

Effects of warm and cold rearing temperature on cardiorespiratory function and environmental stress tolerance in rainbow trout

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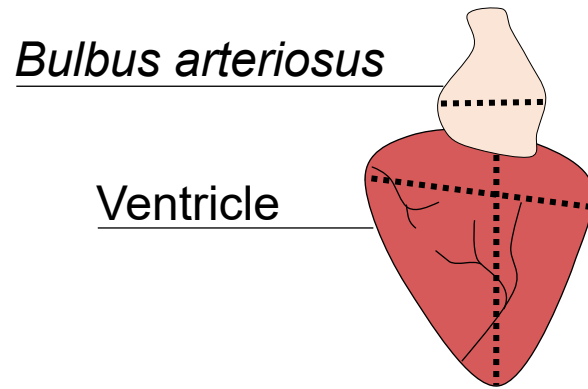


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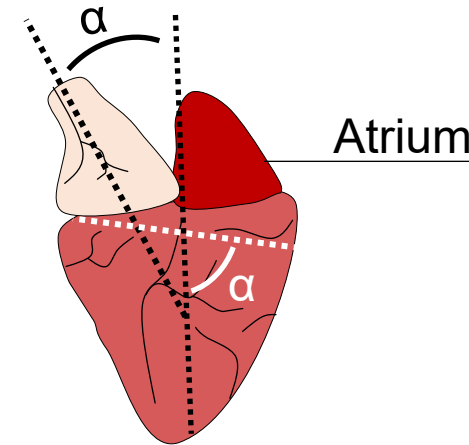
Deviating heart morphology in farmed salmonids



Height and width ratios



Bulbus alignment & ventricular symmetry



Observed in Atlantic salmon and rainbow trout

(Poppe et al. 2003, Brijs et al. 2020, Frisk et al. 2020, Vindas et al. 2024, Hvas et al. 2025)

Deformities associated with warm rearing conditions during juvenile phase

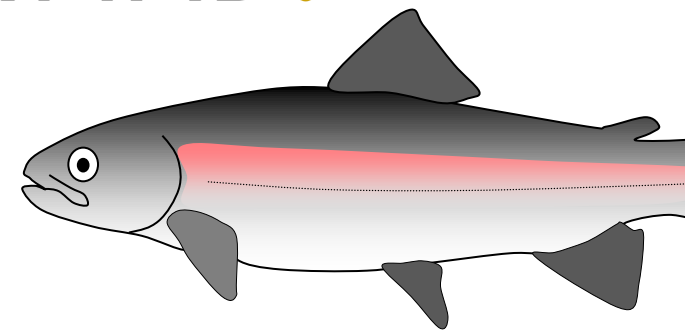
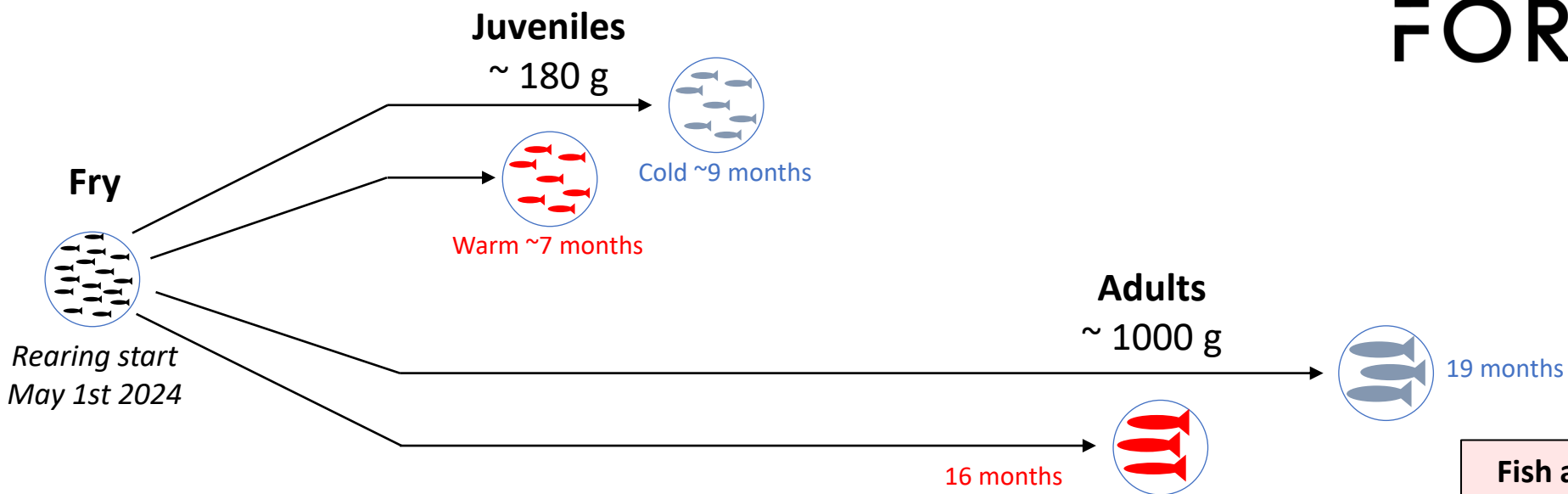
(Frisk et al. 2020, Vindas et al. 2024, Hvas et al. 2025, Brijs et al. 2020)

How do such deformities impact physiological performance and stress resilience?

Warm- & cold reared rainbow trout

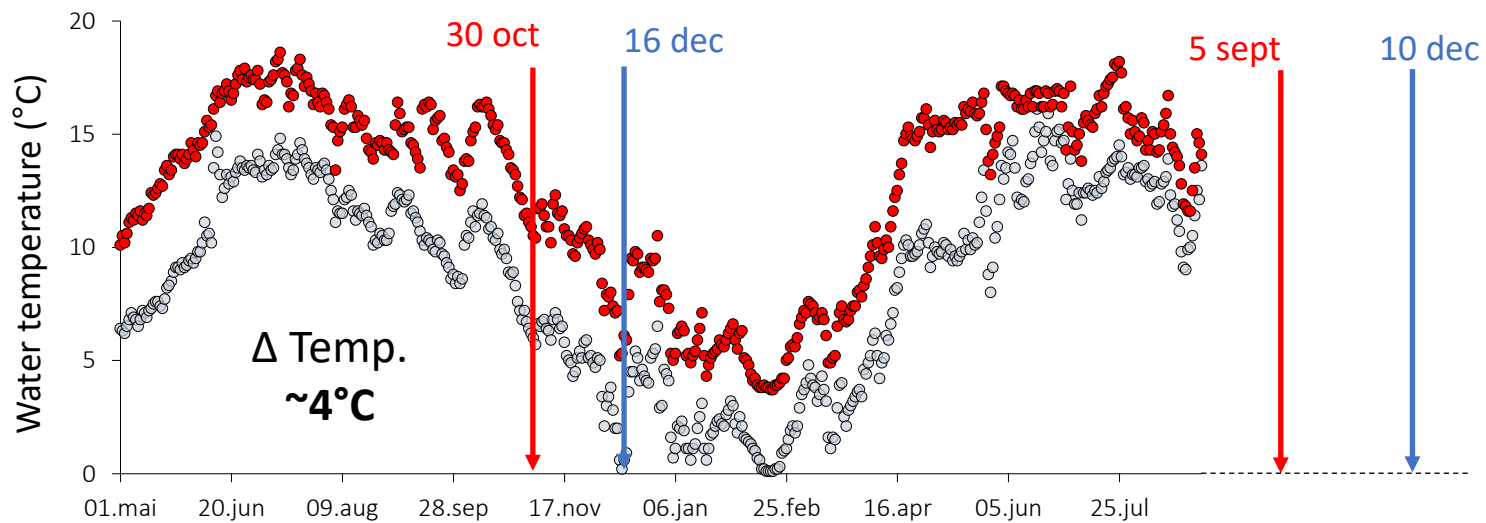
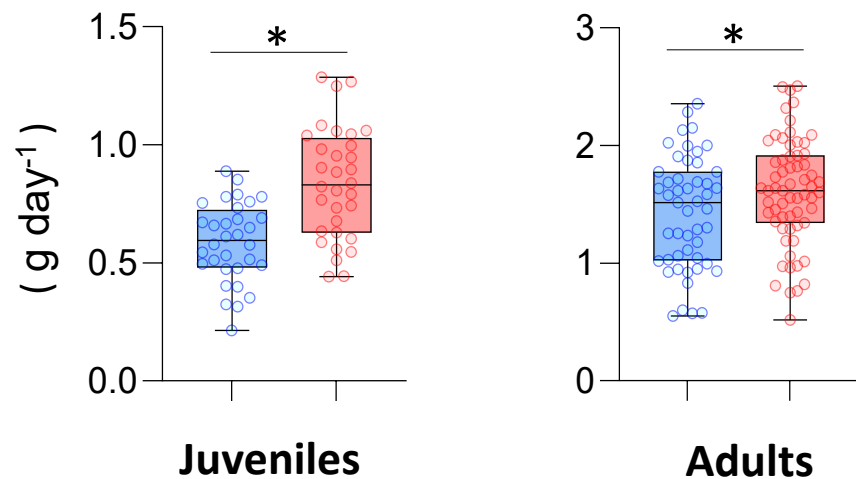


FORMAS



Fish acclimated to 10°C for a month prior to experiments

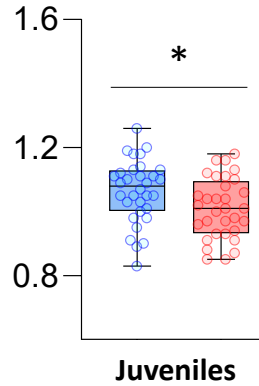
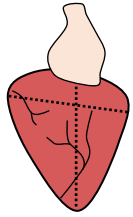
Absolute growth rate



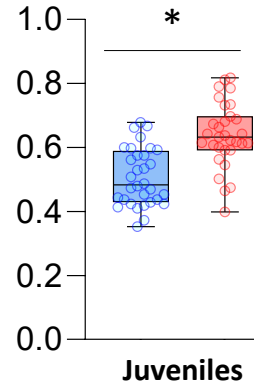
Impacts on cardiac morphology



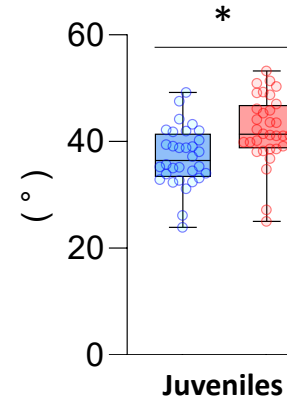
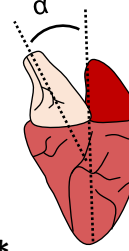
Ventricle
Height:Width Ratio



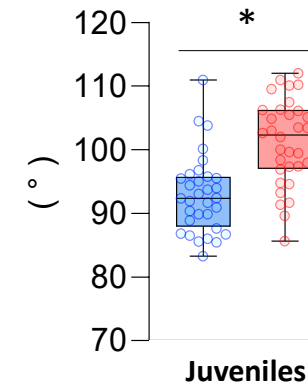
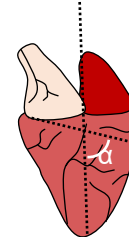
Bulbus:Ventricle
Width Ratio



Bulbus:Ventricle
Alignment (°)



Ventricular
Symmetry (°)



Juveniles, N = 32 / group

Warm reared trout exhibit;

- Rounder ventricles
- Higher Bulbus:Ventricle width ratio
- More misaligned outflow tracts
- Ventricular asymmetry

Are cardiac deformities associated with compromised physiological performances?

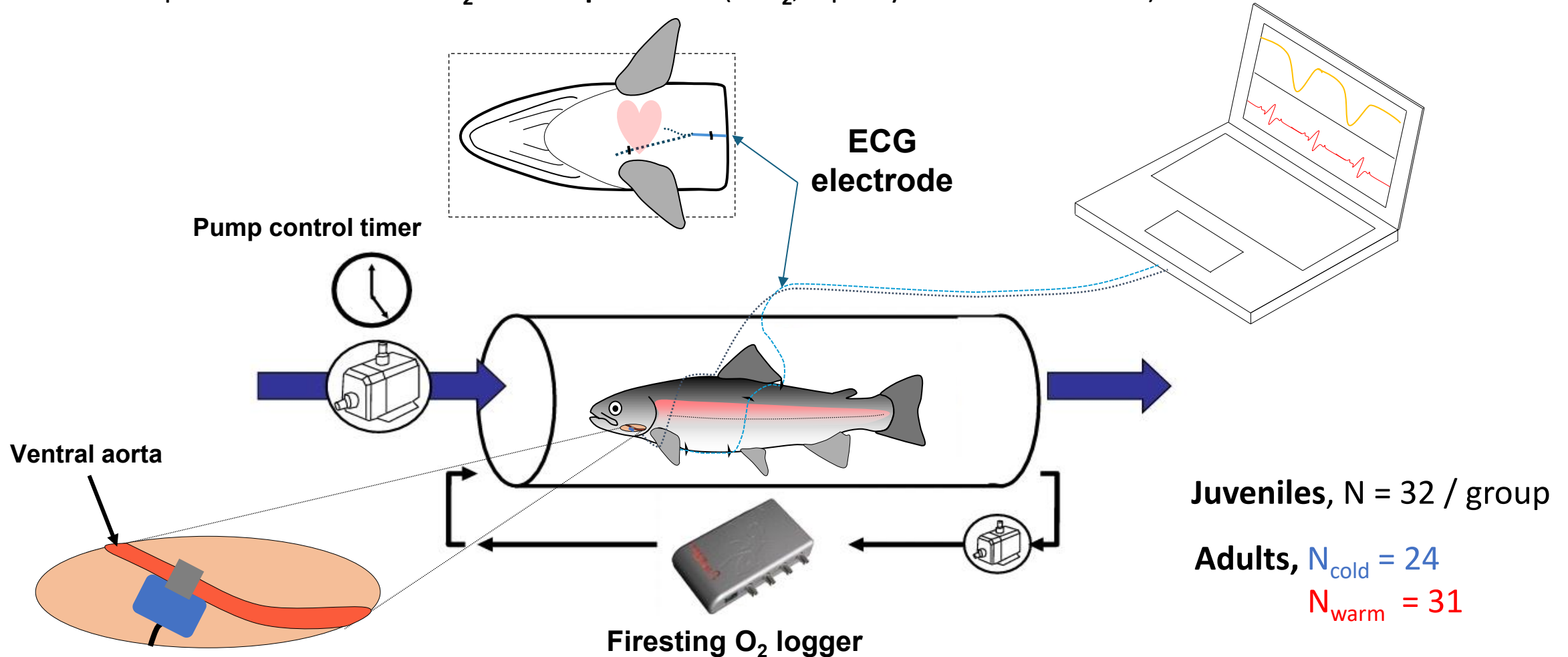
Physiological Measurements



Fish surgically instrumented with electrodes to record the **ElectroCardioGram (ECG) & heart rate**

Adult fish instrumented with Transonic blood flow probe around ventral aorta to record **cardiac output & stroke volume**

Placed in respirometers to record **O₂ consumption rate (MO₂, a proxy for metabolic rate)**



Physical stress protocol - Juveniles



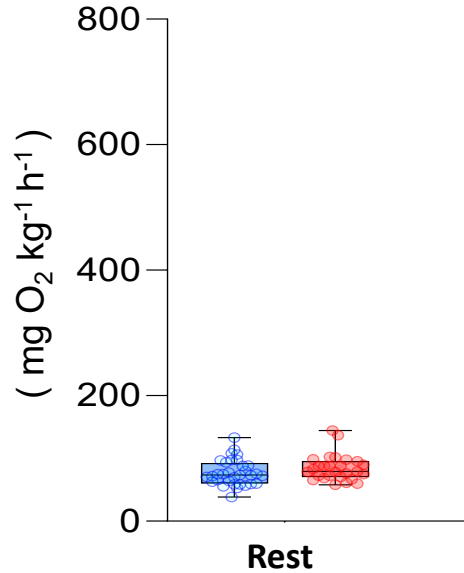
Resting metabolic rate and heart rate attained overnight

Chase protocol to attain **maximum** metabolic rate and heart rate

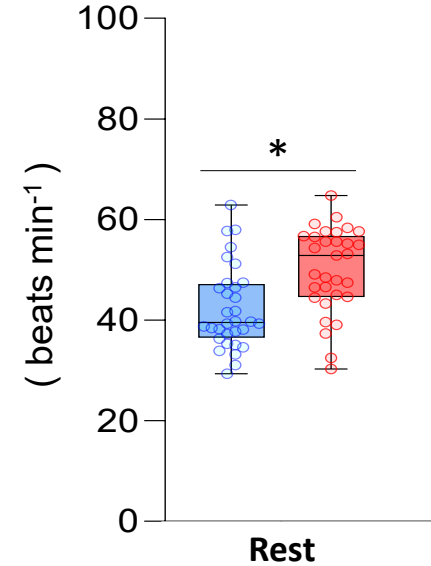
Maximum rate – Resting rate → **Scope** for metabolic rate (*aerobic scope*) and heart rate

■ Warm reared ■ Cold reared

Metabolic rate



Heart rate

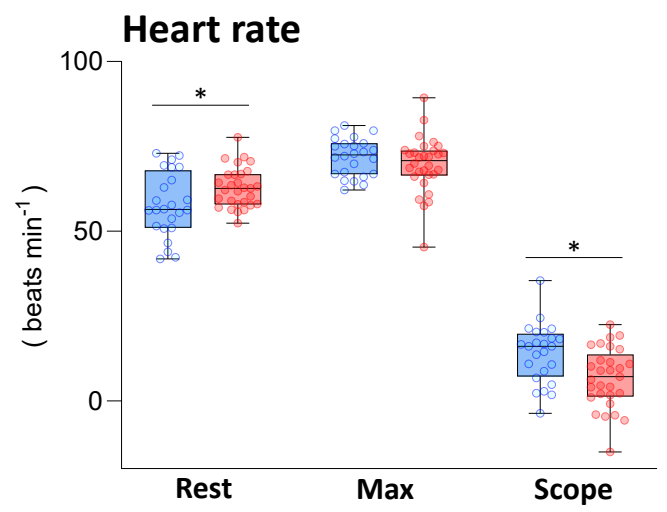
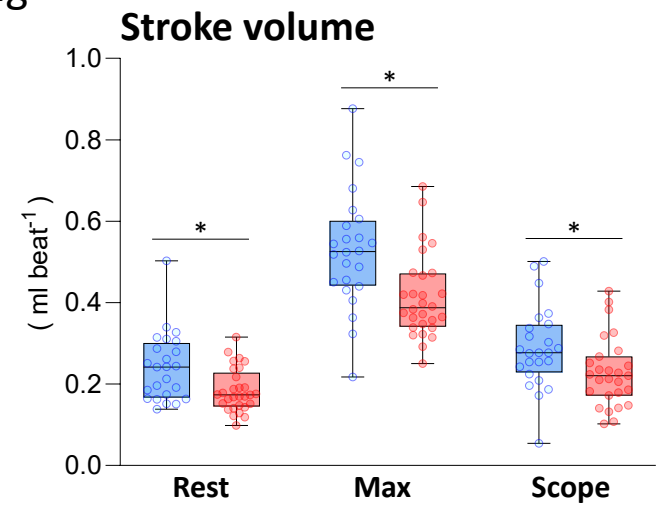
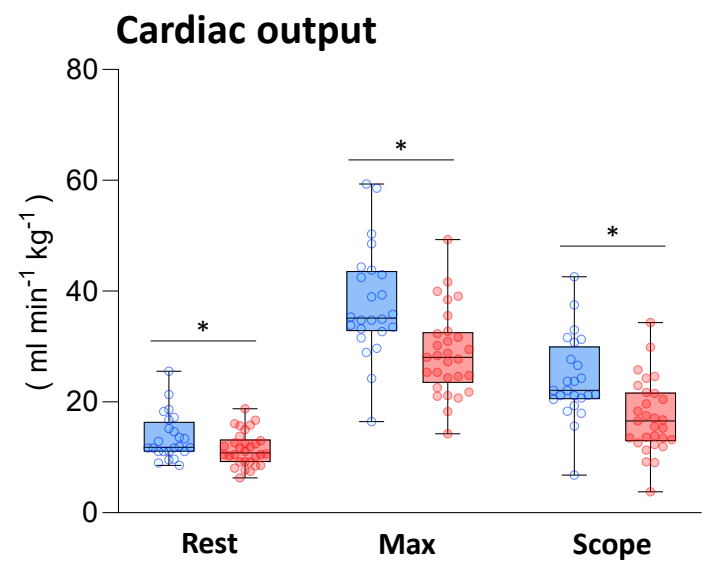
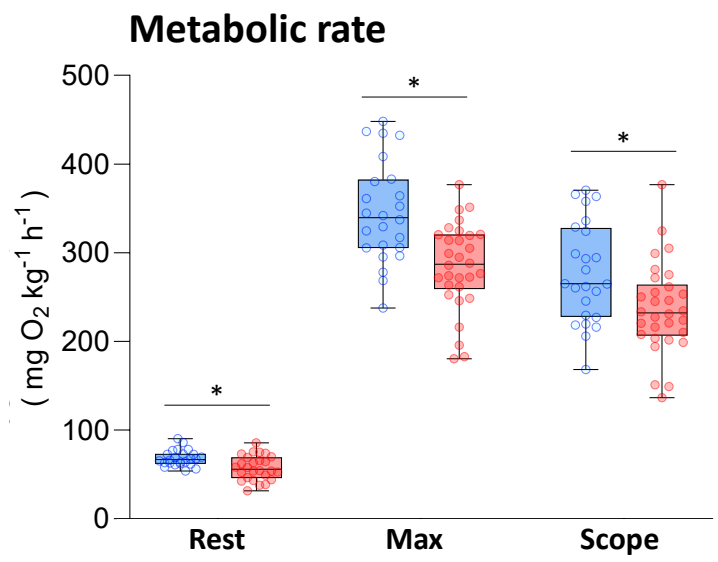


Physical stress protocol - Adults



Resting Metabolic rate, Cardiac output, Stroke volume, Heart rate recorded in the morning

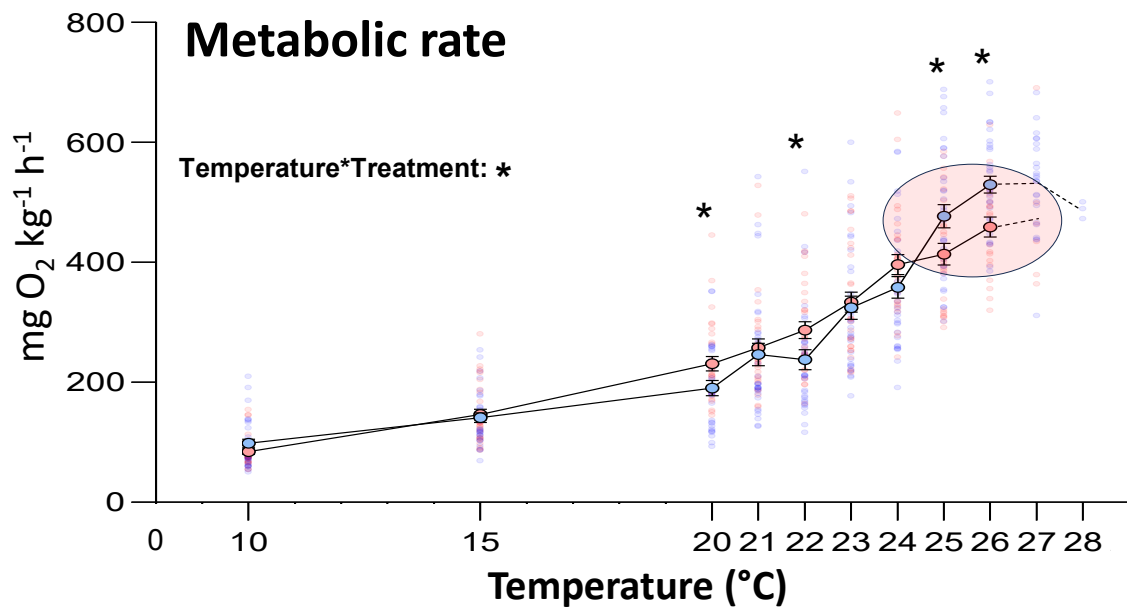
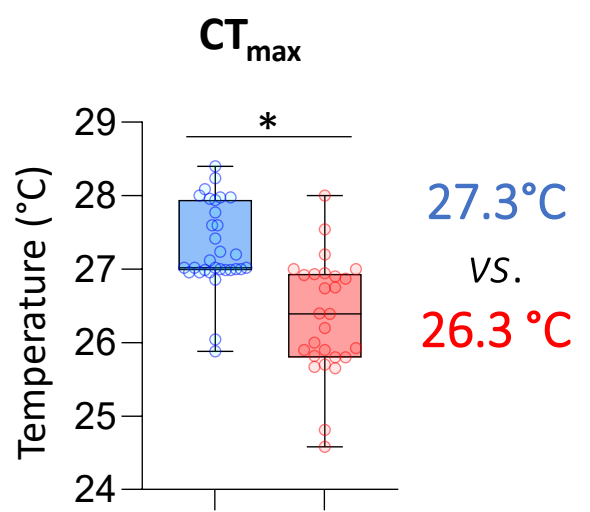
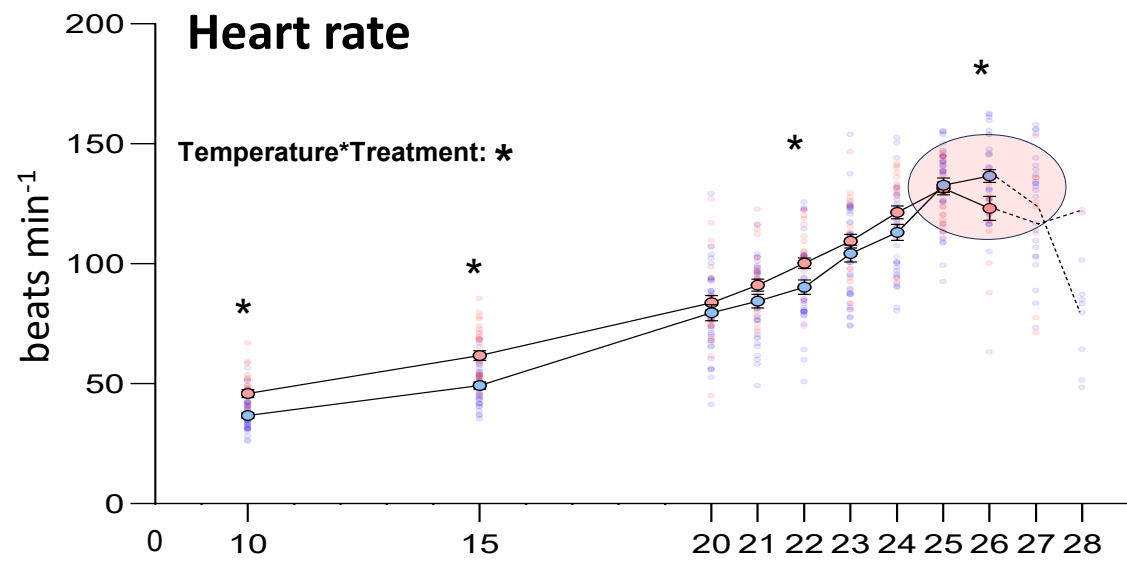
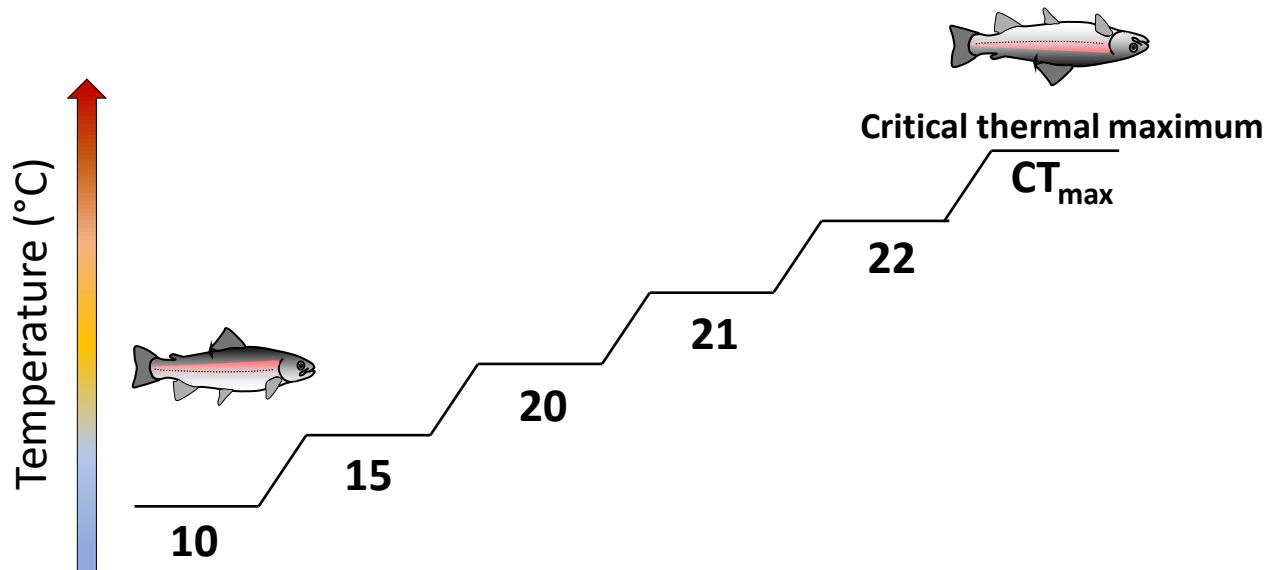
Chase protocol → Maximum performances and scope



Warm rearing impair cardiac performance and metabolic capacity during physical stress across life stages!

Do warm rearing compromise tolerance to environmental stressors?

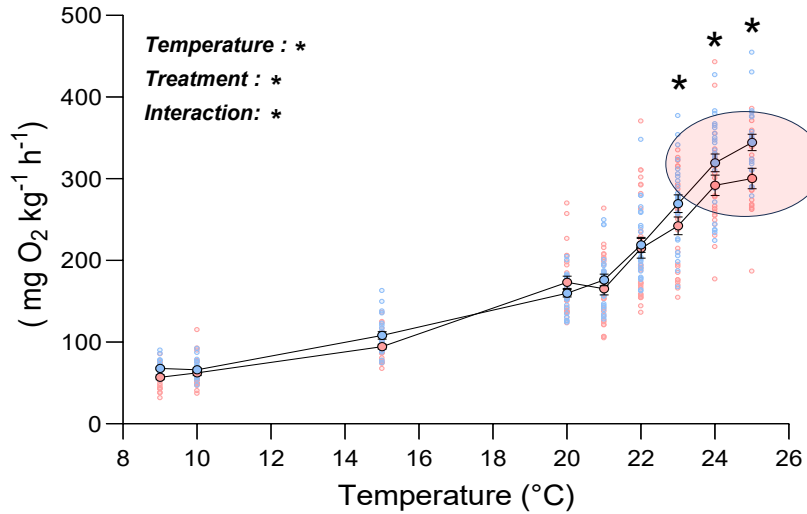
Heat stress protocol - Juveniles



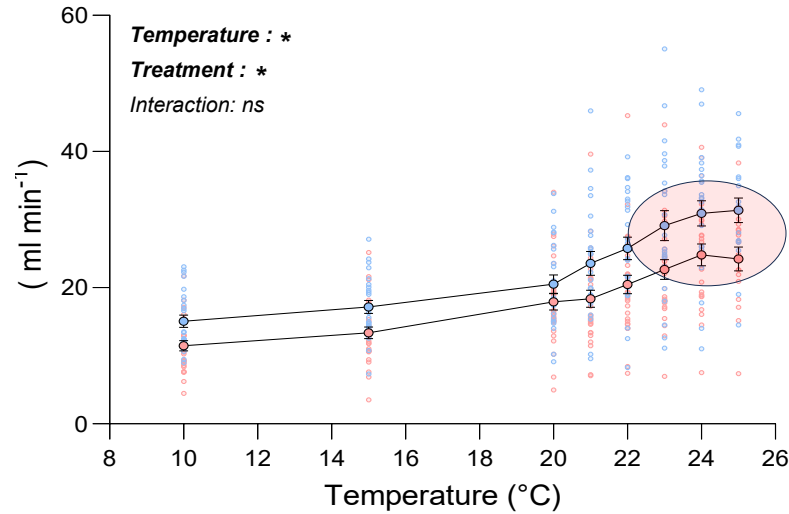
Heat stress protocol - Adults



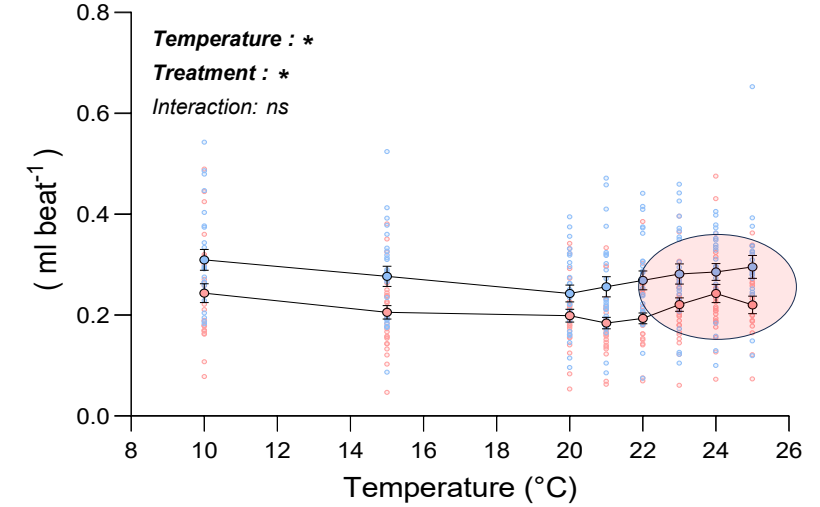
Metabolic rate



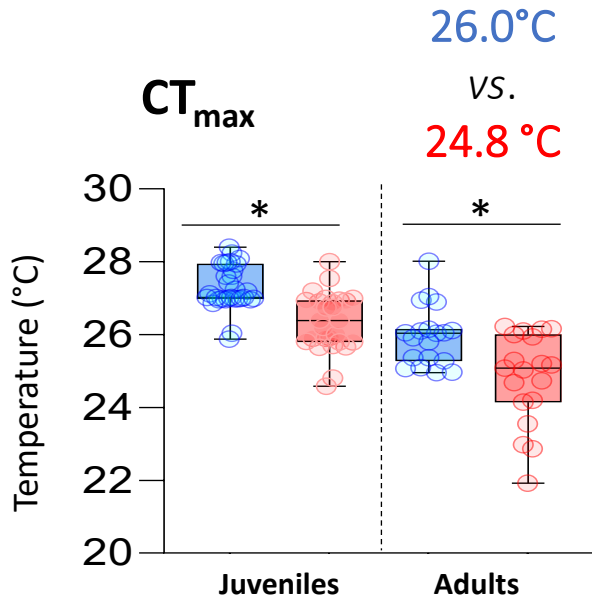
Cardiac output



Stroke volume

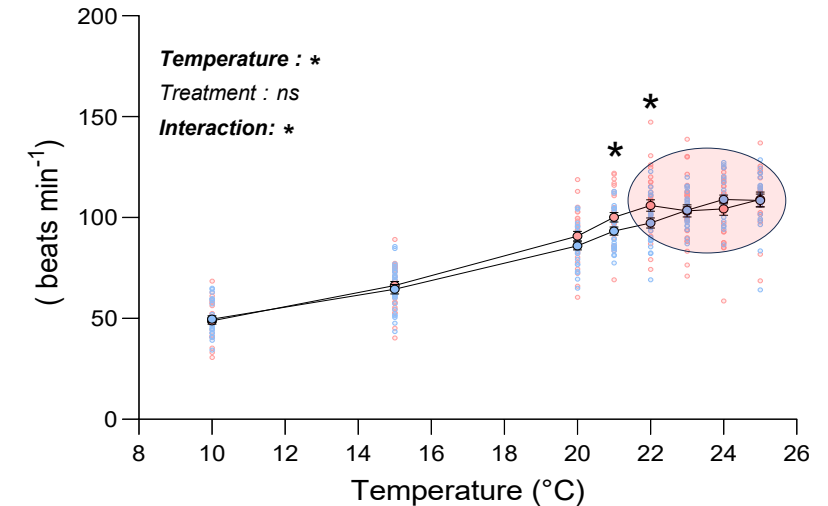


CT_{max}



Warm rearing impair
cardiometabolic performance during
warming, and reduce warming
tolerance across life stages!

Heart rate



Take Home Messages (so far...)



Warm rearing promotes growth rate in rainbow trout, BUT;

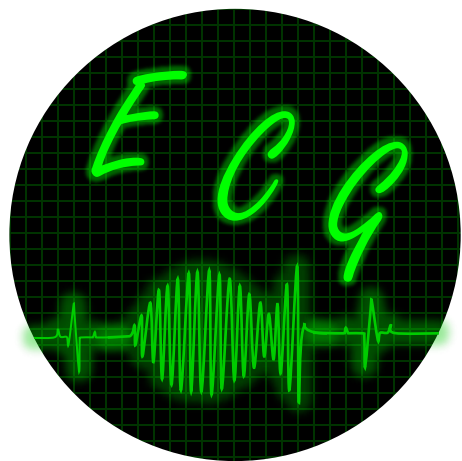
- Cause cardiac deformities
- Impedes cardiac and metabolic performances
- Lower warming tolerance

Fast-growing fish \neq Robust and stress resilient fish

More to come;

- Echocardiography recordings
- Ventral aortic blood pressure
- Histological assessments of ventricular morphology and pathology
- Prevalence and severity of coronary arteriosclerosis
- Link cardiovascular deviations to performance traits

Erik Sandblom
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Elin Egholm
Michael Frisk
Ida Beitnes Johansen
Daniel Morgenroth
Lucas Zena
Helene Wisløff



Jeroen Brijs
Erika Sundell
Ulla Saarinen
Xhoni Dalipi

FORMAS 

Innovation Fund Denmark



knowledge for sustainable aquaculture



Swedish University of
Agricultural Sciences



Norwegian
University of
Life Sciences



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Thanks for
listening!

PHARMAQ

Analytiq

