

# Common effects of varroosis and nosemosis on learning abilities of honey bee foragers *Apis mellifera carnica*

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Negative impacts of the parasitic mite *Varroa destructor* and microsporidian *Nosema ceranae* on homing abilities of foragers were recently demonstrated. Impaired orientation to the nest entrance of diseased bees indicates the deficiency in sensory and/or neural processing that could affect learning. Here we present sensory responsiveness, non-associative and associative learning of artificially infested and infected foragers with *Varroa* and *Nosema*, respectively, by using a proboscis extension reaction paradigm (PER). Prior to learning tests each bee was tested for PER by applying a droplet of water and ascending sucrose solution (1% - 40% weight/volume) to the antenna as a measure of sensory responsiveness. Although infested/infected foragers were initially equally responsive to water and sugar concentrations compared to a control, there were evident differences in learning. Habituation to repeated sugar stimulations of the antennae, a non-associative learning, was faster in both, workers infested with *Varroa* and those infected with *Nosema*. In conditioning, where bees learn to associate the odor with sugar award, a significant reduction of PER response was found 1 min and 12 min after single conditioning in bees infected by *Nosema*, and 1 min in bees infested by *Varroa*. Both *Varroa* and *Nosema* affect learning and its underlying neural and molecular processes in similar way which could contribute to the deficit in homing and nest recognition observed in other studies.