

Immune gene expression in sympatric and allopatric stickleback-tapeworm combinations

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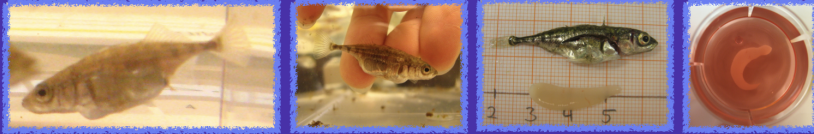


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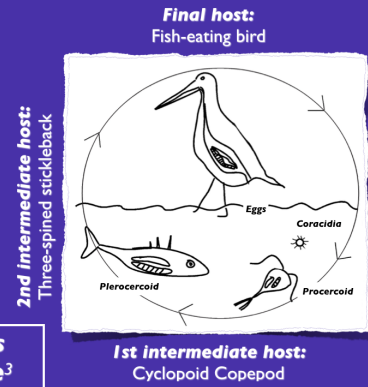
MAX-PLANCK-GESELLSCHAFT

Schistocephalus solidus is a parasitic tapeworm with a complex life cycle. A special characteristic of *S. solidus* is its extremely high specificity to its secondary host, the three-spined stickleback (*Gasterosteus aculeatus*), where it realizes its complete growth. This implies close co-adaptation and makes the stickleback-*S. solidus* system a very suitable model for experimental studies on reciprocal adaptation in host-parasite interactions^{1,2}.

We used lab-bred fish infected with worms from two different co-evolved populations (a Norwegian and a German one) to investigate the specificity of the host immune response at the gene expression level.



Schistocephalus solidus life cycle³

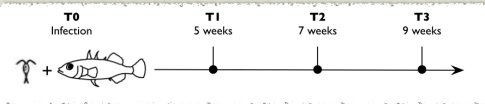


Experimental design

We used a fully crossed design to produce **sympatric** and **allopatric** combinations of three-spined stickleback infected with *S. solidus*.

Host origin \ Parasite origin	German	Norwegian	Control (un-infected fish)
German	DE-(DE)	DE-(NO)	DE-CTL
Norwegian	NO-(DE)	NO-(NO)	NO-CTL

The fish were dissected **5, 7 and 9 weeks post infection**. Parasite and relevant **immunological tissue** samples (headkidney and spleen) were harvested for expression studies.



Gene expression analysis and preliminary results:

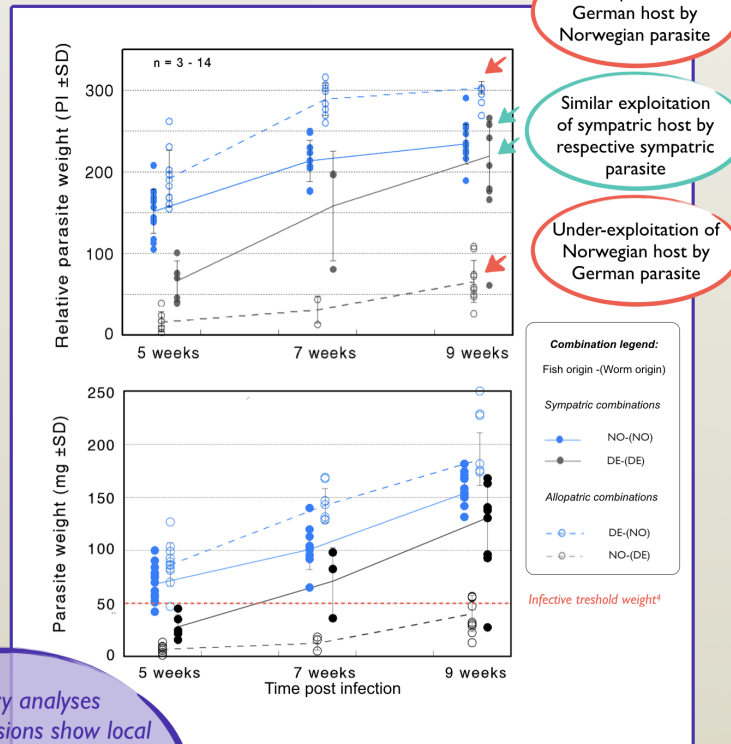
The gene expression of **8 immune relevant genes** has been analyzed by **Real-Time quantitative PCR** and calculation of relative expression ratios.

Gene name / abbreviation	Function	Immune pathway
Interleukin 1 Beta IL-1β	Cytokine	Innate immunity (Th1)
Tumor Necrosis Factor alpha TNFα	Cytokine	Innate immunity (Th1)
Transforming Growth Factor Beta 1 TGF-β1	Cytokine	Innate immunity (Th2)
Macrophage Migration Inhibitory Factor MIF	Lymphokine	Innate immunity
Toll-Like-Receptor 2 TLR2	Antigen recognition	Innate immunity
Superoxide Dismutase 2 SOD2	Antioxidant	Innate immunity
Major Histocompatibility complex class II Beta MHC class II β	Antigen recognition	Adaptive immunity
Immunoglobulin M IgM	Antibody	Adaptive immunity

Preliminary analyses of gene expressions show local adaptation in fish-worm pairs and divergent evolution for host resistance and parasite virulence in the two studied populations.

Phenotypic evidence for local adaptation

Sympatric combinations: potential optimal virulence
Allopatric combinations: potential maladaptation



Over-exploitation of German host by Norwegian parasite

Similar exploitation of sympatric host by respective sympatric parasite

Under-exploitation of Norwegian host by German parasite

Combination legend:
Fish origin - (Worm origin)

Sympatric combinations

- NO-(NO)
- DE-(DE)

Allopatric combinations

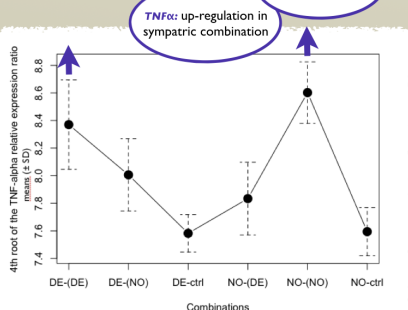
- DE-(NO)
- NO-(DE)

Infective threshold weight!

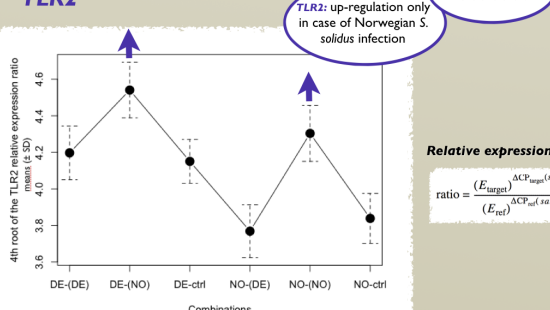
¹ Barber & Scharsack, 2009, Parasitology
² Milinski & Kurtz, 2009, Advances in Parasitology
³ Milinski, 2006, Integrative & Comparative Biology
⁴ Tierney & Crompton, 1992, The Journal of Parasitology
⁵ Pfaffl et al., 2001, Nucleic Acids Research

Mean expression of two immune genes (**TNFα** & **TLR2**) in the different combinations:

TNFα



TLR2



Relative expression ratio⁵

$$\text{ratio} = \frac{(E_{\text{target}})_{\Delta C T_{\text{sample}}}}{(E_{\text{ref}})_{\Delta C T_{\text{sample}}}}$$

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