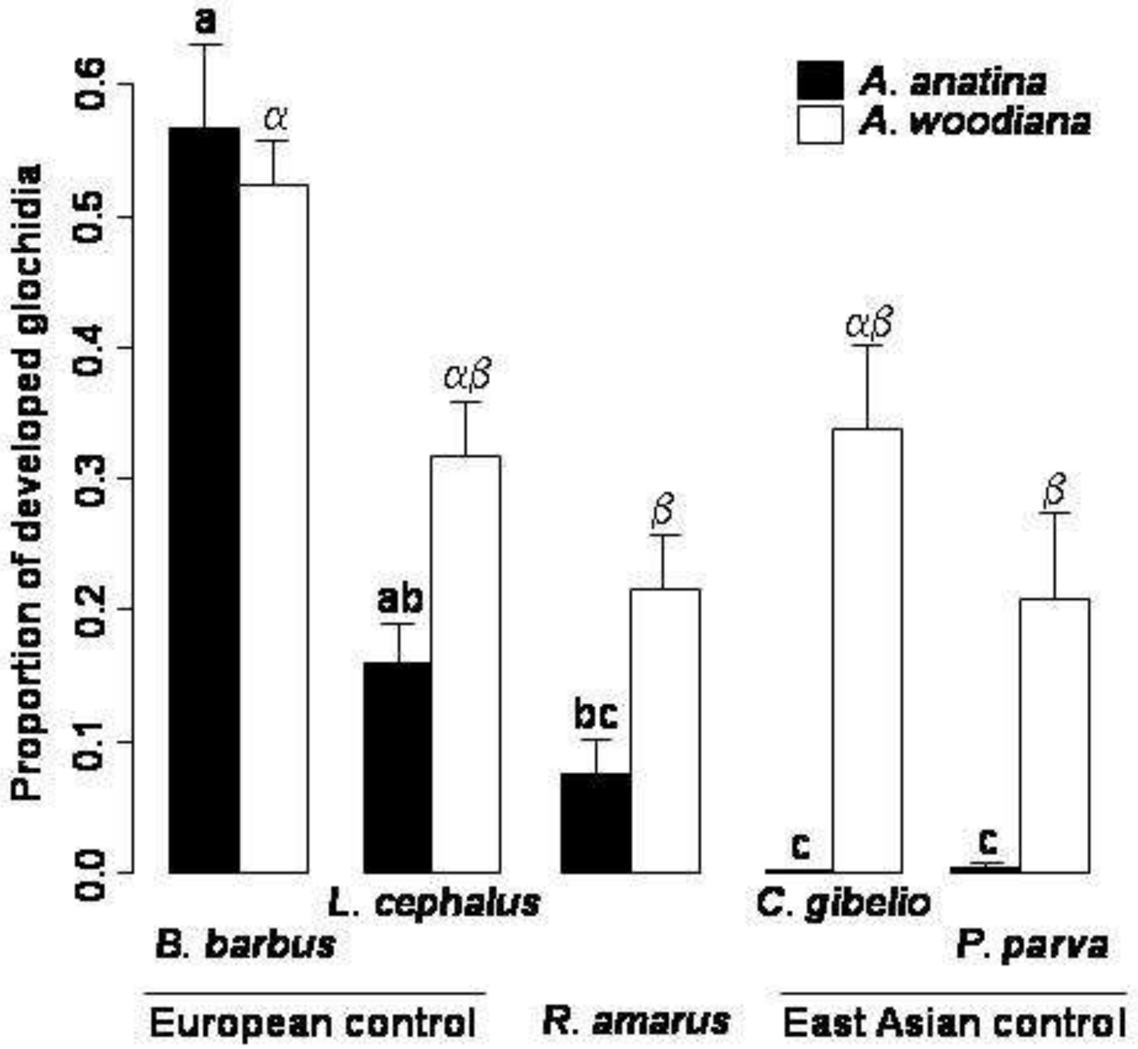


Figure 2. Relative development success (proportion that metamorphosed into juveniles) of glochidia of native *A. anatina* and invasive *A. woodiana* mussels on fish hosts. Error bars represent one SE. Different letters denote pairwise differences between treatment groups.

nature International weekly journal of science

NATURE | NEWS

Invasive species turns parasites into hosts

Asian mussels take the advantage from European bitterling fish.

Jessica Marshall

15 February 2012

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The arrival of an alien species can turn an ecosystem on its head. Researchers have found an invasive mussel that has caused a complete ecological role reversal, turning a host into a parasite and vice versa.

In a study published today in *Biology Letters*[1], the team focused on ecosystems involving European bitterling (*Rhodeus amarus*) — small, pale-silver freshwater fish that lay their eggs in the gills of mussels. The mussels, for their part, release their larvae into the water, where they colonize and develop on fish, including bitterling. Both bitterling — most of which are found in East Asia, except the single species in Europe — and the family of mussels they colonize have evolved mechanisms to resist the other; in some sites throughout the world, one or other may prevail, whereas in others,

Top story

Scientists sound alarm over DNA editing of human embryos

Experts call for halt in research to work out safety and ethics issues.

1. PŘÍMÉ DOPADY INVAZNÍCH DRUHŮ

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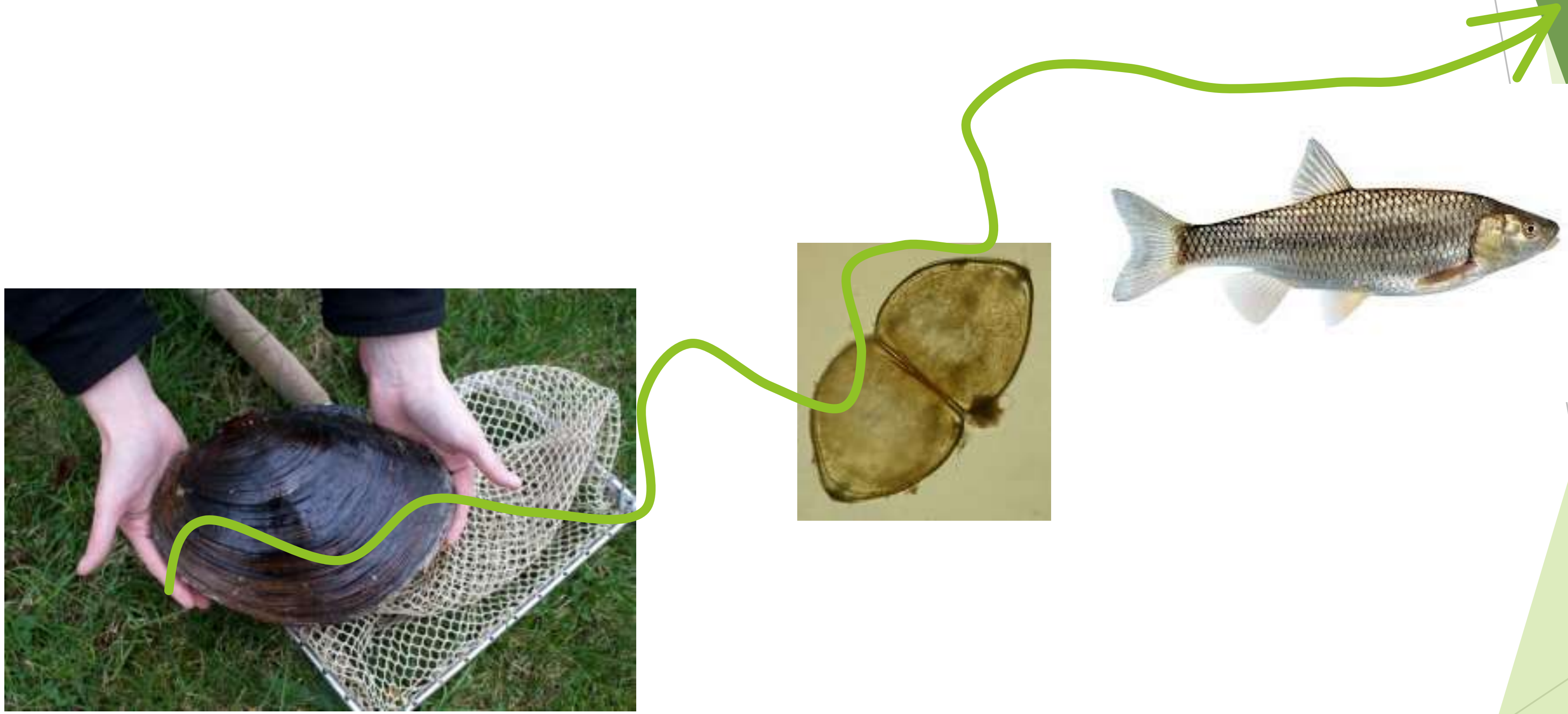

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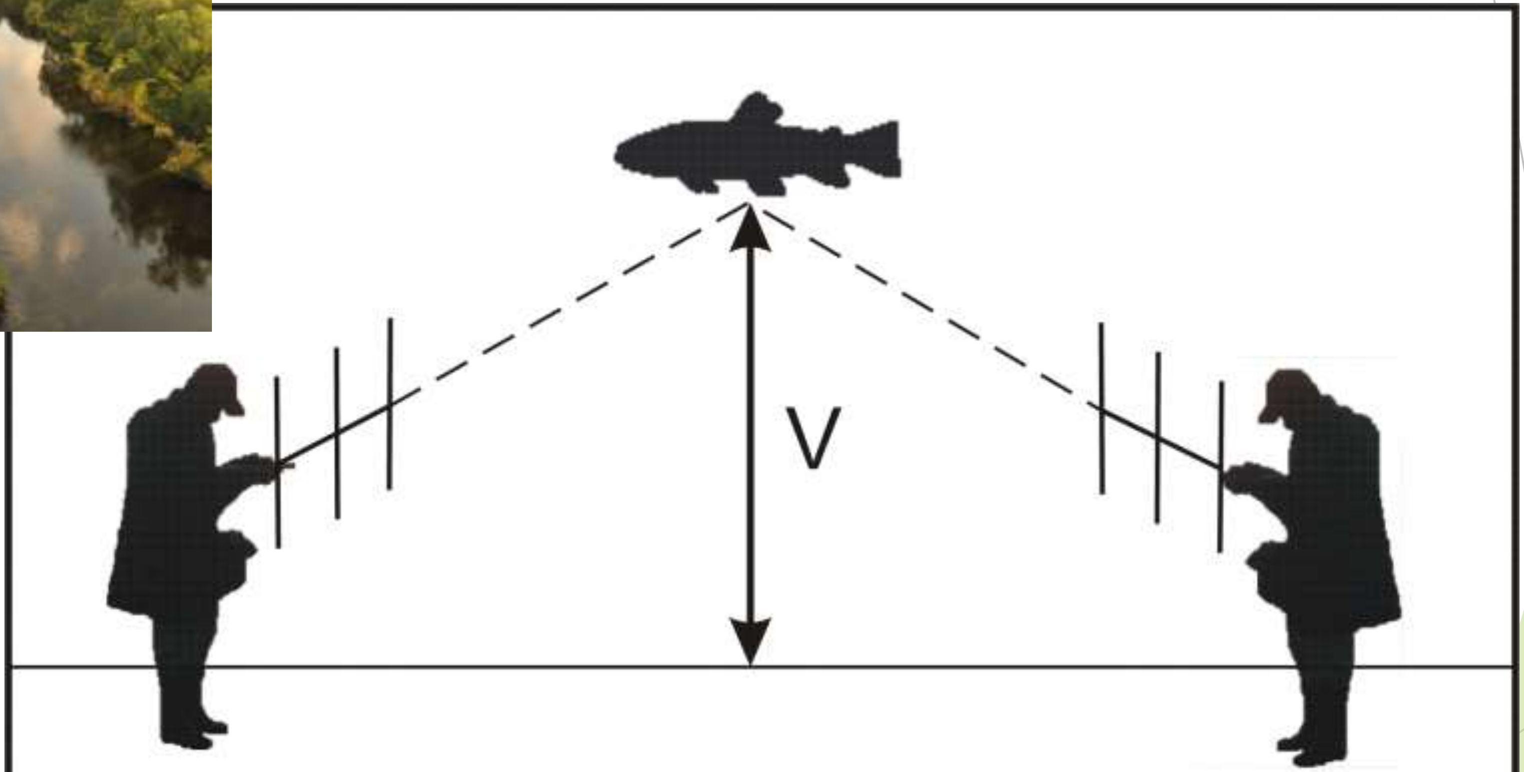

20/20 infested/noninfested host individuals

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telemetry

nanotag

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UNIVERSITY OF ALBERTA

Freshwater Biology
Freshwater Biology (2014) doi:10.1111/fwb.12357

Parasite-induced alterations of host behaviour in a riverine fish: the effects of glochidia on host dispersal

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‡Department of Biological and Environmental Sciences, Animal Ecology, University of Gothenburg, Gothenburg, Sweden

SUMMARY

1. Parasitic species can affect host behaviour in various ways. Freshwater mussels of the superfamily Unionoidea have a glochidia larva that is parasitic on fish. Our aim was to evaluate whether fish exposed to glochidia have distinct behaviour that could affect the upstream dispersal of the parasite
2. Many freshwater mussels are highly endangered, and understanding the relationships with their hosts is important for their conservation. However, research on the behavioural effects of parasitism on fish host activity and/or the upstream dispersal of mussel larvae in nature has received little attention.
3. Specifically, we examined a fish (the chub, *Squalius cephalus*) that hosts the larval stage of a freshwater bivalve (*Anodonta anatina*) and investigated alterations in host behaviour induced by the para- ... ing passive integrated transponde

Journal of Experimental Biology

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ACCEPTED MANUSCRIPT
RESEARCH ARTICLE

Altered thermoregulation as a driver of host behaviour in glochidia-parasitised fish

Pavel Horky, Ondřej Slavík, Karel Douda
Journal of Experimental Biology 2018 : jeb.184903 doi: 10.1242/jeb.184903 Published 23 October 2018

Article Info & metrics PDF

Abstract

Parasites alter their host behaviour and vice versa as a result of mutual adaptations in the evolutionary arms race. One of these adaptations involves changes in host thermoregulation, which has the potential to harm the parasite and thereby act as a defence mechanism. We used a model of the brown trout *Salmo trutta* experimentally parasitised with ectoparasitic larvae called glochidia from the endangered freshwater pearl mussel *Margaritifera margaritifera* to reveal whether parasitation alters

Physiology & Behavior 171 (2017) 127–134
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journal homepage: www.elsevier.com/locate/phb
ELSEVIER

Parasite-induced increases in the energy costs of movement of host freshwater fish

CrossMark

Ondřej Slavík [a],*, Pavel Horký [a], Karel Douda [a], Josef Velíšek [b], Jitka Kolářová [b], Pavel Lepič [b]
[a] Department of Zoology and Fisheries, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, Prague 6, Suchdol 165 21, Czech Republic
[b] Research Institute of Fish Culture and Hydrobiology, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Faculty of Fisheries and Protection of Waters, University of South Bohemia in České Budějovice, Zátiší 728/II, 389 25 Vodňany, Czech Republic

HIGHLIGHTS

- Fish infected by ectoparasitic bivalve larvae paid higher energy costs for movement.
- The energy costs of movement varied over time according to parasitic phase and diurnal cycle.
- Higher values of ASP, ATP, K^+ and Cl^- occurred in the blood plasma of the hosts.
- The physiological status of the fish hosts deteriorated during parasitization.

ARTICLE INFO

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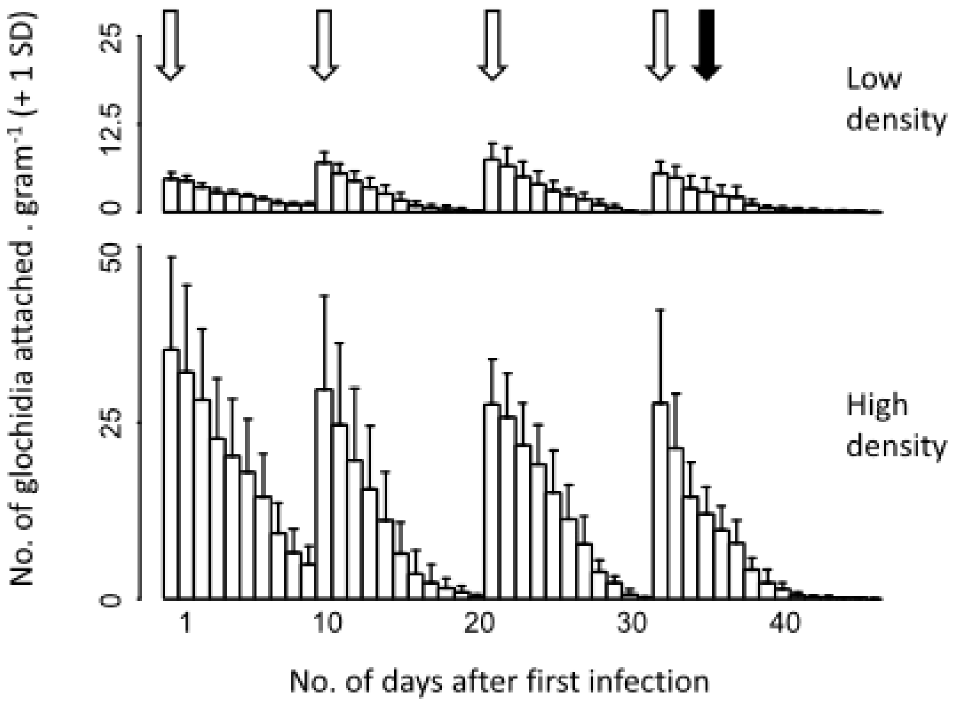
Available online 10 January 2017

ABSTRACT

Parasitization by the larvae (glochidia) of freshwater mussels can cause harm to a fish's gills, resulting in less effective respiration and/or reduced activity by the host fish. The impact of glochidia infections on the host's physiology remains poorly understood, and no information is available concerning energy consumption in parasitized fish. Hence, we obtained glochidia of the invasive unionid mussel *Sinanodonta* (*Anodonta*) *woodiana* and experimentally infected common carp, *Cyprinus carpio*, tagged with physiological sensors to measure energy consumption. We tested the hypothesis that parasitization affects energy consumption in the host fish, reflected as higher energy costs for movement and reduced movement activity over eight days post-infection within a twenty-four-

Vliv na fyziologii hostitelů



Time course for S. woodiana glochidia parasitization in control fish (S. cephalus, n= 7+7) in the low- and high-density treatments. Bars represent mean (+SD) glochidia attached to fish on the respective day gained by calculation from shed glochidia and juvenile mussels. White arrows indicate inoculations (day 0, 10, 21, and 32). A black arrow indicates sampling for fish physiological parameters.

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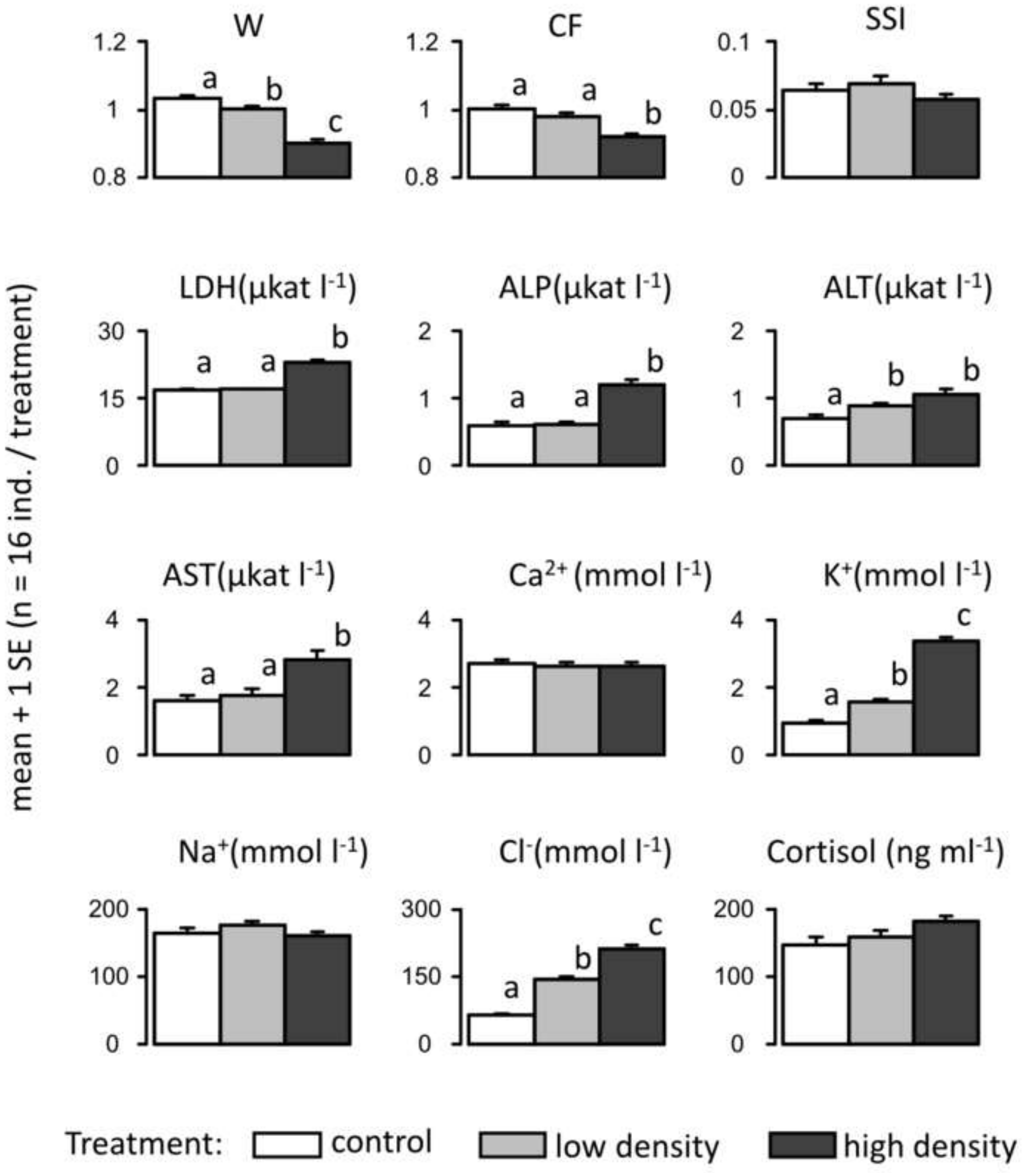

Changes in body weight (W), condition factor (CF), splenosomatic index (SSI), and biochemical parameters in blood plasma (see text for description) of the host (S. cephalus), infested with parasitic larvae of the invasive bivalve S. woodiana. Experimental fish (n= 16 + 16 + 16) were exposed during four consecutive infestations in glochidia baths containing zero, 1170±130 and 8578±687 glochidia liter-1 (mean±SE) in the control and low- and high-density treatments, respectively. Different letters (a, b, c) indicate significant differences among groups (Wilcoxon–Mann–Whitney test, $p<0.05$).

Czech University of Life Sciences Prague

Zdroje pro argumentaci důvodů k omezení šíření u zainteresovaných skupin

Biol Invasions (2017) 19:989–999
DOI 10.1007/s10530-016-1319-7

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ORIGINAL PAPER

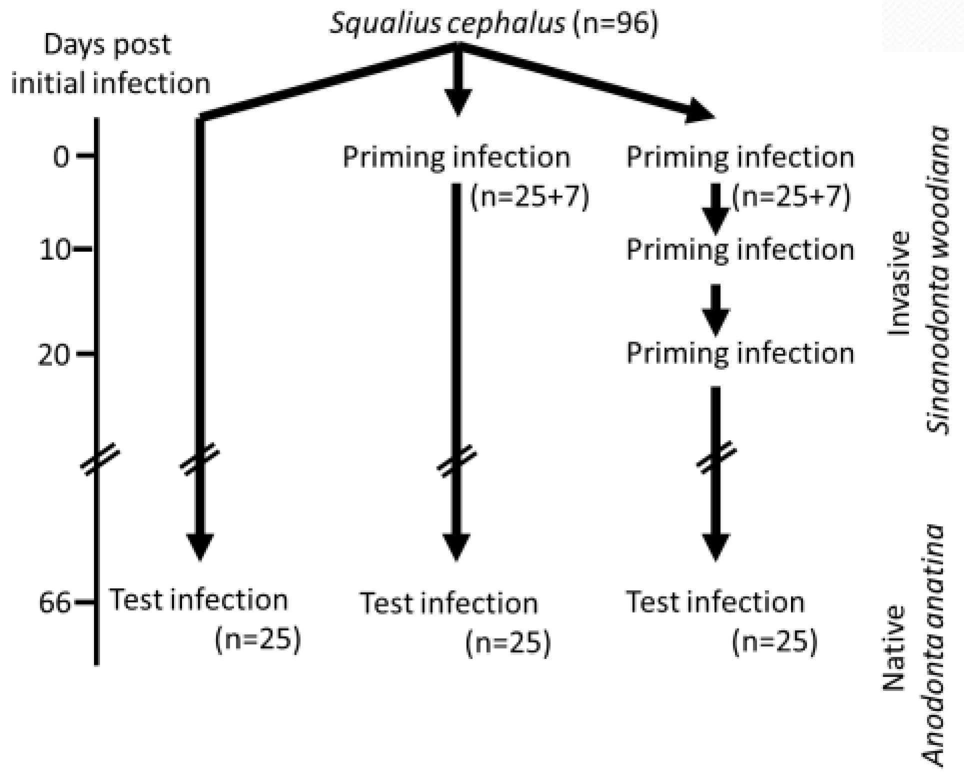
Direct impact of invasive bivalve (*Sinanodonta woodiana*) parasitism on freshwater fish physiology: evidence and implications

Karel Douda · Josef Velíšek · Jitka Kolářová · Kateřina Rylková · Ondřej Slavík · Pavel Horký · Iva Langrová

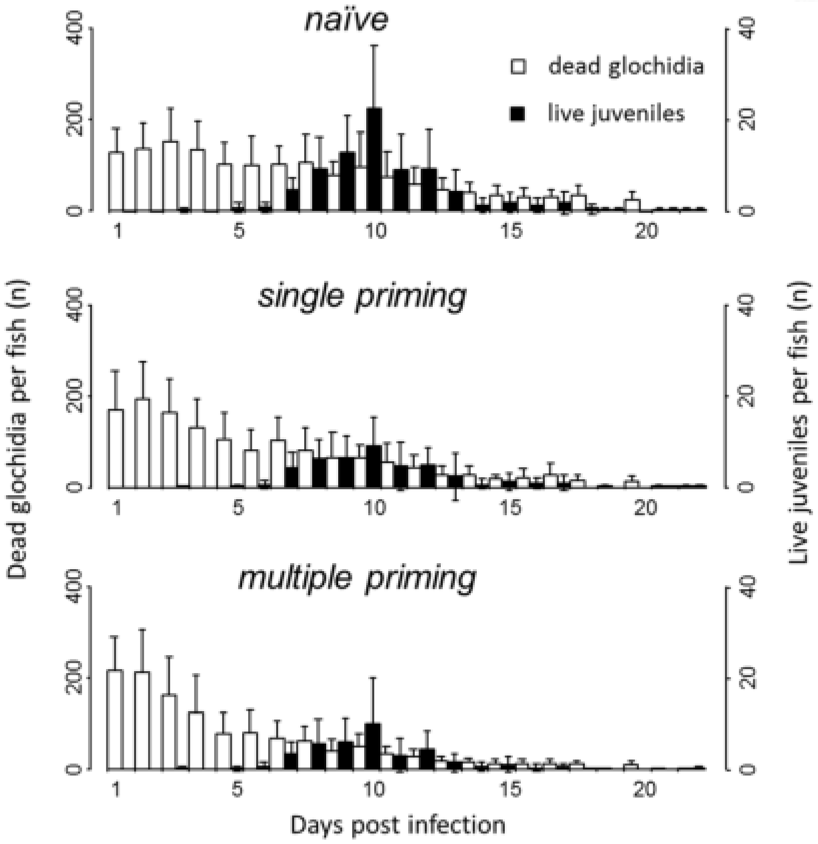
Received: 17 May 2016 / Accepted: 31 October 2016 / Published online: 5 November 2016

Abstract Direct and potentially damaging effects of invasive alien species can remain unnoticed or insufficiently quantified, resulting in a lack of stakeholder awareness. We report for the first time that parasitic larvae (glochidia) of the invasive freshwater mussel *Sinanodonta* (*Anodonta*) *woodiana* (Unionidae, Bivalvia) cause an unexpected reduction in the condition factor of parasitized native fish species. The reduction in the body mass and condition factor of experimentally infested European chub (*Squalius cephalus*) was associated with changes in several physiological parameters measured in host fish plasma. Ion concentrations (potassium, chloride) and enzymes activities (aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase, alkaline phosphatase) were significantly affected; hence, the results reveal the complex effects of non-native glochidia on the homeostasis of the individually tested fish. Changes in host physiology and condition status were recorded also in environmentally relevant infestation intensities (mean

Konkurence o hostitelské zdroje

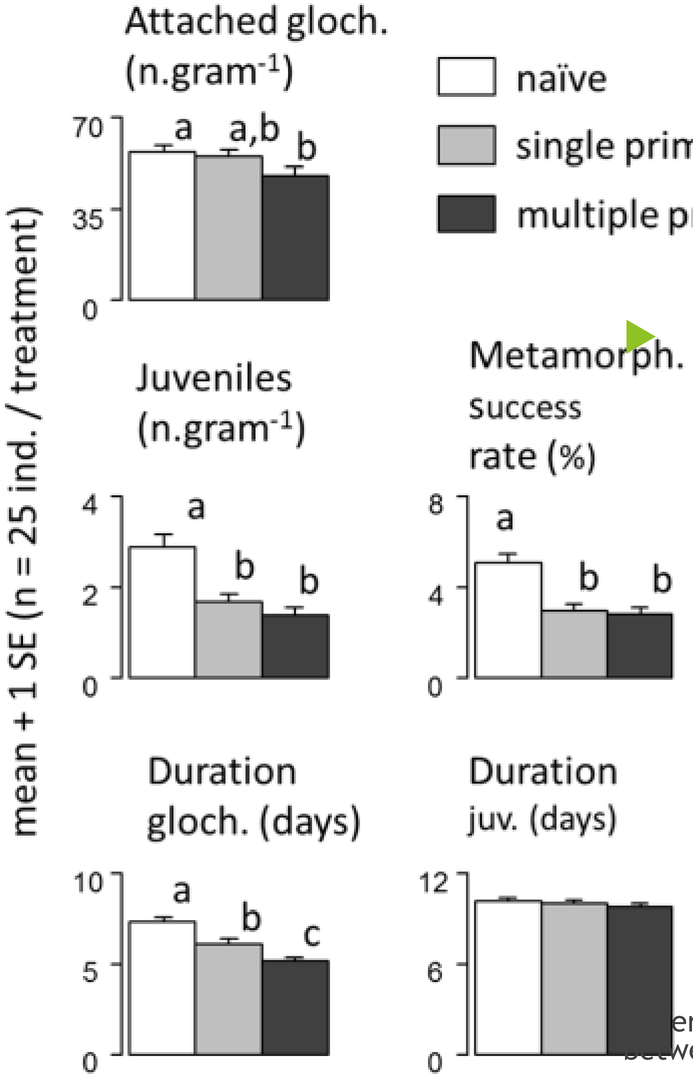


The timing of priming (S. woodiana) and experimental (A. anatina) inoculations. Numbers of host fish individuals used are stated in parentheses.



Developmental dynamics of freshwater mussel A. anatina glochidia on naïve (a), "single priming" (b) and "multiple priming" (c) S. cephalus with glochidia of S. woodiana. Bars represent mean (+SD) glochidia or juveniles detached from fish in the respective day after infestation.

Czech University of Life Sciences Prague



- Differences in the total number of glochidia attached, number of developed juveniles, metamorphosis success rate and duration of parasitism (dead glochidia, live juveniles) between treatment groups.

erent letters (a,b,c) indicate significant differences between groups (Wilcoxon-Mann-Whitney test, p<0.05).

Marrone Bio Innovations

AQUATIC CONSERVATION
Marine and Freshwater Ecosystems

Received: 13 June 2016 | Revised: 15 November 2016 | Accepted: 8 January 2017
DOI 10.1002/aqc.2759

WILEY

RESEARCH ARTICLE

Invasive Chinese pond mussel *Sinanodonta woodiana* threatens native mussel reproduction by inducing cross-resistance of host fish

Seth W. Donrovich[1] | Karel Douda[1] | Věra Plechingerová[1] | Kateřina Rylková[1] | Pavel Horký[1] | Ondřej Slavík[1] | Huan-Zhang Liu[2] | Martin Reichard[3] | Manuel Lopes-Lima[4,5] | Ronaldo Sousa[6]

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Abstract

1. The effects of invasive alien species (IAS) on host–affiliate relationships are often subtle and remain unnoticed or insufficiently quantified. The global decline of freshwater unionid mussel species has been attributed to many causes, but little is known about the interactions of IAS, with their complex life cycle, which includes an obligatory parasitic stage (the glochidium) that develops on fishes.
2. The capacity of a European freshwater mussel, *Anodonta anatina*, to develop on its widespread

Velcí mlži a dopady biologických invazí

- Hostitelské vazby jako klíčový faktor ovlivňující dopady invazí na domácí druhy i šíření invazních druhů
- Několik dosud nepopsaných mechanizmů dopadu invazních druhů
- Nově se objevující rizika


Chris Barnhart


Jiří Hronek