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FOCUS

PROJECT

The Developmental Evolution of Division of Labor

Project of the Focus Group: One of the main problems of evolutionary biology is to understand the origin of phenotypic (morphological, physiological, and behavioral) variation and novelties. Over the last decades a new discipline of evolutionary developmental biology (Evo-Devo) has emerged that attempts to integrate developmental and evolutionary biology in an attempt to provide a comprehensive account of phenotypic evolution. Evo-Devo represents a synthesis of different research paradigms - most prominently of developmental genetics and evolutionary biology. However, these traditions have so far largely remained separate, thus keeping Evo-Devo from reaching its full potential. One reason for this separation is that the current model systems of developmental genetics are for the most part not well suited for evolutionary analysis, as they have been selected for their specific uses in developmental genetics. Social insects on the other hand, which until now have not been studied within this context, have several advantages that make it an ideal model system. Manfred Laubichler and I will convene a working group in theoretical biology that will explore the potential of social insects as a model system for evolutionary developmental biology. This working group will synthesize existing work from hitherto largely separate areas of biology (Evo-Devo, theoretical biology, and social insect research) and produce critical reviews to be published in a special issue of the Journal of Experimental Zoology that will focus on how social insects can be developed as a model system for Evo-Devo. This group will thus define a new research program that can then be further pursued in the laboratories of participants and their colleagues.

Individual Project: Social insects demonstrate a remarkable division of labor in which different individuals engage in different tasks. This division of labor is believed to be a key determinant of their evolutionary and ecological success. However, in the most advanced social insects the vast majority of individuals within a society are sterile workers. In the honey bee, the focus of my research, a colony typically consists of a single reproductive queen and thousands of non-reproductive female workers that constitute a workforce divided into specialized tasks. How does such a social structure evolve? There is no single social genome on which natural selection can act. Evolutionary changes in the social structure of the colony must be derived from changes in the frequencies of genes that have effects on the development of non-reproductive individuals (workers). During my stay at the Wissenschaftskolleg, I will sift through the honey bee selective breeding data I have gathered over the last twenty years and look for the signatures and footprints of selective change at the level of worker development that gave rise to fundamental changes in the social structure of colonies. These changes will guide us in our understanding of the developmental evolution of social behavior.

Recommended Reading

Page, R. E., R. Scheiner, J. Erber, and G. V. Amdam. 2006. "The development and evolution of division of labor and foraging specialization in a social insect." Current Topics in Developmental Biology 74: 251-284.
Page, R. E. and G. V. Amdam. 2007. "The making of a social insect: developmental architectures of social design." Bioessays 29: 334-343.

COLLOQUIUM, 12.01.2010

The evolution of division of labor and foraging specialization in honey bees

How does complex social behavior evolve? What are the developmental building blocks of division and labor and specialization, the hallmarks of complex insect societies? Recent behavioral, genetic, and genomic studies have revealed the developmental origins in the evolution of division of labor and specialization in foraging worker honey bees. Selective breeding for a single social trait, the amount of surplus pollen stored in the nest (pollen hoarding), revealed a phenotypic architecture of correlated traits at multiple levels of biological organization in facultatively-sterile female worker honey bees. Genetic mapping has demonstrated that the phenotypic architecture is a consequence of a genetic architecture rich in pleiotropy and epistasis possibly affecting a reproductive signaling pathway. Gene knockdown studies and transplantation of ovaries provides strong support for the hypothesis that division of labor and foraging specialization are derived from the reproductive cycle of solitary insects and under the control of the ovaries. Ovary development in worker honey bees is under the control of a social genome that results in the joint developmental control of the immature worker larva and its nestmates that feed it.

Page, Jr., Robert E. (Cold Spring Habor,2022)

Identifying a developmental transition in honey bees using gene expression data

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1830551418

Page, Jr., Robert E. (New York, NY,2020)

The art of the bee : shaping the environment from landscapes to societies

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1686501099

Page, Jr., Robert E. (Cambridge, Mass. [u.a.],2013)

The spirit of the hive : the mechanisms of social evolution

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1603873953

Page, Jr., Robert E. (2012)

Development and evolution of caste dimorphism in honeybees – a modeling approach

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1045334596

Page, Jr., Robert E. (Cambridge,2012)

Regulation of behaviorally associated gene networks in worker honey bee ovaries

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1017883998

Page, Jr., Robert E. ([Madison, Wis.],2011)

Rearing honey bees, Apis mellifera, in vitro 1: Effects of sugar concentrations on survival and development : Osman Kaftanoglu, Timothy A. Linksvayer, Robert E. Page, Jr.

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1017877238

Page, Jr., Robert E. (New York, NY [u.a.],2010)

Surgically increased ovarian mass in the honey bee confirms link between reproductive physiology and worker behavior

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1067362460

Page, Jr., Robert E. (Amsterdam,2009)

Regulation of honeybee worker (Apis mellifera) : life histories by vitellogenin

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1029315426

Page, Jr., Robert E. (2009)

Honeybee social regulatory networks are shaped by colony-level selection

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=101783962X

Page, Jr., Robert E. (Cambridge, Mass.,2009)

Social life from solitary regulatory networks : a paradigm for insect sociality

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=870758373