Keynote Speaker

Evolution and Diversification of Acoustic Communication in Arachnids

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Across the eleven living arachnid groups there exists tremendous sensory system diversity with respect to both sensory structures and associated sensory capacities. These various sensory systems can function in both inter- and intra-sexual communication. While chemical communication is ubiquitous throughout all groups, near-field sound communication has thus far been confirmed in only one species of amblypygid - nocturnal predatory arachnids comprising their own order (Class Arachnida, Order Amblypygi). In this foundational system, properties of the air particle displacement display closely match the sensory capacities of amblypygid filiform hairs - the sensory structures shown to receive these signals. In addition to this recently documented example of near-field sound communication, substrate-borne acoustic communication is widespread, complex, and highly varied in particular groups of ground-dwelling spiders. Indeed, the complexity and form of substrate-borne courtship songs is highly variable among closely related species that often overlap in microhabitat use, making spiders excellent models for exploring the evolution and diversification of substrate-borne acoustic communication.

In the wolf spider genus *Schizocosa*, substrate-borne courtship songs are species-specific and they vary in their degree of complexity, as defined by the number of independently identifiable components. Across most species studied to date, vibratory courtship signaling has been shown to be important for males in securing matings, but the degree to which it is importance varies. We used a phylogenetic analysis to explore whether the degree to which vibratory signaling is important in successful mating is correlated with our quantified species-specific song complexity scores. We did not find a correlation between the importance of vibratory signaling for mating and vibratory signal complexity, suggesting that female mate choice may not be the predominant selective pressure influencing courtship song complexity in this genus. Indeed, data from multiple *Schizocosa* species demonstrate a tight match between song properties and microhabitat transmission characteristics, suggesting that the signaling environment, as opposed to female choice, might play a large role in the evolution and diversification of *Schizocosa* courtship songs.

In addition to variation observed across species, within a species and even within an individual, the structure and function of acoustic courtship displays can vary – e.g. across signaling environments, with different receivers, etc. One potentially useful approach for understanding the dynamic nature of animal communication in an evolutionary framework is to adopt a systems approach – to implement comprehensive experimental designs and data collection in combination with systems analytical tools and conceptual interpretations. Core concepts from systems biology (i.e. redundancy, degeneracy, pluripotency, and modularity) and their relationships with system properties (e.g. robustness, flexibility, evolvability) can be readily translated into an animal communication framework. Using this framework to explore courtship communication in *S. floridana*, we uncovered a complex pattern of display structure and function across four signaling environments including two social environments (presence versus absence of a female) and two light environments (light versus dark). We analyzed the data using both traditional trait-specific analyses and signaling phenotype network analyses (Fig. 1), the latter of which is inspired by systems-based approaches. We found that both social context and light environment influenced the structure of the display, as quantified by signal phenotype network analyses. Across light environments, however, specific structure/function relationships remained similar, suggesting system degeneracy – or the existence of different structures with overlapping function. In contrast, structure/function relationships differed across the social environments and our results suggested a novel hypothesis – that different traits in the complex display may serve distinct functions. Ultimately, our systems approach uncovered complexity that was missed by trait-specific analyses and led to novel hypothesis that will lead future research forward.

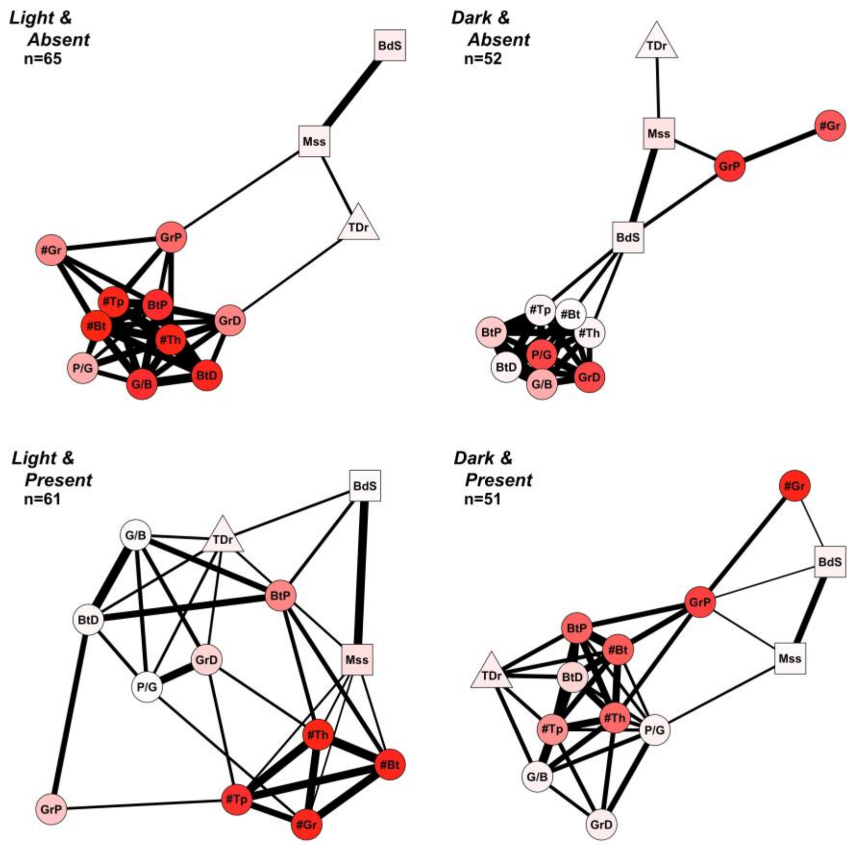

Fig. 1. Signaling phenotype networks for *S. floridana* courtship across four signaling environments. Node shape represents component type (circle – acoustic, square – morphology, triangle – pigmentation. Lines between nodes represent pair-wise correlations, and line thickness reflects correlation strength. Node shadings represent loadings onto the principal component axis that most strongly predict copulation success.