Restless nights when sick: ectoparasite infections alter rest-activity cycles of diurnal fish hosts

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Circadian rhythms

- Timekeeping mechanisms responsible for the cyclic repetition of metabolic, behavioural and psychological processes, typically over a 24-hour period[1].
- Generated by self-sustaining biological clocks, encoded by "clock genes" and entrained by environmental cues such as light and temperature[2].
- Observed in fish of economic importance, govern functional activities from reproduction and maturation to immune responses and disease susceptibility[3].
- Critical in the co-evolution of host-parasite systems, as synchronisation of parasite rhythms to the host can influence infection dynamics and transmission[4].
- Disruption of biological clocks can adversely impact animal health[5].

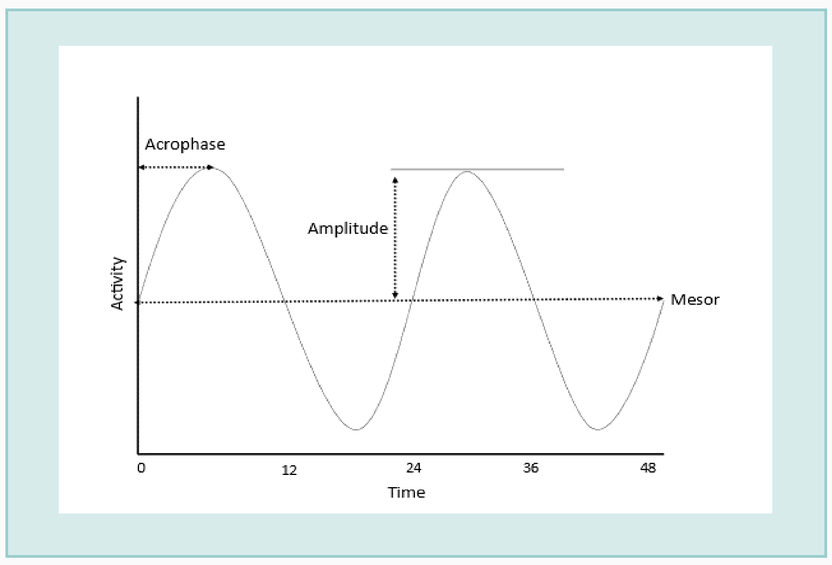
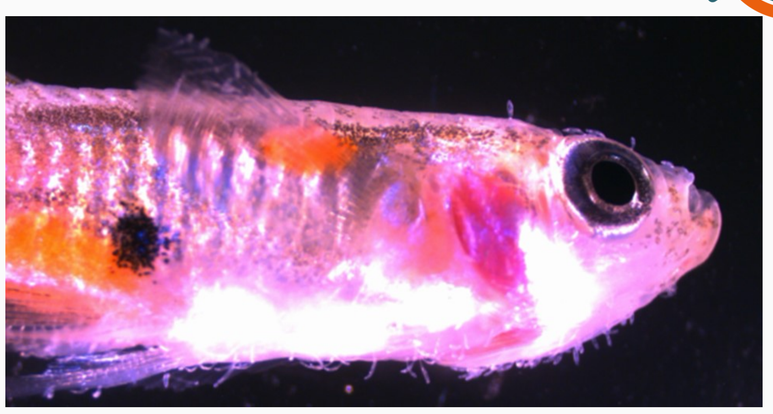


Figure 1. Variables assessed by the 'circacompare' statistics package in each rhythm and then compared between rhythms (including mesor, the rhythm-adjusted mean level; amplitude, half the extend of predictable variation; and acrophase the time the response variable peaks).



Methods

1. Automated monitoring of host behaviour

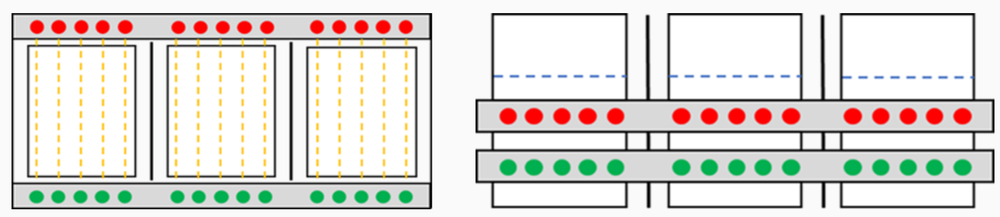


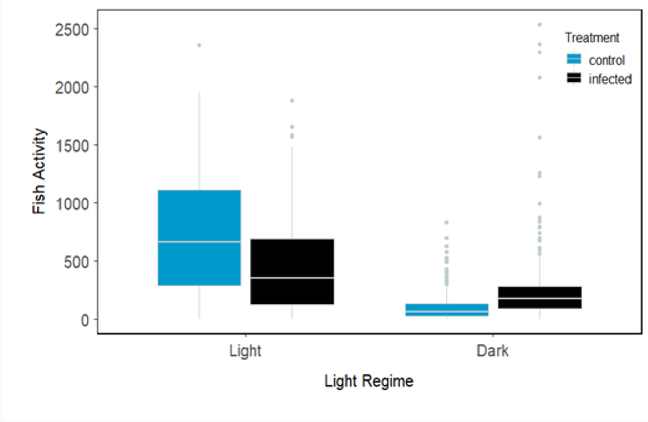
Figure 2. Schematic showing the guppy behavioural arrays. **a.** Birds eye view of the arrays with five infrared beams (yellow dotted line) going through each fish tank from the light emitters (green) to the light receivers (red). **b.** Side view of the arrays with two rows of monitors outside of each tank with the light emitters going through the tank to the receivers. The water level is indicated (blue dotted line) along with the paper dividers between the tanks (black line).

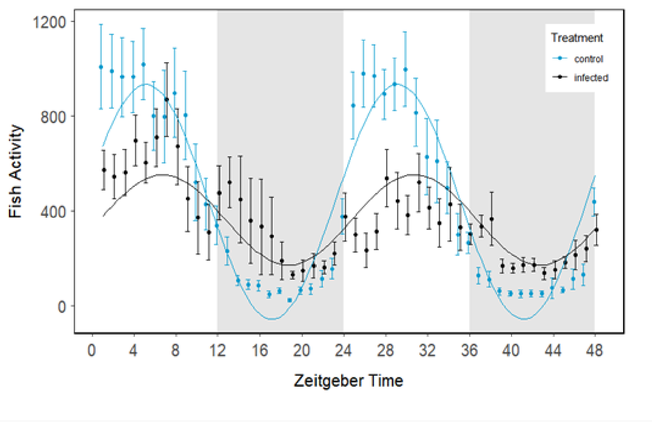
2. Monitoring of parasite activity

Figure 3. The rhythmical variance in parasite activity was studied under two light regimes (12:12 h light: dark and 24 h constant darkness), where the host-seeking motion of the parasite (number of probes as part of their exploratory behaviour) was monitored at different timepoints throughout the day.

Results

Parasites alter host circadian rhythms, resulting in greater nocturnal restlessness both individually and in shoals.

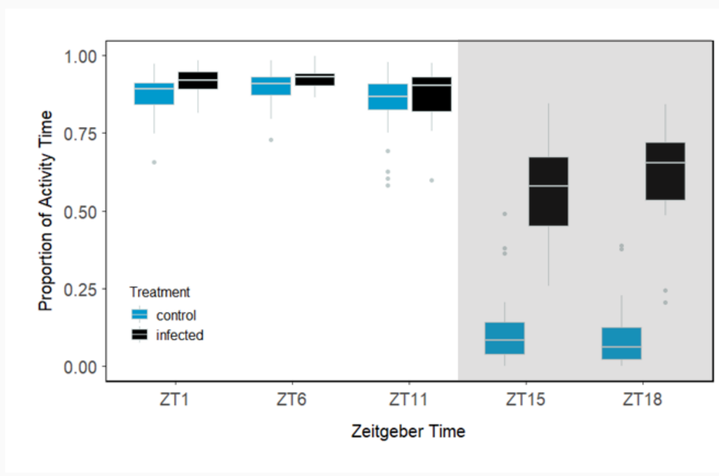


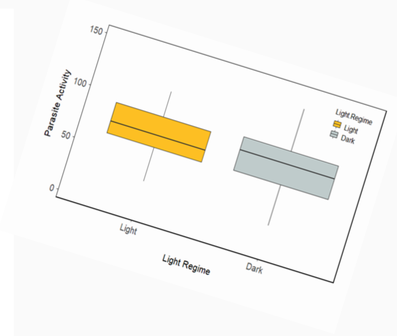


Circadian rhythmicity in activity was present and distinctly different between uninfected and infected fish.

Changes in rhythmical variance may be driven by adaptive immune responses to infection, which are elevated at night.

The use and application of chronotherapy to maximize treatment efficacy could be a potential solution to the problem of infectious diseases.





Parasite behaviour and activity do not exhibit a daily rhythmical variance, but peaks in the dark, coinciding with infected fish behaviour.

Check out the video explaining the study

[1]Sollars, P.J. and Pickard, G.E. 2015. The neurobiology of circadian rhythms. *Psychiatric Clinics of North America* 38(4), pp. 645–665.
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[3]Reebs, S.G. 2002. Plasticity of diel and circadian activity rhythms in fishes. *Reviews in Fish Biology and Fisheries* 12(4), pp. 349–371.
[4]O'Donnell, A.J., Schneider, P., McWatters, H.G. and Reece, S.E. 2011. Fitness costs of disrupting circadian rhythms in malaria parasites. *Proceedings of the Royal Society B: Biological Sciences* 278(1717), pp. 2429–2436.
[5]Bass, J. and Lazar, M.A. 2016. Circadian time signatures of fitness and disease. *Science* 354(6315), pp. 994–999.

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