New research topics for PhD study of Biology and Ecology for the academic year 2025/2026

Pollinators of entomogamic crops in Europe – the study of the importance of main pollinator groups

Supervisor: Assoc. Prof. Petr Bogusch

Annotation: European landscape is covered by a large proportion of arable land. Most of planted crops are anemogamic but still many species are highly dependent on the presence of pollinating insects. In last several years, the role of the honeybee as the universal and best pollinator was re-evaluated and the honeybee is much often reported as domesticated species, which is harmful for populations of native insects. The number of studies comparing the pollinator communities on crops is still quite small and most studies deal only with the honeybee. The main goal of this Ph.D. topic is to clarify, which proportion of all pollinating insects represents the honeybee, if this proportion highly differs among the main crops, and if honeybees profit from large areas of field monocultures in post-socialistic countries. The study will be divided into several topics: 1) to describe the community of pollinators on oilseed rape as the entomogamic crops, which covers the largest part of arable land in Europe; 2) to compare the representation of main pollinator groups (honeybee, bumblebees, native bees and wasps, butterflies and hoverflies) on monocultures of main entomogamic crops; and 3) to study the dominance of larger pollinators in various parts of large monocultures of entomogamic crops. Another part of the research will deal with native species of the family Brassicaceae and their importance for specialised bee species. The results of this study will be published in at leas 3-4 papers in journals with IF in Q1-Q2, of which the Ph.D. student will be the main author (at least two) or co-author. One research topic will be presented in an international conference.

References

Gay C., Gaba S., Bretagnolle V. 2024: The structure of plant–pollinator networks is affected by crop type in a highly intensive agricultural landscape. Agriculture, Ecosystems & Environment 359: 108759.

Klein A.M., Vaissiere B.E., Cane J.H., Steffan Deventer I., Cunningham S. A., Kremen C., Tscharntke T. 2006: Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B, Biological Sciences 274: 303-313.

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Vaughan M, Hoffman Black S. 2008: Native Pollinators. How To Protect and Enhance Habitat For Native Bees. Native Plants Journal 9: 80-91.

Research topic: Monitoring of nephrotoxic mycotoxins in blood donors and their urine in Eastern Bohemian region

Supervisor: doc. RNDr. František Malíř, Ph.D.

Annotation: Mycotoxins are serious contaminants of natural origin that are mainly found in food, where they are produced by toxigenic filamentous microscopic fungi. Among the most important of them are ochratoxin A (OTA) and citrinin both in terms of toxic effects on humans and high occurrence in agro-food commodities, where they can co-occur due to the same producers of the genus *Penicillium*. OTA (PubChem CID: 442530) and citrinin CIT (PubChem CID: 54680783) are among the top 5 mycotoxins from a public health perspective.

Nephrotoxic mycotoxins such as CIT and OTA are commonly simultaneously found in food of plant (e.g. cereals and cereal-based foods, spices, nuts) and animal origin (e.g. cheese) and therefore represent a potential risk to human health. Excessive dietary intake of these mycotoxins represents an increased risk to the organism. There are two ways of asses to dietary exposure to mycotoxins, either by estimating dietary exposure to mycotoxins based on the determination of mycotoxins in foods and knowledge of the consumption of those foods, or with the advantage of determination of the relevant mycotoxins or their metabolites (biomarkers) in human body fluids, e.g. blood, plasma or urine. Estimation of dietary exposure is determined by calculation based on the knowledge of metabolism, distribution, and excretion of mycotoxins and their biomarkers in the organism. Therefore, the focus will be on the determination of OTA and CIT in the serum and urine of these donors.

The applicant's educational background is an advantage: e.g. medical laboratory technician, possibly a medical course, as well as authorization to perform these types of samples.

References:

MALÍŘ, František, OSTRÝ, Vladimír and all. Vláknité mikromycety (plísně), mykotoxiny a zdraví člověka. 1. Brno : Národní centrum ošetřovatelství a nelékařských zdravotnických oborů, 2003. ISBN 80-7013-395-3.

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OSTRY, Vladimir, MALIR, Frantisek and RUPRICH, Jiri. Producers and important dietary sources of ochratoxin A and citrinin. Toxins. 2013. Vol. 5, no. 9, p. 1574–1586. DOI 10.3390/toxins5091574.

Research topic: Anatomical growth response of trees to the impact of geomorphological processes

Supervisor: prof. RNDr. Karel Šilhán, Ph.D.

Annotation: The spatio-temporal reconstruction of historical geomorphological process activity based on the analysis of tree rings (dendrogeomorphology) has always been based on a macroscopic assessment of changes in annual increments (Stoffel & Bollschweiler 2008). However, in recent years, attention has turned to the microscopic analysis of (so far only selected) growth disturbances (Tumajer & Treml 2019). The current trend thus clearly indicates a future direction in dendrogeomorphology. The main objective of this work is to reveal selected anatomical responses of trees to various external disturbances induced by geomorphological processes. The types of reactions, their intensity and 3D extent in the tree trunk induced, for example, by trunk tilting due to the pressure of landslide material or damage to the trunk due to the impact of falling debris during rockfall will be investigated. A further line of work will be to reveal the potential link between the macroscopic response of trees at the level of growth anomalies (growth suppression or relaxation) and the accompanying anatomical changes. An important part of the work will be to detect changes in the intensity of anatomical responses with changing tree age. The results of this work should thus contribute to broadening the spectrum of growth disturbances useful for retrospective analysis of selected natural hazards.

References

Stoffel M., Bollschweiler M. 2008: Tree-ring analysis in natural hazards research – an overview. *Natural hazards and earth system sciences* 8: 187–202.

Tumajer J., Treml V. 2019: Disentangling the effects of disturbance, climate and tree age on xylem hydraulic conductivity of Betula pendula. *Annals of Botany* 123: 783–792.

Research topic: Trophic niche partitioning of co-occurring bat species

Supervisor: RNDr. Michal Andreas, PhD.

Annotation: Temperate bats feed especially on insects. Particular species often hunt in the same habitat and thus share very similar or even the same resources of available prey (Andreas et al. 2012, Arrizabalaga et al. 2018, Andriollo et al. 2021). Despite this fact, the bat populations of Central Europe represent a relatively diversified community, and the question is therefore how syntopically occurring bats share available prey resources and how their trophic niches differ in order to avoid competition. The aim of the study is to obtain a sufficient amount of material that will allow a detailed evaluation of the diet composition of individual species. This will enable an understanding of the role of individual niche factors involved in facilitating the coexistence of given species. Microscopic analysis and/or DNA metabarcoding represent a suitable tools for assessing the spectrum of consumed prey and the subsequent study of differences in trophic niches among particular species. The results will be published in IF journals.

References:

Andreas M, Reiter A, Benda P (2012) Dietary Composition, Resource Partitioning and Trophic Niche Overlap in Three Forest Foliage-Gleaning Bats in Central Europe. Acta Chiropterologica 14:335–345.

Andriollo T, Michaux JR, Ruedi M (2021) Food for everyone: Differential feeding habits of cryptic bat species inferred from DNA metabarcoding. Molecular Ecology 30:4584–4600.

Arrizabalaga A, Clare E, Salsamendi E, Alberdi A, Garin I, Aihartza J, Goiti, U (2018) Assessing niche partitioning of co-occurring sibling bat species by DNA metabarcoding. Molecular Ecology 27:1273–1283.

Research topic: Analysis of plant protein toxins

Supervisor: RNDr. Alena Myslivcová Fučíková, Ph.D.

Consultant: PharmDr. Jiri Dresler, PhD., Military medical institute, Prague

Anotation: Plants are able to produce a number of substances of a proteinaceous nature in order to respond effectively to environmental conditions. In terms of activity, it is a diverse group of lectins, ribosomal inactivating proteins, antimicrobial peptides, pore-forming toxins, protease inhibitors and many others. These proteins show varying degrees of toxicity to bacteria, insects, fungi or animals. Some of these proteins are included in high-risk agens, which are subject to a special handling regime. Numerous studies have been demonstrated investigating the toxic effects and mode of action of these plant proteins in order to investigate the possible applications of their effects in many fields. An example is the study of the effect of viscumin from white mistletoe on cancer cells in order to influence their division, etc.

The aim of the work will be to summarize the recent findings, especially in the field of high-risk toxins and to develop and verify methodologies based mainly on mass spectrometry, which can identify and quantify selected protein toxins in complex material with respect to maximum sensitivity. At the same time, we will test and implement other complementary methods. Special emphasis will be placed on the possibilities of detection and identification of toxins in human biological material, especially in blood. Other areas on which the work will focus on will be to prepare these toxins from their natural producers, or via other routes that are currently possible.

References:

1. Duracova, M.; Klimentova, J.; Fucikova, A.; Dresler, J. Proteomic Methods of Detection and Quantification of Protein Toxins. *Toxins* 2018, *10*, 99. doi: 10.3390/toxins10030099

2. Liuyi Dang, Els J.M. Van Damme.: Toxic proteins in plants, Phytochemistry, Volume 117, 2015, Pages 51-64, doi: 10.1016/j.phytochem.2015.05.020

3. Graeme C. Clark, Stuart Armstrong, Abbie Harrison, Karen Moore, Angela Essex-Lopresti, Jon David, Chris Green, Julian Hiscox, Utilisation of ‘omic approaches to improve the identification, diagnosis and treatment of exposure to the plant toxin ricin, Toxicon, Volume 177, Supplement 1, 2020, Page S31, doi:10.1016/j.toxicon.2019.12.036.

Research topic: Alarm pheromones from German chamomile (Matricaria chamomilla L.) – from genes to metabolites

Supervisor: RNDr. Zuzana Kovalíková, Ph.D.

Annotation: Plants and insects have coexisted for more than 400 million years. The ability of plants to withstand insect predation depends on their ability to quickly recognize the situation and respond to it adequately. One possibility is the production of alarm pheromones, which act as repellents or attractants of insect predators. Chamomile is one of the most cultivated medicinal plants and terpenes in flowers are used in pharmacy. (E)-β-farnesene, germacrene D and germacrene A, can act as pheromones involved in plant-insect interactions. The main goal of the thesis is to better understand the stimulation of alarm pheromone synthesis at gene level due to insect and hormone stimulation and to clarify the relationship between plant ploidy and terpene accumulation. The results will enable growers to use information about the application of natural hormones to stimulate pheromones and thus help reduce the negative impact on plants.

References

Fürstenberg-Hägg J., Zagrobelny M., Bak S. 2013: Plant Defense against Insect Herbivores. *International Journal of Molecular Sciences* 14: 10242-10297.

Ling Ch., Zheng L., Yu X., Wang H., Wang Ch., Wu H., Zhang J., Yao P., Tai Y., Yuan Y. 2020: Cloning and functional analysis of three aphid alarm pheromone genes from German chamomile (*Matricaria chamomilla* L.). *Plant Science* 294: 110463.

Scheader J, Bohlman J. 2015.Biotechnology of isoprenoids. Springer, London.

Stahl E., Hilfiker O., Reymond P. 2018: Plant–arthropod interactions: who is the winner? *The Plant Journal* 93: 703-728.

Research topic: Analysis of pseudoreplications using methods of spatial statistics in ecology

Supervisor: doc. Ing. Jakub Horák, Ph.D.

Annotation: The problem of independent data collection is very often in ecology and biology. This problem is not restricted only to dependent variables but often also to independent environmental variables. One of the ways to solve this problem is to use the methods of spatial statistics and work with pseudoreplications using spatial autocorrelation. The aim of the work will be to work with various pseudoreplicated data and their statistical analysis using different types of models of spatial statistics. The results will be published in journals with IF.

References:

Stejskal J., Horák J. Typta J. (2016) Effect of hybridization in fir trees: higher artificial hybridization leads to higher survival rate. European Journal of Forest Research 135:1097–1105. doi:10.1007/s10342-016-0996-1.

Horák J. (2016) Suitability of biodiversity-area and biodiversity-perimeter relationships in ecology: a case study of urban ecosystems. Urban Ecosystems 19:131–142. doi:10.1007/s11252-015-0492-2.

Horak J., Safarova L. (2015) Effect of reintroduced manual mowing on biodiversity in abandoned fen meadows. Biologia 70:113-120. doi:10.1515/biolog-2015-0009.

Horak J. (2013) Effect of site level environmental variables, spatial autocorrelation and sampling intensity on arthropod communities in an ancient temperate lowland woodland area. PLoS ONE 8: e81541. doi:10.1371/journal.pone.0081541.

Research topic: Plant response to water deficit

Supervisor: assoc. prof. Ing. Jiří Tůma, CSc.

Consultant: RNDr. Zuzana Kovalíková, PhD.

Anotation: From all the abiotic factors that limit the growth and productivity of plants on the continents of our planet, water deficiency comes first. Drought is considered a serious threat, especially in a changing climate. Water deficit in plants significantly affects important physiological and biochemical processes and thus morphological changes, quality and yields of crops. Besides to visible morphological changes, the stress response of plants to drought is manifested by changes in the induction of specific genes, changes in the quantitative and qualitative representation of proteins in cells, basic physiological and biochemical properties, such as changes in photosynthesis intensity, conductivity of stomata, transpiration, etc. At the biochemical level, general plant responses include the synthesis of stress proteins, the formation and removal of reactive oxygen species, the synthesis of 'stress' hormones (abscisic acid, salicylic acid, polyamines) and the synthesis of osmoregulatory compounds (sugars, amino acids, polyalcohols). The aim of the thesis is the research of the influence of water deficit on selected economically important crops at the physiological and biochemical level. Overall, the changes in the formation of selected primary and secondary metabolites, substances related to oxidative stress, and the representation of substances of a hormonal nature will be monitored. Various laboratory methods (HPLC, photometric methods, ELISA, TLC, cytometric) and other methods of molecular biology will be used. The research will be carried out in cooperation with selected workplaces in the Czech Republic and abroad.

Literature:

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Zandalinas SI, Mittler R, Balfagon D, Arbona V, Gomez-Cadenas A (2018) Plant adaptations to the combination of drought and high temperatures. Physiologia Plantarum 162: 2-12.

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