A Novel Synthesis of Individualisation across Behaviour, Ecology and Evolution

Conference organised by the

Collaborative Research Center TRR 212 (NC³)

September 3rd – 5th 2024 in Münster

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Welcome letter

Dear conference attendees, friends, and supporters,

We are happy to welcome you to the conference organised by CRC TRR 212: "A Novel Synthesis of Individualisation across Behaviour, Ecology, and Evolution: Niche Choice, Niche Conformance, Niche Construction (NC3)."

Our CRC TRR 212 is dedicated to deepening our understanding of the causes and processes of individualisation, exploring how these processes lead to individualised niches. By combining insights from behaviour, ecology, and evolution, and enriching them with philosophical and biological concepts, we are developing a ground-breaking synthesis of individualisation.

Researchers from Bielefeld University, University of Münster, University of Mainz and Friedrich-Schiller-University Jena have joined forces in this transregional collaborative research center (**CRC**-TRR). Together, with an innovative etho-eco-evo approach, accounting for the dynamic nature of environmental conditions throughout an animal's life, we provide unprecedented insights into why individuals only occupy a small subset of their species' niche and what this means for ecological adaptation and evolutionary change in our rapidly shifting world.

This conference will feature talks from distinguished guests, CRC members, and alumni on the theme of individualisation.

We look forward to seeing you there!

On behalf of all our CRC members,

The Organising Team

Schedule Overview

Tuesday, 03.09.2024		Wednesday, 04.09.2024		Thursday, 05.09.2024	
		09:00-09:30	Coffee	09:00-09:30	Coffee
		09:30-10:30	Talks	09:30-10:30	Talks
		10:30-11:00	Coffee	10:30-11:00	Coffee
		11:00-12:00	Talks	11:00-12:00	Talks
12:00-13:00	Registration & Coffee	12:00-13:30	Lunch (self org.)	12:00-13:30	Lunch (at venue)
13:00-14:15	Talks	13:30-15:00	Talks	13:30-14:30	Talks
14:15-14:45	Coffee	15:00-15:30	Coffee	14:30-15:00	Closing remarks
14:45-15:30	Talks	15:30-16:30	Talks		
15:30-16:00	Coffee	17:00-18:30	Public Lecture		
16:00-17:30	Talks	19:00	Dinner (Café 1648)		
17:30-19:30	Poster Session				

Detailled schedule on pages 8 to 10.

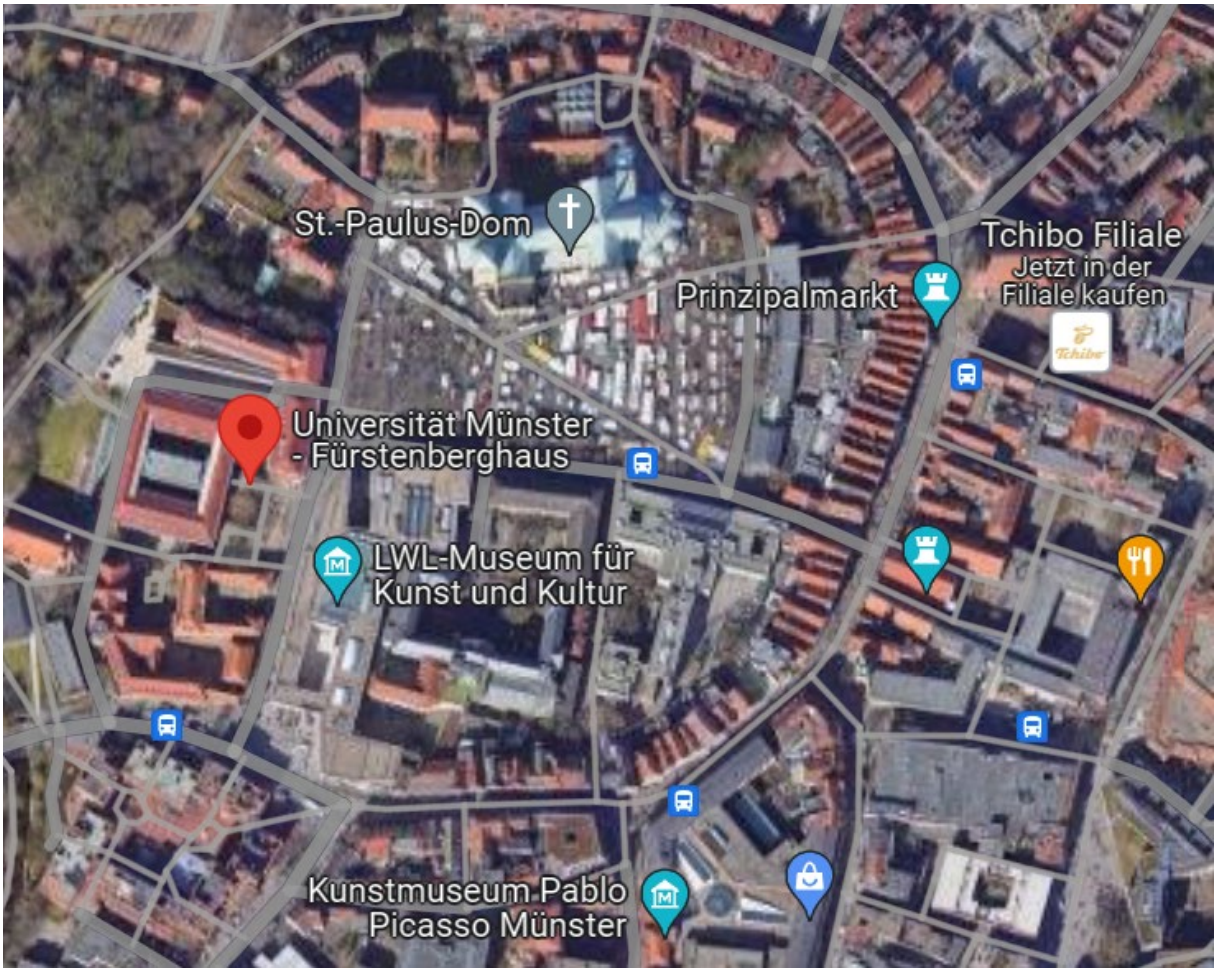
General information

Congress Venue

The NC³ conference will take place in the Fürstenberghaus of the University of Münster.

Address: Domplatz 20-22, 48143 Münster

Google Map link: https://maps.app.goo.gl/yJKGvVkCgjMFyAGL8



Registration and Information

The registration desk is located in the foyer of the Fürstenberghaus. If you have any questions, feel free to ask there.

Washrooms

Washrooms are located at the ground floor [EG].

WiFi

Visitors of the University of Münster can register for the university's network via eduroam, which enables a visitor from one participating institution to gain network access at another. A prerequisite is that the home institution takes part in the eduroam project.

WiFi (SSID): Eduroam
UserID: username@domain (e.g. if your username is darwin123 and your home institution is the University of Cambridge, you would enter darwin123@cam.ac.uk)
Password: Use the password you use to access services at your home institution.

Guests from other institutions which are not a member of the eudroam project can log in to the open WiFi GuestOnCampus, which has a daily data limit of 1 GB per device.

Talks

All talks will be held in the **lecture hall F2** located at the first floor of the Fürstenberghaus. Oral presentations will either be 12 minutes long including two to three minutes for questions/discussion or 30 min long including five to ten minutes for questions/discussion.

Submitting files for your talk: Preferred file format is **pdf** or **PowerPoint**. No other file formats are accepted. Please bring your files in a USB stick and hand them to us ideally one day before your presentation or latest, during the coffee/lunch break before your session. If your talk is on the very first day, you can also send it to us via email on Tuesday morning. The presentation computers will be running Windows 10 and are equipped with PowerPoint and Adobe PDF reader. If there are videos embedded in the presentation, make sure they are uploaded correctly. Please do not consider projecting your presentation from your own laptop, as this will inevitably cause delays.

Posters

Poster boards are set up in the Foyer of the Fürstenberghaus next to the registration desk. The posters should be prepared in portrait format in ISO A0 size (119 cm x 84 cm).

Stickers to attach the posters to the presentation boards are available at the registration desk.

Posters can be on display during the entire conference, but there will one poster session on Tuesday (17:00 – 19:00). For poster numbers, see the list of posters (page 11) provided in this book.

Abstracts

The abstracts of all talks and posters can be found in the book, order by the last name of the presenting author.

Public lecture

On Wednesday evening (17:00 - 18:30) Prof. Dr. Oliver Krüger will give a public lecture on the topic of **Verhalten im Wandel: Westfalen, Arktis, Galapagos** in hopes of engaging and communicating our research to the citizens of Münster and anyone interested. Please feel free to join but be aware that the lecture will be held in German.

Catering

Coffee, tea, water and snacks are available on the 1st floor all day.

For lunch on Wednesday there are various opportunities to have lunch in the vicinity of the Fürstenberghaus.

For lunch on Thursday a self-serving finger-food buffet will be available at the conference venue.

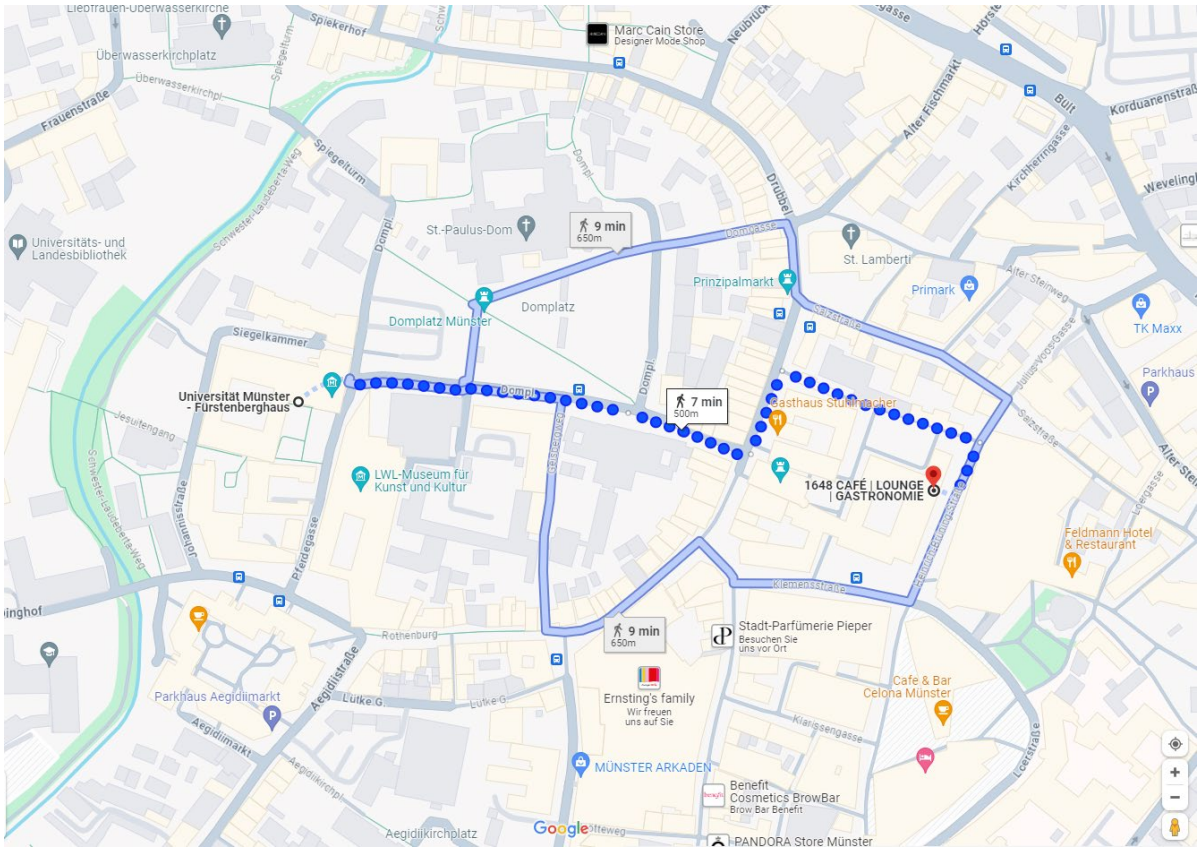
During the poster session, self-serving finger-food buffets and beverages are offered.

All food served during the conference will be vegetarian or vegan.

Conference dinner

The conference dinner will happen on Wednesday, 04.09.2024, from 19:00 to 21:00 at Café 1648 [Heinrich-Brüning-Straße 5, 48143 Münster].

It is 7 min by foot from the conference venue (see map below).



Detailed Programme

Tuesday 03.09.2024				
Start	**End**	**Duration (min)**	**Speaker / Info**	**Talk Title**
12:00	13:00	60	Registration & Coffee	
13:00	13:15	15	Welcome - Oliver Krüger	
13:15	13:45	30	Judith Korb	Long live the queen, the king and the commoner? Life span evolution in termites and the NC³ principles
13:45	14:15	30	Franjo Weissing	The evolutionary ecology of movement behaviour
14:15	14:45	30	Coffee break	
14:45	15:00	15	Rose Trappes	Individualising Variation: Distinguishing Sex Traits and Individual Differences in Biological Practice
15:00	15:15	15	Maria Moiron	Pace-of-life syndrome hypothesis and the meta-analytic evidence for life-history trade-offs at the genetic level
15:15	15:30	15	Lai Ka Lo	Niche construction affects adaptation of *Tribolium castaneum* to *Bacillus thuringiensis*
15:30	16:00	30	Coffee break	
16:00	16:30	30	Barbara Taborsky	The emergence of division of labour through the ontogeny of helping niches
16:30	17:00	30	Oliver Schülke	Intra-annual timing of reproduction alters individualized niches in seasonally breeding macaques
17:00	17:15	15	Pragya Singh	Niche realisation processes in insects: effects of global change and the importance of individual variation
17:15	17:30	15	Break	
17:30	19:30	120	**Poster session** (with drinks and finger food)	
Wednesday 04.09.2024				

09:00	09:30	30	Coffee & chat	
09:30	10:00	30	Pim Edelaar	An experimental test for evolutionary consequences of choice of the environment - or how to remove natural selection from the evolutionary process
10:00	10:15	15	Jules Petit	Phenotypic plasticity under urbanisation: A meta-analysis
10:15	10:30	15	Öncü Maraci, Rebecca Rimbach & Isabel Damas-Moreira	How animals respond to urban niches: A comprehensive cross-species investigation
10:30	11:00	30	Coffee break	
11:00	11:30	30	Susanne Foitzik	Behavioral variability and task specialization in ants and their transcriptional, epigenetic and neurobiological basis
11:30	11:45	15	Laura Schulte	The influence of fire salamander larvae on benthic organisms: evidence of habitat specific differences
11:45	12:00	15	Marie Kaiser	On the Epistemic Roles of the Individualized Niche Concept in Ecology, Behavioral and Evolutionary Biology
12:00	13:30	90	Lunch (self organised: in the city/ Wednesday market)	
13:30	14:00	30	Chaitanya Gokhale	Ecology defines the individual
14:00	14:30	30	Nicolas Rohner	Metabolic Adaptation to Nutrient Limitation in Vertebrates
14:30	14:45	15	Marc Bauhus	Genetic and phenotypic characterisation of immunological niche conformance in cavefish.
14:45	15:00	15	Carlina Feldmann	Inferring individual variation and distinct behavioural patterns using mixtures of hidden Markov models
15:00	15:30	30	Coffee break	
15:30	16:00	30	Sophie Armitage	Individual variation in infection processes: Host and pathogen perspectives
16:00	16:15	15	Anastasiia Enne	Modelling niche conformance of laying dates in great tits (*Parus major*)
16:15	16:30	15	Ane Liv Berthelsen	Remote imagery unveils seasonal variation in Antarctic fur seal occupancy
16:30	17:00	30	Break	
17:00	18:30	90	**Public lecture** Oliver Kruger	Verhalten im Wandel: Westfalen, Arktis, Galapagos
19:00	21:00	120	Conference dinner @ Café 1648	

Thursday 05.09.2024				
09:00	09:30	30	Coffee & chat	
09:30	10:00	30	Marc Naguib	Communication and social organization of zebra finches in the wild
10:00	10:15	15	Maja Drakula	Are trophically transmitted parasites drivers of individual specialization and ecosystem dynamics via niche construction?
10:15	10:30	15	Angelica Coculla	Temporal niche in *Drosophila melanogaster*: how individuals create their own biological rhythm.
10:30	11:00	30	Coffee break	
11:00	11:30	30	Anja Günther	Different vulnerability to environmental change in male house mice following different reproductive strategies
11:30	11:45	15	Jonas Schwarz	Facing environmental change: A tradeoff between individual foraging strategies in Galapagos sea lions
12:00	13:30	90	Lunch (at venue)	
13:30	14:00	30	Andrew Sih	Fear generalisation
14:00	14:30	30	Dan Blumstein	Individuality and trait heritability in yellow-bellied marmots
14:30	15:00	30	Closing remarks – Joachim Kurtz	

List of posters

Poster Number	Name
1	David Vendrami
2	Louisa Bierbaum
3	Sophia Marie Quante
4	Max Mühlenhaupt
5	Nijat Narimanov
6	Melanie Gleske
7	Leon Brüggemann
8	Navina Liebermann-Lilie
9	Svenja Stoehr
10	Nora Schulz & Ana Korsa
11	Reshma R & Tobias Prüser
12	Nayden Chakarov
13	Tania Chavarria Pizarro
14	Jaime M Anaya-Rojas
15	Ulrich Krohs
16	Victor Carranza Pinedo
17	Marlene van den Bos
18	Vishnu Venugopal
19	Peter Nabutanyi
20	Klaus Reinhold
21	Öncü Maraci, Rebecca Rimbach & Isabel Damas-Moreira
22	Dimphy van Boerdonk
23	Filippa Erixon
24	Marion Varga

Poster session: *Poster session will take place on 03.09.2024 at the Foyer of the Fürstenberghaus from 17:30-19:30. Please see the attached list of poster participants and respective poster number. Please prepare your poster in ISO A0 size (119 cm x 84 cm).*

Abstracts

Talks & Posters

Sorted by last name of the presenting author

Niche construction consequences of parasite virulence in eco-evolutionary dynamics

Maja Drakula[1], Joachim Kurtz[1], Jamie M. Anaya-Rojas[1]

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Species interactions are at the core of the interplay between ecological and evolutionary processes. Parasites trigger a plethora of physiological, morphological, and behavioral changes in individual hosts that can cascade to other trophic levels. Consequently, the individualized niches that emerge because of parasitic infections not only increase niche differences among and within host populations via the three mechanisms central to this CRC (niche choice, niche conformance, and niche construction), but can also alter eco-evolutionary dynamics. Hence, parasite-driven individual variation can not only influence the strength of intra- and interspecific interactions, but also alter food web dynamics and ecosystem functioning via indirect ecological effects via high order niche construction effects. Here, we aimed to investigate the niche construction effects of parasites and how they alter eco-evolutionary dynamics. Using three-spined sticklebacks (*Gasterosteus aculeatus*) and their trophically transmitted parasite, *Schistocephalus solidus*, as a model system, we are investigating how individual niche specialization in host species emerges because of parasite infections (parasite niche construction effects) and variation in a parasite trait (i.e., virulence, parasite's niche construction efficiency). We will use stable isotopes and stomach content data from field surveys and mesocosm experiments, together with agent-based models, we address the following research questions: (i) does individual niche specialization in sticklebacks covary with parasite infection and virulence? And (ii) how do niche construction effects of parasite virulence on individual specialization alter eco-evolutionary dynamics? This work sheds light on the importance of parasite traits and host-parasite interactions as drivers of niche individualization and eco-evolutionary dynamics in a multi-species context.

Individual variation in infection processes: Host and pathogen perspectives

Sophie Armitage[1]

[1]Freie Universität Berlin, Institute of Biology, Berlin, Germany

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Pathogens will affect all living organisms at some point in their lives. After becoming infected, a host may not always be able to clear the pathogen, and it may instead die or survive with a persistent infection. This variation in individual infection outcome is ecologically and evolutionarily important because it could affect pathogen prevalence and transmission, as well as virulence evolution. However, the factors causing variation in infection outcome, and how these factors feed in to affect virulence, are not well understood. I will present data from our work on *Drosophila melanogaster*, exploring factors that may affect individual variation in infection risk in wild-collected flies, through to lab experiments where we aim to understand how the host and the pathogen influence virulence. To study the latter, we unpick the host resistance and tolerance responses towards the pathogen, and the pathogen's ability to exploit and cause pathogenicity in the host. Such a virulence decomposition is broadly applicable and can provide insights into host-pathogen interactions.

Genetic and phenotypic characterisation of immunological niche conformance in cavefish.

Marc Bauhus[1,2]

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The vertebrate immune system reflects an important adaptation to parasites in the environment of an individual host by providing an effective defense in the form of innate and adaptive immune responses. Since host-parasite interactions strongly influence the evolution of immune systems, differences in the parasite abundance and diversity can shape immunological phenotypes of hosts. For example, some cave dwelling populations of the Mexican tetra *Astyanax mexicanus* are exposed to low parasite abundances and diversity compared to other cave- and surface dwelling populations. Consequently, these fish invest less into the costly innate immune response but more into the adaptive immune system. In contrast to that, surface populations of the same species show a strong innate immune response following an immune challenge. This raises the question whether an immunological adaptation to a certain parasite abundance and diversity affects the ability of the individual host immune system to conform to changes in the parasite abundance and diversity in the environment. To study this, we characterized the immunological niches of wild cave and surface populations of A. mexicanus in two subsequent years. We sampled fish from different populations, screened them for parasites and measured immune phenotypes as well as other parameters that might affect the immune phenotype (e.g. metabolism). Data from both years suggests that different cave- and surface populations indeed differ in their parasite abundance and diversity. For example, Pachon and Tinaja cave populations were only infected with small monogenean ectoparasites whereas the *Rio Subterráneo* and Los Sabinos cave populations were also infected with nematode endoparasites. In the Rio Choy and Presa El Oyul surface populations, we found a variety of different parasites including monogeneans, trematodes and nematodes. Furthermore, screening the allelic diversity of the major-histocompatibility complex class II (MHC class II), which presents parasite antigens to T-helper cells, revealed that Pachon cavefish show a reduced MHC class II allelic diversity which was not due to a reduced overall genetic diversity. Therefore, this is in line with the reduced parasite diversity that we found in this cave. More data on immune cell composition, gene expression, primary metabolites and stress phenotypes in these wild populations of A. mexicanus will further validate our characterization of the immunological niche.

In a second approach, we will challenge lab-reared fish from the same populations with homo- and heterologous parasite-supernatants that we collected in the field to examine their degree of immunological niche conformance. This will include methods such as image-based flow cytometry to measure immune cell composition, qPCR to reveal changes in immune gene expression, and single-cell RNA sequencing to uncover specific cell types involved in mediating immunological niche conformance. Together with our global characterization of the immunological niche in wild populations of *A. mexicanus*, this project has the potential to provide insights into physiological and genetic frameworks involved in maintaining a functional immune phenotype facing a reduced parasite diversity. Since cavefish do not express autoimmune phenotypes, this might also have important implications for investigating autoimmune diseases following a reduced parasite exposure in humans.

Remote imagery unveils seasonal variation in Antarctic fur seal occupancy

Ane Liv Berthelsen[1], Rebecca Nagel[1,2], Joseph Hoffman[1]

[1]Bielefeld University, Department of Evolutionary Population Genetics, Bielefeld, Germany

[2] School of Biology, University of St Andrews, St Andrews, KY16 9TH, UK

Contact: ane_liv.berthelsen@uni-bielefeld.de

Antarctic fur seals (*Arctocephalus gazella*) are circumpolar mammals under increasing environmental pressure living beyond human inhabitation. While remote research stations monitor select colonies, detailed abundance and population density patterns remain undescribed. Population density influence mate availability, competition intensity and risk of predation or disease, thereby making it an important breeding site factor. Therefore, these patterns are fundamental for our understanding of female niche choice and following pup niche conformance. This study was conducted at two Antarctic fur seal colonies at Bird Island, South Georgia, where despite the proximity the population densities are markedly different. An elevated camera was deployed to sample an image every minute to capture variation across the breeding season. A subset of the images was used to train a neural network to score species and the specific groups: males, females, and pups. We aimed to describe seasonal variation in abundance and density of Antarctic fur seal groups, and the associated predator and scavenger species. We further explored changes in the social and spatial niche over the course of the season.

Forever an optimist? Investigating the temporal consistency of rats' optimism levels within and across different life stages

Louisa Bierbaum[1], Viktoria Siewert[1], Sylvia Kaiser[1], S. Helene Richter [1]

[1]University of Münster, Department of Behavioural Biology, Münster, Germany

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Cognitive judgement bias tests have been established as a powerful tool to assess emotional states in animals. They rely on 'optimistic' or 'pessimistic' interpretations of ambiguous cues and originated from animal welfare science. In light of the increasing interest in animal personalities (i.e., inter-individual differences in behaviour that are stable across time and/or context), however, studies have also begun to systematically investigate stable individual differences in optimism levels. This is particularly interesting, as such personality differences can unfold critical evolutionary and ecological consequences, with differences in optimism levels critically affecting an individual's survival and fitness. Using laboratory rats, the present study therefore aimed at systematically investigating the stability of optimism levels within and across different life stages. More specifically, a cognitive judgement bias test relying on differently grained sandpaper as tactile cues was repeated twice during early (postnatal days (PND) 70-100) and later adulthood (PND 168-191), respectively. Temporal consistency of optimism levels within and across life phases was assessed by analysing the repeatability of optimism scores. The results are discussed against the animal personality framework with a particular focus on potential ecological implications.

Individuality and trait heritability in yellow-bellied marmots

Daniel T. Blumstein[1,2]

[1]University of California, Department of Ecology and Evolutionary Biology, California, USA
[2]The Rocky Mountain Biological Laboratory, Colorado, USA

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The yellow-bellied marmots (*Marmota flaviventer*) at the Rocky Mountain Biological Laboratory near Crested Butte, Colorado, USA have been under continuous study since 1962. We have sufficient statistical power to study individuality in many traits, which we study by quantifying repeatability. But for individualistic traits to evolve, there must be heritable variation and we have estimated the additive genetic variation of a variety of behavioral and morphological traits. By combining an observational genealogy with a molecular genealogy that dates back to 2002, and by using the 'animal model'—a mixed modeling approach that permits us to decompose sources of variation for free-living animals—we have quantified the heritability of a variety of traits. Body mass is a key trait for this hibernating rodent and the rate of mass gain is heritable as is the time that marmots allocate to foraging. Marmot's behave predictable ways when trapped and trap docility is heritable as are sociability (when measured using a mirror image stimulation), and exploration and activity measured in two different contexts (open-field and mirror image simulation experiments). We have studied a variety of antipredator traits and found significant repeatability and heritability for a number of them. Marmots have individually-specific alarm calls and the structure of them is heritable as is the degree to which these calls contain non-linearities that communicate fear to others. Marmot running speed and antipredator vigilance is heritable as is the distance they flee approaching threats. While we know that key social traits are associated with natal dispersal, the tendency to disperse is itself slightly heritable. Finally, there is some heritable variation in the timing of their emergence from hibernation. Overall, most heritability estimates are low, which suggests that individual differences, while detectable, have relatively small impacts compared to a variety of environmental and contextual drivers. Taken together, many consequential marmot traits are not only individually-specific, they are also heritable. This individual plasticity and heritable variation bodes well for their future ability to respond to a rapidly-changing environment.

Life stage- and sex-specific responses to nutritional stress in a holometabolous insect

Leon Brüggemann[1], Pragya Singh[1], Caroline Müller[1]

[1]Bielefeld University, Department of Chemical Ecology, Bielefeld, Germany

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Over the course of their lives, organisms experience different stresses that shape their phenotype. Individuals may deal with stress differently, also depending on the life stage at which they experience it and on their sex. One of these stresses is nutritional stress, such as limitation in food. However, little is known about how responses differ between individuals experiencing nutritional stress early versus later in life or repeatedly, particularly in species with distinct ontogenetic niches. Moreover, females and males may respond differently due to distinct needs. The turnip sawfly, *Athalia rosae* (*Hymenoptera: Tenthredinidae*), is a holometabolous herbivore, which demands different food plant families across its lifespan. Larvae feed on leaves and flowers of various Brassicaceae, while the adult sawflies take up nectar from, for example, *Apiaceae*. Here, we examined effects of starvation, experienced at different sensitive phases, on life-history traits, behaviour and metabolic traits. Therefore, we set up four distinct starvation regimes. Individuals experienced either no starvation, periodical larval starvation, adult starvation or starvation periods in both larval and adult life. Larvae exposed to starvation had a prolonged developmental time but reached a similar adult body mass as non-starved individuals, suggesting the ability to compensate until adulthood. Adult starvation led to a significantly reduced body mass in females only. The adult behaviour, measured as activity, was not impacted by larval starvation, but, by trend, adult starvation led to a higher activity in both sexes. Moreover, individuals starved as larvae could reach similar carbohydrate and lipid contents than non-starved individuals, potentially by building up energy reserves, while adult starvation or starvation in both stages led to reduced energy reserves, here mostly in males. In summary, individuals show differences in niche conformance, with life stage- and sex- specific responses to nutritional stress.

Modeling Organism-Environment Reciprocal Causation Using Goal-Directed Behavioural Causation

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Baedke et al. (2021) argued that theories of organism-environment reciprocal causation fail to maintain epistemic boundaries between organisms and environments and to integrate physical and experiential kinds of reciprocal causation. In this presentation, I propose a model of organism-environment reciprocal causation that meets these criteria. The model addresses niche alteration processes—niche construction, niche choice, and niche conformance (1) using a goal-directed model of behavioral causation. Behavioral causation is understood as a three-step process (2): (a) detecting a discrepancy between a stimulus and a goal, (b) selecting a strategy to address the discrepancy, and (c) feeding back the outcome to the start of the cycle. Step (b), in turn, involves three strategies the individual can choose: assimilation (acting to align the stimulus with the goal), accommodation (changing the goal to align with the stimulus), and immunization (altering the interpretation of the stimulus). I argue that assimilation underlies niche construction, accommodation underlies niche choice, and immunization underlies niche conformance, and explain how step (c) in this model can elucidate organism-environment reciprocal causation.

[1] Trappes et al., 2022
[2[Moors, 2022

Genomics of a morphological and behavioural niche determinant trait in diurnal raptors

Nayden Chakarov[1], Kai-Philipp Gladow[1], Meinolf Ottensmann[1], Tim Maximilian Rapp[1], Tony Rinaud[1], Oliver Krüger[1]

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In some taxa, fitness and behaviour, and likely the balance of NCs are strongly shaped by one simple and visible trait. Colour variation in *birds* of prey may be such a case. Long-term datasets show that colour morph in several buzzard and hawk species correlates with many behavioural and physiological traits, which may contribute to the differential fitness while similar polymorphisms are common across the whole order of diurnal raptors. This poses several hypotheses on how these correlations can arise and whether they are ancestral to the whole order. We used detailed phenotypic analyses of buzzard plumage along with other more clearly defined polymorphisms. We combined these phenotypes with chromosome-level genome assemblies of several raptor species and resequencing of many individuals per species to perform genome-wide association analyses. Identified genomic regions corresponding to morph and fitness variation might predict traits, which should additionally correlate with colour because of pleiotropy or linkage and suggest genetic contributions to the development of behavioural traits. Analysing the different niche occupancy by phenotypes along with the genetic basis of behavioural adaptations gives a rare opportunity to how NC3 mechanisms depend on genetic variation or function despite it.

Temporal niche in *Drosophila melanogaster*: how individuals create their own biological rhythm.

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[1]University of Münster, Institute of Neuro- and Behavioural Biology, Münster, Germany

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In order to adapt to environmental fluctuations, organisms concentrate their activity to favourable hours of the day, which constitutes their temporal niche. The selection and occupation of the correct temporal niche is endogenously regulated by the molecular clock, which utilises environmental cues to synchronise itself and the rhythms it controls to the predominant 24 hours cycles of light and temperature. Exposure to constant light, such as exposure to Artificial Light at Night (ALAN), can disrupt the molecular clock and consequently the ability of individuals to maintain a specific temporal niche. In particular, exposure to constant light fosters the continued degradation of the circadian clock protein timeless (TIM) via cryptochrome (CRY) in *Drosophila*, resulting in the breakdown of the molecular clock oscillations and arrhythmic locomotor behaviour. However, little is known about the effects of constant light on circadian rhythms and the molecular clock when individuals are able to take shelter from the light in an otherwise constantly light-exposed environment. Here, we investigate whether individuals can actively maintain or even restart their circadian clock, and thereby establish their temporal niche in constant light, when they are provided with a light-shed area they can freely chose to visit.

Are trophically transmitted parasites drivers of individual specialization and ecosystem dynamics via niche construction?

Maja Drakula[1], Joachim Kurtz[1], Ella S. Rothe[1], Lena Gerigk[1], Jacob J. Brüning[1], Mats J. Reckert[1], Beatriz Elias Ranelli[1], Jaime M. Anaya-Rojas[1]

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Species interactions are central to the relationship between ecological and evolutionary processes. Parasites, as primary selective agents for most animals, can induce various physiological, morphological, and behavioral changes in their hosts, which may cascade through the food web. This suggests that parasitic infections could drive the development of individualized niches. However, the extent to which these effects on individual niches influence broader ecological dynamics remains unclear. In this study, we explored whether the trophically transmitted parasite *Schistocephalus solidus* can modify the direct and indirect ecological effects of three-spined sticklebacks in experimental aquatic ecosystems. Our research focused on two key questions: (i) Does the presence of *S. solidus* in ecosystems affect the likelihood of observing trophic cascades? (ii) How does *S. solidus* alter the direct and indirect impacts of its host? Our findings indicate that *S. solidus* weakens the indirect ecological effects of sticklebacks, with these effects being strongly influenced by the infection status of the fish. This study highlights the role of parasites as niche constructors and their significance in shaping ecological dynamics.

An experimental test for evolutionary consequences of choice of the environment - or how to remove natural selection from the evolutionary process

Pim Edelaar[1]

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Individuals may be different. Local environments may be different. Combined, this means that local ecological performance may vary across individuals. There are multiple ways that individuals can respond to this, and one of them is choosing the environment in which they do best (cf. 'niche choice'). Theory predicts this could lead to a spatial sorting into locally adapted populations. However, there are very few experimental studies which have tested this. We manipulated local feeding rates by providing wild Tree sparrows with two groups of transponder-operated feeders which were placed some 400 meters apart, and by tagging sparrows with a transponder that only opened feeders in one of the two locations. Unsurprisingly, we observed that sparrows would mostly visit the feeders that gave access to food. More importantly, we also observed that sparrows would breed in the same area as where their transponder type matched the feeder type. As an indirect consequence, this resulted in a high degree of assortative mating with respect to transponder type, and therefore in a high degree of reproductive isolation between these two locally adapted subpopulations. We therefore observed the same ecological and evolutionary consequences as those that can be caused by divergent natural selection - except that divergent natural selection did not cause the observed patterns here. To fit this somewhat paradoxical observation into evolutionary theory, I present a causal model of adaptive evolution that is compatible with standard evolutionary theory, but that expands the interpretation of each of the three classical requirements for adaptive evolution: variation, selection, and heredity.

Modelling niche conformance of laying dates in great tits (*Parus major*)

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Great tits need to time their decision of when to breed, catching peak abundance of caterpillar larvae in order to get enough food for raising nestlings and increase reproductive success (1;2) Changing and variable climate impacts such decisions, forcing individuals to adjust their breeding period. They do this by responding to environmental cues via niche conformance (3). Green-up date can be a good predictor of caterpillar abundance, therefore it can affect the outcome of breeding decision and allow us to estimate how niche conformance is performed (4).

In our study we apply our modelling framework to build a simple model of niche conformance of laying dates to green-up dates. We estimate the fitness function and the niche conformance function from a long-term dataset on great tits (5). We then try to estimate how niche construction impacts fitness, and what role the intraspecific trait variation plays in reproductive success.

[1] Kristensen, 2015.
[2] Visser, 1998.
[3] Visser, 2021.
[4] Cole, 2015.
[5] Cao, 2019.

Matching safety: personality-dependent habitat use and dispersal under heterogeneous risk

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Predation risk is a key determinant of fitness varying in space and time. Animals adjust their habitat use, movement, and dispersal to predation risk and the outcome of these processes ought to be mediated by interindividual differences in boldness, activity, and exploration. Whether and how personality traits affect dispersal across landscapes of risk and matching habitat choice is, however, less clear. Therefore, we aimed to test among-individual covariation between personality traits, microhabitat use, and dispersal tendency by experimentally manipulating predation risk under (near) natural conditions for two vole species (*Microtus arvalis*: n = 7 to 68 depending on analysis; *Myodes glareolus*: n = 144). We repeatedly assessed boldness, activity, and exploration in standardized tests. We determined microhabitat use before and after altering vegetation cover based on capture-mark-recapture and assessed dispersal propensity via RFID-tracking. Among-individual variation in boldness, activity, exploration, and microhabitat use was repeatable. Bolder individuals used microhabitats with lower vegetation cover before and after alterations, suggesting that niche choice is the main process maintaining phenotype-environment correlations in these species. Furthermore, this supports the idea that individual-level selection of the environment according to its safety can improve an individual's fitness prospects and might be seen as an extended phenotypic trait.

Inferring individual variation and distinct behavioural patterns using mixtures of hidden Markov models

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Statistical analyses in ecology are often concerned with individual variation, a crucial indicator for species fitness amid environmental changes like climate change. To gain insight into animals' behaviour from time series data, hidden Markov models (HMMs) provide a flexible and popular modelling framework, which allows inference on behavioural patterns underlying the observed data. While random effects can be included in HMMs to model individual variation and heterogeneity of the population, the resulting models are limited in their flexibility, as only some parameters can be assumed to be individual-specific. Therefore, we propose mixtures of HMMs, which allow all model parameters and even the model structure to vary across subpopulations. The proposed model is used to investigate the intraspecific variability in foraging strategies of Galapagos sea lions, avoiding multi-stage approaches of first clustering the animals into subgroups and subsequently learning about behavioural phenotypes. Instead, the proposed framework integrates these steps and jointly infers group membership as well as behavioural characteristics of each group. The results indicate distinct subpopulations in Galapagos sea lions exhibiting varied foraging strategies.

Behavioral variability and task specialization in ants and their transcriptional, epigenetic and neurobiological basis

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Division of labour is a characteristic trait of insect societies, in which tasks are performed by specialized individuals. Workers focus on brood or nestmate care, while others take risks by foraging for food outside. Theory posits that workers have different thresholds for performing certain tasks when confronted with task-related stimuli, leading to specialization and consequently division of labor. Workers are assumed to react differently to task-related stimuli and not in how they perceive this information. We tested the hypothesis that division of labor is instead due to workers varying in their efficiency in perceiving stimuli for specific tasks. We use transcriptomics to measure mRNA expression levels in the antennae and brains of nurses and foragers of the ant *Temnothorax longispinosus*. We found seven times as many genes between behavioral phenotypes in the antennae compared to the brain. In addition, half of all odorant receptors were differentially expressed, with the 9-exon gene family being overrepresented in the antennae of brood carers. Thus, nurses and foragers apparently differ in the perception of their olfactory environment and task-related signals. We therefore found support for the hypothesis that sensory filters of the antennae predispose workers to specialize in certain tasks. Additional studies in our group showed that histone acetylation plays a role in the regulation of task-specific genes. In addition, we recently demonstrated that workers vary in the number of glomeruli in the antennal lobes by a factor of three, whereas in insects normally glomeruli number corresponds to the number of odorant receptor genes. However, this unexpected variation appeared to be independent of a worker's role as brood carer or forager, and we are still analyzing the effect of this brain organizational variability on ant behavior. Our studies provide insights into behavioral variability in ants and its transcriptional, epigenetic and neurobiological basis.

Behavioural and hormonal profiles in juvenile guinea pig males living in distinct social environments

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The individualised social niche results from the interactions of an individual with its social environment. Since the social environment in which an individual is living can change during lifetime, it is important that individuals are able to conform to different individualised social niches. This social niche conformance can happen through shaping of behavioural and endocrine phenotypes. Our goal in this study is to fully understand social niche conformance in guinea pigs as a model organism by investigating when and how behavioural profiles are modulated in individual males during three phases of ontogeny (juvenility, adolescence, adulthood). Until now, the juvenile phase was examined. For this approach, male guinea pigs live in two distinct social environments: while males of both groups live in heterosexual pairs, males of one are socially stimulated (e.g., an unfamiliar individual is introduced into the focus males home enclosure) regularly, while males of the other group are not. This procedure increases the number of social interactions, which is a crucial factor constituting individualised social niches. In the first project of this study, plasma samples to determine hormone concentrations as well as video material from the behaviour in the home enclosure were collected from ten juvenile males from each treatment group. We hypothesize that male guinea pigs realising different individualised social niches during the juvenile phase differ in their behavioural profiles which are reflected by cortisol responsiveness and/ or basal testosterone and cortisol concentrations. The data is currently being analysed.

Ecology defines the individual

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The talk's thesis will be that individuality arises from ecological dependencies, where dynamic processes scaffold traits like reproduction and heredity, heavily influenced by the environment. The role of timescales is crucial, as the dynamics of the environment and the corresponding selection processes determine the locus of selection, making individuality a variable rather than a static entity. I will discuss this through the lens of ecologically dynamic experiments in yeast. Through endogenisation, ecological processes are internalised, reducing dependence on external factors for specific timescales and creating new levels of individual organisation. Via endogenisation, individuality can evolve by incorporating and stabilising external processes within organisms or systems. Early individuality is thus intertwined with major evolutionary transitions. Such a concept of individuality extends beyond biological systems to cultural, social, and technological contexts, where selection operates in non-biological domains. The conservation of complexities through evolutionary transitions indicates that new individualities retain signatures of previous organisational levels, resulting in a layered and intricate construct. Thus, individuality is defined by a dynamic interplay of ecological influences, temporal dynamics, internal stabilisation, and multi-level selection processes. While I focus on Darwinian individuality, connections to other notions of individuality will be discussed.

Different vulnerability to environmental change in male house mice following different reproductive strategies

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Unprecedented global climate change exposes organisms to much higher rates of unpredictable, fast changing environmental conditions than what evolution has shaped them for. Unpredictable environmental change is therefore becoming an increasing concern for the well-being and survival of many species. One aspect that has not yet been explored in the literature is how individual variation within species facilitates or buffers organisms´ vulnerability to unpredictable change. In house mice (*Mus musculus domesticus*), adult males chose to either become territory holders or roamers that try to achieve fitness by sneaky matings. Territory holders are usually larger and more likely to win aggressive encounters while roamers develop a larger testes-to-body-mass ratio, thus, males show patterns of niche conformance. Using eight replicates of semi-naturally living populations, we experimentally tested how an unexpected shift in resource availability (from better to worse quality food and vice versa), affected male survival and reproductive characteristics. While survival of roamers was not affected by environmental change, territory holders suffered from reduced survival compared to control populations, especially when changing from better to worse quality food. The larger territory holders did not change their body mass, sperm counts or testes-to-body mass ratio in response to environmental change, irrespective of switching from worse to better or vice versa. However, roamers experiencing a shift from better to worse food, decreased investment into these costly reproductive traits, temporarily emphasising self-maintenance over reproduction. Roamers experiencing a shift from worse to better were immediately able to increase investment into reproductive traits. In summary, our data show that specific individuals within a species, even a species that is well-known for it´s fast adaptation potential, are more vulnerable towards environmental change than others. This emphasises the importance of incorporation within-species variation into future studies investigating species responses to environmental change.

On the Epistemic Roles of the Individualized Niche Concept in Ecology, Behavioral and Evolutionary Biology

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We characterize four fruitful and underappreciated epistemic roles played by the concept of an individualized niche in contemporary biology, utilizing results of a qualitative interview study conducted within an interdisciplinary biological research center. We argue that the individualized niche concept (1) shapes the research agenda of the center, (2) facilitates explaining core phenomena related to inter-individual differences, (3) helps with managing individual-level causal complexity, and (4) promotes integrating local knowledge from ecology, evolutionary biology, behavioral biology and other biological fields. We thereby also challenge arguments that the niche concept is superfluous in ecology.

Long live the queen, the king and the commoner? Life span evolution in termites and the NC³ principles

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Why do animals age and why do they age at different pace? In recent years, social insects like termites, ants and some bees and wasps, have become emergent models to study ageing. They are especially suited to address the evolution of ageing because within the same colony / family different individuals show very different ageing patterns. Social insect queens (and in termites, also kings) have extraordinary life spans of up to several decades, while workers are generally short-lived with a life span of a few months only. Using termites as model systems, I will summarize our current understanding how / why sociality changes ageing. I will present experimental results which revealed factors that affect ageing. Finally, I aim to apply the NC³ principles of niche construction, niche choice, and niche conformance to the evolution of life span evolution in termites.

Why is fear experienced negatively? On the evolution of basic emotions

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Why don't we experience positive feelings when we encounter a bear at our campsite in the wilderness, why don't we enjoy being threatened with a knife? Why are we convinced that the valence of fear is negative also in other sentient animals and thus care about animal welfare?

Such questions about the valence of fear and of other basic emotions could easily be answered in terms of adaptive evolutionary processes. This required that the valence of a conscious emotion have an impact on an individual's behavior - which contradicts widely accepted views in the philosophy of mind and in behavioral biology: Consciousness is considered to be an emergent property of highly complex systems like vertebrate brains, accompanying cognitive processes. However, no emergent property can affect the system upon which it emerges. So consciousness must be causally inert for (almost) a priori reasons.

This standard view of the role of consciousness contradicts well-established results from evolutionary biology. The project therefore proposes to replace the a priori approach to consciousness with an empirical one. It outlines a naturalistic model of how the content of conscious experience affects neural processes and behavior, and thus conceives of the valence of basic emotions as selectively relevant. Implications for the NC3 mechanisms are considered.

Is there a trade-off between extra-pair mating and parental care? Niche conformance to experimental manipulation of the social environment in male zebra finches

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How does the sexual competition and the opportunity for extra-pair matings affect male parental care? Per definition, extra-pair paternity can only occur when there is a social bond between mates, and is particularly prevalent in socially monogamous birds with biparental care. However, additional matings might coincide with parental effort, which is costly in terms of time and energy. This may lead to a potential trade-off for the males between securing fertilizations and securing offspring survival through providing parental care. In this pre-registered study, we experimentally manipulated the social environment of the birds to create two levels of sperm competition risk and the opportunity for extra-pair matings: one with sperm competition risk and opportunity for extra-pair mating (Double-pair), and one without (Single-pair). We compared male parental behaviour during egg laying and chick rearing between the two treatment groups. To create a realistic opportunity for extra-pair matings, we removed the non-focal male from the Double-pair treatment group during chick rearing. We measured plasma testosterone and corticosterone levels at different stages of the breeding cycle to identify hormonal correlates of male behavioural adjustment. Contrary to our pre-registered predictions, Double-pair males (i.e. with extra-pair females) increased their incubation behaviour compared to Single-pair males. After the non-focal males have been removed, Double-pair males engaged in extra-pair matings in a relatively high level. However, brood provisioning behaviour was not affected by the opportunity for extra-pair matings, leading to the conclusion that extra-pair matings did not trade-off with parental effort provided to the offspring. Testosterone levels changed during breeding cycle, but social treatment had no effect on either testosterone or corticosterone levels. Our findings suggest that males show good fathering qualities despite confronted with higher sexual competition and opportunity for extra-pair matings, securing survival of the current brood and stabilizing the pair bond to their social mate.

Niche construction affects adaptation of *Tribolium castaneum* to *Bacillus thuringiensis*

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Niche construction is an important eco-evolutionary process whereby organisms modify their ecological niche by altering the chemical, physical, or biological properties of their environment. Niche construction is hypothesised to facilitate adaptation to changing environments, especially important for group-living animals where conspecifics share the same niche and benefit from an increased match with the environment. However, the evolutionary benefits of niche construction have rarely been experimentally tested. Here, we performed experimental evolution with the red flour beetle (*Tribolium castaneum*) as the host and *Bacillus thuringiensis tenebrionis* (*Btt*) as its natural microparasite. Adult red flour beetles modify their environment by releasing quinone-rich stink gland secretions that alter their surrounding microflora. As we could impede the production of stink gland secretions of beetles via RNAi knockdown, we subjected the focal beetles to differentially constructed niches, that is, flour conditioning by either stink gland secretion-producing adults or knockdown adults derived from the same selection lines. We then compared how differentially constructed niches affected host adaptation to *Btt* selection. After nine generations, populations with functional niche construction exposed to *Btt* showed the strongest survival increase against *Btt* infection. *Btt* selection prompted faster host development, particularly in populations in which niche construction was impaired, and they also produced slightly more offspring, indicating the potential costs of niche construction. Transcriptomic analysis revealed divergences influenced by *Btt* selection, notably in cuticle and serine protease genes, and Btt-selected lines differed further by niche treatment, particularly in DNA repair, endocytosis, and transcription regulatory genes. Our findings provide urgently needed but rare empirical evidence on the importance of niche construction for evolutionary adaptation.

How animals respond to urban niches: A comprehensive cross-species investigation

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Urbanisation is undoubtedly among the most severe forms of human-induced alterations, modifying several environmental parameters in very short periods. Adjustments to novel niches generated by urbanisation will likely require simultaneous alterations in multiple systems and biological functions. Although these systems and functions are not independent, studies often focus on a single phenotypic trait such as behaviour, endocrine profiles, oxidative stress, immune function and metabolism independently, ignoring connections and interactions between them. Furthermore, although it is evident that the magnitude of this impact depends on the taxonomic group, studies so far have tried to make generalisations based on the effects of these urban stressors on a single species. Therefore, there is an urgent need for comprehensive studies investigating how urbanisation influences multiple biological functions and systems across different taxonomic groups. To fill these gaps, we have conducted pilot studies investigating how urbanisation influences multiple fitness-related characteristics, such as behaviour, health parameters, metabolic rate, gut microbiota, and gene expression profiles, in the yellow-necked mice (*Apodemus flavicollis*), great tits (*Parus major*), and common wall lizards (*Podarcis muralis*). We will present our preliminary findings on how urbanisation influences these different characteristics. This timely research will further our understanding of the niche choice and conformance in an urbanisation context.

Individual niches through the lens of urbanisation

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The Anthropocene is the era characterised by unprecedented human-induced transformations to global environments. These human-induced rapid environmental changes (HIREC) present wildlife with novel ecological challenges, posing significant threats to biodiversity. Urbanisation is considered the most severe form of HIREC. Nevertheless, organisms differ tremendously in how they respond to urbanisation: while some organisms are severely affected and go locally extinct, others adjust and even thrive in urban habitats. Our project aims to unravel fundamental and timely questions: how do animals adjust to novel niches generated by urbanisation, and why are some individuals better than others in these adjustments? Using urban habitats as natural laboratories, this comprehensive project will explore individual dynamics, including niche construction, choice, and conformance (NC3 mechanisms) in three different taxa: mammals, birds, and lizards. Through physiological, dietary, and health assessments, gut microbiota analysis, and gene expression profiling, we aim to identify common patterns across taxa inhabiting urban environments. This pilot project lays the groundwork for future research exploring urban wildlife dynamics.

How animals respond to urban niches: A comprehensive cross-species investigation

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Understanding the evolutionary mechanisms of individual differences in behaviour and physiology is of crucial importance in ecology and evolution. The “pace-of-life syndrome” hypothesis predicts that behavioural traits are correlated to life-history traits linked to reproduction and survival, under the assumption of genetic trade-offs underpinning those life-history traits. Our meta-analysis on genetic correlations among five key life-history traits showed, contrary to expectations, a positive genetic correlation between survival and other traits, and no evidence for any genetic correlations between the non-survival life-history traits. These results challenge the prevalent assumption of widespread genetic trade-offs between life-history traits, and highlights how such trade-offs might not be as easily quantifiable as expected.

Sexual dichromatism and the impact of climate change on the coloration of fire salamanders in Germany

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The coloration of an animal can serve several functions simultaneously. Recent evidence has highlighted the role of animal coloration in predator avoidance, intraspecific communication (e.g., mate choice) and thermoregulation. Here we study differences in the black-to-yellow-ratio of fire salamanders (*Salamandra salamandra*) comparing males and females from 20 populations in Germany. While the aposematic function of the black-and-yellow-coloration of these salamanders equipped with toxin glands is well understood, the coloration could also play a role in mate attraction as well as thermoregulation with the latter possibly being impacted by climate change. We found strong evidence for sexual dichromatism in this species with males being more yellow than females. Furthermore, fire salamanders from locations that have warmed up more in the past 50 years were significantly more yellow. These results indicate a possible role of fire salamander coloration in mate attraction as well as the role of climate change as an evolutionary driver of color variation highlighting the multi-modality of animal coloration. Future studies should address the role of coloration in mate choice of aposematic species as well as the evolutionary responses of color traits to climate change.

The role of evolving niche choice for herbivore adaptation to host plants

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Birdsong When living in a heterogeneous environment, individuals can choose microenvironments that can provide benefits to their fitness, also known as “niche choice”. Theory predicts that individual choices can promote rapid adaptation in a diverse environment and help maintain genetic diversity. Moreover, individual host plant choice can also be influenced by pleiotropic trade-offs, which can complicate decision-making. In addition, niche choice as a trait can also evolve over time. However, it remains unclear how host plant choice evolves and the extent to which host plant choice evolution contributes to host adaptation and genetic diversity. We develop an eco-evolutionary individual-based model to explore the evolution of host plant choice and adaptation in *phytophagous* insects. We conducted an empirical literature survey on selected insect herbivores and a local-density survival experiment using potato beetles to parametrize the model. In addition to previously explored parameters, our simulations reveal that recombination rate and dominance effects can influence the rate and the limits of the evolution of both host choice and adaptation as well as the maintenance of genetic variation. We found that, in comparison to fixed choice behaviour, the evolution of choice plays a substantial role in regulating the adaptation and facilitates the coexistence of different phenotypes. In addition, species with a higher number of resistance cases have a high rate of host adaptation. Together, this study provides new insights into the evolution of host plant choice and sheds light on the development of pest control strategies in agricultural practices.

Communication and social organization of zebra finches in the wild

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Birdsong is an important model system for animal communication and typically functions in critical life-history events such as mate attraction and territory defense. The zebra finch *Taeniopygia guttata* is the most studied songbird under controlled laboratory conditions. Yet, as males are not territorial, and pairs form long-term monogamous faithful bonds early in life. Conventional theory predicts that zebra finches should not sing much at all, yet they do. Here, I will present recent results on their singing behaviour, movements and social organization, focusing on individually different strategies. These findings on communication and social organization provide novel insights in the social life of birds and specifically the prime laboratory species in avian acoustics, the zebra finch.

Role of niche choice in rapid host adaptation of Colorado potato beetle

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Individuals choose different ecological niches, matching their phenotype, to maximise their fitness. Since niche choice affects individual survival and reproductive success, it can influence many ecological and evolutionary processes. Such choice hence can promote rapid local adaptation and contribute to the maintenance of genetic diversity. Although several studies show that individuals within species indeed choose different microenvironments, the choices often mismatch their phenotypes. Consequently, the questions of how the niche choice evolves and to what extent it contributes to individual adaptation are yet to be addressed. In this project, we seek to tackle these questions with the aid of experimental evolution, metagenomics and gut microbiome analysis using Colorado potato beetles [*Leptinotarsa decemlineata (Coleoptera: Chrysomelidae)*] as study systems. The outcomes will shed light on how phytophagous insects rapidly adapt to different host plants in nature and may facilitate the development of sustainable crop management strategies, a pressing issue in society.

Phenotypic plasticity under urbanisation: A meta-analysis

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Human-induced rapid environmental change (HIREC) is a major concern of the last decades due to the many perturbations it generates in ecosystems. Urbanisation is a widespread and common HIREC which involves disturbances such as fragmentation of habitat, noise pollution or pollutants. A key area of current research is studying how animals cope with these new challenges. Yet, much research performed till now, investigates patterns and changes of individual average responses to face urbanisation. These studies showed that individuals seem to have different ecotypes between rural and urban habitats, but it often remains unclear whether this pattern is due to an adaptive process (e.g., local adaptation) or results from phenotypic plasticity, such as reversible individual flexibility. The aim of this study is to test the hypothesis that individuals of urban populations are more flexible than those of rural populations. Using a meta-analysis approach, we aim to (i) summarise studies that have measured individual variation at the within- and between-individual level under urbanisation for labile traits (behaviour, physiology, life-history), (ii) quantify the proportion of within- and between-individual variation and (iii) test whether the degree of urbanization explains differences for each partition of individual variation. We expect that urban individuals express higher levels of phenotypic plasticity across all types of labile traits although the clearer differences should be present in behavioural traits since they are the most flexible. Specifically, we test three predictions (i) within individual variation (i.e. reversible flexibility) is higher in urban compared to rural populations. (ii) between-individual variation (i.e. indicating individual specialisation) is lower in urban compared to rural populations and, therefore, (iii) urban populations have lower traits expression consistency (i.e. lower repeatability) than rural populations. We hope that our study will help to clarify the mechanisms driving adjustment to urbanization and particularly by revealing how individual variation in the form of reversible plasticity or increased generalisation play a role to mitigate the effects of urbanisation.

The effect of DNA methylation on behaviour patterns in *Pogonomyrmex californicus* founding queens

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Eusocial insects organize themselves into behavioural castes and social context whose regulation has been proposed to involve epigenetic processes, including histone modification and DNA methylation. Chemically altered DNA methylation levels have shown clear changes in the dominance and reproductive behaviour in some species of bees and ants. Here, we investigated the effect of the methylation altering agent decitabine on the behaviour patterns in *Pogonomyrmex californicus* haplometrotic queens at the colony founding stage. We expect that variation in aggressive behaviour correlates with the state of methylation of the genes that have been found involved in aggressive behaviour. Our results showed that behaviour patterns differ between treated and control queens, as treated queens tended to be less aggressive and less active than control queens. Our DNA methylation preliminary results showed there are fewer methylated loci in the control group. Loci that were methylated differentially between groups participated in pathways including housekeeping functions, histone modification and metabolic processes. We expected to have all the DNA methylation data analyse by the time of the NC3 conference.

Hidden potential unveiled: HSP90-buffered reduced eye phenotype alters niche interactions and enhances fitness under light stress in *Tribolium castaneum*

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Evolutionary capacitance is a process allowing populations to 'store' cryptic genetic variation. Under stressful environmental conditions, the 'release' of such variation may produce phenotypic variants. It can thus be considered a potentially important process for the interaction of individuals with their niches and may ultimately allow for enhanced adaptability. Heat Shock Protein 90 (HSP90), is a molecular chaperone known to mediate this process. In the red flour beetle, *Tribolium castaneum*, the reduction of HSP90 led to the release of a new 'reduced eye' phenotype and its subsequent assimilation. These beetles have much smaller eyes and less defined ommatidia.

Here we investigated behavioural changes and potential fitness consequences of the reduced eye phenotype. To address temporal niches, we focussed on potential differences between wildtype and reduced eye beetles in their daily activity patterns. Males of the reduced eye phenotype reacted with diminished startle response to the onset of light. Additionally, choice assays revealed a decrease in negative phototaxis among groups of beetles with reduced eyes. Such altered behavioural response to light might be beneficial for beetles to escape a potentially harmful environment. Finally, in light stress condition, the reduced eye phenotype produced a significantly higher number of offspring than normal eye beetles and the penetrance of this phenotype was increased in such an environment.

Our study thus provides empirical evidence that an HSP90-mediated phenotype can alter niche choice behaviour by changing light taxis of the beetles as well as niche conformance when beetles are confronted with a bright environment. This study supports the hypothesis that HSP90-mediated evolutionary capacitance can enhance evolutionary adaptation by facilitating the expression of advantageous phenotypes under environmental stress.

Exploring optimism: temporal consistency of cognitive judgement bias in rats and its link to other individual characteristics

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Animals that are confronted with ambiguous situations tend to show highly different responses: while some individuals interpret an ambiguous situation optimistically, others tend to make more pessimistic decisions. This phenomenon is known as cognitive judgement bias and has its origin in animal welfare science, where tests concerning decision-making under ambiguity are used to get information about the affective state of an animal. However, evidence is growing that the cognitive judgement bias of an individual shows temporal consistency and is moreover linked to other individual characteristics. In the presented study the aim is to investigate temporal consistency of cognitive judgement bias in rats and to reveal potential links to other individual characteristics. Therefore, rats are repeatedly tested in multiple characterisation phases for their decision-making under ambiguity, their anxiety like behaviour, their laterality and their playfulness. Besides behavioural measurements, the study furthermore extends its focus towards physiological parameters by examining basal corticosterone levels. Based on previous literature, we hypothesise optimistic and pessimistic decision-making to be stable across time and to be linked to some individual characteristics, while being independent of others.

Modelling the evolution of individual variation in a competitive trait

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When competitive traits are costly, negative frequency-dependence can maintain genetic variance. Most theoretical studies examining this problem assume binary polymorphisms, yet most trait variation in wild populations is continuous. We propose that continuous trait variation can result from continuous variation in resource quality and that, specifically, the shape of the resource distribution determines trait maintenance. We used an individualbased model to test which conditions favour the stable maintenance of variation and which cause temporal fluctuations in trait values. This approach, inspired by contrasting outcomes of previous studies regarding variance and fluctuations in trait values, clearly showed a decisive role played by the shape of resource distributions. Under extreme conditions, e.g. the absence of resource variation or with very scarce resources for weak competitors, traits evolved to a single non-competitive or highly competitive strategy, respectively. Most other distributions led to strong temporal fluctuations of trait values or the maintenance of stable standing variation. Our results thus explain the contradicting outcomes of previous theoretical studies and at the same time provide hypotheses to explain the maintenance of genetic variation and individual differences.

Metabolic Adaptation to Nutrient Limitation in Vertebrates

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Adaptation to food deprivation is widespread among animal species, reflecting the intimate connection between genotype, phenotype, and the environment. However, the genetic basis of physiological adaptations to nutrient availability remains an unresolved challenge of both organismal biology and modern evolutionary genetics. We are using the cavefish *Astyanax mexicanus* as a promising research organism to unravel the genetic basis of starvation resistance. *A. mexicanus* exists in two forms: a river-dwelling surface fish and a blind, depigmented cavefish. Whereas the surface forms live in a rich ecological environment, multiple distinct cave populations have evolved metabolic adaptations to nutrient limitations in caves. Importantly, the surface and cave morphs remain interfertile and can be bred in the laboratory. Using recently developed genetic and genomic tools, we have shown that cavefish evolved a massive capacity for fat storage due to increased appetite, adipogenesis, and lipogenesis. In addition, we found that cavefish display elevated blood sugar levels and insulin resistance caused by a mutation in their insulin receptor. Unlike humans with the same mutation, cavefish do not display diabetes markers and live long and healthy lives. Furthermore, cavefish develop hypertrophic visceral adipocytes without obvious signs of inflammation due to reduced amounts of pro-inflammatory cytokines. In a more recent series of studies, we showed that cavefish are thriftier due to decreased muscle mass, improved glycogen production, and efficient recycling of amino acids. As all these extreme adaptations have no negative consequences on the metabolic health, immune response, and lifespan in these fish, it suggests that cavefish develop these phenotypes as part of their starvation resistance and have evolved resilience phenotypes that allow them to tolerate deviations from normal vertebrate physiology. This positions cavefish as a promising model to gain mechanistic insights into disease phenotypes from an evolutionary and adaptive perspective.

Intra-annual timing of reproduction alters individualized niches in seasonally breeding macaques

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Seasonal reproduction is thought of as an adaptation to predictably changing environmental conditions and resources. In mammals where the females carry the burden of gestation and lactation, individual decisions about how to time reproduction within a given breeding season affects a) the environment experienced by the mother during different energy demanding reproductive phases with consequences for future reproduction and b) the conditions experienced by the developing offspring during early sensitive periods. Using long-term data on a population of wild macaques in the North of Thailand, we show how timing of single and consecutive reproductive events can affect offspring survival, development, physiology, and behavior yielding pronounced and lasting phenotypic variation among the offspring and therefore affect the fitness of the same mother through time and different mothers sharing the same fundamental niche.

The influence of fire salamander larvae on benthic organisms: evidence of habitat specific differences

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Salamander larvae can impose a great impact on benthic organisms as they are keystone predators in different kind of aquatic habitats. Gut analysis revealed that their diet consists of invertebrates from the water column and benthic taxa. The impact on endobenthic organisms, especially the meiofauna, is, however, not well understood yet, as these organisms are digested very quickly and can thus not be detected reliably. To avoid this, we investigated the impact of fire salamander larvae from two habitat types, ponds and streams, on meiofauna by analysing consumed prey items from a microcosm. We collected 20 larvae from both, ponds and streams from the wild and transferred them to the lab. We placed each larva individually into a microcosm with sediment and benthic organisms. We also added control samples without larvae. We kept the larvae either for one week or two weeks and counted the number of nematodes, oligochates and rotifers after we removed the larvae.

Nematodes were influenced by pond larvae during the first week and larvae of both habitat types influenced the number of nematodes after two weeks. Oligochates were mainly influenced by stream larvae, but not by pond larvae, independent of the duration of the experiment. Rotifers were influenced by larvae from both habitats, but only during the first week and not during the second week. Our findings suggest that fire salamander larvae are able to reduce the meiofauna through predation. Furthermore, fire salamander larvae show habitat specific differences indicating an adaptation towards the different environmental conditions in the habitat of origin.

Experimental evolution of bacterial resistance is facilitated by niche construction: effects on microbiomes and antimicrobial secretions in red flour beetles

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Niche construction is a critical eco-evolutionary process by which organisms can modify their environment to enhance their adaptation to changing conditions. This process is especially relevant in group-living animals, as it aids in their defense against and adaptation to shared parasites. Despite its theoretical importance, empirical evidence remains scarce. Our ongoing evolution experiment with red flour beetles and their natural microparasite, *Bacillus thuringiensis tenebrionis* (*Btt*), uses RNAi to manipulate beetles to create differentially constructed niches (with and without stink gland secretions). Previous findings indicate that niches with secretions facilitate the evolution of pathogen resistance and influence transcriptomic responses, developmental programs, and early life fecundity. In this study, we analyzed changes in the microbiome via 16s RNA sequencing after 12 and 15 generations of selection. Additionally, we examined genetic changes in quinone secretion profiles using GC/FID after 18 generations. These results provide empirical evidence of the role of niche construction in facilitating evolutionary adaptation, and thereby highlight its significance in eco-evolutionary theory.

Facing environmental change: A tradeoff between individual foraging strategies in Galapagos sea lions

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Individual foraging behavior is of great ecological interest, as the diversification of foraging strategies can affect a population's ability to cope with a changing environment. However, adaptive values, resulting fitness differences, and ecological consequences often remain speculative. In this study, we explore three distinct foraging strategies in a population of Galapagos sea lions: benthic, pelagic, and night foraging. By calculating the horizontal body orientation (pitch) of 34 individuals during foraging episodes within dives, identified using a broken stick algorithm and subsequent vertical sinuosity measurement, we describe the strategy of benthic divers to prey on fish buried in sand by digging them out. We could demonstrate that this foraging behavior results in significant shorter vibrissae of benthic divers due to abrasion, allowing us to visually distinguish benthic divers from the other strategies. Using this information, we compared the reproductive success of benthic and nonbenthic divers, as identified through pictures of their vibrissae, in response to different sea surface temperatures over the last 16 years. Benthic divers demonstrated a stability of pupping rate and offspring's body condition independent of SST, while the reproductive success of non-benthic divers was higher during low SST but greatly declining with warming oceans. Modelling population growth while incorporating this tradeoff between foraging strategies demonstrates that the potential buffer effect toward rising temperatures is not sufficient to stop the decrease in population size of this endangered pinniped.

Fear generalization

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Numerous studies have quantified consistent individual differences (CIDs) in boldness/fearfulness. The majority of this work has focused on CIDs in response to predation risk. Animals, however, commonly face numerous other important threats, e.g., parasites/pathogens, moving vehicles, chemical stressors, and fire. Some studies have quantified the basic fact that animals often 'fear' these threats, but surprisingly little work has addressed CIDs in their response to these other threats and very few studies have tested for correlated fears; e.g., whether individuals that are more fearful (than others) of predators are also more fearful of pathogens, or moving vehicles etc. Following the human literature on fear or anxiety, we term correlated fears - 'fear generalization'. Fear generalization potentially has important ecological and evolutionary implications. For example, if individuals in a high predation regime have evolved a generally fearful personality, they could be pre-disposed to fear fire even if they have never experienced fire. With regard to correlated plasticity in fear, a fascinating possibility is that individuals that have a salient experience with one threat (e.g., predators) become generally fearful of other threats. This would be the animal analog of PTSD. Or, if individuals become habituated to humans, do they become less fearful of actual predators? My lab group recently reviewed extant literature on these topics, much of it from the study of humans, and discussed some ecological implications (Sih et al. 2023 TREE 38:369-380). Here, I: 1) update this review; 2) present new results from lab studies on correlated fears with respect to cues associated with predation risk, fire and pesticides in two invertebrates: one terrestrial, one aquatic; 3) outline proposed experiments studying correlated fears in a human-disturbed mammalian field system; and 4) discuss a framework for predicting whether fears should be correlated or not.

Niche realisation processes in insects: effects of global change and the importance of individual variation

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Insects are a highly diverse and ecologically important group, but predicting their responses to global change remains challenging. Our review explores the key processes involved in insect niche realization, such as niche choice, niche conformance, and niche construction, and their interplay. We demonstrate the influence of these processes on ecological interactions and fitness outcomes across various insect species. Specifically, we show how insects display different degrees of niche specialization and flexibility in response to environmental cues, highlighting the dynamic nature of niche realization. Additionally, we investigate the effects of global change on insect niche realization, providing examples of niche choice, conformance, and construction under anthropogenic land use changes, temperature variations, and altered precipitation patterns. Our study emphasizes the importance of considering intraspecific variation in niche realization, as individuals differ in their responses and these differences may affect species persistence. We discuss the limitations of traditional species-level niche assessments and advocate for incorporating individual-level niche analyses to accurately evaluate species' responses to global change. By integrating insights from various insect taxa, we offer a framework to elucidate the strategies insects use to adapt to global change. This review enhances our understanding of niche realization diversity, which can inform targeted conservation strategies to protect insect biodiversity amid ongoing global change.

Temporal development and stability of foraging strategies in Galapagos sea lions (*Zalophus wollebaeki*)

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Understanding the mechanisms involved in the individualization of foraging behaviour is becoming increasingly relevant, as these individualized strategies can be differently adapted to contrasting conditions and can influence the coping ability of entire populations towards environmental change. Inhabiting the highly variable equatorial Pacific Ocean, Galapagos sea lions (GSL) (*Zalophus wollebaeki*) are confronted with such contrasting conditions, especially increasingly strong interannual fluctuations in sea surface temperature and prey availability due to El Niño and La Niña events. Previous studies have established distinct foraging niches, assumed to remain stable over multiple years, using biologging devices and demonstrated environment-dependent fitness consequences for individuals conforming to different foraging strategies. In this study, we aim to dive deeper into the foraging behaviour and investigate the temporal development and stability of these strategies by re-deploying biologging devices after multiple years on animals that were previously monitored. Through this, we want to investigate individual variation as well as potential adaptations to fluctuating environmental conditions within an individual's respective foraging strategy. While we are expecting a long-term stability of foraging niches even under contrasting climatic scenarios, we might potentially see variation in foraging behaviour within those niches in order to mitigate potential negative climatic effects. By expanding our knowledge on the temporal development of foraging niche polymorphisms, we aim to better understand how niche conformance is affected by environmental conditions.

The emergence of division of labour through the ontogeny of helping niches

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The concept of social niche specialisation suggests that individuals show consistent differences in their social behaviour and in their ability to choose a particular social role. Social niche diversification originates from intra-specific conflict over resources, which selects for character displacement. In analogy to the concept of the ecological niche, social niches are thought to diverge and narrow when there is competition between interacting conspecifics, thereby reducing conflict. In cooperative societies the adoption of a social niche may not always be primarily a consequence of competition. Instead, choosing a social niche may be a response to society demands for particular tasks to be fulfilled. Here I postulate that influences on specialisation can set in long before adulthood, and that already early-life ontogenetic experiences can be the origin of task specialisation and DoL in animal societies. I hypothesize that the demand for certain tasks creates 'helping niches' in cooperative societies, which are a special case of a social niche. These niches are chosen already during early ontogenetic stages in dependence of which tasks other group members are performing. Thus, I propose that early life experiences collected in the larval or juvenile stages can give rise to specialisation in filling particular helping niches when adult. I will present examples of how worker control, non-genetic maternal effects, and own early or stage-specific environmental experiences can induce task specialisation in species exhibiting DoL.

Individualising Variation: Distinguishing Sex Traits and Individual Differences in Biological Practice

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Sex is often thought of as a straightforwardly binary categorical variable. Yet there is considerable variation in would-be sex traits; from genitals and hormones to morphology, neurology and behaviour, there is rarely if ever a categorical binary. We introduce a strategy that researchers use to deal with this variation: Individualising Variation (IV). IV involves treating non-binary and gradual variation as idiosyncratic, as individual differences rather than sex-based differences. Using the contrasting cases of sex identification in field ornithology and the debate about sex differences in neuroscience, we illustrate IV and investigate its epistemic and conceptual consequences. We argue that IV stabilises the ontological picture of sex as categorical and binary. While IV can be an epistemically benign research strategy in some cases, we argue that it can also be epistemically detrimental. This is because of its ability to mask evidence that would otherwise challenge related assumptions about the phenomenon of interest, such as what sexes are and what they look like. We also identify an alternative strategy, De-individualising Variation, which works against IV and helps life scientists recognise variation beyond categorical binaries.

Individual Based Research – A new scien4fic practice?

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In ecology, behavioral biology, and evolutionary biology a common scientific practice is to do research on a group-, a population-, and even on a species-level. However, a new trend seems to be taking root as scientists are becoming more and more interested in the individual differences and how these influence the groups, populations, and species (1; 2; 3) We found that IBR has at least three main characteristics: identifiability, multiple measurements, and individual-based analysis. All individuals should be identifiable. This can be done by spatial separation (placing individual fruit flies into test boxes), phenotypic traits (individual markings of fire salamanders), tagging (ringing birds), or tracking (GPS trackers on sea lion, e.g.: Schwarz et al., n.d.). Multiple measurements means that there has to be more than one piece of information. This can be done with an ongoing test that takes place over a longer period of time, tests that are repeated in a certain interval, or measurements of multiple traits without repetition. Lastly, the analysis of the data should be individual based. While the data can be grouped to calculate averages or variation within the groups, it is also analyzed in a way that allows a clear depic4on of the individual. This makes the final results traceable and individually distinguishable. This list of features is not exhaustive further analysis of IBR is taking place with the focus being on the epistemic consequences of conducing IBR.

[1] Bouchard an Huneman, 2013
[2] Trappes, 2021
[3] Uriarte and Menge, 2018

How do individualized landscapes of fear alter biodiversity at the resource level?

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Perceived predation risk varies in time and space, creating landscapes of fear that affect multiple trophic levels, including prey foraging decisions. Traditionally, these dynamics have been conceptualized and studied as species-specific “layers”. However, individual differences in personality traits are likely to influence how animals perceive predation risk. This among-individual variation in perceived risk ought to ultimately affect resource use and hence individualized niches. This study will test the ecological consequences of individualisation in predator-prey interactions by assessing whether individualized landscapes of fear have cascading effects on biodiversity at the resource level. Perceived predation risk will be quantified using giving-up densities (GUDs), i.e. the food density at which a forager abandons a patch, and biodiversity effects as diversity at GUD (DivGUD). We hypothesize that among-individual differences in risk-taking behaviour and personality will impact both biodiversity and the functional trait distribution of resource communities across local and regional spatial scales. We plan to test 30 individual wild-caught male bank voles (*Myodes glareolus*) in large near-natural grassland outdoor enclosures. We will conduct repeated behavioural phenotyping (activity, boldness, exploration), manipulation of perceived risk via vegetation cover, and GUD-based assessments of risk-taking using two sets of resource communities. By examining the indirect top-down effects of predation we seek to gain insights into how inter-individual differences among foragers influence feeding niche complementarity and its consequences for resource biodiversity.

Movement in novel environments, the consistency of exploration behaviour and its relevance to the wild

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Exploration is a key behaviour for most animals, as they require information about their environment, its resources, enemies and conspecifics, to make adaptive decisions. It is one of the most widely studied behaviours in animal personality research, often used in biomedical behavioural assays, a pre-requisite for niche altering mechanisms, and an essential part of cognitive problem-solving. Despite being a central component of animal behaviour, we lack a universal definition and it is unclear whether proxies, such as movement in a novel environment, actually translate to sampling of information, and to what extent. This might impede our understanding of how individual variation in exploration affects ecologically important processes. Combining lab experiments with behaviour in a near-natural environment, we aimed to test cross-context consistency of exploration and its relevance for space use, movement, and dispersal in bank voles (*Myodes glareolus*). Measures of movement within a novel environment were repeatedly assessed in a standard open field, a specifically designed maze, and large near-natural outdoor enclosures. To investigate whether information drives exploration, we introduced a source of low-novelty information into the maze. Though lab-tested exploration predicts movement in the wild, information gathering might not be its main driver, but rather escape or dispersal propensity.

Inbreeding effect on niche choice and conformance in the Antarctic fur seal

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The ecological and evolutionary consequences of individualization are still poorly understood in wild populations where genetic and environmental factors often interact to produce complex fitness landscapes. Arguably, one of the most important genetic effect in wild populations is inbreeding depression. While it is known that in vertebrates inbreeding correlates negatively with a various fitness components, it remains unclear whether it influences niche choice and niche conformance, as little is known about the relationship between inbreeding and phenotypic plasticity. The Antarctic fur seal (*Arctocephalus gazella*) represents a great candidate to investigate this topic, as high individual variation is present in their reproductive behavior and remarkable variation in inbreeding is expected among individuals, due to the peculiar demographic history of the species. Moreover, the Antarctic fur seal colony breeding on Bird Island (South Georgia) has been closely monitored since 1978, which resulted in an exceptionally detailed long-term dataset that thus provides an ideal opportunity to study how inbreeding constrains niche choice and conformance. To do so, we genotyped more than 3,000 individuals, for which detailed life history data were also available, at 85,000 SNPs using a SNP array and subject a subset of 77 individuals to Whole Genome sequencing (WGS). This data was then used to precisely quantify inbreeding as the proportion of the genome in Runs of Homozygosity (ROH), using the WGS data as a baseline for parameter calibration for ROH calling from the SNP array data. This revealed, as expected, appreciable variation in inbreeding among individuals. Furthermore, the characterization of ROHs length distribution allowed us to time past and contemporary inbreeding events, which we connected to the known demographic history of this species. Finally, the quantification of genome-wide levels of inbreeding for over 3,000 samples allowed us to evaluate its effect on individual variation in reproductive performance and reproductive scheduling.

Effect of NC3 and ITV in competition interaction

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Intraspecific trait variation (ITV) is increasingly being recognized in recent years to be of importance for ecological dynamics. In the context of competitive interactions, the role ITV plays in co-existence is well documented. NC3 mechanisms, by which an individual interacts with its environment, could play a role in addition to ITV in the species competition outcome. In this case, the trait of the individual with whom the focal individual is interacting with will serve as the environment for the focal individual. We specifically modelled a case of competitive interaction between two species with ITV in both species. The individual of each species was assumed to adjust its trait reciprocally to their interacting partner individual of the other species. The reciprocal phenotypic adjustment happens at an ecological time scale and could be viewed as niche mechanisms (conformance and construction in this case depending on who the focal individual is) happening simultaneously. The effect of this individual-level interaction was incorporated to the population dynamics through the competition coefficients, accounting for the effects of nonlinear averaging. We find the niche mechanisms to increase the niche difference between species, reducing the competition coefficient and thus promoting coexistence. The effect of individuality should thus not be limited to consideration of ITV alone, but must be extended to considering both ITV and niche mechanisms in the interacting species.

The evolutionary ecology of movement behaviour

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Movement is an important aspect of the individualisation of animals. On the one hand, movement is a driver of individualisation. Even if movement is random, it will direct different individuals to different types of environment, with different needs and challenges. The diverse adaptations required will often result in an individual-specific package of physiological and behavioural response patterns. This outcome is enhanced if movement is not random and if individuals differ in their movement tendencies and, hence, the environments they have to cope with. On the other hand, individualisation in aspects unrelated to movement is a driver of individual variation in movement tendencies. 'Bold' and 'shy' individuals will move around differently in a novel environment; 'social' and 'asocial' individuals will seek different types of social environment; and 'proactive' and 'reactive' will take on different roles in group movement. Taken together, movement is an important (but underappreciated) aspect of 'animal personalities' (or 'behavioural syndromes'). In my talk, I will review some model studies that illustrate the eco-evolutionary implications of individual differences in movement strategies. I will demonstrate that the evolution of movement strategies can be surprisingly fast, allowing rapid adaptation to novel conditions, such as the rapid evolution of 'social distancing' after the advent of a novel disease. This is of ecological relevance, as the interplay of ecology and evolution can induce quite unexpected eco-evolutionary dynamics if the speed of evolution is similar to that of ecological processes. The focus of my talk will be on theory, but if time allows, I will also report on a mesocosm experiment where the movement of sticklebacks in a population was individually followed over a whole breeding season, illustrating the integration of movement and other behaviours and the implications of individual differences on the breeding pattern of a seminatural population.

Imprint

Abstract Book - A Novel Synthesis of Individualisation across Behaviour, Ecology and Evolution (September 3rd – 5th 2024 in Münster)

Host: Collaborative Research Center TRR 212 (NC³)

Editors: Antje Herde, Dhevi Kalyanaraman & Pia Klatte

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