Ph.D. thesis topics 2026/2027

DSP Ochrana vodních ekosystémů / Protection of aquatic ecosystems

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Responsible compounds in chemical communication of crayfish

Sloučeniny odpovědné za chemickou komunikaci raků

DSP: Ochrana vodních ekosystémů / Protection of aquatic ecosystems

Annotation

Recent studies have shown that biogenic amines, such as serotonin, dopamine and octopamine, affect fighting behaviour and dominance status in crayfish. Our own studies have revealed that chemical communication via urine-borne signals is necessary for crayfish to decide whether to fight. The proposed topic should combine known facts about the role of biogenic amines in urinary signals, not only in agonistic interactions or the decision to fight, but also in other behavioural features of crayfish, such as courtship, maternal care and offspring recognition. The same chemical information would act differently in different situations and for different individuals (e.g. juveniles, adults, berrying females, dominant or subordinate). Similarly, different chemical signals would have different priorities in crayfish interactions. Therefore, the same chemical compound can act as an attractant in one case and a repellent in another, or for another individual. Crayfish seem to be a great experimental model species, as they are probably the most easily cultured crustaceans, and their social interactions and frequently used chemical communication make them ideal subjects for study. The results could help to define the role of specific signals in specific behavioural changes. Last but not least, this work could be a further step towards identifying specific compounds (aside from those already known) that are active in crustacean communication, and their potential application in future studies or as attractants in species regulation efforts.

The main hypothesis

- Biogenic amines present in urine-borne chemical signals modulate crayfish social behaviour in a context-dependent manner. The concentration and composition of serotonin, dopamine, and octopamine in chemical signals influence behavioural decisions related to agonistic interactions, courtship, maternal care, and offspring recognition.
- The behavioural effect of the same chemical compound depends on the physiological and social status of the receiving individual. The same urine-borne chemical signal elicits different behavioural responses in juvenile and adult crayfish, dominant and subordinate individuals, or berrying females.
- Chemical signals involved in crayfish communication exhibit hierarchical priority during social interactions. In situations involving competing behavioural motivations (e.g., aggression versus reproduction), some chemical compounds exert stronger influence on behavioural outcomes than others.
- Crayfish chemical communication involves additional behaviourally active compounds beyond currently known biogenic amines. Previously unidentified compounds present in urine-borne signals and significantly contribute to behavioural modulation.

Aim(s) of the Ph.D. thesis

- To characterize the role of biogenic amines in urine-borne chemical communication across different behavioural contexts in crayfish. This objective will assess how serotonin, dopamine, and octopamine are associated with agonistic interactions, courtship, maternal care, and offspring recognition.
- To investigate how physiological condition, developmental stage, and social status influence crayfish responses to chemical signals. This objective will compare behavioural responses among different developmental stages of crayfish exposed to identical chemical cues.
- To determine the relative importance and prioritization of chemical signals during crayfish social interactions. This objective will experimentally evaluate how competing chemical signals influence behavioural decisions e.g. in parental behaviour.
- To confirm the presence (or identify) novel compounds involved in crayfish chemical communication.This objective will focus on detecting previously unknown behaviourally active compounds.

Possible approaches to reach the aims / to verify the hypotheses

- Experimental laboratory work including munipulation and maintenance of crayfish, manipulave experiments in laboratory conditions, pilot field experiemnts, and injication procedures using specific biogenic amines and their antagonists. Sampling of water, hemolymph and urine for further analysis, elaboration of literature review and analyse the results.Field observations using video-cameras at the places with co-occurrence of invasive and protected/important species.

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Nature-inspired approaches for wastewater treatment and reuse

Přírodou inspirované přístupy k čištění a opětovnému použití odpadních vod

DSP: Ochrana vodních ekosystémů / Protection of aquatic ecosystems

Annotation

Every day we are using water and releasing many chemicals to wastewater. With the growing global concern over water scarcity and pollution, there is a critical need for innovative approaches to wastewater treatment that not only effectively remove contaminants but also recover valuable resources from wastewater streams.

Conventional wastewater treatment is not effective enough to remove pollutants from the wastewater, thus wastewater effluents are recognized as the main source of micropollutants in the aquatic environment. Presence of a wide range of emerging contaminants (such as pharmaceuticals, personal care products, perfluorinated compounds) in wastewater treatment plants effluents was reported.

Intensive research is going on to improve elimination of micropollutants from wastewater. So called green approaches, which promote sustainable and environmentally friendly methods for treating wastewater while also reducing the environmental impact of traditional wastewater treatment processes are gaining a lot of attention nowadays. Natural treatment methods include, for example, the use of stabilization ponds for wastewater treatment. This is a cheap and relatively effective way to reduce the content of nutrients and micropollutants in wastewater. Constructed wetlands are also used for wastewater treatment and have the potential to remove a wide range of micropollutants.

Treated wastewater represents a sustainable water source that could be used for fish farming. However, the reuse of treated wastewater poses certain safety risks. Until now, attention has been paid to the risk of microbial contamination or the accumulation of toxic metals in fish produced this way. However, less information is available on the possible contamination of fish with micropollutants.

The main hypothesis

- Additional wastewater treatment steps can improve quality of wastewater effluents
- Water plants can contribute to the elimination of micropollutants from wastewater
- Wastewater reuse for the fish production can be beneficial using the proper practice of fish handling

Aim(s) of the Ph.D. thesis

- To assess the effectiveness of stabilisation pond and constructed wetlands for the elimination of micropollutants from wastewater.
- To evaluate the bioaccumulation of micropollutants in water plants.
- To analyze the content of micropollutants in fish produced in the pond fed with treated wastewater. In case these substances will be detected, to monitor the duration of their purification after transferring the fish into clean water.

Possible approaches to reach the aims / to verify the hypotheses

- Collection of water, plant and fish samples; development and validation of extraction procedures.
- LC/MS analysis of micropollutants in collected samples.
- Data analysis, risk assessment.

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CENAKVA Research program

RP2 “New” pollutants in the environment and their effect on freshwater ecosystems

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Effects of thyroid-disrupting chemicals on fish and amphibians, focusing on their immune systems

Účinky chemických látek narušujících funkci štítné žlázy na ryby a obojživelníky se zaměřením na jejich imunitní systém

Annotation

Endocrine disruptors, i.e. substances that interfere with the functioning of the hormonal system of exposed organisms, are among the most threatening environmental pollutants. They deserve special attention because they can cause, for example, reproductive system abnormalities, reduced fertility, thyroid dysfunction, or metabolic disorders (diabetes, obesity). Since immunity is susceptible to reprogramming by environmental chemical and endocrine signals, it is thought that endocrine disrupters may also adversely affect the immune system of exposed animals. However, it is often unclear whether the immunotoxicity of endocrine disruptors is dependent on, or completely independent of, endocrine toxicity. Thyroid-disrupting chemicals are a class of endocrine disruptors with a high potential to interfere with the immune system, as the literature data suggest that different immune pathways are under distinct control by thyroid hormones during early vertebrate development. In addition, numerous thyroid-disrupting chemicals have been documented to disrupt immune endpoints (McGuire and Robert, 2023).

Thyroid-disrupting chemicals have been reported in various types of environments, including the aquatic environment. The results of our recent nationwide screening for anti-thyroid activity in surface waters showed that this activity was detected in more than one-third of the water samples (Šauer et al., 2024). It is, therefore, essential to study the effects of thyroid-disrupting chemicals on aquatic animals, especially fish and amphibians, in more detail, as these lower vertebrates already have a fully developed hypothalamic-pituitary-thyroid axis. Research into thyroid-disrupting chemicals has focused on their adverse effects on early development in fish and amphibians. However, it can be hypothesised that thyroid-disrupting substances could also negatively affect their immune response.

The main hypothesis

Some endocrine disruptors reported to be present in aquatic environments interfere with the hypothalamus-pituitary-thyroid axis. As the thyroid controls several immune pathways, thyroid-disrupting chemicals may also affect the immune response of fish and amphibians living in polluted areas. Consequently, animals with an impaired immune response may be more susceptible to pathogens normally found in the aquatic environment.

Aim(s) of the Ph.D. thesis

The aim of this study will be to evaluate the effect of pollutants with anti-thyroid activity on the immune response of exposed fish and amphibians and to assess whether they are more susceptible to pathogens.

Possible approaches to reach the aims / to verify the hypotheses

Model fish and amphibian species will be exposed to substances with anti-thyroid activity during early development when their thyroid and immune systems are forming. These exposed animals and respective controls will then be challenged with pathogens. Model host-pathogen systems will be selected, such as common carp vs. koi herpes virus and African clawed frog vs. rana virus. The immune response and susceptibility of the animals to these pathogens will be studied.

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Funding

- In 2025, a project on the same topic will be submitted to the Czech Science Foundation.
- Additionally, other financial sources from the laboratory will be used.

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RP2 “New” pollutants in the environment and their effect on freshwater ecosystems