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专论与综述

# 高温对昆虫影响的生理生化作用机理研究进展

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摘要 温度是影响昆虫生命活动的重要因素，将其与某一时间的种群数量结合，可用于对昆虫未来种群数量进行预测预报。过高的环境温度常使昆虫的生长发育、生殖及存活等受到严重影响，对这种影响缺乏了解降低了害虫测报的准确性。探明高温对昆虫生理生化的作用机理是了解高温对昆虫生命活动影响的根本途径。总结了高温对昆虫生理生化的重要影响。高温使昆虫表皮的蜡质层瓦解，油脂融化，表皮渗透性增加，虫体大量失水。引起昆虫体内重要离子的浓度发生变化，改变许多重要大分子的电荷状态，使生物大分子的动力学能量增大，离子键、氢键和范德华力降低，分子间疏水作用增强，大分子保持形状的能力降低，空间构象发生改变，从而影响生物大分子行使其功能。高温使昆虫细胞骨架瓦解，细胞遭到破坏；细胞膜内磷脂组分比例改变，细胞膜流动性下降。虫体内重要遗传物质DNA和RNA复杂的二级结构和三级结构在高温下发生改变，对昆虫性状的稳定遗传造成严重影响。细胞内蛋白质的数量和种类组成均发生改变，原有常温下的蛋白质合成系统关闭，空间构象及功能发生变化，而产生耐热性物质（如热激蛋白）的蛋白质合成系统则开启。高温影响酶及酶促反应速率，对昆虫体内神经传导关键酯酶——乙酰胆碱酯酶的影响使昆虫无法进行正常的神经传递，丧失躲避不良环境的能力。高温影响脂质、低聚糖等物质的代谢。最后梳理了高温作用下昆虫各种生理生化指标发生变化之间可能存在的关联性，并提出高温对昆虫造成伤害的顺序过程假设。讨论了不同程度的高温对昆虫造成死亡的机理可能不同。指出了未来该领域研究的重点内容，如高温对昆虫造成损害的最初作用位点；高温伤害的完整生理生化路径；耐热性产生的生化基础；高温对昆虫不同发育阶段或生命过程的具体作用机制等。

关键词 高温；昆虫；生理；生化；作用机理

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# Effects of heat stress on physiological and biochemical mechanisms of insects: a literature review

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**Abstract** Temperature determines life of insects more than many other environmental factors. The most popular method to predict the population development of insects is based on the initial population density of insects at certain time and the environment temperatures during a certain time period. However, the accuracy of the prediction may reduce because of the unknown effects of very complicated high-temperature patterns under field conditions on development, reproduction and survival of the insects. We summarized and reviewed the research results of physiological and biochemical effects of high-temperature on insects. Extreme high-temperature lead to the wax of the cuticle breaking down, lipid melting, and permeability to water consequently increasing dramatically. The concentrations of important ions in insect cells are changed at high-temperature, then consequently altering the charge state of the macromolecular components of the cell and influencing the function of the macromolecules. High-temperature makes cytoskeleton collapse and causes cells destroyed, the fatty acid composition of its phosphoglycerides changed and the "fluidity" of cellular membranes reduced. High-temperature results in an increase in the kinetic energy of the macromolecule, thereby decreasing the ionic, hydrogen, and van der Waals bonds and increasing hydro

phobic interactions of the macromolecule. This, in turn, reduces the ability of the macromolecule t o hold its shape and spatial conformation. The structures and functions of DNA and RNA are cha nged at high-temperature, thus the stable heredity of characters is badly affected. The kinds of pr oteins and quantities of each one in cell are changed. At high-temperature, the normal pattern of p rotein synthesis is suppressed, whereas the system for heat-shock conditions is opened. The spati al conformation and function of normal proteins are altered, and new proteins (such as heat shoc k protein) are produced at the same time. High-temperature inhabits the activity of acetylcholinest erase and disturbs the nerve conduction, and consequently makes insects lose the ability of escapi ng from detrimental conditions. In addition, the metabolism of lipids and oligosaccharide (e.g. fuco se) is affected by high-temperature. We discussed the potential logic relations of various changes i n physiology and biochemistry of insects at high-temperature, and suggested a hypothesis about th e heat injury process to insects. The injury mechanisms of high-temperatures on insects maybe diff er at varying temperature degrees. At last, we pointed out the important aspects in this area neede d to be investigated in future. It includes (1) the most sensitive part of the insect′s body to high-te mperature; (2) key steps to form a complete mechanism of heat injury to insects; (3) mechanism f or induction of heat tolerance; and (4) reasons in biochemistry for different responses of differen t development stages of insects to heat stress.

**Key words** high-temperature _ insect _ physiology _ biochemistry _ mechanism

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