Behav Ecol Sociobiol (2016) 70:993–994
DOI 10.1007/s00265-016-2132-0

EDITORIAL

Editorial: special issue on *Integrative Analysis of Division of Labor*

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Published online: 3 May 2016

Ever since Darwin's masterpiece *On the origin of species by means of natural selection* (Darwin 1859), biologists and laymen alike have been fascinated by the division of labor (DOL) that is characteristic and the key to the success of social insects such as ants, wasps, bees, and termites. Parallels to human societies may be part of the fascination (Foster and Ratnieks 2005). DOL, a prominent example of phenotypic plasticity, occurs at two levels: reproductive DOL (the separation between queen(s) and workers) and worker DOL, the focus of the present special issue. In many social insects, age worker subcastes (temporal polyethism) and in some species morphological worker subcastes perform specific tasks within the colony (Hölldobler and Wilson 1990). Darwin recognized both levels of DOL as paradoxical to his theory of natural selection (see also Ratnieks et al. 2011). With respect to worker DOL, he stated: "But we have not as yet touched on the climax of the difficulty; namely, the fact that the neuters of several ants differ, not only from the fertile females and males, but from each other, sometimes to an almost incredible degree, and are thus divided into two or even three castes" (Darwin 1859, Chapter 7). The paradox of how non-reproducing individuals could themselves be modified by natural selection he explained in terms of benefits to the colony and selection on reproducing relatives more than 100 years before Hamilton formalized kin selection and the evolution of altruistic behavior (Hamilton 1964) ("a graduated series having been first formed, as in the case of the driver ant, and then the extreme forms, from being the most useful to the community, having been produced in greater and greater numbers through the natural selection of the parents which generated them; until none with an intermediate structure were produced"; Darwin 1859, Chapter 7).

The papers in this special issue *Integrative Analysis of Division of Labor* focus on worker DOL in various hymenopterans (specifically in ants and bees). DOL is by no means a static process but highly plastic, as individual tasks are adjusted to the need of the colony (e.g., Robinson et al. 2009). The flexibility of temporal polyethism can be modeled in respect to response thresholds (Robinson 1987; Bonabeau and Theraulaz 1999) that regulate individual task performance. Variation in response thresholds between and within individuals is expected to be due to genetics, aging, and learning (Bonabeau and Theraulaz 1999) but needs more empirical support. Or, as Bonabeau and Theraulaz (1999) stated: "While there is a growing body of evidence showing the effects of genotypic characteristics on response thresholds and task allocation, the two other factors are certainly plausible but remain to a large extent unexplored." Neurobiological and genomic factors also require more attention. The present special issue will not only make a significant contribution to causal aspects of DOL but also considers fitness aspects and the complex interplay of causal and functional aspects.

I congratulate Guest Editor Simon K. A. Robson (Tropical Ecosystems, James Cook University, Australia) and James F. A. Traniello (Department of Biology, Boston University, USA), who has acted here both in the function of Guest Editor and Editor-in-Chief of *Behavioral Ecology and Sociobiology* for invertebrates, to have successfully recruited leading researchers to publish this special issue *Integrative Analysis of Division of Labor*. I am certain that their work will impact future research in the analysis of DOL.

This manuscript is a contribution to the special issue Integrative Analysis of Division of Labor—Guest Editors: Simon K. Robson, James F.A. Traniello

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