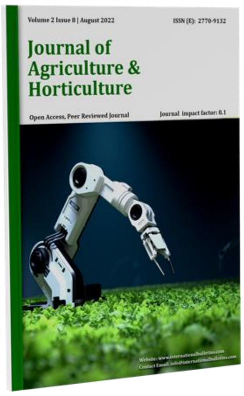

APHID PLANT INTERACTIONS UNDER HIGHER TEMPERATURES: SHIFTS

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Abstract. Temperature rise is expected to impact the interactions between phytophagous species and host plant systems, particularly aphids. As poikilothermic organisms, aphids' development is influenced by temperature, leading to increased development, reproduction, and survival. As a model organism for studying climate change effects, aphids can be affected by oxidative stress, which can impair mitochondrial function. Plants can manufacture reactive oxygen species (ROS) as a defense against phytophagous organisms. Enzymatic systems regulate ROS production and removal, with antioxidant enzymes like superoxide dismutase and catalase protecting aerobic organisms against OS. Enzymes like glutathione S-transferase and β-glucosidase are crucial for defense in plants.

Keywords: aphid, plants, organisms, phytophagous species, interactions between

Introduction. It is anticipated that the temperature rise and other current climatic changes will have an impact on how phytophagous species and host plant systems interact. Since aphids are poikilothermic organisms, the primary determinant of their development is temperature. In response to an increase in temperature, these insects may develop more quickly, reproduce more often, survive the winter better, alter their life cycles, retime their migrations, or alter the dynamics of their communities. Because of their rapid development, high rate of reproduction, and telescoping structure, aphids provide a great model organism for researching the effects of climate change on insects.

Raising the outside temperature affects aphid development as well as cellular and metabolic processes. It can interfere with oxidative phosphorylation and cellular respiration, which can impair mitochondrial function at the cellular level. Oxidative stress (OS) can be brought on by heat stress because it can interfere with the production and scavenging of reactive oxygen species (ROS). ROS can originate from external sources in addition to endogenous ones. Because aphid eating causes damage to plant tissues, plants can manufacture these particles as a defense against phytophagous organisms.

Enzymatic systems, for example, carefully regulate the intracellular balance between ROS production and removal. Antioxidant enzymes, such as superoxide dismutase (SOD) and catalase (CAT), which are present in both plants and aphids, are the first line of defense for aerobic organisms against OS. Enzymes involved in detoxification, such glutathione S-transferase (GST) and β-glucosidase, have several functions. These enzymes' primary job in aphids is to convert foreign substances into less harmful forms through metabolism. These enzymes are crucial for defense in plants. Enzymes known as GSTs are involved in stress tolerance, xenobiotic detoxification, endogenous metabolism, and plant development. Insects that feed on phloem can trigger the plant defensive response, as can other biotic and abiotic causes. Although the effects of rising temperatures on intricate plant-insect interactions were originally revealed by our earlier research, little is known about aphid defense mechanisms.

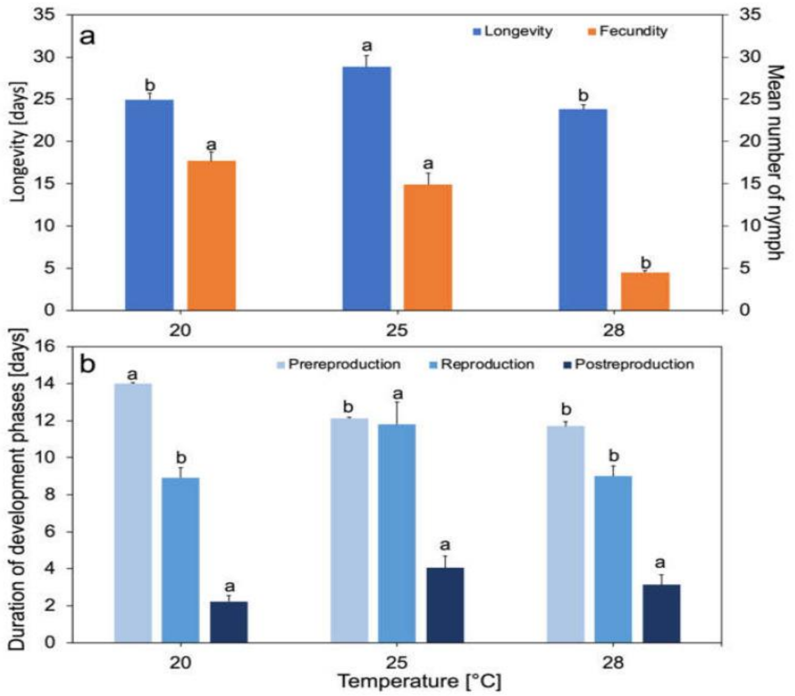

Figure 1 Developmental time and fecundity of apterous Macrosiphum rosae as a function of temperature. Longevity time and fecundity (n = 25 at each temperature 20, 25, and 28 °C) (a). Time of developmental phases of apterous M. rosae (pre-reproduction, reproduction, and post-reproduction) (b). Values marked with different letters differ significantly at $p < 0.05$, for each parameter (Kruskal–Wallis test).

Temperature's Impact on Aphid and Plant Tissue Enzymatic Activity As previously mentioned, the experiment was conducted separately at three different temperatures (20, 25, or 28 °C) and under constant conditions. On each plant, thirty mature M. rosae aphids were planted. Aphids spent two weeks (24, 48, 72, 96, or 336 hours) feeding on the host plant. Before each experiment was conducted, a control (0 h) sample was taken. At every temperature, the enzyme activity was measured in aphid-infected plants as well as concurrently in non-infected plants that were grown as an independent control.

Temperature had a significant impact on the M. rosae population's survival, which peaked at 25 °C (Figure 2a). Every nymph that was examined at every temperature lived to reproduce. Furthermore, at 20 °C, adults displayed the highest average daily fecundity, or roughly 3.5 nymphs per female (Figure 2b).

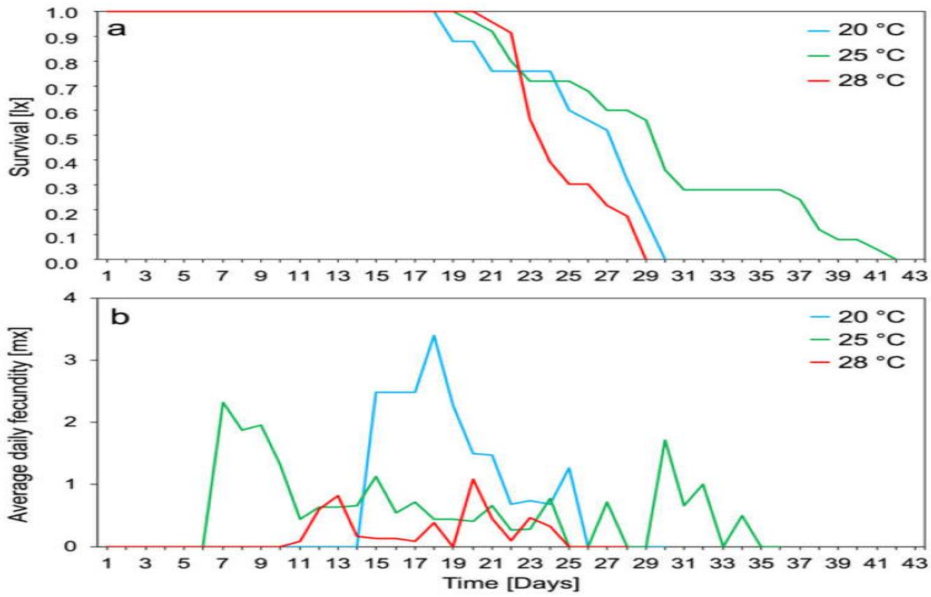

Figure 2 Survival rates (a) and daily fecundity (b) of apterous females Macrosiphum rosae at different temperatures (n = 100 at each temperature: 20, 25, and 28 °C).

Raising the temperature to 28 °C shortened M. rosae's reproductive period and lifespan, which in turn decreased fertility and demographic characteristics. Aphid defense responses varied greatly with temperature; aphid defense responses peaked at 28 °C, while plant defense responses peaked at 20 °C. Aphid defense reactions transpired in two phases. The aphid's defense mechanism responded in the first stage to alterations in the host plant brought on by prolonged abiotic and biotic stress, whereas the second step was the response to short-term exposure to heat (28 °C). The physiological reaction and interactions between plants and aphids are significantly influenced by temperature, which may restrict the aphids' ability to develop.

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