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Heat Stress Impairs the Physiological Responses and DNA damage in the white Rat

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***Abstract*—The outcomes of mild and warmth strain on white rats (Rattus norvegicus) are examined on this review. It demonstrates how those environmental variables reason great alterations in physiology as well as harm to DNA. Elevated frame temperature and quicker heart and breathing quotes are the results of heat stress. However, DNA harm from light pressure from UV radiation results inside the introduction of thymine dimers, that could induce mutations. The assessment additionally demonstrates how these stressors paintings collectively to exacerbate oxidative pressure and cellular harm, which places greater physiological load at the rats. The take a look at sheds mild on how heat shock proteins and DNA repair structures assisted the rats in adjusting to these difficult instances, offering essential new understandings into the environmental consequences at massive.**

Keywords—Heat Stress, DNA Damage, Physiological Responses, Oxidative Stress, Heat Shock Proteins, Environmental Impact

I. INTRODUCTION

One of the most pressing environmental problems of our day is weather trade. It describes lengthy-time period adjustments in climate and temperature which might be normally brought on with the aid of human pastime, particularly because the Industrial Revolution. The average global temperature has significantly extended due to the boom within the attention of greenhouse gases (GHGs) inclusive of carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) in the atmosphere. Global warming is a process that has big results on biodiversity and climate systems on the world (IPCC, 2021).

Heat pressure is a phenomenon brought on by weather alternate's accelerated frequency and depth of heat waves. Heat pressure is the result of an organism's frame temperature rising above its threshold for self-cooling, that could reason physiological stress or even health troubles. Animals categorized as ectothermic, meaning they rely upon out of doors sources to govern their body temperature, need to be particularly concerned approximately this. But endothermic creatures are also impacted, which includes mammals just like the white rat (Rattus norvegicus) (Horowitz, 2014) (Abugre *et al.*, 2024).

Light pressure, that's introduced on by elevated publicity to ultraviolet (UV) radiation due to the ozone layer's depletion and other environmental adjustments, is a full-size contributor similarly to warmness strain. DNA, proteins, and different organic additives can be immediately harmed by way of UV radiation, that could have a negative cascading effect on organisms (Sinha & Häder, 2002) (Kathum, Alsultan and Guda, 2024).

Comprehending the results of stressors on white rats, frequently employed as version species in medical investigations, gives a huge information of wider ecological and biological mechanisms. Intending to light up feasible ramifications for different animals, inclusive of human beings, this examine attempts to analyze the physiological reactions and DNA damage as a result of heat and light pressure in white rats.

II. AIM OF STUDY

This overview ambitions to offer a top level view and synthesis of latest studies at the consequences of mild and heat stress at the physiological reactions and DNA integrity of white rats (Rattus norvegicus). It will overview the literature on physiological changes, DNA harm, restore processes, and the cumulative affects of these stressors. To shed light on more tremendous ecological and biological ramifications, the review additionally seeks to highlight molecular diversifications and viable long-time period affects.

III. CLIMATE CHANGE AND RISING TEMPERATURE

Global temperatures are significantly impacted via climate change, which will increase the quantity of heat stress skilled via living matters. The quantity of greenhouse gases (GHGs) inside the environment has increased dramatically as a result of human sports like burning fossil fuels, deforestation, and extensive agriculture.
Contributing Factors to Climate Change:

A. Industrial Activities

Global temperatures are significantly impacted by means of climate alternate, which increases the quantity of heat pressure experienced via residing matters. The quantity of greenhouse gases (GHGs) within the environment has multiplied dramatically as a result of human activities like burning fossil fuels, deforestation, and in depth agriculture.

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B. *Deforestation*

The amount of bushes that could soak up CO2 decreases due to deforestation because of urbanization and agriculture. For example, deforestation has had a first-rate negative impact on the Amazon rainforest, from time to time known as the "lungs of the Earth," with roughly 17% of the wooded area misplaced inside the closing 50 years (Lovejoy & Nobre, 2018).

C. *Intensive Agriculture*

Greenhouse gas (GHG) emissions are resulting from modern-day agricultural methods that use fertilizers, which launch nitrous oxide (N2O), and livestock rearing, which creates methane (CH4). For instance, just the cattle enterprise accounts for 14.5% of greenhouse gasoline emissions global. (Gerber et al., 2013).

IV. IMPACT OF HEAT STRESS ON THE ENVIRONMENT

The environment is significantly impacted with the aid of warmth strain brought on by climate trade, which has an effect on species distribution, ecosystems, and seasonal rhythms.

A. *Changes in Ecosystems*

a. *Ecological Imbalance*

Animals and vegetation are similarly impacted by way of heat pressure, which upsets the sensitive balance of the environment. For example, coral reefs have seen enormous bleaching events because of their super susceptibility to temperature changes. About two-thirds of the Great Barrier Reef became affected by years in a row of giant bleaching in 2016 and 2017 (Hughes et al., 2017**).**

b. *Shifts in Reproduction and Growth Seasons*

Temperature variations reason many species to alter their growing and breeding seasons, which has an effect at the distribution of assets and the supply of food. For instance, because of expanded springtime temperatures, several chicken species in Europe have been suggested to breed in advance in the season (Both et al., 2006).

B. *Impact of Heat Stress on Plants*

a. *A Delayed or Accelerated Plant Growth*

Plant boom cycles may be disturbed by using growing temperatures. While some plants may expand extra slowly and have worse crop excellent, others may additionally grow more quickly and feature lower production. (Ahmad & Prasad, 2012).

b. *Increased Evaporation and Water Loss*

Increased evaporation prices added on by way of high temperatures purpose vegetation to lose more water. This can cause dehydration and jeopardize plant viability, specially in areas with limited water assets. (IPCC, 2014).

c. *Reduced Crop Yields*

Heat stress can significantly decrease agricultural crop yield and quality, particularly affecting vulnerable crops like wheat and maize (Zinn et al., 2010).

d. *Spread of Pests and Diseases*

Higher temperatures can lead to increased spread of pests and diseases, causing significant damage to crops and decreasing productivity (Ahmad & Prasad, 2012).

e. *Changes in Life Cycles*

Some plants may need to alter their entire life cycle in response to rising Figure (1).

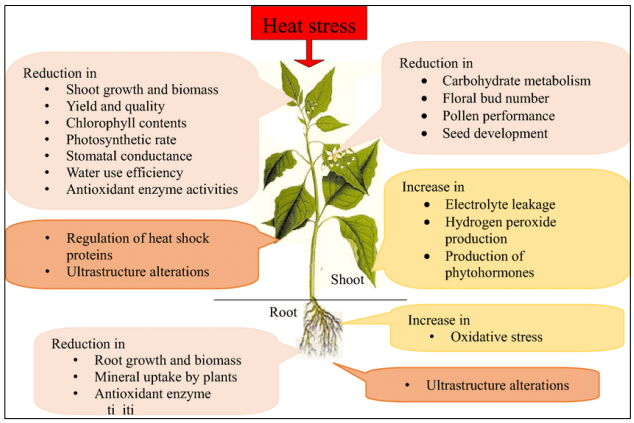

Fig. 1. Possible effects of heat stress on different parts of plants

C. *Impact of Heat Stress on Human Beings*

The increasing global temperatures due to climate change can have severe impacts on human beings by causing heat stress. When exposed to extreme heat, the human body has difficulty maintaining a safe core temperature, which can lead to various health issues.

a. *Heat-Related Illnesses*

Prolonged exposure to high temperatures can lead to heat-related illnesses such as heat exhaustion and heatstroke. Heat exhaustion is characterized by symptoms like heavy sweating, weakness, dizziness, and nausea. If not treated, it can progress to heatstroke, a life-threatening condition where the body's ability to regulate temperature fails, leading to confusion, loss of consciousness, and potentially fatal organ damage (Gerber et al., 2013)

b. *Cardiovascular Strain*

When the body experiences heat stress, it puts extra pressure on the cardiovascular system. The body tries to cool down by sweating and increasing blood flow to the skin, causing the heart to work harder. This can be especially risky for people with existing heart conditions, as it raises the chances of heart attacks and other cardiovascular issues (Lindquist & Craig, 1988).

c. *Dehydration*

When it's hot, you sweat more, which can make you lose a lot of fluids and lead to dehydration if you don't take care of it. Dehydration can cause anything from feeling a bit unwell and dizzy to more serious problems like kidney failure or painful muscle cramps because your body doesn't have enough important minerals like sodium and potassium (Ahmad & Prasad, 2012).

d. Impacts on Vulnerable Populations

Certain groups are more vulnerable to the effects of heat stress, including the elderly, young children, and individuals with chronic illnesses. These populations may have a reduced ability to regulate their body temperature or may be more prone to the complications associated with heat stress. Additionally, people who work outdoors or in hot environments, such as construction workers and farmers, are at higher risk (IPCC, 2014).

e. Increased Mortality Rates

Extreme heat waves have been associated with higher mortality rates, especially in urban areas where the heat island effect can worsen high temperatures. During these events, the number of deaths from heat-related illnesses, cardiovascular problems, and other complications can increase significantly (Allen et al., 2018).

f. Mental Health Effects

Heat stress can also impact mental health by causing irritability, reduced cognitive function, and an increased risk of mental health disorders. Elevated temperatures can worsen existing mental health conditions and contribute to a higher likelihood of heat-induced aggression or mood swings (Tattersall et al., 2012).

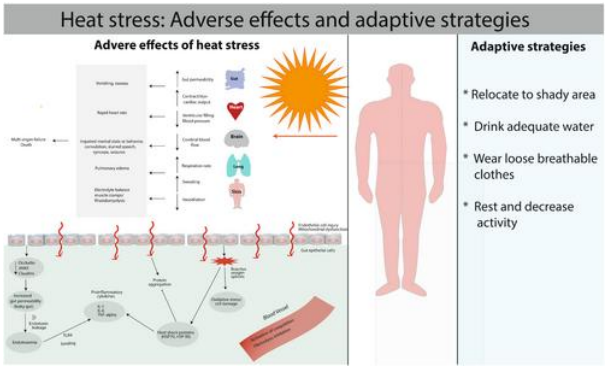

Fig.2. Effects and adaptations of heat stress on humans.

V. Impact of Heat Stress on the Food Chain

Heat stress directly and indirectly impacts the food chain, from primary producers to top consumers.

A. Primary Producers (Plants)

a. Effects of Heat on Plant Growth

Higher temperatures can reduce plant growth and productivity. For instance, wheat and maize yields could significantly decrease with rising temperatures, potentially impacting global food security (Lobell et al., 2011).

b. Geographical Shifts

Some plant species may no longer survive in their current habitats, leading to geographical shifts. For example, certain alpine plant species are relocating to higher elevations to avoid rising temperatures at lower altitudes (Pauli et al., 2012).

B. Primary Consumers (Herbivores)

a. Food Resource Scarcity

Reduced plant productivity leads to food scarcity for herbivores, as observed in warming Arctic regions where a decline in lichen, a primary food source for reindeer, has occurred (Jepsen et al., 2013).

b. Altered Feeding Patterns

Herbivores may alter their feeding habits or relocate to find new food sources. For instance, some herbivorous insects have moved poleward in response to warmer temperatures (Parmesan et al., 1999).

C. Secondary Consumers (Carnivores):

a. Cascading Effects

Reduced availability of herbivores impacts carnivores dependent on them for food. The drop in Arctic fox populations due to decreased lemming (a primary prey) availability is a significant example (Ims & Fuglei, 2005).

b. Increased Competition

The scarcity of prey heightens competition among predators. For example, the decline in sea ice has forced polar bears to move inland, intensifying their competition with grizzly bears for terrestrial food sources (Derocher et al., 2004).

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