# Satellite Symposium
# **Section Morphology**

DZG 2024
116th Annual Meeting of the German Zoological Society
University of Hohenheim, Natural History Museum Stuttgart

Abstract Book

# **Predator-Prey Interactions:**

## From behavioural tactics to morphological adaptations


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# Predator-Prey Interactions

## From behavioural tactics to morphological adaptations

Predation is an important interaction in nature. While predators strive to spatially overlap with prey, prey do their best to avoid predators. Predators are equipped with specific morphologies, like teeth and claws, to hunt efficiently and use a variety of hunting tactics, like ambushing prey. Prey, in contrast, avoid predation by different means, like camouflage, or producing toxic materials, or protect themselves using adjusted morphology (like spines). The symposium will focus on invertebrates, and will be open to all aspects of predator-prey interactions, predator tactics to hunt prey, and prey tactics to avoid predation. We will focus on behavioural and morphological adaptations, with an emphasis on predator specialisation and prey defence mechanisms against predators.

Satellite Symposium of the DZG Section Morphology
organised by Sebastian Büsse & Inon Scharf

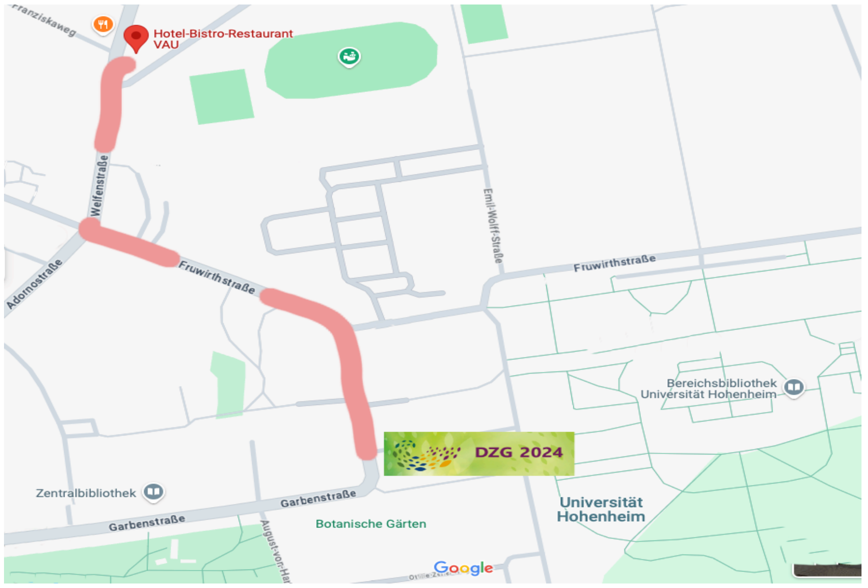
# Organisational Remarks

We, the organisers, are very grateful for the financial support of the German Zoological Society (DZG), the Company of Biologists and the American Society of Naturalists (ASN). Due to the generous funding of the ASN, we are able to refund **all** students and ASN members the symposiums fee (20€), please contact us for more information.

Furthermore, we are pleased to invite all symposium participants to join us to a social dinner (self-paying) at the Restaurant VAU (Welfenstr. 75, Stuttgart) at 8pm (20:00h).

We look forward to welcoming you to our satellite symposium in Hohenheim,

Inon & Sebastian



# Time Table

**Monday, 9.9.2024**

08:30-09:30: Welcome desk “check-in”

09:30-09:40: Opening remarks

(Lecture Hall HS B2 in the Bio-Building, University of Hohenheim)

09:40-10:40: **Plenary 1: Ralph Tollrian**

Morphological inducible defences in Daphnia

10:40-10:50 Short break

10:50-11:50: **Plenary 2: Carita Lindstedt-Kareksela**

Group living and joint antipredator defence

11:50-12:00 Short break

12:00-12:20: Inon Scharf (Rescue behavior in desert ants)

12:20-12:40: Martin Horstmann (Inducible defences in Daphnia predator-prey interaction)

12:40-13:50: Lunch break

13:50-14:50: **Plenary 3: Stano Pekar**

The secret life of prey-specialized spiders

14:50-15:00: Short break

15:00-16:00 **Plenary 4: Phil Braden**

Predation: morphological innovation & extinction in ants

16:00-16:30: Coffee break

16:30-16:50: Denis Meuthen (Antipredator plasticity in a freshwater snail)

16:50-17:10: Christine Kiesmüller (Anti-predator strategies of 100 million-year-old insects)

17:10-17:30: Benedict Stocker (Functional mouthpart morphology in rove beetles)

17:30-18:00: **Open discussion**

Morphology Today as a Symbol of Organismal Biology

20:00: Social dinner (**Restaurant VAU**, Welfenstr. 75, Hohenheim, Stuttgart)

# Abstracts

## Plenary Talks

# Maintenance of group living and cooperation in antipredator defence: what have we learned from gregarious chemically defended pine sawflies so far?

**Carita Lindstedt-Kareksela**

Department of Forest Science, University of Helsinki, Helsinki, Finland

Group members can benefit from the dilution of predation risk, predator confusion and/or cooperative joint effort in antipredator defence such as deterring the predator with defensive secretions. Many of these cooperative defence strategies are based on public goods, i.e. individually costly acts that benefits all the group members. However, public goods are susceptible to exploitation. In my research group, we use semisocial, haplodiploid and chemically defended pine sawflies (*Neodiprion sertifer* and *Diprion pini*) as a model system to study cost: benefit ratio of group living and cooperation in chemical defence. In my talk, I will present experimental studies that provide information of 1) how predation selects group living and contribution to collective chemical defence, 2) how costs of cooperative defence vary under different ecological conditions and 3) how individuals modulate their contribution to group defence under different social and ecological conditions. These experimental results are then compared to patterns observed in natural populations.

# Morphological inducible defences in Daphnia: from molecules to ecosystems

**Ralph Tollrian**

Department of Animal Ecology, Evolution and Biodiversity, Ruhr-University Bochum, Bochum, Germany.

The fascinating ability of organisms to estimate their predation risk, based on chemical cues released by predators, and to form adequate defences against these predators only when the defences are needed, has been reported from unicellular organisms to vertebrates. While protecting the individual, inducible defences bear the potential of influencing population dynamics and food webs. E.g., inducible defences have been found to dampen predator-prey oscillations and to facilitate successful invasions.

Especially the planktonic crustacean Daphnia has been found to respond with inducible defences to a range of their predators (including fish or invertebrates but even carnivorous macrophytes). These defences include morphological, physiological, and behavioural traits. They may be specific to single predators or act as a multi-tool against different predators.

Focusing on morphological defences I will review the system and report results from the inducing chemicals cues to effects on communities. We found transgenerational inductions and an amazing ability to integrate predator and conspecific densities into predation risk estimation and dependent defence formation.

## The secret life of prey-specialized spiders

**Stano Pekar**

Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czechia

Predators appear to be less frequently specialised on their prey than herbivores, parasites or parasitoids. I will present a unifying concept of four types of trophic categories in predators using ecological and evolutionary contexts. I will overview levels of prey specialization found in spiders and then I will focus on trophic adaptations of prey-specialized spiders. I will review the available evidence for psychological, behavioural, morphological, venomic, and metabolic adaptations. Psychological adaptations include specific attention to signals produced by ant-eating spiders. Morphological adaptations are apparent on modified chelicera of woodlice-eating spiders. Behavioural adaptations were known in moth-eating bolas spiders. Metabolic adaptations are known from spider-eating spiders. And venomic adaptations are apparent in ant- and termite-eating spiders. Tracking of prey-specialisation on family-level phylogenies revealed that spider-eating is ancestral and while other specialisations as derived. Finally, I will propose avenues for future research.

## Predation fuels morphological innovation and extinction risk in ants

**Phil Barden**

Department of Biological Sciences, New Jersey Institute of Technology, Newark, New Jersey, USA

Division of Invertebrate Zoology, American Museum of Natural History, New York, New York, USA

Predation conspicuously shapes ant lineages. The obligate consumption of arthropods, and, occasionally, vertebrates, has driven phenotypic evolution in the fullest sense, modifying not only individual-level morphology and behavior but group-level traits such as colony size and division of labor. Examples range from the highly coordinated raiding of millions of nomadic army ant workers to solitary sit-and wait trap-jaw ants. Even as extant ants are highly diverse, the fossil record has recently revealed ancient predators that lay outside of the bounds of modern diversity. Cretaceous hell ants exhibit morphological traits not seen among any of the 14,000 living ant species: elongated scythe-like mandibles and horns that erupt from head capsules. Comparative analyses of extant and fossil taxa provide a clear pathway for the evolution of this aberrant morphological syndrome. I will detail the current state of evidence, which suggests that hell ant morphology is a product of unique morphological integration that was achieved through a specialized mode of solitary predation. Results demonstrate the powerful selective force of predation. At the same time, investigations across animal lineages suggest that predators may be uniquely susceptible to predation. I will also review select examples of total and local extinction in ant predators across the last 100 million years. Taken together, this talk will highlight the dual nature of predation as both a promotor of new morphology and risky life history over deep time.

# Abstracts
Participant Talks

## Different anti-predator strategies of insects in 100 million year old Myanmar amber

**Christine Kiesmüller**[1], Carolin Haug[2,3], Joachim T. Haug[2,3] & Marie K. Hörnig[4,5]

1 University of Warsaw, Faculty of Biology, Institute of Evolutionary Biology, PARADIVE Research Group, Warszawa, Poland

2 Ludwig-Maximilians-Universität München (LMU Munich), Biocenter, Munich, Germany

3 GeoBio-Center at LMU, München, Germany

4 University Medical Center Rostock, Medical Biology and Electron Microscopy Center, Rostock, Germany

5 University of Greifswald, Zoological Institute and Museum, Cytology and Evolutionary Biology, Greifswald, Germany

There is a multitude of animals that predate on insects, such as insectivorous specialists or generalists. Consequently, insects also have a multitude of ecological strategies to fend off potential predation attempts. These anti-predator strategies can be grouped as active and passive defence and strategies for detection and/or recognition avoidance. Active defence comprises defensive strategies associated with particular behavioural patterns, such as group defence or evasion. Group defence is often exhibited by immatures, where several individuals aggregate, occupy a defensive posture and thus protect themselves. Evasion tactics can be e.g. achieved by escaping through jumping, the most prominent example of which is probably found within representatives of Orthoptera (grasshoppers, crickets, katydids and alike).
Passive defensive strategies are usually associated with morphological structures that aid the insect in defending itself. There are e.g. many insect larvae (especially within representatives of Lepidoptera, Hymenoptera and Coleoptera) with defensive structures like hairs, setae or spines that make them more unappealing to potential predators and deter predation attempts. These hairs may also entangle non-vertebrate, especially insect predators, and endanger the predators, such as is the case in skin beetles (Dermestidae). Other passive defensive strategies are e.g. protective cases or mimicry.

Strategies in detection and/or recognition avoidance are e.g. camouflaging or strategies where the insects live inside a specific type of substrate, that reduce their risk of being predated on (among other effects). Camouflaging strategies are e.g. debris-carrying behaviour wherein the debris helps the insect to blend into its background and not be detected or recognized by potential predators. Living inside substrates can be e.g. living inside leaves (some leaf-mining caterpillars) or also include cases of parasitism (many wasps, some beetles, and mantis lacewings).

Here we will present different cases of anti-predator strategies of insects in Cretaceous Myanmar amber (about 100 million years old) and discuss implications of these cases to the evolution of anti-predator strategies in deep time.

# Effects of inducible defences and environmental factors in *Daphnia* predator-prey interaction

**Martin Horstmann**[1], Eva M. Schulenberg[1], Melina Grey[1], Lotte Prünte[1], Yigit Soydan[1], Sarah Becker[1], Linda C. Weiss[1], Ralph Tollrian[1]

1 Department of Animal Ecology, Evolution and Biodiversity, Ruhr-University Bochum, Bochum, Germany

The freshwater crustacean Daphnia is well-known to adapt to changing predator environments by forming phenotypic plasticity, especially inducible morphological defences. While these defensive behavioural and morphological traits have already been described in many species, the actual mode of action reducing the predation rate is unknown in almost all of them. This is e.g., the case in D. longicephala, an Australian species known to form an exuberant head morphology protruding the back of its head to a crest-like structure in the presence of the backswimmer Notonecta, which has puncturing mouthparts. Using morphological measurements of the crest and the second antennae, we e.g., found that the so-called antenna parachute, crucial for locomotion, is increased in Notonecta presence. In behavioural studies we furthermore detected that the crest appears to alter swimming parameters, potentially reducing the perceptibility of D. longicephala to Notonecta. With the recorded predation trials under different light and acoustic noise settings, we also determined the role of the crest in direct predator contact by investigating the puncture sites, revealing a so far undescribed defensive feature of the crest. In our experiments, Notonecta appeared to be mainly visually guided, but can also hunt successfully in absolute darkness. Therefore, we also used particle image velocimetry (PIV) to visualize and compare the flow fields around defended and undefended D. longicephala to understand the cues Notonecta relies on in darkness. With additional computational fluid dynamics we could furthermore determine the hydrodynamic costs of swimming defended. Based on these results we get deeper insights into the morphological defences and environmental factors influencing the predator-prey interaction between D. longicephala and Notonecta.

# A multidimensional approach to antipredator plasticity in a freshwater snail

**Denis Meuthen**[1], Nhamo Mutingwende[1], Dominik Periša[1]

1 Evolutionary Biology, Bielefeld University, Bielefeld, Germany

Phenotypic plasticity, which allows individuals to adjust their phenotype in order to optimally respond to their environment, is a highly relevant topic especially for adaptation and nature conservation. One of the most convincing examples of adaptive phenotypic plasticity is the induction of antipredator defenses in prey animals. Prey organisms respond to the perceived presence of predators with plastic changes in their behavior, morphology and life-history. Unfortunately, these defenses are often only measured in single traits, which neglects the multidimensional nature of adaptive plasticity. To address this issue, we designed a comprehensive, multidimensional approach to investigate inducible defenses in the freshwater snail *Physella acuta*, a classic model system for studying antipredator responses. Applying a split-clutch design, we continuously exposed full-sib *P. acuta* from hatching onwards to either conspecific alarm cues, an innately recognized reliable signal of high predation risk, or a low-risk water control treatment. First, we report how different behavioral, morphological and life-history traits are plastically adjusted in response to high risk. Afterwards, we show how the expression of these defenses is related to each other within individuals and across full siblings. We might also be able to report first results from our attempts to profile the chemical components of the *P. acuta* alarm cue as well as from our attempts to determine the epigenetic mechanisms underlying the defensive phenotype. Our findings may contribute to a better understanding of how different defensive traits are produced and integrated during the plastic production of an antipredator phenotype.

# Comparative functional mouthpart morphology in selected rove beetles (Staphylinidae)

**Benedict Stocker**[1,2], Oliver Betz[1]

1 Department of Evolutionary Biology of Invertebrates, Institute for Evolution and Ecology, University of Tübingen, Tübingen, Germany

2 Stuttgart State Museum of Natural History, Department of Entomology, Stuttgart, Germany

Representatives of the megadiverse rove beetle subfamilies Paederinae and Staphylininae (Coleoptera: Staphylinidae) are mostly considered generalist predators, yet the relationship between the mouthpart morphology and the prey preferences of many species has not been fully understood. In the following, we examine these relationships for selected species using scanning electron microscopy analyses of mouthparts and front legs with a special focus on the mandibles and the tarsus, we relate these findings to data of prey capture analyses. We describe the observed structural properties in detail and quantify relationships between prey type, mouthpart morphology, and predatory performance based on morphometric measurements of both the shape and lever properties of the mandible. We show that the considered Staphylininae have morphological properties usually associated with generalist predation, such as the absence of a mola. Furthermore, we show that the considered Paederinae display additional characteristics that are highly specialized on elusive prey such as Collembola, for example narrow, sickle-shaped mandibles and lever arms favourable for high-speed movement. We have found correlations between mandible shape and leverage as well as body size and prey type that further indicate specialisation within the researched Paederinae. Overall, this exploratory study provides insights into the morphology and prey preferences of the considered species that must have played a major role in their evolution.

# Aspects of rescue behavior in desert ants

**Inon Scharf**[1], Adi Bar[1]

1 School of Zoology, Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel

Central-place foragers, such as eusocial insects, nesting birds, or burrowing rodents, must not only locate food but also return to a central location, such as a nest or burrow. This repeated use of the same routes, especially near their central place, increases their vulnerability to ambush predators. Desert ants of the genus *Cataglyphis*, which are common in sandy habitats, forage individually for scattered dead arthropods and face threats from predators such as spiders, antlions, and lizards. When an ant becomes trapped, its nestmates often engage in rescue behaviors, such as digging around the trapped ant or pulling on its appendages.

In this study, we investigated various aspects of rescue behavior in *Cataglyphis niger*. Our findings show that trapped pupae elicit more rescue efforts than trapped adult ants, but available prey draws more attention than both. Rescue behavior is also location-specific, with trapped individuals closer to the nest receiving priority. Through repeated testing, foraging ants learn to avoid falling into pitfall traps that mimic ambush predators. However, the likelihood of falling into a specific trap depends significantly on its position and whether it is "shadowed" by other traps, highlighting the effectiveness of certain ambush locations from the predator's perspective. Lastly, the presence of a trapped adult in a pitfall trap increased the number of nestmates falling into that same trap, illustrating the risk associated with rescue attempts, as rescuing ants may also become trapped and attacked.

Open
# Discussion

## Morphology Today as a Symbol of Organismal Biology: Cutting-Edge Science or Dying Discipline?

**Sebastian Büsse[1] & Inon Scharf[2]**

1 Cytology and Evolutionary Biology, Zoological Institute and Museum, University of Greifswald, Greifswald, Germany

2 School of Zoology, Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel

On the one hand, today's morphology is dominated by modern methodology. Things like high-resolution microcomputed tomography, serial block-face scanning electron microscopy, high-speed videography, or computer modeling approaches (e.g. FEM, CFD) – to name but a few – are dusting off an old traditional scientific field. This is true for many other subdisciplines of organismal biology, like animal behavior, physiology, and life history.

On the other hand, permanent (tenure-track) positions in such fields are rare, and high-impact journals (whatever that means), as well as funding agencies, are singing from the same hymn sheet: "Basic science, which is not of broad interest".

We look forward to discussing this with you and asking questions such as:

1. Are you inspired by all of the new methods and excited by all the possibilities?
2. What is more important, having a good hypothesis or using cutting-edge tools? Is it worthwhile to repeat older experiments with new tools?
3. How do you see the role of computational models and AI evolving in organismal biology? Are these tools complementing traditional work, or do they risk overshadowing it?
4. Do we collect too much data instead of focusing on summarizing what we already know and reaching conclusions?
5. Should we do more long-term studies? Work alone or in large groups?

We are also happy to discuss academic issues, such as:

1. Do you feel that there are enough opportunities for young organismic biologists at universities, and other scientific institution for professional and personal life planning? What is it like in other countries?
2. What skills should the next generation of organismal biologists focus on acquiring? Is a deep understanding of organismal systems more valuable than technical proficiency in new tools and methods, or vice versa? Should there be a stronger emphasis on soft skills like communication and teamwork, or on technical skills and subject expertise?
3. How can we maximize our chances of getting a position in the near future?