

# Experimental assessment of emerging invasion threat: A host-parasite coevolutionary association modulating invasional meltdown

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**Invasive species may alter entire ecosystems ...**



**... but their impact is typically much subtler**



# Coevolutionary relationships: arms races



Downy-bellied Tyrant *Tyrannus tyrannus*

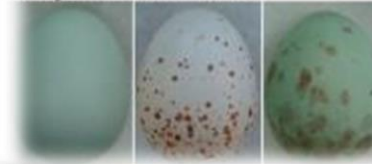


respective Cuckoo Finch eggs

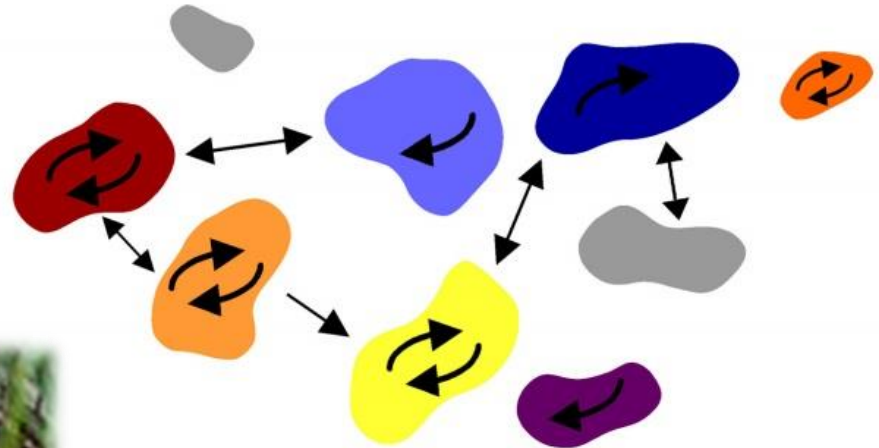
Red-faced Cisticola *Cisticola erythrops*



Rattling Cisticola *Cisticola chiniana*



- **Different equilibria** – different species/populations at different coevolutionary states
- **Species translocations**  
affects such equilibria, with contrasting impacts (positive or negative)



**The role of coevolution in success  
of biological invasions**

**... and their impact on native species**

# Outline

1. **Model system** (bitterling fish and host mussels in Europe)
2. Invasion of **Asian mussel** perturbed the roles in the association
3. Expected arrival of **Asian bitterling** species
4. Experiments **to predict** its effect
  1. Competition for resources (mussels)
  2. Role of co-invasion (invasional meltdown)
  3. Potential for hybridization
  4. Overwinter survival





# Bitterling biology

- uses all 4 sympatric unionids
- embryo development 1 month



# European bitterling, *Rhodeus amarus*

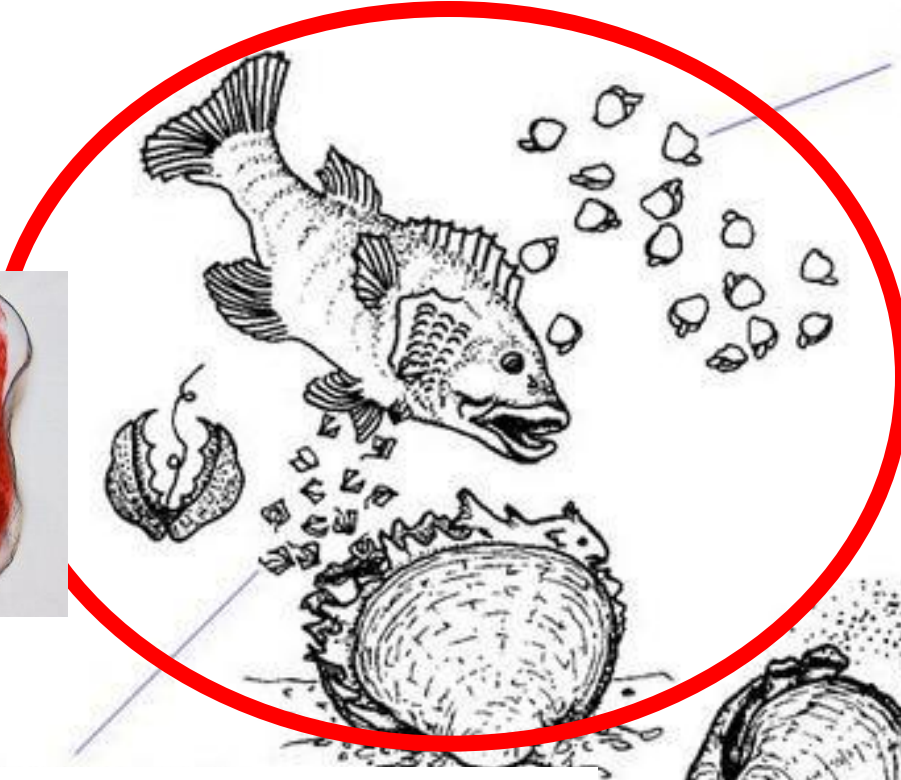


single bitterling in Europe, 60+ spp in Asia



# Unionid life cycle

glochidia feed on fish, metamorphose, and drop off the fish, but may be rejected



- eggs develop into glochidia
- glochidia released when ripe
- glochidia must attach fish fin or gill



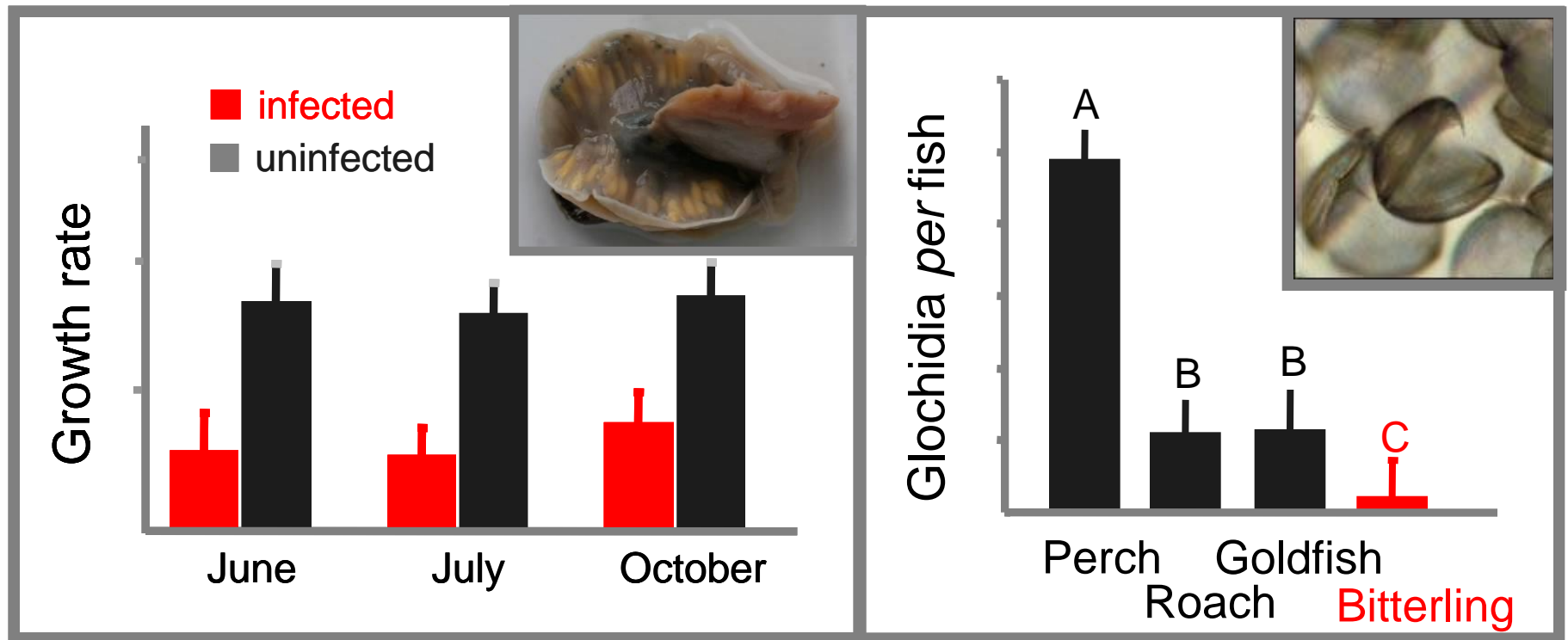
Mussel eggs fertilized internally  
inside female gills

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# *Rhodeus amarus* parasitize unionids in Europe

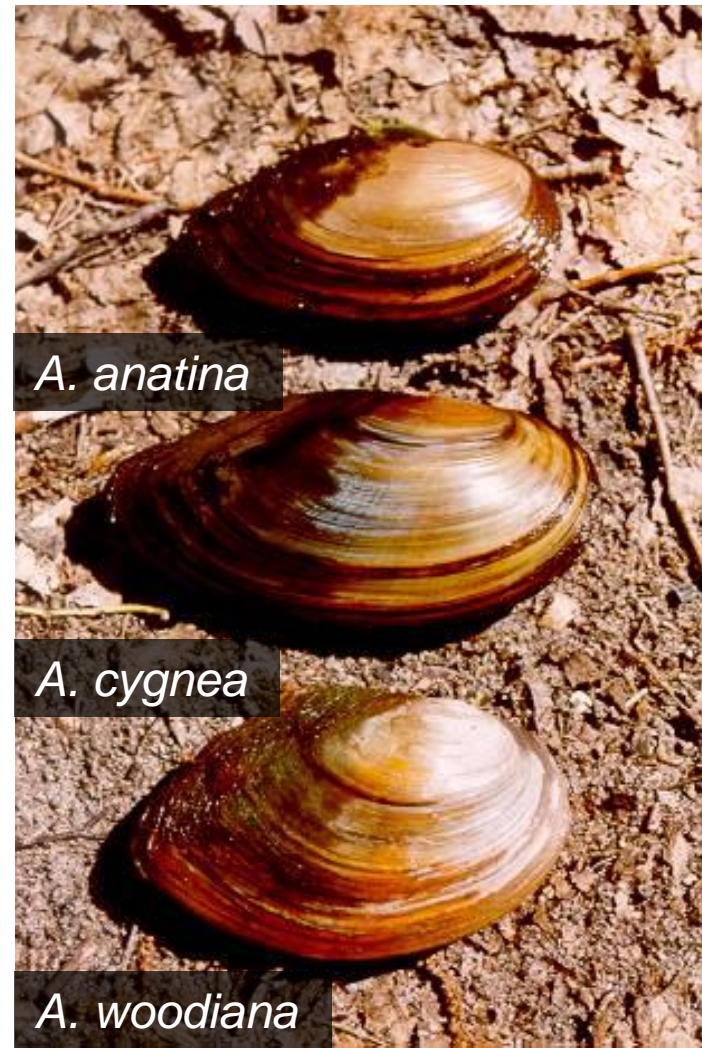
1. hosting *R. amarus* embryos is costly for mussels
2. avoid infection by glochidia of European unionids



compete for oxygen, disrupt water  
flow, damage epithelium

# *Anodonta woodiana*

- East Asian origin, sympatric with many bitterling species
- established in Europe since 1970s
- worldwide invasion in progress

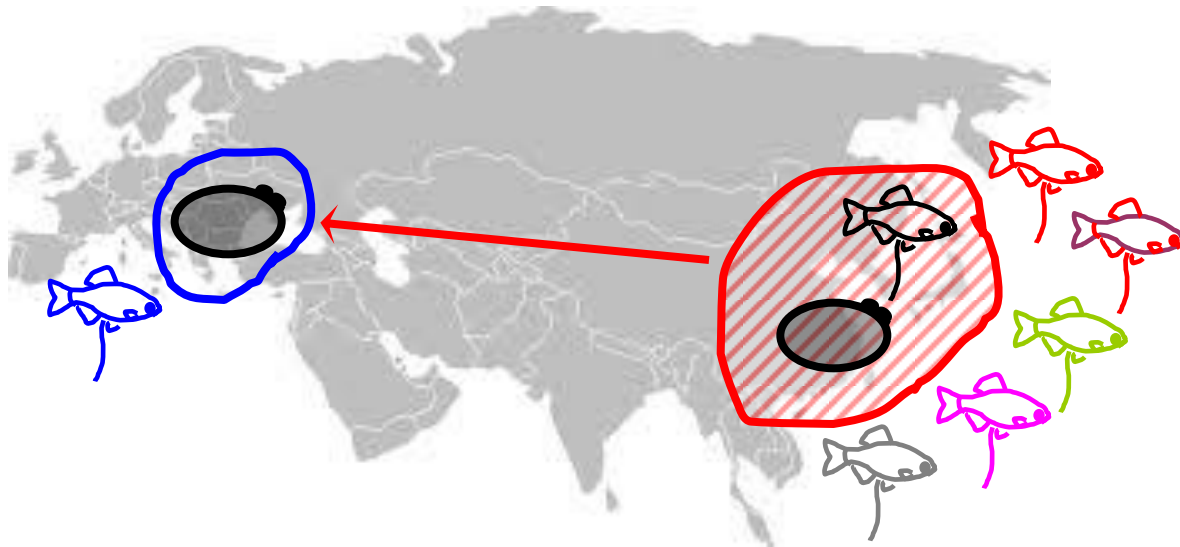




# Translocation across coevolutionary mosaic

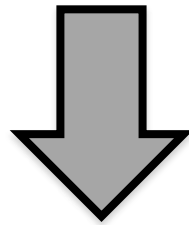
From high bitterling density and diversity

... and hence strong selection to avoid bitterling parasitism



# Consequences of *A. woodiana* invasion for *R. amarus*

- European *R. amarus* unable to exploit *A. woodiana*
- *R. amarus* is parasitized by *A. woodiana* glochidia



## Host-parasite role reversal

Reichard, M. et al. (2012). An invasive species reverses the roles in a host-parasite relationship between bitterling fish and unionid mussels. *Biology Letters*, 8, 601-604.

Reichard, M. et al. (2015). Population-specific responses to an invasive species. *Proceedings Royal Society B*, 282: 20151063.

# Asian *Rhodeus ocellatus*



Asian *R. ocellatus*



European *R. amarus*

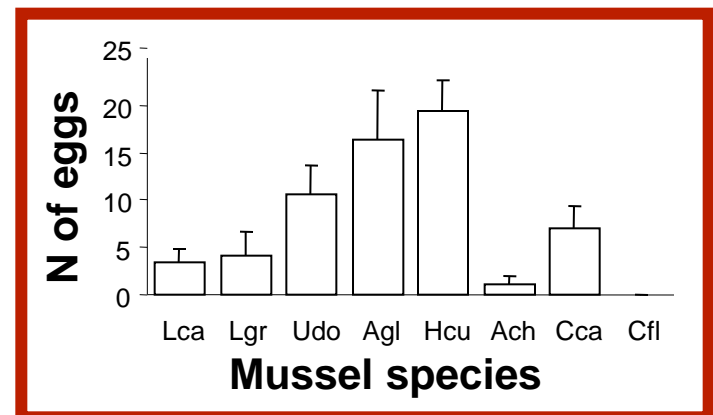


# Predicting invasion potential of *R. ocellatus*

- Now available in pet shops in Europe
- Invasive elsewhere (Japan, middle Asia, Oceania)
- Able to live in similar climatic conditions to *R. amarus* (?)
- Parasitizing a wide range of unionids – including *A. woodiana*

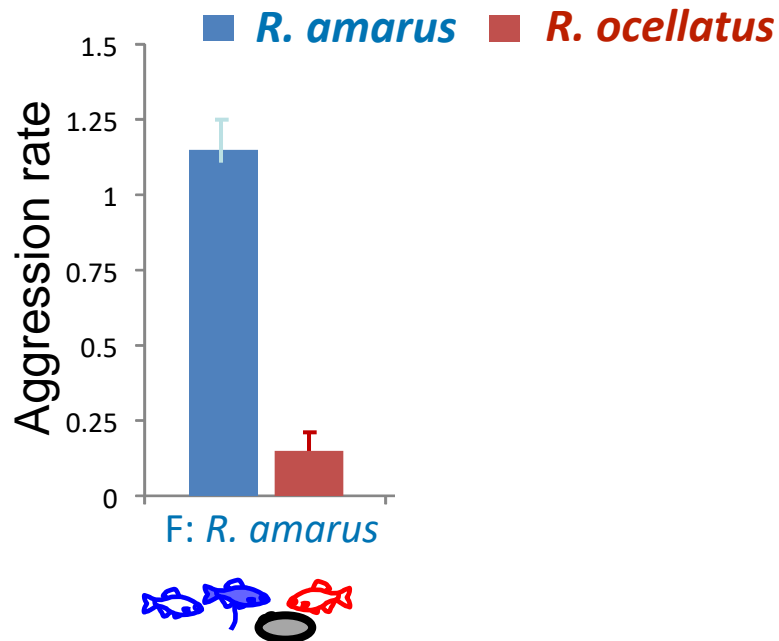


***R. ocellatus* host musel use:**



# 1. Competition for host mussels

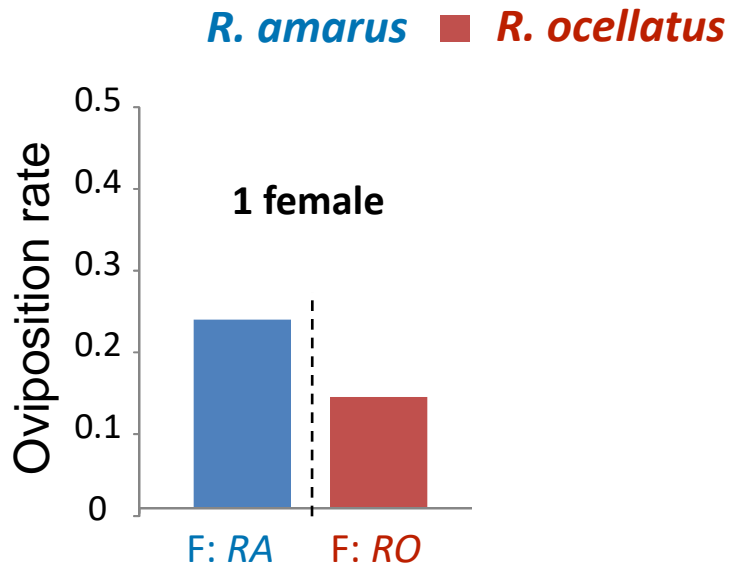
## Male aggression



**Male European *R. amarus* more aggressive:  
displace Asian *R. ocellatus* from monopolizing mussel hosts.**

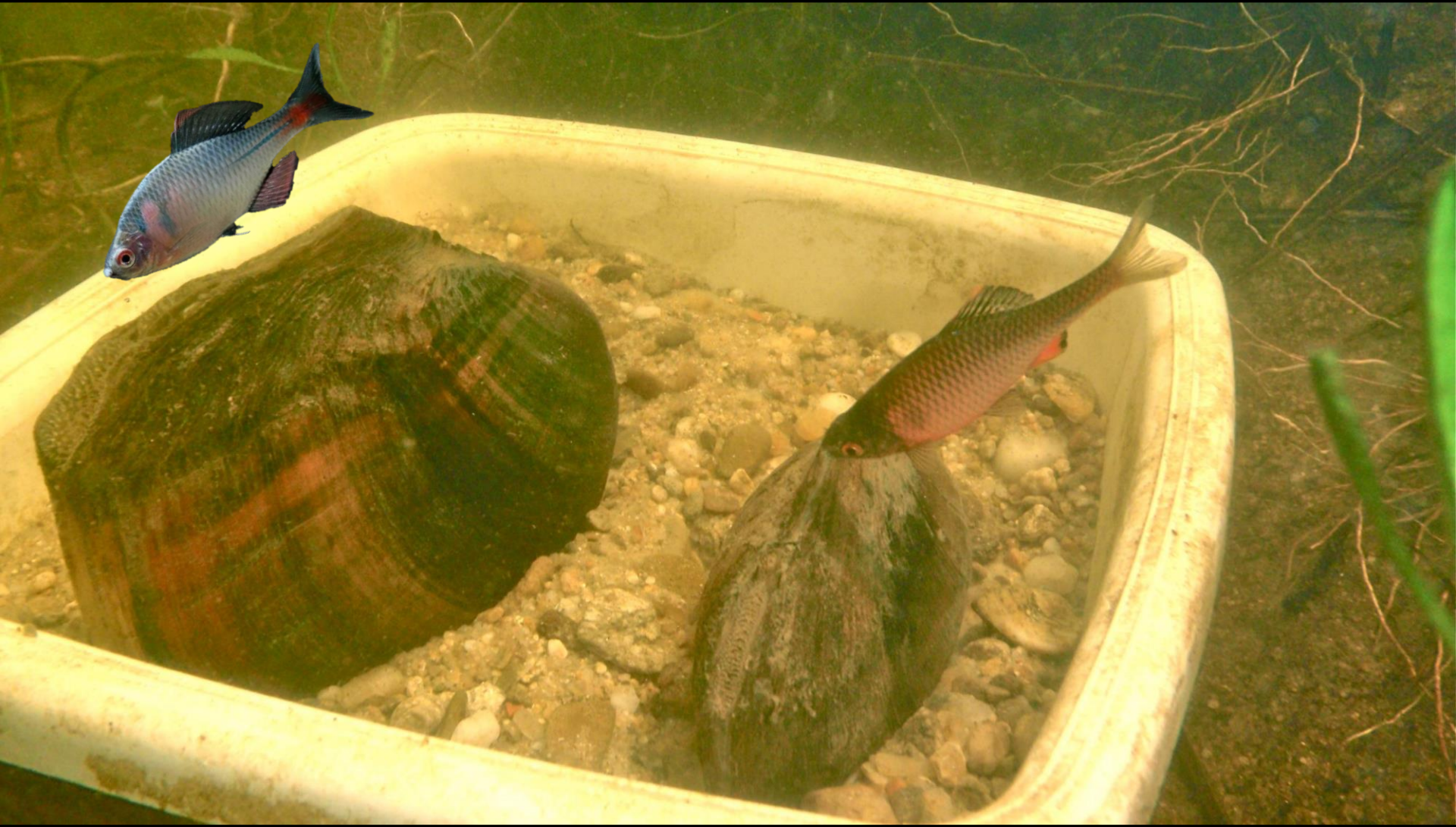
# Competition for host mussels

## Female oviposition



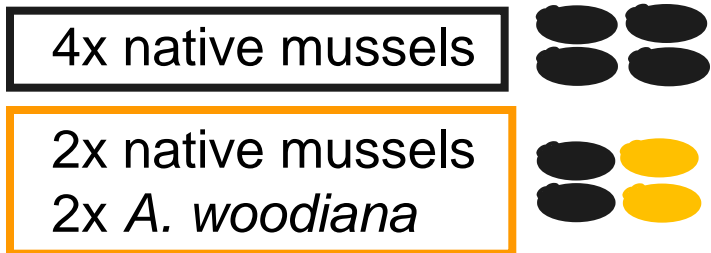


But Asian *R. ocellatus* can use Asian *A. woodiana*  
... while European *R. amarus* not



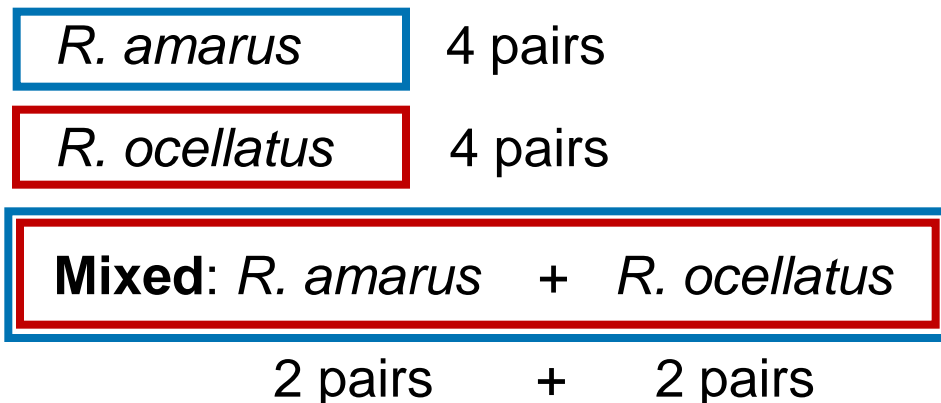
## 2. Demographic experiment

Two mussel treatments:



**X**

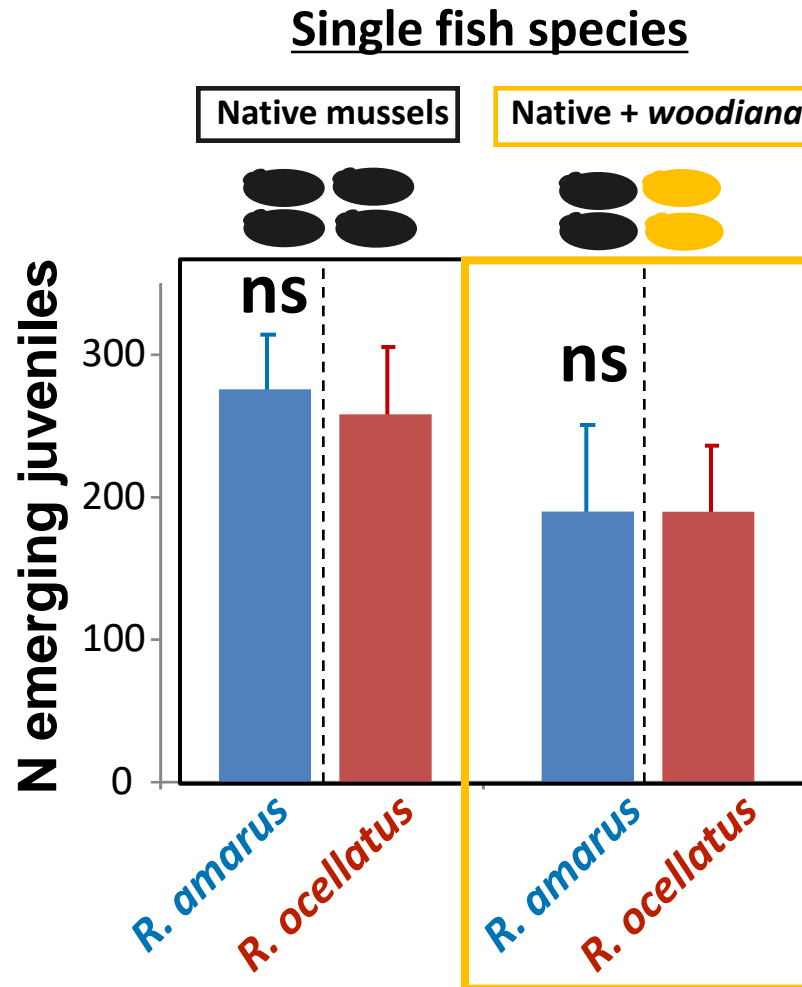
Three fish treatments:



Garden experiment:  
March – October (42 tubs)

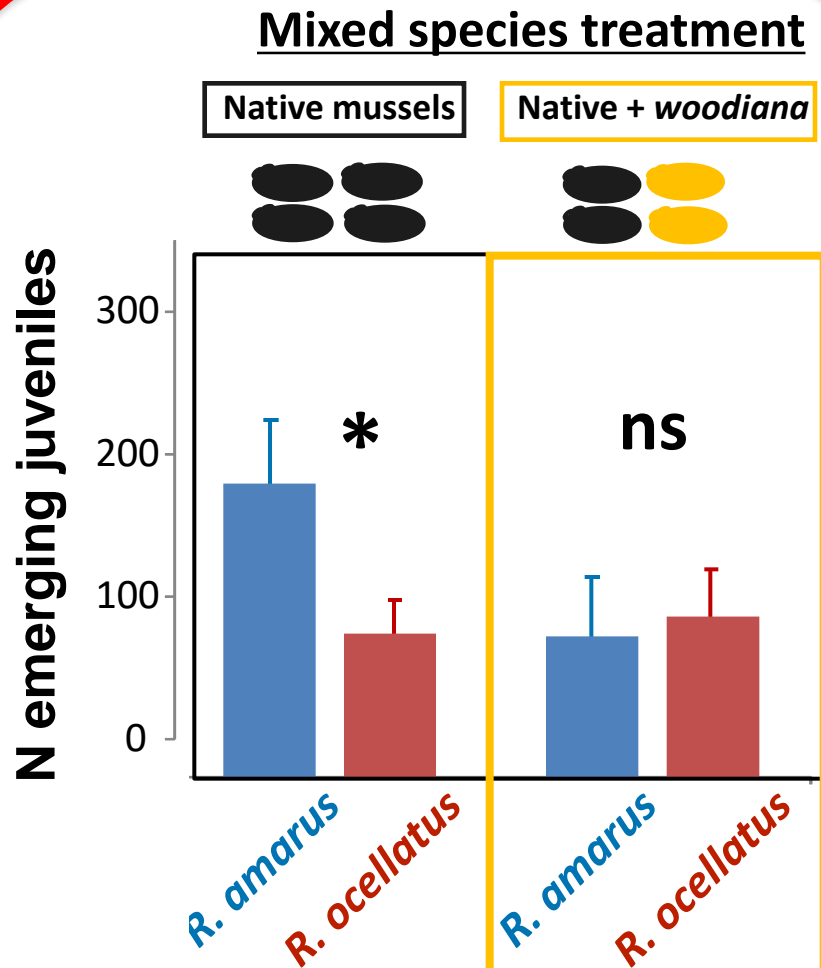
- daily count of juveniles  
emerging from mussels

# Reproductive success: controls



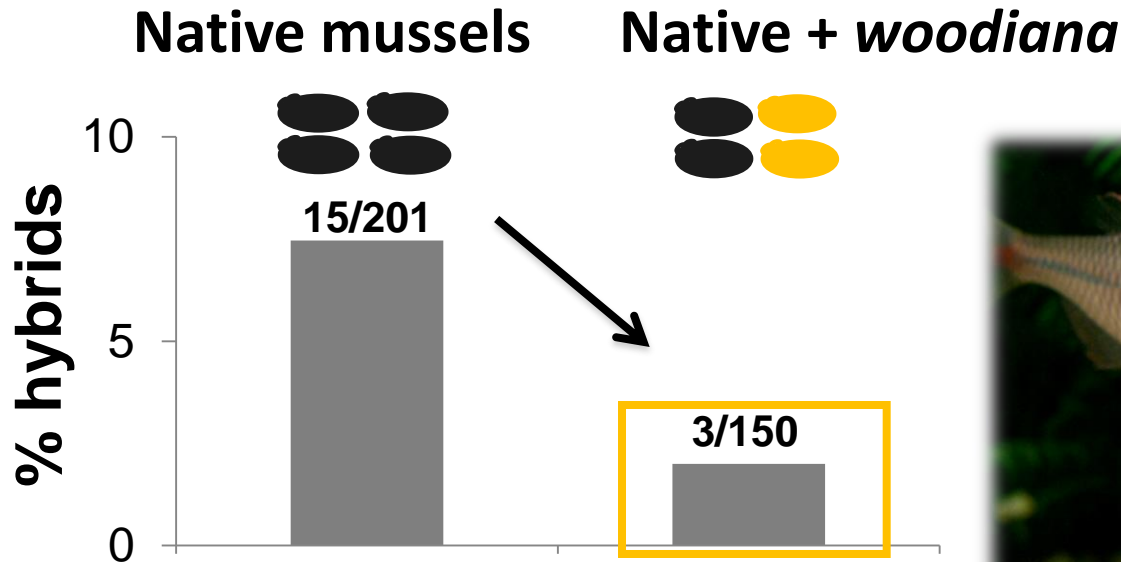


# Reproductive success: competition





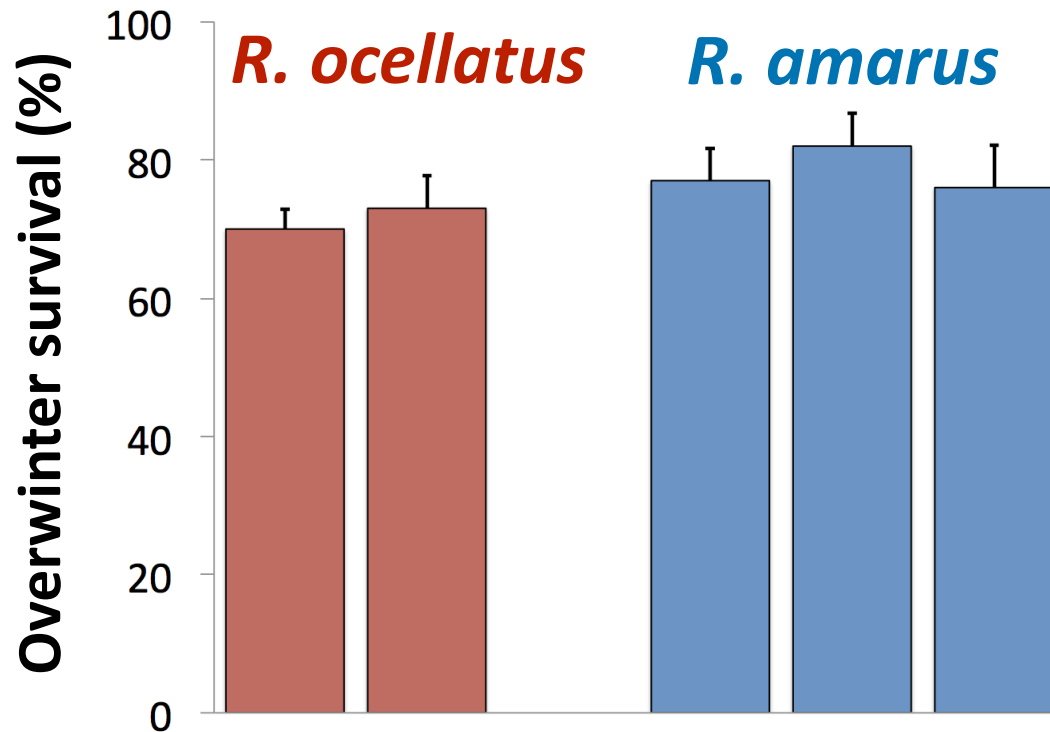
# 3. Hybridization?



Relatively low level  
...but present.



# 4. Overwinter survival



**Very good overwinter survival.**

# Conclusions

1. Native bitterling species superior in securing breeding resources
2. Non-native bitterling species benefits from invasion of its co-evolved partner
3. Potential for hybridization
4. Good overwinter survival

**The fate of potential invasion by *R. ocellatus* depends on the establishment success of its co-evolved host, *A. woodiana***

# Thank you for your attention!

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