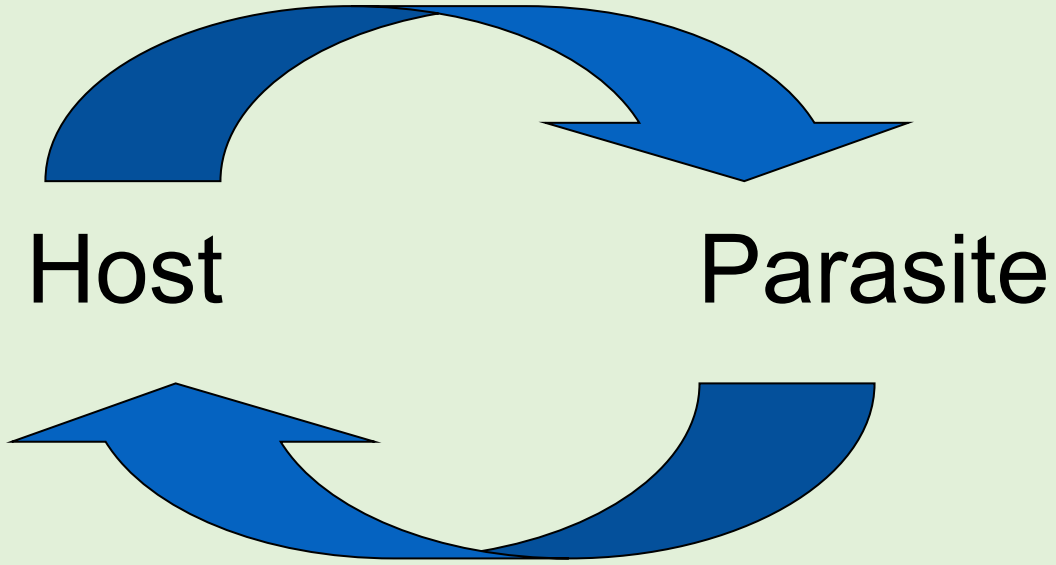
Project module / BSc topics in the Kurtz group

Background: Rapid coevolution of hosts and parasites
Evolutionary ecology of immune defenses



Red Queen Hypothesis:
Arms race between host and parasite
"In this place it takes all the running you can do, to keep in the same place."

Project module / BSc topics in the Kurtz group

Approaches: Laboratory and field work

Red flour beetle
(Mehlkäfer)
Tribolium castaneum

Three-spined stickleback
(Dreistachliger Stichling)
Gasterosteus aculeatus

Mexican tetra ('cavefish')
(Mexikanischer Höhlenfisch)
Astyanax mexicanus

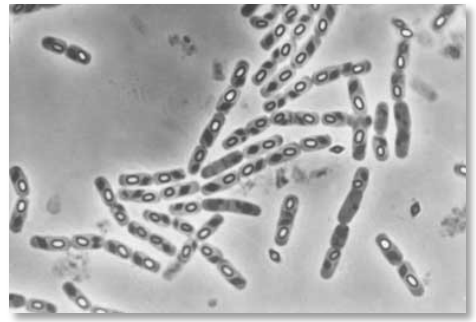
Supervisors:

Dr. Nora Schulz, Zoë Länger, Tobias Prüser

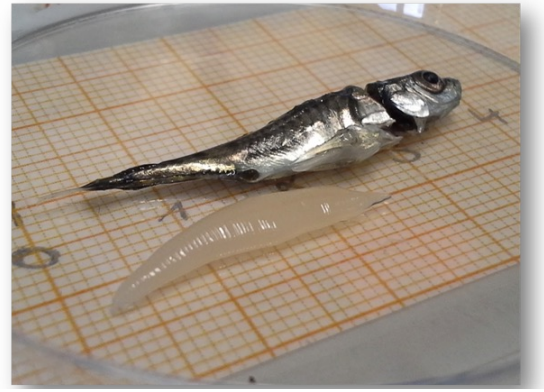
Dr. Jaime Anaya-Rojas, Maya Drakula

Dr. Robert Peuß, Marc Bauhus

Parasites



Bacterium
Bacillus thuringiensis



Tapeworm
Schistocephalus solidus

Exploring DNA Methyltransferase 1 activity in beetles with distinct methylation status

Supervisors: Zoe Länger and Dr. Nora Schulz

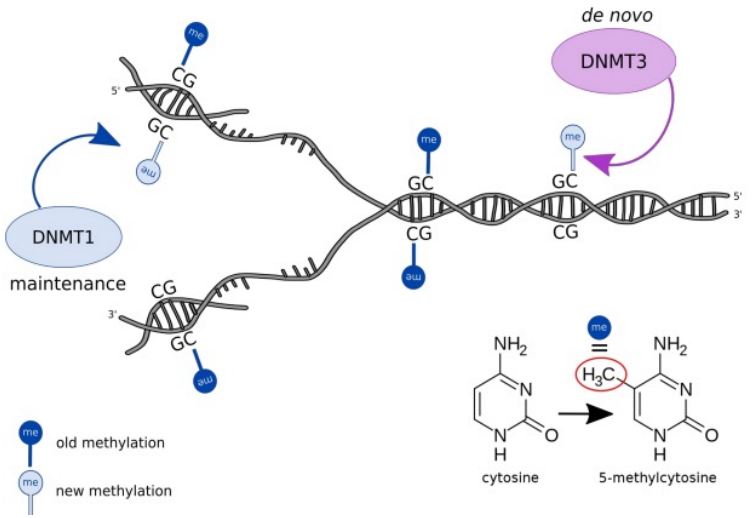
Background: In vertebrates, DNA methylation and histone modifications are key epigenetic mechanisms. Surprisingly, insects, particularly beetles, display diverse epigenetic regulation. Some beetle species lack DNA methylation, with partial or complete loss of DNA methyltransferase, *Dnmt* genes. Knockdown of these genes can have lethal effects, indicating additional functions beyond DNA methylation.

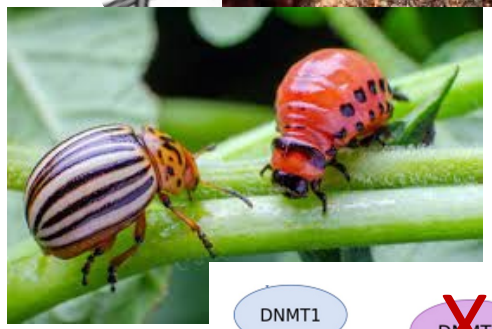
Aim: Investigating DNMT1 DNA methylation activity in beetles with and without DNA methylation, using DNMT activity assays. Using chemical inhibition of the methylation site to compare phenotypes to those of DNMT1 gene knockdowns.

Methods: Molecular work, establishing bioassays, DNMT1 chemical inhibition or knockdown via RNAi

Literature:

- Glastad, K. M., Hunt, B. G., & Goodisman, M. A. (2014). Evolutionary insights into DNA methylation in insects. Current Opinion in Insect Science, 1, 25-30
- Kausar, S., Abbas, M. N., & Cui, H. (2021). A review on the DNA methyltransferase family of insects: Aspect and prospects. International Journal of Biological Macromolecules, 186, 289-302.
- Schulz, Nora KE, et al. "Dnmt1 has an essential function despite the absence of CpG DNA methylation in the red flour beetle *Tribolium castaneum*." Scientific reports 8.1 (2018): 16462





Unraveling the Beetle Beat: Investigating Circadian Clock Mechanisms in *Tribolium castaneum*

Supervisors: Tobias Prüser & Dr. Nora Schulz

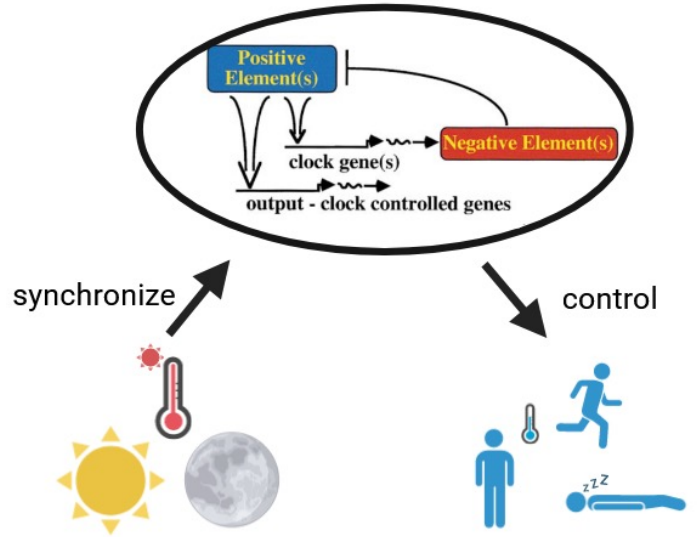
Background: Internal clocks, which are present in almost all organisms are synchronized with the environment and control both physiological and behavioural processes. In insects, we observe a wide variation in oscillator mechanisms, but for most species the genetic underpinnings remain unknown.

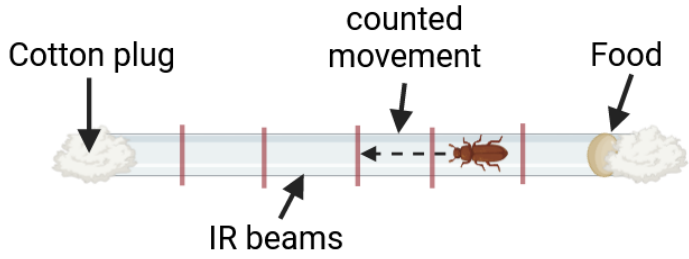
Aim: We will investigate the expression patterns and behavioral control function of the negative regulator genes *timeless*, *period* and *cryptochrome-2*. This will help us to understand the mechanisms of the circadian clock in the red flour beetle and allow us to further investigate the cause of the variation in its behavioral patterns.

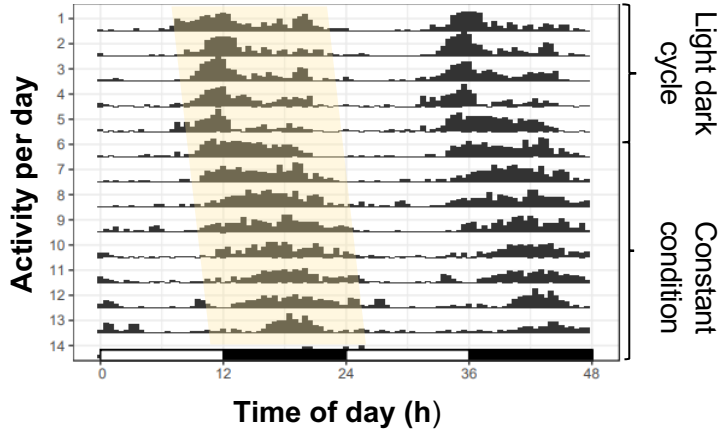
Methods: Gene expression analysis (RT-qPCR) , knockdown via RNAi, Locomotor activity assays

Literature:

- Beer, K.; Helfrich-Förster, C.: Model and Non-model Insects in Chronobiology. Frontiers in behavioral neuroscience, 2020.
- Benita, M.; *et al.*: Inter- and intraspecific female behavioral plasticity drive temporal niche segregation in two Tribolium species. Behavioral Ecology, 2024.
- Li, C.-J.; et. al: Functional analysis of the circadian clock gene *timeless* in *Tribolium castaneum*. Insect science, 2018.







Unveiling Hidden Traits: Hsp90 Inhibition and Beetle Eye Phenotypes

Supervisor: Dr. Nora Schulz

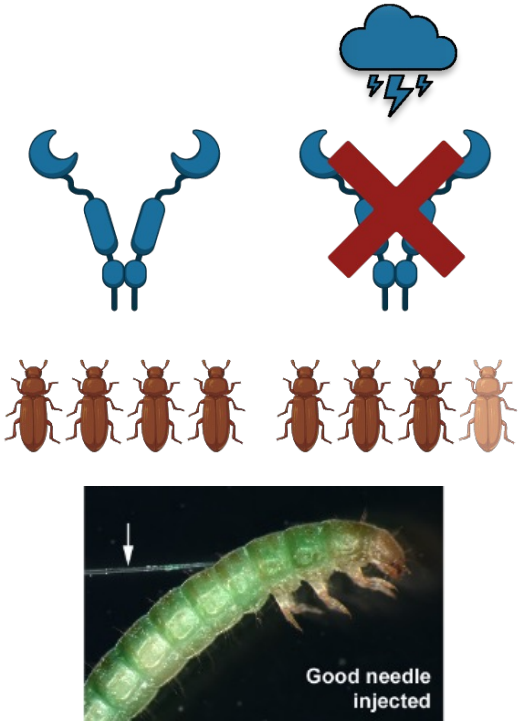
Background: Stress-induced release of cryptic genetic variation occurs when the chaperone protein Hsp90 is compromised, revealing previously hidden adaptive traits. This mechanism has been documented in various insects, where it influences evolutionary dynamics by assimilating new phenotypes into populations.

Aims: This project will focus on breeding heterozygous flour beetles carrying the recessive reduced eye trait and experimentally inhibiting Hsp90 to trigger its phenotypic expression. We will test the hypothesis that Hsp90's absence exposes this cryptic trait. Additionally, the study will examine the *atonal* gene's role in the manifestation of the reduced eye phenotype.

Methods: gene expression analysis (RT-qPCR) , RNAi, chemical inhibition assay, phenotyping

Literature:

- Aboelsoud, R., Kurtz, J. An HSP90-regulated reduced-eye phenotype in Tribolium shows fitness benefits and thus provides evidence for evolutionary capacitance *bioRxiv* 690727 (2019).
- Rutherford SL, Lindquist S. Hsp90 as a capacitor for morphological evolution *Nature* 396(6709):336-42. (1998)
- Takahashi, K.H. Multiple capacitors for natural genetic variation in *Drosophila melanogaster*. *Mol Ecol*, 22: 1356-1365. (2013)



normal eye

reduced eye

Can the effects of virulence of a manipulative parasite alter community dynamics?

Supervisors: Maja Drakula and Dr. Jaime Anaya-Rojas

Model system: host = Three-spined sticklebacks (*Gasterosteous aculateus*)
pathogen = Tapeworm (*Schistocephalus solidus*)

Background: Trophically transmitted parasites have strong effects on their host; however, whether these effects are strong enough to alter ecological dynamics is still unknown.

Aim: We will measure the effects of *S. solidus* on three-spined sticklebacks and their effects on multiple aspects of stickleback's interactions with their environments such as feeding behavior **(student 1)** and their impact on ecosystem functioning (**student 2**).

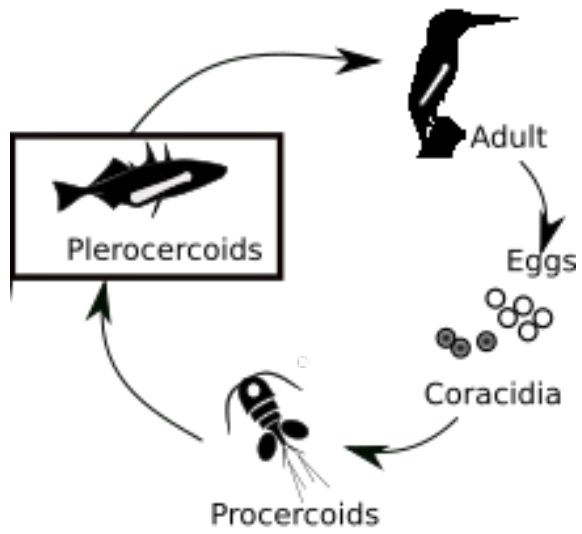
Methods: Mesocosm experiments, Fish rearing, phenotyping, animal identification, dietary analyses, community ecology, and ecosystem measurements.

Literature:

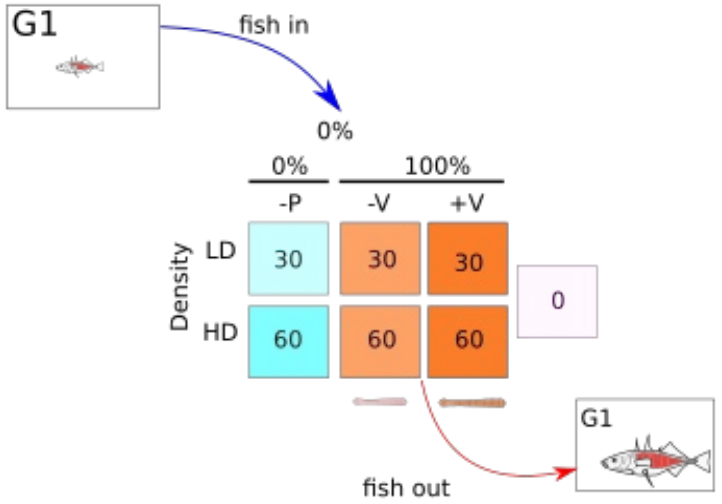
1.Anaya-Rojas, J. M. *et al.* *Ecology* e02744 (2019) doi:10.1002/ecy.2744.

2.Brunner, F. S., Anaya-Rojas, J. M., *et al Proc National Acad Sci* **114**, 3678–3683 (2017).

***S. solidus* life cycle**



Experimental design



Immunological responses of cavefish to their natural parasites

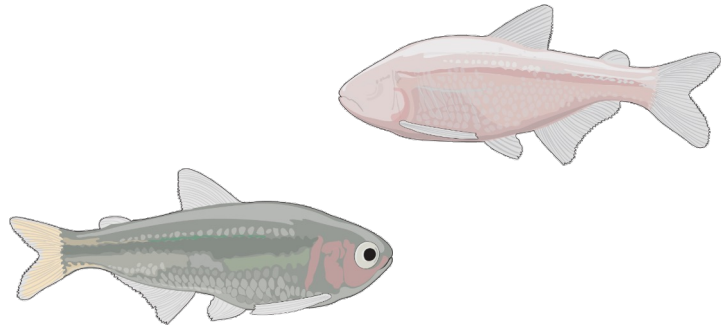
Supervisors: Marc Bauhus and Robert Peuß

Model system: host = Mexican cavefish (*Astyanax mexicanus*)
pathogens = parasite isolates from caves

Background: *A. mexicanus* consists of several different ecotypes (mainly cave and river ecotypes) that differ in various traits, including immune relevant traits, due to adaptations to different ecosystems. Here, we try to understand how different ecological factors affect the evolutionary trajectory of the host immune system.

Aim: We will measure the effects of parasitic antigens, that we collected in the field, on leucocytes from different *A. mexicanus* ecotypes to test how adaptations to different environments alter immunological responses.

Methods: Fish dissections, primary cell culture methods, various mol bio methods



Literature: Peuß R et al., 2020: Adaptation to low parasite abundance affects immune investment and immunopathological responses of cavefish. *Nat. Ecol. Evol.*: 4: 1416-1430. doi: 10.1038/s41559-020-1234-2