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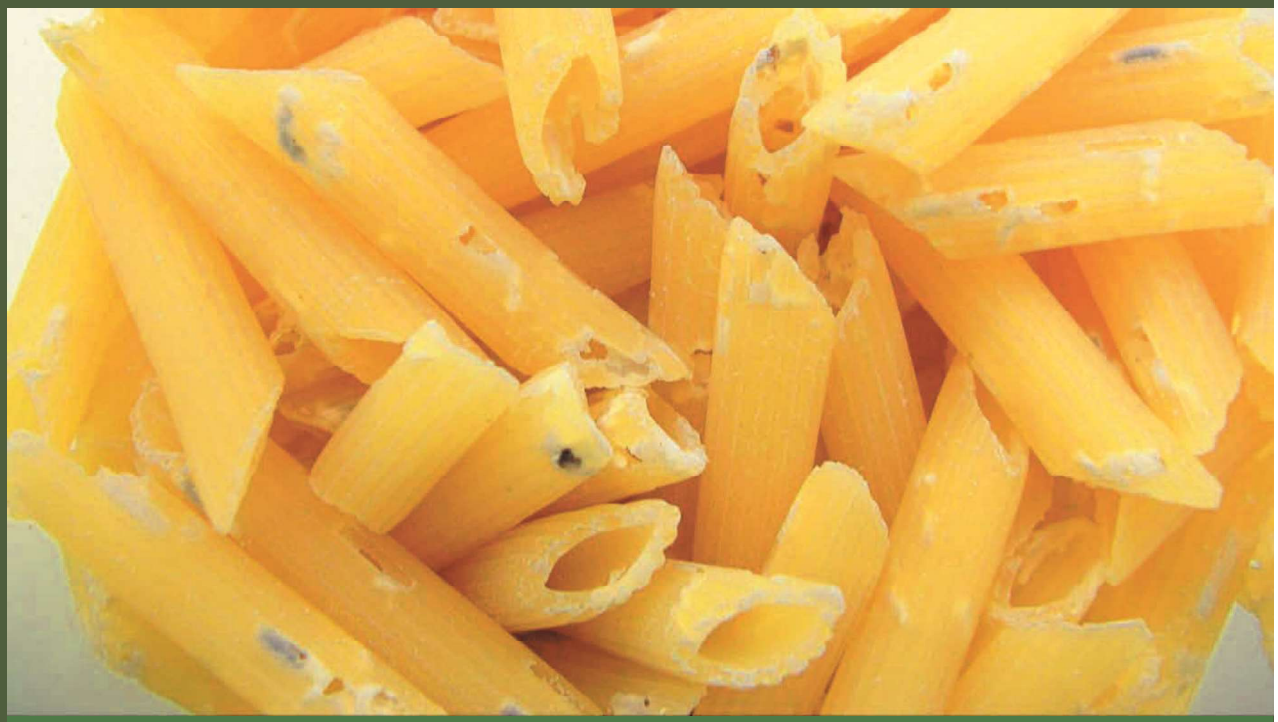

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The new trends in Eco-Evo research in stored product entomology

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Abstract: The last few years has ushered in significant advancements in the understanding of the ecology and evolution of stored product insect pests. This paper reviews some key developments in the last years, focusing on pivotal areas such as pest resistance, host shifts, new innovative biological control methods as well as application of bioinformatics, machine learning and artificial intelligence for integration of data and decision making. All these new topics in stored product entomology are critical for the integrated protection of stored products.

The evolution of pest resistance to chemical treatments has become a paramount concern. Numerous studies have documented the genetic mechanisms underlying resistance in major stored product pests. Recent research has identified specific genetic mutations and metabolic pathways that confer resistance to phosphine and pyrethroids, highlighting the need for diversified management strategies. The spread of resistance alleles through pest populations has been tracked using advanced genomic tools, providing insights into the spatial and temporal dynamics of resistance evolution. For instance, mutations in the DLD gene, associated with phosphine resistance, have been extensively studied, revealing the adaptive changes at the molecular level that allow pests to survive chemical treatments (Alzahrani and Ebert, 2019). Moreover, the role of cytochrome P450 enzymes in detoxifying insecticides has been a focus, uncovering the metabolic resistance mechanisms that pests employ (Chen et al., 2022). This knowledge is crucial for designing targeted interventions that can delay or counteract resistance development.

Host shift, another evolutionary phenomenon, has also seen substantial research attention. The ability of pests to adapt to new environments has profound implications for food security and pest management. *Acanthoscelides obtectus* is a prime example, demonstrating the complexities of host shift dynamics (Savković et al., 2023). Traditionally associated with common beans, *A. obtectus* has been observed to infest other legume species, such as cowpea and chickpea. Studies have shown that this host shift is facilitated by genetic plasticity and ecological adaptability, allowing it to exploit new food sources when its primary host is scarce. Research into the genomic basis of these shifts has revealed that certain alleles may confer an enhanced ability to digest and detoxify compounds in alternative hosts, thus promoting survival and reproduction on a novel diet. These findings underscore the importance of monitoring and management in a way that mitigates the risks associated with host shifts, ensuring that pest management strategies remain effective.

The integration of ecological and evolutionary principles into stored product pest management has been bolstered by the new innovative control methods, such as the Trojan Female Technique (TFT). TFT presents a novel and promising approach that involves introducing females carrying mitochondrial DNA mutations that cause male sterility without affecting female carriers. This technique has the potential to suppress pest populations over

time, as the affected males are unable to reproduce. Research into the application of TFT for stored product pests such as *A. obtectus* has shown promising results, with studies demonstrating the successful introduction and spread of mitochondrial mutations (Vukajlović et al., 2024). This approach leverages natural mating processes, reducing the need for chemical interventions and potentially offering a sustainable and environmentally friendly pest control strategy.

Integration of large amounts of data about life history traits of stored product pests, anti-nutritional seed components like protease inhibitors as bioinsecticides and seed protectants employs a holistic approach to develop new and improve existing methods for controlling stored product pests while optimizing preventive storage measures. Primary goal of this research is to reduce post-harvest losses caused by these pests by leveraging conventional and modern "omics" technologies, studying insect responses to seed traits, and using smart technologies like machine learning and neural networks to create pest-tolerant seed ideotypes. This emphasizes the identification of seed traits responsible for tolerance and/or preference to specific pests and the development of seeds that are more productive, reliable, and less dependent on pest protection.

This review underscores the importance of a multidisciplinary approach that combines ecological, evolutionary, and technological perspectives to address the complex challenges posed by stored product pests. Continued research in these areas will be essential for advancing management practices and ensuring the protection of stored products in an era of rapid environmental change.

Key words: stored product entomology, pest resistance, host shift, Trojan Female Technique, life history traits, machine learning, neural networks

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