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Abstract Booklet

Keynotes:

Evolution of hand dexterity in humans and other primates

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The enhanced dexterity of the human hand is considered unique within the animal kingdom and has fascinated scientists since the time of Darwin (1871) and even da Vinci (1510). This dexterity is typically thought to have evolved via two important transitions in human evolution: habitual bipedal locomotion that 'freed' our hands from the functional requirements of locomotion and ever-increasing complexity in our tool use. However, many other primates are capable of dexterous behaviours, including tool use, with hand morphology that differs from that of humans. Moreover, fossil evidence of the evolution the human hand reveals a more complex, non-linear story, in which our ancestors likely still used their hands for climbing through much of our evolution. I will discuss fossil evidence of the hand from some of our early human relatives (hominins) and what the external and internal morphology of these fossils can tell us about how hominins may have used their hands for tool behaviors and for climbing. I will further present on how the study of living primates, including their locomotor and tool use behaviours, can help us to understand the evolution of human tool use and dexterity, and what is truly unique (or not) about the human hand.

Lessons from functional morphology: how macro- and microevolution have shaped elongated genitalia in leaf beetles

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Animal forms are highly diverse, and this diversity is the outcome of evolution. Evolutionary events producing this diversity do not occur randomly. There are morphological features that, although highly divergent from ancestral forms and thus considered novel, have been repeatedly acquired. Constraints are thought to play an essential role in evolution, yet their nature remains unclear. The elongation of genitalia represents a noteworthy case for clarifying the nature and evolutionary consequences of a constraint. This is because genital elongation has evolved repeatedly, with numerous instances in insects, where species are often reported to possess penises longer than their body length. In insects, this elongation is especially striking, as the structure is stored internally and dynamically extended and retracted during copulation, suggesting that the challenges of maneuverability and storability may function as constraints. In the first half of this talk, a series of studies addressing this macroevolutionary

aspect will be presented. In the second part, the microevolutionary aspect will be highlighted. Another striking feature of animal genitalia is the coevolution of female and male genitalia. Although the evolutionary mechanisms behind this phenomenon have been extensively studied, the mechanical interactions between female and male genitalia have long been neglected, and the exact evolutionary mechanism underlying coevolution remains unclear. A series of our in-depth biomechanical studies on the intromission of elongated tube-like female and male genitalia in leaf beetles unveiled unexpectedly sophisticated penetration mechanics and structural and material adaptations in female and male genitalia. We consider these findings to be a key factor in the hyper-diversification of female and male genitalia and will discuss a possible evolutionary mechanism for it.

Micromechanical mysteries of the most sensitive mechanoreceptor

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Morphology is the study of form; know the form and you will discover the function. This premise holds especially true for sensory systems both at the macroscopic and microscopic scale. Here, I will introduce the tantalizing mystery of how the most specialized type of animal mechanoreceptor works at the microscopic scale. The micromorphology of the sensory ending of insect chordotonal organs is known for over 65 years, and we have only started to uncover data-driven hypotheses of how it operates at the mechanical and electrophysiological level.
Insect chordotonal organs (CO) underlie proprioception, vibration and sound detection. As such, COs are essential for a multitude of behaviours from flying and biting to egg-laying and predator avoidance. In rare cases insect COs have evolved into dedicated auditory organs. The external macro-morphology of COs are as varied as the insects in which they are found. In contrast, at the microscopic level, the sensory ending of CO neurons is conserved in all insects, suggesting a conserved mode of operation. Insects have a single sensory cilium for each CO neuron and each cilium has a widening (dilation) towards its distal end, dynein arms near its base (reminiscent of motile cilia), and are enclosed in an inaccessible cavity by a supporting scolopale cell. The small size and inaccessibility of the sensory cilium has severely hampered our ability to understand how it works and led to wild conjecture as to how it operates. We have only recently imaged movements of the sensory ending *ex vivo* and individually mechanically stimulated the sensory ending whilst recording the transduction current. In addition, we have genetically knocked down two candidate transduction ion channels and discovered, in opposition to the rest of the field, that both contribute to the transduction current. In this plenary I will guide you through the success and failures that has led us to a new working model of how CO neurons operate.

Keynote Contest Talk:

Convergent evolution of sensory palps in Scalibregmatidae (Annelida)

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The evolution of palps in Annelida is still under strong debate, although their consistent dual-root innervation pattern across all major lineages studied to date is widely accepted. Nevertheless, their repeated reduction—and potential re-evolution—remains a central question in Annelida. Within the sedentary Scalibregmatidae, most species are burrowing deposit feeders that entirely lack anterior appendages. Yet the derived *Axiokebuita–Speleobregma* clade bears conspicuous palp-like structures, raising the question of whether these are homologous to the true palps of other annelid taxa or if these appendages represent a rare case of convergent evolution.

To clarify this, we compared three taxa representing successive morphological conditions: (1) *Travisia sp.* (Travisiidae), which possesses a smooth prostomium without any head appendages; (2) *Scalibregma celticum*, which bears short, lateral prostomial horns; and (3) *Axiokebuita cavernicola*, which carries elongated, densely ciliated palp-like appendages. Using immunohistochemistry, confocal laser scanning microscopy, azan-stained histological sections, and 3D reconstruction, we analyzed the neuronal and muscular innervation patterns of these anterior structures.

Our findings show that *Travisia* lacks any pro- or peristomial neurite bundles that could serve as precursors for head appendages. In *Scalibregma*, the prostomial horns receive a diffuse neuronal innervation coming from nearly all brain regions, indicating a sensory structure without the characteristic dual-root pattern of true palps. In *Axiokebuita***,** all five appendage nerves arise exclusively from the dorsal root of the circumoesophageal connectives, closely matching patterns of antennal innervation in other annelid groups rather than the dorsal–ventral dual innervation typical of palps.

Together, these results suggest that Scalibregmatidae constitute the first known annelid lineage in which palp-like head appendages re-evolved after an ancestral loss of true palps, providing clear morphological evidence for convergent evolution within a character complex previously regarded as deeply homologous.

Talks*:

*Abstracts marked with a bee () are student talks. They are eligible for the Best Talk Prize, and you can VOTE for them.

Unravelling the *Haploniscus hydroniscoides* Birstein, 1963 species complex through integrated methods of taxonomy and molecular analyses

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Recent studies discover an increasing number of “cryptic” species complexes amongst deep-sea isopods – even taxa already known to science - are growing. However, species delineation often faces problems of ambiguity in such instances, underlining the necessity of using integrative taxonomy to unravel these cryptic taxa. Molecular data hinted at the existence of a potentially undiscovered species complex within the abundant and widely distributed deep-sea isopod *Haploniscus hydroniscoides* Birstein, 1963 from the North Pacific. To test this hypothesis an integrative taxonomical approach combining morphological analyses such as geometric morphometrics with molecular barcode data (16S, COI) was applied. This approach revealed the existence of seven distinct, yet closely related species, each characterized by unique biogeographic distributions spanning abyssal to hadal depths. The taxonomic description of these novel taxa and their diagnostic features further provide important insights into the systematics of the family Haploniscidae Hansen, 1916, a group known for requiring a thorough taxonomic re-evaluation.

Glimpses on the evolution of phylactolaemate bryozoans

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Phylactolaemates are a small group of exclusively limnetic bryozoans. Like all bryozoans, they are colonial, sessile suspension feeders. Each colony consists of individual zooids, that comprise a protective cystid, which constitutes the body wall, and a retractable polypide bearing a lophophore with ciliated tentacles. Phylactolaemates represent the sister group to all other bryozoans, making them crucial for understanding the evolution of bryozoans in general. Recently, a transcriptome-based phylogeny of phylactolaemates was erected. Within this analysis, the ambiguously discussed species *Plumatella fruticosa* could confidentially be placed as sister taxon to the morphologically very different families Cristatellidae and Pectinatellidae. The morphology of *P. fruticosa* was assessed via confocal microscopy, histology and 3D reconstruction. The investigation provides arguments against the affiliation of *P. fruticosa* with other plumatellids, leading to the erection of a new family, Hirosellidae. With this new family in place, data on the morphology of almost all phylactolaemate family now exist. Historical and recent data were considered to compile a morphological character matrix that was mapped onto the newly erected phylogeny. The results showed that, in addition to the high degree of phenotypic variation in phylactolaemates, many lineage-specific innovations had evolved independently. Moreover, many

apomorphic characters were identified and the ancestral state reconstruction indicates that the last common ancestor formed ‘serial’ colonies with large interzooidal distances and non-encrusting body walls. This contrasts with ‘clustered’ families featuring short interzooidal distances. The latter character and the presence of encrusted cystids as present in most ‘serial’ but not ‘clustered’ families, represent derived traits.

Art & science and the invention of morphology

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The systematic study of form, shape and structure emerged early through a dynamic interplay between art and science. Driven by observational precision to create visual representations that capture geometric and anatomical patterns of the natural world. These depictions became foundational data to explain recurring forms though empirical data and to ultimately classify the living world. As scientific methods evolved, *a morphology was initiated*, yet it continued to draw from artistic techniques of visualization and conceptual abstraction. This interaction enabled the identification of structural laws, growth patterns and transformational processes that govern the living and non-living forms. Today, morphology is the overarching discipline of biology, shaped by creativity and analysis – art offering an intuitive insight into form, while science provides the rigor to study it. Thus, morphology provides a framework that reveals not only how forms appear, but why they emerge, vary, and evolve.

What is the penis? Establishing the groundplan of male insect genitalia.

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The male genitalia of insects are resplendent in their structural, functional, and evolutionary diversity, yet are damned in their anatomical complexity, resulting in centuries of debate about their inter-ordinal homologies and morphological terminology. In this brief talk, I will summarize comparative observations of male insect genitalia in the broader context of Pancrustacea and Ecdysozoa, and I will use the alignment of skeletomusculature to propose a resolution to the groundplan of Hexapoda and Pterygota. Time permitting, I will discuss musculature as evidence for homology and the notion of hierarchical homology.

Conserved behaviors, divergent webs: Dragline-attachment modules in *Anelosimus baeza* (Theridiidae) and other web-builders

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Organizing behavior into modules is an ideal framework for understanding spider web-building. Analyses of finished webs are informative but cannot resolve many fine-scale actions. Here we directly describe dragline-attachment behaviors in the subsocial theridiid *Anelosimus baeza* (Araneae: Theridiidae) that underlie its three-dimensional "basket" architecture. We video-recorded construction in 14 colonies and 17 individual spiders in box setups, and compared these behaviors to those reported in other theridiids and orb weavers. Many behaviors in *A. baeza*—notably under-line locomotion with a single leg IV maintaining dragline control and leg-III guidance during placement—are shared broadly across araneoids despite divergent final architectures. We also document features that clarify how similar modules yield different outcomes: brief exploratory descents from multiple web locations; absence of **break-and-reel** relocations; and short, rapid placements, including occasional spinneret-only contacts in box meshes. In colonies, we observed "attachment around the corner" and communal sheet filling by multiple spiders with minimal interference, suggesting tolerance and potential coordination. Together, these results indicate that conserved behavioral modules are flexibly parameterized to meet architectural demands, providing a plausible route by which conserved behavioral modules generate different web designs. Such flexibility may have facilitated evolutionary diversification of web architectures across spider lineages.

Show me your belly – mechanically protected metasomal attachment pads in male *Afroheriades* bees (Hymenoptera, Megachilidae) enable contamination-free mating grip

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Adhesive devices in insects serve multiple purposes, including attachment to mating partners. Environmental factors can increase their importance during copulation and challenge the functionality and performance of these systems.
Afroheriades Peters, 1970 (Hymenoptera, Megachilidae) is a group of small-sized solitary bees that is endemic to South Africa. They represent a highly localised, morphologically distinctive osmiine lineage with very limited known species diversity and obscure life history. Males typically curl their abdomen ventrally and conceal the surface of the metasomal sternites, putatively exposing them only during copulation. Females, in contrast, use a ventral scopa on the metasomal sternites for pollen collection. However, behavioural observations are scarce and literally nothing is known about their reproductive biology, but morphological examination allows for inference of mating strategies and provides insights into the evolution of the reproductive biology in this genus.
We investigated the metasomal structures of *Afroheriades dolichocephala* (Friese, 1925) using scanning electron microscopy, confocal laser scanning microscopy and µ-computed tomography and uncovered a complex system of structures distributed over several male metasomal sternites contributing to

copulatory attachment. These include a unique attachment pad on the fifth metasomal sternite, consisting of soft adhesive setae, and a number of other setal structures and cuticular ridges arranged in alignment with each other.
While females possess a suitable smooth and glabrous area corresponding to the position of the male attachment pad, contamination by pollen is likely in this area and harmful for the contact generation of the adhesive system. The staggered sequence of supporting structures enables protection of the attachment pad against damage and contamination, and removal of pollen from the system.
We here describe a peculiar case of a fine-tuned cascade of morphological features, arising from environmental pressures that interfere with mating in this species, sustaining copulatory contact and adhesive functionality under environmentally imposed challenges.

Valvilli architecture and its role in venom pumping

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Venom delivery in aculeate hymenopterans (i.e., ants, bees, and stinging wasps) is mediated through a slender piercing stinger, yet the detailed mechanisms that control fluid movement inside this system remain poorly understood. In most of these insects, venom injection involves a pumping system that operates via paired cuticular structures (i.e., valvilli), which are thought to move in a strict antiphasic pattern to generate pressure within the valve chamber, as inferred from studies on honeybees. However, ants have received far less attention, and the internal operation of their valvilli remains undocumented. We examined the valvilli of *Diacamma* nr. *indicum* using micro-computed tomography (micro-CT), histology, serial block-face scanning electron microscopy (SBF-SEM), and confocal laser scanning microscopy (CLSM) to characterize their three-dimensional organization and cuticular composition. Our results show that the valvilli consist of a rigid basal region, flexible hinge zone, and paired lobes that project into the valve chamber. CLSM and SBF-SEM revealed discrete material zoning within the lobes, with a rigid core and flexible margins supported by stiff cuticular bands extending longitudinally from the core toward the distal margin. Micro-CT scans of stingers fixed at different points in the actuation cycle revealed two motion patterns: (i) an alternating displacement consistent with existing models and (ii) a synchronous posture in which both valvilli were displaced distally and compressed within the narrowed distal chamber, which has not been previously documented. The presence of both states suggests that the valvilli can operate through a broader set of movements than the strictly antiphasic cycle proposed for honeybee stingers. These results provide the most detailed account of ant valvilli to date, clarify how their internal architecture supports dual-phase actuation during venom pumping, and highlight the need to reassess current models of stinger function across Hymenoptera.

From land to water and back again: Neuroanatomical adaptations of the olfactory system in Hemiptera

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Hemiptera constitutes one of the largest and most diverse insect orders. Members of the heteropteran sub-order, known as 'true bugs', have successfully adapted to a variety of terrestrial and aquatic ecosystems. Evolutionary diversification gave rise to a lineage of secondarily aquatic true bugs (Infraorder: Nepomorpha) developing novel morphological, physiological and behavioural adaptations to freshwater environments. An exception to the aquatic lifestyle of Nepomorpha is the superfamily of Ochteroidea, which has secondarily adapted from water back to land. Despite anatomical observations, suggesting anosmia in aquatic true bugs due to the absence of olfactory brain structures typical for terrestrial insects i.e., the lack of antennal lobe (AL; primary olfactory centre) with distinct glomeruli, and of mushroom body (MB) calyces (a secondary olfactory centre), recent studies of the antennal sensilla in nepomorphan species, revealed chemoreceptive sensilla. With the present study we revisit the neuroanatomical layout of the olfactory system in three species: the backswimmer *Notonecta glauca* (Notonectidae), the creeping bug *Ilyocoris cimicoides* (Naucoridae) and the velvety shore bug *Ochterus marginatus* (Ochteridae), with emphasis on their transitions from land-to-water (*Notonecta, Ilyocoris*) and water-to-land (*Ochterus*) and their respective adaptations. In addition to the morphometric assessment and comparison of the brain regions of interest, single neuron staining techniques are employed to identify and characterise the neuronal components of the olfactory pathway, including afferent antennal sensory neurons, projection neurons that connect the sensory neuropiles with the central brain, and MB intrinsic cells (Kenyon cells).

Evolution and functional morphology of the ant waist: Biomechanical principles underlying its architecture

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The waist of hymenopterans, derived from modifications of the abdomen, is considered an important functional innovation that has contributed to their remarkable species diversity. This structure is thought to provide flexibility that facilitates their parasitic lifestyles and defense strategies. The waist is not only crucial for understanding the evolutionary history of ants, bees, and wasps but also serves as an important taxonomic character system. However, functional and anatomical studies of the waist remain very limited. Here, we investigate the skeletomuscular architecture of the ant waist and its influence on abdominal movement using synchrotron scan data and computer simulations. We further explore the morphological diversity of the waist and its possible origins. To do so, we selected phylogenetically related groups that differ in the direction of abdominal motion and conducted comparative analyses. Our findings shed light on the functional, morphological, and biomechanical understanding of the ant waist.

A bloody mystery – morphological investigations shed light on the function of the glycerid venom system (Glyceridae, Annelida)

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Glyceridae are venomous annelids living in various marine environments. They possess an eversible proboscis with four terminally situated jaws to grab their prey and produce a distinct venom to paralyze the latter. For decades it was assumed that putative venom glands that are associated with the jaws produce the venom. However, immunohistochemical analyses and *in-situ* hybridization approaches indicated that the venom is produced in another morphologically distinct area, named as pharyngeal lobes. Due to lacking investigations, most of the existing morphological studies investigated the venom system of Glyceridae based on the assumption that the putative venom glands produce the venom and therefore did not consider to investigate other structures associated with the jaw apparatus. Hence, a detailed morphological investigation of the venom system including the pharyngeal lobes is still lacking. Therefore, we used an integrative morphological approach including scanning electron microscopy (SEM), immunohistochemistry as well as histological azan serial sections to reconstruct the venom system of *Glycera* sp. nov.. Our investigations represent the first comprehensive morphological analysis of the glycerid venom apparatus and provide a detailed picture of the putative venom glands as well as the pharyngeal lobes. Hence, the entire system is embedded in a dense scaffold of differently orientated muscles and innervated by a dense meshwork of distinct neurite bundles. Furthermore, the putative venom glands – presumably used for storage of the venom cocktail - are directly connected to the jaws via a prominent duct. Our investigations provide a detailed view on the different substructures of the venom system in *Glycera* sp. nov. and represent an important overview necessary for further investigations dealing with the assignment of functions for respective parts of the glycerid venom system.

Hiding behind a giant – Untangling the gemsnakes of the *Liophidium torquatum* complex from Madagascar

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Liophidium torquatum (Boulenger, 1888) is a species of gemsnakes (Pseudoxyrhophiidae) endemic to Madagascar, but considered to be widespread over large parts of the island.
New phylogenetic data revealed that this taxon is paraphyletic, with one clade of the *L. torquatum* species complex being more closely related to *Liophidium mayottensis*, an island giant endemic to the Comoran island of Mayotte, than to other populations of the taxon.
We herein demonstrate that *Liophidium torquatum* in its broad current definition needs to be split into three species based on differentiation in (I) multiple mitochondrial and nuclear markers, (II) colour patterns, (III) hemipenal structures, and (IV) distinct distribution ranges of each species.

Thus, we recover the true *L. torquatum* as a monophyletic taxon and will describe two species new to science. We also shed light on the evolutionary history of *L. mayottensis*, proposing its colonization of Mayotte from Madagascar via the South Equatorial Current.

The evolution of retinotectal development in Anurans with different reproductive modes.

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Most anurans exhibit an indirect life cycle consisting of an aquatic larva (tadpole) and a typically semi-terrestrial adult. Deviations from this ancestral life cycle have evolved repeatedly and independently, and include species having terrestrial tadpoles and direct developing species that entirely lack the free-living larval stage. Among these derived reproductive modes, direct development has received the most attention. The investigated direct-developing species frequently show a mosaic of the recapitulation of tadpole-characters, their reduction or loss and the evolution of completely novel characters. One of the best-studied character systems is the development of the nervous system in the direct-developing *Eleutherodactylus coqui*. In this species, growth and differentiation of the retina and tectum opticum (retinotectal system) exhibit an altered developmental pattern compared to other nervous system components. Retinotectal growth is strongly accelerated, while its cellular differentiation appears delayed. This led to the hypothesis proposed by Schlosser (2008) that the modular organization of the nervous system contributes in large parts to the developmental repatterning during the evolution of direct development. In this study we investigate retinotectal development in anurans with aquatic-indirect (e.g., *Hyperolius*), semiaquatic-indirect (*Hemisus*) and terrestrial-indirect (*Breviceps, Arthroleptella*) reproductive modes as well as a direct-developing species (*Arthroleptis wahlbergii*). By combining histology with X-ray microscopy and morphometric methods, we investigate the diversity of retinotectal development. We further aim to test whether the observed alterations of retinotectal development are associated with direct development or if this pattern can be expanded to terrestrially developing species in general.

The clavicle as a key to digging in moles (Talpidae): A comparative analysis of shoulder morphology and microanatomy in extant and extinct taxa

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Fully fossorial moles represent one of the most extreme cases of fossorial adaptations, while the family Talpidae encompasses a wide range of lifestyles and degrees of fossoriality. Since the shoulder plays a central role in digging and locomotion, the variation in gross morphology and bone microanatomy of the shoulder bones reflects the diversity in lifestyles. Using micro-CT scan, we generated anatomical

plates of the shoulder bones to compare morphological differences across lifestyles. Particular interest was given to the clavicle and its articulations to the sternum since they are crucial for humeral-rotational digging, yet have been less discussed. Close examination of the clavicles revealed a previously unreported structure, the clavicular-clavicular facet, which is most developed in fully fossorial moles and potentially indicative of fossorial specialization. Additionally, a substantial tri-lobed soft tissue was observed between the clavicles and the sternum in a fully fossorial species, suggesting an adaptation to digging-related stresses. Contrary to expectation, overall bone volume fraction did not show a clear pattern with fossoriality, but relative bone volume increased with greater fossoriality. This suggests that the relative amount of bone content, rather than compactness alone, may be more important for shoulder function in digging moles. Lastly, we examined several fossil clavicles from the early Oligocene fissure Ehrenstein 12, which represent the earliest talpid fossil clavicles known to date. At least two morphotypes were identified, and could correspond to *Tegulariscaptor minor* and other coeval talpid species of similar sizes. They were most likely semi-fossorial, providing valuable insight into early mole evolution.

A new weird cricket (Orthoptera, Gryllidea) from mid-Cretaceous Kachin amber in northern Myanmar

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Gryllidea, one of the most species-rich groups in Orthoptera, are characterized by relatively scarce fossil records until the K-Pg extinction. This study describes a unique Mesozoic cricket, Fortigryllus xiangrui gen. et sp. nov., based on a well-preserved specimen from mid-Cretaceous Kachin amber in northern Myanmar. It exhibits very peculiar morphologies including fore-, mid-, and hindlegs nearly equal in robustness, and exceptionally stout femora in all three pairs of legs. Although it has some putative synapomorphies with the Phalangopsidae, the lack of information on the genital characters forbid us to accurately attribute it to a precise family. Crawling is tentatively proposed as a mode of locomotion in this Mesozoic cricket. This new find reveals a novel morphology in Cretaceous crickets and suggests a great potential biodiversity of crickets in this mid-Cretaceous ecosystem.

Biting and feeding mechanisms of the Mediterranean medical leech (*Hirudo verbana*)

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Hematophagous leeches have evolved a suite of morphological, anatomical and functional adaptations that enable efficient host attachment, biting, and blood feeding. While medically relevant species like *Hirudo verbana* and their respective features—for example its salivary components—have been well documented, the biomechanics of leech attachment have only recently been elucidated, showing that *H. verbana* employs a variety of attachment strategies that allow the animal to attach to airtight and porous substrates. In this study, we present a novel methodological approach for visualising the surface of the anterior sucker during biting and feeding on various transparent technical and natural substrates. We achieved this by applying a chemical cocktail that is perceived by the leeches as a food stimulus and triggers the biting as well as the feeding processes so strongly that they can be fed on transparent blood substitute solutions, enabling video analyses of these processes. The resulting kinematic analysis allowed us to describe a multi-stage biting and food intake process, quantify the jaw's kinematics, and determine its penetration depth in substrates. Additionally, we were able to gain initial qualitative insights into the adaptability and flexibility of the biting apparatus and the mechanical abrasion of the leech teeth. These findings provide new insights into the functional complexity of leech biting and feeding, and could also inspire the development of novel microsurgical devices.

Cuticle composition and material properties of mandibles reflect ecological demands on trap-jaw ants

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Power amplification mechanisms (PAM) evolved several times to enhance bite speed in the so-called trap-jaw ants. Besides morphological adaptations in the mandible-head articulation, these fast strikes may require adaptations in the mandible cuticle to efficiently transmit force and withstand the loads involved. Such adaptations could reflect gradients in cuticle sclerotization, material properties, and deposition of metals. We investigated whether trap-jaw ant mandibles exhibit such features by analyzing four species representing two independent PAM appearances, the genera *Odontomachus* (*O. bauri* and *O. chelifer*) and *Strumigenys* (*S. eggersi* and *S. louisianae*). We employed energy-dispersive X-ray spectroscopy (EDX) to assess the elemental composition along the mandibles, confocal laser scanning microscopy to quantify autofluorescence patterns related to the degree of sclerotization, and nanoindentation to measure cuticle hardness and stiffness. In the *Odontomachus* species, the entire mandible exhibited strong red autofluorescence, indicating a higher and more uniform degree of sclerotization. In *Strumigenys*, otherwise, sclerotization was graded, with red autofluorescence on the teeth, green along most of the shaft, and blue patches at the base, transitioning from more sclerotized teeth towards less sclerotized mandible shaft and base. Nanoindentation was performed only on *Odontomachus* species, which exhibited a graded pattern where teeth were harder and stiffer than the mandible shaft and base. EDX analyses revealed elevated Zn concentration in all species' teeth in comparison with the rest of the mandible, but this was higher among *Strumigenys* species than *Odontomachus*. The more sclerotized mandibles of *Odontomachus* may more effectively transmit

forces, optimizing their defensive strikes against the substrate to flee potential threats. In contrast, *Strumigenys* mandibles, with highly sclerotized and Zn-enriched teeth but softer shafts, appear adapted for piercing soft-bodied prey while minimizing the reaction forces generated upon contact. These findings suggest distinct mechanical optimizations in trap-jaw ants driven by their differing ecological and behavioral demands.

Revealing the overlooked: Pelvic girdle morphology in non-percomorph teleosts

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Fish fins are essential for effective locomotion in aquatic environments. In addition to the unpaired anal, dorsal and caudal fins, gnathostomes have two sets of paired fins: the pectoral and pelvic fins. Both fins received some attention in relation to the evolution of land-dwelling vertebrates, as the limbs of tetrapods evolved from these fins. However, the actinopterygian pelvic girdle itself has been understudied, with only a few investigations examining this structure within a broader taxonomic framework. Consequently, there are still many gaps in our knowledge of pelvic fin morphology, its evolution, as well as its importance in an ecological and locomotory context.
This study aims to improve our knowledge of the diversity and evolution of the pelvic girdle in non-percomorph teleosts, by examining cleared and double-stained specimens.
Preliminary results reveal considerable variation of the pelvic girdle between orders. While smaller clades usually exhibit only negligible variation between species, larger clades, especially when considering ground-dwelling species such as the Siluriformes, present a high diversity in their pelvic girdle morphology. Nevertheless, the general structure of the pelvic girdle of non-percomorph teleosts can be summarized as following:
The main element of the pelvic girdle is (1) the basipterygium, which is usually triangular in shape and can accommodate multiple processes. (2) There are up to four radials posterior to the basipterygium, with the most medial radial often being the largest. (3) The fin rays usually articulate with the radials but may also articulate directly with the posterior margin of the basipterygium, the articulatory facet. (4) There is often a pelvic splint on the lateral side of the fin rays.
Fish fins are essential for effective locomotion in liquid environments. In addition to the unpaired anal, dorsal and caudal fins, gnathostomes have two sets of paired fins: the pectoral and pelvic fins. These fins have both received some attention in relation to the evolution of land-dwelling vertebrates, as the limbs of tetrapods evolved from these fish fins. However, the pelvic girdle in particular has been understudied, with only a few studies examining this structure within a broader taxonomic context. Consequently, there are still many gaps in our knowledge of pelvic fin morphology.
This study aims to improve the understanding of the diversity and evolution of the pelvic girdle in non-percomorph teleosts, by examining cleared and double-stained specimens.
Preliminary results indicate that the pelvic girdle can vary considerably between orders. However, within orders or families, it usually exhibits only a slight diversity. The main element of the pelvic girdle is (1) the basipterygium, which is usually triangular in shape and can accommodate multiple processes. (2) There are up to four radials at the posterior end of the basipterygium, with the medial radial often being the largest. (3) The fin rays usually articulate with the radials, but in sometimes articulate directly with the posterior end of the basipterygium, the articulatory facet. (4) There is often a pelvic splint on the lateral side of the fin rays.

Stop and go: silk flow controlling muscles in the anterior lateral spinneret of spiders (Araneae)

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Silk production is an autapomorphy of spiders, with silk being extruded through spigots on the spinnerets, which are paired appendages at the abdomen's posterior end. Initial findings revealed that spinnerets possess intricate musculature, enabling the precise construction of silk-based materials. Among these muscles are those potentially controlling silk flow within the spinning duct of the major ampullate gland, located in the anterior lateral spinnerets. In orb-weaving spiders, three muscles associated with a valve-like structure in this duct have been described. This structure might enable the spiders to brace without the help of legs during abseiling manoeuvres, or to tailor the stiffness of the silk by modifying shear forces during spinning. However, it was unclear if this apparatus is an autapomorphy of the orb-weaving or all spiders. To clarify this, a comparative anatomical study was conducted utilising micro-computed tomography (µCT), which revealed diverse configurations of possible silk-controlling muscles across different spider lineages. While the early branching Mesothelae and Mygalomophae lack muscles associated with spinning ducts, at least one such muscle has been identified in most araneomorph ('modern') spiders, with the exceptions of some families (e.g. Pholcidae, Oecobiidae, and Hersiliidae). The most complex arrangement, consisting of three muscles and a duct valve, was observed in Deinopidae, some Uloboridae, and all studied representatives of the super-family Araneoidea, except for Linyphiidae. Three muscles are also present in Sparassidae, although it is not yet known if there is also a valve-like structure present. This indicates multiple occurrences of either the acquisition or loss of muscles. My ongoing research investigates whether the observed differences in the configurations of the silk flow controlling apparatus impact its function and efficiency. These results are important for the understanding of how spiders of different evolutionary lineages may use silk and modulate its mechanical properties in varying ecological contexts.

Morphological and biomechanical perspectives on radular diversity

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The radula—a chitinous, tooth-bearing feeding apparatus—has been central to the ecological and evolutionary success of the Mollusca, especially within the highly diverse Gastropoda. Radular teeth, notable for their remarkable functional specialization, exemplify an exceptional integration of form and function across multiple biological scales. In this review, we synthesize current knowledge on the extraordinary diversity of radular morphologies, material properties, and biomechanical systems that contribute to tooth performance, mitigate material failure, and reduce wear.

Radular tooth morphologies display striking variation shaped by both phylogenetic history and ecological adaptation, ranging from piercing structures in carnivorous taxa to scraping forms in herbivores. Tooth arrangement, together with gradients in material properties—arising from mineralization, cross-linking, and protein tanning—enables radulae to interface effectively with a wide array of substrates. Complex radular kinematics facilitate manipulation of ingesta, while interlocking tooth architectures contribute to efficient force transmission and optimal stress distribution, allowing even the exploitation of lithic surfaces without reliance on high concentrations of iron, apatite, or silica. Insights from finite element analyses and physical modeling further highlight the structural and functional sophistication of radular systems.

Investigating tracheal ultrastructure across Arthropoda: First large-scale comparison of taenidial measurements

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In the past, the frequency of taenidia (spiral- or ring-like reinforcements of tracheae present in most arthropod lineages) and the space between them (intertaenidial space) were used for phylogenetic argumentations, e.g. to justify an independent evolution of the tracheal system of Protura from that of the remaining hexapods. However, older studies indicated that these traits depend on the tracheal diameter, which was seldomly considered during measurements and comparisons. Our investigation aims to give the first large-scale overview of taenidial measurements in relation to tracheal diameter, which includes over 40 species representing most of the major hexapod orders, several lineages of myriapods, and most of the trachea-bearing lineages of arachnids. Several tracheae of each species were imaged using SEM and different parameters such as taendial width, width of intertaenidial space, and tracheal diameter were measured. Our results show a surprisingly congruent positive correlation between the tracheal diameter and taenidial width for all species investigated. In contrast, relationships between the tracheal diameter and intertaenidial space width seem more complex and varied between different lineages. The influence of phylogenentic aspects, relevant lifestyle aspects, and morphological aspects of the tracheae are evaluated to infer the degree of functional dependency. With the present investigation we lay the foundation for more in-depth comparisons of tracheal ultrastructure in the future.

Evolutionary genital morphology of caecilian amphibians updated

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Sex is the motor of organismal evolution. Caecilian amphibians are a unique group of tropical vertebrates well adapted to lead a subterranean life. Among the evolutionary key innovations are genitalia such as the male phallodeum, a unique copulatory organ which is everted and safeguards internal fertilization. Since the caecilian cloaca is ontogenetically a part of the digestive system it is not a separate structure exclusively dedicated for reproduction such as the squamate hemipenis. Nevertheless, complex and diverse morphologies have evolved in all caecilian families that include different patterns of longitudinal ridges, tuberosities or crests, but also various forms of paired blind sacs. Here we present a comparative overview of the overwhelming diversity of caecilian genitalia, both for females and males. Using specimens housed in natural history museum collections around the globe we explored the cloacal anatomy of both sexes of several taxa representing the major clades and reproductive modes via classic dissections and conventional histology combined with state of art soft tissue µCT-scans. We interpreted our results within an evolutionary framework based on most recent phylogenetic hypothesis, to check for gains and losses of specific genital morphologies and for sexual selection issues but also if morphological patterns are linked to the highly variable reproductive modes. In summary our comparative integrative approach into the complex reproductive morphology of caecilian amphibians offers prime potential for our understanding of the evolution of vertebrate reproduction.

Morphology and embryonic development of the muscle system in the ctenophore *Mnemiopsis leidyi*

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Ctenophores occupy a key phylogenetic position as one of the earliest-branching animal lineages, making them essential for reconstructing the evolutionary origins of key animal characteristics. They possess a complex body plan that includes differentiated cell types such as neurons and muscle cells. Yet the morphological architecture, ultrastructure, and embryonic development of the ctenophore muscle system remain poorly understood. Single-cell expression data show that ctenophore *Mnemiopsis leidyi* possesses four molecularly distinct muscle-cell populations. Intriguingly, although *Mnemiopsis* lacks morphologically defined striated muscles, single-cell studies reveal that one of these populations expresses markers typically associated with striated muscles in other animals, while another cluster expresses markers characteristic of smooth muscles. This raises the question of whether these transcriptionally distinct muscle populations can also be distinguished morphologically.

To address this, we performed transmission electron microscopy to characterise muscle ultrastructure and conducted a detailed confocal analysis following phalloidin staining. Our results suggest the presence of at least three morphologically distinct muscle cell types at the early larval stage of *Mnemiopsis*. Remarkably, one type of body-wall muscle exhibits a unique pear-shaped organization. Using advanced 4D microscopy together with confocal imaging, we characterised the embryonic development of the muscle system in *Mnemiopsis leidyi*. Combined with laser ablation and blastomere-labeling experiments, these approaches enabled us to trace the embryonic origin of the different muscle-cell populations.

Functional morphology of pygopodia in semi-aquatic firefly larvae (Coleoptera, Lampyridae)

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Pygopodia are terminal abdominal appendages present in the larvae of several insect lineages, functioning as substrate-contacting structures for positioning and stabilization. They appear as simple or elaborately branched structures depending on the taxon, and their morphology shows substantial diversity across groups. In fireflies (Lampyridae), pygopodial characters are widely used in larval taxonomy and have been functionally suggested to contribute to substrate attachment. However, their functional roles and underlying mechanisms remain poorly understood. Firefly larvae also display an unusually broad ecological range, spanning terrestrial, semi-aquatic, and aquatic habitats, a level of ecological divergence that appears relatively uncommon within a single beetle family. This makes the functional relevance of pygopodia especially compelling to investigate.
Considering that different ecological conditions involve distinct mechanical constraints, this study focuses on *Pygoluciola qingyu*, a semi-aquatic species inhabiting wet and unstable stream margins where maintaining attachment is particularly challenging. We use scanning electron microscopy to document the external structures of the pygopodia, which consist of twelve soft branches equipped with hooks and spines arranged into a three-dimensional grasping array. Confocal laser scanning microscopy reveals a clear material difference, with the hooks showing localized sclerotization compared with the uniformly soft branch tissue. Histological staining shows only thin peripheral muscle fibers and no central musculature, indicating that branch kinematics arise from pressure-driven deformation of the soft cuticle and soft tissues inside, with small peripheral muscles providing local adjustment. Friction experiments performed on substrates of different roughness demonstrate that the pygopodia substantially enhance attachment, especially on surfaces with coarse roughness under both dry and wet conditions. Together, these findings clarify the functional basis of pygopodial performance in *P. qingyu*, providing a mechanistic framework for interpreting pygopodial diversity across the ecologically varied larvae of fireflies.

Chemosensing everywhere: about the sensory equipment of locomotory appendages in the house centipede *Scutigera coleoptrata* (Chilipoda, Notostigmophora)

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Having a cuticularized skin, arthropods receive most of their sensory stimuli via sensory hairs, called sensilla. In adaptation to the different chemical and physical natures of environmental stimuli, evolution led to an enormous diversity of sensilla transducing one, two or even several stimuli to ciliated receptor cells. Both external and internal ultrastructural traits may reveal the probable function(s) of a given sensillum. Our knowledge about the typology and function of sensilla is mainly based on studies conducted in insects. Myriapods, however, still remain widely understudied in this respect, even on a morphological level. As for the sensory equipment of centipedes, our knowledge grew recently not least because of in-depth SEM surveys of taxonomists and evolutionary morphologists. However, studies on many sensillum types across centipede subtaxa still miss complementary insights from their internal anatomy, as provided by TEM. This contribution presents a study case on the house centipede, *Scutigera coleoptrata*. In this species, only the antenna was thoroughly investigated so far, including the finding of a CO_2-receptor (organ of Tömösvary), a combined pressure- and hygroreceptor (scape organ), mechanoreceptors (sensilla trichodea) and contact-chemoreceptors (beak-like sensilla). However, it is still unknown, which type of sensillum on the antennae *S. coleoptrata* uses for olfaction or thermoreception. Additionally, nearly nothing was known about the sensory equipment of the 14 pairs of locomotory legs and the single pair of elongated ultimate legs. This study sets out to fill this gap. Based on the analysis of semithin sections and combined SEM and TEM datasets, we are now able to define four different types of sensilla that occur on the tarsomeres of the locomotory legs: obelisk-shaped sensilla (mechanoreception), beak-like sensilla (contact-chemoreceptiom) and, being a new addition, glandular sensilla. We can therefore conclude that all appendages of *S. coleoptrata* are sensitive to mechanical and chemical stimuli.

Comparative study of SIFamide-like immunoreactive neuronal patterns reveals an ancestral neuron type in the chelicerate brain

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Comparative studies of the spatial expression of neuroactive substances (e.g., neurotransmitters, neuromodulators) have contributed important insights into the structure and evolution of the arthropod central nervous system (CNS). In some instances, this was accompanied by the discovery of reliably identifiable, stereotypical neuron types that are shared between major lineages and therefore likely homologous. Pioneering studies on the highly conserved neuropeptide SIFamide in ticks and sea spiders have provided first indications that characteristic neuronal patterns may be present in the chelicerate CNS.

Extending these preliminary findings, this study employed fluorescent immunolabeling coupled with confocal laser scan microscopy to describe and compare the SIFamide-immunoreactive neurons in the CNS of five additional chelicerate groups. In addition to taxon-specific patterns, several neuron types

can be identified that display similar soma positions and projections across groups. In particular, one brain neuron type with soma in the anterior protocerebrum and contralaterally descending main neurite is shared by almost all chelicerates examined and appears to be part of their ground pattern. Beyond this, this type shows striking similarities to SIFamide-immunoreactive neurons in all insects studied so far and potentially also in crustaceans. This may even indicate homology across arthropod subphyla, revealing a CNS feature that putatively dates back to the last common ancestor of arthropods.

Between conservation and colonization: Amphipoda (Crustacea: Peracarida) from a marine protected area and a fouling community in the Northern Adriatic

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Habitat destruction, artificial structures, species introductions - Humans influence the marine ecosystem in many ways, often resulting in a decline of biodiversity. The aim of this project was to investigate the diversity of amphipods in mediterranean marine habitats with different degrees of anthropogenic influence, alongside a brief introduction to amphipod identification using scanning electron microscopy and light microscopic pictures. Samples were collected in the marine protected area (MPA) of Brijuni National Park (Croatia) as well as from biofouling of the pillars of five gas platforms in the northern Adriatic Sea. The amphipods present in these samples were identified morphologically to species level. In the MPA, a total of 40 different amphipod species were found, including four species endemic to the Mediterranean (*Lysianella dellavallei*, *Ampithoe riedli, Leptocheirus mariae and Autonoe rubromaculatus)*. Only one species, *Caprella scaura*, was classified as non-native and potentially invasive. In contrast, only four amphipod species were recorded in the artificial habitat of the gas platforms, all of which were classified as either invasive (*Jassa slatteryi*, *Stenothoe georgiana*) or cryptogenic, meaning of unclear origin (*Elasmopus rapax*, *Stenothoe valida*). The Shannon diversity index was calculated for both areas, as well as the relative abundance of each species. Brijuni MPA had a higher Shannon index, while the relative abundance of most species was low compared to the artificial habitat. The findings of this study highlight the importance of marine protected areas in safeguarding local fauna and preserving native and endemic species. At the same time, they demonstrate how artificial structures in marine ecosystems can facilitate the introduction, establishment, and potential mass proliferation of non-indigenous species (NIS).

Symbiotic algae in an acoel worm: tissue-dependent intracellularity and interaction with host cells

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Photosymbiosis, or the association between a host and photosynthetic organisms, is widespread and ecologically relevant in marine environments. Most animals harbour their photosynthetic endosymbionts within cells or specialised organs. However, within Acoela, whereas some species harbour intracellular dinoflagellates, others host apparently extracellular green algae. Extracellular symbionts interspersed among animal cells are likely to interact with their host in a completely different way than intracellular symbionts. A morphological characterisation of these interactions is still lacking. We use histology and Transmission Electron Microscopy (TEM) to investigate the symbiosis between the acoel flatworm *Convolutriloba macropyga* and the green alga *Tetraselmis* sp. We describe the distribution of the photosymbionts within the worm and their preferred localisation at the body wall, as well as their close association with the nervous system and reproductive organs. At a cellular level, while the symbionts are extracellular when associated to the body wall, in internal tissues algal symbionts can also be found inside parenchymal cells, suggesting digestion or transport by parenchymal cells. This indicates that *C. macropyga* can interact with its symbionts in more than one way. Furthermore, using TEM, we compare the ultrastructure of Tetraselmis algae upon symbiosis establishment in *C. macropyga* juveniles with their free-living state. Upon entering the host, the algae lose their flagella and thecae but retain their eyespots; intracellular algae are found only within parenchymal cells containing digestive vacuoles, similarly to the pattern observed in adults. Overall, our observations reveal that the interaction between acoel cells and algal symbionts is more complex than previously described: the symbionts are not exclusively extracellular, and their interaction varies with different types of animal cells. This detailed characterisation offers a basis for functional and evolutionary studies of photosymbiosis, as well as of how animals can interact with foreign cells within their tissue.

The head anatomy of Smicromyrme (Hymenoptera: Mutillidae) and comparisons considering ants and other aculeates

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Ants are among the most diverse eusocial insects and dominate almost all terrestrial ecosystems. Their success is at least partly attributed to their unique combination of eusocial, predatory, and ground-living lifestyles. In recent years, anatomical studies of ants have progressed, revealing new morphological features that may relate to aspects of their successful lifestyle. However, understanding of ant morphological evolution is hindered by limited anatomical knowledge of most other Aculeata. Various

elements of the ant lifestyle occur in different combinations across the group, providing ample ground for evolutionary insight.
Mutillidae are particularly interesting in this context, as they have wingless females like ant workers but live a parasitoid lifestyle. Yet their anatomy has not been investigated with modern methods, and information on internal features such as the skeletomuscular system is extremely scarce. Here, we present the first anatomical reconstruction of a mutillid head based on synchrotron μCT scanning. Compared with other aculeates, we note the presence of filament-attached fibers in the mandibular muscle, rarely observed outside ants. The studied mutillid has simple oral arms on its prepharyngeal sucking pumps, differing from the ant groundplan condition. The sucking pump musculature generally conforms to other aculeates, but interestingly, muscle hy2 originates on a distinct process near the antennal socket not found in other groups. This likely represents an analogous condition to the torular apodeme of crown ants. Unlike other aculeates, *Smicromyrme* has three scapo-pedicellar muscles rather than two. In addition to well-developed mandibular glands and small prepharyngeal glands, we also found a maxillary gland and a small potential gland in the labium. Our comparisons provide new insights into the evolution of head features across Aculeata and open avenues for interpreting features potentially crucial to the success of groups such as Formicidae.

Step by step: Organogenesis during crab metamorphosis

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Brachyuran crabs such as the Asian Shore Crab *Hemigrapsus sanguineus* have a biphasic life cycle consisting of planktonic Zoea and benthic adults and the semi benthic Megalopa as an intermediate stage. Metamorphosis from the last Zoea to the Megalopa involves significant morphological changes, particularly affecting appendage functionality. This study asks the question which developmental changes take place at the level of internal organs in *H. sanguineus* larvae, particularly during the final Zoea, with a focus towards metamorphosis into the megalopa. To answer this question, egg-bearing females were sampled in July 2025 on the intertidal rocky shore of Helgoland and kept in temperature constant rooms at 18°C (Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, Biologische Anstalt Helgoland, Germany). Freshly hatched larvae were then reared at 21°C with daily water and food (*Artemia spp.* nauplii) changes. We fixated Zoea 5 every day from freshly moulted to the last day before metamorphosis (duration 7 days) for further analysis. At the University of Greifswald, we employed immunohistochemical techniques with markers against the neuropeptide FMRFamid, the presynaptic protein Synapsin and a nuclei marker to assess structural changes within the nervous system. Combined with confocal laser scanning microscopy, our data shows sequential changes to occur in the nervous system, mainly in the ventral nerve cord. The synaptic areas (neuropils) associated with the thoracic appendages that will become the walking legs in the megalopa, increased in size over the seven sampled days. Connections within and between the leg neuropils increased as determined by stained against FMRFamid. However, signals of Synapsin between the leg neuropils seem to decrease, while the neuropils grow. Our findings indicate that, at the level of internal organs, metamorphosis may be a rather gradual process than an abrupt step in development. Our next analyses will include serial histological sections and 3D reconstructions of further internal organs.

Functional morphology and sexual selection of the copulatory structures in the millipede *Acanthopetalum carinatum* (Callipodida, Diplopoda)

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Sexual selection greatly influences the evolution of animals and their genitalia. This phenomenon is particularly well studied in many groups of Hexapoda. Comparable in-depth studies of other arthropod groups will help to test general hypotheses on selection mechanisms underlying genital diversity. In males of the diplopod group Helminthomorpha, one or more pairs of anterior walking legs transform into secondary copulatory organs (gonopods) that interact species-specifically with the female copulatory organs (vulvae). The complex interaction of the morphologically extremely diverse genitalia is thought to be key factor for the radiation of this species-rich group involving various sexual selection mechanisms—including sperm competition, lock-and-key mechanism, female choice, and cryptic female choice.
To reconstruct the sexual selection mechanisms involved in the evolution of helminthomorph gonopods, we investigated the functional morphology of the copulatory organs in *Acanthopetalum carinatum*. This species belongs to the Callipodida, a helminthomorph group that has not been previously examined in this context. The copulatory interface of frozen mating pairs was reconstructed using 3D µCT scans in combination with confocal laser scanning microscopy (cLSM). This approach provides insights into their material properties and allows functional interpretations of various subcomponents of these complex organs. The findings are discussed in an evolutionary context by comparison with other species, enabling inferences about the sexual selection mechanisms acting upon these structures.

Flow field analysis reveals hydrodynamic differences between ecological morphs of *Daphnia*

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Daphnia is a genus of small crustaceans inhabiting the pelagic zone of limnic ecosystems worldwide. Their locomotion movements repeat cyclically, consisting of an active antennal downstroke (i) with upwards propulsion and a passive phase in which the antennae are repositioned and spread out (ii) to slow sinking (iii) until the next downstroke. In daphnid locomotion, friction forces predominate inertness, so that fluid set in motion by force impulses like antennal movements, rapidly decelerates again. Therefore, the flow around *Daphnia* is characterised by strong gradients and velocity changes. One way to analyse the water flow around *Daphnia* is Particle Image Velocimetry (PIV). PIV gives the water flow as vector fields and is established for zooplankton. However, previous analyses of PIV recordings only allowed comparison of individual locomotion cycles. To average multiple locomotion cycles and statistically compare different ecological morphs of *Daphnia* (undefended and defended against a predator), we developed a MATLAB algorithm based on alignment and interpolation of vector fields. In both morphs, the downstroke creates two vortices at the tips of the antennae and a jet that persists as velocity maxima during the sinking. Water velocities significantly differ between the morphs, being higher in the immediate vicinity of the body of undefended *Daphnia* and lower at their antennae,

compared with defended individuals. Our newly established method therefore gives new insights into *Daphnia's* ecology regarding predator-prey relationship and costs of inducible defences.

The hidden anatomy of ricefish reproduction: A histological perspective

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Teleosts exhibit a wide range of reproductive strategies. In external-brooding species, developing eggs may be attached to the body of one of the parents, requiring the evolution of morphological structures that facilitate attachment. All ricefishes (Beloniformes: Adrianichthyidae) share the distinctive trait that females carry fertilized eggs behind their pelvic fins, where the eggs are anchored to the reproductive system via long attaching filaments. However, while transfer brooding females strip off their eggs onto vegetation after only a few hours, pelvic brooding females carry the eggs until the embryos hatch. Previous studies have shown that pelvic brooding entails a complex suite of morphological adaptations associated with prolonged egg carrying and that this strategy evolved independently in two distantly related lineages (*Oryzias* and *Adrianichthys*). Here, using histological sections from females and males of three transfer brooding (*O. dopingdopingensis*, *O. asinua*, and *O. nigrimas*) and four pelvic-brooding species (*O. sarasinorum*, *O. eversi*, *O. kalimpaaensis*, and *A. oophorus*), we show inter-specific key differences in their reproductive systems. For instance, in *A. oophorus*, an enlarged sphincter-like muscle maintains egg attachment, whereas in *O. eversi* and *O. sarasinorum*, a specialized structure, the plug, forms during brooding. Unexpectedly, we also found substantial differences in sperm duct morphology not only between pelvic and transfer brooding species but also between the two pelvic-brooding genera. These findings indicate that prolonged egg-carrying drives morphological adaptations in both sexes and that it might be in some cases species- specific.

From larvae to worm-like adult: Morphogenesis in a vermetid gastropod

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Worm snails (Vermetidae), a clade of marine sessile gastropods exhibit an unconventional body plan, yet their developmental biology remains largely unknown. Here, we present the first integrative characterization of morphogenesis including neurogenesis, myogenesis, and shell formation in our model vermetid, *Thylaeodus cf. rugulosus*. *Thylaeodus* displays an extraordinary form of brood care: serially aligned embryo capsules are attached to the inside of the adult shell, containing multiple developmental stages alongside nurse embryos on which larvae feed. Despite their unusual adult morphology, vermetid larval development follows a typical gastropod trajectory, progressing through trochophore and veliger stages. Hatchlings emerge as crawling intermediate stages and typically settle close to the mother animal, attach permanently to the substrate, and transition to an elongated, worm-like adult.

Neurogenesis partly conforms to the gastropod-typical pattern but shows a significantly delayed establishment of the spiralian-typical larval apical organ. Although the gastropod-conserved five-cell serotonergic configuration forms in trochophore stage, the first apical tuft elements appear only after torsion as paired tubulin-positive cells, which persist through hatching and increase in number. After torsion, the chiastoneurous nerve loop is established and pedal nerves extend into the developing foot;

hatchlings already possess an adult-like nervous system with fused cerebral–pleural, pedal, and abdominal ganglia. Myogenesis initially follows a gastropod-typical pattern with first muscle fibers during the trochophore stage and a complete primary larval muscle set before torsion. However, unlike most gastropods, *T. rugulosus* main larval retractor does not degenerate at metamorphosis but seems to be retained and subsequently forms the adult columellar muscle.
This study provides a foundational developmental framework for future projects on the molecular aspects that underlie the establishment of the unusual, worm-shaped adult vermetid body plan. The unusual myogenic pattern and the apical organ morphology highlight how life-history transitions, encapsulated development, and sessility may contribute to reshaping the gastropod developmental program.

Comparative morphology and ultrastructure of the reproductive system in the House Centipede *Scutigera coleoptrata* (Chilopoda)

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To face functional questions and investigate how animal organ systems work, it is crucial to include histological and ultrastructural data. The reproductive organs of centipedes have mainly been illustrated through line drawings based on dissections and, in some cases, histological sections. The histological organization and ultrastructure of the genital organs are known only for selected genera. In the House Centipede *Scutigera coleoptrata*, the genital organs are described based on histological sections with little ultrastructural data confined to double spermatogenesis within the testes. This study aims to increase knowledge about the functional morphology of *S. coleoptrata´s* genital organs using a multimodal microscopic approach. We investigated the structure of female and male genital organs by analyzing µCT-scans, paraffin, and semi-thin sections. Transmission electron microscopy (TEM) was applied to examine the systems and understand the functional ultrastructure of organ compartments. Our reconstructions fit existing schemes in literature for both sexes. However, we found that the proportions of the vasa efferentia and vas deferens in males differ from previous descriptions. In females, our investigation revealed new insights into the structure of the ducts of the accessory glands and spermathecae, and their connections to the genital atrium. Histology and TEM revealed circular musculature surrounding the ducts of the spermathecae, likely involved in sperm uptake and/or release. Further TEM images of spermathecae and accessory glands allow a better understanding of the functional morphology of the female reproductive system regarding fertilization and oviposition. In males, current TEM imaging of the sexual system will provide details of seminal vesicles, genital atrium, and accessory glands. This study adds to existing morphological descriptions in *S. coleoptrata* by presenting comprehensive morphological data on reproductive organs based on both invasive and non-invasive methods. This is a first step to meet our future goal, elucidating and documenting the reproductive behavior of *S. coleoptrata*.

Sped up shape: Measuring phenotypic evolution of threespine stickleback in an ongoing natural experiment

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Is it possible to predict evolution in nature? Theory and experimental studies in the lab suggest that evolution may be, to some degree, predictable. But how do these findings apply to real-world conditions? To test the predictability of evolution in nature, we have established a natural experiment in which populations of threespine stickleback (*Gasterosteus aculeatus*) have been reintroduced to eight fishless lakes in the Alaskan Kenai peninsula. Four of these lakes have comparatively benthic habitats with largely invertebrate prey, and the other four have more limnetic habitats with largely zooplanktonic prey To test whether stickleback evolve predictable morphological phenotypes associated with these largely dietary niches, we have collected photographic and uCT data from the fish used for the introductions, as well as specimens collected over the past six years from the introduction lakes. To analyze these phenotypes, however, requires accurate annotation and measurement of the nearly 20,000 thousand photographs taken under field conditions, as well as hundreds of uCT specimens that will be collected for this project. To this end, we have designed and applied machine-learning (ML) based pipelines to filter raw and landmark data accurately and efficiently both 2D and 3D formats. These pipelines include semiautomatic object detection, photographic alignment, splitting of a multi-scan into regions of interest for each specimen, reconstruction of targeted anatomical structures, and geometric morphometrics. We present our preliminary findings based on data from the last six years of sampling in this project, demonstrating the considerable time and cost savings of this approach while minimizing error. These findings add to a growing body of work showcasing the possibilities of using ML to extract high-throughput, high-dimensional data. In addition, we indicate the value of natural experimental studies for understanding whether the direction, tempo and mode of evolution is predictable.

From cabinets to collectomics: Discovering females and larvae of Strepsiptera in a historical collection

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Natural history collections house material from centuries of collecting efforts. In the Phyletisches Museum (PMJ) ca. 1 Mio specimens are deposited, some of them dating back as far as the 17th century. Modern imaging techniques have the potential to gain new insights from this historical material. However, a large part of the PMJ's insect collection has not been revised by scientists in recent times. We now screened the entire Auchenorrhyncha collection and found several specimens parasitized by two species of the genus *Halictophagus* (Halictophagidae, Strepsiptera). These historical findings are the only records of the two species in Germany to date and suggest a broader range of their distribution. In addition, the previously unknown females and primary larvae, likely belonging to *Halictophagus curtisii*, were morphologically documented using state-of-the-art techniques such as synchrotron-radiation

based x-ray µCT and scanning electron microscopy. The data generated in this study cover the field of collectomics and can seamlessly be used as a basis for the emerging discipline of museomics. In taxonomic and systematic research and in the context of environmental changes pinned insects may play an outstanding role in the near future as their DNA is not damaged by formalin-fixation and thus can yield remarkable results after even more than 100 years. Our results underpin the value of historical material for modern research questions, especially for species, that are rarely found in nature.

Looking behind — *in vivo* investigations on structural motions inside the locust ear

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A sense of hearing allows prey location and predator avoidance as well as acoustic communication. For this, an ability to determine the direction of a sound can be crucial. Animals which are small compared to the wavelength of sound, such as insects, face particular challenges in this regard. Insects have developed a variety of hearing organs. For example, some use their antennae as flagellar ears, while others possess tympanal ears, which may be positioned at different positions on their bodies. These usually involve mechanosensitive sensory cells (chordotonal organs). The ears of acridid grasshoppers are located in the first abdominal segment, with the chordotonal Müller's organ attached to the back of the tympanum. These species have hearing ranges between less than 1 kHz up to about 40 kHz (Suga, 1960, Jpn J Physiol 10). Tracheal sacs, which are transparent to sound, lie between the ears and it is assumed that these tracheal sacks connect both ears. This coupling of the ears could be relevant for directional hearing at lower sound frequencies (Römer & Schmidt, 2016, Biol Cybern 110) and is not fully understood.
We employ a technique called optical coherence tomography (OCT) to monitor motions of structures on and inside the body using interferometry. With OCT, we investigate the mechanics of the locust ear *in vivo*, focusing on the tympanal membrane and the wall of the tracheal sac surrounding the ear inside the insect. Across the entire hearing range of the animal, we measure sound-induced vibrations and create vibrometry maps of mechanical responses to different frequencies. With our motion data on structures surrounding the hearing organ, we expect to produce significant advances in the research of insect ear mechanics.

Developmental repatterning „types“ underlying the evolution of cranial morphological diversity in South American killifishes.

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With more then 34.000 described recent species, bony fishes (Teleostei) exhibit extraordinary evolutionary success in terms of morphological disparity and species richness. Large parts of this success are attributed to the highly diverse cranial morphology. The viscerocranium, a modular component of the cranium comprising the mandibular, hyoid, and branchial arches, plays a central role in feeding and respiration. What are the developmental modifications that can alter viscerocranial morphology and lead to the evolution of specialized diets and trophic radiation, thereby facilitating niche construction?

Annual killifish of the genus *Austrolebias*, which inhabit ephemeral ponds in South America and persist through diapausing eggs, show striking trophic radiation that evolved in concern with the occupation of unpredictable habitats. In this study, we compare viscerocranial development in the generalist species *Austrolebias nigripinnis* and the derived piscivore *A. elongatus*. Using synchrotron scans, confocal microscopy, and cleared-and-stained specimens, we quantified the timing of cartilage and bone formation in viscerocranial and other skeletal elements to test for the role of heterochrony in the evolution of the specialized piscivore morphology. Furthermore, we quantified the growth of selected skeletal elements to test for differences in growth patterns (isometric vs. allometric) between *A. nigripinnis* and *A. elongatus*. Our results demonstrate that changes in the developmental timing and growth rate underlie the evolution of piscivory in *A. elongatus*.

Fossil morphology illuminates coevolution of Insects and vertebrates in the Mesozoic: examples from katydids and giant cicadas

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Fossil morphology represents a precious window which provides irreplaceable information for investigating the taxonomy, palaeoecology, and evolution of extinct lineages. Insects are the most diverse groups on earth and preserved with plenty of fossils. Disentangling their ecological roles are crucial for understanding the evolution of terrestrial ecosystems, however, reconstructing the adaptive evolution of extinct insects has been proven to be highly challenging. Here, we conduct integrated approaches to reveal the macroevolution of two insect clades, katydids (Hagloidea) and giant cicadas (Palaeontinidae), on the basis of newly compiled morphological datasets. Our results provide novel information for coevolution of insects and vertebrates in the Mesozoic, and highlight the significance of fossil morphologies. 1) Acoustic evolution of katydids. We present a database of the stridulatory apparatus and wing morphology of Mesozoic katydids and analyze the evolution of their acoustic communication. Our results demonstrate that katydids evolved complex acoustic communication including mating signals, intermale communication, and directional hearing, by the Middle Jurassic; evolved high-frequency musical calls by the Late Triassic. The Early—Middle Jurassic katydid transition coincided with the diversification of mammalian clades, supporting the hypothesis of the acoustic coevolution of mammals and katydids. 2) Flight evolution of giant cicadas. We reveal the flight evolution of the Mesozoic arboreal insect clade Palaeontinidae. Our analyses unveil a faunal turnover from early to late Palaeontinidae during the Jurassic–Cretaceous, accompanied by a morphological adaptive shift and improvement in flight abilities including increased speed and enhanced maneuverability. The

adaptive aerodynamic evolution of Palaeontinidae may have been stimulated by the rise of early birds, supporting the hypothesis of an aerial evolutionary arms race between Palaeontinidae and birds.

Interactions with ants and possible functions of the foveal system of ant-like litter beetles (Pselaphinae, Staphylinidae)

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In Pselaphinae, a hyper-diverse subgroup of rove beetles (Staphylinidae, Coleoptera), myrmecophily has evolved multiple times independently. Adaptations linked to an association with ants are found across all lineages of Pselaphinae, and also in species that are not considered myrmecophilous. This includes ant-like habitus, strong reinforcements of cuticular structures and complicated systems of cuticular invaginations (fovea) found in all body tagmata. The fovea function, as well as the lifestyle of most of the pselaphine species remained mysterious, and until now there have been no studies on the ultrastructure of the foveae.
Since the function of those structures is most likely the key to understanding the incredible evolutionary success of pselaphines, we used a combination of morphological techniques (SEM, µCT, 3D reconstructions, semi- and ultra-thin sections) and behavioral experiments to clarify this issue. We found out that the openings of the thoracic foveae in non-myrmecophilous *B. curtisii* are surrounded by setae, which are connected to clusters of unicellular glands underneath the foveal cuticle. The fovea in most of the examined pselaphines contains wax-like secretions. Our first behavioral experiments inside of colonies of *Lasius niger* and *Tetramorium caspaetum* (Formicidae) show that the ants seem not to detect *B. curtisii,* neither chemically nor visually, and do not express hostile behavior. However, even explorative grasping with mandibles can be damaging to the cuticle of tiny (1.2 mm) beetles, which would explain the thickened cuticle and strong mechanical reinforcement. Additionally, we observed a complex grooming behavior in *B. curtisii*, that apparently only happens in presence of ants and could be used to distribute secretions across the cuticular surface. Further behavioral experiments, as well as a chemical analysis of the gland secretions on the surface of the pselaphine cuticle are necessary to further study the nature of the relationship between pselaphines and ants.

Posters*:

*Abstracts marked with a bee () are student posters. They are eligible for the Best Poster Prize, and you can VOTE for them.

Cooperative minds in the abyss: reproductive adaptation and social coordination in deep-sea Spionidae (Annelida)

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Deep-sea benthic habitats are typically characterized by low annelid diversity, yet several taxa display unexpectedly complex behaviors that challenge traditional assumptions about polychaete biology. In environments defined by extreme pressure, limited food availability, and spatially heterogeneous

resources, cooperative sexual strategies may offer substantial evolutionary advantages. However, direct observations in deep-sea annelids have remained scarce due to technological limitations.
In this study, we present high-resolution images and videos in their natural environment as well as morphological data uncovering the reproductive adaptations and structured interactions among deep-sea Spionidae. Using autonomous imaging platforms, we captured striking behavioral patterns including cooperative mating behavior, coordinated sediment manipulation, and collective foraging. Morphological approaches give hints towards the anatomical adaptations related with such impressive annelid behaviors.
Our observations further reveal behavioral traits not previously attributed to annelids: excessive mating dances and reproductive cuddle piles combined with deceptive behavior, in which subordinate worms employed misleading postures or rapid color shifts to distract conspecifics and gain temporary access to the best mating grounds; and signs of hierarchical structuring, with certain individuals occupying consistently advantageous positions within the annelid cuddle piles.
These findings indicate a level of anatomical adaptations as well as related behavioral happenings far exceeding expectations for deep-sea annelids. We propose that such cooperative strategies, supported by morphological changes of the annelid body plan, may represent key adaptive responses enabling survival and reproduction in low-diversity deep-sea ecosystems. Our study highlights the importance of in situ observations of complex behavior in extreme marine environments and opens new avenues for comparative morphological research questions in Annelida.

Impact of body size and wing morphology on the sound frequency of calling songs in the field cricket *Gryllus bimaculatus*

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As a mechanism of female choice for larger males as mating partners, it was suggested that female crickets should prefer conspecific males that produce calling songs with lower sound frequencies. However, several studies failed to show a correlation between male body size and the sound frequency of their calls. Male field crickets sing by rhythmically rubbing their front wings together, which have specific structures for sound production. During each wing-closing movement, a sound pulse is produced when the hard edge of the left wing (plectrum) scratches over a line of cuticle teeth (file) at the ventral side of the right wing. The resulting vibration of both wings are amplified, phase shifted, filtered and emitted as sound waves by membranous wing areas (chord, harp and mirror). Here we analysed how different body size indicators (mass, length and width) and the morphology of wing structures for sound production (file length, teeth distance, as well as chord, mirror and harp area) correlate with the dominant sound frequency of the calling song within and across 2 captive populations of *Gryllus bimaculatus* that differ significantly in body size (L-crickets, S-crickets). To test for the impact of their genetical differences and developmental conditions, we also produced hybrids by crossbreeding (H-crickets) and raised S-crickets under L-cricket conditions (S_L-crickets). The sound frequency of the calling song did not significantly correlate with any of the other parameters within either of the 4 groups, but significant correlations were found between body size, wing areas and sound frequency when tested across all tested animals.

Diversity and development of the prototroch in Trochozoa

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The prototroch, a preoral ring of ciliated cells used for swimming and feeding, is the eponymous structure of the trochophore, the iconic larva of Trochozoa. The cell-lineage of the cells constituting the prototroch, the trochoblasts seems to show a stereotypic pattern in nearly all investigated species. The trochoblasts cease to divide already early during embryogenesis and start to develop cilia, making the resulting prototroch the first differentiated structure in the trochophore. As a strictly larval structure, the prototroch is restricted to the larval phase of the trochozoan life-cycle. Although the prototroch has been in the focus of investigations for more than 100 years, there are still open questions regarding (1) the exact composition of the prototroch in different trochozoan lineages, (2) the maintenance of prototroch cells during larval development, and (3) the fate of the prototroch cells during metamorphosis of the trochophore to the juvenile. These questions are addressed using different stains and detection with CLSM in several trochozoan species. The results show that the prototroch is a structure that has diversified considerably during the evolution of its bearers.

Strong modifications of abdominal sclerites in Pselaphinae (Coleoptera: Staphylinidae) as an adaptation to association with ants

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Rove beetles (Staphylinidae) are generally known for their shortened elytra and highly flexible abdomen, which in combination with pygideal adrenal glands, is used for defense. Although Pselaphinae belong to Staphylinidae and also use their abdomen for protection, they followed a different evolutionary path and have undergone a row of drastic morphological modifications. These tiny (0.7 - 4mm) beetles possess highly sclerotized, relatively immobile abdomen, where some segments may even be fused. Those adaptations might likely have happened due to their strong association with ants. One way to survive these unavoidable encounters is to hide, optically or chemically. Another way is to strengthen your exoskeleton to avoid being crushed. This evolutionary path has likely led to the vast diversification of Pselaphinae (>10,000 described spp.).
Until recently, the morphological documentation of most pselaphine species has been quite sparse, with almost no information on the inner structures. With the help of µCT and 3D reconstructions we thoroughly examined the abdominal structures of a myrmecophilous pselaphine, *Batrisus formicarius,* and compared them with those of other pselaphines, as well as those of closely related non-pselaphine rove beetles. What we found in *Batrisus formicarius* is not only a heavily sclerotized abdomen with fused segments, but a series of internal adaptations of the exoskeleton. Deep cuticular invaginations (foveae) form massive internal crossbars that provide stability. Additionally, sclerotized bubble-like structures strengthen weak points between the segment boundaries. Together with similar structures in the thorax and a robust head *Batrisus formicarius* and other pselaphines are well adapted to live close to ants, which offers plenty of new accessible niches.

Comparative gait analyses in two differently sized drosophilid fly species running on slippery and non-slippery substrates

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The scarcity of species-specific data on insect locomo5on hinders the integra5on of behavioural, ecological and evolu5onary knowledge for the most species-rich group of animals. This lack of informa5on contrasts sharply with the growing number of theore5cal approaches to animal locomo5on, which highlight the dependency of locomo5on traits, such as specific adapta5ons in dynamics, energe5cs and control, on morphological characteris5cs. In order to probe model outcomes within a rather narrow framework, here, we examine the level locomo5on of two drosophilid fly species compara5vely that differ in size and weight. Following ini5al compara5ve morphometric analyses of leg and aDachment structures, we inves5gated the walking behavior of wild type specimens of *Drosophila melanogaster* and the twice as large *Drosophila virilis* on a experimental running track equipped with flooring of differing surface structures. To simulate the range of surface condi5ons that the animals would usually encounter in their natural habitats, the flooring was made from slippery PTFE, non-slippery paper, and microrough sandpaper. The runs were recorded simultaneously from top and side using a high-speed video system, which enabled us to analyse the horizontal and sagiDal kinema5cs and dynamics of the body, as well as the coordina5on paDerns of the legs. With this approach we strive to answer the ques5on of how the locomotor system of differently sized Drosophilids copes with different substrates.

Characterisation of the defence system of *Latia neritoides* (Mollusca; Gastropoda; Hygrophila)

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Bioadhesives are produced by various organisms, ranging from prokaryotes to plants and animals. The biologically often complex substances evolved over millions of years to adapt to specific needs such as attachment to the substrate, food capture, predation, and defence. The latter is the case in *Latia neritoides*, an endemic freshwater snail of the northern island of New Zealand/Aotearoa. When attacked

by predators, the snail releases a bioluminescent mucus, spread by the fast-flowing water to deter them. This mucus is also sticky and adheres to the predators themselves. Regardless of their hypothesised function, the underlying gland system and production origin remain largely understudied, and some of the chemicals involved in the bioluminescent as well as sticky secretions remain elusive as well.
Histochemical and morphological examinations of the lateral foot region revealed two promising types of glandular cells. However, personal observations suggest that the luminescent component is primarily released from the pneumostome. Using a µ-CT stack, we examined the entire animal for mucus reservoirs and alternative glandular cell structures that may be involved in the defence mucus system. Comparison of the protein profiles generated by electrophoretic separation of the defence and trail mucus shows substantial variation in total protein concentration, number and physicochemical properties of the proteins. Among those, we have discovered unknown proteins that appear to be unique to the luminescent mucus.
Broadening our understanding of these unique proteins in defensive mucus enhances our knowledge of the luminescent mucus system of *Latia neritoides* and contributes to the development of novel aqueous medical adhesives suitable for moist environments, including tissue adhesives and haemostatic agents.

Taxonomic revision of the bee-mimicking robber fly genus Hyperechia Schiner, 1866 (Diptera: Asilidae), including seven new species and four new synonyms

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The large and charismatic, carpenter bee-mimicking robber fly genus *Hyperechia* Schiner, 1866 (Diptera, Asilidae, Laphriinae) is reviewed for the first time in 50 years using morphological examination of 873 museum specimens and 446 photographic records. 21 valid species (including seven new to science) are recognized and four new junior synonyms are found. All species are depicted (including sexual dimorphism and intraspecific variation as well as genital morphology for selected species), and a diagnosis for the new species is presented. The expanded record distribution of *Hyperechia* is mapped, the genus is now known from almost every country of Sub-Saharan Africa as well as India, Sri Lanka, Indonesia and Malaysia. A photographic record from Saudi Arabia (most likely representing *H. pellitiventris* or an undescribed species) expands the known range into the Palearctic region. The occurrence of *H. bomboides* on Cabo Verde represents the first record of the family on this archipelago. *Hyperechia* were found to be specialized on Hymenoptera as prey and bees of the genus *Xylocopa* as larval hosts, representing the second recorded instance of a parasitoid lifestyle within Asilidae. Larvae and pupae are depicted and the loose connection of mimicry and host specialization is discussed. Known hosts are shown for all species while mimicry models and phenological data are shown exemplarily. This revision finally makes a neglected taxon identifiable for both researchers and amateurs, thereby representing one piece to the puzzle of illuminated biodiversity. It sets the foundation for further molecular and morphological research on the unique lifestyle of this bee-

Symbiosis establishment between the acoel *Convolutriloba macropyga* and the green algae *Tetraselmis Sp*.

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Acoels are marine invertebrates found across all oceans and a remarkable range of habitats, from shallow coastal waters to deep-sea environments. Their ecological success is partly attributed to the ability of many species to form photosymbiotic relationships with algae or dinoflagellates. *Convolutriloba macropyga*, a member of the Convolutidae, establishes photosymbiosis with green algae and has attracted interest not only for this association but also for its unusual dual reproductive mode. This hermaphroditic species can reproduce both asexually and sexually, resulting in two distinct routes of symbiont acquisition: vertical transmission of algae during asexual reproduction and horizontal uptake from the environment during sexual reproduction. Horizontal acquisition occurs through ingestion of free-living algae, yet the cellular and morphological steps underlying symbiosis establishment have been poorly investigated so far. By means of confocal imaging, this study investigates the early changes in number and spatial distribution of *Tetraselmis* sp. algae taken up by the juveniles within the first six days after the initial contact. We observed a progressive increase in the number of acquired algae during longer exposure periods. Notably, algal numbers continued to rise even after exposure ceased, suggesting proliferation of algae within the juveniles' tissues. Furthermore, algae distributed near the body walls increased with prolonged passing of days, resembling the symbiont distribution at the body periphery typical of adults. This pattern points to a movement of algae towards morphologically relevant regions associated with stable photosymbiosis even after just a few days from algal uptake. Our findings elucidate the earliest events driving the establishment of photosymbiosis in *C. macropyga* and provide insight into general patterns of horizontal symbiont acquisition in acoels. Understanding these initial steps may contribute to a broader perspective on the evolution and morphology of host–symbiont integration in marine invertebrates.

The ear region of dormice: Part I. Septal compass of the middle ear cavity in extinct and extant glirids (Gliridae, Mammalia)

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The ear region of rodents is highly specialized and plays an essential role in communication. Rodent ear morphology can also be used to distinguish between different locomotion styles. Inside the bony skull, rodents have an inner ear with a vestibular system for sensing the equilibrium of the organism and a well-developed middle ear for detecting sound, composed of a cavity and three auditory ossicles (malleus, incus, and stapes). In the rodent family Gliridae**,** commonly known as dormice, the middle ear

cavity shows several morphological specializations that support their sensitive hearing abilities. The middle ear is relatively spacious in many species, providing good acoustic resonance and improving the transmission of sound vibrations. This enlarged cavity is separated by distinct bony septa, the distribution pattern of which represents a phylogenetic signal. In this study, this distribution is visualized and interpreted with the 'septal compass' and 'septal formula' to elucidate phylogenetic issues in extant and extinct species. Except *Glis glis*, all the investigated glirids possess a posterior medial diverticulum. A high number and complex distribution of bony septa in the Japanese taxon *Glirulus japonicus* is seen and does not fit in any other septal compass schema of Eusciurida (sciurids, glirids, *Aplodontia rufa*). The specimen of the extinct insular giant *Leithia* sp. investigated here possesses an additional ventral cavity, which is not seen in any other species in our sample. The distribution of septa in the epitympanic recess is variable and does not represent any phylogenetic distribution known up to now. Therefore, it becomes apparent that investigating the bony septa of the middle ear alone is insufficient for phylogenetic analyses. For further studies, we will include characters of the auditory ossicles and the bony labyrinth to better understand the variation of the internal ear architecture within the dormouse lineage.

Bone to be wild:
A microanatomical study of the long bones in two caudates species

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Amphibians are speciose living at the interface between terrestrial and aquatic environments with various reproductive strategies. While some are still strongly linked to water and changed morphotype through mating season and stay a long time in the water, other just lay their young, already larvae instead of eggs and go directly back to land. These different strategies could have an impact the bone microanatomy which is a really plastic structure. To explore this possibility, we selected two species of Salamanders, *S. Salamandra* and *I. alpestris*. For the first, only female go back in water and lay the offspring in water then go directly back to land, while the later stay in water through mating season, male even developing a different morphotype. We found that while larvae are clearly separate from adults for both species, there is no clear distinction for juvenile which are either microanatomicaly considered larvae or fully adults. In adults, mating season and the laying of young in water is not visible for S. Salamandra. In I. alpestris, while we previously thought that the external morphotype could reflect the microanatomical organisation, it is not the case. However, if we separate individuals by the time they were taken in nature (out of mating season, before mating season, mating season and after mating season), we can observe a difference especially between out of mating and after mating). These results offer a brand-new perspective on microanatomical studies in amphibians and on the importance to allow of the moment the specimens was taken for collections.

Look, lock, lunch: Vision in robber flies with different hunting strategies

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Robber flies (Diptera: Asilidae) are predatory insects that rely on visual perception to locate and capture prey. They perch in open spots before hunting down their prey in fast and short pursuits. Within the family, three perching positions have been evolved: 1) head pointing downwards, 2) head pointing upwards, and 3) flexible body orientation during perching. Our study examines the variations in the visual systems of robber flies that employ these hunting strategies and investigates how vision relates to ecological roles. We applied micro-computed tomography (µCT) to acquire detailed three-dimensional data on the compound eyes of multiple species spanning the robber fly phylogeny. Using this data, we compared the topology of facet sizes and inter-facet angles across compound eyes and inferred information on visual acuity, sensitivity, and visual field size and orientation. Our imaging and analysis pipeline uncovered relationships between eye morphology, vision, and ecological specialization in these formidable hunters.

Upward vision: How mayflies split their visual world

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Male *Cloeon* mayflies possess hypertrophied dorsal “turbanid” eyes whose functional role has remained poorly quantified. Here, we compare the visual sensitivity, spatial acuity, and field-of-view (FOV) of these dorsal eye regions with those of the male’s lateral compound eyes and with the standard compound eyes of females. Using a yet unpublished computational method that extracts facet positions, facet diameters, and inter-facet angles from grating phase contrast micro-CT (GBPC-CT) scans, we estimate regional optical performance across eye types. GBPC-CT allows unprecedented tissue contrast without potential artefacts in the delicate eyes from drying or staining. Our analyses show that turbanid eyes exhibit substantially enlarged facets and reduced inter-facet angles, conferring enhanced sensitivity and improved vertical acuity relative to lateral regions. We additionally characterize the dual-rhabdom architecture of turbanid ommatidia and contrast it with the single-rhabdom design of standard compound eyes. Our results provide the first quantitative, whole-eye comparison of visual capabilities in male and female *Cloeon*, refining hypotheses about the role of dorsal eye specialization in mating and species recognition.

Three-dimensional sonography for imaging of human facial muscles: establishment of a standardized examination protocol

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Two-dimensional sonography is a standard for facial muscle imaging in patients with facial nerve related diseases. However, this neglects the fact that these are three-dimensional (3D) structures that deform in complex ways during mimic movements and emotional expressions. Volumetric 3D measurements in computed tomography or magnetic resonance imaging are time-consuming, expensive, and are not suitable for frequent repeat measurements. 3D facial sonography could be an alternative, that could even be used in motion.
A protocol has been developed to enable standardized recording of facial muscles, as well as the masseter muscle, as a control. Magnetic field-based tracking of a linear 15 MHz ultrasound probe and specialized software allow images from a standard sonography recording to be spatially arranged. The muscles are then manually segmented using 3D data analysis software.
The protocol was tested on the first group of healthy participants. 3D volumetry and gray value analysis were established for the following muscles: *M. occipitofrontalis* (Venter Frontalis), *M. orbicularis oculi*, *M. zygomaticus major*, *M. orbicularis oris*, *M. depressor anguli oris*, *M. depressor labii inferioris*, *M. mentalis*, *M. masseter*. This study outlines the protocol's development process, the results and limitations of the measurements taken thus far.
3D sonography, following our protocol, has the potential to become a reliable method for examining facial muscles at rest and their deformation during contraction. This will establish a better understanding of the complex facial muscle deformation during facial expressions in healthy individuals, as well as in patients with impaired facial motor functions. Further test measurements, including patients with facial palsy, are necessary to verify its reliability. However, to make the leap to clinical practice, it must be possible to automate segmentation and minimize this time-consuming part of the process.

The detailed head anatomy of the barklouse Loensia (Psocodea: Psocidae)

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The bark- and true lice (Psocodea) are a pivotal group in the insect tree of life with more than 12,000 described species. Linked to their evolutionary success is the high diversity of feeding modalities, ranging from nearly generalized chewing-biting types to the evolution of stylets used for piercing and sucking that are retracted inside the head during rest (entognathous condition) in the Anoplura. While the head morphology of the parasitic forms received a reasonable amount of scientific attention in the last century, studies on the head anatomy of “Psocoptera” are scarce. Our knowledge of the atmospheric water-vapour absorption apparatus or the histology of head tissues in general is still fragmentary. We studied the head anatomy of the genus Loensia (Psocomorpha: Psocetae) using (SR)-µCT, histology, photography and SEM, and examined both female and male specimens. The major difference between both sexes was the relative volume of the compound eyes (ca. 40% in male vs. ca. 15% in female) and enlargement of the optic lobes, suggesting males majorly rely on enlarged compound eyes for mate finding. Several new terms for previously undescribed structures are introduced such as the medial rods of the salivary sclerite or the lamellate band of the mortar. Some complications of the muscle homology introduced by previous authors were resolved and compared to all previously published data on psocodean head anatomy. We also found a small labial muscle, originating laterally on the prepalpiger lobe and inserting on the lateral base of the labial palp, that was not described before in Psocodea. The water-vapour absorption apparatus is unlike in previous treatments not only a single apomorphy but represents a character complex consisting of at least 10 different character states. This apparatus was likely one of the key innovations in the evolution of Psocodea and allowed for their widespread diversification.

Apocrita to Aculeata: Evolutionary Insights from the Genitalia of Trigonalyidae

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Trigonalyidae is an enigmatic family of narrow-waisted wasps (Apocrita). Their life history is fascinating and they are a key morphological bridge to the stinging wasps, Aculeata, but knowledge on this group is limited. Previous work on this phylogenetically important group has used CLSM and SEM, which provide useful yet limited information about internal structures of the genitalia and provide constrained views for understanding the geometry of the system. The objectives of the present work are to use µ-CT-based digital dissection: (1) to establish homologies of the genital skeletomusculature; (2) to recognize previously overlooked morphological features; and (3) to provide a new level of observational detail for the genital groundplans of Aculeata and Apocrita. Insights include the discovery of additional muscles in Trigonalyid genitalia, retention of the so-called “digiura” of the volsella, and reconstruction of structures interacting with the penites. Notably, the endophallic sclerite was observed, which is functionally significant yet has previously only been directly observed once. This work provides a foundation for expanded morphological work on the genitalia of a megadiverse insect order—the Hymenoptera.