ANIMAL BIOLOGY EARLY CAREER RESEARCHER SYMPOSIUM
3–7 OCTOBER 2022
TVÄRMINNE ZOOLOGICAL STATION OF THE UNIVERSITY OF HELSINKI, FINLAND

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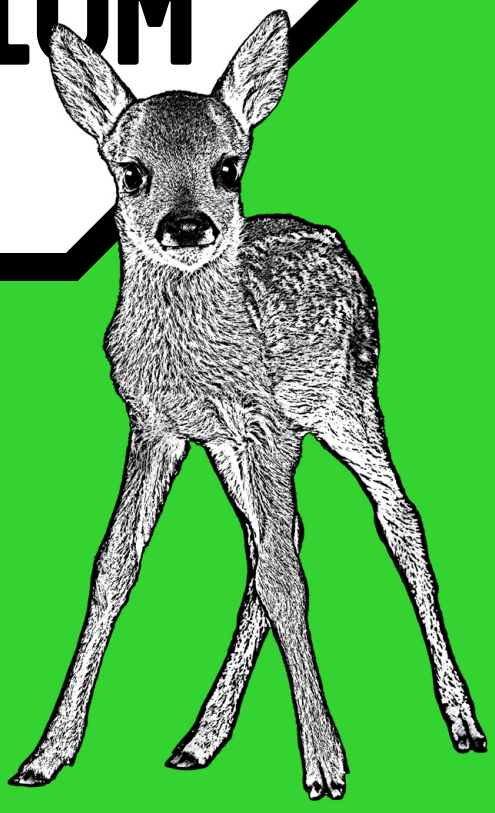
ANIMAL BIOLOGY EARLY CAREER RESEARCHER SYMPOSIUM



SOCIETY FOR EXPERIMENTAL BIOLOGY

CONTENTS

DELEGATE INFORMATION

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The SEB Early Career Researcher Symposium in Animal Biology will take place at Tvärminne Zoological Station, Finland from 3rd October to 7th October 2022. The Symposium brings together early career researchers from across the Animal Biology Section to showcase their work and meet and connect with other ECRs within a unique setting and laid-back atmosphere in picturesque southern Finland.

The meeting will be intended for in-person attendance. Virtual attendance is limited to those who would otherwise have to cancel, for example, due to illness, to allow for presentations to be delivered virtually. This limitation is because our aim is to facilitate in-person attendance by having no registration fees.

PROGRAMME

The programme includes four invited keynote presentations, short presentations by the attendees (15 minutes), poster presentations, as well as social activities and an authentic Finnish sauna by the Baltic Sea. There will be an optional 2h Open Electronics Workshop on building your own research equipment led by PhD & engineering student Sergey Morozov from the University of Helsinki. Sergey has established the FishResp and PumpResp platforms for making open electronics tools available to all biologists.

Posters can be displayed throughout the event. For oral presentations, slides should be uploaded and checked in the seminar room computer on the day of presenting

TRAVEL INFORMATION

Transportation to Tvärminne from Helsinki will be provided on the afternoon of Monday, 3rd October, at 3pm, and return transportation to Helsinki from Tvärminne will be provided on the morning of Friday 7th, October. Arrival to Helsinki will be at about 11am on Friday. The bus on Monday 3rd October will depart from a bus stop for charter busses located in front of the museum Kiasma; please see below map for pickup location:

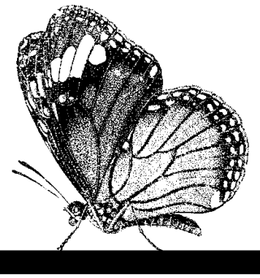
Please inform Jenni Prokkola (+358 40 747 8387) or Eirik Åsheim (+47 478 07 480) if unable to catch the bus on Monday as planned. Jenni will be traveling on the bus.

SEB will not in any circumstances reimburse travel costs between Helsinki and participants' home countries.

ACCOMMODATION/CATERING

Accommodation and meals (breakfast, lunch, coffee, and dinner) are included in the (free) registration. Accommodation will be in student housing at the zoological station (mostly in twin rooms). Accommodation in Helsinki or elsewhere before or after the symposium is not reimbursed. Bed linen and towels are provided. If you have special requests, please inform us during the registration. The station and accommodation facilities are accessible for wheelchair users, and we will arrange for accessible transportation to the station upon request.

The venue is in a remote location and there are no shopping opportunities nearby the zoological station. The attendees have a chance to buy beverages/alcoholic drinks/snacks for the week during the transport to Tvärminne on Monday (euros and credit / debit cards accepted). There are communal fridges where personal drinks and food can be stored and small kitchenettes with basic appliances in the dormitory buildings.



WI-FI INTERNET ACCESS

Internet access is available during the meeting and free of charge.

Log in details as follows:
Network name: HelsinkiUni guest
Password: uniguest (all lower case)

If anyone has access to Eduroam, that is also available at the station.

LIABILITY

Neither the Society for Experimental Biology nor Tvärminne Zoological Station will accept responsibility for damage or injury to persons or property during the meeting. Participants are advised to arrange their own personal health and travel insurance.

PHOTOGRAPHY

No photographs are to be taken of the speakers and their slides during the event unless consent is given by the speaker.

*Please note: The SEB will be taking photos during the event for promotional purposes. If you have any concerns, please notify a member of the SEB team

CERTIFICATE OF ATTENDANCE

Delegates requiring a certificate of attendance should email events@sebiology.org following the event.

SOCIAL MEDIA

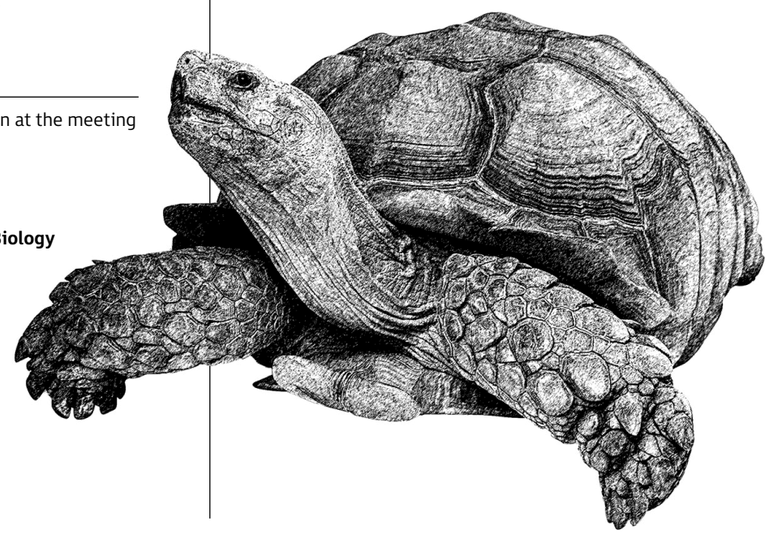
We're looking to increase the conversation at the meeting using Twitter so please get tweeting!
Follow the conversation: #SEBECR
SEB Twitter: **@SEBiology**
SEB Instagram: **@sebiology_**
SEB Facebook: **www.facebook.com/SEBiology**

CONSIDERATION OF COVID-19

In order to make this meeting as safe as possible, we have planned for the following protective measures against the spread of Covid-19.

We will provide the attendees with:
- FFP2/3 masks (masks not mandatory unless it is a general requirement at the university)
- Rapid antigen tests for each day of the meeting (recommendation to self-test)
- Additional ventilation in the lecture room
- Possibility to isolate in a single room if an attendee gets infected
- Social activities outdoors, weather permitting

The attendees are requested to help the meeting run safely by:
- Performing a rapid antigen test before traveling to the symposium and only traveling if the test is negative and you have no respiratory symptoms
- Taking the provided antigen test upon arrival to Tvärminne and every day before joining others for breakfast, if comfortable doing so
- Self-isolating if testing positive during the meeting



INVITED SPEAKERS

PROF. SHAUN KILLEN
PROFESSOR OF ECOPHYSIOLOGY, UNIVERSITY OF GLASGOW

Monday 3rd October **18:30**

WHO LEADS AND WHO FOLLOWS? THE INTERPLAY BETWEEN METABOLIC PHENOTYPE AND SOCIAL BEHAVIOUR IN FISH

Social behaviours come with a variety of costs and benefits for individual animals. For this reason, individuals tend to vary in their degree of sociability. Recent evidence suggests that this behavioural variation is linked to various traits associated with bioenergetics, including metabolic rates and locomotor ability. On the one hand, underlying variation in metabolic traits (e.g., maintenance metabolism, maximum metabolism) seems to affect sociability by affecting predator avoidance, foraging needs, and competitive ability.

Specifically, an animal's energetic status influences not only whether an individual will join a group of conspecifics, but also the behaviour of individuals that have already joined groups. Conversely, an animal's social environment can feedback to affect its physiological traits and performance. This can occur via the effects of aggression and competition but also through stress reduction and the energy-saving benefits of moving in groups. Here I review this interplay between social behaviour and individual physiology, including the modulating role of additional factors such as temperature and oxygen availability. I also discuss ways in which these links may be relevant in the context of human predation on fish populations and fisheries-induced evolution.

DR. JULIA NOWACK
READER IN ANIMAL PHYSIOLOGY, LIVERPOOL JOHN MOORES UNIVERSITY

Tuesday 4th October **09:00**

"COOL" MAMMALS AND WHAT THEY CAN TELL US ABOUT THE EVOLUTION OF ENDOTHERMY

The evolution of endothermy represents one of the most important transitions in vertebrate history. While we are still unclear about the events leading to endothermy, it is more and more likely that endothermy evolved via heterothermy, the ability of animals to reduce metabolic demands in a state of torpor. In recent years it has also become apparent that mammalian heterotherms are found in several climatic regions, including tropical and subtropical habitats.

Interestingly, tropical species often show a higher phenotypic plasticity in terms of triggers and patterns of torpor than species from temperate and artic regions: For example, torpor use cannot only be triggered by food availability, but also hostile and unpredictable climatic conditions, supporting the idea that heterothermy may also have enabled certain mammal lineages to survive the global wildfires and post-impact winter at the K-Pg Boundary. As mammals evolved under climatic conditions similar to modern day tropics, the recent findings have implications on how we picture ancestral thermoregulation and can help shed further light on how endothermy evolved and why it is not universally expressed in today´s mammals.

The talk will describe our latest understanding of phenotypic plasticity in torpor use together with the costs and benefits of various patterns of torpor and discuss the implications of these findings in the light of the evolution of endothermy.

DR. ROSE THOROGOOD
ASSOCIATE PROFESSOR IN BEHAVIOURAL ECOLOGY, UNIVERSITY OF HELSINKI

Wednesday 5th October **10:15**

FROM INDIVIDUALS TO SPECIES INTERACTIONS: HOW THE SOCIAL ENVIRONMENT SHAPES COEVOLUTION

When Niko Tinbergen and others proposed that the evolution of animal behaviour could be studied in the wild, a revolution began. After decades of behavioural ecology research, we now know that behaviour responds to selection and is one of the most plastic traits in animal biology. It is also often described as a species' 'first line of defence' against changing environments. However, how behaviour influences evolution is only just beginning to be appreciated.

Here I'll use a classic study system in behavioural ecology, the coevolution of cuckoos and their reed warbler hosts, to show how considering the social environment can expand our understanding of trait evolution and discuss whether it can either facilitate or hinder how species adapt to changing environments.

DR. VALENTINA DI SANTO
ASSISTANT PROFESSOR OF FUNCTIONAL MORPHOLOGY, STOCKHOLM UNIVERSITY

Thursday 6th October **09:00**

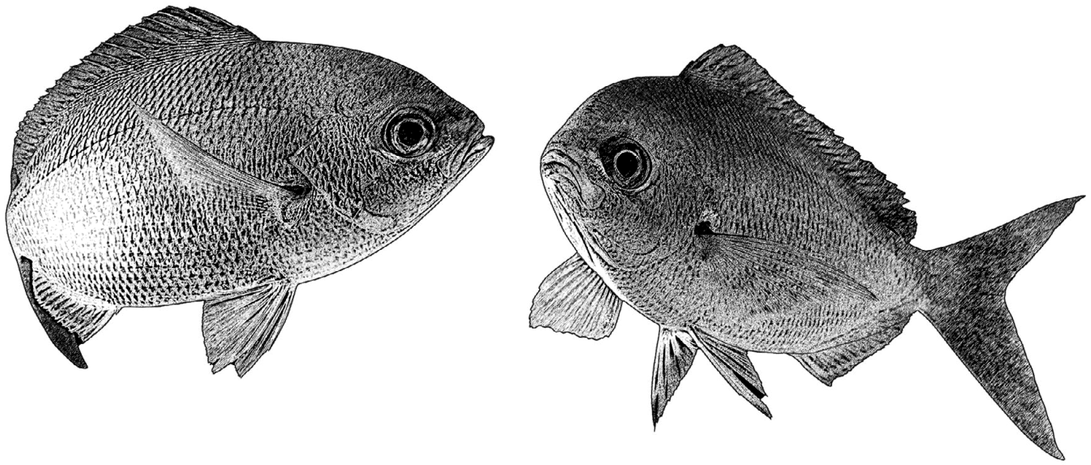
HOW FISHES SAVE ENERGY: EXPLORING BIOMECHANICAL AND PHYSIOLOGICAL PERFORMANCE OF LOCOMOTION

Swimming ability has contributed to the evolutionary success of fishes, and its mechanics have been studied extensively across groups. Fishes exhibit an astounding diversity of locomotor behaviours, from classic swimming with their body and fins to jumping, flying, walking, and collective behaviours such as schooling. During my talk, I will discuss how fish can increase locomotor efficiency during solitary and collective swimming across a range of speeds.

PROGRAMME DAY BY DAY

PROGRAMME DAY 1 MONDAY 3RD OCTOBER 2022

TIME	SPEAKER	INSTITUTION	ABSTRACT NUMBER	TITLE
15:00	Bus leaves Helsinki Address: Mannerheiminaukio 2, next to Kiasma museum. The bus will stop in a supermarket on the way for beverages.			
16:50 - 17:10	Arrival at Tvärminne			
17:10 - 17:30	Getting settled in rooms			
17:30 - 18:30	DINNER			
18:30 - 19:30	**Keynote 1:** Shaun Killen	University of Glasgow, UK	13171	Who leads and who follows? The interplay between metabolic phenotype and social behaviour in fish
19:30 ONWARDS	Socialising: Pub quiz			

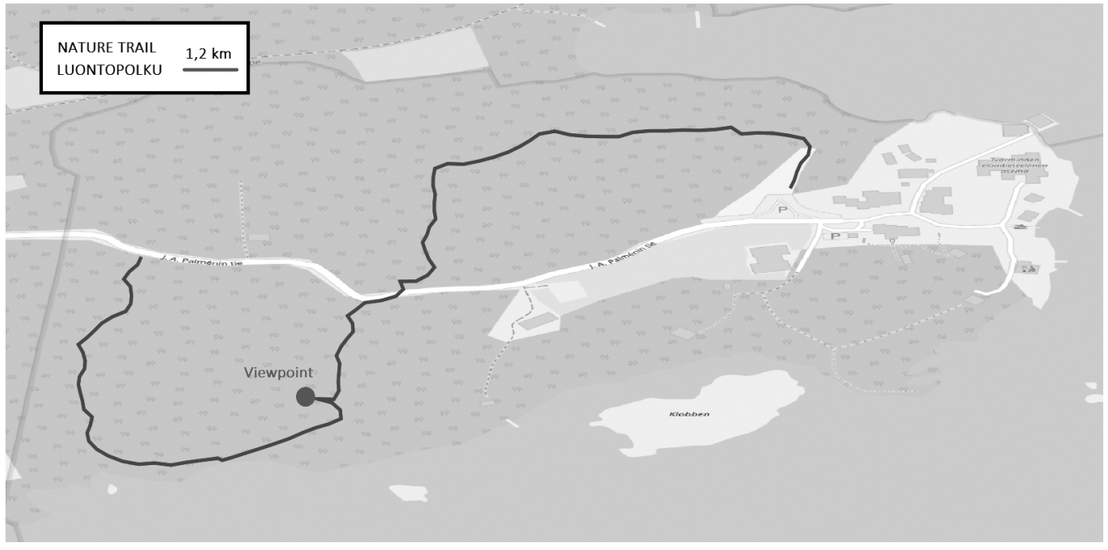


PROGRAMME DAY 2 TUESDAY 4TH OCTOBER 2022

TIME	SPEAKER	INSTITUTION	ABSTRACT NUMBER	TITLE
08:00 - 08:45	BREAKFAST			
09:00 - 09:45	**Keynote 2:** Julia Nowack	Liverpool John Moores University, UK	13172	"Cool" mammals and what they can tell us about the evolution of endothermy
09:45 - 10:05	Janina Bethge	Universität Hamburg, Germany	13169	Sportive lemurs respond to challenging seasons with elevation of their metabolic rate
10:05 - 10:25	Ashlee Mikkelsen	Department of Natural Sciences and Environmental Health University of South-Eastern Norway	13188	Breaking all the rules: Small-bodied brown bears may choose a vegetarian lifestyle while maintaining high reproductive output
10:25 - 10:45	Gerardo Antonio Cordero	University of Lisbon Centre for Ecology Evolution and Environmental Changes, Portugal	13159	Intrinsic versus extrinsic sources of phenotypic variance in animal development: Shell pattern formation in turtles
10:45 - 11:00	BREAK			
11:00 - 11:20	Floriane O'Keeffe	Trinity College Dublin, Ireland	13183	Examining the effects of simultaneous and sequential co-infections using Daphnia magna as an experimental system
11:20 - 11:40	Niamh McCartan	Trinity College Dublin, Ireland	13184	The effect of extreme weather events on Daphnia magna infected by a microsporidian parasite
11:40 - 12:00	Katie O'Rourke	School of Biotechnology Dublin City University, Ireland	13187	Responses of daphnids upon chronic exposures to pharmaceuticals - A combination of metabolic and physiology endpoints
12:00 - 13:00	LUNCH			
13:00 - 13:20	Jamie McCoy	University of Plymouth, UK	13167	Measuring the most sensitive stages of life as a spectra of energy - an approach to understanding environmental sensitivity
13:20 - 13:40	Amelia Munson	University of Glasgow, UK	13174	Effects of changing temperatures on social behavior via effects to metabolism in the common minnow (Phoxinus phoxinus)
13:40 - 14:00	Angela Albi	Max Planck Institute of Animal Behaviour, Germany	13181	Parasite-induced variation of individual and group behaviour in guppies
14:00 - 14:20	Jacinta Kong	Trinity College Dublin, Ireland	13162	Can we improve our ability to interpret ectotherm thermal tolerance?
14:20 - 14:40	Sergey Morozov	University of Helsinki, Finland	13205	Open electronics applications in experimental biology: current state and future perspectives
14:40 - 15:10	COFFEE + BUN + POSTERS			
15:10-17:10	Open electronics workshop by Sergey Morozov			
17:00 - 18:00	DINNER			
18:00-18:45	Poster session			
18:45 ONWARDS	Swimsuit sauna & socializing: Women's sauna 19-20:30, men's 20:30-22. Bring your swimsuits!			

PROGRAMME DAY 3 WEDENSDAY 5TH OCTOBER 2022

TIME	SPEAKER	INSTITUTION	ABSTRACT NUMBER	TITLE
08:00 - 08:45	BREAKFAST			
09:00 - 10:15	Ilse Klockars: Station introduction & tour			
10:15 - 11:00	**Keynote 3:** Rose Thorogood	University of Helsinki, Finland	13173	From individuals to species interactions: how the social environment shapes coevolution
11:00 - 11:20	Alena Lemazina	Max Planck Institute for Biological Intelligence, Germany	13194	Song duels facilitate context-dependent changes in canary song syntax and its underlying premotor neural activity
11:20 - 11:40	Elisa Thoral	Lund University Department of Biology Section for Evolutionary Ecology, Sweden	13186	Cold or hot spells: long-term consequences for mitochondrial metabolism in Japanese quail and comparison between different tissues
11:40 - 12:00	Matteo Vecchi	Università di Jyväskylä, Finland	13182	Assesing anhydrobiotis performances - The diversity and evolution of desiccation resistance in tardigrades.
12:00 - 13:00	LUNCH			
13:00 - 13:20	Thomas Wagner	University Regensburg, Germany	13192	A systematic examination of learning in the invasive ant Linepithema humile reveals very rapid development of short and long-term memory
13:20 - 13:40	Adrian Fisher II	Arizona State University, USA	13177	The impact of a widely used fungicide on honey bee (Apis mellifera) health
13:40 - 14:00	Nadja Verspagen	University of Helsinki, Finland	13157	Variation in phenotypic plasticity in Glanville fritillary butterfly larvae from a latitudinal cline
14:00 - 14:20	Katharina Ruthsatz	Technische Universität Braunschweig, Germany	13191	A new actor on the stage of global change: Effects of microplastics pollution throughout amphibian metamorphosis
14:30 - 15:00	COFFEE + BUN			
15:00 - 17:00	Outside activity: games, walking (see map below)			
17:00 - 18:00	DINNER			
18:00 ONWARDS	Socializing			



PROGRAMME DAY 4 THURSDAY 6TH OCTOBER 2022

TIME	SPEAKER	INSTITUTION	ABSTRACT NUMBER	TITLE
08:00 - 08:45	BREAKFAST			
09:00 - 09:45	**Keynote 4:** Valentina Di Santo	Stockholm University, Sweden	13170	How fishes save energy: exploring biomechanical and physiological performance of locomotion
09:45 - 10:05	Yangfan Zhang	Harvard University, USA	13161	Understanding the bioenergetics and biomechanics of fish schooling behavior
10:05 - 10:25	Alice Leavey	University College London, UK	13151	Modelling the effect of different skeletal proportions on hindlimb kinematics in frogs
10:25 - 10:45	Theodora Po	University of California Irvine, USA	13178	The Collective Mechanics of Sea Star Locomotion
10:45 - 11:00	BREAK			
11:00 - 11:20	Vincent Mélançon	Université de Montréal, Canada	13180	Body condition and mitochondrial metabolism of naturally infected sunfish (Lepomis gibbosus)
11:20 - 11:40	Dércia Santos	Universidade de Trás-os-Montes e Alto Douro, Portugal	13202	Behavioral responses in zebrafish (Danio rerio) to microplastics and copper exposure
11:40 - 12:00	Marie Levet	Université de Montréal, Canada	13165	Energetic costs of mounting an immune response in a coral reef damselfish Pomacentrus amboinensis
12:00 - 13:00	LUNCH			
13:00 - 13:20	Daniel Sadler	University of Jyväskylä, Finland	13153	Do fisheries influence adaptation to climate change?
13:20 - 13:40	Daphne Cortese	University of Glasgow, UK	13175	The effects of hypoxia on intergenerational plasticity in fish
13:40 - 14:00	Davide Thambithurai	Ifremer, France and University of Glasgow, UK	13179	Investigating the relationship between acute warming, size and metabolic rate in wild gilthead bream (Sparus aurata)
14:00 - 14:20	Lucie Gerber	University of Oslo, Norway	13164	Improving organ preservation: Another lesson from the champion of anoxia tolerance, the crucian carp (Carassius carassius)
14:20 - 14:40	Zara Cowan	Norwegian University of Science and Technology	13185	TBC
14:40 - 15:10	COFFEE + BUN			
15:10 - 15:30	Justine Chartrain	University of Jyväskylä, Finland	13197	Semiochemical-based mate searching behaviour in tardigrades: comparing the sexes
15:30 - 15:50	Zowi Oudendijk	Helsinki University, Finland	13156	Evolution and prevalence of de novo synthesized pyrazines as chemical defence in Arctiinae species.
15:50 - 16:10	Areeba Khan	University of Hull, UK	13154	Impact of short-term pH change on crayfish anti-predatory behaviour
16:10 - 16:30	BREAK			
16:30 - 16:50	Luca Pettinau	University of Turku, Finland	13152	Fit mums, fit juveniles? Effects of maternal exercise training on thermal tolerance and life history traits in brown trout offspring
16:50 - 17:10	Lucas Zena	University of Gothenburg, Sweden	13189	Electrocardiographic manifestations of myocardial ischemia in Rainbow trout (Oncorhynchus mykiss)
17:10 - 17:30	Ana Lopes	ISPA - University Institute of Psychology Social and Life Sciences, Portugal	13203	The role of different stressors on reproductive success of a marine temperate fish species
17:35 - 17:55	Jenni Prokkola	Natural Resources Institute Finland (LUKE)	13160	Energetics of life-history variation: genetic associations between metabolic rates and age-at-maturity in Atlantic salmon
18:00	FAREWELL DINNER			
19:30 ONWARDS	Swimsuit sauna & socializing: Men's sauna 19:30-21:00, women's 21:00-22:30. Bring your swimsuits!			
	FINAL FESTIVITIES			

PROGRAMME DAY 5 FRIDAY 7TH OCTOBER 2022

TIME	
08:00 - 08:45	BREAKFAST
09:00	Departure by bus to central Helsinki
10:45 - 11:00	Arrival in Helsinki

ABSTRACTS

13191: A NEW ACTOR ON THE STAGE OF GLOBAL CHANGE: EFFECTS OF MICROPLASTICS POLLUTION THROUGHOUT AMPHIBIAN METAMORPHOSIS

Wednesday 5th October **14:00**

Katharina Ruthsatz (Technische Universität Braunschweig, Germany), Marie Domscheit (Technische Universität Braunschweig, Germany), Anja Schwarz (Technische Universität Braunschweig, Germany), Ruth Meyer (Technische Universität Braunschweig, Germany), Sarah-Maria Schaeffer (Technische Universität Braunschweig, Germany), Miguel Vences (Technische Universität Braunschweig, Germany), Karolin Engelkes (Leibniz-Institut zur Analyse des Biodiversitätswandels, Germany)

@ katharinaruthsatz@gmail.com

Microplastics (MPs) are a fast-growing source of environmental pollution and might represent risks for wildlife. However, such risks are still mostly unknown for amphibians. If ingested with the natural food source, MPs act as artificial fibres that reduce food quality with possible ramifications for growth, development, and energy budgets. We investigated the effects of polyethylene microplastics in two life stages (larvae and juveniles) of the African clawed frog (*Xenopus laevis*) on larval growth, development, gut length, body condition as well as their standard metabolic rate (SMR). We conducted morphometric measurements in juveniles to determine possible carry-over effects of MPs ingestion. In both life stages, we investigated whether MPs accumulated in the body. We found that MPs ingestion resulted in sublethal effects on development and metabolism in larval *X. laevis*, lead to carry-over effects on juvenile body shape, and accumulated in the animal body. In larval stage, gut length increased in response to MPs ingestion indicating that MPs induced digestive plasticity. Body condition and mass were similar across experimental groups, indicating that larvae fully compensated for low nutrient and energy density by developing longer intestines. However, SMR and age increased and decreased in response to MPs ingestion, respectively. In juveniles, body width was larger in animals exposed to MPs during larval stage. Our findings provide first insights into the complex effects of MPs on amphibians across life stages and suggest that juvenile amphibians might be a major transfer path for MPs from freshwater to terrestrial ecosystems.

13192: A SYSTEMATIC EXAMINATION OF LEARNING IN THE INVASIVE ANT LINEPITHEMA HUMILE REVEALS VERY RAPID DEVELOPMENT OF SHORT AND LONG-TERM MEMORY

Wednesday 5th October **13:00**

Thomas Wagner (University Regensburg, Germany), Henrique Galante (University Regensburg, Germany), Tomer Czaczkes (University Regensburg, Germany)

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The Argentine ant (Linepithema humile) is one of the most damaging and widespread invasive ant species worldwide. However, control attempts often fail due to insufficient bait uptake, or bait abandonment. Increasing preference for, and consumption of, bait is thus an important requirement for successful control. Learning and within-nest information transfer might be a potential tool for achieving this goal. We conducted a systematic investigation of olfactory learning and route learning in Argentine ants. The ants showed very strong and rapid route learning, choosing the correct arm in a Y-maze 65% of time after just one visit, and 84% correct after two. Odour learning was even more rapid, reaching up to 85% correct choices after just one exposure to flavoured food. Having two cues (surface odour and food flavour) does not improve learning significantly over just one cue. Learning is long-lasting, with 73% correct choices after 48h. Food flavour information is transferred efficiently between nestmates in the nest, driving preference: naïve ants housed with ants fed on flavoured food show a strong preference (77%) for that odour after 24h.

Overall, Linepithema humile are outstanding learners. This, coupled with efficient intranidal information transfer and strong pheromonal recruitment, may help explain their ability to discover and then dominate resources. However, these strengths could potentially be used against them, by exploiting learning and information transfer to increase toxic bait uptake. Steering ant preference by leveraging learning might be an underappreciated tool in invasive alien species control.

13182: ASSESING ANHYDROBIOTIS PERFORMANCES - THE DIVERSITY AND EVOLUTION OF DESICCATION RESISTANCE IN TARDIGRADES

Wednesday 5th October **11:40**

Matteo Vecchi (Università di Jyväskylä, Finland), Lorena Rebecchi (Unviersity of Modena and Reggio Emilia, Italy), Łukasz Michalczyk (Jagellonian University, Poland), Daniel Stec (Polish Academy of Sciences, Poland), Sara Calhim (Università di Jyväskylä, Finland)

@ matteo.m.vecchi@jyu.fi

Anhydrobiosis (the ability to survive environmentally induced loss of body water) is the most widespread and studied form of cryptobiosis in tardigrades. Unfortunately, not only do laboratory protocols vary considerably between research groups and across study organisms, but there are few phylogenetic comparative studies on how this trait evolves. Our aims are to quantify anhydrobiotic performances and develop new analysis methods for data from anhydrobiosis experiments.

We subjected more than 20 species of tardigrades to anhydrobiosis following a standardized desiccation protocol. We then rehydrated the anhydrobiotic animals and recorded the number of motile animals at different time points. To analyse this data, we developed a new approach based on the Bayesian fitting of a cumulative Weibull distribution function on proportion of motile individuals against monitoring time points. This method estimates both the overall survival and recovery speed and combine them into one Anhydrobiosis index. We estimated the anhydrobiotic index for the examined Macrobiotidae populations under the standardized desiccation protocol. These values were then analysed in a phylogenetic context.

We demonstrate that our combination of experimental protocol and analysis method not only can estimate reliable anhydrobiotic performance measures, but also provides an intuitive visualization of the estimated parameters. Secondly, the phylogenetic comparative study highlighted a considerable variability in anhydrobiotic performance, even between closely related species of Macrobiotidae. The three measures of anhydrobiotic performance (overall survival, recovery speed and anhydrobiotic index) show weak phylogenetic signal, suggesting a fast evolution of anhydrobiotic performances in response to environmental pressures.

13202: BEHAVIOURAL RESPONSES IN ZEBRAFISH (DANIO RERIO) TO MICROPLASTICS AND COPPER EXPOSURE

Thursday 6th October **11:20**

Dércia Santos (Universidade de Trás-os-Montes e Alto Douro, Portugal), Ana Luzio (Universidade de Trás-os-Montes e Alto Douro, Portugal), Luís Félix (Universidade de Trás-os-Montes e Alto Douro, Portugal), Sandra M. Monteiro (Universidade de Trás-os-Montes e Alto Douro, Portugal)

@ dsantos@utad.pt

Behaviour output provides an early warning sign of pollutants toxicity and integrates multiple levels of biological effects. The knowledge regarding the behavioural toxic effects associated with microplastics (MPs) and heavy metals exposure is still scarce. This study aimed to evaluate the long-term (30days) effects of MPs (2 mg/L) and copper (Cu, 25 µg/L), alone or combined, in the zebrafish (Danio rerio) locomotor, anxiety, and social behaviours. Genes involved in pathways linked to the control of behaviour (apoptosis, cholinergic, serotonergic, and dopaminergic pathways) were also evaluated. Our findings showed that MPs and Cu exposure modulated acetylcholinesterase, by increasing its activity. When considering dopaminergic system-related genes (thandslc6a3), an upregulation was observed in MPs, Cu25 and Cu25+MPs groups, while the serotonergic pathway transcripts were not affected. For the apoptosis-related genes, in the MPs group was observed an increase of casp8, casp9 and casp3 expression. Changes in zebrafish behaviour (mean speed, total distance moved, inactivity in the aquaria, and social/shoaling behaviour) were observed in the MPs and Cu-exposed fish. The results showed that MPs and Cu25 alone caused hypoactivity, while the mixture resulted in a state of hyperactivity. The increased AChE activity, and/or apoptosis, and dopaminergic-related genes alterations may have contributed to these changes. Our results highlight the multiplicity of toxic effects of MPs and Cu in the zebrafish brain, which, in turn, can result in behavioural changes.
This work is supported by National Funds by FCT, under the projects UIDB/04033/2020, ATLANTIDA (ref. NORTE-01-0145-FEDER-000040), and the FCT-PhD grant (PD/BD/127992/2016).

13180: BODY CONDITION AND MITOCHONDRIAL METABOLISM OF NATURALLY INFECTED SUNFISH (LEPOMIS GIBBOSUS)

Thursday 6th October **11:00**

Vincent Mélançon (Université de Montréal, Canada), Sophie Breton (Université de Montréal, Canada), Stefano Bettinazzi (University College London, United Kingdom), Marie Levet (Université de Montréal, Canada), Sandra A Binning (Université de Montréal, Canada)

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Parasites can affect host behaviour, cognition, locomotion, body condition and other physiological traits. Changes to host aerobic metabolic rates are likely responsible for these parasite-induced performance alterations. Whole-organism metabolic rate is underpinned by cellular energy metabolism driven most prominently by the mitochondria. However, few studies have explored how mitochondrial enzymatic activity relates to parasite infection, compared to other environmental stress factors, despite being a putative site for metabolic disruptions causing performance impairments during infection. We studied correlations among natural parasite infection, host body condition and the activity of key mitochondrial enzymes in target organs from wild-caught pumpkinseed sunfish (*Lepomis gibbosus*) to better understand the cellular responses of fish hosts to endoparasite infection. Enzymatic activity in the heart, gills, spleen, and brain of infected fish was not significantly related to parasite infection or host body condition. However, the activity of cytochrome C oxidase, an enzyme involved in oxidative phosphorylation, in fish hearts was higher in individuals with a lower body condition when not looking at parasite infections. Activity of citrate synthase, an enzyme of the tricarboxylic acid (TCA) cycle, was also significantly different among organs with the heart and the brain displaying the highest CS enzymatic activity. These results provide preliminary information regarding the likely mitochondrial pathways affecting host body condition, the maintenance energetic requirements of different organs and their specific dependency on particular mitochondrial pathways. These results help pave the way for future studies on the effects of parasite infection on mitochondrial metabolism.

13188: BREAKING ALL THE RULES: SMALL-BODIED BROWN BEARS MAY CHOOSE A VEGETARIAN LIFESTYLE WHILE MAINTAINING HIGH REPRODUCTIVE OUTPUT

Tuesday 4th October **10:05**

Ashlee J Mikkelsen (Department of Natural Sciences and Environmental Health University of South-Eastern Norway, Norway), Keith A Hobson (Department of Biology University of Western Ontario, Canada), Agnieszka Sergiel (Institute of Nature Conservation Polish National Academy of Sciences, Poland), Anne G Hertel (Department of Biology Ludwig Maximilians University of Munich, Germany), Andreas Zedrosser (Department of Natural Sciences and Environmental Health University of South-Eastern Norway, Norway)

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Obtaining and allocating limited food is a problem for wild populations in which food is heterogeneously distributed through space and time; and dietary deficiencies can result in stunted growth, disease, or reproductive failure. Brown bears (Ursus arctos) are physiologically carnivores, but they vary in use of landscapes and diets. Many consume little meat, instead relying on vegetation and invertebrates. Greater carnivory in bears is associated with greater body sizes, densities, and reproductive output. Despite access to meat, brown bears in Sweden are relatively small bodied and consume large amounts of berries. We used stable isotopes in hair of a wild population of brown bears in south-central Sweden 1995 – 2015 to estimate annual proportions of ants, moose, and three berry species across the entire population and between females and males to determine if bears in this population were protein limited, which may explain their smaller body sizes and illustrate a trade-off between growth and reproduction. We found that females consumed less meat than males and overall brown bears consumed less meat and protein than was predicted. Females' diets in the population were only 3% meat, but reproductive output in this system matches North American Populations in which meat made up a 27 times larger proportion of the diet. These results indicate that across brown bear populations, meat may serve different functions in maximizing fitness.

13162: CAN WE IMPROVE OUR ABILITY TO INTERPRET ECTOTHERM THERMAL TOLERANCE?

Tuesday 4th October **14:00**

Jacinta D Kong (Trinity College Dublin, Ireland), Nicholas C Wu (Western Sydney University, Australia)

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Thermal tolerances, such as critical temperatures, indicate how environmental temperatures affect individuals and provide a basis for assessing climate change vulnerability across species. However, many ectotherm life cycles are characterised by discrete life stages and microhabitat preferences may vary among species, and methods to assay thermal tolerance are not standardised. Variation in thermal tolerances among species may be driven by confounding variation from methodology, and by confounding interactions between microhabitat preference and ontogeny that can generate a 'thermal bottleneck', which sets the climate vulnerability for a complex life cycle. Since confounding variation may mask trends in large-scale comparative studies of complex life cycles, we evaluate two approaches to resolving ontogenetic and environmental drivers of thermal tolerance and methodological variation. Using phylogenetically informed, multi-level models with a global dataset of upper critical temperatures from 438 Anuran species, we find ontogenetic trends in thermal tolerance are similar across microhabitat preferences and standardising critical temperatures against common methodological variation had little impact on our conclusions. Our results suggest thermal bottlenecks are not present in anuran life cycles and imply strong developmental or genetic conservatism of thermal tolerance within families and ecotypes. We discuss considerations for resolving confounding variation to interpret thermal tolerance at a macrophysiological scale.

13186: COLD OR HOT SPELLS: LONG-TERM CONSEQUENCES FOR MITOCHONDRIAL METABOLISM IN JAPANESE QUAIL AND COMPARISON BETWEEN DIFFERENT TISSUES

Wednesday 5th October **11:20**

Elisa Thoral (Lund University Department of Biology Section for Evolutionary Ecology, Sweden), Maria Correia (Lund University Department of Biology Section for Evolutionary Ecology, Sweden), Elin Persson (Lund University Department of Biology Section for Evolutionary Ecology, Sweden), Imen Chamkha (Lund University Department of Clinical Sciences Mitochondrial Medicine, Sweden), Eskil Elmér (Lund University Department of Clinical Sciences Mitochondrial Medicine, Sweden), Joshua Tabh (Lund University Department of Biology Section for Evolutionary Ecology, Sweden), Andreas Nord (Lund University Department of Biology Section for Evolutionary Ecology, Sweden)

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Predictions for the future suggest an increase in the frequency and intensity of extreme events, such as heat waves and cold snaps. This is predicted to have significant consequences on mitochondrial function and, hence, cellular capacity to produce energy. It is therefore relevant to study how mitochondrial efficiency is affected by the thermal environment, and if any thermal sensitivity changes over the life of the animals. We exploited the fact that non-mammalian vertebrates contain mitochondria in their red blood cells to study how environmental temperature and life stage affected mitochondrial metabolism. We reared Japanese quails in cold or hot conditions from hatching until reproductively mature, after which hot and cold birds were transferred to a common garden at intermediate temperature in a fully factorial design. Moreover, since we do not know how well blood respiration correlates to mitochondrial function in tissues with more defined roles in metabolism and thermoregulation, we also measured mitochondrial function in skeletal muscle and liver homogenates once the birds had spent at least two months in the common garden. This experiment will allow us to better understand the consequences of extreme temperature events on mitochondrial function in multiple tissues, and also provide unprecedented insight into the extent to which blood measurement can be used as a minimally invasive predictor of organism-wide mitochondrial metabolism.

13172: "COOL" MAMMALS AND WHAT THEY CAN TELL US ABOUT THE EVOLUTION OF ENDOTHERMY

Tuesday 4th October **09:00**

Julia Nowack (Liverpool John Moores University, United Kingdom)

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The evolution of endothermy represents one of the most important transitions in vertebrate history. While we are still unclear about the events leading to endothermy, it is more and more likely that endothermy evolved via heterothermy, the ability of animals to reduce metabolic demands in a state of torpor. In recent years it has also become apparent that mammalian heterotherms are found in several climatic regions, including tropical and subtropical habitats. Interestingly, tropical species often show a higher phenotypic plasticity in terms of triggers and patterns of torpor than species from temperate and artic regions: For example, torpor use cannot only be triggered by food availability, but also hostile and unpredictable climatic conditions, supporting the idea that heterothermy may also have enabled certain mammal lineages to survive the global wildfires and post-impact winter at the K-Pg Boundary. As mammals evolved under climatic conditions similar to modern day tropics, the recent findings have implications on how we picture ancestral thermoregulation and can help shed further light on how endothermy evolved and why it is not universally expressed in today´s mammals. The talk will describe our latest understanding of phenotypic plasticity in torpor use together with the costs and benefits of various patterns of torpor and discuss the implications of these findings in the light of the evolution of endothermy.

13153: DO FISHERIES INFLUENCE ADAPTATION TO CLIMATE CHANGE?

Thursday 6th October **13:00**

Daniel E Sadler (University of Jyväskylä, Finland), Stephan Van Dijk (University of Jyväskylä, Finland), Phillip C Watts (University of Jyväskylä, Finland), Silva Uusi-Heikkilä (University of Jyväskylä, Finland)

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Overfishing may be the biggest threat to aquatic ecosystems; indeed, the extremely high mortality rates and distinct size selectivity can cause evolutionary change in exploited populations. Consequently, fished populations may become more vulnerable to other anthropogenic stressors due to reduced genetic variation and selection towards certain life-history strategies. We utilise three populations exposed to size selective harvesting: large-selected (removing 75% of the smallest individuals from the population, leaving the largest individuals), small-selected (removing 75% of largest individuals from the population, leaving the smallest individuals, mimicking fisheries), and random-selected (removing 75% of a population at random). Five generations of size-selective harvesting induced numerous phenotypic changes in exploited populations together with large-scale genetic changes. These populations have now recovered from harvesting stress for nine generations. To determine the vulnerability to thermal stress of size-selectively exploited fish populations, we exposed individuals to three temperature treatments (34°C; 28°C; 22°C). We assessed differences among the selection lines in life history traits (growth and reproduction), physiological traits (metabolic rate and CTmax), behavioural traits (activity and feeding behaviour), and genetic traits. We found that selection lines showed different responses to the thermal stressors, with particularly strong responses at 34°C, showing large alterations in life history traits. Furthermore, our control line (random-selected) showed greater resilience to thermal stress, particularly in relation to growth and metabolism suggesting fisheries-induced selection can erode adaptive potential. Our results allow for a greater understanding of synergistic stressors on fish populations under future climatic scenarios.

13174: EFFECTS OF CHANGING TEMPERATURES ON SOCIAL BEHAVIOUR VIA EFFECTS TO METABOLISM IN THE COMMON MINNOW (PHOXINUS PHOXINUS)

Tuesday 4th October **13:20**

Amelia Munson (University of Glasgow, United Kingdom), Daphne Cortese (University of Glasgow, United Kingdom), Shaun Killen (University of Glasgow, United Kingdom)

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Social behaviour is an important part of the life of many animals with consequences for foraging and predator avoidance. In many species, individuals consistently vary in how social they are, which has consequences for group level dynamics. Recent work has found that individuals with a higher metabolic rate are less social, likely because they prioritize finding food over avoiding predators. In ectothermic animals like fish, temperature influences metabolic activity with higher temperatures leading to an increase in metabolic rate. As an individual fish moves through its environment, it is exposed to temporally and spatially different temperatures which could alter the individual motivation to engage in social behaviour. Warming temperatures caused by climate change could also lead to reductions in social behaviour and changes in overall group cohesion via effects on metabolic rate. However, the speed by which changes in metabolic rate affect expressed social behaviour is not well understood. To test this, we acclimated common minnows (Phoxinus phoxinus) to three different temperatures (14, 17 and 20˚C) over 4 weeks. We then measured maximum metabolic rate, standard metabolic rate, and aerobic scope at acclimation temperature. In addition, we measured the routine metabolic rate, individual social behaviour, and group cohesiveness over a gradient of ramping temperatures (up to 23˚C). The results of this study will shed light into the effects of environmental change not only on an individual's physiology and behaviour but also on group behaviour, which is essential to better predict the capacity of species to cope with climate change.

13185: EXAMINING CLIMATE VULNERABILITY ACROSS LIFE STAGES IN FISH

Thursday 6th October **14:20**

Zara-Louise Cowan (Norwegian University of Science and Technology), Anna H Andreassen (Norwegian University of Science and Technology), Leon Green (University of Gothenburg), Sandra Binning (University of Montreal), Josefin Sundin (Swedish University of Agricultural Sciences), Jeremy De Bonville (University of Montreal), Timothy Clark (Deakin University), Fredrik Jutfelt (Norwegian University of Science and Technology)

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Climate change is projected to have broad impacts on aquatic ecosystems, ranging from effects at the individual level to altering the structure and functioning of ecosystems. Ectothermic animals may be particularly sensitive to warming as their basic physiological functions are strongly influenced by environmental temperature. In a recent, high-profile Sciencearticle, it was proposed that some life stages of fish (embryos and spawners) are much more vulnerable to climate warming than other life stages; however, this research has been criticised on empirical and theoretical grounds. Intrigued by this high-stakes controversy, we conducted preliminary experiments testing thermal tolerance in all life-stages of two temperate species of fish. Contrary to expectations, all life stages showed very similar thermal tolerances, thus the question of which life-stages are most at risk from climate warming remains unresolved. Building on these preliminary experiments, we will empirically settle this important question using a series of experiments on multiple life stages in select temperate and tropical, marine and freshwater species.

13189: ELECTROCARDIOGRAPHIC MANIFESTATIONS OF MYOCARDIAL ISCHEMIA IN RAINBOW TROUT (ONCORHYNCHUS MYKISS)

Thursday 6th October **16:50**

Lucas A Zena (University of Gothenburg, Sweden), Andreas Ekström (University of Gothenburg, Sweden), Daniel Morgenroth (Swedish University of Agricultural Sciences, Sweden), Tristan McArley (University of Gothenburg, Sweden), Albin Gräns (Swedish University of Agricultural Sciences, Sweden), Michael Axelsson (University of Gothenburg, Sweden), Henrik Sundh (University of Gothenburg, Sweden), Erik Sandblom (University of Gothenburg, Sweden)

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Coronary arteriosclerosis appears to be an ongoing condition in many salmonid fishes, which may lead to e.g., myocardial ischemia. The potential of salmonids to recover from myocardial injury is essential for fish regularly exposed to stress, e.g., in iteroparous salmonids species and fish in aquaculture. Here, we aimed to investigate the consequences of experimental coronary artery occlusion on cardiac morphological characteristics andin vivocardiac function in juvenile rainbow trout (Oncorhynchus mykiss) allowed to recover for 3 days (short-term recovery) and from 117 to 173 days (long-term recovery) after coronary artery occlusion. Coronary artery occlusion in the short-term recovery group resulted in elevated resting heart rate along with reduced cholinergic tone on the heart relative to sham operated fish. Moreover, we observed markedly abnormal patterns in the electrocardiogram, such as changes in QRS morphology (e.g., reduction in the QRS voltage, prolonged QRS interval and apparent fragmentation of the QRS complex). In addition, we also observed the appearance of atrioventricular block that was precipitated by muscarinic receptor blockage (atropine). Fish from the long-term recovery group exhibited normalized resting heart rate along with restored cholinergic tone, and normalized electrocardiogram relative to sham-operated trout. All coronary artery ligated fish from the long-term recovery group showed ventricular revascularization, which was confirmed by perfusing the coronary vessels with silicone injection compound (Microfil). Taken together, we demonstrate that rainbow trout may cope with the aversive effects caused by coronary artery obstruction through plastic ventricular remodelling, which over time alleviates the adverse effects on cardiac function.

13165: ENERGETIC COSTS OF MOUNTING AN IMMUNE RESPONSE IN A CORAL REEF DAMSELFISH POMACENTRUS AMBOINENSIS

Thursday 6th October **11:40**

Marie Levet (Université de Montréal, Canada), Sandra A Binning (Université de Montréal, Canada), Shaun S Killen (University of Glasgow, United Kingdom), Redouan Bshary (Université de Neuchâtel, Switzerland), Simona Colosio (Université de Neuchâtel, Switzerland), Joanna Miest (University of Greenwich, United Kingdom), Dominique G Roche (Carleton University, Canada)

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The immune system is a critical first line of defence against pathogens, but mounting an immune response is energetically costly. Quantifying such costs based on energy changes caused by immune stimulation remained challenging due to response variation across time and different doses of immune stimulants. Here we tested the metabolic costs of mounting an immune response in a coral reef damselfish (Pomacentrus amboinensis) following injection with different amounts of lipopolysaccharide (LPS), an endotoxin. Fish were divided into eight treatment groups: handling control, saline injection and one of 6 LPS injections with concentrations ranging from 3 mg/kg – 100 mg/kg. We measured the oxygen consumption of the fish, for 24h, before and after LPS injection. We quantified the cost of immune activation by measuring the difference in oxygen consumption rate pre-injection and post-injection. We also measured spleeno- somatic index and immune gene expression post-injection to determine if a change in oxygen consumption was associated with the induction of an immune response. We found that fish exposed to higher doses of LPS (between 30mg and 100 mg) increased their metabolic demands compared to control groups. While we did not find any significant differences in SSI across treatment, immune gene expression levels were higher than controls for fish exposed to 3mg, 30mg, 50 mg, and 100 mg of LPS. Overall, our results highlight the complexity of evaluating the energetic cost of immune activation, which is both dose-dependent and influenced by an individual's metabolic traits.

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13160: ENERGETICS OF LIFE-HISTORY VARIATION: GENETIC ASSOCIATIONS BETWEEN METABOLIC RATES AND AGE-AT-MATURITY IN ATLANTIC SALMON

Thursday 6th October **17:35**

Jenni Prokkola (Natural Resources Institute Finland (LUKE), Finland)

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Life-history variation is produced by trade-offs in energy allocation, suggesting energetics shape life-history evolution. The Atlantic salmon (*Salmo salar*) exhibits strong variation in age-at-maturity, with strong genetic control via two genomic regions, *vgll3* and six6. This enables implementing genomic prediction methods to test potential genetic correlations, and subsequent co-evolution, between age-at-maturity and physiological traits. Here, we tested how variation in these life-history genomic regions affect several metabolic phenotypes: standard and maximum metabolic rates, and aerobic scope, as well as tissue-level metabolism, in juvenile Atlantic salmon. We found no evidence for covariation between standard metabolic rate and the genomic regions, but we found that *vgll3* affected the maximum metabolic rate and aerobic scope, and that the two regions had epistatic effects on maximum metabolic rate. We then measured proxies of aerobic and anaerobic capacities from several tissues to understand how tissue-specific energetics can mediate these effects. The results provide insights to the mechanistic basis of life-history variation as well as to metabolic constraints on life-history evolution.

13156: EVOLUTION AND PREVALENCE OF DE NOVO SYNTHESIZED PYRAZINES AS CHEMICAL DEFENCE IN ARCTIINAE SPECIES.

Thursday 6th October **15:30**

Zowi Oudendijk (Helsinki University, Finland), Johanna Mappes (Helsinki University, Finland)

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Pyrazines are volatile, nitrogen containing heterocyclic compounds widely distributed in plants, insects, fungi, and bacteria and they act as an odour signal to repel predators. In insects, pyrazines are known to be used for a wide range of functions, such as mating attractants and aggression stimulants. However, recently more attention is being paid to their role as a defensive chemical. Aposematic and polyphagous insects can obtain methylalkylpyrazines through sequestration from the host plant or *de novo* synthesis by the organism itself. Studies on *de novo* synthesis of defensive compounds within insects are well known among beetles and other insects, while in moths and butterflies (Lepidoptera) this is yet to be explored. A well-studied model species, the wood tiger moth (*Arctia plantaginis*) was found to carry two unique defensive chemicals; sequestered pyrrolizidine alkaloids from their diet and *de novo* synthesized methoxypyrazines that they emit from their specialised cervical glands as neck fluid when they are provoked. For my doctoral research, I will examine whether other Arctiinae species and close relatives of *A. plantaginis* release neck fluid when provoked, and whether if it contains pyrazines and if these are *de novo* synthesized. From this research, we will gain understanding of when this trait evolved, and its diversity and importance as a chemical defence across Arctiinae and other insects.

13183: EXAMINING THE EFFECTS OF SIMULTANEOUS AND SEQUENTIAL CO-INFECTIONS USING DAPHNIA MAGNA AS AN EXPERIMENTAL SYSTEM

Tuesday 4th October **11:00**

Floriane O'Keeffe (Trinity College Dublin, Ireland), Rebecca Pendleton (Trinity College Dublin, Ireland), Celia V Holland (Trinity College Dublin, Ireland), Pepijn Luijckx (Trinity College Dublin, Ireland)

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The recent outbreak of Covid-19 has highlighted the ever-present need to understand the drivers of the outbreak and spread of disease. Although much of the research investigating diseases focuses on single infections, natural systems are dominated by multiple infections. Indeed, up to 80% of infections in human systems are multiple infections. Multiple infections may occur simultaneously but are often acquired at different timepoints in what are known as sequential infections, and the timing of infection may impact the outcome of infection. Using waterfleas (*Daphnia magna*) as a model organism, we examined the outcome of sequential and simultaneous multiple infections with two microsporidian parasites (*Ordospora colligata* and *Hamiltosporidium tvaerminnensis*) in a fully factorial deign with nine treatments. We found no effect of multiple infection on fitness of *O. colligata*, while *H. tvaerminnensis* growth was impeded in multiple infection treatments. Lower spore production of *H. tvaerminnensis* can be attributed to the earlier mortality of animals exposed to the multiple infection treatments, thus giving *H. tvaerminnensis* less time to grow. Similar patterns of virulence were observed in animal fecundity, where animals exposed to multiple infection treatments produced fewer babies than animals exposed to single *H. tvaerminnensis* treatments. This may suggest that populations infected with *H. tvaerminnensis* may experience increased virulence following co-infection by *O. colligata*. This study will also provide the basis to examine the effects of increased temperatures on co-infection, as previous studies have shown that these parasites have different responses to increases in temperature.

13152: FIT MUMS, FIT JUVENILES? EFFECTS OF MATERNAL EXERCISE TRAINING ON THERMAL TOLERANCE AND LIFE HISTORY TRAITS IN BROWN TROUT OFFSPRING

Thursday 6th October **16:30**

Luca Pettinau (University of Turku, Finland), Tytti Uurasmaa (Department of Biology University of Turku, Finland), Jenni M. Prokkola (University of Helsinki Organismal and Evolutionary Biology Research Programme, Finland), Amelie Crespel (Department of Biology University of Turku, Finland), Eila Seppänen (Natural Resources Institute Finland (Luke), Finland), Katja Anttila (Department of Biology University of Turku, Finland)

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Farming fish for stocking is the most common conservation tool for brown trout (Salmo trutta). However, hatchery fish have often difficulties coping with natural conditions having low survival in the wild. In addition, with the current context of global warming, there is an urgent need to improve the stocking programmes to enhance fish survival. For example, current brood-stock rearing conditions do not allow fish to display their normal swimming behaviour which negatively affect their cardiorespiratory physiology. As cardiac functions are strongly related to the capacity of fish to handle high temperatures, hatchery reared fish might be especially vulnerable to heat waves, reducing their survival prospects even more. Recent studies have shown that aerobic exercise training can improve cardiac function and cardiac thermal tolerance in farmed fish. However, it is unknown whether the benefits of exercise training might be transmitted to the next generation. Therefore, our aim was to investigate the effects of training on cardiac thermal performance of adult brown trout and test for the occurrence of transgenerational inheritance. We trained the dams with two different water flow conditions: a control condition (0.2 bl/s) and exercise training program (0.7 bl/s for 6h per day, for 5 weeks), and assessed their cardiac thermal performance and reproductive success. Thereafter we examined the survival rate of the offspring at different life stages, as well as the genetic and non-genetic inheritance of thermal tolerance. By combining these different approaches, this project is providing new insights on the determinants of fish thermal tolerance.

13173: FROM INDIVIDUALS TO SPECIES INTERACTIONS: HOW THE SOCIAL ENVIRONMENT SHAPES COEVOLUTION

Wednesday 5th October **10:15**

Rose Thorogood (University of Helsinki, Finland)

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When Niko Tinbergen and others proposed that the evolution of animal behaviour could be studied in the wild, a revolution began. After decades of behavioural ecology research, we now know that behaviour responds to selection and is one of the most plastic traits in animal biology. It is also often described as a species' 'first line of defence' against changing environments. However, how behaviour influences evolution is only just beginning to be appreciated. Here I'll use a classic study system in behavioural ecology, the coevolution of cuckoos and their reed warbler hosts, to show how considering the social environment can expand our understanding of trait evolution and discuss whether it can either facilitate or hinder how species adapt to changing environments.

13170: HOW FISHES SAVE ENERGY: EXPLORING BIOMECHANICAL AND PHYSIOLOGICAL PERFORMANCE OF LOCOMOTION

Thursday 6th October **09:00**

Valentina Di Santo (Stockholm University, Sweden)

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Swimming ability has contributed to the evolutionary success of fishes, and its mechanics have been studied extensively across groups. Fishes exhibit an astounding diversity of locomotor behaviours, from classic swimming with their body and fins to jumping, flying, walking, and collective behaviours such as schooling. During my talk, I will discuss how fish can increase locomotor efficiency during solitary and collective swimming across a range of speeds.

13154: IMPACT OF SHORT-TERM PH CHANGE ON CRAYFISH ANTI-PREDATORY BEHAVIOUR

Thursday 6th October **15:50**

Areeba Khan (University of Hull, United Kingdom), Thomas Breithaupt (University of Hull, United Kingdom)

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Threat of predation can induce dramatic changes in the prey's behaviour and physiology. Predation ultimately leads to death and hence, anti-predatory responses are crucial for survival. In aquatic environments, chemical signals indicating predatory threats can be affected by water acidification. Changes in pH of water may not only impact the sensory processes involved in chemoreception but may also affect central neural processes involved in stress responses such as the anxiety-like behaviour recently described in crayfish. In this study, we compared the anti-predatory behaviour among crayfish in response to chemical stimuli (alarm odour, i.e., haemolymph from conspecifics) and physical stimuli (manual handling to mimic transient capture by predator) upon short-term exposure to two different pH (acidic: pH6, normal: pH8). Manual handling was used as a control stressor to determine whether short-term exposure to low pH affects the central processes involved in anxiety-like behaviour. Haemolymph glucose levels which correspond to changes in serotonin, were analysed to indicate stress. We observed that crayfish did not effectively respond to alarm odour at pH6 and were less stressed than those at pH8 in behaviour trials and glucose level measurements. However, there was no statistically significant difference in response to manual handling in the two pH groups where animals were found to be equally stressed in behavioural and glucose analysis outcomes. The results of our study indicate that short-term exposure to low pH might not involve central-nervous system processes but may impact peripheral processes such as those involved in chemical detection of alarm odour in crayfish.

13164: IMPROVING ORGAN PRESERVATION: ANOTHER LESSON FROM THE CHAMPION OF ANOXIA TOLERANCE, THE CRUCIAN CARP (CARASSIUS CARASSIUS).

Thursday 6th October **14:00**

Lucie Gerber (University of Oslo, Norway), May-Kristin Torp (University of Oslo, Norway), Gigi Lau (University of British Columbia, Canada), Göran Nilsson (University of Oslo, Norway), Sjannie Lefevre (University of Oslo, Norway), Kåre-Olav Stensløkken (University of Oslo, Norway)

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Understanding the detrimental effects of ischemia-reperfusion injury on donated organs is an active area of research with important implications for updating organ preservation protocols and to meet the growing demands for viable and functioning organs in transplantation. In most vertebrates, oxygen limitation and subsequent re-oxygenation is associated with mitochondrial production of reactive oxygen species (ROS) and a cascade of cell damaging events. Yet, the anoxia-tolerant crucian carp (*Carassius carassius*) has evolved a unique ability to survive months without oxygen and to protect and repair from damage after re-oxygenation. Hence, the crucian carp offers an excellent model species to shed light on the physiological mechanisms underlying anoxia and re-oxygenation tolerance. Here, we investigated whether the crucian carp shows tissue oxidative damage when exposed to 5 days of anoxia and to 5 days of anoxia followed by 3 or 24 hours of normoxic recovery. This was done by measuring levels of protein carbonylation for protein oxidation, and 4-hydroxynonenal for lipid peroxidation in the liver, brain, heart, and gills. In addition, we used high-resolution respirometry to compare mitochondrial complexes contribution to respiration and ROS production in isolated mitochondria from the heart of the anoxia-tolerant crucian carp and the anoxia-intolerant mouse, at both 37C and 8C (i.e., a temperature used to preserve organs during cold ischemic time). We found key differences that may 1) contribute to better understanding the mechanisms that underpin anoxia and re-oxygenation survival and 2) help develop strategies to improve organ preservation and increase the availability and function of donor organs.

13159: INTRINSIC VERSUS EXTRINSIC SOURCES OF PHENOTYPIC VARIANCE IN ANIMAL DEVELOPMENT: SHELL PATTERN FORMATION IN TURTLES

Tuesday 4th October **10:25**

Gerardo Antonio Cordero (University of Lisbon Centre for Ecology Evolution and Environmental Changes, Portugal), Jose Vicente Bataller (Centro de Conservación de Especies Dulceacuícolas de la Comunitat Valenciana, Spain)

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Developing organisms frequently experience suboptimal environments that destabilize tissue-scale processes and induce abnormal phenotypes. This is likely common in species that provide little parental care and lay eggs in the external environment, such as most reptiles. For instance, the development of the turtle's shell has provided striking examples of abnormal pattern formation, which are presumably caused by environmental disturbances and possibly altered tissue microenvironmental conditions. To test these hypotheses, we simulated extremely hot and dry egg incubation environments and inhibited muscle contraction during critical windows for shell pattern formation and growth. Although offspring survival was rather high, the shape of the dorsal shell was altered in response to thermal and hydric stress, as well as the inhibition of embryonic muscle contraction. We elaborate on how temperature, moisture, and mechanical stressors might interact with developmental genes to yield malformed or asymmetric shells owing to developmental instability. We also discuss potential consequences on organismal performance. Our study supported the prediction that perturbed developmental environments amplify phenotypic variance. These results are informative in clarifying how environmentally sensitive phases of the reptilian life cycle may respond to droughts and heat waves, while exploring how within-organism parameters might also influence developmental plasticity.

13179: INVESTIGATING THE RELATIONSHIP BETWEEN ACUTE WARMING, SIZE, AND METABOLIC RATE IN WILD GILTHEAD BREAM (SPARUS AURATA)

Thursday 6th October **13:40**

Davide Thambithurai (IFREMER and UNIVERSITY OF GLASGOW, France), Theo Navarro (IFREMER MARBEC, France), Jerome Bourjea (IFREMER MARBEC, France), Gilbert Ditto (IFREMER MARBEC, France), David McKenzie (CNRS, France)

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The maximum body size of many ectotherms has decreased as climate has warmed; this trend has been particularly strong in fishes. The gill-oxygen limitation (GOL) hypothesis is among the best-known paradigms to explain this decline in size; proposing that as fishes grow, there is a decoupling between gill respiratory surface area and body volume, with gill surface increasing at a slower rate than body volume. The result is that once a specific size is attained, all oxygen supplied by the gills is used in meeting basal metabolic demands, and fish cannot invest energy in other activities. This mechanism is exacerbated by a warming climate, as metabolic rate is higher in warmer conditions. We investigated GOL hypothesis assumptions in wild gilthead bream (Sparus aurata). We did this by challenging fish ranging in size (mean ± sd = 327 ± 188 g) to undertake intense aerobic swimming – 80% of theoretical aerobic capacity - whilst simultaneously increasing temperature (CTSmax). Results showed that the metabolic cost of swimming increased steadily with temperature up to a point of fatigue. In general, larger fish had lower CTSmax, suggesting that when faced with acute warming smaller fish are better able to meet their metabolic demands. Although we saw some consistent global trends, there were some clear outliers, we suggest possible reasons for this. These data demonstrate that as waters warm, larger individuals of some fish species may struggle to meet their metabolic demands. Further empirical evidence is needed to understand the physiological basis of this phenomenon.

13167: MEASURING THE MOST SENSITIVE STAGES OF LIFE AS A SPECTRA OF ENERGY – AN APPROACH TO UNDERSTANDING ENVIRONMENTAL SENSITIVITY

Tuesday 4th October **13:00**

Jamie C.S. McCoy (University of Plymouth, United Kingdom), Oliver Tills (University of Plymouth, United Kingdom), John I. Spicer (University of Plymouth, United Kingdom), Simon D. Rundle (University of Plymouth, United Kingdom)

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During early development, animals are typically more sensitive to environmental change. Developmental responses to elevated temperatures are hugely multifaceted and encompass changes to form, function and performance at timescales ranging from minutes to days. Manually measuring such responses is therefore inherently limited. 'Energy proxy traits' (EPTs) are a new approach, involving the measurement of energy across different temporal frequencies in the fluctuations of pixels from video of developing animals. EPTs can characterise acute and chronic responses to environmental stress, but they remain untested in comparing the sensitivity of different species, a significant precursor to establishing their utility as a scalable and comparative approach to measuring biological responses. Using EPTs I tested the thermal sensitivity of embryos of three freshwater gastropod species with distinct differences in their embryonic development, specifically, in the timings of a number of key physiological and behavioural developmental events. EPT spectra were significantly different between species, temperatures, and development stages, with differences corresponding with the onset of multiple developmental events. Furthermore, differences in the relative timings of developmental events between species, individuals and temperatures were reflected in EPT spectra through development. Universality of measurements that extend between species and stages of development will further our understanding of developmental phenotypic responses to environmental change, but also push the boundaries of how we measure responses of animals during their most dynamic early life stages.

13151: MODELLING THE EFFECT OF DIFFERENT SKELETAL PROPORTIONS ON HINDLIMB KINEMATICS IN FROGS

Thursday 6th October **10:05**

Alice Leavey (University College London, United Kingdom), Dr Laura B. Porro (University College London, United Kingdom), Dr Christopher T. Richards (Royal Veterinary College, United Kingdom)

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Amphibians employ a diverse array of locomotor styles in a variety of ecological niches, making them ideal organisms for investigating the relationship between morphology, function, ecology, and phylogenetic history. Previous studies and findings from our research indicate that hindlimb segment proportions (length of femur versus tibiofibula etc.) differ between species utilizing different locomotor modes and have therefore been hypothesised to perform discrete functions. Uncertainty remains in what the biomechanical implications are of these differences in musculoskeletal anatomy, due to the high complexity (e.g., multiple degrees of freedom, distal accumulation of motion down the joint) of the frog hindlimb. Using skeletal measurements obtained from 3D digital dissections of micro-CT scans, we have modelled jumping motion for 164 taxa from all 56 recognised anuran families. We then used computational models to hypothetically explore how each hindlimb segment contributes towards motion. The data obtained forms the precursor to future dynamics modelling, which will determine the impact of hindlimb structure on the torques and moment arms about each joint during jumping. Additionally, our model indicates the potential to infer the locomotor behaviours of extinct taxa using fossil measurements. Overall, this work contributes towards obtaining direct mechanical evidence for how variations in limb segment proportions influence locomotor multi-functionality across the frog phylogeny.

13205: OPEN ELECTRONICS APPLICATIONS IN EXPERIMENTAL BIOLOGY: CURRENT STATE AND FUTURE PERSPECTIVES

Tuesday 4th October **14:20**

Sergey Morozov (University of Helsinki, Finland)

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Designing scientific equipment based on open electronics boards, such as Arduino and Raspberry Pi, has become a recent trend in experimental biology. Indeed, such hardware systems might represent an affordable alternative to expensive commercial products which potential for customisation is often limited. The latter is especially important for conducting novel experiments requiring serious modifications to an existing setup or even the integration of several independent systems into one. Here, we will overview recent applications of the open electronics platforms used in physiological studies and at animal research facilities. Both laboratory and field setups will be presented starting from shuttle box systems and automatic feeders to remote animal tracking and phenotyping devices. The more detailed technical comparison between open hardware and proprietary instruments will be demonstrated based on aquatic respirometry systems including water pump controllers, swim-tunnel motor regulators, sensors, and data acquisition tools. This practical example will clearly illustrate benefits, limitations, and perspectives of open electronics for experimental biologists.

13181: PARASITE-INDUCED VARIATION OF INDIVIDUAL AND GROUP BEHAVIOUR IN GUPPIES

Tuesday 4th October **13:40**

Angela Albi (Max Planck Institute of Animal Behaviour, Germany), Jacob Davidson (Max Planck Institute of Animal Behaviour, Germany), Sandra Binning (Département de sciences biologiques Université de Montréal Canada, Canada), Jessica Stephenson (Department of Biological Sciences University of Pittsburgh Pittsburgh PA USA, United States), Iain Couzin (Max Planck Institute of Animal Behaviour, Germany)

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In the ecology of fish, parasite infections often induce multidimensional changes and can affect host morphology, physiology, and movement abilities. However, how parasites affect behaviour and how infected individuals interact with other conspecifics in a group, is not yet fully understood. In our study, we describe how guppies' behaviour changes after the infection of the ectoparasite Gyrodactylus. At the individual level, we compare swimming kinematics and metabolic costs of uninfected to infected guppies. We find that parasites do not induce unidirectional changes on the host's physiology or locomotion ability across different flow regimes. However, using linear discriminant analysis we find combinations of features that better discriminate between different classes of different parasite loads. Moreover, we find that modulation of pectoral fin use across flow regimes is predictive of values of maximum critical swimming speeds. In the social behaviour context, we find that on average infected guppies spend more time in isolation, measure higher nearest-neighbour distance and are mostly found in the periphery of big groups. Moreover, after a group fission, parasitized fish are more likely to transition to isolation, compared to uninfected conspecifics. These results are partly explained by changes in swimming speed, but it remains unclear whether changes are due to an active avoidance or passive self-isolation mechanism Overall, we show how physiological and behavioural measures can be used to better understand the role of parasites for group living organisms.

13187: RESPONSES OF DAPHNIDS UPON CHRONIC EXPOSURES TO PHARMACEUTICALS – A COMBINATION OF METABOLIC AND PHYSIOLOGY ENDPOINTS

Tuesday 4th October **11:40**

Katie O'Rourke (School of Biotechnology Dublin City University., Ireland), Beatrice Engelmann (Department of Molecular Systems Biology Helmholtz-Centre for Environmental Research (UFZ) Leipzig, Germany), Rolf Altenburger (Department Bioanalytical Ecotoxicology Helmholtz Centre for Environmental Research (UFZ) Leipzig, Germany), Ulrike E. Rolle-Kampczyk (Department of Molecular Systems Biology Helmholtz-Centre for Environmental Research (UFZ) Leipzig, Germany), Konstantinos Grintzalis (School of Biotechnology Dublin City University, Ireland)

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Pharmaceuticals have been recognised as emerging contaminants of significant concern, via several pathways of entry, pharmaceuticals eventuate into freshwater systems where they pose sub-lethal effects to aquatic organisms. Exacerbated by their increased consumption and poor removal rates from waste water treatment plants, pharmaceutical compounds have been classed as pseudo-persistent in the aquatic environment and their monitoring is imperative. In some cases, their environmental levels could be undetectable, thus, highlighting the need to develop sensitive tools to monitor the aquatic environment. The objective of this study was to assess the impact of several pharmaceuticals on the model organism *Daphnia magna*. Following chronic exposure to five frequently detected pharmaceuticals in surface waters, molecular and phenotypic endpoints of daphnids were measured. Markers of enzyme activities were combined with metabolic perturbations to assess the impact of diclofenac, metformin, gabapentin, carbamazepine, gemfibrozil and their mixtures on daphnids. Enzyme activities used as markers of physiology in daphniids included phosphatases, β-galactosidase, peptidase, lipase, lactate dehydrogenase, and glutathione-S-transferase. These enzymes revealed significant trends upon different pharmaceutical exposure and their mixtures and were accompanied by metabolic perturbations in glycolysis, the pentose phosphate pathway and the TCA cycle, with distinct metabolic fingerprints for each pharmaceutical and their mixture. Chronic exposure to pharmaceuticals at low concentrations resulted in increases and decreases of enzymes of metabolism and detoxification, these alterations were also coupled with noteworthy changes in several central metabolic pathways.

13197: SEMIOCHEMICAL-BASED MATE SEARCHING BEHAVIOUR IN TARDIGRADES: COMPARING THE SEXES

Thursday 6th October **15:10**

Justine Chartrain (University of Jyväskylä, Finland), Emily Knott (University of Jyväskylä, Finland), Lukasz Michalczyk (Jagiellonian University, Poland), Simo Puro (University of Jyväskylä, Finland), Riikka Tynkkynen (University of Jyväskylä, Finland), Sara Calhim (University of Jyväskylä, Finland)

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Semiochemical communication is widespread and used across multiple contexts, from finding food to attracting mates. Animals up to 1mm can use (1) trail pheromones laid on the substrate by a moving animal and/or (2) short-range diffusion of molecules from an origin (diffusing signals). Tardigrades are a microscopic animal phylum largely neglected in behavioural ecology. Yet, there is evidence that both types of chemical cues are used: in one species, immotile receptive females attracted males using diffusing signals, whereas a predator-prey species dyad detected each other's trails. In this study, we aimed to test the role of (1) trail pheromones and (2) diffusing signals in the mate searching behaviour of both male and female Macrobiotus polonicus. To this end, we individuals were either (1) allowed to move freely and simultaneously or (2) placed in specially designed double choice chambers. We found that males move more and preferentially associate with the female vs. the male stimulus for diffusing signal. In contrast, females did not behave differently towards each sex. In the trail pheromone experiment, as with the choice chamber trials, males were more behaviourally active: they followed trail cues, approached, and then followed the opposite-sex individual more often than females. These sex-specific behaviours are in agreement with previous descriptive mating observations of tardigrades, where males initiated the interaction by tracking and approaching. More importantly, our study suggests that multiple signalling cues – deposited and diffused – could be involved in mate attraction and/or finding behaviour in this animal group.

13194: SONG DUELS FACILITATE CONTEXT-DEPENDENT CHANGES IN CANARY SONG SYNTAX AND ITS UNDERLYING PREMOTOR NEURAL ACTIVITY

Wednesday 5th October **11:00**

Alena Lemazina (Max Planck Institute for Biological Intelligence, Germany), Susanne Hoffmann (Max Planck Institute for Biological Intelligence, Germany), Lisa Trost (Max Planck Institute for Biological Intelligence, Germany), Manfred Gahr (Max Plank Institute for Brain Research, Germany)

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We look for context dependent changes in the song structure and underlying neural control in the domestic canary (*Serinus canaria forma domestica*). We investigate changes in the framework of overlapping countersinging, which has a significant role in canaries' courtship behaviours. Overlapping interactions have been studied in many species, but mainly by using an artificial countersinging partner like e.g., playbacks. However, changes in song syntax occurring in natural encounters are not well studied. To tackle this question, we used a method that enables us to record individual vocalizations and neural premotor activity in several songbirds simultaneously. For song analysis we used both conventional song measurements and network analysis. We find that canaries modify the syntax of their songs when they are overlapped by adding more trills and thus increasing song complexity and duration compared to song performed without competitor (solo). In contrast, birds that initiate the overlapping interaction and mask the opponent's song did not change the global structure of their songs in comparison to their solo songs. Further, a bird's social status can influence song structure: dominant males sing longer songs with more phrases than subdominant birds. Most interestingly, during the production of overlapping songs, brain nuclei HVC shows a higher activity than during solo singing. These results hint to the importance of the social environment for a bird in song production and song syntax.

13169: SPORTIVE LEMURS RESPOND TO CHALLENGING SEASONS WITH ELEVATION OF THEIR METABOLIC RATE

Tuesday 4th October **09:45**

Janina Bethge (Universität Hamburg, Germany), Jean Claude Razafimampiandra (Université d'Antananarivo, Madagascar), Arne Wulff (Universität Hamburg, Germany), Kathrin Dausmann (Universität Hamburg, Germany)

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Animals experience seasonal changes of environmental and ecological conditions in most habitats. Fluctuations in ambient temperature have a strong influence on thermoregulation, particularly on small endothermic mammals. However, different mammalian species cope differently with these changes. Understanding the physiological responses of organisms to different seasons and analysing the mechanisms that account for intra- and interspecific differences and the ecological consequences of these variations is important to predict species responses to climatic changes. Consequences of climatic changes will be most pronounced in climatically already challenging habitats, such as the dry regions of western Madagascar. We aimed to identify the seasonal responses and adaptive possibilities in energy budgeting of *Lepilemur edwardsi*, a small primate of this habitat, by measuring metabolic rate (open-flow respirometry) and skin temperature in the field during different seasons. Metabolism was generally low metabolism, but our study did not detect any signs of regular heterothermic episodes, despite the fact that these are known in other lemurs that are living sympatrically and have a similar lifestyle. Surprisingly, *L. edwardsi* responded seasonally by elevating its metabolic rate in the poor-resourced dry season, compared to the better-resourced wet season, presumably to master detoxification of their increasingly toxic diet. As body mass decreased over this time, this strategy is obviously not energetically balanced on the long term. There is reason to be concerned that *L. edwardsi* has a very small scope to adjust to changing conditions as experienced due to climate change.

13178: THE COLLECTIVE MECHANICS OF SEA STAR LOCOMOTION

Thursday 6th October **10:25**

Theodora Po (University of California Irvine, United States), Matt McHenry (University of California Irvine, United States)

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It is largely mysterious how a diversity of animals with tens or hundreds of appendages control locomotion. Sea stars walk through the coordinated action of hundreds of tube feet, despite lacking a brain. We investigated the collective mechanics of locomotion in sea stars through a combination of experimentation and mathematical modeling. Kinematic measurements of Protoreaster nodosus showed that sea stars generate two locomotor gaits under variable loads. We found that these animals increase the number of tube feet recruited per powerstroke in response to an increase in submerged weight. Our mathematical model of mechanics simulated this recruitment pattern without centralized control, showing that the response to loading is an emergent property of locomotion generated by an array of tube feet. This type of collective control can be used to study control systems of a variety of organisms and engineered devices.

13184: THE EFFECT OF EXTREME WEATHER EVENTS ON DAPHNIA MAGNA INFECTED BY A MICROSPORIDIAN PARASITE.

Tuesday 4th October **18:00**

Niamh Mc Cartan (Trinity College Dublin, Ireland), Floriane O' Keeffe (Trinity College Dublin, Ireland), Pepijn Luijckx (Trinity College Dublin, Ireland)

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Climate change is leading to more extreme weather globally. Indeed, heatwaves and cold spells have increased in frequency. However, the effect of extreme weather events on disease dynamics has rarely been empirically tested. This may impede the generation of accurate models for future disease dynamics and outbreaks. Especially, as recent work has suggested that extreme weather events may, under some conditions, lead to greatly increased disease burden. The underlying mechanisms or conditions under which extreme weather can lead to increased disease burden, however, remain unknown. Here, I explore how four different properties of heatwaves affects infection rates and spore burden in the *Daphnia-Ordospora* host-parasite system. In total, 1176 *Daphnia* were individually exposed to *Ordospora colligata* in a full factorial design with 64 treatments, varying in timing (in relation to the day of exposure), duration, and amplitude of heatwaves at four mean temperatures (14, 17, 20, and 23 degrees C). Each host was checked for infection and burden after they naturally died or by the end of the experiment after 32 days. Preliminary results suggest that there is a three-way interaction between the duration, timing of the heatwave in relation to exposure, and the mean temperature the heatwave is applied to. Heatwaves occurring during exposure increases parasite burden, whereas heatwaves occurring 10 days post-exposure reduce parasite burden. This highlights the complex nature of host-parasite interactions in relation to extreme weather which may be overlooked in mathematical models that ignore extreme weather events.

13175: THE EFFECTS OF HYPOXIA ON INTERGENERATIONAL PLASTICITY IN FISH

Thursday 6th October **13:20**

Daphne Cortese (University of Glasgow, United Kingdom), Amélie Crespel (University of Turku, Finland), Neal Dawson (University of Glasgow, United Kingdom), Lucy Cotgrove (University of Glasgow, United Kingdom), Shaun Killen (University of Glasgow, United Kingdom)

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Oxygen availability in aquatic ecosystems is highly variable because it is affected by many abiotic and biotic factors. As a result, many aquatic organisms experience acute and chronic hypoxic episodes during their life which has impacts at different levels of organization. For example, organisms can switch to anaerobic biochemical pathways, increase ventilation rate to maintain aerobic metabolism or modify their behaviour in order to avoid hypoxia. While such compensatory mechanisms allow individuals to survive hypoxic episodes, it is not clear to which extent parental effects and developmental plasticity also contribute to coping with hypoxia. Here, adult zebrafish, *Danio rerio*, were exposed to normoxia (100% air saturation) or hypoxia (60% air saturation) for three weeks and offspring of breeding pairs from each treatment were split and reared under each condition. Enzymes involved in aerobic and anaerobic pathways, aerobic metabolic rates and behavioural traits were measured in both adults and 2-months old offspring under both air saturation conditions to mimic acute exposure to hypoxia. Preliminary results show that acute hypoxia decreases aerobic scope in adults. Similar decreases in aerobic scope are observed in offspring that come from parents living in normoxia when exposed to both acute and prolonged hypoxia. Offspring of hypoxia exposed adults do not show a decreased aerobic scope in hypoxic conditions, suggesting beneficial parental effects. The results of this study will provide insights into both within- and among- generational responses to hypoxia in fish, critical in light of increasing incidents of hypoxia due to eutrophication and human-induced climate change.

13177: THE IMPACT OF A WIDELY USED FUNGICIDE ON HONEYBEE (APIS MELLIFERA) HEALTH

Wednesday 5th October **13:20**

Adrian L Fisher II (Arizona State University, United States), Gloria DeGrandi-Hoffman (United States Department of Agriculture, United States), Brian H Smith (Arizona State University, United States), Jennifer H Fewell (Arizona State University, United States), Jon F Harrison (Arizona State University, United States)

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The honeybee (*Apis mellifera*) is essential for crop pollination worldwide. Despite their importance, honeybees and other pollinators face ongoing declines due in part to pesticide exposure in the foraging environment. Honeybees frequently encounter fungicides, in particular, because they are applied to blooming crops. To assess the effects of the widely used fungicide Pristine® (25.2% boscalid, 12.8% pyraclostrobin) we exposed colonies to concentrations of the fungicide reflecting levels detected in almond orchards. Chronically exposed hives experienced reduced worker populations and increased winter mortality. We also observed elevated rates of pollen foraging and consumption, potentially indicating impaired protein processing. Pristine® consumption induced several sublethal effects on individual workers including precocious foraging, reduced longevity, reduced cognitive abilities, and lower thorax mass. Adverse effects of fungicide exposure also resulted from reduced exposure durations simulating the bloom period of a major bee pollinated crop but with differences in severity by season. A four-week exposure to the fungicide Pristine® reduced worker longevity, induced precocious foraging and temporarily reduced colony population levels during summer. Fall exposure was not associated with negative outcomes and coincided with differing colony conditions including reduced brood production and pollen consumption. Together, these findings support the hypothesis that fungicides such as Pristine® negatively impact honeybee health at least partly by impairing protein digestion.
This research was supported by USDA 2017-68004-26322.

13203: THE ROLE OF DIFFERENT STRESSORS ON REPRODUCTIVE SUCCESS OF A MARINE TEMPERATE FISH SPECIES

Thursday 6th October **17:10**

Ana F. Lopes (ISPA - University Institute of Psychology Social and Life Sciences, Portugal), Sam Dupont (Gothenburg University, Sweden), Ana M. Faria (ISPA - University Institute of Psychology Social and Life Sciences, Portugal)

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Fish reproductive success is linked with couple's ability to mate and produce clutches that successful hatch. This energetically costly process can be jeopardized by changes in environmental stressors, like elevated temperatures and low pH levels. These changes may also lead to an impairment of primary production and depletion of zooplankton, affecting food availability and impacting fish's energetic demands. To understand the role of these stressors on fish reproduction we tested two populations of a semi pelagic fish, the two-spotted goby, *Pomatochistus flavescens*, living on the extremes of their distribution in the European Coast. The Portuguese population (southern limit) was exposed to 2 levels of temperature and food availability; The Swedish population (northern limit) was exposed to 2 levels of temperature and pH. Overall results showed the Portuguese population reproduction was mainly affected by low food availability which impaired reproduction. In male reproduction, the expression of cyp11b1, a gene with a pivotal role in the synthesis of the most important fish androgen, 11-ketotestosterone, was significantly reduced. High temperatures did not affect the reproductive success, however led to changes at the offspring level, with increased saturated fatty acid content (embryos), and increased lipid peroxidation (larvae). In the Swedish population, however, high temperature impaired the reproductive performance, with hatching success ranging from 3 to 10% when compared to 56% of successfully hatched clutches in ambient conditions. These results suggest the two populations are differently affected by the common stressor studied – temperature. Understanding these differences is essential for the species fitness.

13161: UNDERSTANDING THE BIOENERGETICS AND BIOMECHANICS OF FISH SCHOOLING BEHAVIOUR

Thursday 6th October **09:45**

Yangfan Zhang (Harvard University, United States)

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Schooling is a synchronized behaviour used by many species of fish and has been proposed to reduce the cost of locomotion by allowing individual fish to conserve energy when swimming in groups. But few previous studies have directly measured schooling energetics and tested how energy use changes as schools of fish change speed. We studied how fish schools swim in both laminar and turbulent flows and compared that with the energy expenditure of solitary individuals under both conditions. We discovered that the minimum cost of fish swimming as a school occurs at an intermediate speed, and that fish schools substantially reduce total energy expenditure at high speeds. Turbulent flow conditions produced more variable kinematics and increased the energetic cost of swimming both by individuals and in groups. We suggest that energy conservation is probably one of the principal drivers of the evolution of schooling behaviour given the ecological importance of high-speed swimming.

13157: VARIATION IN PHENOTYPIC PLASTICITY IN GLANVILLE FRITILLARY BUTTERFLY LARVAE FROM A LATITUDINAL CLINE

Wednesday 5th October **13:40**

Nadja Verspagen (University of Helsinki, Finland), Suvi Ikonen (University of Helsinki, Finland), Michelle DiLeo (University of Helsinki, Finland), Marjo Saastamoinen (University of Helsinki, Finland)

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Phenotypic plasticity may play a crucial role in the persistence of species under climate change as it allows for a more rapid response to environmental stress than through evolutionary adaptation. Levels of plasticity may be expressed differently between individuals or populations depending on the environment, making it a trait under selection. We used the Glanville fritillary butterfly (Melitaea cinxia) larvae originating from a latitudinal cline across its European range to assess whether plasticity in response to thermal condition varies among populations (i.e., are there GxE interactions). For this, we performed a full-factorial common garden experiment where we measured growth rate, mass and fat content in pre-diapause larvae that were reared at four temperatures (25, 28, 31 and 34 °C). Larval growth rate, mass and fat content all increased with rearing temperature and also differed with latitude, indicating genetic differences. Furthermore, we found stronger plastic responses for growth rate and mass in the larvae originating from north compared to those from south, showing that genetic differences for plasticity exist (GxE). As the larvae from higher latitudes experience a shorter growing season with more variable thermal conditions than those from lower latitudes, they may have evolved to take advantage of any increase in temperature. Interestingly, plasticity levels for fat content did vary among the populations, suggesting more canalized response for this trait. Overall, our results suggest a complex interplay between genetic and environmental factors that may impact how species cope with a changing environment.

13171: WHO LEADS AND WHO FOLLOWS? THE INTERPLAY BETWEEN METABOLIC PHENOTYPE AND SOCIAL BEHAVIOUR IN FISH

Monday 3rd October **18:30**

Shaun Killen (University of Glasgow), United Kingdom)

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Social behaviours come with a variety of costs and benefits for individual animals. For this reason, individuals tend to vary in their degree of sociability. Recent evidence suggests that this behavioural variation is linked to various traits associated with bioenergetics, including metabolic rates and locomotor ability. On the one hand, underlying variation in metabolic traits (e.g. maintenance metabolism, maximum metabolism) seems to affect sociability by affecting predator avoidance, foraging needs, and competitive ability. Specifically, an animal's energetic status influences not only whether an individual will join a group of conspecifics, but also the behaviour of individuals that have already joined groups. Conversely, an animal's social environment can feedback to affect its physiological traits and performance. This can occur via the effects of aggression and competition but also through stress reduction and the energy-saving benefits of moving in groups. Here I review this interplay between social behaviour and individual physiology, including the modulating role of additional factors such as temperature and oxygen availability. I also discuss ways in which these links may be relevant in the context of human predation on fish populations and fisheries-induced evolution.

POSTER ABSTRACTS

13204: ATLANTIC SALMON (SALMO SALAR) MATURATION TIMING STRONGLY AFFECTED BY TEMPERATURE, POPULATION, AND AGE-AT-MATURITY GENOTYPE

Tuesday 4th October **18:00**

Eirik R Åsheim (University of Helsinki, Finland)

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Age at maturity is a key life history trait involving a trade-off between survival and reproduction and is an important factor for population structures. In ectotherms, a warming environment may have a dramatic influence on development and life history which may differ between populations. While an increasing number of studies have examined population-dependent reactions with temperature, few have investigated this in the context of maturation timing. Atlantic salmon is a relevant study species for this topic as it displays considerable variation in maturation timing, and a large proportion of this variation has been associated with a genomic region including the strong candidate gene *vgll3*.

Here, I present a poster on a large-scale common-garden experiment where we found strong effects of temperature, population, and *vgll3* genotype on maturation in 2-year-old male Atlantic salmon. A temperature-increase of 1.8°C resulted in 4.8 times increase in maturation probability; This temperature effect was population-specific and was higher in the southern- compared to the northern population, potentially due to a higher intrinsic growth in the southern population as well as growth-temperature interaction. The early-maturation *vgll3**E allele associated with a significantly higher maturation probability, but there was no *vgll3*-interaction with temperature or population. Our findings demonstrate that 1) populations can vary in their response to temperature change in terms of maturation timing, 2) that high intrinsic growth could be associated with higher thermal sensitivity for life history variation, and 3) that the *vgll3*-effect on maturation timing might be similar between populations and different thermal environments.

13193: DIVERSITY OF ENAMEL ORGAN FEATURES IN SQUAMATE REPTILES

Tuesday 4th October **18:00**

Daria Razmadze (University of Helsinki, Finland), Julia Eymann (University of Helsinki, Finland), Nicolas Di-Poï (University of Helsinki, Finland)

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Due to their astonishing diversity and a key role in the evolution of vertebrates, teeth are among the best targets for ecological and evolutionary studies. A modern detailed picture of tooth morphogenesis has been formed based on studies utilizing a classic model—the laboratory mouse. It has been shown that in mammals, signals from enamel knot (EK) signalling centres regulate tooth development and shaping. So far, data on tooth morphogenesis outside of mammals is fragmentary and limited.

Squamates represent a key model to assess major aspects of vertebrate tooth diversity because they occupy diverse ecological niches and show a great variety of dentition phenotypes. Our recent studies have shown the existence of multiple events of evolutionary origins and losses of tooth complexity in this group. We studied four lizard species with different dentition types that represent major events in the evolution of multicuspidness in squamates utilizing multidisciplinary approaches. As a first step in unveiling developmental mechanisms underlying the diversity of tooth complexity, we obtained data on morphology, cell fate, and the main conserved gene expression profiles of the enamel organ. Although our data confirm the presence of an EK-like region in squamates, some key features of the reptilian enamel organ also differ from the typical mammalian structure. More interestingly, the size, shape, molecular profile, and cell fate in the EK-like region vary in different lizards. Together, our data provide new insights into the crucial importance of developmental changes and innovations underlying tooth complexity in vertebrates.

13201: ELEVATED CO_2 IS A MAJOR BRAIN-SPARING MECHANISM IN BIRTH ASPHYXIA

Tuesday 4th October **18:00**

Alexey Pospelov (University of Helsinki, Finland), Tommi Ala-Kurikka (University of Helsinki, Finland), Juha Voipio (University of Helsinki, Finland), Kai Kaila (University of Helsinki, Finland)

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Aims: Birth asphyxia (BA) is a period of severe systemic O_2 deprivation (hypoxia) and build-up of CO_2 (hypercapnia). Most animal models of BA neglect the fundamental hypercapnia component. Here, we have studied the multiple protective roles of CO_2 during oxygen deprivation.

Methods: 11-day-old rat pups were exposed to pure hypoxia, pure hypercapnia, or their combination (i.e., asphyxia) by altering the O_2 (from 21% to 5-9%) and CO_2 (up to 20%) concentrations of the inhaled gas. Brain and body pH and PO_2 levels were measured using microsensors.

Results: An increase in ambient PCO_2 strongly suppressed the fall in brain PO_2 during asphyxia, obviously reflecting a brain-sparing vasomotor response. Moreover, extending the hypercarbia exposure beyond the asphyxia strongly suppressed post-asphyxia EEG and behavioural seizures. The effects of hypercarbia were mimicked by intraperitoneal or intravenous application of both highly membrane-permeant and impermeant inhibitors of carbonic anhydrase (CAIs).

Conclusions: The increase in CO_2 which is always associated with birth asphyxia has brain-sparing effects (elevated oxygenation; suppression of the ictogenic action of hypoxia). These effects can be enhanced and prolonged by elevation of the ambient CO_2 level or by application of CAIs during the post-asphyxia recovery.

13200: POSSIBLE SEASONALITY EFFECT ON ENERGY METABOLISM IN RED-FOOTED TORTOISE HATCHLINGS (CHELONOIDIS CARBONARIA)

Tuesday 4th October **18:00**

Pierina J Mendoza Yengle (Pavol Jozef Šafárik University, Slovakia), Lucas A Zena (University of Gothenburg, Sweden), Kênia C Bícego (São Paulo State University, Brazil)

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Studies on energy metabolism of South America tortoise's species are scarce, as the case of the red-footed tortoise (*Chelonoidis carbonaria*). Even though it is an effective dispersal species for seeds, it has been used as food and illegally traded. Seasonality has been suggested for C.carbonaria due to some lethargy observations in adults during winter, however it has not been tested in early life stages of high-energy costs for growth. We addressed this issue in *C.carbonaria* hatchlings kept under human care. Resting metabolic rate (RMR) was measured after 10 days of fasting at 28 and 18°C during different seasons at 6 and 12 months old. A possible seasonality effect on RMR was determined by using General Linear Model with month as a factor and age as a covariate, and Tukey post-hoc test. A significant effect on the RMR at 28°C was observed, and the highest (36.35 ± 5.05 $kJ.kg^{-1}.\ day^{-1}$) and lowest value (22.43 ± 6.23 $kJ.kg^{-1}.\ day^{-1}$) were reached in months that correspond to spring and winter, respectively. Non-significant effect was identified under 18°C, and animals were more inactive and spent more time sleeping. The effect of the seasonality on the RMR highlights its importance to being considered for the captive management of wild reptiles, since their daily energy requirements will be different in each season, and these must be reached by offering appropriate quantity and quality of energy in their food. Our results suggest a possible seasonality pattern in *C.carbonaria*, which needs further research.

13168: REDEFINING THERMAL LIMITS: THERMAL WINDOWS, HEAT DISSIPATION, AND THERMOLABILITY IN THE BASOENDOTHERMIC TENREC ECAUDATUS

Tuesday 4th October **18:00**

Ana M Breit (University of Maine, United States), Michael Treat (University of Las Vegas, United States), Gilbecca R Smith (University of Las Vegas, United States), Marshall D. McCue (Sable Systems International, United States), John R.B. Lighton (Sable Systems International, United States), Frank Van Breukelen (University of Las Vegas, United States), Danielle L. Levesque (University of Maine, United States)

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Endothermy allowed the ecological dominance of birds and mammals by enabling the decoupling of body temperature from environmental temperatures. Endothermy likely evolved in a series of steps selecting for body temperature and its correlated higher aerobic capacity. In some extant endothermic species these steps are still visible, allowing us to further understand how thermoregulation works in the absence of high and stable body temperatures. By studying the extremely thermally-labile common tenrec (*Tenrec ecaudatus*), we were able to quantify how thermolability affects the shape of the relationship between metabolic rate and ambient temperature. To test their thermoregulatory capabilities, we used flow-through respirometry over a range of ambient temperatures to measure O_2 consumption and H_2 O and CO_2 production of 16 captive tenrecs. In a separate experiment, we used infrared thermography to measure surface temperatures of tenrecs to identify and quantify their thermal windows. We found a high degree of inter-individual variability in normothermic body temperatures and metabolic rates. At low temperatures, tenrecs fluctuated between relatively high and relatively low metabolic rates, but these changes in metabolic rates were not correlated to changes in body temperatures. Tenrecs retain many of the ancestral mammal characteristics (nocturnal, insectivores, relatively unspecialised limbs) and inhabit environments similar to those present during the evolution of endothermy in mammals. A further understanding of thermoregulation in this unique mammal may therefore give us insight into the evolution of endothermy and the link between metabolism and body temperature.

13176: WARMING TOLERANCE IS OXYGEN-LIMITED IN COLD-ACCLIMATED BUT NOT WARM-ACCLIMATED ZEBRAFISH

Tuesday 4th October **18:00**

Diana L Silva Garay (Norwegian University of Science and Technology, Norway), Anna H Andreassen (Norwegian University of Science and Technology, Norway), Marie Reiersen (Norwegian University of Science and Technology, Norway), Rasmus Ern (Norwegian University of Science and Technology, Norway), Fredrik Jutfelt (Norwegian University of Science and Technology, Norway)

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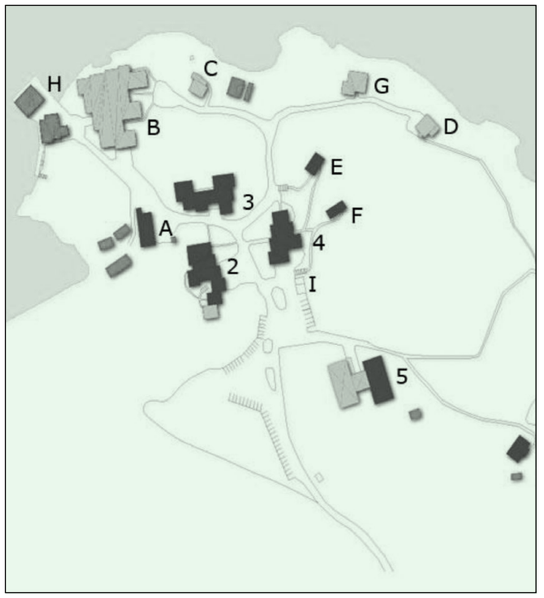
There has been much debate about which physiological mechanisms fail during acute warming, especially regarding the role of oxygen on the upper thermal tolerance limits. We investigated whether ambient oxygen saturation limits the upper thermal tolerance (measured as CTmax) and compensatory response of thermally acclimated zebrafish, Danio rerio(n=322). A first group of 207 zebrafish were acclimated to three temperature treatments (20°, 28°, and 34°C) and exposed to three oxygen saturations (30, 100, 200%) that simulate their abiotic habitat conditions. Our model showed that oxygen level and acclimation temperature had a significant effect on the zebrafish CTmax outcome. Cold acclimation (20°C) led to 2.8°C lower mean CTmax when compared to CTmax obtained at the control temperature treatment (28°C), while warm acclimation (34°C) led to a 1.5°C increase in mean CTmax. Furthermore, the effect of oxygen level on CTmax was more pronounced in cold acclimated zebrafish. Plasticity of aerobic scope (AS) and CTmax were further investigated in a second group (n=113) of cold acclimated zebrafish (20°C) under four oxygen saturations (50, 100, 150, 250%). Results show that AS increased with an increase of oxygen saturation, whereas CTmax values of both studied groups increased with oxygen saturation until reaching a plateau at 150%, before declining at 250%. Our study shows that the increase in oxygen level did not increase CTmax at higher acclimation temperatures, indicating that oxygen limitation is highly context dependent. Mechanisms beyond oxygen supply may determine failure at warm acclimation temperatures.

SITE MAP



Tvärminnen Eläintieteellinen Asema, J.A. Palménin Tie 260, 10900 Hanko.

A. Palmeniana

B. Päärakennus
Huvudbyggnaden
Main Building

2. Tutkija-asuntola
Forskarbostaden
Researcher Accommodation

3. Oppilasasuntola
Elevbostaden
Student Accommodation

4. Huoltorakennus + Pinkkula
Servicehuset + Pinkkula
Service Building + Pinkkula

5. Paviljonki
Paviljongen
Pavillion

C. Sjövilla
Sjövillan
Sjövilla

D. Kohagsvilla
Kohagsvillan
Kohagsvilla

E. Karhulippu
Björnflaggan
Bear Flag

F. Stiptalo
Stiphuset
Stip House

G. Sauna
Bastun
Sauna

H. Laituri + venevaja
Bryggan + båthuset
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