Editorial

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The idea to put together a special issue on spider research originated in the ‘SpiderWeb’ community, a group of around 60 international scientists which meet biennially to report on current achievements in spider and arthropod research and discuss future strategies. The meetings encompass all aspects of spider research and range from evolutionary-developmental (evo-devo) approaches, using the spider model *Parasteatoda tepidariorum*, to systematics, ecology, morphology and the medical use of spiders. In this special issue, we attempt to give an overview of current spider research, highlighting studies in the respective areas.

The issue is divided into two sections. In the first section, development and evolution of the spider body plan, three papers investigate the early embryonic event of axis formation. Oda et al. discuss the mechanisms of axis duplication in spiders. While this is a well-studied phenomenon in vertebrates, much less is known about it in spiders. Oda et al. review historical and current twinning experiments in various spider species, including molecular approaches. Heingard and Janssen examine the same question in the model spider *P. tepidariorum* by analysing the role of the forkhead box transcription factor FoxB. Decreasing FoxB function results in embryos with partially duplicated median germ bands indicating a role in dorso-ventral axis formation. The article by Pechmann combines molecular and classical transplantation experiments in the enigmatic Brazilian White Knee Tarantula to demonstrate conserved mechanisms of axis duplication. In addition, Pechmann provides detailed descriptions of the developmental stages in living and fixed embryos and a tran-

scriptome as resources for further studies. Besides classical transplantation experiments, the papers by Oda et al. and Pechmann provide new technical approaches (namely laser ablation and bead transplantation), to induce axis duplication in spiders.

The next couple of articles address the question of how the different shapes of the arthropod head have evolved. Schacht, Schomburg and Bucher investigate evolutionary variations in anterior head patterning of arthropods. They show that one of the transcription factors (FoxQ2) of the conserved anterior regulatory network has similar functions in insects and spiders but might be regulated in a different way. The article by Schomburg et al. looks into the causes for the different morphology of the tritocerebral head segments, which in insects corresponds to an appendage-free so-called intercalary segment without appendages, while the homologous segment bears the pedipalps in spiders. The applied candidate gene comparison based on *Drosophila* intercalary segment genes uncovered only three differentially expressed genes. The authors suggest that de novo approaches are required to identify taxa-specific genes that might have shaped the evolution of the pedipalpal segment.

The unique spider pedipalps (and 1st walking legs) are also focus of the next following article by Schacht, Francesconi and Stollewerk. They analyse the distribution and the development of the pattern of the sensory equipment of the *P. tepidariorum* anterior appendages. They show that except for small mechanosensory setae, external sense organs appear in fixed positions on the pedipalps and first walking legs, arranged in longitudinal rows along the proximal-distal axis or in invariable positions relative to morphological landmarks. A comparison with other Entelegynae spiders shows that these features are conserved.

In the second section of the issue, ecology and biodiversity, Nolan et al. address the problem of the phylogenetic placement of the diverse chelicerate species, specifically the position of scorpions, which is the subject of a controversial debate. By analysing a set of gene duplicates in scorpions and spiders, they show that the expression patterns of these

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paralogs closely match, whereby one paralog consistently retains the putative ancestral pattern seen in arachnids (e.g. mites) with single copies of these genes. The results support a close evolutionary relationship of spiders and scorpions, rather than basal placement of the latter.

In spiders, reproduction is a fascinating but also complex subject. To avoid hybridisation, co-evolution has led to a huge variety of species-specific morphological as well as behavioural characters. Cordellier et al. review the sexual dimorphism of spiders and the current knowledge of variations in the underlying sex determination processes. The authors explain why spiders are excellent for studying aspects of sexual dimorphism, sexual reproduction and sex determination. Furthermore, they provide a roadmap for investigating the genetic diversity of sexual dimorphism in spiders.

Spiders show a range of lifestyles from solitary to living and sharing resources in colonies. Although most spider species live solitary, sociality has evolved several times independently in various spider families (Johannesen et al. 2007; Settepani et al. 2017). In this context, Grinsted et al. investigate the link between the evolution of cooperative hunting and the body size of predators and prey. They show that cooperative prey capture does not have to be associated with larger caught prey per se, but with an increase in the ratio of prey to predator body size, which can also be achieved by the evolution of smaller predator size. This direction of evolution can indeed be observed in social *Stegodyphus* species.

Spiders play important roles in terrestrial food webs, not only as predators but also as preys (Nyffeler and Birkhofer 2017; Foelix 2011). Understanding the distribution of spider species and their interactions in ecological communities is therefore informative for conservation strategies. Kennedy et al. review how advanced technology such as amplicon-based DNA coding and third generation sequencing can improve our understanding of the local diversity and interactions of spiders with their environment. Finally, spider models can be developed into significant resources for medical use. Spider silk is the strongest known natural fibre (e.g. Blackledge and Hayashi 2006) and is used in medical applications, for example as supporting matrix for skin transplants and artificial blood vessels. *Nephila edulis* is one of the species used for silk production in laboratories. In the article by Liebisch et al., the biology and breeding conditions of *N. edulis* are discussed as well as established methods for harvesting silk.

Naturally, we can only give a small glimpse into the world of spiders and the diverse projects of the spider community but we hope that this issue will give food for thought and attract more researchers to the field. In the future, new

functional tools (like CRISPR/Cas9 genome editing) and the growing number of spider genomes (e.g. Kono et al. 2019; Sánchez-Herrero et al. 2019; Sanggaard et al. 2014; Schwager et al. 2017) might help to get a better understanding of spider biology.

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