

# Multiple ecological scales of host-parasite interactions

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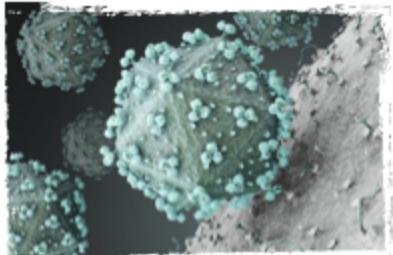
Thesis examination  
30<sup>th</sup> May 2017, Kiel





*Cymothoa exigua*

“A **parasite** is an organism that has evolved morphological or physiological adaptations to live in or on a **host**, exploiting its nutrients and decreasing its fitness, but seldomly killing it.”



Virus



Fungus



Bacteria



Cestodes



Trematodes



Insects



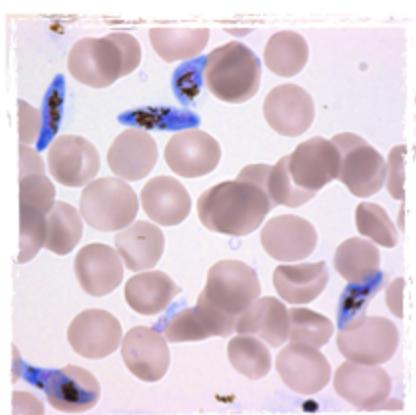
Arachnids



Acanthocephalans



Nematodes



Protozoan



Plants



Crustaceans



Bird

30-50% of species are parasitic  
All organisms are parasitised

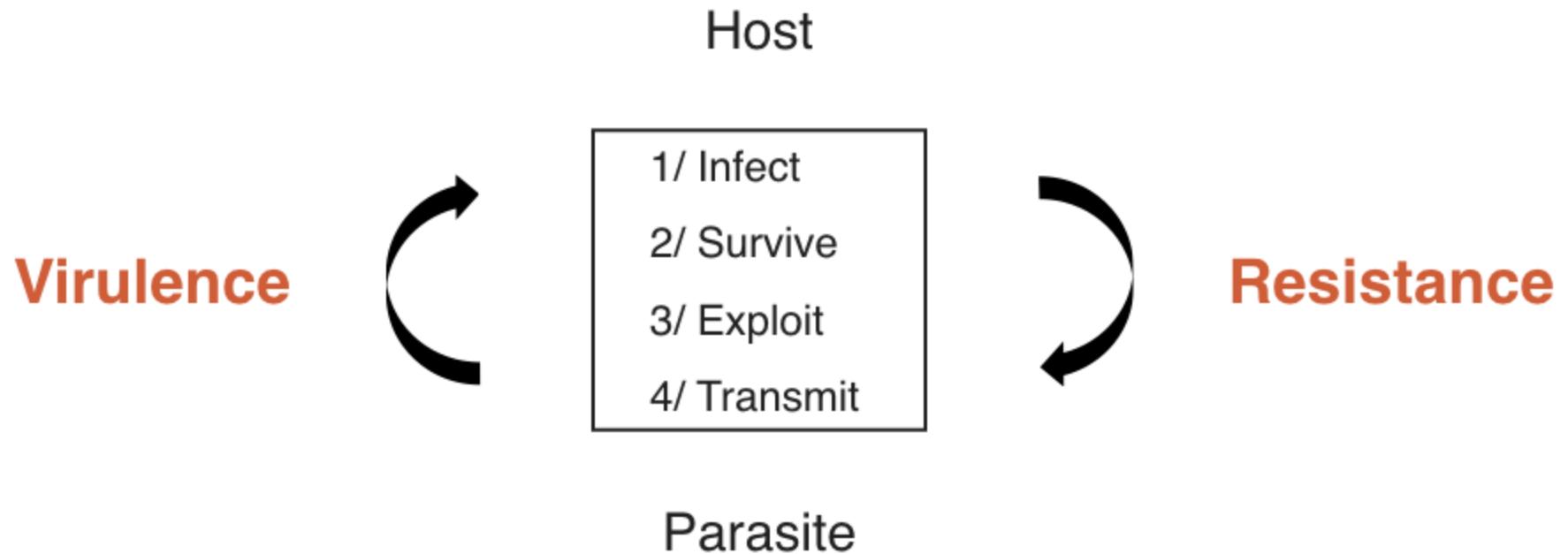
## **Important ecological & evolutionary implications!**

ecological speciation

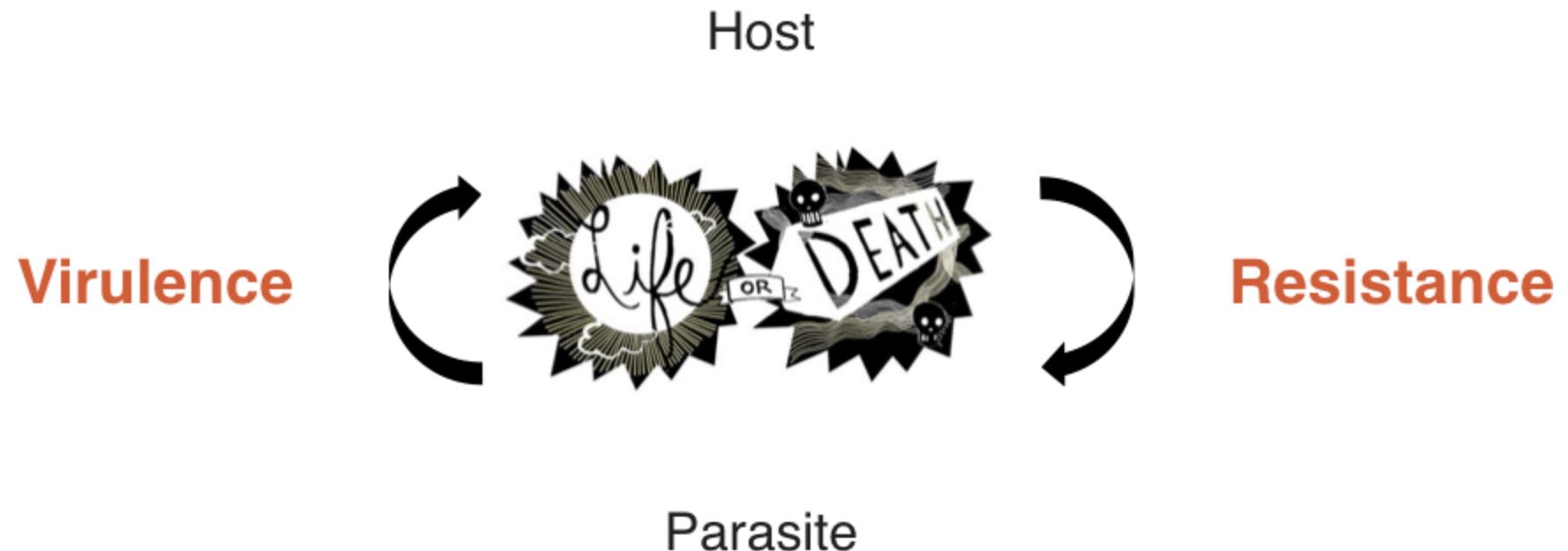
genetic diversity

sexual reproduction

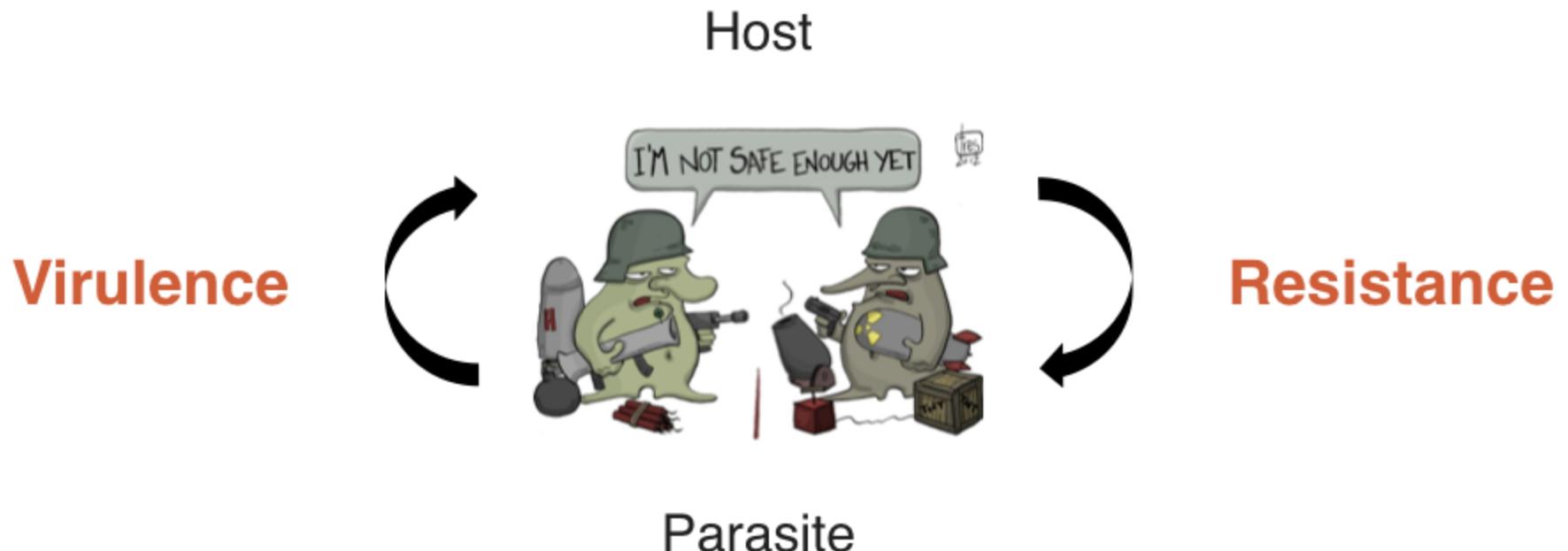
# Host-Parasite interactions



# Host-Parasite interactions

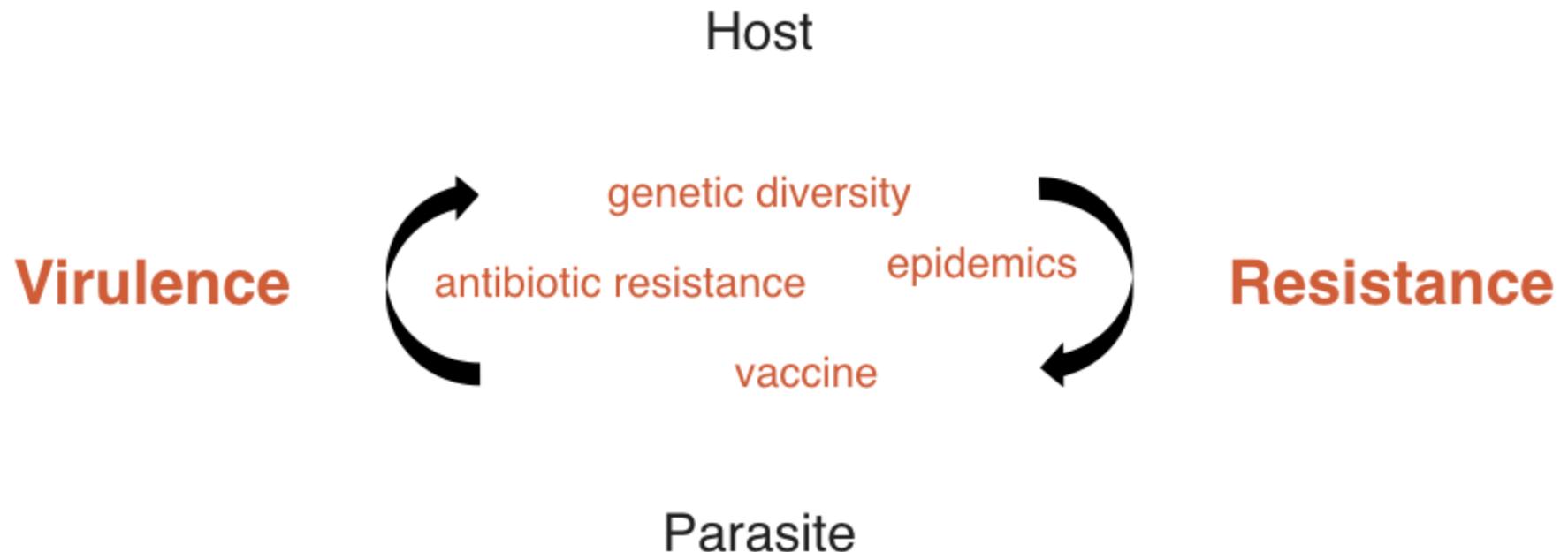


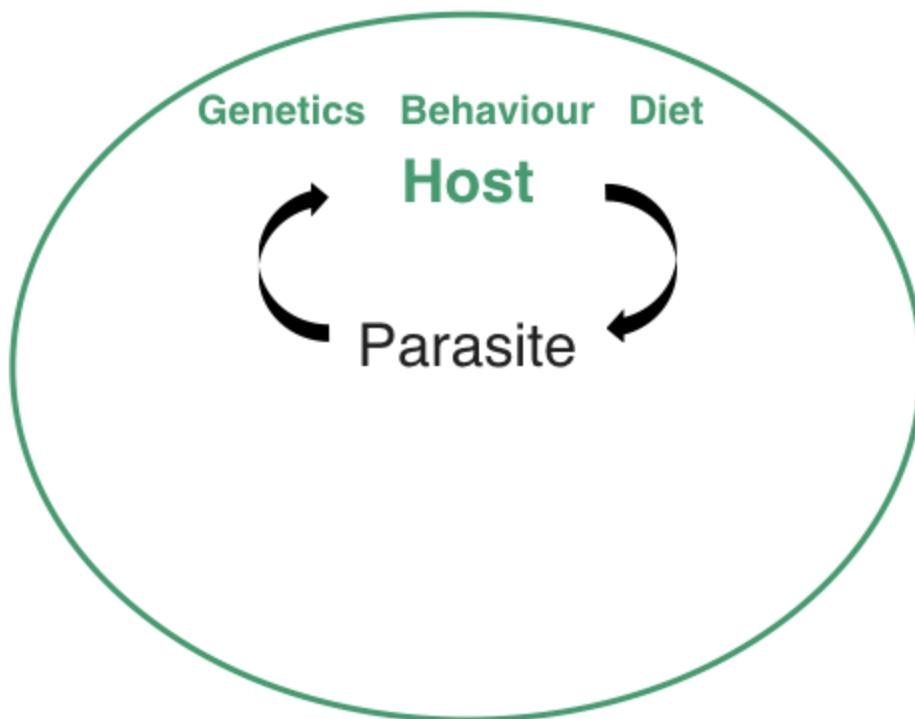
# Host-Parasite interactions



Coevolutionary arms race

# Host-Parasite interactions





adapted from Viney & Graham 2013 Adv Parasitol

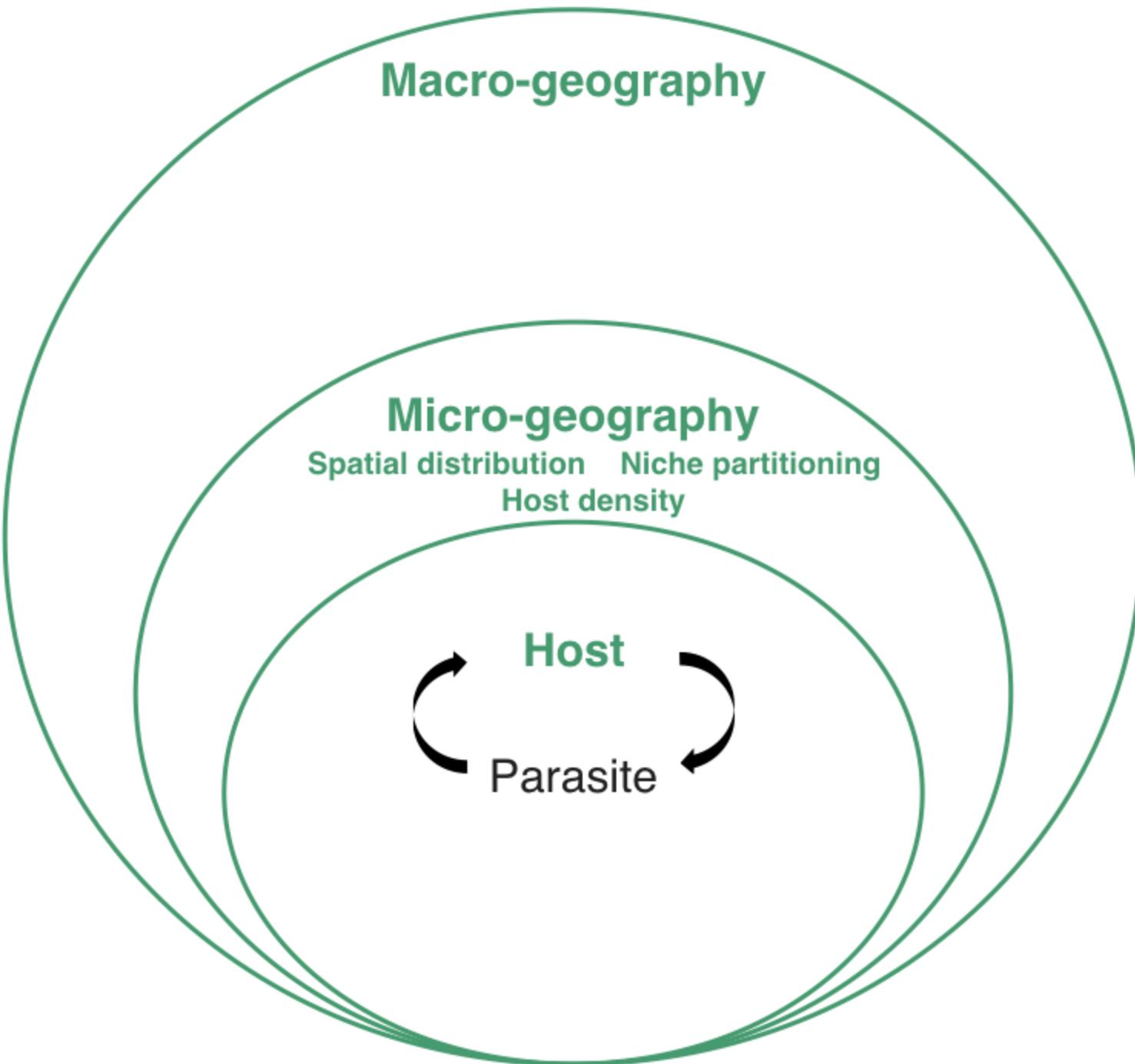
# Macro-geography

Habitat   Climate   Diet   Other hosts/parasites

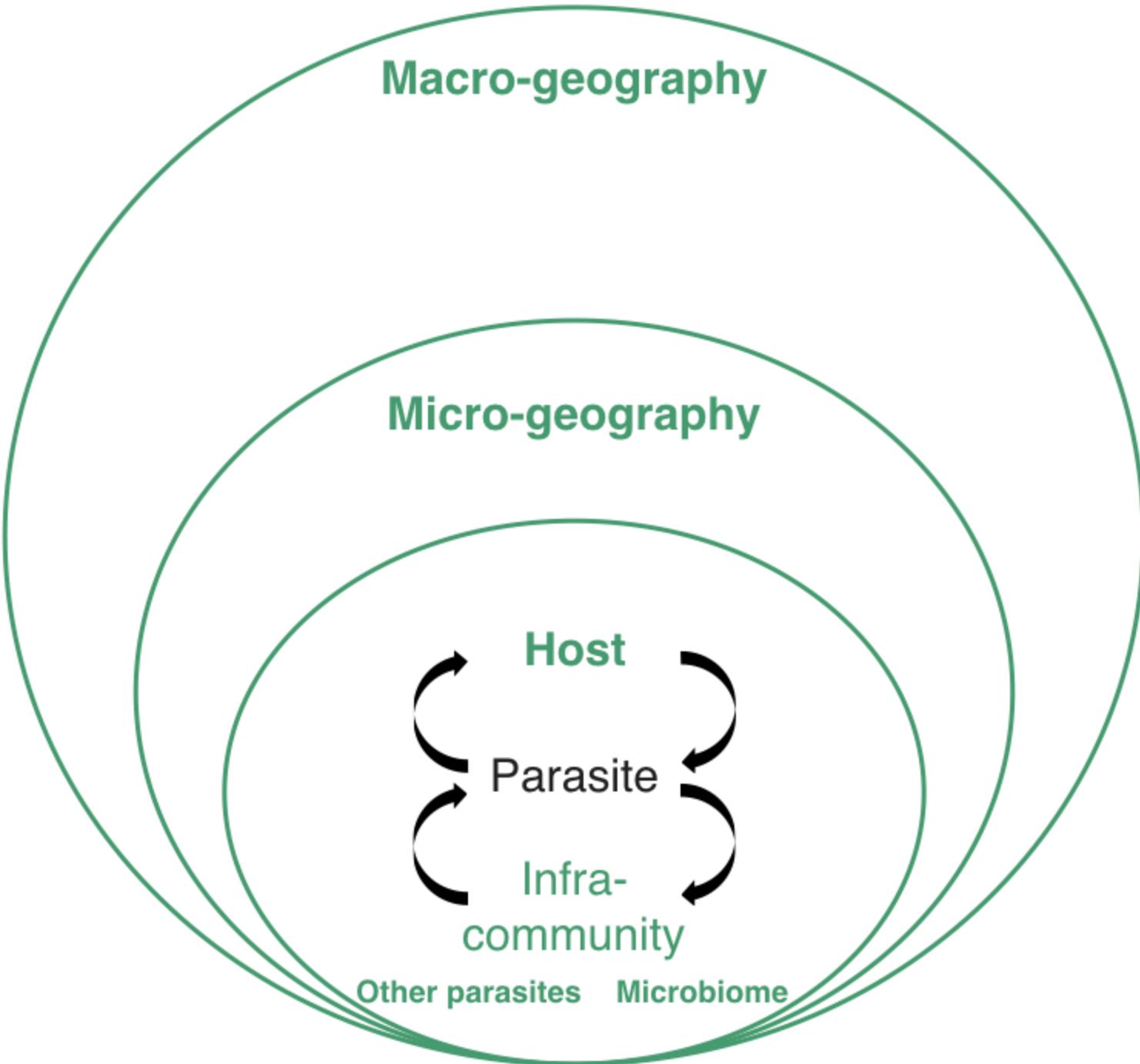
Host

Parasite

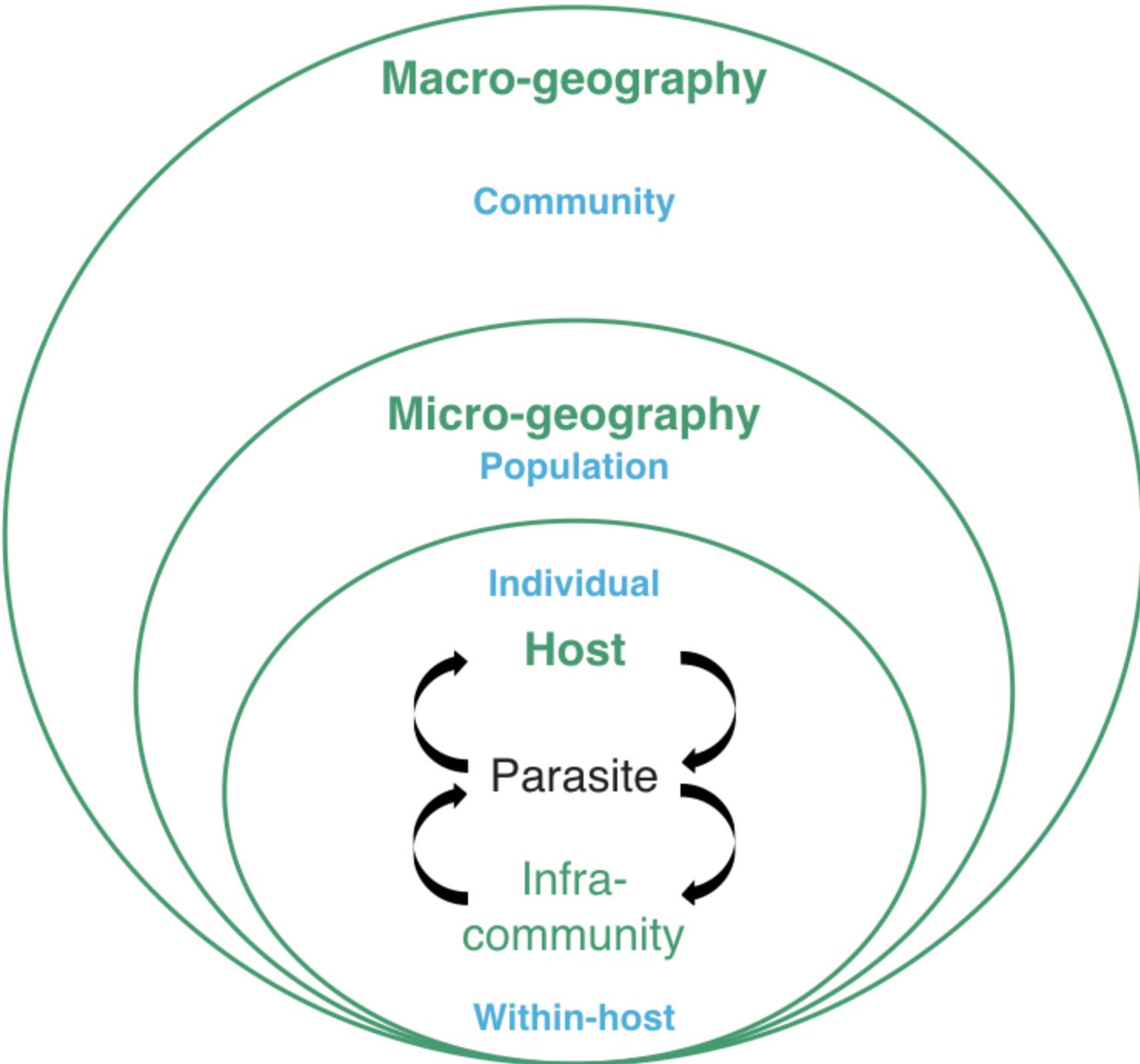
adapted from Viney & Graham 2013 Adv Parasitol



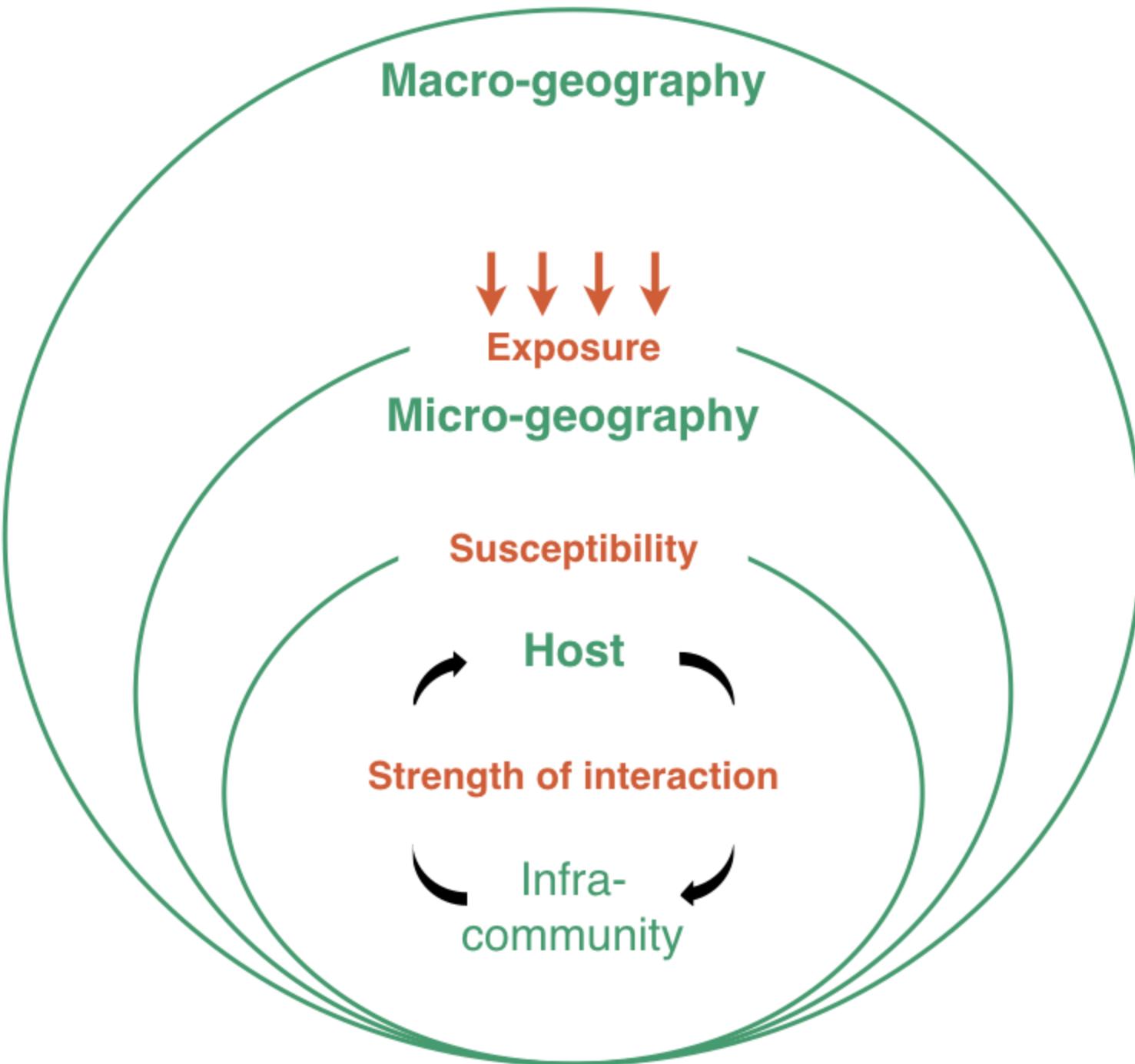
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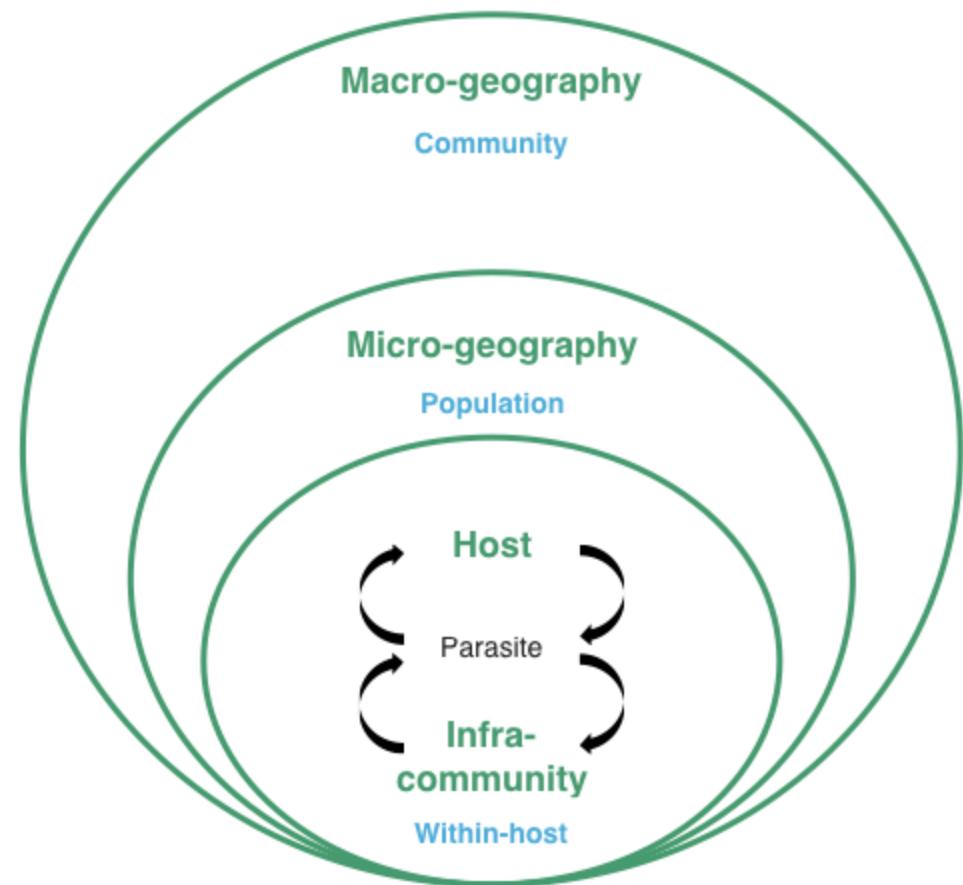
adapted from Viney & Graham 2013 Adv Parasitol

# Host-Parasite interactions

## 1/ Community & populations

## 2/ Populations

## 3/ Within-host



# Host-Parasite interactions

## 1/ Community & populations



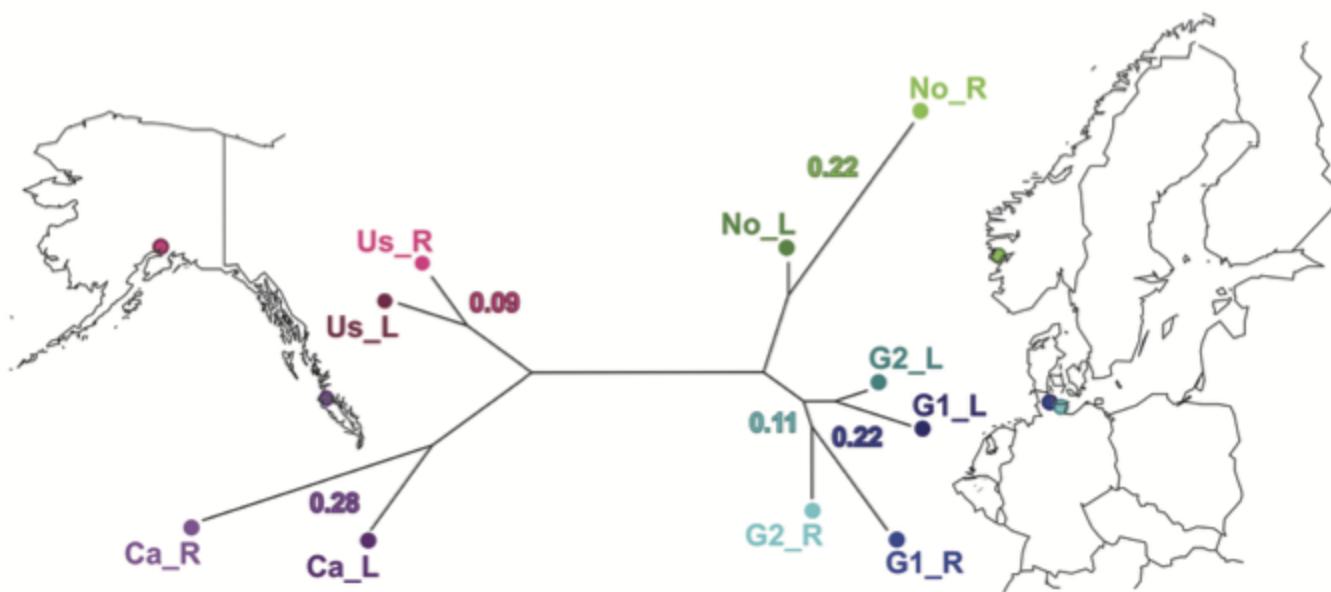
Parasite-mediated divergence

## 2/ Populations

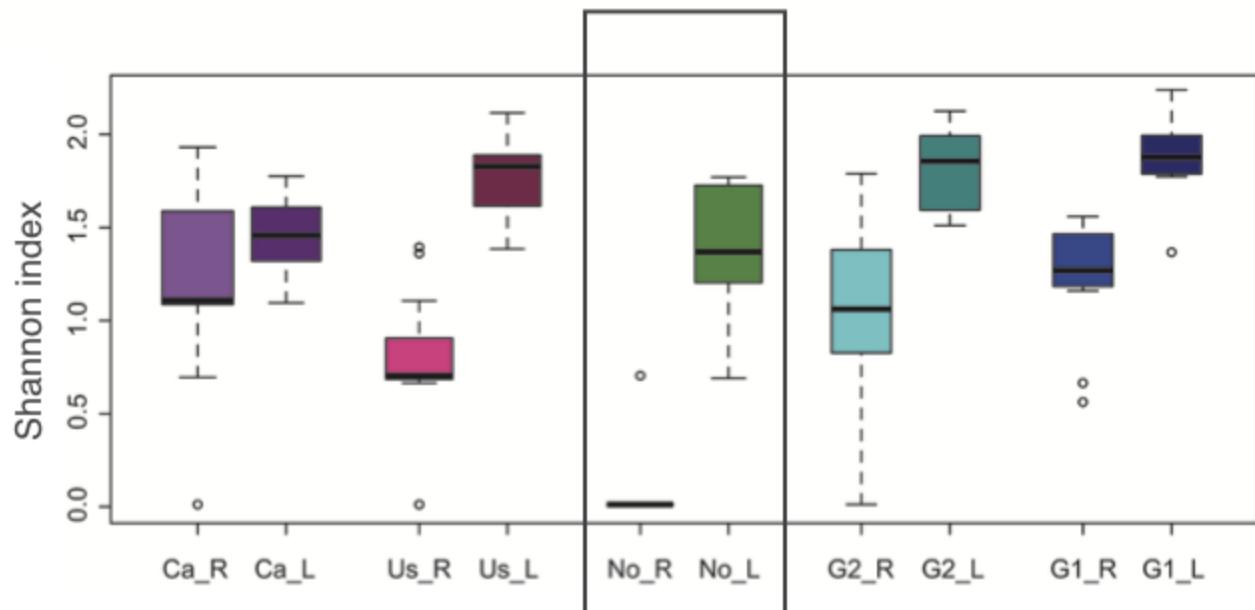
## 3/ Within-host

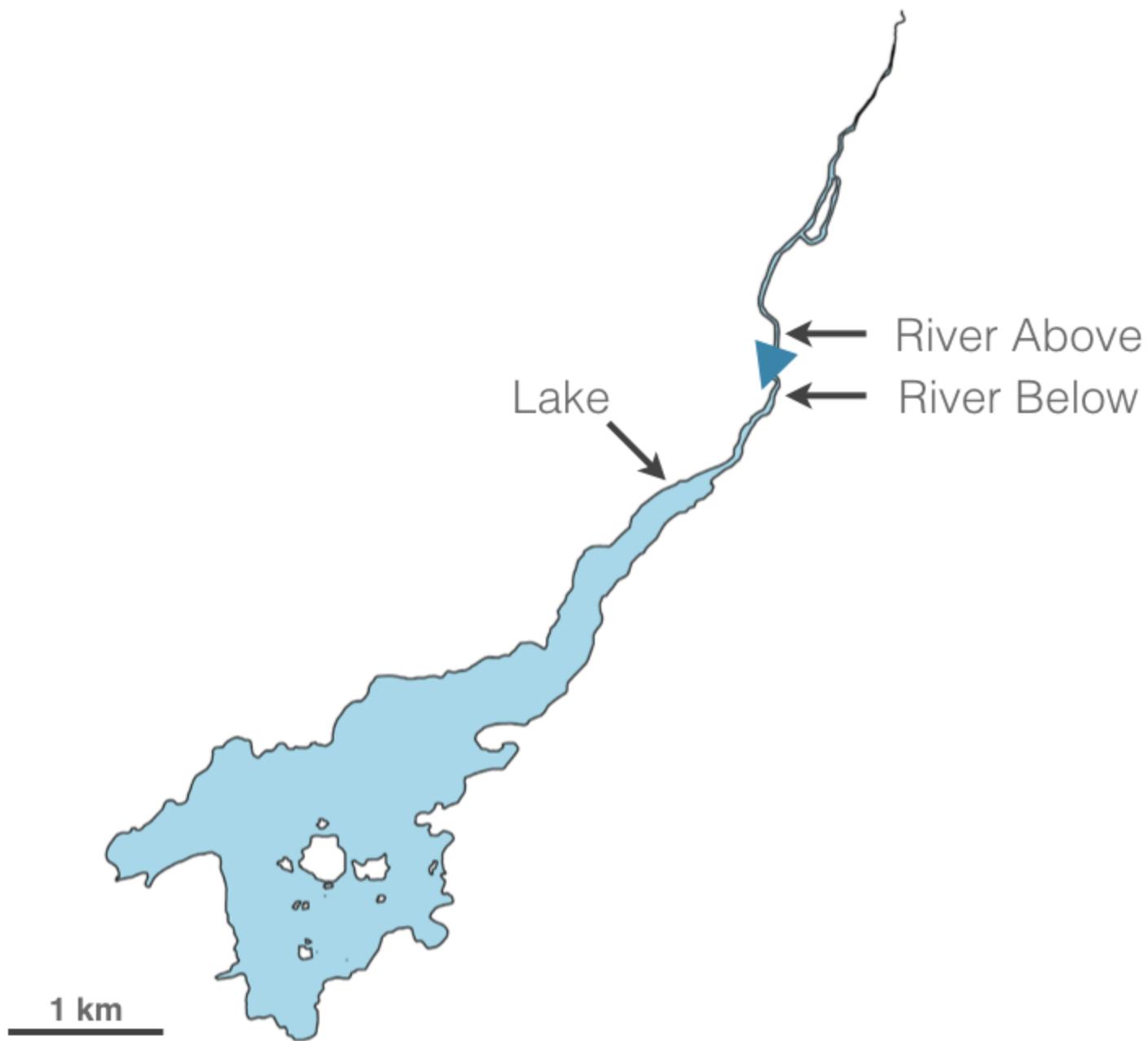
# Three-spined stickleback





### Norwegian populations







4 years field survey:

- Host population genetic structure
- Parasite communities

**RA**



**RB**



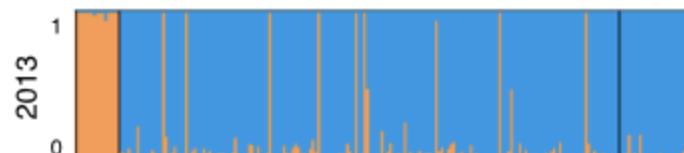
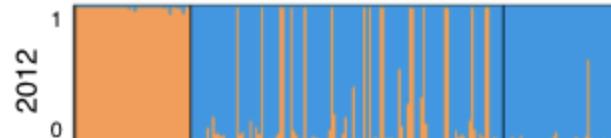
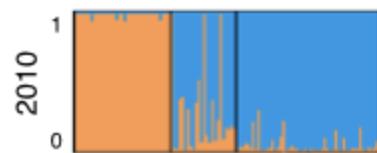
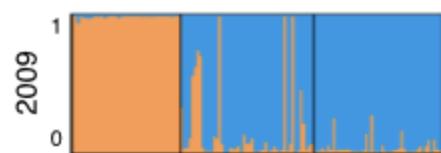
**L**



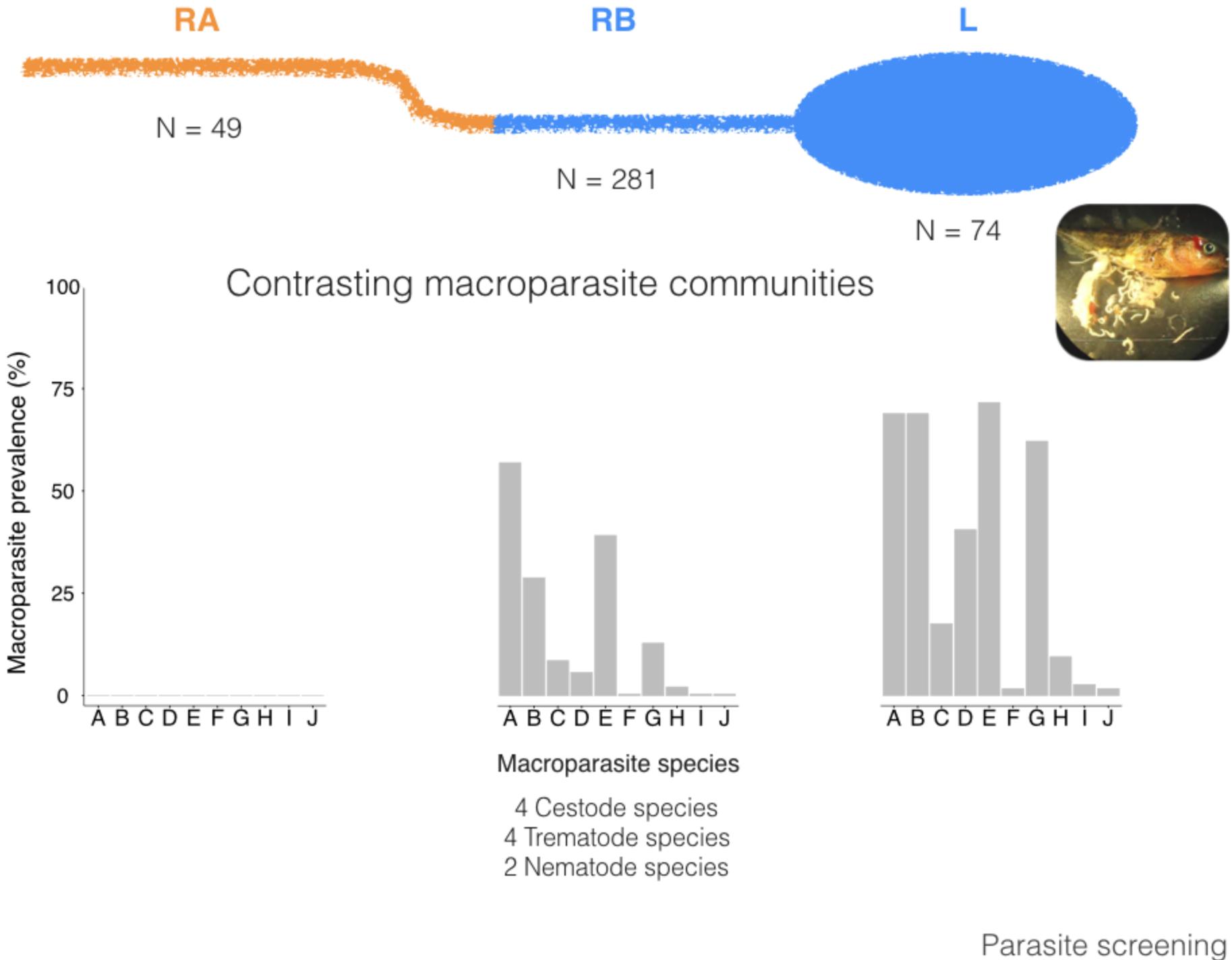
8 microsatellites

K = 2

10% migrants (N = 34)  
4% admixed (N = 16)



Population genetic structure

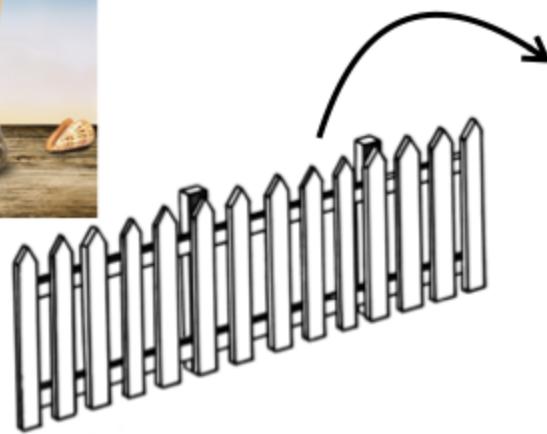


RA



RB

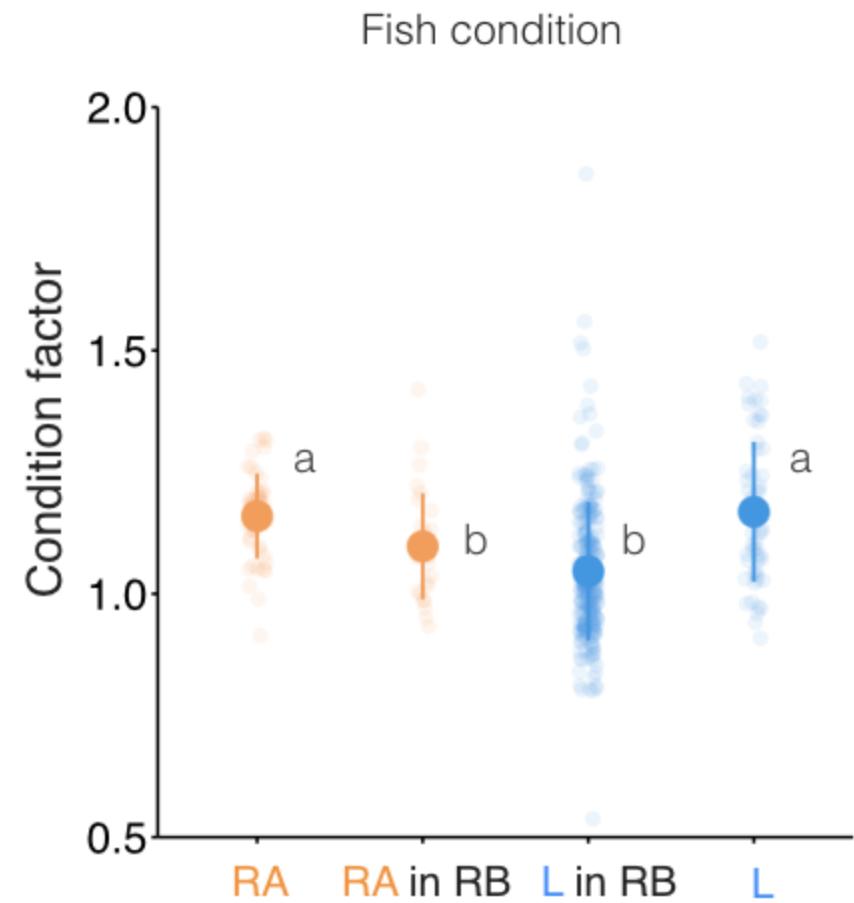
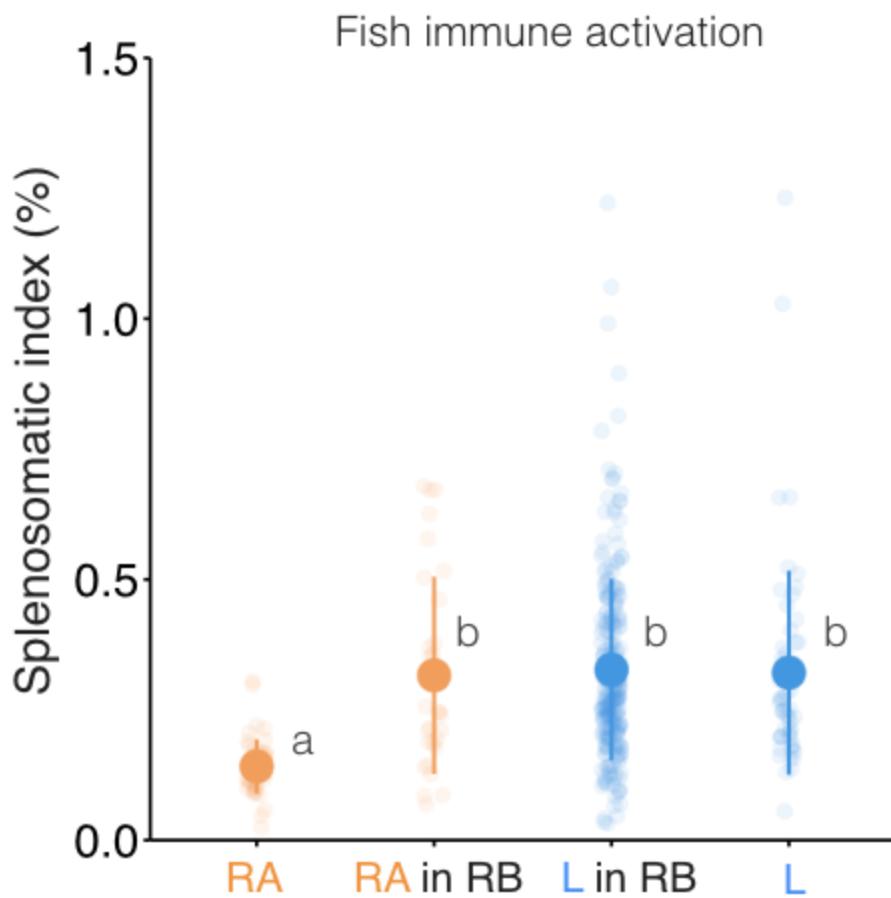
L



Parasite community



Immune cost too high for migrants?



# Experimental exposure to assess parasite resistance

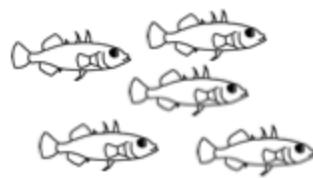
RA      vs.      L



Wild caught fish

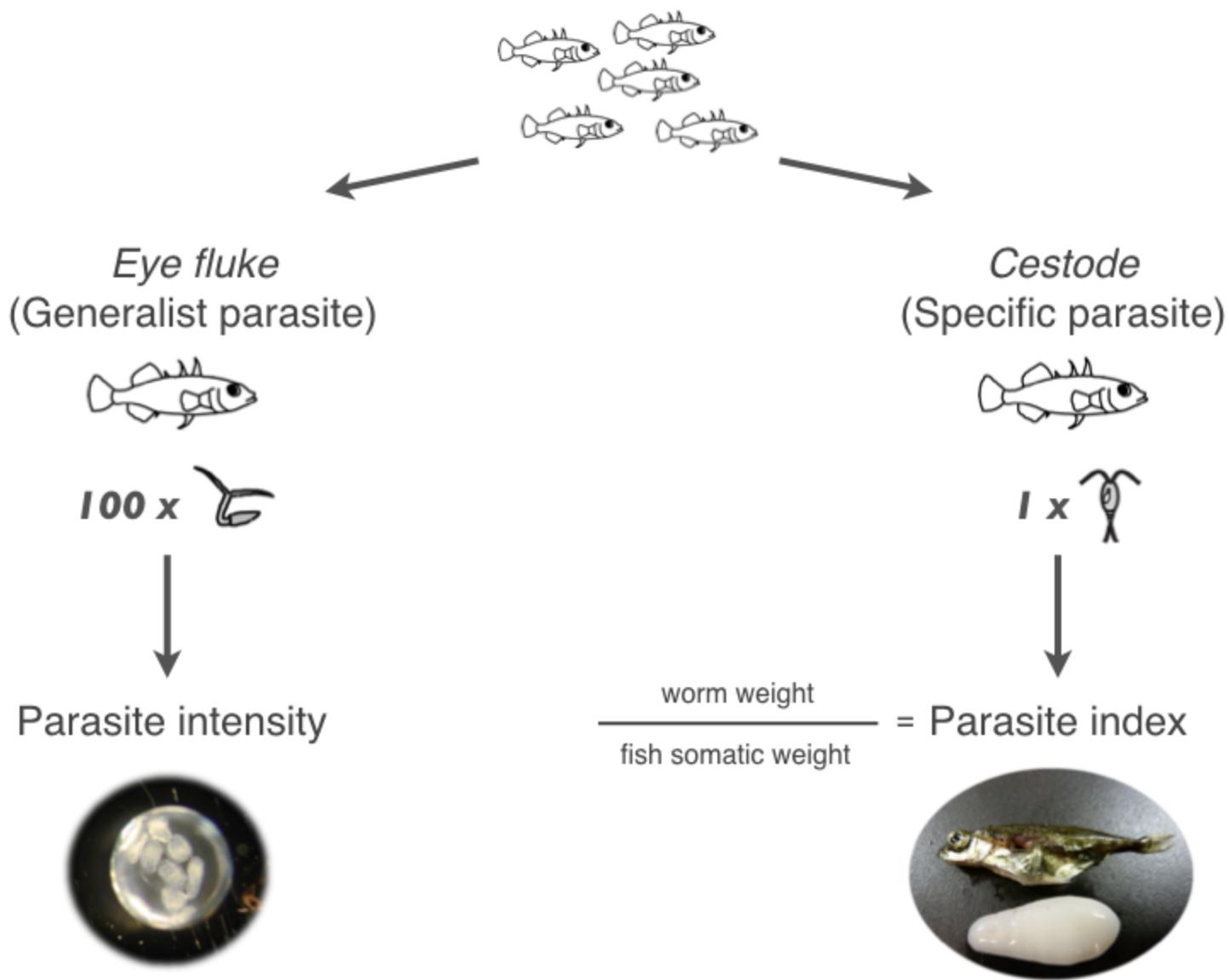


Lab-bred fish families



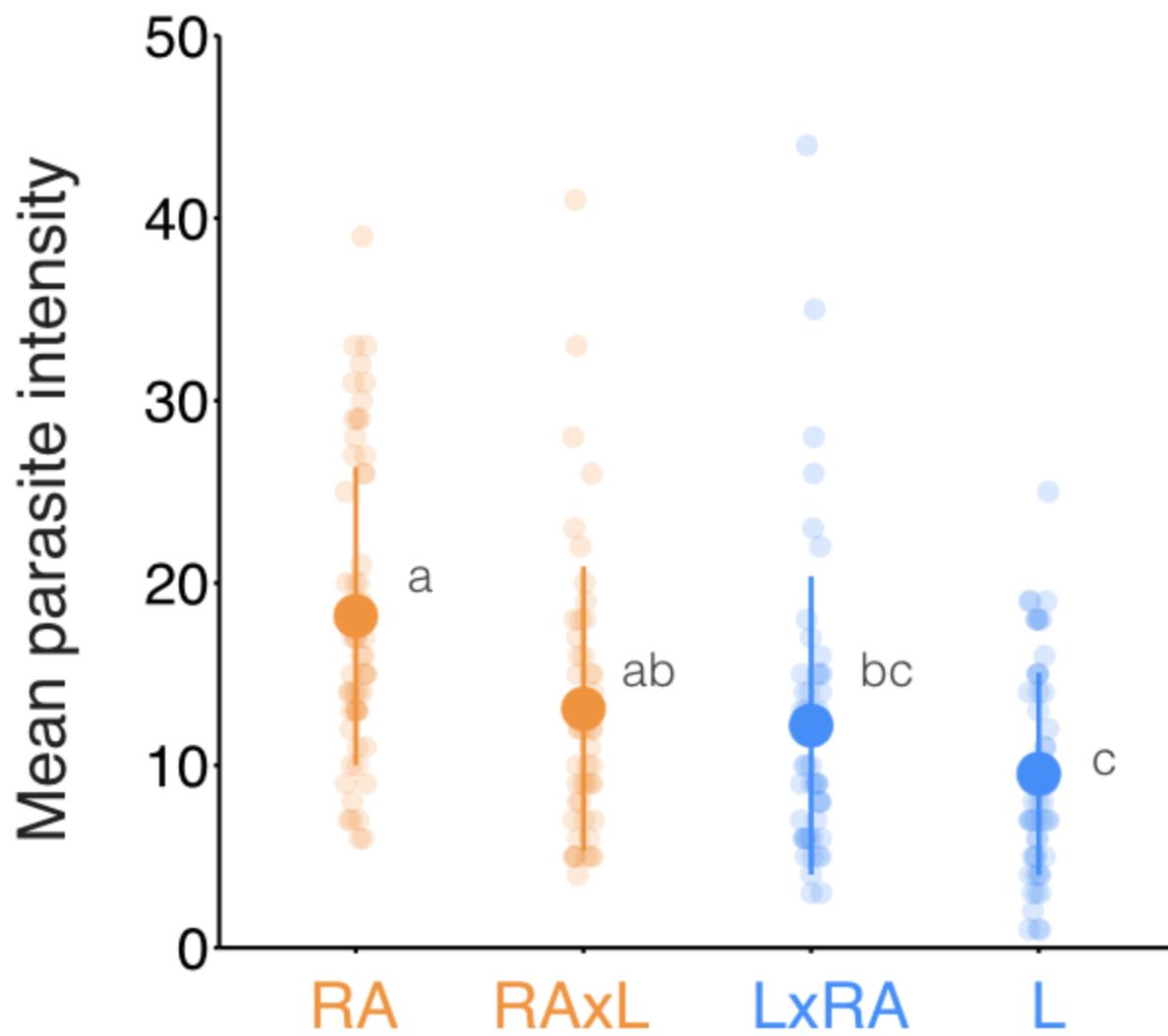
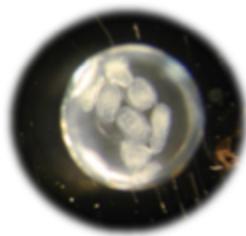
<b>RA</b>	N = 5
<b>Lake</b>	N = 5
<b>Hybrids</b>	N = 2x4

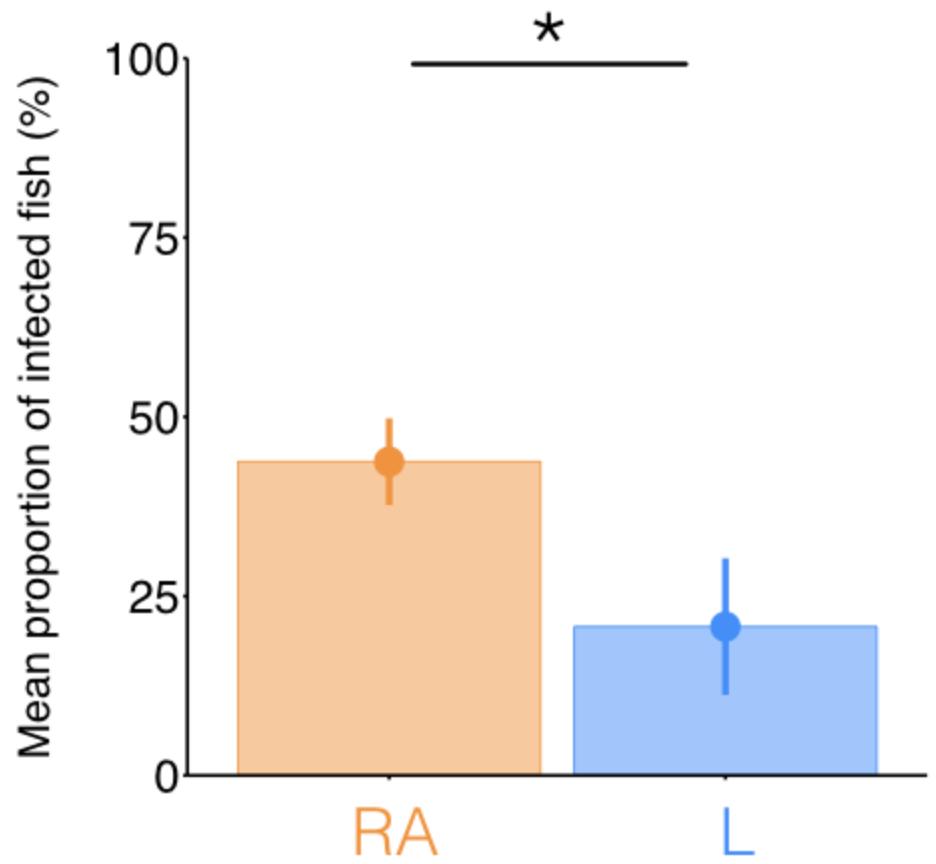
## Lab-bred fish families



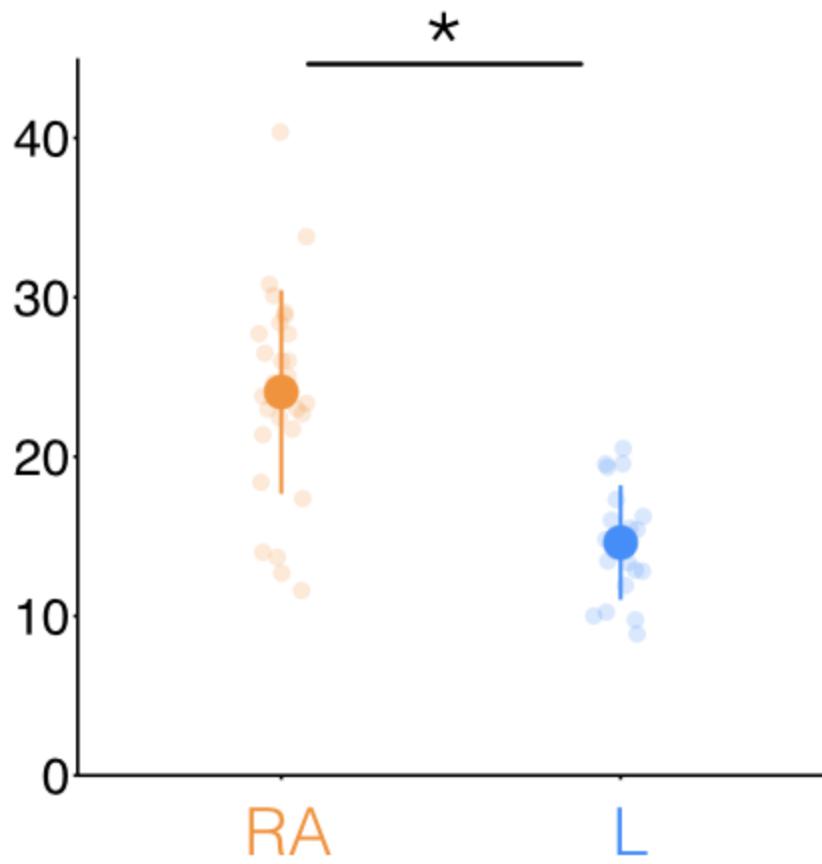


*Eye fluke*



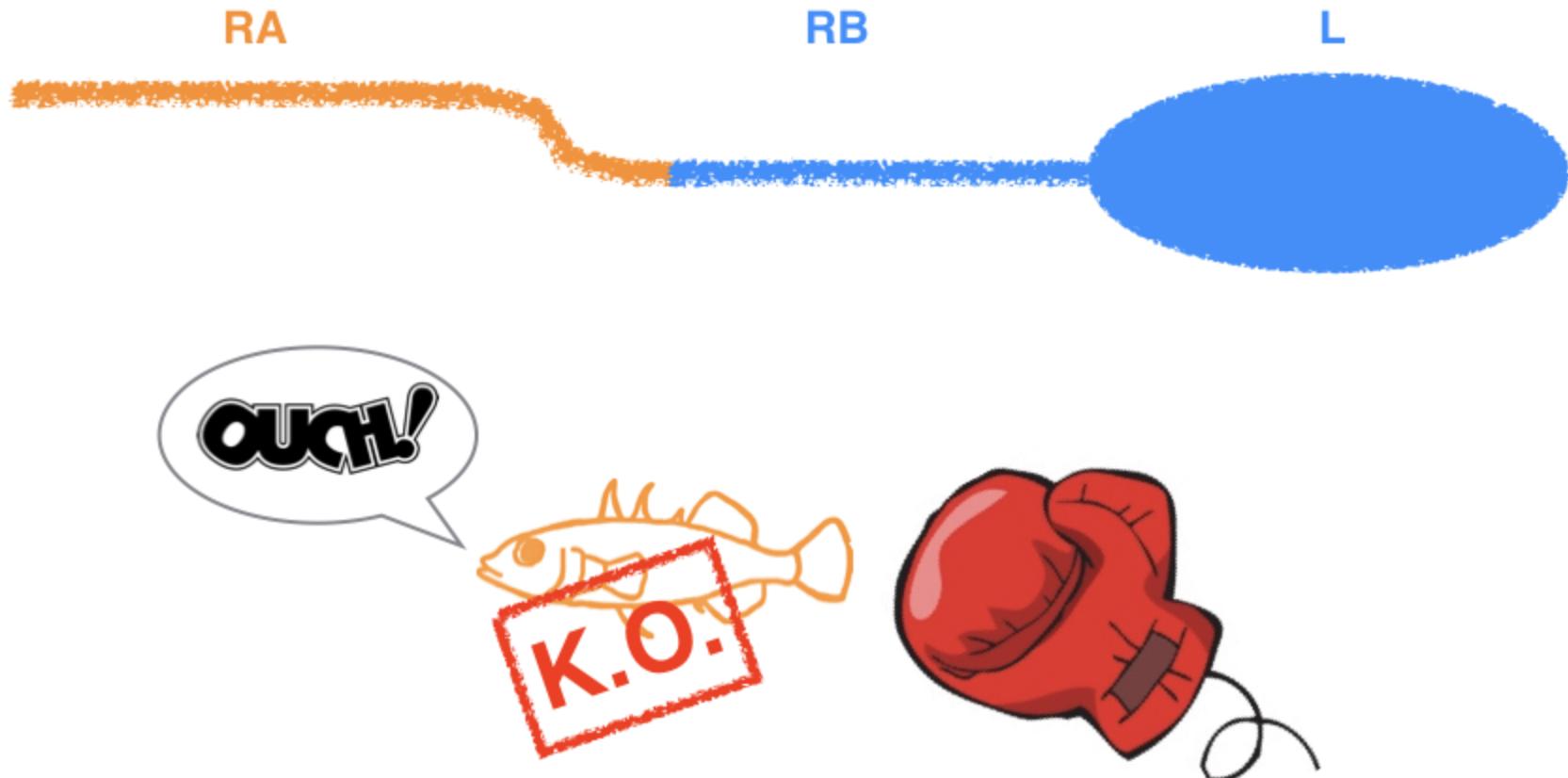


Mean parasite index (%)



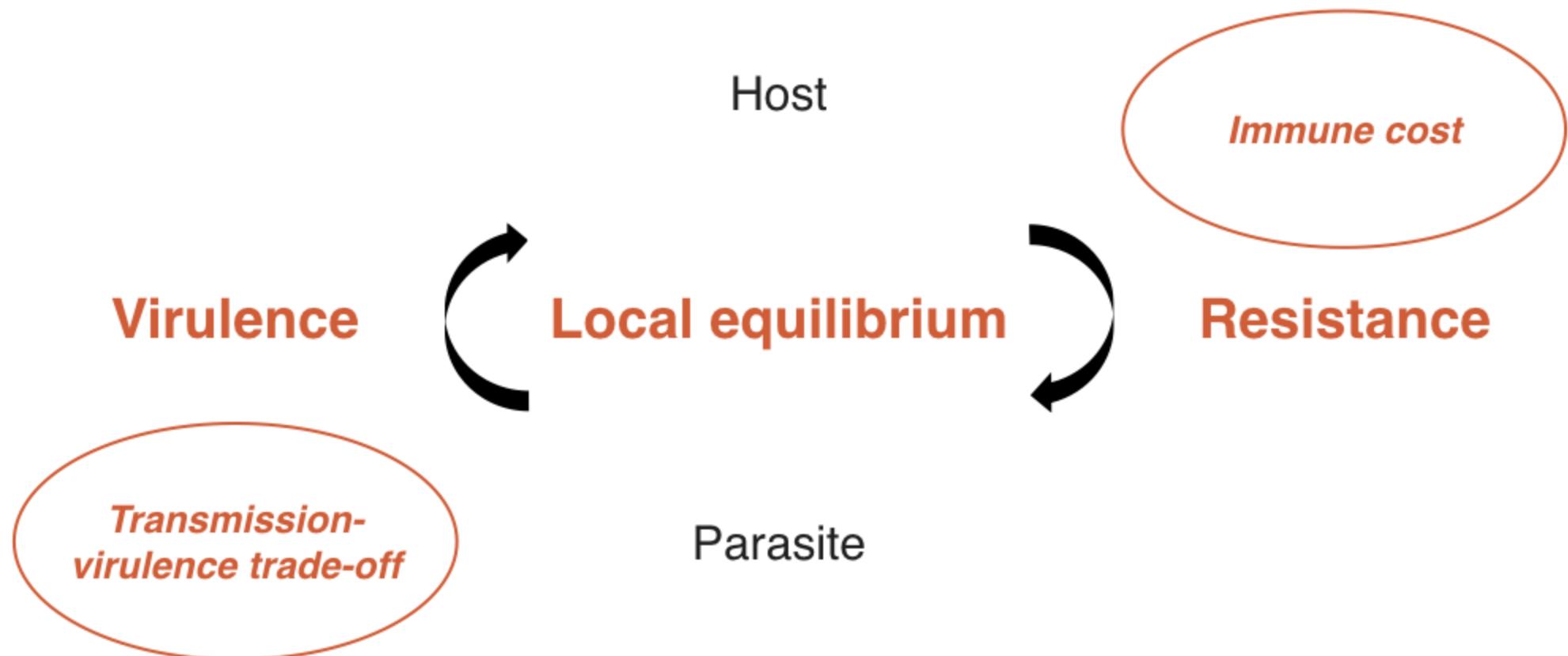
*Cestode*





Parasite community

# Host-Parasite interactions



# Host-Parasite interactions

## 1/ Community & populations



Parasite-mediated divergence

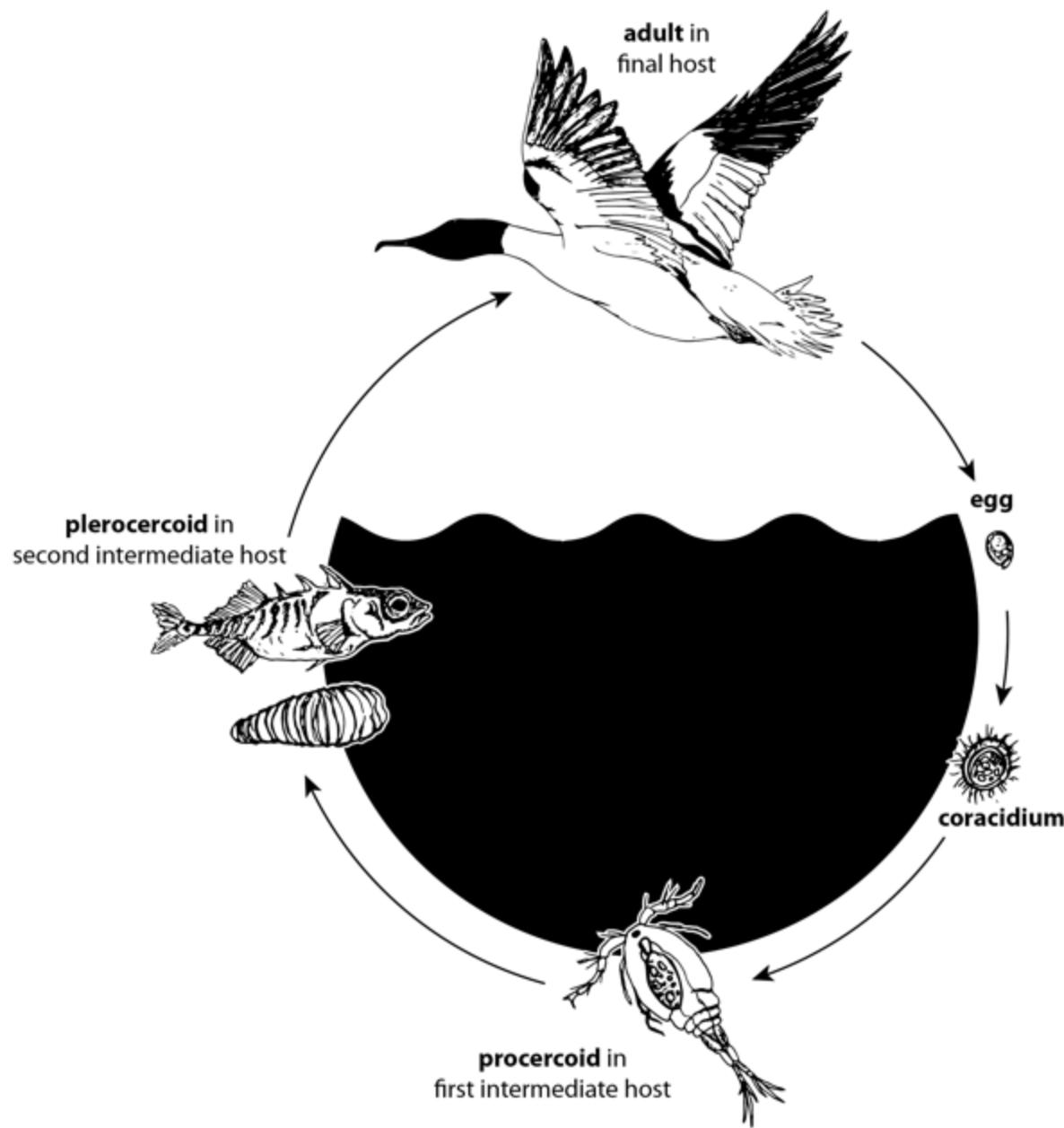
## 2/ Populations



Local adaptation

## 3/ Within-host

# *Schistocephalus solidus*



*Schistocephalus solidus*



# *Schistocephalus solidus*

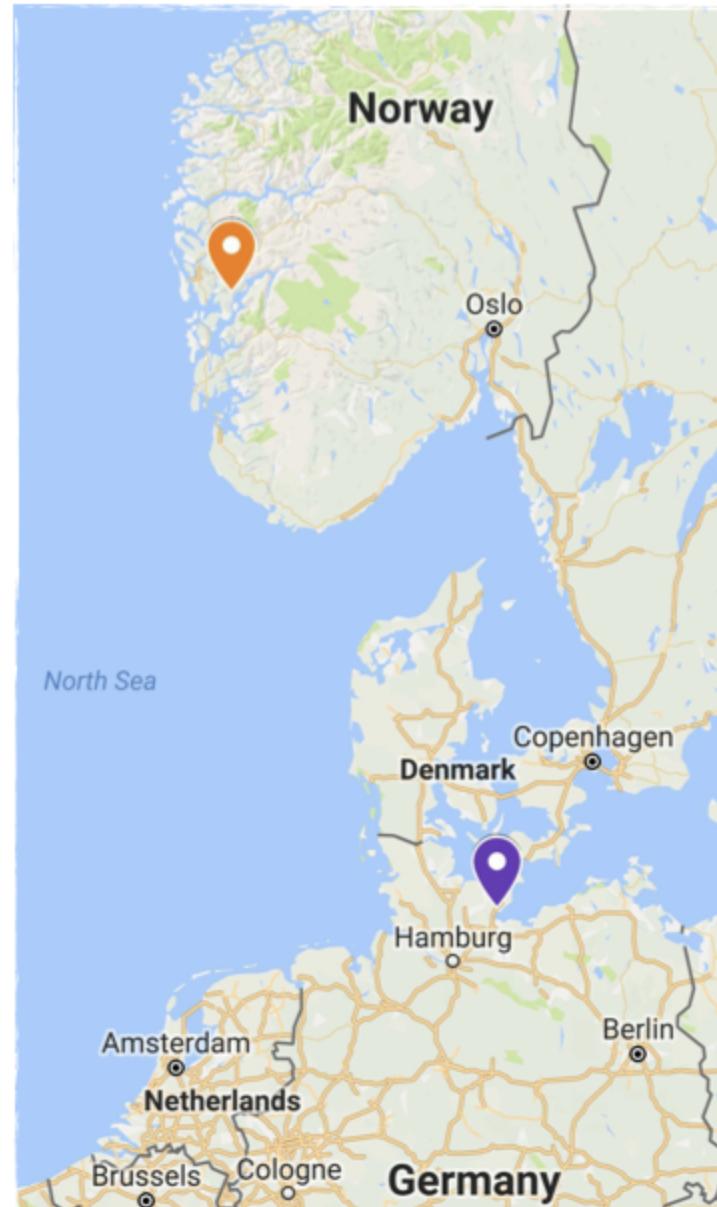
$$\text{Parasite index} = \frac{\text{worm weight}}{\text{fish somatic weight}}$$



Lake (NO) 

60%

Strong selection



 Estuary (DE)  
< 1%  
Relaxed selection

	Parasite DE	Parasite NO
Host DE		
Host NO		

	Parasite DE	Parasite NO
Host DE	Sympatric	Allopatric
Host NO	Allopatric	Sympatric



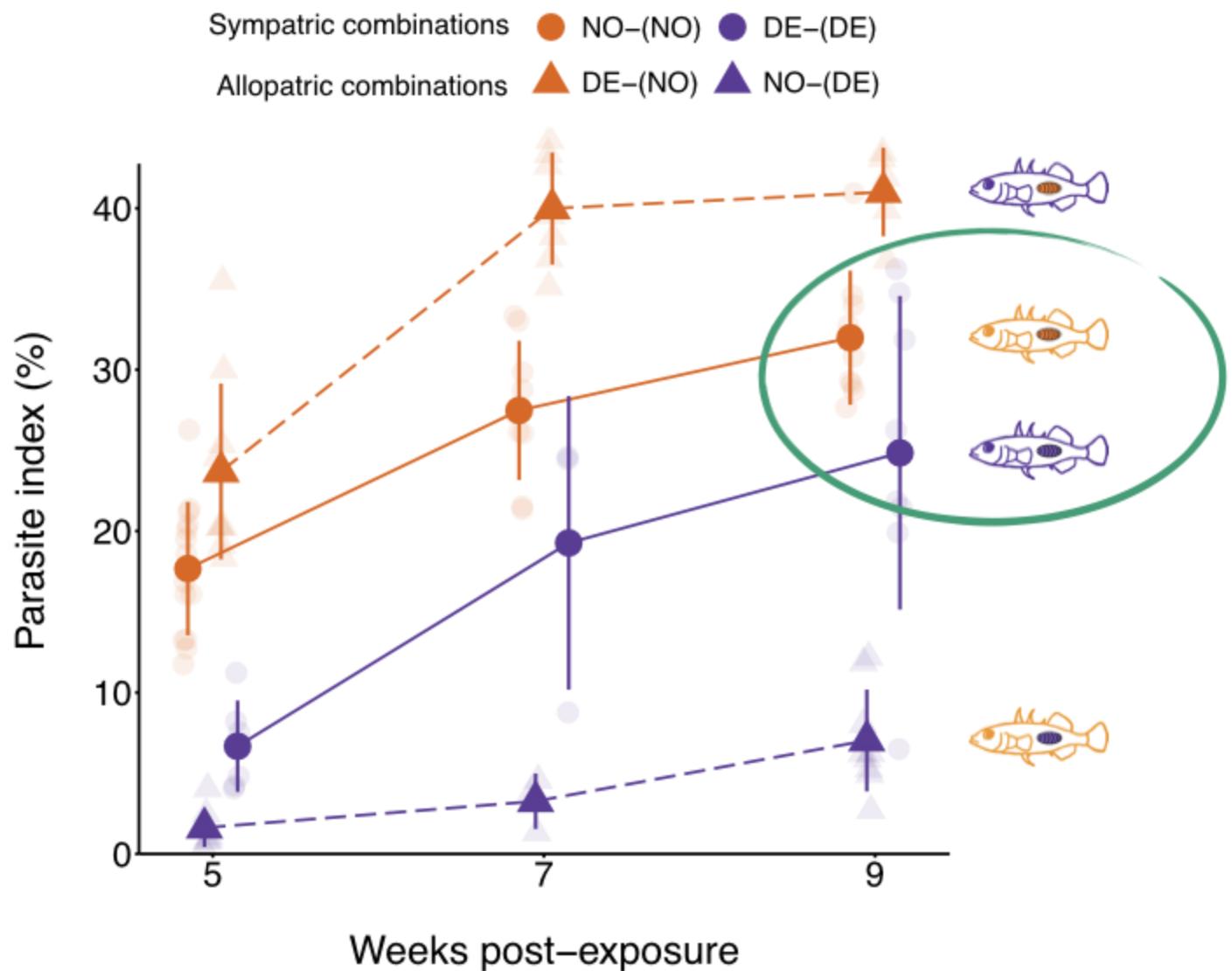
T0  
exposure

T1  
5 weeks

T2  
7 weeks

T3  
9 weeks





	Parasite DE	Parasite NO
Host DE	Optimal	Over-exploitation
Host NO	Under-exploitation	Optimal

# Host-Parasite interactions

## 1/ Community & populations



Parasite-mediated divergence

## 2/ Populations



Local adaptation

## 3/ Within-host



Virulence expression



Within-host competition influence virulence expression?



VS.



**High virulence (Hv)**  
Norwegian worm

**Low virulence (Lv)**  
German worm





Total parasite Index tPI = proxy for virulence

Discrete parasite index dPI = proxy for individual virulence



**High virulence (Hv)**  
Norwegian worm

vs.



**Low virulence (Lv)**  
German worm

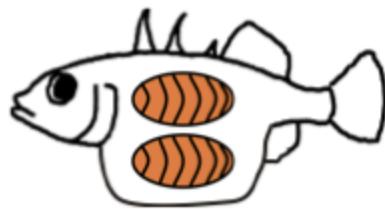


Hv



Lv

Single infection



Hv + Hv



Lv + Lv

Double homologous infection



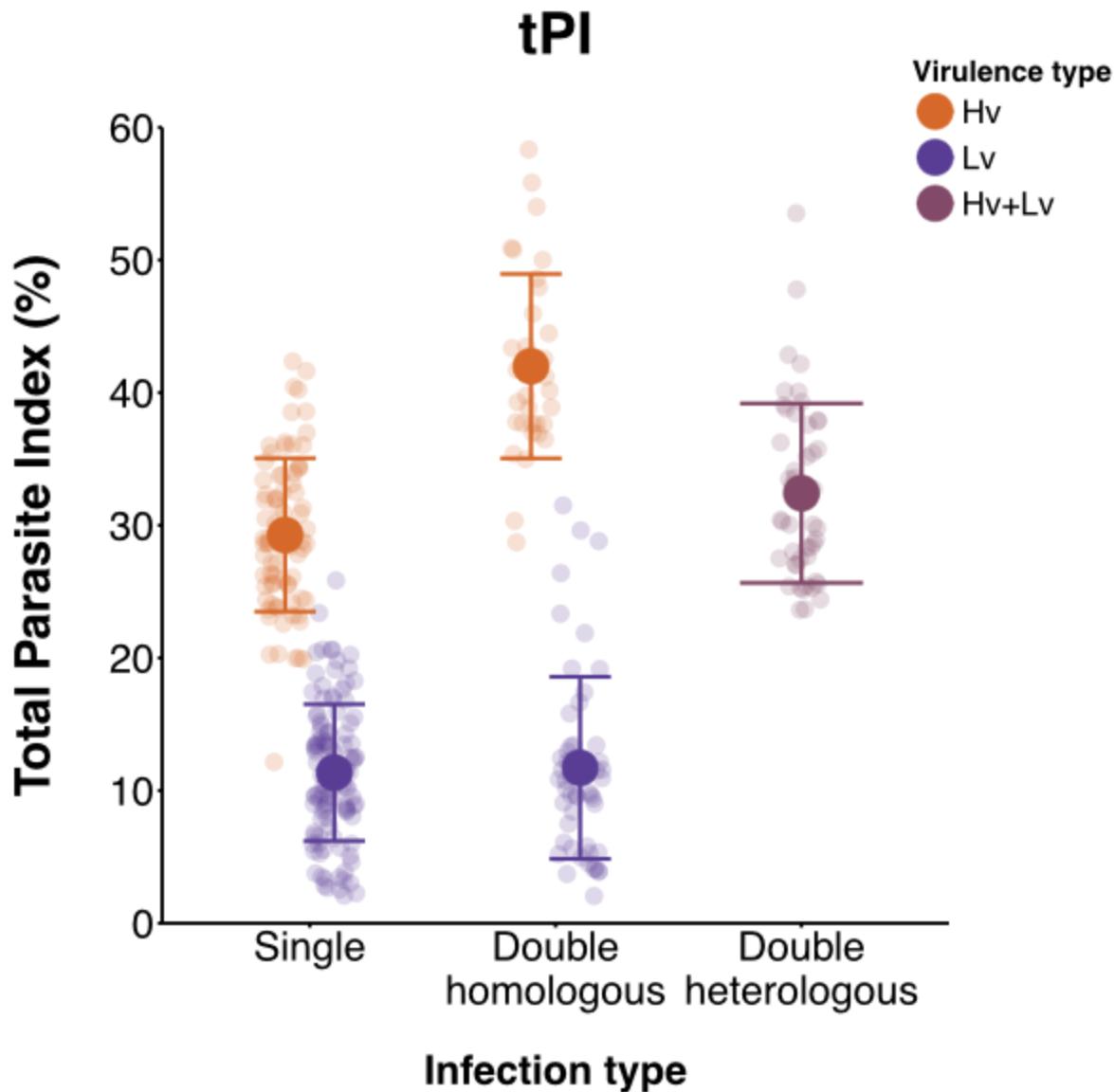
Hv + Lv



Double heterologous infection

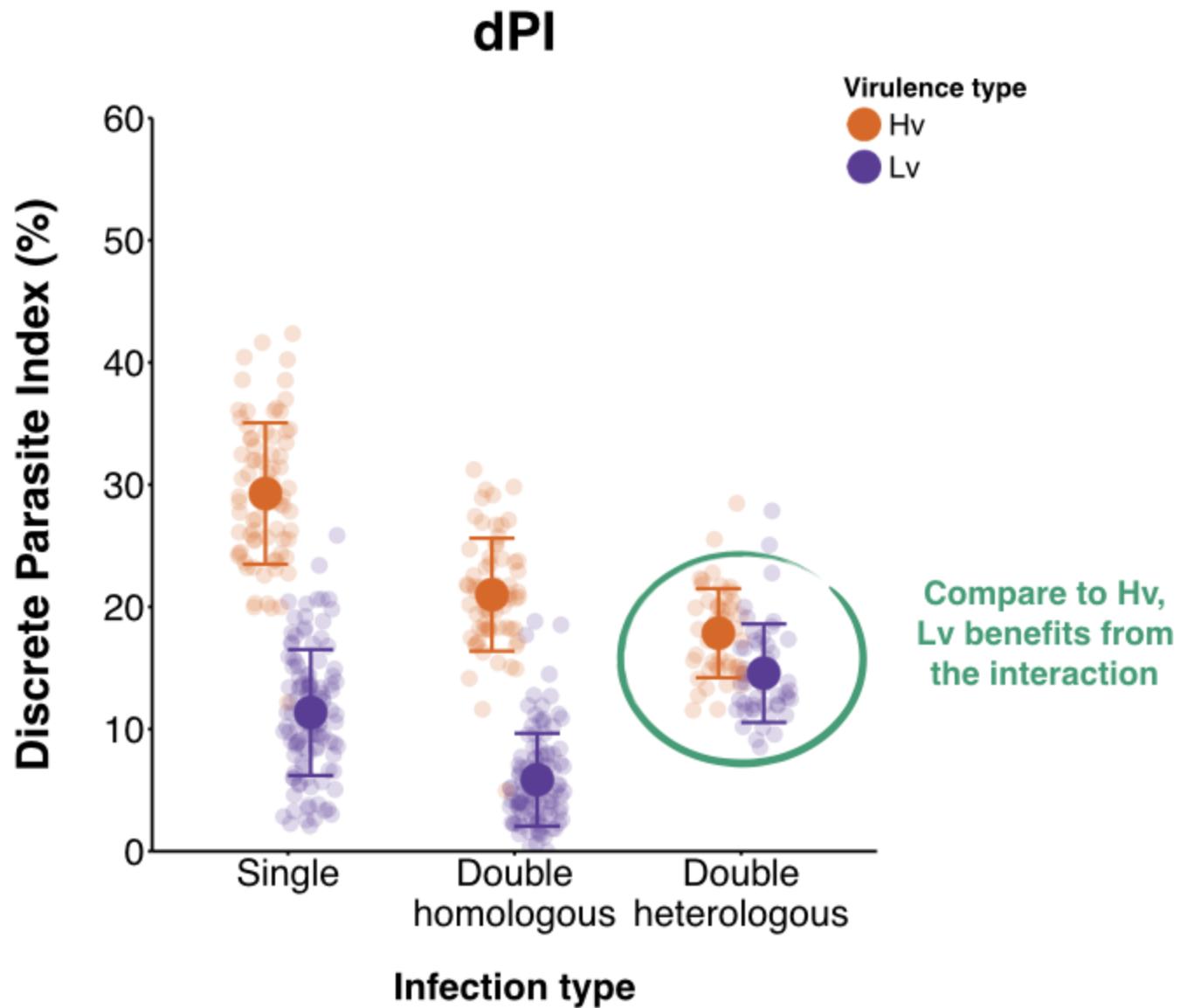
# Total Parasite Index

( $F_{4,321} = 354.502$ ,  $p < 0.0001$ )



# Discrete Parasite Index

( $F_{5,453} = 325.807, p < 0.0001$ )





Host = pool of resources



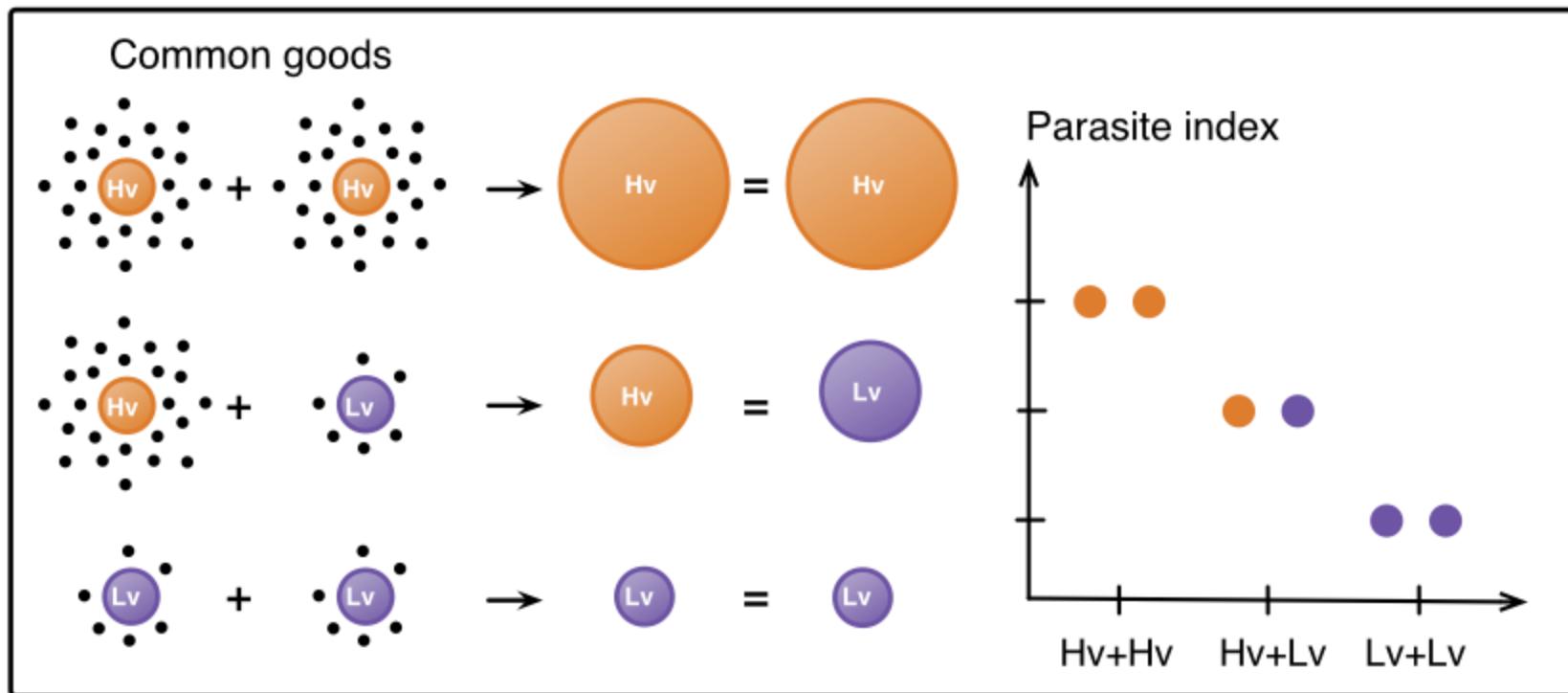
Goods

Common goods  
*Rivalrous & non-excludable*



Nutrients

# Virulence Model



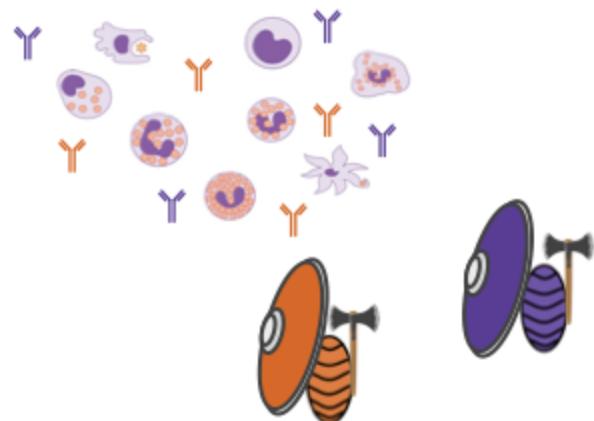


Host = pool of resources



Goods

Strain-specific goods  
*Rivalrous & excludable*





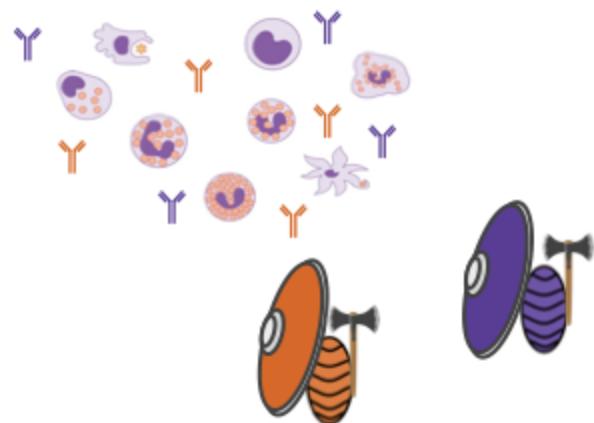
Host = pool of resources



Secretory/excretory products:  
interfere with host immune response

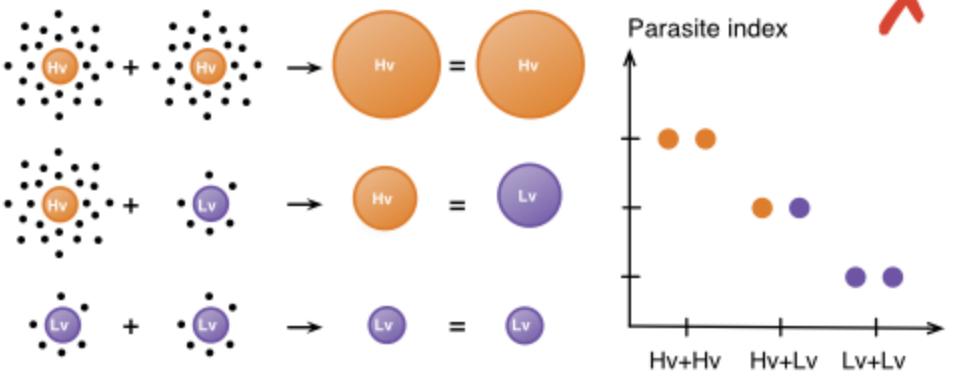
Scharsack et al. 2013 Fish & Shellfish Immunol  
Franke et al. 2014 Fish & Shellfish Immunol

Strain-specific goods  
*Rivalrous & excludable*

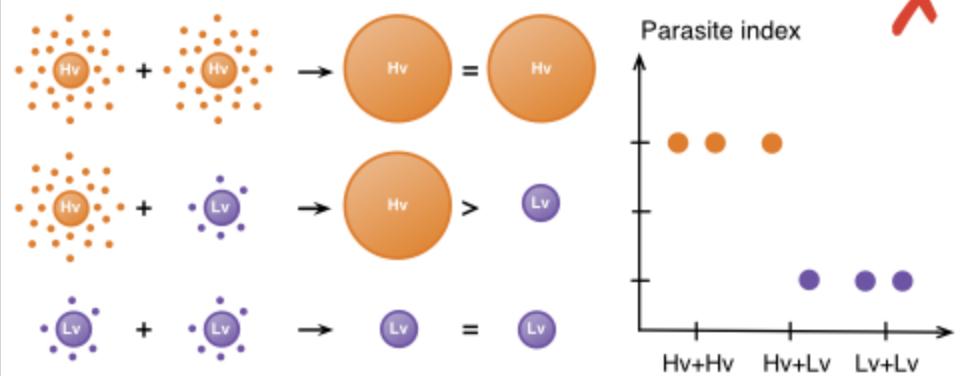


# Virulence Model

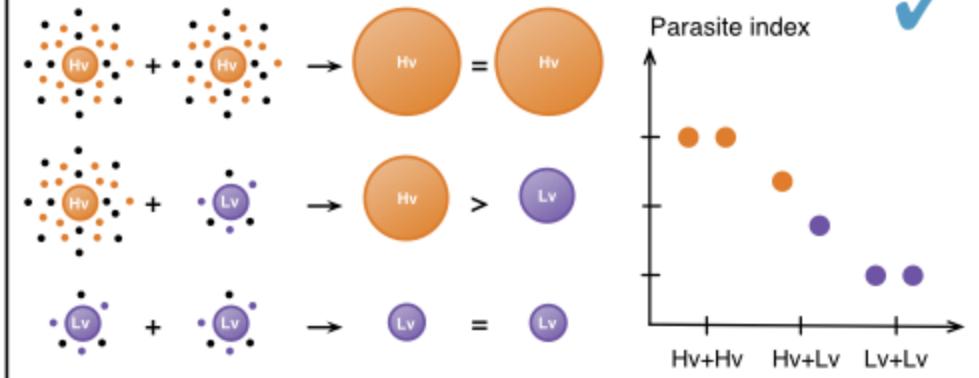
Common goods



Strain-specific goods



Common goods + Strain-specific goods



# Host-Parasite interactions

## 1/ Community & populations



*Divergence in parasite exposure risk & immune cost can shape host immunocompetence*

## 2/ Populations



*Different co-evolutionary histories lead to local adaptation towards a similar relative resistance-virulence optimum*

## 3/ Within-host



Intra-specific competition in co-infection can affect expression of virulence

# Acknowledgements

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Department of Evolutionary Ecology  
Parasitology Group

Deutsche  
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**DFG**

DFG Priority Program



host-parasite  
coevolution