Project *brief*

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Automated detection of fish activity in recirculating aquaculture systems

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- **The behaviour of fish can provide information about the state of animal welfare.**
- **Behavioural changes can only be identified if the baseline activity of the fish is known.**
- **A method using radio waves and RFID transponders was tested to automatically record the activity of rainbow trout inside recirculating aquaculture systems.**
- **The baseline activity recorded at optimal plant functionality serves as a reference in order to identify behavioural changes that may occur during critical a plant status and critical husbandry conditions.**

Background and aims

Recirculating aquaculture systems (RAS) are modern production systems for the controlled rearing of aquatic organisms. The various technical components of RAS are continuously monitored in order to safeguard optimal rearing conditions inside these systems. To date, however, there is no established procedure that provides information on the organisms reared inside RAS.

Information on behaviour and activity of the reared fish is of great interest for various reasons. Suboptimal rearing conditions, stress inside the rearing units and also diseases often first become apparent through changes in behaviour. The animals themselves act as a kind of biosensor. Activity and behaviour can thus provide information about husbandry conditions inside RAS. Hence, deviations from baseline activity can indicate issues within the rearing system. In addition, behaviour as well as deviations from standard behavioural patterns can serve as welfare indicators and possibly be used as threshold for online monitoring of RAS functioning and within alarm systems.

Approach

The project investigated whether the behaviour of rainbow trout inside RAS can be automatically recorded by means of RFID (radio frequency identification) transponders and accelerometers. Two experiments were conducted in order to investigate whether the behaviour of the reared fish changes during a critical plant status or at suboptimal rearing conditions that potentially may compromise welfare of the reared animals. A triggered failure in the single circulating pump was selected as an example for a critical plant condition. For the second experiment, a range of stocking densities served as an example for potentially suboptimal rearing conditions. It should be determined whether the used sensor systems can automatically record data that help to detect any resulting behavioural changes. In addition, it should be evaluated whether these changes can be recorded and distinguished from baseline behaviour. Baseline activity was determined during times of optimal system functioning.

Results

The two experimental approaches revealed that the behaviour of rainbow trout can be recorded automatically using both RFID transponders as well as accelerometers. The collected data allowed to derive a baseline activity of the reared fish which was determined during times of optimal system functioning. Baseline activity served as a reference and is specific for each rearing system. Both sensor systems allowed to record a diurnal behavioural pattern that is typical for farmed rainbow trout (Fig. 1).

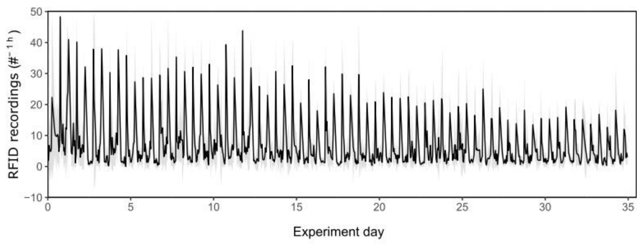

Figure 1: Mean baseline activity of rainbow trout inside RAS collected by means of a RFID system during an experimental trial of 35 days. Grey shaded areas indicate standard deviation.

When compared to the data recorded during optimal system functioning, the triggered failure in the circulation pump prompted strong behavioural changes in the fish that could also be clearly recognized visually (Fig. 2). This change in behaviour could be recorded automatically and distinguished from baseline activity.

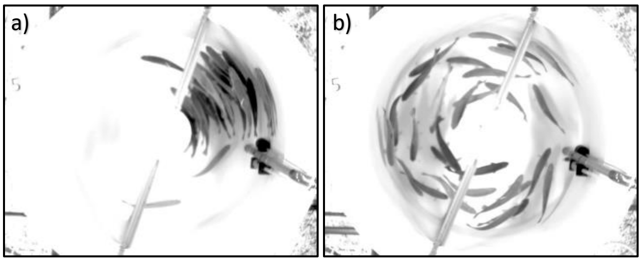

Figure 2: Top view of the rearing tank of small-scale RAS stocked with rainbow trout during (a) optimal system functioning and (b) during a triggered technical failure in the circulating pump.

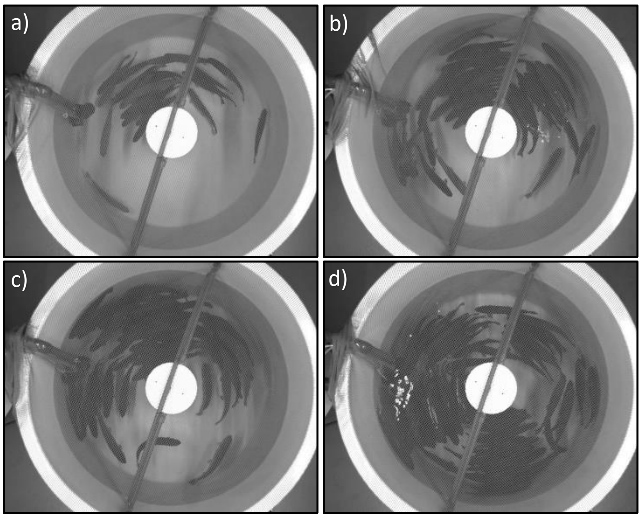

Figure 3: Top view of the rearing tank of small-scale RAS stocked with rainbow trout during the experiment on “stocking density”. Images show densities of (a) 20, (b) 40, (c) 60 und (d) 80 kg m^{-3}.

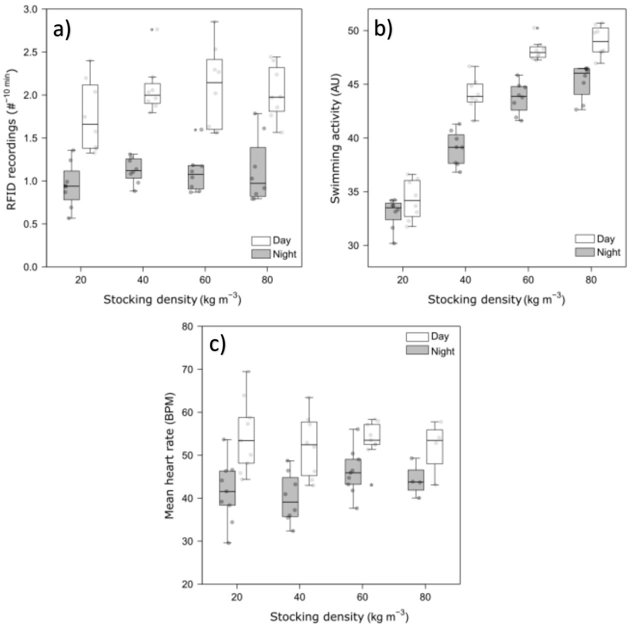

Figure 4: Data collected from rainbow trout using three different sensor types at stocking densities of 20, 40, 60 und 80 kg m^{-3}. (a) Mean baseline activity collected via RFID transponders, (b) swimming activity collected via accelerometers and (c) heart rate.

At stocking densities between 20-80 kg m^{-3} (Fig. 3), rainbow trout showed a diurnal behavioural pattern typical for the species. At all densities, activity could be recorded automatically. The RFID system for the collection of behavioural data, however, proved robust towards increasing stocking densities (Fig. 4a). The accelerometer tags allowed to collect data, showing an increase in activity with higher stocking density (Fig. 4b). Heart rate, with increases being indicative for stress, did not change over the different stocking densities (Fig. 4c). Within the examined test environment, stocking densities between 20-80 kg m^{-3} therefore proved to be an insufficient stressor.

The results of the project show the opportunities for the automated recording of fish behaviour inside RAS. Due to the high level of mechanization, RAS provide an ideal environment to apply automated methods to collect data on fish activity. The collected information may also be integrated into the visualization of RAS. Via threshold values, it is also possible to include the data into an alarm system for monitoring of RAS. In this way, information on the reared organisms may be recorded immediately and not indirectly only, e.g. via the collection of water quality parameters. RFID transponders are particularly promising for recording baseline activity also representing a cost-effective approach. The information collected could also meet the requirements of "Big Data" and be used to develop approaches using artificial intelligence (AI) techniques.

Conclusions & advice

- Fish activity can be automatically recorded and continuously monitored by means of digital sensor systems inside recirculating aquaculture systems (RAS).
- Unlike camera systems, sensor systems used to record activity are unaffected by production conditions, such as turbidity or illumination.
- During times of optimal RAS functioning, fish show a baseline activity.
- The baseline activity of the fish may serve as a reference helping to detect deviations from standard behaviour and identify behavioural abnormalities.
- The reference value on baseline activity is specific to the respective rearing system.
- Technical malfunctions and altered rearing conditions prompt changes in the behaviour of rainbow trout.
- RFID based systems represent a cost-effective approach in order to record fish activity in an automated manner.
- Accelerometers are an excellent way to record swimming activity of free-swimming fish at very high resolution, but are expensive and complex to use.
- Further research should include additional stressors from fish farming practice and continue testing digital data collection systems for their suitability.

Further Informationen

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