Abstract

Insects are of particular interest, due to the size of their brain and the "simplicity" of their instinctual behavior, sometimes referred as "programmed behavior". Despite this apparent simplicity, insects have survived through the ages and drastic changes of the environment. How a "programmed behavior" can be modulated in changing environments is still unclear. The male silkmoth is a suitable model given that the neuroethology underlying its pheromone-searching behavior has been studied extensively. Indeed, serotonin and nitric oxide are related to female pheromone neural processing. To clarify the role of neuromodulators on insects' behavior in response to environmental changes, I first studied internal modifications of the brain by performing ethological and pharmacological experiments combined with electrochemical detection of biogenic amines using a high performance liquid chromatography system. I found that serotonin plays a key role in sensitivity to pheromone. Serotonin in the brain showed a circadian variation, similarly to the daily sensitivity of the male to female pheromone. Serotonin's effects on pheromone sensitivity most probably took place in the first olfactory center, the antennal lobe, given that application of serotonin on the antennal lobes increased pheromone sensitivity and application of serotonin antagonists showed the opposite tendency. Nitric oxide had a similar effect to serotonin on pheromone sensitivity and was not related to serotonin presence in the moth's brain. Interestingly, nitric oxide seemed to modulate the synthesis of tyramine and dopamine in the brain. I also studied modifications external to the brain by analyzing adaptation of the pheromone searching behavior to its environment through habituation

experiments. Short term (30 minutes) and long term (24 hours) habituation experiments led to a decrease in pheromone sensitivity, which confirmed the capability of the neural system to modulate its response when exposed to a repeated innocuous stimulus. Short term habituation did not lead to any measurable modification of biogenic amine levels. In contrast, long term habituation was related to serotonin levels in the higher olfactory center, the protocerebrum. These results confirm that neuromodulators can affect the pheromone-searching behavior of the male silkmoth in several ways. One single neuromodulator can act differently on different sites: in the antennal lobe, serotonin enhanced sensitivity to pheromone, while in the protocerebrum, serotonin was related to long term modification of the neural pathway following long term habituation. Furthermore, different neuromodulators can have the same effect on the behavior (serotonin and nitric oxide similarly increased the pheromone sensitivity) and their levels can be related to one another (nitric oxide modified tyramine and dopamine levels). Thus, "programmed" behaviors in insects are highly flexible, due to a complex combination of neuromodulators activity in variable areas of the neural system.