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Effects of Rapid Heat Hardening of Honeybee Mother Queens (Apis mellifera) on the Oxidative Response of Their Daughter Workers during Heat Stress

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Rapid heat hardening is the process whereby organisms exhibit improved survival in extreme temperatures following a short period of exposure to milder temperatures. This study aimed to investigate the effects of rapid heat hardening of honeybee mother queens (Apis mellifera) during the larval stage on the oxidative response of their daughter workers during heat stress. Twenty accepted mother queen (MQ) larvae at the age of two days were selected and divided into two incubation treatment groups (n = 10). The control group (non-heat-treated mother queens, nH-T MQ) was maintained at 34.5 C for 15 min and 70% relative humidity (RH), and the pre-heat-treated (pre-heat-treated mother queens, pH-T MQ) group was subjected to 41 C for 15 min and 70% RH. After queens mating and establishing good colonies, about 300 workers were collected from brood combs of each treatment group. Workers were incubated in digitally controlled thermo-incubators for one hour at temperatures of 35, 40, 45, 50, and 55 °C. mRNA levels of several antioxidant genes in the thorax were evaluated using real-time qPCR, including catalase, glycosylase domain-containing protein-4, superoxide dismutase, thioredoxin-2, thioredoxin reductase-1, vitellogenin, methionine sulfoxide reductase, thioredoxin peroxidase-4, and glutathione peroxidase-like-1. Furthermore, the concentrations of glutathione peroxidase, super oxidase dismutase catalase, cytochrome P450, peroxidase, and glutathione reductase were determined by ELISA. Results showed that daughter workers of the pH-TMQ exhibited higher survival rates at elevated temperatures than those of the nH-TMQ. The pH-TMQ also showed improved basal and dynamic expression of several of the tested genes and enzymes, which indicated a protective response against heat stress and the effectiveness of tissue hardening in oxidative stress and antioxidant activity response. These recorded changes may improve the thermotolerance acquisition of workers during heat stress conditions and ultimately help to formulate a comprehensive improvement program.