



DNA Barcoding and Its Application in Entomology

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Insects are the most diverse group of organisms on earth and recent estimates predict that globally there are approximately 5.5 million and 7 million species of insects and terrestrial arthropods, respectively with 1.5 million coleopteran species alone (Stork, 2018). Although, only 1.024 million insect species are named and described (Zhang, 2011) i.e., 81 % of insect species are still to be discovered, named and described. In the ever-expanding realm of biological sciences, DNA barcoding has emerged as a groundbreaking tool, revolutionizing the field of insect identification. This technique harnesses the power of genetics to provide a reliable and efficient means of distinguishing between species, offering unprecedented insights into the intricate world of insects.

Need for DNA Barcoding

Traditional methods of insect taxonomy often relied on morphological characteristics, which could be difficult in resolving cryptic species complexes, understanding sexual dimorphism or polymorphism within same species, immature stages identification, sometimes time-consuming, subjective, and error-prone. Additional restrictions on this conventional method are imposed by the dearth of specialists in the morphotaxonomy of particular insect groups (Shashank et al., 2022). DNA barcoding is a molecular technique that seeks to standardize and streamline the identification process, providing a reliable means to sort out the above-mentioned lacunae and complement the morphotaxonomy.

Principles of DNA Barcoding

At the heart of DNA barcoding is the utilization of a short, standardized DNA sequence from a specific region of the genome. The mitochondrial cytochrome c oxidase I (COI) gene, characterized by its conserved regions and variable intergenic spacers, has become the marker of choice for insect barcoding. This gene's characteristics enable the generation of unique DNA sequences for each species, akin to a barcode for easy identification.

The process begins with the collection of insect specimens, followed by DNA extraction and amplification of the target gene using polymerase chain reaction (PCR). Subsequent sequencing and comparison of the obtained DNA barcode with existing databases, such as the Barcode of Life Data Systems (BOLD) and National Center for Biotechnology Information (NCBI), facilitate species identification. The universality of the COI gene allows for comparisons not only within insects but across diverse taxa.

Applications of DNA Barcoding in Insect Identification: A Multifaceted Approach

The applications of DNA barcoding in entomology extend far beyond species identification. One of its primary utilities lies in the resolution of taxonomic uncertainties, facilitating the discovery of new species, identification of immature life stages, and the clarification of species complexes. DNA barcoding has unveiled hidden biodiversity, exposing cryptic species that eluded traditional morphological assessments. Furthermore, this technique plays

a pivotal role in ecological studies and conservation efforts by accurate identification of insect species, researchers can assess biodiversity, monitor population dynamics, and evaluate the impact of environmental changes. This information is indispensable for making informed decisions regarding habitat conservation and management.

In agriculture, DNA barcoding has proven instrumental in pest control strategies. Accurate identification of pest species allows for targeted and effective control measures, minimizing the use of broad-spectrum pesticides and reducing environmental impact. Precision in pest identification also aids in preventing the introduction of invasive species, safeguarding ecosystems and agricultural productivity.

Challenges and Future Prospects

DNA barcoding has undeniably transformed insect identification but still many challenges persist. Intraspecific genetic variation, hybridization, and incomplete reference databases pose hurdles to accurate identification. Ongoing efforts to address these challenges include expanding reference databases, exploring alternative genetic markers, and incorporating machine learning algorithms to enhance the accuracy of species assignments. The future of DNA barcoding in insect identification holds exciting possibilities. Integration with other omics technologies, such as genomics and metabolomics, promises a more holistic understanding of insect biology. Moreover, advancements in nanopore sequencing and portable DNA analysis devices may further democratize access to this technology, empowering researchers, and enthusiasts alike.

Conclusion

In conclusion, DNA barcoding has emerged as a transformative force in entomology, reshaping our understanding of insect diversity and ecology. Its applications extend from taxonomic clarification to ecological monitoring and pest management, marking a paradigm shift in how we approach insect identification. As technology continues to evolve, the genetic secrets encoded in insect DNA promise to unlock new dimensions in our exploration of the natural world. DNA barcoding stands as a testament to the power of genetics in unraveling the intricate tapestry of life, one gene at a time.

References

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