Bachelor thesis project

Chemical communication and intraspecific aggression in ants:

Cuticular hydrocarbons as cues in colony recognition in Cardiocondyla obscurior

Background: *Cardiocondyla obscurior* is a small invasive ant species. As a consequence of regular genetic bottlenecks and high frequencies of inbreeding, populations of *C. obscurior* are suspected show very little genetic and phenotypic variation.

In social insects, cuticular hydrocarbon (CHC) profiles are important cues in discriminating nestmates from non-nestmates. If ants from two different colonies have very similar CHC profiles (as suspected for *C. obscurior*), they will likely consider each other members of the same colony. For invasive populations of *C. obscurior* this suggests that colonies could function as so-called unicolonial unit, where the different colonies cooperate and not compete. Unicoloniality is an important trait in invasive ants, often being a crucial factor for their ecological impact.

We already confirmed in a previous Bachelor project that aggressive interactions are generally low between workers of different colonies. However, we also confirmed that nestmates receive less aggression than non-nestmates and that with increasing distances, aggressive interactions increase as well.

In this Bachelor project, we will study CHC profiles in colonies of *C. obscurior* collected from different populations across the world, aiming to characterize phenotypic differences within and between these populations. In addition, we will assess aggressive interactions between and within populations, in order to better understand the sociobiology of this invasive species.

Figure 1: Workers and brood of the model species *Cardiocondyla obscurior*.

Objectives: The aim of this project is to characterize cuticular hydrocarbon profiles of workers from different colonies of *C. obscurior* and to study nestmate recognition and aggression behavior within and between populations. This project will involve: (1) Gas chromatographic analysis coupled with mass spectrometry (GC-MS-MS) to establish colony/population specific CHC profiles (2) performing aggression assays between different colonies, (3) establishing novel protocols to assess nestmate recognition in *C. obscurior*.

Requirements: Interest in ants and, social evolution and invasion biology; interest in chemical ecology and working with live insects; patience to conduct repetitive behavioral observations; willingness to analyze gas chromatograms

Methods: Ant maintenance, behavioral observations, gas-chromatography coupled with mass spectrometry, chemical analysis

Supervision: Dr. Jan Büllesbach (Room 221, buellesb@wwu.de),
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Molecular Evolution and Sociobiology Group (wwu.de/Evolution/molevolsocbio/).

Bachelor thesis project

Phenotypic evolution in invasive ants:

The role of HSP90 in rapid adaptive change

Background: Colonies of *Cardiocondyla obscurior*, a tiny tree-dwelling ant species of the subfamily Myrmicinae, are spread across the world's tropics by the international trade of plants and plant materials. These introduction events of a single colony regularly are the starting point for establishing stable populations of *C. obscurior* in novel habitats. Thus, these new populations develop from an extremely low genetic diversity. However, *C. obscurior* has repeatedly proven to be successful in adapting to novel environments, despite the lack of genetic diversity.

This Bachelor thesis project is designed to shed light on the molecular mechanisms that allow *C. obscurior* to rapidly adapt to novel environments.

In a previous Bachelor thesis project, we tested the role of the chaperone Heat Shock Protein 90 (HSP90) in creating novel phenotypic variations as potential raw material for adaptation to novel environments. HSP90 is involved in phenotypic canalization effects, regulation of epigenetic modification and the suppression of transposable elements. Each of these aspects might contribute to the generation of adaptive variation.

We already confirmed in a previous Bachelor project that pharmacological inhibition of HSP90 induces increased phenotypic variation in *C. obscurior*. This corroborates other studies that also found a HSP90-dependent mechanism creating novel phenotypic variability. Under natural conditions, organisms could profit from this mechanism to adapt to novel environments.

Figure 2: A queen of the model species *Cardiocondyla obscurior*.

Objectives: The aim of this project is to establish RNAi protocols for *C. obscurior* to knock down HSP90 expression *in vivo*. This project will involve: (1) developing and optimizing microinjection protocols for *C. obscurior*, (2) establishing RNAi knock downs for HSP90 (3) quantifying the inhibition of HSP90 expression and potential effects on related genes in qPCR experiments, and (4) morphometric measurements of individual ants following *HSP90* inhibition.

Requirements: Interest in ants and phenotypic evolution; interest in molecular work and working with live insects; patience and steady hands to establish microinjection protocols.

Methods: Ant breeding and maintenance, RNAi knock down, PCR, RNA extractions, cDNA synthesis, qPCR, ant morphometrics

Supervision: Dr. Lukas Schrader, Room 106, lukas.schrader@wwu.de, Molecular Evolution and Sociobiology Group (wwu.de/Evolution/molevolsocbio/).

Selected Literature:

Schrader, L., Kim, J. W., Ence, D., Zimin, A., Klein, A., Wyschetzki, K., et al. (2014). Transposable element islands facilitate adaptation to novel environments in an invasive species. *Nature Communications*, *5*, 5495. http://doi.org/10.1038/ncomms6495

Specchia, V., Piacentini, L., Tritto, P., Fanti, L., D'Alessandro, R., Palumbo, G., et al. (2010). Hsp90 prevents phenotypic variation by suppressing the mutagenic activity of transposons. *Nature*, *463*(7281), 1–5. http://doi.org/10.1038/nature08739

Bachelor thesis project

Worker policing and reproductive conflict

Behavioural and chemical aspects of colony organization in *Camponotus* ants

Background: While social insect colonies (*e.g.* bees, ants, termites) are often regarded as harmonic societies and workers as selfless supporters of their nest, this view has been challenged in recent years. It appears that workers are in conflict with queens for reproduction (i.*e.* who is allowed to lay eggs in a colony). Also between workers there is conflict over egg-laying. This becomes especially apparent in queen-less colonies where workers compete for egg-laying. However, when a queen is present, these conflicts are harder to spot. This is due to an efficient control mechanism in insect societies: policing! Workers check whether eggs are laid by the queen or by a worker, and eggs laid by workers are destroyed. Also, workers who appear to be 'pregnant', *i.e.* with developed ovaries, are often attacked. In both cases, namely identification of worker laid eggs and fertile workers, chemical cues seem to be responsible for the detection.

Objectives: The aim of this project is to identify *(i)* whether worker policing by egg eating does occur in the ant species *Camponotus maculatus; (ii)* whether worker policing by aggression occurs; *(iii)* whether specialisation in policing occurs; *(iv)* whether policing is restricted to the egg stage; *(v*) whether chemical cues or signals are involved in the recognition of eggs, larvae, fertility.
Depending on the interests of the candidate, the main focus of the project may be adjusted accordingly.

Requirements:
- Interest in cooperation and conflict resolution in social organisations
- Eagerness to learn new techniques and approaches
- Curiosity

Methods:
- Behavioural assays for aggression; brood care; egg-laying; egg-recognition
- Chemical identification of compounds potentially involved in communication (GC-MS/MS)
- Physiological measurements (*e.g*. fat content, ovary development)
- Paternity analysis (microsatellites, *i.e*. DNA extraction, PCR, sequence analysis)

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Selected Literature:

Endler, A., Liebig, J., Schmitt, T., Parker, J. E., Jones, G. R., Schreier, P., & Hölldobler, B. (2004). Surface hydrocarbons of queen eggs regulate worker reproduction in a social insect. *Proceedings of the National Academy of Sciences of the United States of America, 101*(9), 2945-2950. doi: DOI 10.1073/pnas.0308447101

Endler, A., Hölldobler, B., & Liebig, J. (2007). Lack of physical policing and fertility cues in egg-laying workers of the ant *Camponotus floridanus*. *Animal Behaviour, 74*(5), 1171-1180. doi: http://dx.doi.org/10.1016/j.anbehav.2006.10.031

Ratnieks, F. L. W., Foster, K. R., & Wenseleers, T. (2006). Conflict resolution in insect societies. *Annual Review of Entomology, 51*, 581-608. doi: 10.1146/annurev.ento.51.110104.151003