From Courtship Songs to Parallel Evolution: Decoding *Chrysoperla's* Secrets

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The *Chrysoperla* genus, encompassing a diverse array of lacewings within the Neuroptera order, is distinguished by its elegant members known for intricate wing patterns and distinctive features. These lacewings, particularly notable during their larval stage, exhibit a predatory nature, actively contributing to the biological control of garden pests. Among the species in this genus, *Chrysoperla carnea* takes centre stage as a green lacewing species with vibrant green colouration. Renowned for its significant role in natural pest control, *C. carnea* is a beneficial predator, especially effective against aphids and other soft-bodied pests. Its presence is a welcomed ally in agricultural ecosystems, aiding gardeners and farmers to balance pest management and environmental sustainability. In addition to their ecological significance, lacewings in the Chrysoperla genus are known for their unique courtship behaviour, often involving intricate courtship songs. This courtship song, a fascinating component of their reproductive behaviour, adds another layer to the intricate world of Chrysoperla lacewings, highlighting their complex and nuanced interactions within their ecosystems.

Green lacewings within the *Chrysoperla* genus, notably the 'carnea group,' were initially believed to constitute a single Holarctic species, *Chrysoperla carnea* (Stephens), based on similar adult specimens found across North America, Europe, northern Africa, and Asia (Tjeder, 1960). These cryptic species, identified by Duelli in 1996, engage in substrate-borne songs as part of their courtship behavior. Rather than striking the substrate, they utilize abdominal vibrations through a process termed tremulation (Michelsen *et al.*, 1982). These vibrations, travelling through the substrate, are picked up by subgenual organs in the tibiae of potential mates (Devetak *et al*. 1978).

The vibrational songs serve a discriminatory function at close range, aiding in mate selection. Both male and female lacewings partake in producing these songs, allowing individuals to synchronize their mating signals during a prolonged heterosexual duet as a prerequisite to copulation. Due to strict genetic control, the song phenotype contributes to reproductive isolation, as individuals with different songs fail to match up (Wells and Henry 1992). The songs of *Chrysoperla* green lacewings consist of volleys of low-frequency abdominal vibrations repeated regularly. Some species have relatively simple songs composed of single-volley SRUs repeated many times, while others produce more complex songs with longer, multi-volley SRUs, responding to similar songs from potential mates.

Fig 1: Adult of *Chrysoperla* sp.

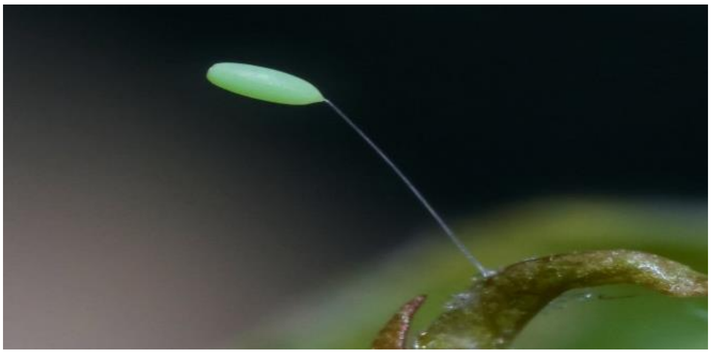

Fig 2: Egg of *Chrysoperla* sp.

Song Evolution

In his 1993 experiment, Wells investigated hybridization in lacewings to explore genetic incompatibility. Courtship songs play a crucial role in reproductive barriers among lacewings in the genus *Chrysoperla*, as seen in *Chrysoperla plorabunda*. Heterotypic matings, involving different song morphs, are less likely than homotypic matings, contributing to postzygotic isolation. Experimental crosses between sympatric P1 and P3 morphs of *Chrysoperla plorabunda* reveal delayed egg laying and lower hatching success in heterotypic crosses compared to homotypic crosses. Backcrosses with P3 morph males or females are less successful, with delayed mating. These findings suggest behavioral isolation and provide genetic evidence supporting the idea that song morphs in the *C. plorabunda* complex represent distinct biological species. A striking example of parallel song evolution is demonstrated between the well-known European species, *Chrysoperla pallida*, and a recently identified vibrant-green North American species, *Chrysoperla calocedrii* sp. *nov*. Henry's study in 2012 delves into the parallel evolution of these two different lacewing species. To validate this parallelism, the research establishes that: (1) the songs of both species exhibit measurable similarities in multi-volley temporal and frequency structure; (2) the songs share a common genetic pathway; (3) each species fails to distinguish between its own and the other's song in playback trials, confirming acoustic niche overlap; (4) the two species readily engage in normal duets in the laboratory, leading to copulation and the production of robust hybrid offspring with an intermediate song phenotype; (5) they possess distinct morphologies in both adults and larvae, indicating different adaptive responses and independent evolutionary histories; and (6) they occupy relatively distant positions in a Bayesian phylogenetic analysis of 4630 bp of protein-coding mitochondrial DNA, dismissing the alternative hypothesis of similarity through recent common ancestry.

Conclusion

In summary, the *Chrysoperla* genus showcases intricate lacewing dynamics, with notable species like *Chrysoperla carnea* contributing significantly to natural pest control in agriculture. Their courtship rituals, marked by substrate-borne songs, reveal a complex interplay of genetics and behavioral isolation, influencing the distinct biological species within the *C. plorabunda* complex. Wells' 1993 study delves into hybridization, demonstrating how courtship songs contribute to reproductive barriers, influencing egg laying and hatching success. Meanwhile, Henry's 2012 research unveils a parallel song evolution between European species *Chrysoperla pallida* and North American species *Chrysoperla calocedrii* sp. nov., emphasizing their distinct evolutionary paths despite geographic separation. In essence, *Chrysoperla* lacewings exemplify a fascinating blend of ecological significance and intricate behaviors, underscoring the importance of understanding and preserving their role in maintaining ecosystem balance.

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