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Gene co-citation networks associated with worker sterility in honeybees

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The evolution of reproductive self-sacrifice is understood from kin theory, yet our understanding of how actual genes influence the expression of reproductive altruism is only beginning to take shape. As a model in the study of social behaviour, the honeybee *Apis mellifera* has yielded hundreds of genes associated in their expression with differences in reproductive status of females, including genes associated with sterility, yet there has not been an attempt to link these candidates into functional networks that explain how workers regulate sterility in the presence of queen pheromone. In this study we use available microarray data and a co-citation analysis to describe what gene interactions might regulate a worker's response to ovary suppressing queen pheromone. We reconstructed a total of nine gene networks that vary in size and gene composition, but that are significantly enriched for genes of reproductive function. The networks identify, for the first time, which candidate microarray genes are of functional importance, as evidenced by their degree of connectivity to other genes within each of the inferred networks. Our study identifies single genes of interest related to oogenesis, including eggless, and further implicates pathways related to insulin and dopamine signaling as potentially important to reproductive decision making in honeybees. The networks derived here appear to be variable in gene composition, hub gene identity, and the overall interactions they describe. One interpretation is that workers use different networks to control personal reproduction via ovary activation, perhaps as a function of age or environmental circumstance. Alternatively, the multiple networks inferred here may represent segments of the larger, single network that remains unknown in its entirety. The networks generated here are provisional but do offer a new multi-gene framework for understanding how honeybees regulate personal reproduction within their highly social breeding system.