



Biogenic amines and division of labor in eusocial Hymenoptera

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Division of reproduction is fundamental to the organization of societies in eusocial Hymenoptera. Biogenic amines are key factors involved in the switching of reproductive physiology and modulation of social behaviors. Dopamine, one of biogenic amines, has a pivotal role in the formation of reproductive states in females. For example, queens have larger amounts of dopamine in the brains in comparison to workers in several eusocial hymenopterans. Brain dopamine levels in the reproductive workers are positively correlated with ovarian activities. It has been also reported that dopamine application promotes ovarian activation in the workers. In contrast to the reproductive roles of dopamine, octopamine contributes largely to non-reproductive social behaviors including flight for foraging, aggression for guarding and associative learning for several tasks. These roles of biogenic amines are seen in the life cycle of a single female in solitary species, implicating a decoupling of physiology and behavior into reproductive and non-reproductive states in eusocial species. Juvenile hormone promotes reproduction with dopamine in primitively eusocial species, whereas it regulates non-reproductive social behaviors with octopamine in the highly eusocial species. Targets of juvenile hormone might have been changed from dopamine biosynthesis to octopamine biosynthesis, or from both to octopamine in highly eusocial species, which might make it possible to regulate reproduction in response to various social stimuli without constraint from juvenile hormone.