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Bioinformatics in Entomology: A New Frontier of Insect Research

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Abstract

Recently, there is enormous growth in insect related research data due to quick advancements in biological sciences, thereby requiring computational methods for efficient storage, organisation and analysis. Bioinformatics field has made a substantial contribution to agricultural research by integrating biology, data analytics and computer science. The specialized field of bioinformatics known as "entomo-informatics" is concerned with the management and interpretation of genomic, proteomic and physiological data pertaining to insects. Data analysis and its access are made easier by using platforms such as Molecular Database on Indian Insects (MODII), i5K and the National Agricultural Bioinformatics Grid (NABG). Key applications include genome sequencing, DNA barcoding, sequence alignment, phylogenetic analysis, protein structure prediction and pest-specific insecticide design. Additionally, bioinformatics tools aid in RNA interference (RNAi)-based pest management and molecular docking studies. Entomological research can be strengthened through integration of all computational methods by enabling evolutionary studies, genetic pest control strategies and in silico toxin-protein interactions. Entomo-informatics has the potential to significantly contribute to the advancement of sustainable pest management and insect science.

Keywords: Bioinformatics, Database, Entomo-informatics, Insects and pest management

Introduction

The rapid experimental and technological advancements in biological sciences have led to an exponential increase in insect science data, making the creation of computational databases necessary for effective storage, organization, indexing and meaningful interpretation. Because of this urge, the multidisciplinary area of bioinformatics has arisen, which combines data analytics, computer science and biology to handle and evaluate complicated biological data (Habeeb and Chandrasekar, 2014). Bioinformatics has begun to exhibit its significant influence on worldwide agricultural research and development (Chilana *et al.*, 2012). The Centre for Agricultural Bioinformatics (CABin) is a new branch of the Indian Agricultural Statistics Research Institute, New Delhi, which was launched by the Indian Council of Agricultural Research (ICAR), New Delhi, with the assistance of a team of multidisciplinary research professionals. The main motive of this centre is to foster agricultural biotechnology research with computer means. In addition to introducing India's first supercomputing hub, ASHOKA (Advanced Supercomputing Hub for OMICS Knoweldge in Agriculture), the center has developed the National Agricultural Bioinformatics Grid (NABG) (Anonymous, 2014).

The application of methods and tools of bioinformatics to arrange, analyze and interpret the insect genomic, proteomic, biochemical, physiological and other complex data is called as "Entomo-informatics". This has emerged as a distinct scientific discipline, playing a crucial role in modern entomological research. Figure 1 clearly shows that there is abruptly increased in genomic studies in recent decade because of advancements in entomo-bioinformatics.

Database

Computer databases are becoming an increasingly important

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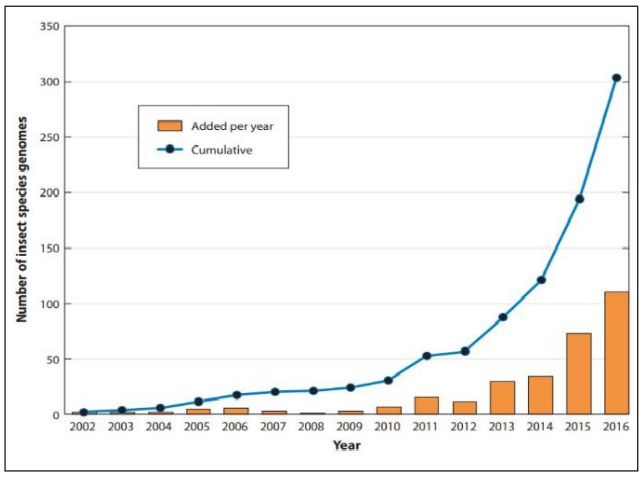

Figure 1: Number of insect species with genomics in the GenBank database from 2002 to 2016

tool for organizing the enormous volumes of biological data that are currently available and thereby helping researchers efficiently access and retrieve relevant information (Anonymous, 2023). It is nothing but the large virtual space or a computerized archived where we can store, organize and analyzed biological data in such a way that information can be retrieved anytime. There are mainly three categories of biological databases namely: sequence databases, structure databases and specialized databases.

1. *Sequence Databases*: Also called as primary or archival database.

Nucleic acid: *E.g.*, NCBI, EMBL, IWGSC and DDBJ

Protein: *E.g.*, SWISS-PROT, TrEMBL and PIR

2. *Structure Databases*: Also referred as secondary or derived database.

Protein: *E.g.*, PROSITE, Pfam, BLOCKS and PRINTS

3. *Specialized Databases*: *E.g.*, FlyBase, LocustDB, BeeBase, AphidBase, ButterflyBase, SilkBase

4. *Other Platforms*: The most commonly used tools in bioinformatic analysis of insect related data were mentioned in Table 1.

BIPAA:

BioInformatics Platform for Agroecosystem Arthropods (BIPAA) offers online access to genomic data for several arthropod species and serves as a central platform to support genomics and post-genomics projects created on insects related to agroecosystems.

i5k-Arthropods:

A team of experts are working on basic and applied biological issues as part of the 5000 Arthropod Genomes Initiative (i5K). Experts solved problems of researcher through genomic and genetic analysis.

MODII:

A number of databases are connected by the Molecular Database on Indian Insects (MODII), an online database that includes Insect Pest Info, Insect Barcode Information System (IBIn), National Bureau of Agricultural Insect Resources (NBAIR) genomic resources, Insect Whole Genome Sequence, Insecticide Resistance Gene Database and genomic tools.

Table 1: Commonly used tools in Entomo-informatics

Sl. No.	Tools	Purpose
1.	BLAST, FASTA	Sequence alignment
2.	Augustus, Glimmer, GeneMark	Gene prediction
3.	Rosetta, I-TASSER	Protein structure prediction
4.	DAVID, InterProScan	Functional annotation
5.	PhyML, MEGA	Phylogenetic analysis
6.	Limma, edgeR	Differential gene expression analysis
7.	Clustal W, Macaw	Multiple sequence alignment
8.	GenBank, ENSEMBL, UCSC	Genomic data
9.	SWISS-PROT, PDB, Pfam	Protein data

Applications of Entomo-Informatics

There are numerous uses for entomo-informatics (Habeeb and Chandrasekar, 2014).

1. Retrieve Genomic Data

The insect genomic databases comprise of information of all proteins, biochemical and physiological processes that occurs in an insect. The widely used platforms for storing and retrieving the biological data include the NCBI (National Center for Biotechnology Information), DDBJ (DNA Databank of Japan) and EMBL (European Molecular Biology Laboratory).

2. Genome Sequencing

Used to identify the complete genetic makeup of a specific organism or cell type. *E.g.*: Whole genome sequencing.

3. DNA Barcoding

Helps to discovery of new species by using entomo-informatics platform such as BOLD database which is used to identify and assign unknown specimens to species.

4. Sequence Alignment and Phylogeny

Sequence alignment technique is mainly used to find areas of similarity between DNA, RNA, or protein sequence, while scientists can better comprehend the evolution of species by using construction of phylogenetic trees. *E.g.*: MEGA software.

5. Prediction of Protein Structure

Numerous databases and bioinformatics techniques are available for predicting primary, secondary and tertiary structures of protein.

E.g.: Protein Data Bank (PDB).

6. Pest-specific Insecticide Designing

Molecular docking enables scientists to develop pest-specific

insecticide design which is helpful in pest management. *E.g.*: SWISS-Dock.

7. Primer Designing

This can be applied to the design of species-specific primers for the amplification of target genes.

8. RNAi as Bioinformatic Domain

It is a sequence specific pest management approach and by using bioinformatic tools we can use RNAi technique in pest management.

Future Prospects

• Deciphering the evolutionary background of pests has enormous potential as a future approach to enhancing pest control methods.

• Entomo-informatics could be used to identify specific gene of interest for genetic control of insect pests.

• In silico docking may be utilized to design specific pesticide molecule by assessing importance, compatibility and interactions between protein and toxin.

Conclusion

Bioinformatics pivotal role in advancing entomology as it offers a powerful tool for analyzing and deciphering massive information related to the insects. By integrating the biology and informatics, researchers can uncover the valuable insights of conservation and overall knowledge about the insect life which can contributes to the advancements in pest management. To put it in a nutshell, this field aids in the organization and comprehension of data pertaining to biological molecules on a broad scale that provide greater depth and new dimension to biological investigations. Therefore, entomo-informatics proves to be an essential component of entomological research in future days to come.

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