CHANGES IN OXIDATIVE AND ANTIOXIDANT SYSTEM IN RAT LIVER MITOCHONDRIA DURING SUMMER AND WINTER

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Abstract: *Living in a seasonal environment requires periodic changes in animal physiology, morphology, and behavior. The winter phenotype of small mammals living in temperate and boreal zones can differ significantly from summer with many traits that improve energy conservation or reduce energy loss. However, there is considerable variation in the development of the winter phenotype among individuals in the population, and some expressing a non-responsive phenotype (non-responders) are insensitive to shortening days and maintain a summer phenotype throughout the year.*

Keywords: *Oxidative Stress Antioxidant Defense Nonshivering Thermogenesis Winter Phenotype Polymorphism Photoreactivity Heat Production Seasonal Adjustments.*

The antioxidant defense system, a highly conserved biochemical mechanism, protects organisms from the harmful effects of reactive oxygen species (ROS), a byproduct of metabolism. Both invertebrates and vertebrates are unable to modify the physical factors of their environment, such as photoperiod, temperature, salinity, humidity, oxygen content, and food availability, according to their requirements. Therefore, they have developed mechanisms to modulate their metabolic pathways to cope with changing environmental challenges in order to survive. Antioxidant defense is one such biochemical mechanism. At low concentrations, ROS regulate several physiological processes, while at high concentrations, they are toxic to organisms. because they disrupt cellular functions by oxidizing biomolecules. Seasonal changes in antioxidant defenses allow species to maintain proper ROS titers to perform various physiological functions, such as overwintering, aestivation, migration, and reproduction against changing environmental physical parameters, and at the same time we we collected data available in the literature on the seasonal variation of the antioxidant defense system in different species of invertebrates and vertebrates. The main objective was to understand the relationship between the different biological phenomena and seasonally conserved antioxidant defense system seen in different animal species. We collected data available in the literature on the seasonal variation of the antioxidant defense system in different species of invertebrates and vertebrates.

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The types of seasons and their duration may vary from one ecological region to another and affect the physiology of the flora and fauna that inhabit them [1]. Changes in environmental factors such as temperature, duration of exposure to sunlight, humidity, precipitation, oxygen and salinity in water bodies depend on seasonal physiological changes observed. A number of important physiological responses of animals, such as reproduction, hibernation, aestivation, immune functions, behavior, and susceptibility to various diseases, are greatly influenced by two important environmental indicators, such as day length and temperature [2, 3]. Since all the above physiological phenomena are manifestations of the metabolic state of the animal, any change in seasonal factors

Hamster Physiology, Seasonal changes in different morphological and behavioral traits have different physiological and genetic bases (for review, see Cubuk et al. 2016; Williams et al. 2017; Dardente et al. 2019), so in this heterogeneous group any clear interpretation of the observed changes is hindered. As we hypothesize that oxidative status (pro- and antioxidant markers) is related to the use of torpor and NST ability is related to the winter phenotype, we believe that excluding partial responders from the analyzes allowed us to avoid misinterpretation of the obtained results. Before implantation, all loggers were covered with paraffin wax and calibrated against an accurate mercury thermometer to within 0.5 °C. Data from the loggers were used only to differentiate phenotypes. Before implantation, all loggers were covered with paraffin wax and calibrated against an accurate mercury thermometer to within 0.5 °C. Data from the loggers were used only to differentiate phenotypes. Before implantation, all loggers were covered with paraffin wax and calibrated against an accurate mercury thermometer to within 0.5 °C. Data from the loggers were used only to differentiate phenotypes.

Highly reactive and nonspecific in nature, ROS usually oxidize biomolecules such as lipids, carbohydrates, proteins, and DNA, thereby disrupting normal cellular functions. Shifting of the balance between oxidants in favor of oxidants to antioxidants is called "oxidative stress". Oxidative stress is considered a cause or consequence of several pathophysiological conditions, diseases, and aging processes. The antioxidant defense system includes enzymatic and non-enzymatic components. The enzymatic system contains a cascade of enzymes known as antioxidant enzymes (AOEs). Antioxidant enzymes are ubiquitous and their catalytic nature is highly conserved. Some of them exist in many forms. The first member of this cascade is superoxide dismutase (SOD), which dismutates O2 •− to H2O2. Hydrogen peroxide is neutralized by two enzymes. One is catalase (CAT) and the other is glutathione peroxidase (GPx). Catalase decomposes H2O2 to oxygen and water, while GPx reduces H2O2 and organic hydroperoxides by coupling with reduced glutathione (GSH) oxidation. Glutathione reductase (GR) plays a major role in generating reduced glutathione from oxidized glutathione by oxidizing NADPH. Next, NADPH is generated from NADP by the enzyme glucose-6-phosphate dehydrogenase (G6PDH). There are three types of SOD depending on the prosthetic group they carry. They are Fe-SOD, Mn-SOD and Cu-Zn SOD.

This review attempts to summarize the information available in the literature on seasonal changes in the antioxidant defense system and OS markers in invertebrates and vertebrates. It is concluded that the seasonal variation of the antioxidant defense system may be an evolutionary strategy for different adaptations of animals to different physical aspects of the environment. In addition, the variation of seasonal factors in the global food chain cannot be denied, since the larval or embryonic forms of invertebrates constitute the first line of primary productivity. It is known that different signs of the seasons can regulate metabolic functions in tissues through the corresponding receptors, which in turn

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