ISEPEP 9

9th International Symposium on the Environmental Physiology of Ectotherms and Plants

10-14 July 2022

Rennes

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Journal of Experimental Biology

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Welcome to the ISEPEP 9

Dear participants,

On behalf of the ISEPEP9 organizing committee, we are delighted to welcome you at Rennes (France) for the ninth edition of the International Symposium of the Physiology of Ectotherms and Plants (ISEPEP9). More than ten years after its first visit to France in 2010, ISEPEP is thus back in Rennes.

ISEPEP is one of the rare meetings focused on the environmental physiology of ectotherms (usually with a strong focus on ecophysiology of invertebrates) and attracts a large cohesive group of researchers working in this area. Assessing and predicting the effects of the environment and human activities on ectotherm populations indeed requires a better understanding of the physiological mechanisms of individuals to cope with the variability of their environment.

The three-day conference will include world-class keynotes, many scientific talks, and posters. The last day will be dedicated to the excursion at Saint Malo, where we will have a cruise on the sea to have a unique view of the historical city. Brittany is beautiful place and July is a stunning time of year to visit the region so we expect this visit to be memorable.

Despite the pandemic context, we are delighted to finally have the chance to meet face-to-face to report, present, share and discuss scientific questions, achievements, issues and challenges in the field of environmental physiology and ecotoxicology. We are eagerly anticipating an excellent meeting with brilliant scientists and students from many countries around the world (about 20 different nationalities).

We are grateful to the members of the organizing committee, the members of the scientific committee and all volunteers who have arranged the beautiful program.

Finally, we would also like to thank the numerous sponsors of the ISEPEP9 conference.

Have a nice symposium and a beautiful moment at Rennes.

Hervé COLINET and David RENAULT

Scientific Committee:

COLINET Hervé, UMR CNRS EcoBio, UR1, F
RENAULT David, UMR CNRS EcoBio, UR1, F
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PINCEBOURDE Sylvain, Inst Rech sur la Biol de l'Insecte, Univ de Tours, F
WIEGAND Claudia, UMR CNRS EcoBio, UR1, F
COUTELLEC Marie-Agnès, UMR Decod, INRAE, Rennes, F
OVERGAARD Johannes, Aarhus Univ, Denmark
HOLMSTRUP Martin, Aarhus Univ, Denmark
MARSHALL Katie, The University of British Columbia, Canada

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NIVARD Mariette, UMR CNRS EcoBio, UR1, F
CLOTEAU Romuald, UMR CNRS EcoBio, UR1,F
RIVAS Johanna, UMR CNRS EcoBio, UR1, F
SIMOES-BERTON Bréa UMR CNRS EcoBio, UR1, F

General information :

Venue :

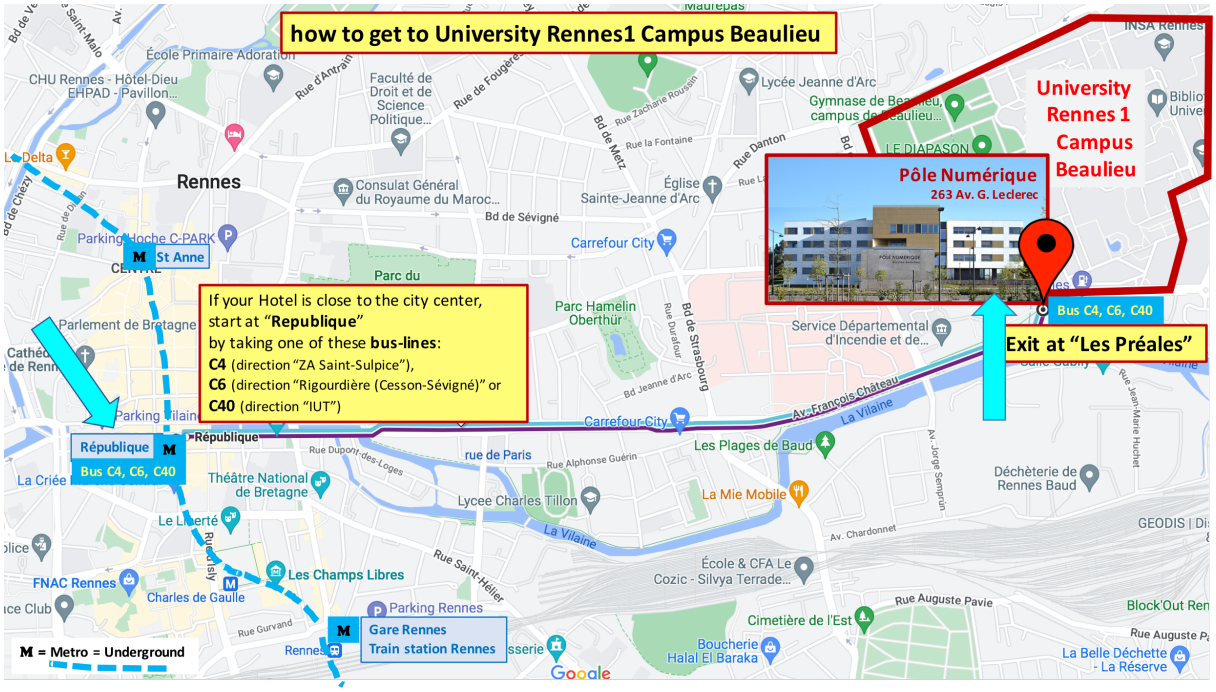
Pôle Numérique Rennes Beaulieu PNRB
263, Avenue General Leclerc,
Rennes, University Rennes1 Campus Beaulieu

How to get to Rennes and to the venue:

By Flight: Airport Rennes St Jaques https://www.rennes.aeroport.fr/destinations/liste
from the Airport to Rennes city center
there is a bus-line number C6 which takes you to town within 40 minutes
or – take a taxi (but think of sharing to reduce the carbon footprint)

By Train: Rennes SNCF: the train station is very close to the town centre and connected to metro and bus services (Link to the public transport "STAR": https://www.star.fr/accueil)

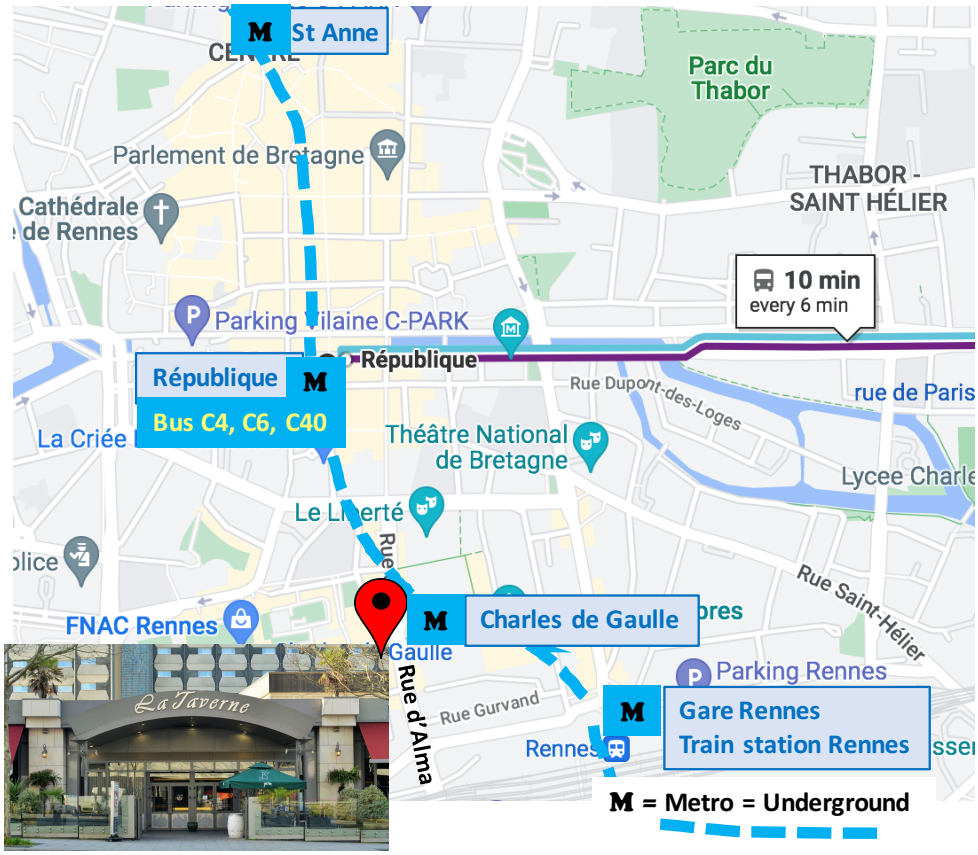
From the city centre to the venue:



Registration	Sunday	10th July	16 – 20 h	PNRB
	Monday	11th July	8 – 10 h	PNRB
	Internet:	Wi-Fi connection will be with your registration		
Icebreaker	Sunday	10th July	16 – 20 h	PNRB

Gala Dinner Wednesday 13th July 20 h

La Taverne 2 rue de l'Alma Rennes
Metro : Charles de Gaulle



Excursion

Thursday 14th July all day event:

- **8.30 am** : meeting at the parking in front of the "Pôle Numérique Rennes Beaulieu - PNRB", the venue where we have the conference.
- **8.45 am** : departure by bus
- **10.0 am :** walk around the "Pointe du Grouin" at Cancale : spectacular view over the Channel.

https://www.tourismebretagne.com/destinations/les-10-destinations/cap-frehel-saint-malo-baie-du-mont-saint-michel/la-pointe-du-grouin/

- **11.30 am :** departure by bus and stop at the "Anse Duguesclin" for lunch on the beach.

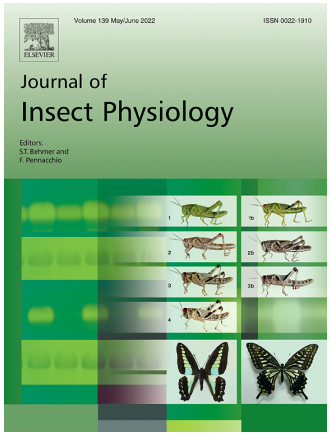
https://www.saint-malo-tourisme.com/offres/plage-de-lanse-du-guesclin-saint-coulomb-fr-3646046/

- **1.00 pm :** departure by bus and stop at Saint Malo (Office du Tourisme, Esplanade saint Vincent) for a free visit of the fortified historical city and its surroundings.

- **3.45 pm :** meeting at the pier (south of the fortified Saint Malo city) at the "Compagnie Corsaire" in front of the door of Dinan for a 1h30 cruise around the city (boat departure at 4.10 pm).

- **6.30 pm :** departure by bus to go back to Rennes. Meeting point at Esplanade Saint Vincent, office du Tourisme.

Return to Rennes at 20 h



Special Issue in Journal of Insect Physiology

Guest Editors:	**H. COLINET & D. RENAULT**
	(feel free contact us for inquiry)
Final Manuscript Submission Deadline:	
	31-dec-2022

Arthropods must cope with natural and anthropogenic changes in their environment that constantly challenge their homeostasis. Physiology plays a central role in the regulation and maintenance of cellular homeostasis. Physiological responses to stress and toxic substances thus act as a filter between environmental changes and the ecological performance of individuals. Ecophysiological and ecotoxicological studies therefore provide functional links between the causes and effects of environmental variations. In this special issue, we invite physiological studies that examine and predict the effects of environmental and human-related stressors e.g., temperature, salinity, xenobiotics, pathogens on arthropods. These studies will highlight the useful and necessary contribution of stress physiology and toxicology to better understand and predict the ecology of arthropods in a changing world.

The Editorial Manager submission system is ready for submission “VSI: Environmental stress" Special issue title: Environmental stress physiology and toxicology: necessary insights in a changing world

Short title: VSI: Environmental stress

The submission website for this journal is located at:

https://www.editorialmanager.com/insphy/default1.aspx

To ensure that manuscripts are correctly identified for inclusion into the special issue it is important that authors select “VSI: Environmental stress” when they reach the “Article Type” step in the submission process.

Program

Sundy july 10	Monday july 11		Tuesday july 12		Wednesday july 13	
	08:00	REGISTRATION				
	08:20	REGISTRATION				
	08:40	REGISTRATION	08:40	KEYNOTE (30 min + 10 min	08:40	KEYNOTE (30 min + 10 min)
	09:00	Opening of the conference	09:00	**Lucie Gerber**	09:00	**Julian Dow**
	9:20	Lourdais O	09:20	Unfried L	09:20	Jørgensen LB
	9:40	Holmstrup M	09:40	Simoes-Berton B	09:40	Andersen M
	10:00	Pincebourde S	10:00	Slotsbo S	10:00	Poulsen JP
	10:20	**Cofee break**	10:20	**Cofee break**	10:20	**Cofee break**
	10:40	**40 min**	10:40	**40 min**	10:40	**40 min**
	11:00	Kervella M	11:00	Tully T	11:00	Lubawy J
	11:20	Rivas J	11:20	Dillon M	11:20	Schilman PE
	11:40	Urbański A	11:40	Süess P	11:40	Yilmaz VM
	12:00	Krams I	12:00	Yoshida M	12:00	Lima C
	12:20		12:20		12:20	
	12:40	**Lunch**	12:40	**Lunch**	12:40	**Lunch**
	13:00	**(100 min)**	13:00	**(100 min)**	13:00	**(100 min)**
	13:20		13:20		13:20	
	13:40		13:40		13:40	
	14:00	Overgaard J	14:00	Roberts KT	14:00	Wagner M
	14:20	Cormier SB	14:20	Overgaard J	14:20	Martinez-Alarcon D
	14:40	Devlin J	14:40	Convey P	14:40	Wiegand C
	15:00	Lubawy J	15:00	Willot Q	15:00	Luckenbach T
	15:20	**Cofee break**	15:20	Touzot M	15:20	Beringue A
	15:40	**40 min**	15:40	**Cofee break**	15:40	**Cofee break**
> 4pm to 8pm	16:00	**KEYNOTE (30 Min + 10 min**	16:00	**40 min**	16:00	**40 min**
	16:20	**Hans Pörtner**	16:20	Li Y	16:20	Kreiman L
	16:40	Marshall K	16:40	Leclerc M	16:40	Leroy C
	17:00	Lipaeva P	17:00	Glass J	17:00	Eke Tanchou MA
	17:20	Bedulina D	17:20	Cabon V	17:20	Deconninck G
	17:40	END OF DAY	17:40	Jerbi M	17:40	Hunter-Manseau F
			18:00	Intro to ISEPEP10	18:00	CLOSING SESSION & AWARD
					18:20	END OF DAY
				18:00 - 20:40		
				POSTER SESSION		
				& DRINKS		
					20:00	**GALA DINER**
						LA TAVERNE
						(Rennes city Center)
			20:40			
			21:00	END OF DAY		
REGISTRATION & ICE BREAKER						

SESSIONS COLOR CODE

- **Stress physiology**
- **Ecotoxicology**
- **thermal responses: mechanisms**
- **Thermal responses : traits & phenotypes**
- **Dietary stress & responses**

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Keynote 1 **Prof Hans Pörtner**

Prof. Pörtner studied at Münster and Düsseldorf Universities where he received his PhD and habilitated in Animal Physiology. As a Research and then Heisenberg Fellow of the German Research Council he worked at Dalhousie and Acadia Universities, Nova Scotia, Canada and at the Lovelace Medical Foundation, Albuquerque, New Mexico, USA. Currently he is Professor and Head of the Department of Integrative Ecophysiology at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research in Bremerhaven, Germany. He acts as an associate editor 'Physiology' for Marine Biology and as a co-editor of the Journal of Thermal Biology. He is the author of numerous reference works on the subject of global warming.

Dr Hans Pörtner co-chairs the IPCC working group II on climate change impacts, adaptation and vulnerability. He also heads the Department of Integrative Ecophysiology at the Alfred Wegener Institute. In 2018 he was one of the authors of the IPCC's special report on global warming of 1.5 degrees Celsius. During the IPCC Fourth Assessment cycle Dr Pörtner served as Lead Author on the Working Group III Special Report on Carbon Capture and Storage, and during the Fifth Assessment Cycle as Coordinating Lead Author of Chapter 6 (Ocean Systems of the Working Group II Report, as a member of the author teams for the Working Group II Summary for Policymakers and Technical Summary, and as a member of the Core Writing Team for the Synthesis Report. In October 2015 he was elected Co-Chair of Working Group II for the Sixth Assessment cycle.

His research interests include the effects of climate warming, ocean acidification, and hypoxia on marine animals and ecosystems with a focus on the links between ecological, physiological, biochemical and molecular mechanisms limiting tolerance and shaping biogeography and ecosystem functioning.

Questions and approaches around climate change impacts on marine animals: a physiologist's view

Hans Pörtner [*1]

1 Alfred Wegener Institute, Bremerhaven, Germany

Climate change drivers in the ocean entail ocean warming, acidification and loss of oxygen due to warming and enhanced stratification. These drivers individually and together affect ocean life. While some approaches compare the effect size of these individual drivers, other approaches strive to develop an integrative view. Based on principle considerations temperature emerges as a master variable shaping the functioning of all life forms in the ocean. Such functioning depends on the thermal performance curve as a reaction norm characterizing individual species and their lifestages. Unifying principles around the thermal performance curve of species emerge and explain species vulnerability to climate change. Overlapping thermal performance curves characterize the temperature range at which species can co-exist at ecosystem level. The talk puts each of the drivers into context and puts an emphasis on how the interaction of drivers plays a role in the thermal tolerance and performance of marine animal species. It also addresses the question whether and to what extent such findings can be applied to understanding animal life in different climate zones.

Keynote 2 **Dr. Lucie Gerber**

Lucie Gerber graduated with a MSc in Biodiversity and Evolution from the University of Montpellier II (France); where she completed her graduate research projects with Prof. Guy Charmantier, Dr. Audrey Caro and Prof. Olivier Gros, after her undergraduate studies at the University of Antilles (Guadeloupe). Lucie received her Ph.D. from the University of Southern Denmark, where she studied nitric oxide signaling and environmental stress in fishes under the supervision of Dr. Steffen Madsen and Prof. Frank B. Jensen; and in collaboration with Prof. William (Bill) S. Marshall (St. Francis-Xavier University, NS, Canada). Her first postdoctoral research study with Dr. Johannes Overgaard at Aarhus University, on insect cold tolerance and osmoregulatory capacity, was acknowledged by the Canadian Society of Zoologists in 2018 (Finalist of the Presidents' Award Competition). As a Postdoctoral Fellow, she also investigated the effect of warm- and hypoxic-acclimation on mitochondrial responses to heat and hypoxia stress in fishes with Prof. Kurt Gamperl at Memorial University (Canada), before she returned to Scandinavia. Lucie is currently based in the lab of Sjannie Lefevre and Göran Nilsson at the University of Oslo (Norway), where she studies metabolic and mitochondrial adaptive responses to O_2 limitation.

Lucie is an early-career comparative physiologist interested in how ectotherms cope physiologically with variations in temperature, salinity and oxygen of their environment; primarily focusing on the identification of cellular/molecular mechanisms underlying metabolic and osmoregulatory responses, and on the evaluation of the role of mitochondria and nitric oxide signaling in the adaptive and acclimatory responses shaping environmental tolerance, and fitness, of ectotherms.

Understanding the resilience of ectothermic animals to climate change requires uncovering the cellular mechanisms shaping thermal acclimation capacities and limits

Lucie Gerber [*1]

1 Department of Biosciences, University of Oslo, Norway

Ectotherms are particularly susceptible to climate change as they largely depend on thermal fluctuations of their surrounding environment to regulate their body temperature. Ectotherms' thermal tolerance and ability to cope physiologically with thermal stimuli are thus grounded in both their capacities to elicit a rapid homeostatic response to acute thermal stress and to thermally acclimate (phenotypic plasticity). These capacities to mount such responses, and ensure homeostasis, are driven by physiological adjustments triggered by thermal stimuli. Understanding the cellular mechanisms underlying these adjustments is a complex and challenging task, yet essential and to better link cellular mechanisms to phenotypic plasticity and whole organism's thermal tolerance. The thermal sensitivity and acclimation capacity of mitochondrial and osmoregulatory functions are particularly relevant given the critical consequences of their temperature-induced responses for the performance and fitness in many terrestrial and aquatic ectotherms. For instance, in the chill-susceptible locust (*L. migratoria*), water and ion transport across the hindgut exhibit thermal compensation following cold-acclimation that contributes to their enhanced cold tolerance and shifted onset of chill-injuries. In the cold-active and highly aerobic Atlantic salmon (*S. salar*), cardiac mitochondrial coupling and ability to mitigate reactive oxygen species release also exhibited thermal compensation following warm-acclimation that further the capability for cardiac acclimation to warmer temperatures displayed by this species. Assessment of ectotherms' ability to elicit modifications at the cellular and molecular levels through thermal acclimation timely contributes to our understanding of their thermal limits and tolerance, through which predictions regarding their resilience to climate change can be made possible.

Keywords: Thermal acclimation, Fish, Insects, Osmoregulation, Mitochondrial Function

*Speaker

Keynote 3 **Prof Julian Dow**

Julian Dow graduated with an MA in Natural Sciences from the University of Cambridge, where he also took his PhD in Zoology under the supervision of Simon Maddrell, FRS. After a Harkness Fellowship to work with William Harvey in Philadelphia, he returned to a Research Fellowship of St Catharine's College, Cambridge. Since 1984, he has been based in the University of Glasgow, where he is Professor of Molecular and Integrative Physiology.

Prof Julian Dow switched from chemistry to zoology as an undergraduate and developed a lifelong interest in insect biology while his class was collecting insects on a small triangle of wild ground in Cambridge called 'Paradise' – the same area that the young Charles Darwin had studied a few years previously. He is fascinated in particular by the ability of insects to thrive in the widest range of environments with modifications to their simple body plan; and in particular, the structure and function of their excretory (renal) tubules. Although he has worked on many species of insects, his early adoption of the vinegar fly Drosophila melanogaster as a model to combine physiology and genetics, has proved transformational for our understanding of insect homeostasis.

Prof Julian Dow has served in senior strategic roles in the UK's Biological and Biotechnology Research Council, is Deputy Chair of the UK REF2021 research assessment exercise and has served on the Councils of the Society of Experimental Biology, Physiological Society and the European Society for Comparative Endocrinology. He is an editor of the Journal of Experimental Biology. He is also a Fellow of the Royal Society of Edinburgh (FRSE).

Physiology and genetics of homeostasis: the remarkable renal system of insects

Julian Dow *[1]

1 Institute of Molecular Cell & Systems Biology, University of Glasgow - United Kingdom

Insects are extraordinarily successful in thriving across a huge environmental range. Critical to this success is the homeostatic regulation of their internal environment. Across a wide range of scales, this homeostasis is achieved with essentially the same body plan. Nearly all insects have Malpighian tubules, which form the renal system, generating a primary urine and excreting toxins and unwanted metabolites. Although scaling arguments suggest that terrestrial insects are in continual danger of desiccation, insect tubules secrete fluid faster than any other transporting epithelium. This potent secretory process is thus under tight central control. Despite challenges of scale, progress in understanding insect renal function has been accelerated hugely by studying the vinegar fly Drosophila melanogaster, allowing the combination of physiological and genetic analysis. This talk will review recent progress (from our lab and elsewhere) in understanding tubule transport mechanisms and their control mechanisms, and explore the key role of tubules in trying to maintain homeostasis when the insect is subjected to environmental stress. Having proposed a Drosophila-based model for insect function, we will explore its generality in the extremely diverse Class Insecta, and look ahead to the exciting prospect of assigning functions down to the single cell level, based on newly available scRNAseq datasets.

*Speaker

Session Stress physiology

Importance of water constraints in a warming world: insight from European vipers

Olivier Lourdais * [1;2]

1 School of Life Sciences, Arizona State University (SOLS ASU), Tempe – United States
2 Centre d'Etudes Biologiques de Chize (CEBC), CNRS : UMR7372 Villiers en Bois – France

One of the greatest current threats to biodiversity is climate change. Terrestrial ectotherms are dependent on thermal conditions that influence their physiology, behaviour and ultimately fitness. While temperature has attracted considerable attention, water is also a crucial resource that must be considered. For instance, the regulation of water balance can conflict with thermal needs and reproductive requirements. Therefore, water constraints should mediate physiological and behavioural trade-os at the individual levels. During periods of prolonged drought, increasing temperatures and decreasing water availability frequently covary. These combined effects are especially relevant in ectotherms who rely on optimal temperatures for survival but lose greater volumes of water at higher temperatures European vipers (Genus Vipera) are a monophyletic group composed of 14 species representative of Eurasian terrestrial biodiversity and the evolutionary processes that have shaped it. These small to medium-sized viviparous, venomous snakes have contrasted non overlapping distribution. My talk will address how water constraints influence behaviour, life history and distribution in this group. During pregnancy, short-term water constraints directly maternal physiology and result in parental-ospring conflicts. Desiccating conditions may induce behavioural compensatory responses and the selection of specific hygrometric conditions to limit water loss. At early life stages water constraints affect offspring morphology and growth but the magnitude of these eects varies among species. Incorporating water requirements is important to address future changes in species distribution and vulnerability climatic changes.

Keywords: Water constraints, stress, reproduction, climate change

*Speaker

Drought tolerance of Collembola: The importance of vertical distribution, life-form and physiological acclimation

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Many Collembola species live in soils where the pore air most of the year is saturated with water vapor. Indeed, several soil dwelling (euedaphic) species are considered semi-aquatic animals rather than truly terrestrial. Further, Collembola are small organisms with poor desiccation resistance, but field investigations show that these animals nevertheless are resilient to even severe drought. In our research, we try to understand the physiological mechanisms enabling Collembola to survive in dry soils. In this presentation we will discuss the moisture conditions in drying soil, and how low soil water potential inflicts on the water balance and physiological responses of Collembola. We show that euedaphic Collembola are able to osmoregulate and adjust their osmotic pressure to the surrounding soil water potential much below the permanent wilting point of plants.
Our results show that reproduction is, by far, the most sensitive life-history trait ceasing already at modest soil water potentials (-15 kPa). However, body growth and activities of juveniles and adults may continue in moderately dry soil until the soil water potential reaches ca. -100 kPa. Should severe drought occur, normal body functions are paused, but surviving adults and juvenile individuals contribute to the resilience of Collembola populations at very low soil moisture. Lastly, we show that surface living Collembola are not necessarily more drought tolerant than euedaphic species even though drought conditions are often more intense on the soil surface than in the deeper soil layers.

Keywords: Desiccation, drought tolerance, Collembola

*Speaker

What ants tell us about metabolic ageing

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Some theories on ageing emphasise the importance of metabolism and oxidative stress to explain longevity. Mitochondria being at the crossroads of bioenergetics and ROS theory of ageing offers the opportunity to explore both at the same time. Social insect workers and queens share the same maternally inherited mitochondria through the germline, but are characterized by remarkable disparity in lifespan i.e. months vs. decades. The aim of our work was therefore to establish the first step in energetic proles of the different castes of black garden ant, *Lasius niger*. We conducted our analyses on different scales, from the individual to the mitochondria. This way, ants from different castes were placed into respiration chambers, to establish their metabolic rate (oxygen consumption being based on the mass). Our results matched the rate of living theory predictions, with values 5 to 6 time lower in long-lived queens. Oldest workers (foragers) also showed the highest metabolic rates. In order to dene which mitochondrial determinant between density and/or activity explains these results, we measured densities by PCR, and also used electron microscopy on different tissues to characterize the structure of the organelle. Mitochondrial activities were measured with the first tricarboxylic acid cycle enzyme, citrate synthase. Lastly, we explored oxidative barrier as catalase activity, and stress markers (glutathione, aconitase/fumarase ratio).

*Speaker

Exploring plasticizers mix impacts on glycolytic enzyme activities on the moth larvae *Spodoptera littoralis* (Noctuidae)

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Plastics and plasticizers manufacturing has greatly developed over the years due to their wide range of use. Because of plastic discharges, the main plasticizers, Bisphenol A (BPA) and Di(2-ethylhexyl)phthalate (DEHP) have quickly become significant environmental pollutants, often co-occurring in contaminated soil and water. As these compounds are classified as Endocrine Disrupting Chemicals, it is crucial to increase our understanding of their effects on animals, including terrestrial invertebrates that have been less examined than their aquatic counterparts so far. Indeed, no previous work has investigated enzyme activity or expression variations in terrestrial invertebrates exposed to BPA or DEHP. If their tendencies are similar to aquatic invertebrates, we expect a decrease in glycolytic enzyme activities. Thus, in the present work, we investigated the impacts of BPA and DEHP contaminated food on the moth *Spodoptera littoralis*. To that aim, larvae were food exposed from L4 to day 6 of L7 to food with only BPA at 1 g/g, DEHP at 1.1 g/g, or the mix of both. Then, we examined the impact of these contaminants on the individuals' energetic metabolism by measuring the activity of 4 glycolytic pathway enzymes: Hexokinase (HK), Phosphoglucose Isomerase (PGI), Phosphofructo-Kinase (PFK) and Pyruvate Kinase (PK).

Keywords: Bisphenol A, Di(2, ethylhexyl)phthalate, Endocrine Disruptor Chemical, glycolytic enzymes, *Spodoptera littoralis*

*Speaker

How desiccation and CAPA-PVK neuropeptides shape the immune system activity of burying beetles, *Nicrophorus vespilloides*?

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Environmental conditions, especially related to winter, are crucial for shaping activity of insect immune system. One of the stress factors characteristics of this season is desiccation, associated with limitation of water available in the environment. Here, we report the effects of short-term desiccation and recovery time on the functioning of immune system of burying beetle *Nicrophorus vespilloides*. Also, the impact of Tenmo-PVK-2, the member of the CAPA-PVK neuropeptide family, was investigated to better understand observed changes. Short-term desiccation caused reduction of haemocyte adhesion ability, which was correlated with reduction of their phagocytic activity. In addition, there was a significant increase in phenoloxidase (PO) activity and the level of proPO expression, which may suggest sealing the cuticula by melanin deposition and prevention of water loss. After 1 h of recovery time, the activity of tested cellular and humoral mechanisms was mostly back to the control level. However, inhibition of the activity of PO and down-regulation of proPO were noted. These results suggest that some changes in immune system functioning during stress conditions may not have an immune function. Interestingly, part of the effects characteristic of recovery time were also observed after the application of Tenmo-PVK- 2, mainly related to haemocyte morphology. These results indicate that CAPA-PVK neuropeptides may also influence on activity of burying beetle immune system. This work was supported by the grant No. 2016/21/N/NZ4/00123 from the National Science Centre (Poland) and ID-UB Project (045/06/POB2/0004).

Keywords: desiccation, insect immune system, neuropeptides

*Speaker

Serotonin-dependent repression of glucose metabolism by induced stress in Drosophila melanogaster

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Neurophysiological stress has been implicated in developing metabolic disorders such as diabetes and obesity. Here we report that inducing predator stress, a condition similar to human psychological disorders, impairs carbohydrate metabolism in Drosophila melanogaster by systemic inhibition of Akt protein kinase. Administration of metformin and a precursor of the neurotransmitter serotonin reversed these effects. Our results demonstrate a direct link between psychological stress and metabolic impairment and provide a novel animal model to explore the mechanisms responsible. Possible links to the temperature-associated mechanisms are discussed.

*Speaker

Session Thermal responses mechanisms

Finding the right thermal limit: a framework to reconcile ecological, physiological, and methodological aspects of critical thermal limits in ectotherms

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Upper and lower thermal limits (CTmax/CTmin) are frequently used to parameterise the fundamental niche of ectothermic animals and to infer distribution limits under current and future climate scenarios. However, there is considerable debate associated with the methodological, ecological and physiological definitions of critical thermal limits. The recent (re)introduction of the Thermal Death Time (TDT) model has reconciled some of these issues and now oers a solid mathematical foundation to model CTmax or CTmin by considering both intensity and duration of thermal stress. Supported by empirical data, we here outline a reconciling framework that integrates the TDT model, which operates at stressful temperatures, with the classic Thermal Performance Curve (TPC) that typically describes biological functions at permissive temperatures. Further, we discuss how the TDT model is founded on a balance between disruptive and regenerative biological processes that ultimately separates and denes the boundaries of the TDT and TPC models, respectively. Collectively, this framework allows inclusion of both repair and accumulation of thermal stress, and therefore also offers a consistent conceptual approach to understand the impact of high temperature under fluctuating thermal conditions. Finally, this reconciling framework allows improved experimental designs to understand the physiological underpinnings and ecological consequences of ectotherm temperature tolerance.

*Speaker

Overwintering in domesticated honeybees (Apis mellifera) causes metabolic reprogramming and modulates mitochondrial substrate utilization while enhancing cellular immunity

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The eusocial insect, Apis mellifera, known to be of great importance economically and agriculturally has important adaptation mechanisms to survive extreme seasonal temperature dierences. Many factors negatively impact honeybee health causing a global decrease in their population year after year. However, the major losses of managed honeybee colonies occur during winter and the cause remains thus far unknown. Here, we monitored for 12 months' colonies of honeybees that endured North American climate, where temperatures in winter and summer reach extremely low and high values, to assess the metabolism and immune system of honeybees transitioning from a summer to a winter phenotype. Our results show that complex I induced respiration during winter is drastically reduced compared to summer, but that overall mitochondrial respiration is increased during winter owing to succinate and glycerol-3-phosphate being prominent substrates used. Pyruvate kinase, lactate dehydrogenase, aspartate aminotransferase, citrate synthase and malate dehydrogenase tend to have reduced activity levels in winter unlike hexokinase, NADH dehydrogenase and pyruvate dehydrogenase which display opposite trends. Gene expression of highly important immunity proteins like Vitellogenin and Defensin-1 were also increased in winter bees, and a stronger phagocytic response as well as a better hemocyte viability was observed during winter. Thus, a global increase in mitochondrial respiration due to the reorganization of substrate utilization favoring succinate and glycerol-3-phosphate while negatively aecting complex I of the ETS is occurring during winter. Overall, this study highlights previously unknown adaptations allowing honeybees to survive the harsh winter conditions.

Keywords: Mitochondria, Metabolism, Honeybees, Immune system, Adaptation

*Speaker

Coping with multiple extreme abiotic stressors in Antarctica's terrestrial ecosystems

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Terrestrial invertebrates in Antarctica experience harsh abiotic conditions and have evolved a suite of adaptations to survive in these environments. While low temperature is the most conspicuous feature of Antarctica, invertebrates experience multiple stressors, including variation in temperature, water availability, and osmotic conditions. Here, we present two studies on molecular and physiological responses to ecologically relevant stressors in Antarctica. First, we assessed consequences of winter temperature variation in the midge Belgica antarctica. We subjected larvae to three simulated winters scenarios: warm (-1C), normal (-3C) and cold (-5C), within three distinct habitat types for 180 days. Survival, energy stores and locomotor activity were signicantly lower following the warm winter than at lower temperatures, but tissue viability and stress gene expression did not dier across winters. Survival was considerably lower in larvae overwintered in Prasiola crispa algae, although the mechanism is unclear. Heat shock proteins had lower abundance in larvae kept in living moss, suggesting it is less stressful to overwinter in this substrate, perhaps due to more dened structure aording less direct contact with ice. Second, we present preliminary results from a study quantifying transcriptomic responses across multiple sublethal stressors. Larvae were exposed to either freezing, heat stress, desiccation stress, hyperosmotic stress or hypoosmotic stress for 24 h and sampled immediately after or following 12 h recovery. Our general hypothesis is that multiple stress tolerance in B. antarctica is governed by a combination of cross-talk and cross-tolerance, which will be reected by shared gene expression modules between various stressors.

Keywords: Antarctica, Abiotic stress, Climate change, Transcriptomics, Survival

*Speaker

The response of tropical cockroach *Gromphadorhina coquereliana* to cold stress

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Insects as poikilotherms have limited ability to regulate body temperature, thus they developed strategies to survive under adverse thermal conditions, especially at temperatures around 0C. These include physiological adaptations, which, through metabolic changes, condition the increase of cold tolerance. The synthesis of cryoprotectants, changes in the lipid composition or the osmotic potential of body fluids can be mentioned. These are commonly found in insects in which the cold stress occurs in natural conditions. However, do insects that aren't exposed to low temperatures in natural environment also possess such mechanisms and can they survive cold stress? An interesting model for such studies is the tropical cockroach *Gromphadorhina coquereliana*, which occurs naturally on Madagascar. We have tested how cockroaches react to low temperature by measuring the changes of 50 metabolites (saturated and unsaturated fatty acids, TGA, amino acids, polyols and sugars) in fat body and hemolymph after cold stress (3x3h of 4C) and during recovery time (24h after stress). We've also checked how cold aects mitochondria of the insect with the emphasis on UCPs. We observed signicant increase in cryoprotectants, glycerol, trehalose and proline during stress as well as in unsaturated fatty acids. In addition, we observed a decrease in UCP expression and activity in muscle mitochondria and an increase in fat body mitochondria. Our data show that although G. coquereliana naturally isn't exposed to severe cold, it possesses mechanisms allowing to survive such constraints.
This work was financed by grant no 2017/24/C/NZ4/00228 from National Science Center, Poland

Keywords: cold stress, tropical insect, mitochondria, fatty acids, metabolism

*Speaker

Mechanisms of freeze tolerance in the bay mussel Mytilus trossulus

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The biochemical correlates of freeze tolerance have been well-explored in both vertebrates and arthropods, but there is another phylum containing freeze tolerant animals that have been much more poorly explored: the molluscs. Molluscs that live in the intertidal zone in temperate and Arctic regions experience subzero temperatures regularly through the winter, yet because they are osmoconformers they cannot accumulate low molecular weight cryoprotectants as terrestrial vertebrates and insects do. The bay mussel Mytilus trossulus is ubiquitous in the northern Pacic, is an ecosystem engineer for many rocky intertidal systems, and is freeze tolerant. Our laboratory group at UBC has been exploring the mechanisms of freeze tolerance in this species through measuring both the plasticity and intraspecic variation of both high and low molecular weight cryoprotectants. We have found this species is freeze tolerant year round, although freeze tolerance is increased in winter months and in animals from higher shore positions that experience greater thermal stress. While many osmolytes are correlated with increased freeze tolerance, using manipulative experiments, we have found that only TMAO drives increased freeze tolerance. We have also characterized a protein ice nucleator in this species, and its activity appears to be present in all tissues and during all seasons. Finally, we have begun to explore repair processes following freezing, nding that while freezing causes significant tissue damage, it is rapidly repaired. Taken together, freeze tolerance in M. trossulus is a plastic and multifactorial system with both parallels and important divergences from previously-studied freeze tolerant animals.

Keywords: freeze tolerance, mollusc, TMAO, ice nucleation

*Speaker

High-throughput dynamic proteome analysis of an endemic Baikal amphipod reproducing in winter: intersexual dierences and adjustment to winter conditions

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Over the past ten years, high-throughput omics approaches have helped to slightly lift the veil on the mystery of the molecular bases of reproduction of crustaceans. However, the molecular processes of reproduction in amphipods remain in the shadows. Here we examined the proteomes of Eulimnogammarus verrucosus, a cold-adapted amphipod species endemic to Lake Baikal, collected in the eld in months of its reproduction (September, November, December, January) and in June. Proteome data were obtained with LC-MS/MS applying tandem mass tag (TMT) labeling. The proteomes of females and males showed a strong sexual dimorphism regarding the abundances of certain proteins. Sex-specic dierences between the proteomes were seen either throughout the entire reproduction period or only during amplexus state. During reproduction, the female E. verrucosus proteome was characterized by increased proteins of/related to: (i) egg constituents, (ii) production of egg lipoglycoproteins, (iii) lipid enrichment in the egg, (iv) transport of lipoprotein and lipids, and (v) molting. Male-specic proteins showing increases during the months of reproduction were detected only in animals that had been in amplexus and comprised glycolytic proteins and sarcomere proteins. Furthermore, increases in proteins likely involved in adaptation to winter conditions, such as low temperatures, change in diet, and a drop in oxygen concentration were observed. Baikal amphipod proteomes from animals sampled at dierent times of the year could clearly be related to the dierent states of the respective sex in the reproduction cycle and to the adjustment of the animals to winter-specic abiotic environmental conditions.

Keywords: reproduction, adaptation to winter, amphipods, amplexus, proteome, Lake Baikal

*Speaker

Metabolic and transcriptomic adaptations to low temperatures in Baikal endemic amphipods

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Amphipods endemic to the ancient Lake Baikal are physiologically active at temperatures 0 - 5C; in contrast, amphipod species from other waters in temperate regions, including species potentially invasive to Lake Baikal, become inactive at cold temperatures. The high physiological activity in cold water may be the selective advantage for Baikal endemics in comparison with non-Baikal amphipods. This talk will give an overview on recent studies on biochemical and molecular adaptations to low temperatures in Baikal endemic in comparison to a Holarctic amphipod species. Activities of metabolic enzymes, tissue levels of key energy metabolites, and the overall changes in gene expression were analyzed in the animals, exposed in the lab to 1.5 C for four weeks. Compared to the Holarctic amphipod *Gammarus lacustris* (Sars, 1863), the Baikal endemic species demonstrated no reduction in aerobic metabolism upon the exposure. Furthermore, transcriptomics revealed upregulation of genes related to hibernation in the Holarctic amphipod, which was not the case in the Baikal endemics. The experiments demonstrated two strategies of adaptation to cold temperatures in the studied Baikal endemic amphipods: 1) the cold-loving species *Eulimnogammarus verrucosus* (Gerstfeldt, 1858), which reproduces in winter, has low and stable metabolic rates at and below its optimal temperatures; 2) the warm-loving *E. cyaneus* (Dybowsky, 1874) has a relatively high metabolic rate, but the compensation on the level of mitochondria was found both at biochemical and transcriptomic level. This strategy may allow *E. cyaneus* to remain competitive in a wide temperature range both in summer and winter.

Keywords: amphipoda, Baikal, transcriptomics, cold adaptation, metabolic adaptation

*Speaker

Mitochondrial (dys)function at high and low temperature extremes - complex I as a common culprit?

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Temperature is among the most important factors shaping the biogeographical distribution of ectotherm species. Thermal constraints on aerobic metabolism have been observed in several phyla at both high and low temperature and thermal adaptations of mitochondrial function are believed to play an important role for the variable thermal performance of ectothermic animals. Using a comparative system of Drosophila species with dierent thermal tolerance, we examined the thermal sensitivity of mitochondrial function at both high and low temperature extremes to explore a potential relation to organismal thermal tolerance. Mitochondrial function was measured in permeabilised thoraces using a substrate-uncoupler-inhibitor titration protocol to sequentially stimulate components of the electron transport system. Preliminary results show that complex-I-driven respiration is severely challenged at both high and low temperature. Especially, complex-I-driven respiration fails at a species-specific temperature that correlates strongly with minimal and maximal tolerance (CTmin and CTmax). However, for all species and at all temperatures, it was possible to restore a stable total oxygen consumption across temperatures when alternative substrates were provided (proline, succinate and glycerol- 3-phosphate). These observations suggest that loss of neuromuscular function and mortality at temperature extremes are more associated with failure of complex-I-driven respiration, rather than rates of fully stimulated respiration. Ongoing investigations are now examining if/how failure of complex-I-driven respiration could be associated with lowered energetic P:O ratios and/or increased production of reactive oxygen species, as these responses could explain the apparent connection to organismal failure.

Keywords: mitochondria, temperature stress, thermal tolerance, respiration rate, Drosophila, electron transport system, mitochondrial exibility

*Speaker

Ionoregulatory adjustments underlying variation in the Drosophila critical thermal minimum

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At their critical thermal limits, animals experience a general loss of performance which often manifests as a loss of coordinated movements ultimately leading to paralytic or coma-like phenotypes. In insects, this loss of function has been attributed to a loss of central nervous function caused by a spreading depolarization (SD) event, which in turn is triggered by an inability to maintain ion homeostasis. This results in a rapid surge in extracellular K^+ concentration which silences central neurons. This neurophysiological limit to performance is not static, and most insects are capable of altering the threshold for SD in response to thermal acclimation. However, the physiological mechanisms underlying variation and plasticity in the temperature leading to SD remain largely unknown. The key regulators of central nervous system ion homeostasis are Na^+ channels, K^+ channels, and the Na^+/K^+-ATPase. Thus, it seems likely that the function of one or more of these leads to SD and by extension that variation in channel or pump function underlies variation in the SD threshold. Using a comparative model system of cold- and warm acclimated *Drosophila melanogaster*, my work has centred around the potential role(s) of K^+ channels and the Na^+/K^+-ATPase in lowering the threshold for cold-induced SD. This talk will synthesize the findings from a range of electrophysiological, pharmacological, molecular and genetic knock-down experiments.

Keywords: spreading depolarization, Na+/K+ pump, ion channel, CNS, plasticity

*Speaker

Staying polarized at the poles: how cold adapted insects preserve membrane polarization at low temperature

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Many insect species lose neuromuscular function in the cold due to a mismatch in active and passive membrane ion-transport. In insect muscle the activity of especially Na^+-K^+-ATPase is responsible for maintaining ion gradients and thereby indirectly cell polarization, but the pump also contributes directly to polarization due to a considerable electrogenic effect. Using 10 Drosophila species with markedly different cold tolerances in a comparative experiment, we investigated if chill-tolerant species maintain membrane polarization through superior Na+ K^+-ATPase activity and further investigated if such increased activity comes at a general energetic cost at low temperature. For all ten species, we measured muscle membrane potential in flies bathed in hemolymph buffer at 21C and 0C with and without ouabain (Na+-K^+-ATPase blocker). Here we found that chill-tolerant species maintained a strong electrogenic eect of Na^+-K^+-ATPase activity in cold while this effect was almost eradicated in chill-sensitive species exposed to cold. Metabolic rate (estimated from CO_2-expiration rate, VCO_2) at eight temperatures from 18.5C to 0.5C showed that cold-tolerant species reduced metabolic rate more in the cold. Thus, in contrast to our hypothesis we found chill-tolerant species to have considerably higher Q10-values in the range of temperatures that cause coma for many of the sensitive species. The stronger cold-induced decrease in metabolic rate of cold adapted species is not aligned with the evidence of sustained active transport at the cellular level, but we discuss how this adaptation may represent a general adaptation to food scarcity during winter.

Keywords: Insect, Drosophila, cold exposure, depolarization, electrogenic, metabolic rate

*Speaker

The effect of MIP/AST neuropeptide on cross-talk between insect immune response and temperature tolerance in *Tenebrio molitor* beetle

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Through the process called neuroendocrine integration, nervous and endocrine system interplay together to regulate a number of physiological processes and maintain system-wide homeostasis in regular as well as stressful situations such as temperature stress. One of the most important molecules in the nervous system of all living animals are neuropeptides, which regulate physiological processes and among them, one of the largest groups are allatostatins (ASTs). They are pleiotropic peptides regulating e.g. muscle contraction, synthesis of digestive enzymes or metabolism. Stress-response signaling pathways have been well explored and are highly interactive, it is also clear that some mechanisms of cellular protection are effective against different forms of stress. The aim of this study was to determine the eect of MIP allatostatin Tenmo-MIP 5 on cross-talk between immune response and temperature tolerance. We've measured the survival, expression of six immune-related genes (Tenecin, Attacin, Coleoptericin, Defensin, Cecropin and Toll), total hemocyte count, phagocythosis and phenoloxidase activity after injection of the neuropeptide at 10-6 M concentration, temperature stress (-5 C or 40 C for 1 hour) or combined. Both temperature stress and peptide injection caused significant increase in most of the tested parameters, showing activation of immune response, but the mortality after temperature stress does not change compared to control. However, when combined, temperature stress and peptide injection caused significant increase in mortality. This imply that the overactivation of the immune response in *Tenebrio molitor* affects survival in adverse environmental conditions. This work was financed by grant no 2019/35/D/NZ4/02731 from National Science Center, Poland.

Keywords: temperature stress, neuropeptides, allatostatins, Tenebrio molitor beetle
*Speaker

Two physiological regulatory mechanisms for thermotolerance in insects

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Temperature is an important abiotic factor aecting many physiological processes in insects, which influence their geographical distribution. The thermal tolerance range is given by the minimum (CTmin) and maximum critical temperature (CTmax) with extreme temperatures having deleterious eects. So, there are many behavioral and physiological mechanisms to avoid extreme temperatures. We analyzed two physiological mechanisms, i.e., the role of HSPs and the evaporative cooling in Rhodnius prolixus, a model organism in insect physiology, and an important vector of Chagas disease. Results showed that exposure to moderate heat (1h at 37C) or cold (1h at 10C) increase thermotolerance by aecting both, CTmax and CTmin, and HSP70/HSP90 RNAi knockdown insects showed lower resistance to low and high temperatures compared with their controls. In addition, we demonstrated, by thermolimit respirometry and video thermo-imaging, a signicant decrease of body-temperature and extension of its upper limits of temperature resistance (CTmax) by evaporative cooling. These results provide further insight into the physiological adaptations of insects to harsh environmental conditions aecting their geographical distribution, which is of great importance especially when analyzing invasive insects, pests or vectors of diseases such as triatomines.

*Speaker

Combining physiology with functional genomics: Towards an integrative view of cold tolerance in Drosophila

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Temperature is one of the major factors influencing the geographical distribution and abundance of many animals. As the body temperature of ectotherms such as insects mainly follows the external environment, tolerance towards thermal extremes is essential for adaptation to new environments such those arising through range expansion or climate change. In our laboratory, we established the vinegar fly Drosophila ananassae as model to elucidate the genetic basis of cold tolerance. We identified candidate genes for cold tolerance by means of comparative transcriptomics and a genome-wide QTL mapping experiment with cold-tolerant and cold-sensitive fly strains. Additionally, flies were measured at various cold-tolerance phenotypes with and without precedent cold acclimation. To facilitate efficient manipulation of candidate genes and consequently, to directly link different genetic variants to the segregating phenotypes and to investigate the influence of cold stress on fly physiology, we established molecular genetics tools for genome editing by CRISPR/Cas in this species. To gain functional information for these candidate genes not only for the whole organism but also for individual tissues particularly relevant for cold tolerance (e.g. those involved in ion and water balance), we currently explore these tools to perform tissue-specific genome editing. Our results will shed light on thermal adaptation of natural populations. The combination of state-of-the-art functional genomics and genome editing methods will not only elucidate the function of genes and polymorphisms associated with cold tolerance, but also allow the analysis of additional phenotypes and comparison with other species to identify general patterns of environmental adaptation.

Keywords: Cold stress, cold tolerance, physiology, CRISPR/Cas9, population genomics, chill coma recovery time, lethal time at low temperature, critical thermal minimum, lethal low temperature

*Speaker

The changes in energy reserves and genetic activity levels during recovery from freezing in the Antarctic midge *Belgica antarctica*

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Antarctic insects have special adaptations to endure prolonged freezing during Antarctica's dramatic winter, but the long-term consequences of freezing stress are uncertain. The midge *Belgica antarctica* is the only terrestrial insect endemic to Antarctica, and it must quickly recover after a freeze/thaw event to repair damage and resume normal physiological processes. However, these repair processes are energetically expensive, which can pose long-term consequences to development and reproduction since these midges cannot feed as adults. In this study, we are assessing long-term consequences of freezing stress by measuring changes in gene expression and energy reserves during a 15-day recovery period from non-lethal freezing. Preliminary RNAseq results indicate that there are large-scale changes in gene expression during early phases of recovery, and relatively few genes are differentially expressed between control and frozen larvae later in recovery. We will test the hypothesis that genes involved in repairing freezing injury (e.g., genes involved in restoring osmotic gradients and protein damage) will increase activity early in recovery, which will deplete energy reserves to support these demanding activities. During the later phases of recovery, we predict that genes involved in metabolism and development will increase expression as larvae resume activity and replenish depleted energy reserves. In ongoing analyses, we are quantifying energy reserves to determine the extent to which changes in metabolic gene expression coincide with energy reserves. Our study can provide clues on potential fitness consequences of freezing in *B. antarctica*, as there are limited opportunities to replenish reserves during the ephemeral Antarctic growing season.

Keywords: *Belgica antarctica*, freezing tolerance, energy reserves, RNA seq, recovery.

*Speaker

Session Thermal responses traits & phenotypes

Extended phenotypes: buffers or amplifiers of climate change? Environmental physiology should provide answers

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Historic approaches to understanding biological responses to climate change have viewed climate as something external that happens to organisms. Organisms, however, at least partially influence their own climate experience by moving within local mosaics of microclimates. Such behaviors are increasingly being incorporated into models of species distributions and climate sensitivity. Less attention has focused on how organisms alter microclimates via extended phenotypes: phenotypes that extend beyond the organismal surface, including structures that are induced or built. We argue that predicting the consequences of climate change for organismal performance and fitness will depend on understanding the expression and consequences of extended phenotypes, the microclimatic niches they generate, and the power of plasticity and evolution to shape those niches.

Keywords: Niche construction, microclimate, thermal tolerance, temperature, heat budget

*Speaker

Testing the capacity for the evolution of thermal plasticity in experimental populations of Drosophila melanogaster

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In ectotherms, thermal environment has a substantial influence on growth and development, regulation of metabolism, and reproduction. To cope with variable thermal environments, insects rely on a combination of thermal adaptation and plasticity to optimize survival and performance. While plastic responses (i.e., acclimation) occur within a single generation, the capacity for thermal acclimation is a trait itself, and we would expect acclimation capacity to evolve in response to a change in thermal environment. In this research, populations of wild-caught flies are undergoing experimental evolution to address the evolutionary capacity of different types of plasticity. Distinct thermal regimes were designed to select for different types of thermal acclimation: adult acclimation, developmental acclimation, or short-term hardening. Control populations are maintained at a constant 25C each generation. To select for adult and developmental acclimation, the adult or larval flies are exposed to 18C and 25C in alternating generations. To select for rapid thermal acclimation capacity (i.e., hardening), flies were given daily cold shock (0C) for 2 hours or heat shock (34C) for 1 hour. Flies are being kept in these thermal environments for a minimum of 21 generations, and periodically throughout the experiment we are measuring basal thermal limits and acclimation capacity. We predict that flies kept in thermally variable environments will have increased acclimation capacity, but that distinct types of acclimation (developmental acclimation, adult acclimation, and hardening) will evolve independently. This project will provide insight into the evolution in phenotypic plasticity of thermal responses.

Keywords: acclimation, plasticity, experimental evolution, hardening

*Speaker

Laboratory and field temperature-related developmental rate and viability in *Drosophila suzukii* : How to design ecologically relevant experiments and make accurate predictions ?

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Drosophila suzukii is an invasive pest of soft-skinned fruits. The development of larvae in ripening fruits can cause enormous crop losses. To apply appropriate control measures at the right time, it is necessary to accurately predict development patterns and phenology across seasons. Various population dynamics models exist for *D. suzukii* ; however, these are based on laboratory data that lack ecological relevance (e.g. constant temperatures). For instance, most terrestrial ectotherms experience diurnal and seasonal variations in temperature, and these effects have not been taken into account. Here, we studied and compared developmental rates and viability of *D. suzukii* under constant and fluctuating temperatures (ranging from 8 to 35C). We compared the data obtained with the survival/development patterns obtained under thermal conditions simulating a daily winter/summer thermoperiods, but also with the patterns observed in the field (microcosms in cages). We used a range of linear and non-linear models. In fluctuating conditions, development occurred at temperatures that were supposed to be lethal in constant regimes and high viability was observed in most fluctuating conditions. Linear and non-linear models both fitted experimental data but resulted in slightly different estimated parameters. This study highlights important choices to be made in the design of ecologically relevant experiments and in the selection of models to be used, to better predict phenology and viability. The success of invasions and the establishment of new invasive populations is a major concern in the context of climate change. Accurate predictions of population dynamics are therefore essential to facilitate the control measures.

Keywords: *Drosophila suzukii*, pest, temperature, ecologically, relevant model, developmental rate, climate change, viability, thermal tolerance

*Speaker

From terrestrial ecophysiology to green transition of aquacultures

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Aquaculture is globally the fastest growing food production sector, but the industry's sustainability needs to be improved. Most sh feed today, also live-feed, is enriched with fish oil to meet the sh nutrition requirements for essential unsaturated omega-3 fatty acids. However, it is not sustainable to exploit the marine environment by overfishing to be able to feed fish in aquacultures. Ecophysiology research in the oligochaete *Enchytraeus albidus* has unexpectedly led to finding a new sustainable sh feed. One of the advantages of E. albidus is that they can de novo synthesise essential highly unsaturated omega-3 fatty acids, which circumvents the need for enrichment with fish oil. Propagation of them is easy, and several sh species grow well on them. We have, through our research, found ways to increase E. albidus contents of essential omega-3 fatty acids by feeding them different waste products from the industry. We have found the optimal temperature and salinity for population growth, and we are currently trying to develop a cryopreservation technique based on their natural freeze tolerance, a technique that will ensure long shelf life and stable supplies to fish farmers.

Keywords: Applied ecophysiology, Freeze tolerance, *E. albidus*, fish feed

*Speaker

The shape and genetic variance of the thermal reaction norm of mortality in the collembola *Folsomia candida*

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Global and most local temperatures are increasing due to global change. This warming trend, often accompanied by more extreme climatic events, has significant effects on terrestrial life forms which can suffer from massive mortality when temperatures approach their critical limits. Soil organisms are partly protected by the thermal inertia of the soil, which acts as a buffer to the low and high extremes reached by air temperature. But despite this protection, soil organisms may at some point suffer from extreme thermal events. To better understand the capacity of soil organisms to resist to such events, it is important to know their critical thermal limits, their potential for plastic acclimation, and the level of genetic variation of these traits to foresee their adaptive potential. We used the collembola *Folsomia candida* as an experimental soil organism to address these questions. We characterized the shape of the thermal reaction norms of mortality, by measuring the mortality rate of collembola exposed to 13 temperatures (between -15and +37C) during 2, 4 or 24h. To quantify the adaptive potential of this species to face extreme temperatures, we measured and compared the shapes of these reaction norms using nineteen clonal lineages of Folsomia collected in various natural habitats, and that have evolved in potentially contrasted thermal environments. We present the shapes of the reaction norms over the full species' thermal niche, the temperatures where genetic variation is observed, and how the thermal reaction norms change depending on the duration of exposure to extreme temperatures.

Keywords: Reaction norm, mortality, plasticity, genetic variation, evolution, thermal niche

*Speaker

Thermal physiology of queen bumble bees throughout the life cycle: from weathering fall cold snaps to overwintering metabolism to spring emergence

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Bumble bees are critical pollinators with population declines on multiple continents linked to changing climates. A growing body of work has documented effects of extreme temperatures on workers during the growing season; but we have comparatively little information effects of temperature on queen bumble bees, which emerge in fall, mate, and overwinter prior to starting new colonies in the spring. This annual life cycle (workers, males, and old queens die in fall) means that population persistence depends on success of fall queens. Here, I'll discuss our work investigating effects of temperature on queens across Fall, Winter, and Spring. Queens survived an early fall snowstorm by retreating to buffered microclimates. Cooling temperatures appear to be the primary cue for overwintering, and queens show suppressed metabolism only after prolonged exposure to cold temperatures. Yet, even after 6+ weeks below 4 C, queens are still responsive, capable of rapid return to normal activity. Both modeling approaches and empirical data suggest that suppressed metabolism is likely critical for minimizing use of fixed energy stores over winter.

Keywords: winter, cold tolerance, metabolic suppression, phenology

*Speaker

Respirometric patterns and metabolic rates in diapause of the green veined-white *Pieris napi*

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The metabolic rate of insects is intrinsically intertwined with respirometric patterns. While the metabolic rates have been studied intensively in diapause, the respirometric patterns are more elusive. We studied the influence of temperature and metabolic rates on respirometric patterns. We used the green veined-white butterfly *Pieris napi* to investigate the time and temperature dependence of respirometric patterns and metabolic rate at key time points during diapause. Winter metabolic rates are influenced by temperature, with higher temperatures leading to increased metabolic rates at all stages of diapause. Furthermore, we were able to show that insects in diapause induction, the phase leading into diapause, change their respirometric pattern from continuous breathing to discontinuous gas exchange (DGE) in a matter of 5-7 days. In diapause maintenance, insects uphold the DGE even at warm (20C) temperatures. Pupae change from DGE to continuous gas exchange at warm temperatures only after diapause has terminated. While DGE has a higher CO2 expulsion per peak in warm temperatures, the peaks are shorter than in cold temperatures, indicating a higher control of the DGE in warm temperatures. A single DGE cycle leads to a similar expulsion of CO2 in all temperatures. Therefore, we investigated the period, the length between peaks and found that the length of the periods in warm temperatures significantly decreased, leading to more DGE cycles at warmer temperatures. Here we revealed that a physiological change, diapause, in an insect locks the mode of respiration. Only once the physiology changes is this protected mode of respiration released.

Keywords: Diapause, Respirometric patterns, DGE, metabolic rate
*Speaker

Long winter breaks obligatory diapause in the Antarctic midge

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The Antarctic midge, *Belgica antarctica* is the only insect endemic to the Antarctic Peninsula and its offshore islands. It has a 2-year life cycle and spends most of this period in the larval stage. Embryos, pupae, and adults are found only during the austral summer. Although its physiology, such as the mechanisms of environmental stress tolerance, has been extensively studied, there is little information on how they adapt to the Antarctic seasons. We reared this midge in the laboratory to clarify the ontogeny of their prolonged life cycle and identify environmental cues that promote development. In laboratory conditions at a constant temperature, 1st instar larvae could develop to the 4th (final) instar, but the 4th instar larvae arrested their development and failed to pupate. The observation revealed the 4th instar larvae enter obligatory diapause. We found that 4th instar larvae exposed to simulated Antarctic winter conditions for 3 and 6 months successfully resumed their development after cold exposure, whereas only a small portion of larvae kept under Antarctic summer conditions resumed their development. The longer chilling treatment made more larvae resume their development. Larvae synchronously developed into adults approximately 1 month after the winter experience, and this corresponds to the field observation. We found the Antarctic insect uses obligatory diapause in combination with a required chilling period to set the timing of the emergence of short-lived adults.

Keywords: diapause, Chironomid, Antarctica

*Speaker

Winter environment directly impacts energetic investment in post-winter reproduction

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Winters in temperate environments pose energetic challenges for organisms inhabiting them due to extended duration of minimal resource availability. To conserve limited energy stores, dormant organisms suppress energetic demand during winter. For ectothermic organisms, rate of energy use is temperature dependent, and depletion of winter energy stores is dependent on overwinter thermal environment. Energy that remains at the end of winter can be invested in growth or reproduction, making overwinter conditions vital in determining the amount of energy that can be invested in these processes. The extent that winter environment impacts post-winter energetic investment remains poorly understood in insects, a topic that is becoming increasingly urgent to understand as climate change alters the energetic demands of winter. Here, we examined post-winter energy stores in the leaf beetle *Chrysomela aeneicollis*, and found that after emergence, energy stores increased, but in males the increase was in the fat body, while females invested their income into ovarian development and egg production. We also found that females with larger energy stores were more likely to be gravid in the first ten days after emergence. Together this indicates that females primarily rely on post-winter income for reproduction, but can use remaining capital from dormancy for early egg clutch production. This provides a mechanism for winter environment to directly impact early adulthood reproductive output by determining the amount of capital remaining at the end of winter, which has implications for organisms in highly seasonal environments where reproduction is limited to a short summer window.

Keywords: Winter, Energy use, Reproductive strategy, Energy allocation

*Speaker

Extreme thermal sensitivity escalates heat failure in ectotherms with climate warming

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Temperature affects the rate of all biochemical processes in ectotherms and is therefore critical for determining current and future distribution under global climate change. Here we show that the rate of biological processes maintaining growth and homeostasis in the permissive temperature range increase by a modest 7 % per C of warming (median Q10 = 1.9 from 1,351 rates across 314 species). In alarming contrast, we show that processes related to heat failure in the stressful temperature range are characterized by an extreme temperature sensitivity causing heat failure to increase by more than 100 % per C of warming across a broad range of taxa (median Q10 = 1,592 from 123 rates across 112 species). The impact of this extreme thermal sensitivity implies that the projected increase in frequency and intensity of heat waves will amplify heat mortality for many ectotherms with extreme and disproportionate consequences. Combining the extreme thermal sensitivities with projected increases in maximal temperature across the globe we predict that even moderate warming scenarios will increase heat failure rates by 858% (terrestrial) and 182% (aquatic) by 2100. These projected changes in heat failure rates are even more dramatic locally and imply that we risk underestimating the impact of even modest global warming.

*Speaker

Potential impacts of changing winter conditions on the structure of High Arctic microarthropod communities

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Arctic terrestrial invertebrates overwinter in situ in soil and vegetation. They are involved in key ecosystem process, including decomposition, mineralisation, pollination, and as prey items. This fauna is tolerant to the winter conditions of the Arctic, including low winter soil temperatures. However, rapid environmental changes are occurring, with locations such as Svalbard experiencing warming rates up to four times the global average. These changes also include alterations in precipitation (quantity and form; snow or rain) and wind direction. These will modify the conditions experienced by the overwintering fauna. We employed a manipulation experiment using naturally accumulating snowpack to moderate soil winter soil temperatures, combined with an extended incubator treatment, to map the duration limits of naturally induced cold tolerance. We demonstrate that the Collembola fauna can tolerate temperatures of -25C but that, in areas devoid of snow accumulation and when soil temperatures dip below -30C, signicant mortality occurs. Experimental exposure to a further 12 month period at -6C, as a proxy for snow cover not being lost during the short summer, resulted in additional mortality for Collembola. By contrast, while oribatid mites displayed similar survival over a natural winter as the Collembola, they were highly resistant to the extended exposure at -6C, with no additional mortality. We conclude that snow depth and winter air temperatures interact to regulate soil invertebrate populations over local scales and, hence, the functioning of the Arctic soil ecosystem. Environmental changes currently being observed will continue to modify this fauna and its local and micro-scale distribution.

Keywords: overwinter survival, snow cover duration, snow depth, thernal buering

*Speaker

Thriving in the cold: tolerance to low temperatures and metabolic rate track distribution in ants

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Colder climates pose two important challenges for ectotherms. First, they entail the occurrence of cold-extreme episodes and second, they constrain the amount of energy available for development and reproduction. As a consequence, increased cold-tolerance is commonly observed in ectotherms found in higher altitude/latitude environments, which may be accompanied by metabolic adaptations. In insects, the occurrence of metabolic cold adaptation to mitigate the effects of lower annual temperatures has received ambiguous support, but might directly be related to cold-tolerance at the functional level. In this study, our objectives were thus threefold. First, we (i) aimed at validating the occurrence of metabolic cold adaptation within a single consistent phylogenetical framework made of 13 ant species covering a wide latitudinal distribution in western Europe. Second, we (ii) set to explore the climatic factors driving metabolic cold adaptation using a soil-surface temperature climatic database, and (iii) probe for the potential association of metabolic rate and cold tolerance. We show a clear metabolic compensation effect in higher latitude species, with increased respiration rate at lower temperatures and comparatively reduced standard metabolic rate thermal sensitivity (Q10-SMR) as temperature increases. Respiration rates and Q10-SMR values further track climatic parameters characteristic of colder climates. Finally, we explored the relationship between cold-tolerance and metabolic rate at low temperatures, and how ecient this association is at predicting species' latitudinal distributions.

Keywords: Ants, cold tolerance, metabolic cold adaptation, metabolic rate, biogeography

*Speaker

Plasticity of thermal tolerance following cold or warm acclimation within a freeze-tolerant soil invertebrate distributed from the Arctic to temperate regions

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Species distribution is constrained by seasonal and daily thermal variation. Changing thermal conditions is particularly challenging for ectotherms, which use basal thermotolerance and phenotypical plasticity to mitigate thermal stress. For this reason, thermal acclimation ability, considered a type of phenotypic plasticity, is expected to be important for species' local adaptation and persistence in response to global warming. The Arctic region is particularly concerned, as the environmental consequences of climate change are more pronounced than in other regions of the world. Rising temperatures reduce the insulating snow cover and, paradoxically, increase the risk of soil freezing. Soil-dwelling ectotherms may not only experience more extremely warm days during the polar summer, but also more frequent freezing and thawing events. In this context, our study aims to evaluate the plasticity of thermotolerance after short (1 day) or longtime (several weeks) acclimation to cold (5C) or warm (20C) conditions in a freeze-tolerant earthworm, *Enchytraeus albidus*. This species is an ecologically important secondary decomposer found in rotting seaweed from the Arctic to temperate regions. A previous study showed variation in thermotolerance in *E. albidus* populations collected along a climatic gradient, suggesting that acclimation responses could differ between populations within this species. Using geographically distinct populations of *E. albidus* collected along the thermal gradient, we aim to evaluate whether acclimation responses are related to habitat thermal variability. Since evolutionary adaptation is a slow process, phenotypic plasticity of thermotolerance could represent a relevant component of the acute response to variable temperatures in the context of climate change.

Keywords: Phenotypic plasticity, acclimation ability, climate change, thermotolerance, enchytraeidae

*Speaker

Different thermal stress response may explain the shift aphid dominance hierarchy

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The frequency and magnitude of extreme temperature events are increasing worldwide due to climate change. Previous studies found that extreme climatic conditions altered the demographic rates of three co-occurring aphid species (*Sitobion avenae*, *Metropolophium dirhodum* and *Rhopalosiphum padi*), and shifted aphid dominance hierarchy. We hypothesized that such a shift in dominant species may be driven by distinct physiological abilities to respond to thermal stress. Hence, we compared heat and cold thermal tolerance of three aphid species using thermal tolerance landscape approach and calculated the daily injury accumulation under the natural environment temperature. Lt_{50} (median mortality time) of aphid species were estimated and used to generate thermal death time (TDT) curves across a broad range of stressful temperatures (34 to 40° C, -3°C to -11°C). Result showed *M. dirhohum* had a lower $CT_{max(1h)}$(temperature when Lt_{50} is 1h), lower $CT_{min(1h)}$ and higher z-value (Higher thermal sensitivities correspond to lower z-values at high temperature and opposite at low temperature) than other two species, suggesting it was the most vulnerable to high temperatures, but the most tolerant to low temperatures. On the contrary, *R.padi* survived better than the two other aphid species at high temperatures, but was sensitive to low temperatures. The injury accumulation model also showed *R.padi* accumulated significantly higher injury during winter while *M. dirhohum* got more heat injury during summer. Our results partly explain the field observations that the proportional abundance of *R.padi* increases with the increased frequency of high temperature extreme events. Further, it suggested a trade-off between heat and cold tolerance.

Keywords: Thermal tolerance, Aphids, Extreme temperature events

*Speaker

The thermal ecology of a pollinator-thermogenic plant relationship: integrating physics, chemistry and thermal biology in climate change studies

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Pollinating insects are influenced by abiotic factors (e.g. temperature), including when visiting the flowers. Little is known however about the impact of flower temperature patterns of pollinator biology. Several plant species display the ability to produce metabolic heat (thermogenesis), increasing thereby their own temperature. We focused on the interaction between thermogenic flowers (*Arum maculatum, A. italicum*), and their pollinators (flies Psychoda). These flowers rely on a deceptive method to attract pollinators, by emitting odors resembling the odor of their breeding site. They trap pollinators in the floral chamber imposing their temperature. The aim of this study was first to compare the flower temperature and odors of two sympatric species of Arums and to measure the impact of different microclimatic conditions on the temperature of the flowers and their volatile organic compounds. Secondarily, we investigated the thermal biology of one of their pollinators (*Psychoda sigma*) according to different temperature patterns. We observed a differentiation of volatiles and temperature patterns between the two sympatric Arum species, while both are visited by the same pollinators. The thermal tolerance limit of the fly was relatively close to the temperatures measured in flowers and varied according to the mean developmental temperature and to the daily variance of rearing temperature. The thermal preference results further showed that pollinators preferred rather low temperatures (~8/10C), with a more pronounced cold preference when raised at lower temperatures. These results raise the question of the sustainability of this relationship (thermal trap of the flower?).

Keywords: Pollination, deceiptive method, thermal trap, Arum italicum, Psychoda

*Speaker

Evaporative cooling and reducing heat production allows honey bees to beat the heat when nectar foraging

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Climate change is causing many regions of the world to become warmer and dryer. Will these trends limit insect pollination? Large, endothermic insect pollinators have considerable capacities to thermoregulate during flight, but their thermoregulatory mechanisms and upper thermal limits for flight remain poorly understood. We studied the effect of air temperature (20, 30, and 40C) and nectar loads (0-75% of unloaded weight) on body temperatures, metabolic rates, wingbeat frequencies, and water-loss rates during flight of honey bees, *Apis mellifera*. Thorax temperatures and metabolic rates of flying bees rise with increasing nectar load without changes in water-loss rates at air temperatures of 20C and 30C, with maximal thorax temperatures of 38-40C, respectively. When flying at air temperatures of 40C, thorax temperatures were 46C regardless of nectar load. Thoracic thermoregulation in the heat was made possible by a decrease in metabolic heat production and wingbeat frequency, coupled with evaporative heat-loss that increased exponentially with thorax temperatures above 42C. In desert areas, thermoregulation at high temperatures may be constrained by nectar/water availability, whereas in regions with high humidity, flight will be restricted to lower air temperatures. This research was partially supported by USDA 2017-68004-26322.

Keywords: Thermoregulation, thermal performance, flight aerobic metabolism, evaporative heat loss, flight kinematics, heterothermic homeothermy, honey bees

*Speaker

Behavioural thermoregulation in a fast changing environment: How do ectotherms adjust their thermal preferences in the context of an urban heat island?

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Cities are ideal natural laboratories to investigate the response of organisms to rapid global change. A range of abiotic conditions along urbanisation gradients can foster wildlife to cope with contrasted environments within narrow geographical areas. Among the ma- jor factors induced by urbanisation, temperature is known to profoundly affect ecology by generating urban heat islands (UHI). Because ectotherms have variable body temperature, they are especially sensible to fluctuating environmental temperatures and thus to harsh urban conditions. Yet, they are able to behaviourally thermoregulate. Mobility is therefore a key mechanism which can lead to contrasted selection pressures on populations at a city scale. In our study, we intend to determine if preferred temperatures differ in populations of two common arthropods collected in contrasting thermal zones: a Lycosid spider (*Pardosa saltans*) and a terrestrial isopod (*Oniscus asellus*). To measure thermal preferences, we used an experimental set up enabling to track the position of individuals along a thermal gradient. This contribution aims to present our results and to answer if mechanisms occur in ectotherm populations, allowing them to cope with altered thermal conditions due to urbanisation,an accelerating global trend.

Keywords: arthropods, behavioural thermoregulation, thermal preferences, urban heat island

*Speaker

The influence of thermal developmental acclimation on *Aphidius colemani* host-foraging behaviour at high temperature

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Thermal developmental acclimation can play an important role in shaping physiological, morphological, and behavioral traits at the adult stage. We explored the effect of three constant developmental temperatures (10, 20, and 28C) on life-history traits of the aphid parasitoid *Aphidius colemani*. We then explored how developmental temperature could aect parasitoid host exploitation behaviors, when exposed to high temperature (28C). Developmental time was longer at lower temperatures, resulting in bigger emerging parasitoids. Egg-load was also higher for those developing at low temperatures. Emergence rates and parasitoid survival (once placed at high temperature) were the highest for parasitoids developed at 20C. The expression of all behavioral items (time spent walking searching for hosts, number of antennal and ovipositor contacts with hosts) when exposed to 28C was higher for parasitoids reared at 20C, followed by those reared at 10C, then those reared at 28C. It resulted in the highest parasitism rates by parasitoids reared at 20C, followed by those reared at 10C, and the absence of parasitized aphids by parasitoids reared at 28C. Finally, we showed that parasitoid residence time on aphid patches was determined by both developmental temperatures and the number of host encounter without oviposition. We revealed that developing at 28C did not lead to increased adult performance at 28C, probably because of complex interactions and trade-offs between developmental costs at high temperature and optimal foraging behaviours (e.g., parasitoid size and fecundity or host-handling capacities).

Keywords: developmental plasticity, aphid, climate change, heat, acclimation, behaviour

*Speaker

Session Ecotoxicology

Variability of tolerance to methylisothiazolinone among independent lines of *Daphnia pulex* over four generations

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Isothiazolinones are a family of broad-spectrum biocides widely used in industry and consumer products. These compounds are recognised as strong irritants, with the first cases of contact allergies being reported in 1984, resulting in their restriction by EU legislation. The less harmful of these molecules - methylisothiazolinone (MIT) - is still being used in cosmetics, household cleaners, hygiene products and various industrial applications. Despite this widespread use, the release of MIT from urban sources to aquatic environments and its potential impacts on aquatic organisms have received little attention. Few studies have reported the toxicity of MIT to non-target species. The present work addressed this current knowledge gap by evaluating acute MIT toxicity to *Daphnia pulex* (Cladocera), as well as its sublethal effects on fertility and growth under environmental concentrations. To account for intraspecific genetic variation in sensitivity, the design involved six clonal lines of *D. pulex* stemming from distinct natural populations or commercial strains. Clones exhibited strong variation in their responses, which points to the need to incorporate genetic diversity into ecological risk assessment procedures. In addition, the six clonal lineages were monitored over four generations to compare direct, multigenerational and maternal effects of exposure, as short-lived species are usually exposed to a stressor for more than a generation. These chronic exposure conditions were used to assess physiological endpoints and their change across generations.

Keywords: Ecotoxicology, *Daphnia pulex*, intraspecic variability, multigenerational

*Speaker

Evolutionary toxicology by anthropogenic pollution in invasive crayfish populations

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Evolution as a contemporary process that can affect changes from one generation to the next has only recently been considered in toxicology. While rapid evolution has recently been linked with the increase of invasive capacity of Invasive Alien Species (IAS), it is still not taken into consideration for Invasive Species Predictive Schemes and risk assessments. The Louisiana crayfish, *Procambarus clarkii*, has a strong adaptive capacity to a variety of aquatic environments, including highly contaminated water bodies, and different salinities. Here, we studied three invasive populations of *P. clarkii* that inhabit water bodies at different salinities and pollution levels in the South of France. The results obtained from morphogeometry analysis, and molecular data showed differences between populations. Physiological and molecular responses are population-specific when they are exposed to pollutants and salinity shock. Our results suggest that in *P. clarkii*, the capacity to inhabit polluted environments and the capacity to inhabit water bodies with different salinity levels are not related. While the capacity to face pollutants seems to share a common ancestor in these three populations, the capacity of dealing with salinity change seems to be a more recently acquired trial.

*Speaker

Enduring toxic cyanobacteria on multiple levels: metabolomics, life trait impacts and adaptations in *Daphnia magna*

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Daphnia magna are one of the key freshwater zooplanktons that connect primary production to the consumers' food-web. As a non-selective filter feeders *D. magna* consume phytoplankton, hence they are amongst the first affected by cyanobacterial mass proliferation. Cyanobacteria thrive in eutrophic fresh waters and produce a wide range of bioactive and potentially toxic metabolites. The most commonly investigated cyanobacterial metabolite is microcystin-LR (MC-LR), a potent liver-toxin in vertebrates. This presentation aims to give an overview from Daphnia's uptake of the cyanobacterial toxin MC-LR, its impacts on life traits, the possibility to detoxify it via the glutathione-S transferase (GST) pathway, possible impacts on other metabolism functions, and transgenerational effects. Fluorescence labelled antibodies evidenced the presence of MC-LR not only in gut cells of the exposed *D. magna*, but also in their developing progeny. Thus, impacts of MC-LR in on life traits and physiological responses were investigated in acute, chronic and multigenerational exposure scenarios. During chronic exposure, survival decreased concentration dependently, but pre-exposure enabled offspring a better endurance. If the F0 generation was continuously exposed, their offspring took longer to reach maturity and their survival decreased, even if they were raised in control medium. Cessation of eggs/embryos and malformation of neonates were caused by cyanobacterial toxins. Offspring of pulse exposed parent generation however, developed tolerance in terms of better survival which correlated to increased activity of GST and antioxidant (catalase) enzymes. Non-targeted metabolomic analysis showed significant changes only after 2 days of exposure, affecting different pathways.

Keywords: detoxication, acclimatisation, GST, transgenerational eects
*Speaker

Adaptation or acclimation? How does the amphipod *Gammarus pulex* thrive in polluted habitats?

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The freshwater amphipod *Gammarus pulex* occurs in both pristine and anthropogenically polluted sections of European rivers. We addressed the question, whether (1) pollutants cause the separation of genetically distinct, locally adapted *G. pulex* populations or (2) whether *G. pulex* from differently polluted stream sections are genetically homogeneous and acclimated to site-specific conditions. By genotyping 16 microsatellite markers and based on DNA sequences of a segment of the mitochondrial cytochrome oxidase I (COI) gene we analyzed the genetic population structure of *G. pulex* from rivers in central Germany. An array of micropollutants in water and amphipod tissue samples were measured to determine pollution levels and toxicity potentials of contaminants at the sampling sites. Genetic data indicated intact gene flow within each river, no separation of genetically differently adapted *G. pulex* populations by water pollution was indicated. In a toxicological lab experiment, *G. pulex* from a more highly polluted site was more sensitive to the model toxicant imidacloprid than *G. pulex* from a more pristine site.
Tissue levels of chemical contaminants and their toxicity potential were higher in individuals from the more polluted site, presumably leading to susceptibility for adverse effects in animals from this site. The genetic diversity of *G. pulex* from sites with higher anthropogenic pollution levels were reduced. In conclusion, (1) *G. pulex* is able to acclimate to higher pollution levels and may even benefit e.g. from higher nutrient levels at polluted sites; (2) yet, at polluted sites the species is affected by decreased genetic diversity due to contaminants.

Keywords: anthropogenic pollution, evolutionary toxicology, *Gammarus pulex*, LC, HRMS, microsatellites, population genetics

*Speaker

Responses of a microorganism-poacea-aphid interaction system under edaphic exposure to low doses of herbicide

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Agriculture intensification has been accompanied by the loss of semi-natural habitats and massive use of pesticides to control pests and weeds, leading to a widespread contamination of surrounding terrestrial ecosystems from residual to high concentrations. However, little is known about the impact of low doses of pesticides on whole terrestrial interaction networks. Our study aims at unravelling the effects of low doses of a photosynthesis inhibitor (Isoproturon) on a Poacea plant - Aphid herbivore interaction system in the lab, mimicking interaction networks within grassy strips adjacent to cultivated crops, and assess the impact of Sphingomonas bacteria (able to degrade the herbicide) on these effects. We found that even if no effect of the herbicide was observed at a macroscopic scale, edaphic exposure to low doses of Isoproturon led to plant shoot contamination (aphid contamination is currently assessed) and metabolic shifts (particularly strong in plants exposed for a short time) in both plants and aphids. Herbicide degrading bacteria were sufficient to reduce pesticide substrate contamination and suppress this strong effect but a side-effect of these bacteria on the long run under herbicide exposure suggests secondary effects of the degradation products it generated. Moreover, non degrading bacteria drastically impacted plant metabolism, especially on younger plants, underlining the impact of soil bacterial communities in general on plants and herbivores. This study allowed to underline how pesticides could impact the networks surrounding cultures and therefore the services it supports, but also highlighted how central is the effect of soil bacteria in these chronically polluted systems.

Keywords: Pesticide, trophic interaction, low doses, metabolism, edaphic exposure, soil bacteria

*Speaker

Session Dietary stress & responses

Synergistic effects of developmental temperature and rearing diet on the thermal tolerance and performance of a cactophilic Drosophila

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The developmental temperature has a profound effect on the fitness of ectotherms. Also, diet composition has been shown to affect a range of relevant characters in these organisms. However, the combined effects of these factors have been rarely tested. The present study will focus on the combining effect of developmental temperature and rearing diet on the thermal tolerance and performance of the cactophilic species *Drosophila buzzatii*. Specically, we measure chill coma recovery time, as well as the fitness components of juvenile survival, developmental rate and ovariole number at six developmental temperatures to construct thermal performance curves for each diet. Using these data, we tested the synergy of these factors on the plasticity of thermal performance and tolerance. Remarkably, we found that only when flies were reared on a semi-natural diet and under a daily temperature
fluctuation (DTF) (4-16C; mean = 10C) cactophilic flies can complete development in about 90 days (duration of winter) and attained a high cold tolerance. Conversely, if flies were reared under constant temperature (10C) or on a standard diet (with or without variable temperatures) they failed to complete their development. So, only when more than one natural treatment was included, i.e., seminatural diet and DTF, we found that flies can overwinter as larvae and pupae. The natural diet of necrotic cactus consumed by cactophilic Drosophila combined with winter thermal variability allows overwintering survival and enhanced cold tolerance.

Keywords: diet, cold tolerance, daily temperature fluctuation

*Speaker

Mitochondrial adjustments in Drosophila following drastic dietary changes

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In nature, dramatic fluctuations in dietary resources are often observed, and this variation has shaped the evolution of most cellular processes to ensure suitable mitochondrial, cellular and whole organism functions. Indeed, adjustments at the cellular level to restore homeostasis are essential to survive this type of stress. The mitochondrial unfolded protein response (UPRmt) is crucial for maintaining mitochondrial functions and for the survival of organisms to this type of stress. In this study, we aimed to evaluate the UPRmt in Drosophila melanogaster raised on a series of different diets. We hypothesized that mechanisms involved in the UPRmt are activated after a period of moderate stress, represented in our study by a 24 hrs fasting period, and that they alleviate some of the negative impacts from subsequent stressors i.e., a high-fat diet. Our results suggest that the molecular pathways controlling the UPRmt are modulated by various diets and are responsive to a fasting period. Drosophila also showed important increases of mitochondrial respiration when exposed to a high-fat diet, followed by a drastic decrease after few days suggesting mitochondrial dysfunctions. However, this important reduction is lessened when a fasting period is incorporated before the high-fat diet treatment. Furthermore, when a fasting period is added before a high-fat diet treatment, Drosophila longevity is significantly higher compared to when the fasting period is omitted. These results suggest that mitochondrial functions are highly plastic when organisms are confronted with multiple nutritional stress and that the UPRmt is an important process for maintaining adequate cellular functions.

Keywords: Mitochondria, Drosophila, nutrient, metabolism, molecular pathways

*Speaker

Impact of the nutrition type on the phenotype of Black Soldier fly larvae

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A rapid population increase, and urbanization have raised concern on two major issues: 1) food security particularly the supply of proteins, and 2) management of wastes produced from increased consumption. Globally, poor solid waste disposal ranks as the second most serious environmental problem. In Europe alone, around 100 million tons of food waste are produced each year and in middle-income countries, 2/3 of the organic waste generated is neither collected nor treated. Consequently, wastes are either dumped in open area heaps to undergo natural composting and be fed on by scavenging animals or simply burned. However, the reduction ability of waste coupled with Black Soldier Fly Larvae (BSFL) rich in nutrient prole renders them attractive candidates to serve as an alternative source of protein for domestic animals feed and organic waste management tool. It's in this context that this research was initiated and aims to evaluate the phenotype of BSFL raised on two different substrates (catering waste and fodder). To achieve this goal, larvae were raised on optimal conditions of their development in order to determine the effect of substrate on their growth performances by evaluating the: number of larvae per box; average weight of larvae per stage; weight gain; mortality rate; food intake; food conversion and finally the bioconversion balance of waste by the BSFL. At the end of this research, the impact of diet on the phenotype of BSFL and the bioconversion of organic waste into compost will be known.

Keywords: Black soldier fly larvae, nutrition, phenotype, organic waste and bioconversion

*Speaker

Wolbachia helps *Drosophila suzukii* dealing with diet changes

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The invasive fly *Drosophila suzukii* is considered highly successful. The use of mature fruits, a niche neglected by other drosophilids, and its polyphagy may have contributed to its worldwide spread. Yet, being polyphagous exposes the fly to substrates varying in nutritional composition and some are unfavorable for larval development. Some insects may rely on symbiotic bacteria (e.g., Wolbachia) to better perform on a priori unfavorable substrates. The role of *Drosophila suzukii's* Wolbachia strain (wSuz) is still undetermined but its mutualistic role to deal with abiotic stress has been mentioned. In few insect species, Wolbachia was found to be a nutritional mutualist. The aim of this study was to explore wSuz role in *D. suzukii* adaptation to different diets. To simulate a substrate change, we placed Wolbachia infected and uninfected flies (one female and three males) maintained on a corn-based medium or a grape-based medium on either one or the other media during 30 days. The effect of Wolbachia together with diet treatments was assessed on female fecundity, egg-to-pupa and egg-to-adult development time, mortality, and offspring weight. We found that diet affected female fecundity but Wolbachia did not. However, Wolbachia reduced mortality during larval development regardless of the diet. Our results contribute to a better understanding of wSuz and underline its role on diet tolerance. Better understand the role of symbionts in invasive species could lead to better management strategies.

Keywords: Diptera, endosymbiont, mutualism, invasive species, development

*Speaker

Linking the nutritional states of wild bees to floral resources availability to assess habitat quality

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All bees have in common to rely on oral pollen and nectar for their growth, reproduction and survival. Nectar contains carbohydrates fuelling their energetic demands, and pollen provides proteins, amino acids, lipids, and sterols required for their ovary development and larval diets. A decrease in the diversity and abundance of environmental floral resources may therefore generate a nutritional stress for bees. However, besides some studies on model species such as honeybees, little is known about the influence of floral resource abundance and diversity on the nutritional health of wild bees and thus their sensibility to changes in landscape-level floral resources. To investigate this question, we measured the nutritional state of bees at the community level (26 species from 4 families) in grasslands under different managements in Belgium and Germany. We especially analyzed the proteins, glycogen and triglycerides contents since they are essential to several life history traits (ex. reproduction, immune functions and diapause) and their storage are essentially generated from pollen and nectar consumption. The variation of those nutritional state indicators will then be analyzed in relation with landscape variables such as the local oral resources density and diversity and the land use intensity. By measuring the nutritional state of wild bee species sampled on the field, the ultimate goal will be to identify which species are affected by which grassland traits (floral density, diversity, and management practices) and therefore better assist the conservation of wild bees by adjusting floral enhancement schemes.

Keywords: wild bees, health indicators, conservation, landscape gradient

*Speaker

POSTERS

Poster # 1

How a tropical insect, the cockroach *Gramphodorina coquereliana*, reacts to cold stress by the metabolic response?

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Insects can be met in almost every type of environment, except deep down ocean. It is possible due to their exceptional adaptabilities to different and changeable conditions, especially temperature which is one of the most critical for surviving. Which is why many strategies have evolved to protect organisms against cold stress. It is not surprising, that they are found in insects from terrestrial or subpolar zones. But it is interesting how tropical insects, which are occasionally exposed to low temperature in nature, react on cold, and whether they have developed any strategies to avoid cold stress. In our studies, we focused on metabolic response to cold stress. We analysed levels of lipids, carbohydrates, and amino acids directly after the cold stress and during the recovery time in three time-points. The data showed that the most significant changes concern the composition of saturated and unsaturated fatty acids and the level of sterols and triglycerides. Interestingly, we also observed a significant change in the level of lactic acid. That might suggest switching between anaerobic and aerobic type of respiration depending on conditions - stress or recovery time. For better understanding of that phenomenon, we analysed the activity of lactic dehydrogenase in fat body and muscles. Moreover, we noticed increased level of proline and others amino acids which act as cryoprotectants. Obtained results suggest that despite the tested cockroach species is not affected by cold stress in natural environment, it possesses some strategies allowing to survive in unfavourable temperature conditions.

Keywords: cold stress, metabolism, lipids, carbohydrates, recovery time, tropical insects

*Speaker

Poster # 2

Adaptive biochemical response of the Red Palm Weevil, Rhynchophorus ferrugineus, to deal with cold stress

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The red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier (Coleoptera: Dryophthoridae), is considered one of the most destructive palm pests in warm areas worldwide. However, RPW has demonstrated invasion capacity even in areas with unfavorable winter temperatures. In addition, we recently showed that the RPW larval-pupal transition continues almost undisturbed even during the quiescence induced by cold stress. In this work, we studied the physiological basis underlying its adaptive strategy against low temperatures. Especially, we analysed the main low-molecular-weight biochemical substances acting as possible endogenous cryoprotectants, as well as their efficiency in reducing cold injury by preserving K+/Na+ homeostasis. Wild pre-pupae were cold-treated (5.0, 0.5 .C) or non-treated (23 ± 1 C) for 7 days. We then determined the levels of: (a) glucose, trehalose and glycerol, by spectrophotometry, (b) amino acids, by liquid chromatography and (c) potassium and sodium, by inductively coupled plasma mass-spectrometry. Cold-treated larvae increased their potassium level, suggesting some degree of chill injury. However, part of the cold exposed animals developed an efficient overall cryoprotective response which primarily includes glucose, as well as glycerol and several amino acids (mainly alanine). Our study shows for the rst time that RPW is able of deploying effective physiological mechanisms for a rapid response to cold, which could be relevant to improving predictive models of geographic distribution, especially in a context of climate change. The knowledge of the specific molecules involved would also allow future studies to try to prevent its adaptive strategy, either by natural or chemical methods.

Keywords: red palm weevil (RPW), palm pest, tropical insect, coleoptera, cold hardening, adaptive strategy, low molecular weight substances, cryoprotectant, glucose, glycerol

*Speaker

Poster # 3

The reproductive cost of Drosophila melanogaster: effects on the cold

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In order to maintain their survival, species often make trade-offs between survival and reproduction, often resulting in reduced reproduction. For instance, in temperate areas Drosophila species usually reduce or even stop completely their reproductive activity to cope with cold stressful winter period, in a process called reproductive dormancy. In *Drosophila melanogaster*, this response is rather weak, reversible and often resumes as soon as temper- atures allows egg maturation (i.e. reproductive quiescence). The responses to overwintering by oogenesis stop suggests a cost of reproduction and/or an increased stress tolerance by reduced reproductive activity; yet, this hypothesis has not yet been properly tested for cold tolerance in Drosophila. Here, we compared cold tolerance of gravid versus virgin females, assuming that the latter would lay fewer eggs. We performed a range of cold tolerance assays to determine if virginity promoted cold tolerance. Virgin female's indeed laid less eggs than gravid ones, but this quantitative reduction of oogenesis did not promoted cold stress tolerance. We then attempted to artificially induce a complete stop of oviposition by pharmacological interventions. To do so, we used Rapamycin and Phloroglucinol, two com- ponents known to reduce the oviposition's activity in Drosophila species. Our results showed that Rapamycin's effect of fecundity was mixed and that it did not enhance the flies' cold tol- erance. On the other hand, Phloroglucinol suppressed oviposition activity and significantly enhanced cold tolerance. Further works is ongoing to clarify the effect of Phloroglucinol on stress tolerance.

Keywords: reproduction, survival, tradeoff, cold
*speaker

Poster # 4

Insect responses to extreme high temperatures

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Global change includes a substantial increase in the frequency and intensity of extreme high temperatures (EHTs), which could influence insect at individual, population and community levels. However, little attention has been paid to the impacts of EHTs, due to unpredictable change of fluctuating natural temperatures and difficulty to experimentally simulate the characters of EHTs. We characterized field EHTs, used cereal aphid and diamondback moth as model insects, and simulated in the lab or led to study the response and adaptation of these insects to ETHs. We found that EHTs lead positive or negative impacts to insect, which depends on the intensity, duration and frequency of EHTs, and the temporal sequence of hot and mild phases. Among them the finding that warmer night of EHTs raises the optimum temperature for insect development challenges the "Kaufmann effect". Few days of EHTs could affect insect through immediate effect and carry over effects by cross-stage and cross generation effects. More frequent EHTs alter the structure of cereal aphid communities across large temporal and geographical scales. Importantly, we also found that these insects could buffer the fatal effects of EHTs by adaptive mechanisms such as thermoregulation behavior, phenotypic plasticity, developmental stage specific thermal response and adaptive evolution. We argue that the impacts of EHTs on insects can be resolved from integrative approaches considering natural thermal regimes. Thermal extremes, perhaps more than the gradual increase in mean temperature, drive insect responses to climate change, with crucial impacts on pest management and biodiversity conservation.

Keywords: Climate change, Extreme climate, Demographics
*Speaker

Poster # 5

Thermotolerance of the spotted-wing *Drosophila suzukii*: effect of sex and anesthesia

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The spotted-wing fly, *Drosophila suzukii*, is a pest insect species with increasing interest in its thermotolerance traits. However, most studies focus only on survival to different time exposures to extreme temperatures, and mainly in female flies. Furthermore, it has not been analysed yet if anesthesia used for its manipulation affects these measurements. We proposed to perform three standard thermotolerance assays: Critical temperatures minimum (CTmin) and maximum (CTmax), and chill-coma recovery time (CCRT) on both, female and male flies. In addition, we analyzed the effects of anesthesia by brief exposures to: cold (1 minute at -7C), anoxia by CO_2 or N2 (1 minute). Critical temperatures were measured using a dynamic method starting at 25ºC, followed by a ramp of increasing (CTmax; using "thermolimit respirometry") or decreasing temperature (CTmin) at 0.25 or -0.25C min-1 respectively. For CCRT measurements, insects were exposed to ca. 0C for 14 hours, and then time to recover was recorded. Results showed a significant higher cold and heat tolerance in females than males, in terms of their CTmin and CTmax, respectively. Cold anesthesia shows a signicant decrease of 0.60ºC in CTmax for both sexes (37.250.79) relative to all others groups (37.740.53 control, 37.750.78 N2 and 37.710.48 CO2). No effects of sex and anesthesia were showed in CCRT. We conclude that cold anesthesia seems to have detrimental eects on heat tolerance, and females have broader tolerance range than males, which could help them to survive extreme temperatures in temperate regions.

*Speaker

Poster # 6

Impact of ramping temperatures on life-history traits and phenotypic plasticity in small populations

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Global warming affects the survival of small populations. It is necessary to predict the fate of these populations in regimes with changing temperatures in order to inform future conservation decisions. We already combined branching process modelling and experiments to predict probabilities of extinction at constant temperatures. We now investigate the impact of progressive temperature increases on life history traits (survival, fecundity, size) in the springtail *Folsomia candida* and use the results to predict probabilities of extinction in changing environments. Temperature reaction norms of adult traits are estimated on adults subjected to temperatures which increase with different speeds. Effects of these regimes on fecundity, egg and juvenile survival are estimated at the temperatures where eggs were laid and at near-critical temperatures. Estimations of critical thermal limits (CTL) for springtails raised in different temperatures also provides us with data on intergenerational and transgenerational effects. We also discuss the potential effects on extinction risks of plasticity and transgenerational plasticity.

Keywords: life, history, small populations, springtail, thermal limit, extinction, plasticity

*Speaker

Poster # 7

Climate change, host plant availability and irrigation shape future region-specific distributions of the English grain aphid (*Sitobion avenae*)

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Understanding where species occur using species distribution models has become fundamental to ecological and environmental applications. Much attention is paid to invasive species, however, questions about climate change related range shifts of widespread insect pest species remain unanswered. Here, we incorporated bioclimatic factors and host plant availability into CLIMEX models to predict the global distribution of English grain aphid (*Sitobion avenae* F.), a major pest of cereal grain crops under future climate scenarios. Additionally, to demonstrate the relevance of a frequently used management strategy that may mitigate the eects of climate change, we incorporated the application of irrigation in our models. Our models predicted that the area potentially at high risk of outbreaks of *S. avenae* would contract from 46.8% to 42.5% of the global land mass. This contraction was underlined by regional shifts in both directions: expansion of risk areas in North America and Europe and contraction of risk areas in South America, Africa, Australia, and most of Asia. In addition, we found that host plant availability limited the potential pest distribution, while the application of irrigation expanded it. Our study provides insights into potential risk areas of an insect pest and how climate, host plant availability, and a frequently used management strategy, namely irrigation, affect the occurrence of an insect pest. Our results thereby support agricultural policy makers, farmers, and other stakeholders in their development and application of management strategies aimed at maximizing crop yields and minimizing economic losses.

Keywords: climate change, irrigation, species distribution

*Speaker

Poster # 8

Effect of climate on reproductive strategies of the cereal aphids guild along a longitudinal gradient

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In temperate climates, with warming winters, an increasing number of ectotherm species remain active throughout winter instead of diapausing. In autumn, the decrease of photoperiod and temperature induces a production of sexual morph in aphid population. Sexual reproduction allows aphids to lay diapausing eggs which are resistant to cold, while parthenogenetic populations are more vulnerable to unpredictable cold events. The cereal aphids guild composed by *M. dirhodum, S. avenae* and *R. padi* has a wide geographic range. They show different reproductive strategies which could affect their survival success during winter. Sexual reproduction is assumed to be favoured in climates with cold winters whereas this strategy might be abandoned in climates with mild winters, which has been poorly studied on longitudinal gradients. On the European cline, we expect to observe a gradient of sexual morph from west to east. In this context, we studied a longitudinal gradient in Europe characterised by constant photoperiod and increasingly cold winters from west Britany to the Czech Republic. Clones of *M. dirhodum, S. avenae* and *R. padi* have been collected in autumn 2021, in Brittany, Belgium and the Czech Republic, on three separate 500 m fields. They were reared in the laboratory under sexual reproduction induction conditions (LD: 11:13, 13C, 16000 lux, RH: 70%). Adults phenotyping at the third generation allowed us to obtain the proportion of sexed morph produced by each of the 21 studied clones. The results produced by this study will be presented and their consequences on aphid evolution will be discussed.

Keywords: reproductive strategies, climate, aphids, longitudinal gradient

*Speaker

Poster # 9

The physiological underpinnings of geographical range limits

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Melampus is a genus of high intertidal Ellobid snails that are found around the world in primarily tropical regions. Among the taxa that occur in temperate regions, a single species complex (formerly *M. bidentatus*) occurs in habitats that freeze. The three species in the complex have partially overlapping ranges and different latitudinal extents. They have broad dispersal capabilities and extensive available habitat, suggesting that larvae from each species have the potential to arrive and succeed in regions where they do not occur. Therefore, we hypothesize that their different geographic extents are due to differences in physiological tolerance. Tests of cold tolerance alone suggest that this does not differ among species. We are now testing their respond to combined stressors found in their environment: namely temperature and salinity. Using comparative transcriptomics and whole genome sequencing, we hope to better understand the genomic basis of this stress tolerance and to identify variation among taxa.

Keywords: freeze tolerance, mollusca, intertidal, joint stressors

*Speaker

Poster # 10

Phylogenetic isolation of host trees affects traits of entire multi-taxa community

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A host tree can be phylogenetically separated from its neighbors by millions of years, and thus become an evolutionary island for its community of arthropods. Communities of macroevolutionary islands resemble those of geographic islands in term of diversity, but do they also resemble in terms of sorting of species phenotypes? Specically, (i) do phylogenetically isolated trees select for smaller predators, passive dispersers, larger phytophages and active dispersers, as well as more generalists; (ii), do phylogenetically isolated trees limit the matching between size and environmental conditions because of the low rate of colonization? We focused on three dierent taxa, with dierent feeding habits and dispersal modes. We find that predators and passive dispersers tend to be smaller on phylogenetically isolated tree. There is a selection for generalists only for heteroptera, so it seems that ecient dispersers are not particularly selected by their specialization rate on islands trees. The relationship between environmental conditions and size changed with phylogenetic isolation in 7 out of 12 tests. The relationships tend to decrease on highly isolated hosts, or sometimes reverse, maybe because of the low number of preys and the weak competition on isolated trees. Phylogenetic islands seem to display the same type of characteristics than geographic islands concerning phenotypes of a multi taxa community of arthropods. However, other traits than size must be considered to characterize a community.

Keywords: Island biogeography, phenotypes selection, environmental matching, Quercus, arthropods, forest.

*Speaker

Poster # 11

Body stores of emerging aquatic insects: allometry, mating system and dispersal strategies

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Dispersal is a determining feature in the life cycle of insects and a key factor of their energy budget. If the body stores of terrestrial insects are relatively well documented, those of aquatic insects remain poorly studied. We assayed the body stores (protein, carbohydrate and lipid contents) of emerging imagoes of aquatic insects belonging to18 families, thus encompassing a wide diversity of life-history traits (mating and dispersal strategies). We highlighted an allometry between body stores and mass. When mass increase, the proportion of triglyceride and free carbohydrate relatively decrease whereas protein and glycogen contents relatively increase. After correction for allometry, we found significant effects on aquatic insect body stores. Ephemeroptera have more free carbohydrates and Diptera more proteins than other orders. Males of swarming species contained more free carbohydrates and triglycerides (Diptera and Ephemeroptera) or glycogen (Trichoptera). Passive dispersers of Diptera are characterized by high triglycerides, protein and glycogen contents while active dispersers of Plecoptera and Trichoptera are characterized by a low free carbohydrate, triglyceride and glycogen contents. Each body store was associated with specific life history traits or with taxonomy, emphasising the importance of considering each body store independently. The main structuring factors underlying body store patterns seem to be flight-related (i.e. swarm and dispersal). However, our study estimates the role of flight indirectly, throughout the biological traits of insects. Future works should focus on identifying the use of body stores during flight and characterizing the proteins to validate the links between body stores and energy allocation to flight.

Keywords: aquatic insects, allometry, proteins, carbohydrates, lipids.

*Speaker

Poster # 12

Comparison of responses to starving depending on ambient salinity in two specialist species of wolf spiders: *Pardosa purbeckensis* and *Pardosa saltans* (Araneae, Lycosidae)

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Although wolf spiders, mainly composed of ground-hunting species, are known to tolerate long periods of starving, the physiological responses associated with this stress are still poorly understood, particularly when interacting with other stressful factors like salinity. In this study, we wanted to assess the physiological response to the salinity of *Pardosa purbeckensis*, a salt marsh species, and *Pardosa saltans*, a forest species, and to study its possible interaction with starving over time. For this purpose, females of both species were experimentally deprived of food and placed in a medium saturated with fresh (0‰) or saltwater (35‰). A drastic reduction in key compounds of glycolysis was detected, corresponding to an expected response to starving. The species *P. purbeckensis* seemed to be more sensitive to starving, with a loss of dry mass and an alteration of the Krebs cycle over time, while *P. saltans* seemed more sensitive to soil salinity, with higher body water losses. Finally, the absence of accumulation in compatible solutes, under saline conditions, and for both species, suggests that starving would mitigate the deleterious effects of salinity, even if survival times tended to decrease in salted conditions for both species.

*Speaker

Poster # 13

Fertility in a changing world: the integrative biology of plasticity in reproductive traits

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How animals cope with systematically altered and more variable environmental conditions is a key concern under climate change. A major question is how climate change will impact fertility, and the knock-on consequences this will have for population viability and biodiversity. One mechanism that potentially allows organisms to deal with variability in environmental conditions is phenotypic plasticity, whereby a single genotype can produce different phenotypes suited to different environments. My lab focuses on understanding the proximate mechanisms and adaptive significance of such reproductive plasticity. In this presentation, I will: (a) introduce the main model system we have been using to pursue these questions, the free-living flatworm *Macrostomum lignano*; (b) present insights we have gained about plasticity in one crucial life history trait in response to variable social environmental conditions, namely sex allocation, which in this simultaneously hermaphroditic model organism means the relative investment into the male versus female sex functions; and then (c) describe ongoing work to test the degree to which plasticity in reproductive traits may also mitigate insults to fertility caused by extreme thermal and salinity conditions increasingly predicted under climate change.

Keywords: fertility, phenotypic plasticity, sex allocation, oogenesis, spermatogenesis

*Speaker

Poster # 14

Pathogen avoidance in female *Drosophila melanogaster*

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Pathogens are ubiquitous and infection casts a strong selection pressure on living organisms. Besides physiological defences, individuals can protect themselves through pathogen avoidance ("behavioral immunity"). In particular, this may include avoiding laying eggs where infection risk for the offspring is high. In this study, we tested if Drosophila females avoid laying eggs in environments contaminated by a pathogenic fungus. When given the choice between clean food or food contaminated with *Metarhizium brunneum* fungal spores, females tended to lay more eggs on clean food. Similarly, females preferred food with non-infectious dead bodies (flies killed by freezing) to the one with flies killed by the fungus. Our findings suggest that females avoid infectious food for laying eggs but their perception of infection risk differ depending on the infectious objects.

Keywords: pathogen avoidance, *Drosophila melanogaster*, oviposition, infection risk

*Speaker

Poster # 15

Plant secondary metabolites as potential bioinsecticides? Studies of furfural, 2-undekanone, (E)-2- decenal and (E, E)-2,4-decadienal effects on reproduction of pest *Tenebrio molitor*

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Did you ever wonder about food free from synthetic pesticides? Plant-derived substances might be the answer to restore healthy food without agriculture consequences like soil deterioration and toxicants accumulation. Among them are plants' secondary metabolites which show potential to be bioinsecticides, since they present wide range of biological activities like food intake, oviposition disturbances or growth inhibition. As a model object, we chose insects reproduction system. As one of the biggest problems in pest management is a huge number of eggs laid in short period, we focused our attention on oogenesis and oviposition as worthwhile, but often neglected elements of pest control.

The purpose of the studies was assessment of effects of four plant secondary metabolites: (E)-2-decanal, furfural, 2-undecanone and (E, E)-2,4-decadienal (delivered by injection) on ovarian development, content of Vg transcripts in fat body, oviposition, and larvae hatching of the beetle model species - Tenebrio molitor. Additionally, we tested repellent activity of compounds. Studies showed great biological potential of compounds causing, in various ways, reduction of ovaries volume, affecting follicular epithelium development, and changing vitellogenin transcripts number. Application of compounds resulted in changes of dynamic and number of laid eggs but without reduction of injected females' survival rate. Moreover, we observed reduced hatchability of larvae. Additionally, studies showed that tested compounds possess high repellent activity when administrated with food. They also affected the distance of movement path and speed of locomotion.

Our results showed that tested compounds might be taken into consideration as natural agents in plant protection.

Keywords: Plant secondary metabolites, insects, bioinsecticides, pest control

*Speaker

Poster # 16

How glycoalkaloids modify the activity of crucial metabolic enzymes in insects?

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Glycoalkaloids (GAs) are plant-derived substances with high biological activity. They constitute a natural protection from pathogens and herbivores in many plant species. These substances have potential to become bioinsecticides so their influence on insects' tissues needs to be analyzed. There are only a few studies concerning the mechanisms of GAs action in these organisms. The studies of GAs in insects are focused mainly on the lethal and sublethal eects, thus, their activity remains largely unknown. The activity of GAs can be evaluated through checking their ability to change metabolism. The aim of our studies was to determine whether these compounds have impact on the activity of enzymes of crucial metabolic pathways in insects. The research was conducted on larvae of the *Tenebrio molitor* beetle. In the research, three GAs in concentrations 10-8 and 10-5 M were tested: solanine, chaconine and tomatine. The level of enzymes activity was determined in the fat body and gut cells of the beetles injected with the tested compounds. The activity of main enzymes of glycolysis, Krebs cycle and beta-oxidation of fatty acids such as phosphofructokinase, citrate synthase and 3-hydroxyacyl-CoA dehydrogenase was measured with spectrophotometric methods. The preliminary analysis revealed the effect of the analyzed substances on activity of tested enzymes in insects. These results suggest that GAs have impact on insect physiology and influence on metabolic pathways in beetle cells. Taken together, this research provides important insights into GAs action in insect tissues.

Keywords: Solanaceae, glycoalkaloids, insects, *Tenebrio molitor*, metabolism

*Speaker

Poster # 17

Pollutants affecting the antibiotic resistance of bacteria associated with the oyster *Crassostrea gigas*

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The massive use of antibiotics in human and veterinary medicine has led to the emergence of resistant bacteria/pathogens in the environment. This also applies to aquatic and marine ecosystems, where organisms can enrich these medicinal substances and resistant strains, opening up a direct route to humans by seafood consumption. In addition, other substances such as trace metals and pesticides originating mainly from the use of agrochemicals on farms can also be enriched, and impact the evolution of bacterial resistance to antibiotics and their effects on aquatic organisms. To answer the question if aquatic pollutants can amplify antibiotic resistance in marine organisms, we carried out experiments in controlled environments where juvenile oysters are exposed to various heavy metals (copper, cadmium, mercury, lead) and pesticides (glyphosate, S-metolachlor, pendimethalin) regularly found in European coastal areas. After exposure to different concentrations of pollutants, targeted culture approaches with ampicillin and tetracycline helped to identify and quantify resistant bacteria. Complementary omics approaches will then be used to characterize the underlying antibiotic-resistant genes. Together these molecular and experimental results will allow us to scale up future experiments to the European level jointly conducted in three coastal sites; Germany, France, and Spain.

Keywords: Aquatic pollutants, antimicrobial resistance, oysters

*Speaker

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