TRENDS IN AGRICULTURE SCIENCES

Special Issue on

"BEES AND OTHER ARTHROPODS: INFLUENCE SUSTAINABLE CROP YIELD"

23rd October 2024

ORGANIZED BY

SCHOOL OF AGRICULTURE

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Vol 3 Special Issue 3

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(Declared as Deemed - to - be - University under section 3 of UGC Act 1956)

INTERNATIONAL CONFERENCE ON “BEES AND OTHER ARTHROPODS: INFLUENCE SUSTAINABLE CROP YIELD”

16th Oct 2024

ORGANIZED BY
SCHOOL OF AGRICULTURE
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Background of the Programme:
About SOA and BIHER:

Bharath Institute of Science and Technology (BIST) started with Sri Lakshmi Ammal Educational Trust as the first self-financing Engineering College in Tamil Nadu in 1984. The trust then established Sree Balaji Dental College and Hospital in 1989. Sree Balaji Dental College and Hospital was first recognized as a Deemed to be University by MHRD in July 2002, under section 3 of UGC Act 1956 and placed under the purview of new trust of Bharath Institute of Higher Education and Research (BIHER). The Bharath Institute of Science and Technology (BIST) and other institutions under the ambit of Bharath Institute of Higher Education and Research (BIHER).

Bharath Medical College and Hospital (BMCH), Chennai
Sree Balaji College of Nursing, Chennai
Sree Balaji Medical College and Hospital (SBMCH), Chennai
Sree Balaji College of Physiotherapy
Sri Lakshmi Narayana Institute of Medical Sciences (SLIMS), Pudhucherry

It is functioning in a sprawling area of 603 acres of land with 1.3 crore sq.ft buildings located in 6 Campuses both in Tamil Nadu and Pudhucherry with the state of the art infrastructure facilities.

The School of Agriculture was started in the year 2018 has teaching and research programmes which encompass as per the ICAR syllabus and Norms. The aim of the School of Agriculture is to provide academic training and conduct research in the interdisciplinary areas of Agriculture with a particular emphasis on extending the knowledge generated from these studies. All these calls for a technology intervention which can be offered by the agricultural faculty established by Bharath University.

Why is 20 May celebrated as World Bee Day?

We have been celebrating this day since 2018, thanks to the efforts of the Government of Slovenia with the support of Apimondia that led the UN General Assembly to declare 20 May as World Bee Day. The date for this observance was chosen as it was the day Anton Janša, a pioneer of modern apiculture, was born.

When was World Bee Day first celebrated?

World Bee Day is celebrated on May 20 every year to raise awareness about the importance of bees and other pollinators. It was first designated by the United Nations in 2017 to acknowledge the critical role bees play in sustaining ecosystems and food production.

Objectives of the Conference:

To celebrate world bee day
To create awareness on the importance of bees and other pollinators
To share the knowledge available with researchers, academicians, and other stakeholders for addressing the need to conserve the existing pollinators and flower visitors
To encourage the apiary component in the fields to improve the quantitative and qualitative yield of the crops.

Themes:

- Bees on sustainable crop yield.
- Preservation and conservation strategies of bee population.
- Art of Apiary culturing .
- Threats in apiculture.
- Organic and bio diversified farming on crop Improvement ecosystem .
- Insects as Bio-Indictors in Environmental Health
- Effect of climate change on Arthropod diversity
- Insect plant interaction and Habitat management
- Influence of innovative tools biotechnology, nanotechnology and molecular biology on insects and plant relationship.
- Insecticide poisoning on beneficial insects

Who can participate?

The participation is open to all individuals, researchers, teachers, students, organizations and NGOs, who are engaged in the research on Honey bee and beneficial insects in the cropping ecosystem.
Registration Fee:

Category	Amount in Rupees
Foreign Delegates	2000
Industrialists	1000
Scientist/Faculty/ Research Scholars	700
Students	200

The conference registration fee includes all sessions, materials, Snacks, and working lunch. Registration fee does not include accommodation charges.
Dates & Venue:
Date of Conference : 16.10.2024 & Civil block
Last date for abstract and full paper submission: 1.10.2024
Payment details :
Punjab National Bank
Account name : School of Agriculture
Account No. : 4557002100002983
IFSC Code : PUNB0455700
Spot registration on 16.10.2024 at 9.00 AM
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The Abstract will be published in the form of ISBN book
The selected Full papers will be published in reputed Journal at the cost of Rs 2000/ article and same will be informed to the authors

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ORGANIZED BY SCHOOL OF AGRICULTURE BIHER


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PROGRAMME SCHEDULE

DATE: 23-10-2024 **Venue: Smart Room, ECE** **TIME: 10 am to 4 pm**

INTERNATIONAL CONFERENCE ON "BEES AND OTHER ARTHROPODS: INFLUENCE SUSTAINABLE CROP YIELD"

TIME	PROGRAM	
10.00 am	Thamizh thai vazhthu	
10.05 am	Lighting of the Kuthuvilakku	
10.10 am	Welcome Address:	**Dr. A. Sadasakthi** Dean, SoA, BIHER.
10.20 am	Presidential Address & Release of the Proceedings:	**Dr. M. Sundararajan** Vice Chancellor, BIHER.
10.30 am	Inaugural Address:	**Dr. N. S. Venkataraman** Retired Professor and Head, TNAU.
10.40 am	**Lead Speakers**	1. **Honey bees for the livelihood of the farmers and public - Dr. N. Muthukrishnan**, Former Dean, TNAU, Tiruvannamalai. 2. **Bees for sustained food supply and biodiversity - Dr. K. Vanitha**, Senior Scientist, ICAR. 3. **Success Story of Beekeeping - Mrs. Jospine,** Honey bee Entrepreneur VIBIS Honeybee Farm, Madurai. 4. **Pollination and Pesticides-Bee Aware - Dr. Loveson Allwin,** Associate Professor, Department of Agricultural Entomology, AC & RI, TNAU, Killikulam. 5. **Bee Poisoning due to Chemical Pesticides: Preventive and Curative Measures - Dr. A. Rajini,** Head – Quality Control, BioScience Research Foundation, Kanchipuram. 6. **Role of Predators in Pest Management - Dr. M. Muthupandi,** Scientist, ERI, Loyola College, Chennai.
12.30 pm	Lunch Break.	
1.30 pm	Oral Presentations: Online & Offline Mode.	
3.30 pm	Certificate Distribution-Dean, SoA, BIHER.	
3. 45 pm	Concluding Remarks: Dr. S. Malarvannan, Associate Professor, SoA, BIHER.	
3.55 pm	Vote of Thanks: Dr. V. Abarna, Associate Professor, SoA, BIHER.	
4.00 pm	National Anthem.	

About Trends in Agriculture Sciences

Trends in Agriculture Science (ISSN: 2583-7850) stands as a venerable bastion of scholarly inquiry within the expansive domain of agricultural sciences. As an open-access, peer-reviewed journal, it serves as an indispensable conduit for the dissemination of cutting-edge research findings, scholarly discourse, and practical insights pertaining to the multifaceted realms of agriculture and its allied fields.

With an unwavering commitment to scholarly excellence, Trends in Agriculture Science provides a hospitable platform for a diverse spectrum of scholarly contributions, including original research articles, comprehensive reviews, concise communications, illuminating success stories, and engaging popular articles. Encompassing a wide gamut of disciplines such as agronomy, plant breeding and genetics, soil science and management, agricultural biotechnology, horticulture, animal husbandry and veterinary science, food science and technology, as well as agricultural economics and rural development, the journal embodies a holistic approach to advancing agricultural knowledge.

Central to the scholarly ethos of Trends in Agriculture Science is its robust peer-review process, characterized by meticulous scrutiny and rigorous evaluation. Through this discerning editorial mechanism, the journal upholds a steadfast commitment to quality assurance, ensuring that only the most innovative, original, and scientifically meritorious contributions garner a coveted place within its esteemed pages.

Embodying a spirit of scholarly immediacy, Trends in Agriculture Science espouses a fervent dedication to expeditiously disseminating research findings to the global scientific community. By fostering a dynamic exchange of ideas, insights, and innovations, the journal catalyzes transformative progress within the realm of agricultural sciences, thereby contributing to the collective pursuit of knowledge and the advancement of human welfare.

In sum, Trends in Agriculture Science stands as a venerable bastion of scholarly inquiry, providing a scholarly sanctuary wherein researchers, practitioners, and enthusiasts converge to explore, discover, and shape the future trajectory of agriculture and allied disciplines.

TRENDS IN AGRICULTURE SCIENCES

(ISSN: 2583-7850)

About Editors

Guiding the editorial vision of Trends in Agriculture Science is Dr. V Kasthuri Thilagam, Ph.D.,a distinguished luminary whose tenure as Editor-in-Chief underscores a profound commitment to scholarly rigor and editorial integrity. Dr. Thilagam's stewardship ensures the maintenance of the highest standards of academic excellence and scholarly discourse within the journal,thereby fostering an environment conducive to intellectual exploration and academic advancement.

Assisting in navigating the intricate editorial terrain is Dr. Shaikh Nasrul Islam, the esteemed Managing Editor, whose astute leadership and editorial acumen facilitate the seamless orchestration of the journal's operations.

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TRENDS IN AGRICULTURE SCIENCE
Vol. 3 Special Issue 03 November 2024, Page: 01-04

The role of organic farming in sustaining pollinators' population- A review

N.S.Venkataraman and A.Sadasakthi
School of Agriculture, Bharath Institute of Higher Education and Research,Chennai

Introduction

Pollination is crucial for crop production globally, with 75% of major human food crops relying on insects for this process. In agriculture, pollination not only helps produce the edible parts of important crops but also ensures the availability of seeds for the following year's planting. Pollination specifically involves the transfer of pollen from the stamen to the stigma of a flower for fertilization. Pollen transfer can be accomplished through wind, water, or animals. Pollinators are animals that facilitate the transfer of pollen from one flower to another. While animal pollinators include hummingbirds, bats, and small rodents, the majority are insects such as beetles, bees, flies, ants, wasps, and butterflies. However, with the decline of the domestic honey bee as well as native bee populations, our food security is at risk. Seventy-five percent of the crops grown for human consumption rely on pollinators, predominantly bees, for a successful harvest (Tracy and Jessica, 2015). Bees alone are responsible for about 80 per cent to 100 per cent of the pollination of crops, especially those related to the production of seeds and fruits (Rosemeire *et al*, 2009). Among the total pollination activities, over 80 per cent are performed by insects. Honeybees are however critically important for crop pollination worldwide (Levin and Waller, 1989; Watanabe, 1994; Thapa, 2006; Klein *et al*, 2007) and the yields of some fruit, seed and nut crops can decrease by more than 90 per cent without these pollinators (Southwick and Southwick, 1992).

Causes of declining bee populations

Numerous studies have established that populations of the domesticated honey bee as well as a wide array of wild bees are in decline due to a number of hazards including pesticides, pathogens, parasites, poor nutrition and habitat loss. One of the reasons, primarily attributed by farmers and apiculturists, is the increasing use of GM crops. The farmers and beekeepers are

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more concerned about the indirect effects of GM crops. The timing and length of flowering in GM crops may pose a significant threat to bees. Some GM crops flower earlier or later than conventional crops, which can cause a mismatch in when bees need nectar and pollen and whenit is available. This mismatch could ultimately lead to a drop in honey production, which can lead to starvation in bee colonies.

Many studies have indicated habitat alteration as a key cause in bee reduction. Rapid urbanization, agricultural development, and deforestation have resulted in the degradation and fragmentation of natural habitats vital to pollinator survival.

Monoculture has simplified insect biodiversity in several ways. It has lowered the quantity of pollinators and insects that naturally manage crop pests. Furthermore, monocultures produce an environment conducive to pest growth, resulting in an additional drop in bee populations owing to pest-borne illnesses. Agricultural intensification through monoculture farming has increased reliance on synthetic agrochemicals such as insecticides and fertilizer. Environmental pollution, including fertilizers, synthetic pesticides, sewage, landfill leachates, air pollution and industrial chemicals, is a significant contributor to bee decline, ranking second only to habitat change.

Impact of bee decline

India, with its predominantly agrarian economy, heavily relies on the activity of pollinating bees to optimize the yield of 70 per cent of food crops. The relative yield growth rate of pollinator-dependent crops declined after 1993, indicating pollinator limitation.

Recent research indicates that the decline in bee populations is resulting in a decrease in crop yields, which has impacted the accessibility and cost of nutritious foods such as fruits, vegetables, legumes, and nuts

Combating bee decline

Promoting organic farming represents a promising alternative to intensive agriculture and has the potential to address bee decline caused by pesticide use, monoculture, and genetically modified crops. Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. A number of studies have conducted that organic farms support more pollinators than conventional farms (Kremen *et al*, 2002; Andersson, 2014; Kehinde and Samways, 2014). Organic farming requirements prohibit the use of toxic

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pesticides; support higher levels of biodiversity than conventional farms, and can contribute to pollinator conservation in a number of ways.

Organic farming bans the use of synthetic inputs while increasing biodiversity on-site and in neighboring fields, resulting in increased bee species richness, increased numbers of solitary bees and bumblebees, and improved pollinator rates. Furthermore, all very hazardous and fatal insecticides for bees should be outlawed as soon as feasible. Furthermore, India's Pesticide Management Bill, 2020, requires revision to ensure effective pesticide bans and management, as it lacks mechanisms for lowering and mitigating pesticide dangers.

By introducing plant heterogeneity into farming systems by way of crop rotations, hedge row planting, and by fostering native plant diversity within and around farmland, any farm can combat pollinator malnutrition and habitat degradation. Additionally, the incorporation of integrated pest management techniques that encourage beneficial pest predators can help conventional farmers reduce the quantity of chemical pesticides used and, in turn, the level of bee exposure to pesticides. Finally, organic farming benefits all of agriculture simply by supporting healthier pollinator communities essential to nutritious food production regardless of farming method

Conservation measures need of the hour for Bee keeping

In the face of the declining bee population, implementing conservation measures is of paramount importance, and this task involves cooperation from various stakeholders.

Promoting Pollinator-Friendly Practices: To ensure the health and survival of bees, we need to encourage pollinator-friendly agricultural practices. This involves reducing pesticide usage, creating bee-friendly habitats, and diversifying crops. NGOs in India significantly promote these practices, particularly in rural and agricultural communities.

Raising Awareness and Education: Awareness about the importance of bees and the dangers they face is crucial. NGOs and other educational institutions are fundamental in educating farmers, beekeepers, policymakers, and the public about the value of bees, the need for their conservation, and the importance of sustainable agricultural practices. They also run campaigns that advocate for the preservation of natural habitats and encourage citizen participation in bee conservation efforts.

Policy and Regulation: Government organization and other NGOs can also influence policy and regulation to protect bees. They advocate for the development and implementation of policies that promote pollinator conservation, regulate pesticide usage, and protect natural habitats.

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Soil Reaction is A Source of Nectar Production

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Soil is a primary source for all living organisms. Its chemical reactions play a major role in soil fertility status and influence the populations of flora and fauna. A neutral soil can support a greater availability of macronutrients such as nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), and magnesium (Mg), as well as most micronutrients (Zn, Cu, Al, and Fe) which are available in slightly acidic to moderately acidic conditions, except for molybdenum. Molybdenum, a micronutrient, is only available in soils with neutral to alkaline pH levels. Lovell states that, 'Plants growing in soils to which they are adapted are more vigorous and produce more nectar than in soils in which they do not flourish.' In his section on New York State, Lovell emphasizes, 'New York well illustrates the importance of understanding soil properties not only for the farmer but also for the beekeeper.

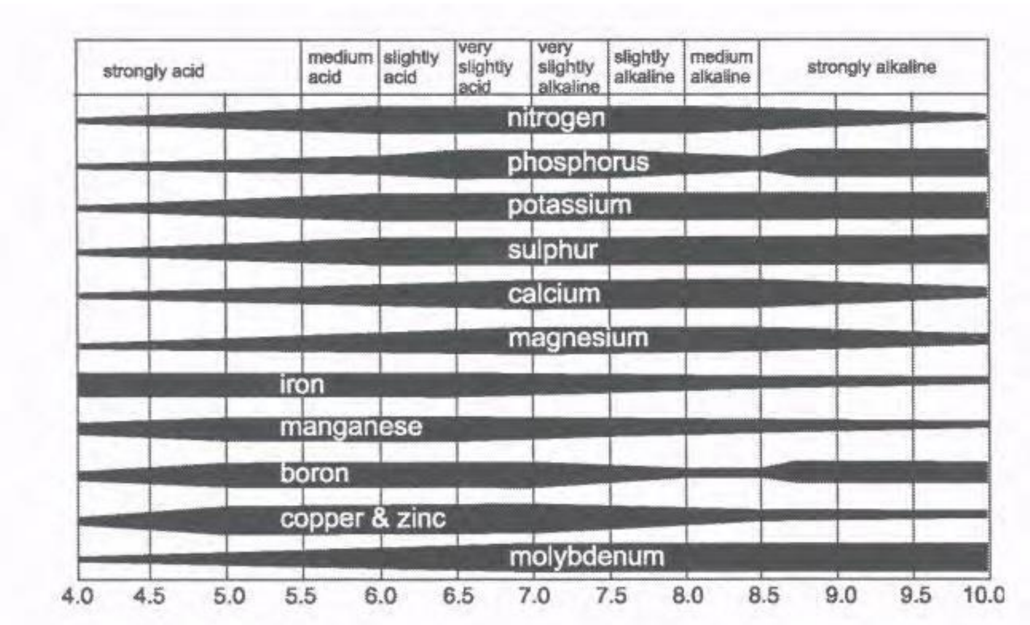

Figure 1. Chart of the Effect of Soil pH on Nutrient Availability

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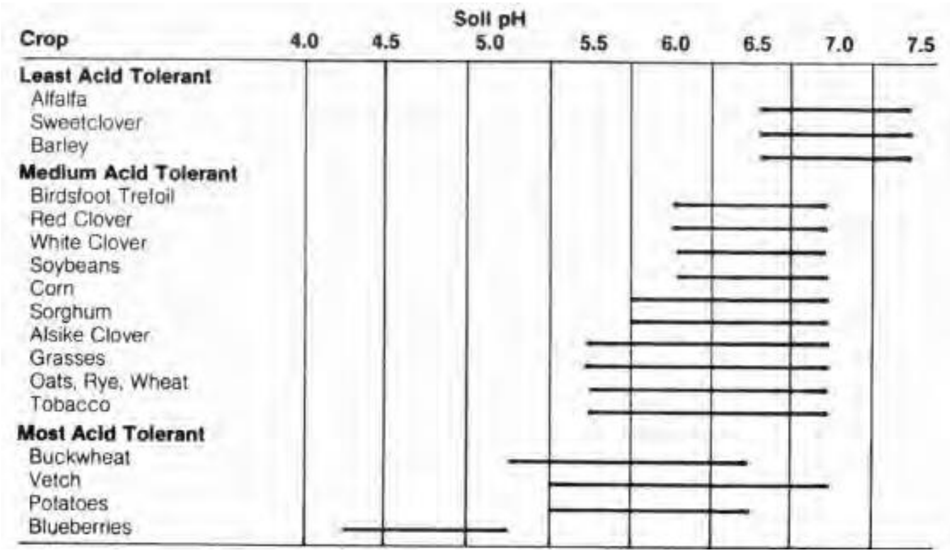

Figure 2. Range of pH Tolerances for different crops. (Purdue Forage Information)

Fig. Spotted Knapweed (Photo by Peter Borst)

Michael Johnston (2023) gave an example of plants that prefer high lime soils but will grow in other soils include spotted knapweed and purple loosestrife. Both of these plants have been spreading throughout New York State. In areas with high pH soils, these two plants (along with white clover and basswood) contribute to a sustained honey flow that begins in early July and continues through the end of August. Though knapweed and loosestrife are now common in areas with acid soils; beekeepers there still report a dearth from mid-July until goldenrod starts blooming in the middle of August. So these two plants grow on these acid soils but do not produce much nectar there.

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Another greatest examples of calciphobes are plants that belong to the Ericaceae, another very important family of honey plants. Included are blueberry, cranberry, Manzanita and madrone in North America. Common heather or ling in Great Britain is also in the Ericaceae. All grow in strongly acid soils. For example, blueberry prefers a range of 4.2 to 4.8 pH. These plants rely on their association with mycorrhizae to obtain nutrients that are not readily available in acid soils. Mycorrhizae are ground fungus that are symbiotic with the roots of most plants. Their mycelium reaches further than the root hairs of plants and being a fungus, they break down the organic matter present in soil. While the mycorrhizae supply nutrients, the plant repays with sugars and carbohydrates. Bees contribute $15 billion to crop value annually by pollinating approximately 75% of the fruits, vegetables, and nuts within the United States alone (Hamilton, 2013). Declines in honeybee colonies are a critical threat to agriculture, the economy, and our global food supply (Grossman, 2013).

In conclusion, soil chemistry plays a foundational role in shaping plant growth, nutrient availability, and the overall health of ecosystems that bees rely on for nectar. The balance of macronutrients and micronutrients in the soil, regulated by pH levels, directly influences the vigor of nectar-producing plants. Neutral or slightly acidic soils provide optimal conditions for most essential nutrients, whereas specific plants, like those in the Ericaceae family, have adapted to thrive in more acidic soils through their symbiotic relationships with mycorrhizal fungi. This intricate interplay between soil fertility and plant adaptation underscores the importance of understanding soil properties not only for agricultural success but also for sustainable beekeeping. Regions like New York State exemplify the need to consider soil characteristics when managing honey production, as plants adapted to particular soils produce more nectar, sustaining honey flow during critical periods. Additionally, declines in honeybee populations, vital for pollinating a wide variety of crops, further highlight the urgency of maintaining healthy soils to support both plant and bee health. By ensuring diverse and fertile soils, we safeguard the future of agriculture and food security through the essential pollination services that bees provide.

Reference:

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Review On Honey with Its Structural, Medicinal and Biological Properties.

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Honey has been one of the most prized and cherished natural goods available to humans. In addition to being used as a nutritional supplement, honey is also utilized in traditional medicine to treat a variety of clinical ailments, from cancer treatment to wound healing. The focus of this review is to highlight the many medical applications of honey. Honey has long been used as a nutritional supplement and to cure a variety of conditions, including piles, eczema, worm infestation, hepatitis, bronchial asthma, throat infections, TB, weariness, dizziness, and eye disorders. Antioxidant, antibacterial, anti-inflammatory, antiproliferative, anticancer, and antimetastatic properties have all been linked to the components of honey. Numerous indicators point to the usage ofhoney is used in the management of wounds, diabetes, cancer, asthma, and gastrointestinal, neurological, and cardiovascular conditions. Because of its antioxidant, antibacterial, anti-inflammatory, and phytochemical qualities, honey may be used therapeutically to treat illness. The two main bioactive compounds found in honey are flavonoids and polyphenols, both of which have antioxidant properties. Modern scientific literature suggests that honey may be helpful and protective for the treatment of a number of disease conditions, including diabetes mellitus, respiratory, gastrointestinal, cardiovascular, and nervous system disorders. Because honey contains a variety of antioxidants, it may even be helpful in the treatment of cancer. Finally, honey may be used as a natural therapeutic agent for a range of medical conditions.

Key words: *Eye disorders, Biological Properties, Treatment of cancer, Flavonoids*

1. INTRODUCTION

A natural product, honey is made by honeybees (Apis mellifera; Family: Apidae) from the nectar of flowers. Humans have utilized honey from prehistoric times, around 5500 years

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ago. The majority of the ancient population, including the Mayans, Babylonians, Greeks, Chinese, Egyptians, Romans, and Egyptians, used honey for both nutritional and therapeutic purposes. The only naturally occurring substance created from insects, honey has uses in industry, cosmetics, medicine, and nutrition. Honey is regarded as a healthy diet and is enjoyed by people of all ages, including men and women. Honey can be kept unopened at room temperature in a dry place and doesn't need to be refrigerated because it never goes bad. Honey has a water activity (WA) of 0.56 to 0.62 with a pH value of almost 3.9. Since ancient times, honey has been used as a natural sweetener because of its high glucose content (honey is 25% sweeter than table sugar). In addition, the use of honey in drinks is becoming increasingly popular. Today, information about the use of honey to treat many human diseases can be found in general journals, magazines and natural product books, showing many unknown functions. before. Evidence suggests that honey has many health benefits, including antioxidant, anti-inflammatory, antibacterial, antidiabetic, respiratory, digestive, cardiovascular and nervous system protection effects. Although many studies have been conducted on honey, few have been published. This study, a comprehensive review of the current literature, highlights the medicinal benefits of honey in disease management.

2. METHODS

A literature review was conducted to identify new literature demonstrating the effectiveness of honey in the treatment of diseases. Several online databases were consulted, including the Web of Science, ScienceDirect, and PubMed. The following keywords were used individually and in combination as inclusion criteria for articles considered for this review: honey antioxidant, anti-inflammatory, antibacterial, antidiabetic, apoptosis, respiratory, gastrointestinal, and cardiovascular and nervous system. This review spans 42 years with publications from 1970 to 2014. Approximately 200 results were obtained from the initial searches. Sections of these articles were reviewed to ensure relevance.

MEDICINAL

2.1. HISTORY OF HONEY

Evidence from Stone Age paintings shows treatment of disease with bee product such as honey originated from 8000 years ago. Ancient scrolls, tablets and books-Sumerian clay tablets (6200 BC), Egyptian papyri (1900–1250 BC), Veda (Hindu scripture) 5000 years, Holy Koran, Bible, and Hippocrates (460–357 BC) illustrated that honey had been widely used as a

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drug. Qur'an vividly indicated the activity of therapeutic value of honey. The Lord has inspired the bees, to build their hives in hills, on trees, and in man's habitations, from within their bodies comes a drink of varying colors, wherein is healing for humankind, verily in this is a sign, for those who give thought. Although a number of papers have been published about honey, most of them have focused on the biochemical analysis, food, and nonfood commercial utilization. In traditional medicine, honey is used for many ailments, including eye diseases, asthma, throat, tuberculosis, thirst, hiccups, fatigue, dizziness, hepatitis, constipation, ringworm, piles, eczema, healing wounds and ulcers.

2.2. NUTRITIONAL AND NON-NUTRITIONAL COMPONENETS OF HONEY

Today, about 300 types of honey are known. These types are related to the types of nectar collected by honey bees. The main composition of honey is carbohydrates, which make up 95-97% of the dry weight. In addition, honey contains important compounds such as proteins, vitamins, amino acids, minerals and organic acids. Monosaccharides (fructose and glucose) are the main sugars in honey and may contribute to the nutritional and physical benefits of honey. I tuaatu i temonosakkarider, he itiaketedisakkarider (sucrose, galactose, alfa, beta-trehalose, gentiobioseoglaminaribose), trisakkarider (melzitose, maltotriose, 1- ketose, panose, isomaltose, glucose, erulose, isomaltose, isomaltosan, isomaltosan, isomaltose. Most of these sugars are formed during the ripening and ripening of honey. Gluconic acid, the product of the oxidation of glucose, is the main organic acid in honey. In addition, small amounts of acetic acid, formic acid and citric acid have been detected. These organic acids are responsible for the acidic nature (pH between 3.2 and 4.5) of honey. Honey also contains essential amino acids such as the nine essential amino acids and non-essential amino acids except asparagine and glutamine. It has been reported that Proline is the first amino acid in honey, followed by other amino acids. Enzymes (diastase, invertase, glucose oxidase, catalase and acid phosphatase) make the most important protein substances in honey. The vitamin level in honey is low and does not come close to the daily amount. Of all the water-soluble vitamins found in honey, vitamin C is the most important. About 31 different minerals have been found in honey, including all the essential minerals such as phosphorus, sodium, calcium, potassium, sulphur, magnesium and chlorine. Many important elements have been found in honey such as silicon (Si), rubidium (RB), vanadium (V), zirconium (Zr), lithium (Li) and strontium (Sr). However, some heavy m*et al*s such as lead (Pb), cadmium (Cd) and arsenic (As) are considered contaminants. Previous studies have identified more than 600 volatile compounds in honey that contribute to its biological medicinal properties. There are few volatile compounds in honey, but aldehydes, alcohols, hydrocarbons, ketones, acid esters, benzene and its derivatives, pyrans, terpenes and derivatives, norisoprenoids, and sulfur, furan and the cyclic compound. Flavonoids and polyphenols, which act as antioxidants, are the two most important biological molecules in honey. Recent evidence has shown the presence of approximately 30 types of polyphenols in honey. The presence and levels of these polyphenols in honey may vary depending on the flower source, climate and geographical conditions. Certain biological compounds, including galangin, Quercetin, kaempferol, luteolin and isoramanthin are found in all types of honey, while naringenin and hespertin are only found in certain types. In general, the most common phenolic and flavonoid compounds found in honey are gallic acid, syringic acid, ellagic acid, benzoic acid, cinnamic acid, chlorogenic acid, caffeic acid, isorhamnetin, ferulic acid, myristicin, chrysin, coumaric acid, apigenin and coercic. . Kaempferol, hespertin, galangin, catechin, luteolin and naringenin. Honey compounds have been shown to have antioxidant, antimicrobial, anti- inflammatory, anti-proliferative, anti-cancer and anti-metastatic effects.

2. 3. STRUCTURES OF MAJOR FLAVONOIDS, ORGANIC ACIDS, AND PHENOLIC ACIDS IN HONEY

Flavonoids refer to a group of active natural compounds with a 15-carbon structure consisting of two benzene rings joined by a heterocyclic pyran ring. They are generally classified as flavonols (quercetin, kaempferol, and pinobanksin), flavones (luteolin, apigenin, and chrysin), flavonones (naringenin, pinocembrin, and hespertin), isoflavones (genistein), and anthocyanidins. Some flavonoids, including genistein, chrysin, luteolin, and naringenin, have been reported to exhibit estrogenic activity and are called phytoestrogens.Antioxidants such as oxygen play a role in preventing damage as antioxidants found in foods and in the human body. Although the role of natural antioxidants

2. 4. BIOLOGICAL ACTIVITIES OF HONEY

2. 4. 1. ANTIOXIDANT ACTIVITY

The human body is not fully understood; however, studies show that the role of natural honey in many aging processes and the process that changing the most reactive substance from oxygen, radicals. It shows free and reactive oxygen species. (SPEAKING). It is formed during metabolism. These substances interact with the membrane and protein components in the cell membrane, enzymes and DNA. These negative reactions lead to many diseases. Fortunately, antioxidants neutralize free radicals before they can do any damage. Enzymatic and non-

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enzymatic substances are used as antioxidant defenses. The ability of honey to have antioxidant properties is related to the brightness of honey. Therefore, dark honey has a higher antioxidant value. It has been shown that phenolic compounds are the main reason for the antioxidant activity of honey, because the level of phenolics affects the amount of honey scavenging radicals. Other studies show that the antioxidant activity is related to the formation of many active compounds in honey. Therefore, honey has the potential to work as a food supplement.

Antioxidant According to scientific literature, only honey and conventional treatments can be a new antioxidant to control oxidative stress. In fact, from the majority of these data obtained from experimental studies, there is a great need to study this antioxidant effect of honey in various human diseases.

2. 4.2. ANTIMICROBIAL ACTIVITY

The main factors for antimicrobial activity of honey are the enzymatic glucose oxidation reaction and some of its physical aspects, but the other factors that can show antimicrobial activity of honey include high osmotic pressure/low WA, low pH/acidic environment, low protein content, high carbon to nitrogen ratio, low redox potential due to the high level of reducing sugars, a viscosity that limits dissolved oxygen and other chemical agents/phytochemicals. Due to the properties of honey such as low WA and water acidity, glucose oxidase, and hydrogen peroxide, honey does not help in the growth of yeast and bacteria. The peroxidase is not all origin of antibacterial level of honey, but many products with low antibacterial level were discovered in honey including terpenes, pinocembrin, benzyl alcohol, 3,5-dimethoxy-4-hydroxybenzoic acid (syringic acid), methyl-3,5-dimethoxy- 4-hydroxybenzoate (methyl syringate), 2-hydroxy-3-phenylpropionic acid, 2-hydroxybenzoic acid, 3,4,5-trimethoxybenzoic acid, and 1,4-dihydroxybenzene.

Many studies have shown that the antibacterial activity of honey is the least inhibitory concentration. Therefore, honey is the minimum concentration necessary for the overall growth of immunity. Among the many types of honey, Manuka honey has the highest level of non-peroxide activity. Studies have shown that Escherichia coli and Staphylococcus aureus can be inhibited with Manuka honey. The antibacterial activity of honey has been shown to be effective against many bacterial and fungal pathogens.

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peroxide activity. Studies have shown that Escherichia coli and Staphylococcus aureus can be inhibited with Manuka honey. The antibacterial activity of honey has been shown to be effective against many bacterial and fungal pathogens.

2.4.3. APOPTOTIC ACTIVITY

Cancer cells are characterized by a very low apoptotic cycle and uncontrolled cell growth. Chemicals used to treat cancer induce apoptosis. Honey induces apoptosis in many types of cancer cells by reducing the mitochondrial membrane. Honey increases caspase 3 activation and poly (ADP-ribose) polymerase (PARP) cleavage in human colon cancer cell lines, related to its high phenolic composition. Furthermore, apoptosis is induced by altering the expression of pro- and anti-apoptotic proteins in colon cancer. Honey increases the expression of p53, caspase 3 and the pro-apoptotic protein Bax and also reduces the expression of the anti-apoptotic protein Bcl2.

Honey produces ROS, which leads to the activation of p53 and p53, which in turn alters the expression of pro and anti-apoptotic proteins such as Bcl-2 and Bax. Oral consumption of honey increases the expression of pro-apoptotic protein Bax and decreases the expression of anti-apoptotic protein Bcl-2 in tumor tissue of Wistar rats. Intravenous injection of Manuka honey affects cancer cell lines through the induction of caspase 9, which activates caspase-3, a killer protein. Apoptosis induced by Manuka honey also involves PARP activation, DNA fragmentation and loss of Bcl-2 expression. The apoptotic properties of honey make it a natural property as an anticancer agent, as many currently used chemotherapy drugs are apoptosis-inducing substances.

2.4.4. ANTI-INFLAMMATORY AND IMMUNOMODULATORY ACTIVITIES

Chronic inflammation can prevent healing by damaging tissue. According to current literature, honey reduces the inflammatory response in animal models, cell culture and clinical studies. The phenol content in honey is responsible for the anti-inflammatory effect. These phenolic compounds and flavonoids suppress the pro-inflammatory activities of cyclooxygenase-2 (COX-2) and/or inducible nitric oxide synthase (iNOS). Honey and its compounds play a role in regulating proteins such as iNOS, ornithine decarboxylase, tyrosine kinase and COX-2. Various types of honey have been found to induce tumor necrosis factor alpha, interleukin-1 beta (IL-1β) and IL-6 production. Honey increases the production of T and B lymphocytes, antibodies, eosinophils, neutrophils, monocytes and natural killer cells during primary and secondary immune responses in tissue culture. It was shown that slow absorption

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leads to the production of short chain fatty acids (SCFA). This means that eating honey can lead to SCFA production. The immunomodulatory effects of SCFA have been established. Therefore, honey can restore immune response through these fermentable sugars.

The sugar, Nigro oligosaccharide, found in honey has been shown to have anti-inflammatory properties. The non-sugar compounds of honey are responsible for disease modification.

2. 5. MEDICINAL PROPERTIES

2. 5. 1. HONEY AND WOUND

Honey is the oldest wound healing remedy known to man, as some newer substances have failed. Experimental studies show many articles that support its use in wound healing due to its biological activities, including antibacterial, antiviral, anti-inflammatory and antioxidant activities. Honey induces leukocytes to release cytokines, which initiate tissue- building cycles. In addition, the immune response to disease is activated. Honey has also been reported to stimulate other immune response properties (growth of B and T lymphocytes and phagocytic activity). Honey produces antibodies. There is a lot of evidence that suggests the use of honey in the management and treatment of acute wounds and mild burns and mild burns and burns. Although some studies show that honey is effective in treating ulcers and leg ulcers, more research is needed to strengthen the current evidence.

2. 5. 2. HONEY AND DIABETES

There are strong evidences which indicate the beneficial effects of honey in the treatment of diabetes mellitus. These results point out the therapeutic prospects of using honey or other potent antioxidants as an adjunct to standard antidiabetic drugs in the control of diabetes mellitus. Regarding the restrictions associated with using of antioxidants, other interventions targeted at decreasing ROS generation may also be used as an adjunct to conventional diabetes therapy. In one of the clinical trials of Type 1 and Type 2 diabetes mellitus, the application of honey was associated with dramatically lower glycemic index than with sucrose or glucose in type 1 diabetes and normal. Type 2 diabetes has values similar for honey, glucose, and sucrose. In diabetics, honey can lower plasma glucose levels compared to dextran. In normal and hyperlipidemic patients, blood lipids, homocysteine and C-reactive protein are also reduced. However, many questions remain, especially regarding the nature of diabetes mellitus management and interventions targeting oxidative stress and hyperglycemia. In addition, the medical benefits of honey in the treatment of diabetes may not be limited to

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controlling blood sugar, but may also be extended to improve cancer-related problems.

2. 5. 3. HONEY AND CANCER

According to recent research, honey may have multiple anticancer pathways. Research has shown that honey inhibits several cell-signaling pathways, such as those that cause apoptosis, are antimutagenic, antiproliferative, and reduce inflammation, which confers anticancer properties. Honey alters the immune system's reactions. Several cancer types, including melanoma, adenocarcinoma epithelial cells, cervical, endometrial, liver, colorectal, prostate, renal cell carcinoma, bladder, human nonsmall cell lung cancer, osteosarcoma, leukemia, and mouth cancer cells (oral squamous cell carcinoma), have been shown to respond negatively to honey in terms of preventing cell proliferation, inducing apoptosis, altering cell cycle progression, and causing mitochondrial membrane depolarization. Furthermore, in animal models, honey has been shown to suppress a number of tumor types, including bladder, hepatic, colon, breast, and melanoma carcinomas. However, additional research is required to fully understand the protective effects of honey against cancer.

2. 5. 4. HONEY AND ASTHMA

In folk medicine, honey is frequently used to alleviate fever, coughing, and inflammation. It has been demonstrated that honey has the power to lessen asthma-related symptoms or to function as a preventive measure to stop asthma from starting. In animal models, oral honey ingestion was used as a treatment for both bronchial asthma and chronic bronchitis. Moreover, research by Kamaruzaman *et al*. demonstrated that honey administration successfully prevented ovalbumin-induced airway inflammation by lowering asthma-related histological alterations in the airway and also prevented the development of asthma. It has also been found that goblet cell hyperplasia that secretes mucus can be successfully removed by honey inhalation. To better understand the processes by which honey decreases asthma symptoms, more research is necessary to examine these effects of honey.

2. 5. 5. HONEY AND CARDIOVASCULAR DISEASE

Antioxidants found in honey, such as flavonoids, polyphenols, vitamin C, and monophenols, may be associated with a reduced risk of cardiovascular failure. In coronary artery disease, the protective effects of flavonoids, such as antioxidants, antithrombotic, antiischemic, and vasorelaxant properties, may (a) improve coronary artery dilation, (b) reduce platelet coagulability, and (c) inhibit low-density lipoprotein oxidation. The antioxidants found in different types of honey are diverse, but the main ones are caffeic acid, quercetin, phenethyl esters, kaempferol, galangin, and acacetin. Several studies have shown that certain honey polyphenols have promising pharmacological functions in reducing cardiovascular disease. However, in vitro and in vivo studies and clinical trials need to be initiated to further validate these compounds in medical applications.

3. CONCLUSION

There is sufficient evidence to recommend the use of honey in the treatment of medical conditions. Evidence is needed to support the use of honey in all areas of clinical practice. Studies have shown that the medicinal benefits of honey may be due to its antibacterial, anti-inflammatory, apoptotic and antioxidant properties. This review should provide physicians with noteworthy evidence regarding the use of honey in the medical field. Although there are several studies that have examined the effectiveness of medicinal honey, more studies are needed to cover all the medicinal benefits of honey.

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Threats to Bees: A Multidimensional Point of View: Short Review

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Bees play an essential role in ecological sustainability and agricultural productivity through pollination, crucial for food security and biodiversity. Recently, bee populations and apiculture have faced numerous threats from environmental changes, agricultural practices, and soci*et al* shifts. This review explores five key dimensions of these threats: environmental impacts, agricultural and chemical threats, and the influence of veganism, diseases, and the effects of pollution. Climate change, habitat loss due to urbanization and agricultural expansion, and pesticide use all significantly harm bee populations. While vegan agriculture is often seen as eco-friendly, the heavy reliance on monocultures, such as soy and almond farming, reduces bee-friendly habitats. Diseases such as Varroa mites, Nosema, and Colony Collapse Disorder (CCD) have further exacerbated bee population declines globally. Finally, pollution from air pollutants and environmental toxins affects bees' foraging abilities and overall health. Despite increased awareness, significant research gaps remain regarding the cumulative effects of these threats and potential long-term solutions. This review emphasizes the need for integrated conservation efforts and sustainable agricultural practices to ensure bee survival and ecosystem stability.

Keywords: Bee decline, threats to bees, veganism impact, bee diseases, environmental impacts

Introduction:

Bees are among the most important pollinators around the world with over 20,000 species and can be used as indicators of health status. These tiny creatures help in pollinating almost 75% of global crops as well as 90% of wild flora, hence becoming essential for food production as well as the sustainability of ecosystems (Klein *et al*., 2007). Apart from pollination, bees provide products such as honey, beeswax, and royal jelly, which are very important economically to world economies, especially the rural communities. For several decades now, there has been growing concern that the bee population around the world is dwindling. It has been witnessed that the number of bees in Europe has reduced by over 30% during the past decade alone (Potts *et al*., 2010). Losses of managed honeybee colonies have been reported as high as 40% by North American beekeepers in 2020 (Kulhanek *et al*., 2021). A recent research study noted that bee abundance has declined by up to 20% in India (Steinhübel *et al*., 2021). Such alarming losses become a matter of concern and necessitate immediate attention, since the downward trend may lead to widely observable effects in ecosystems and agricultural productivity.

The decline in bee populations is linked to several threats, each posing significant challenges. Climate change disrupts temperature patterns and seasonal flowering cycles, diminishing bee survival rates and foraging efficiency (Rader *et al*., 2020). Habitat loss in urbanization and agricultural expansion reduces nesting sites and foraging resources (Winfree *et al*., 2009). Overuse of pesticides and herbicides, and monoculture farming further add to an inhospitable environment for bees, as do diseases like Varroa mites, Nosema, and CCD continuing to destroy colonies worldwide (VanEngelsdorp *et al*., 2009). While vegan agriculture has often been viewed as environmentally friendly, monocultures of soy and almonds eradicate clover and alfalfa that can provide a source of nourishment for bees (Mallinger *et al*., 2016). Moreover, pollution in the form of air pollutants and heavy m*et al*s compromised the immune systems of the bees and reduced their reproductive output (Li *et al*., 2015).

This review explores the various threats bees face and the mechanisms behind them, focusing on key dimensions like pathogens, pesticides, environmental changes, agriculture, and veganism's indirect effects on bees. Each section will delve into these threats, their impacts on bee health, and possible mitigation strategies.

Section 1: Environmental Effects Climate Change:

Climate change is the most adverse factor against bees in that it alters the environmental factors by which the bees depend to survive. It probably upset the synchrony of bees with plants and lead to a deprivation of flowers from blooming at their right time and foraging times for them (Rader *et al*., 2020). Droughts, storms, and floods-general extreme weather events-

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limit the availability of floral resources and habitats suitable for the bees (Kerr *et al*., 2015). By 2070, studies predict that 65% of bees will experience significant population declines (Rahimi & Jung, 2024).

Urbanization:

Urbanization and agricultural expansion exacerbate habitat loss, fragmenting landscapes that bees rely on for foraging and nesting (Winfree *et al*., 2009). Reduced wildflower meadows and forests, and decreased availability of bee-friendly habitats, cause them to travel farther to obtain necessary resources, elevating their energy expense and stress level, according to Garibaldi *et al*. (2011).

Section 2: Biological and Chemical Threats Pesticides and Chemicals:

Heavily cultivated pesticides and herbicides in industrialized farming have become a major threat to bees. Among these, the neurotoxic pesticides known as neonicotinoids affect bees' foraging behavior, navigation, and communication, which leads to colony collapse (Goulson *et al*., 2015). Sublethal doses also downgrade their immune response, making them more prone to disease and leading to lesser reproductive successes. The glyphosates also deprive them of nectar-rich plants (Kleijn *et al*., 2015).

Monoculture Farming:

Monoculture farming, through the cultivation of a single crop over large areas, reduces biodiversity and creates less pollinator-supportive environments (Gabriel *et al*., 2010). There is a dearth of diversity in plant species, limiting the availability of pollen and nectar upon which the bees draw for nutrition and health. The reliance on chemical inputs in monoculture systems will make matters worse, reducing bee populations.

Section 3: Impact of Vegan Agriculture on Bees Monoculture and Vegan Agriculture:

Monoculture farming of crops like soy, almonds, and avocados is only more relevant in a world of growing demand for plant-based products as part of vegan diets. Veganism was meant to stop the dying and suffering of animals; monoculture agriculture, however, pushes out diverse ecosystems from their habitat and diminishes bee-friendly plants like clover and alfalfa (Mallinger *et al*., 2016). Additionally, almond farming, which heavily depends on bee pollination, exposes bees to pesticides and stressful foraging conditions, leading to high mortality rates (Sagili & Burgett, 2011). The transportation of bees across long distances for pollination services exacerbates disease and pest transmission.

Section 4: Disease and Disorder

Varroa Mites and Nosema:

Varroa mites are parasitic mites that weaken bees by feeding on their hemolymph and transmitting viruses like the Deformed Wing Virus (DWV). Similarly, Nosema, a fungal pathogen, infects bees' digestive tracts, reducing foraging efficiency and colony productivity (Fries, 2010). Both these diseases, along with CCD, have caused widespread colony losses globally.

Colony Collapse Disorder (CCD):

CCD is a complex and poorly understood phenomenon, possibly linked to pesticide exposure, malnutrition, and pathogen interactions (Evans &Schwarz, 2011). Addressing these issues requires better disease management practices, breeding for disease-resistant bees, and reducing the stress factors that exacerbate outbreaks.

Section 5: Pollution

Air Pollution and Heavy M*et al*s:

Pollution from air pollutants like ozone and particulate matter interferes with bees' ability to detect floral scents, reducing foraging efficiency and pollination rates (Li *et al*., 2015). Heavy m*et al*s such as lead and cadmium, which accumulate from industrial activities, contaminate bee habitats, impair cognitive function, and reduce reproductive success (Hladun *et al*., 2016).

Environmental Toxins:

Environmental toxins, including those in polluted water sources, compromise bee health by weakening their immune systems and making them more vulnerable to diseases and parasites (Di Prisco *et al*., 2013). The cumulative effects of pollution are not fully understood, but reducing environmental pollutants is essential for conserving bee populations and protecting ecosystem services.

Discussion:

The threats to bees are numerous and multifaceted, with climate change, habitat loss, pesticide exposure, diseases, and pollution all playing critical roles. Climate change disrupts flowering cycles and reduces habitat availability, while pesticides impair bee cognition and foraging behavior. Diseases like Varroa mites and CCD continue to devastate bee populations,

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exacerbated by stress from industrial farming practices. Pollution from heavy met *al*s and air pollutants further weakens bees, reducing reproductive success and pollination rates. Sustainable farming practices that promote biodiversity and reduce chemical inputs are essential to mitigating these threats (Goulson *et al*., 2015; Gabriel *et al*., 2010).

Integrated conservation strategies that address these multifaceted challenges are crucial. Further research is needed to understand the cumulative effects of these stressors and to explore the long-term impacts on both wild and managed bee populations. Policymakers should implement stricter pesticide regulations and encourage sustainable agricultural practices to protect bee habitats (Potts *et al*., 2010; Klein *et al*., 2007). Public awareness campaigns can help communities contribute to conservation efforts.

Conclusion:

Bees and apiculture face significant threats from climate change, habitat loss, pesticide exposure, monoculture farming, diseases, and pollution. Addressing these issues requires a multifaceted approach, including sustainable agricultural practices, improved disease management, and efforts to reduce environmental pollutants. Future research should prioritize interdisciplinary studies to better understand the cumulative effects of these threats on bee populations. Collaboration between scientists, farmers, and policymakers is essential for the long-term survival of bees and the ecosystems they support.

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TRENDS IN AGRICULTURE SCIENCE

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Apiary and agriculture systems for environmental and ecological security

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Agricultural well-being and the inherent biological interdependence are still beset by a number of issues that significantly impede environment, ecology, local economic and social development. These issues include low family farm productivity, limited market access for agricultural products, and environmental and natural resource abuse. Farming is an intricate web of interconnected soil, plant, animal, and tool systems. labour, capital, power, and other inputs that farming controls in part households and had a variety of influencing degrees according to political, economic, social and institutional dynamics that function on a variety of levels. In recent decades, the pursuit of sustainability has contributed to the increased interest in agricultural diversity, productivity, and human well-being. This landlocked region's population, which consists primarily of the most vulnerable and impoverished strata, is almost entirely agro-pastoral and many also engage in apiculture. But more research and understanding are needed to determine the precise nature of the linkages between these global objectives. In order to provide food security and safeguard the environment, the "Eco-responsible apiculture for the protection of the environment" ,seeks to promote the apicultural sector's growth. Pollination is a special ecosystem service that apiaries can only offer if they are both commercially and ecologically sustainable. In terms of the environment, economy, and society, pollination is an essential ecosystem service. Thus, increasing the profitability of beekeeping operations which are primarily conducted in rural areas is imperative. Millions of beekeepers around the world rely on apiculture for their livelihoods and well-being, making it a widely practiced business. Bees, in conjunction with natural pollinators, are essential to the preservation of biodiversity, the survival and propagation of several plant species, the health of forests, increased agricultural productivity, and the ability to adjust to climate change. Fostering agricultural systems with greater diversity and decreasing dependence on harmful chemicals can promote higher pollination rates. Both the ecology and human populations stand to gain from this strategy's improvements in food quality and quantity.

Keywords: *agricultural diversity, apiculture, food security, natural pollinators, apiculture)*

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Introduction:

Bees play a vital role in pollination, which is essential to the upkeep of ecosystems. They are essential to the preservation of biodiversity, the survival of a wide variety of plants, the promotion of forest regeneration, the provision of sustainability and climate change adaption, and the enhancement of both the quantity and quality of agricultural production systems. In actuality, pollinators are necessary for the continued production, productivity, and quality of almost 75% of the world's crops that supply fruits and seeds for human use. Apiculture, or beekeeping, encompasses all activities related to the practical management of social bee species. Yap, N.T *et al*, 2015 the complex connection between environmental health and public health, with a focus on beekeeping's under-utilization. The four pillars of availability, accessibility, use, and stability are all included in the notion of food security, which was developed during the World Food Summit in 1996. This comprehensive framework lays the groundwork for understanding the important facets of food security. The loss of beehive colonies and disregard for apiculture can have serious effects on the environment and public health. Examining the sometimes-ignored relationship between beekeeping and food security and identifying the complex relationships between pollinators and crop sustainability [Hecklé,R*et al*;2018].As important pollinators of vital food crops, honeybees provide both ecological and socio-economic benefits. Even though it is obvious that beekeeping increases food security and enhances the nutritional value of bee products, commercial beekeeping presents a theoretical framework that covers ecological systems theory, social ecology, resource-based perspectives, livelihood diversification, sustainability, and beekeeping are highlighted along with their significance in comprehending and enhancing food security.

Environmental sustainability lies at the core of apiculture's contribution to rural development. By promoting bee-friendly agricultural practices and habitat conservation, beekeeping contributes to the preservation of biodiversity and ecosystem resilience (Kassa Degu, T *et al,* 2020). The presence of managed beehives can enhance pollination services, thereby increasing crop yields and improving food security for rural communities. Additionally, beekeeping encourages land stewardship practices that prioritize ecosystem health and natural resource management, thereby mitigating the adverse impacts of intensive agricultural practices and land degradation. The issue of whether beekeeping is a sustainable activity is raised, along with other difficulties and potential. In light of this, from a social the industry's sustainability is undeniable from an environmental standpoint. The creation of domestic earnings and/or savings from other natural sources might be used to support the claim that these outflows help the community overall. Bees have a multitude of uses in agriculture, environmental conservation, and beekeeping's beneficial effects on human welfare.

Beekeeping in environmental aspects:

Because beekeeping is a natural practice, it has a big impact on rural development's environmental aspects. Beekeeping is essential to the health of ecosystems, the preservation of biodiversity, and sustainable land management, even outside its economic and social sphere. The fact that beekeeping aids in pollination is arguably its most well-known environmental advantage (Devkota,K *et al*; 2016). In order for flowering plants, including many crops, to reproduce, bees are essential pollinators. In order to pollinate fruits, vegetables, nuts, oilseeds, and other crops and increase agricultural productivity and food security, both wild and managed honeybee populations are important (Al Naggar, Y *et al*, 2018). Higher pollination rates can result from the placement of controlled beehives in agricultural settings and enhance the yield and quality of crops among order to optimize the benefits of pollination, beekeepers frequently locate their hives among meadows, fields, and orchards. Beekeeping increases agricultural productivity and minimizes environmental effect by improving crop pollination. This also lessens the need for synthetic pesticides and fertilizers, encouraging sustainable farming practices.

Protection of habitats:

By providing food and nesting places for bees and other pollinators, beekeeping can aid in the preservation of habitat. In order to guarantee the year-round availability of a variety of floral resources, beekeepers frequently maintain their apiaries in balance with natural ecosystems [Iwasaki, J.M *et al*, 2021]. By maintaining native plant species and offering habitat for pollinators, birds, and other wildlife, beekeepers also help biodiversity and ecosystem resilience [Puvača, N *et al*, 2024]. Moreover, beekeeping has the potential to encourage the preservation of naturally occurring habitats and florally diverse landscapes. Landowners and beekeepers may collaborate government organizations and conservation groups to create bee-friendly environments including riparian buffers, hedgerows, and wildflower meadows. In addition to helping bees, these initiatives support more general conservation goals including preventing soil erosion, safeguarding watersheds, and mitigating the effects of climate change.

Preservation of habitat:

Beekeeping can help preserve habitat by giving bees and other pollinators places to nest and eat. Naturally occurring ecosystems are frequently respected by beekeepers while managing them apiaries, guaranteeing a year-round supply of a variety of floral materials [Iwasaki, J.M *et al*, 2021]. Through the support of native plant species and the provision of habitat for pollinators, birds, and other wildlife, beekeepers also contribute to biodiversity and ecosystem resilience [Puvača, N *et al*;2024]. Additionally, maintaining naturally occurring habitats and floral-rich landscapes can be encouraged by beekeeping. It is possible for

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beekeepers to create bee-friendly habitats including hedgerows, riparian buffers, and wildflower meadows in collaboration with landowners, government agencies, and conservation organizations. The conservation goals of soil erosion reduction, watershed preservation, and climate change mitigation are all furthered by these initiatives, which also help bees. Given that honey bees are thought to be the planet's finest guardians and defenders in the current era (Rudolph, 2010), and in light of the statement made by Albert Einstein that "**man would have four years left to live if the bee disappeared off the face of the globe,"** No pollination, no bees, no plants, no animals, and no humans left.

Ecological land administration:

Natural resource conservation and ecosystem health are given top priority in beekeeping's promotion of sustainable land management techniques. In order to reduce their reliance on artificial inputs and increase biodiversity in agricultural environments, beekeepers frequently use agro-ecological practices [Hill, R *et al*;2019]. Beekeepers play a vital role in maintaining soil fertility, water quality, and the general integrity of ecosystems by using organic beekeeping methods which include avoiding chemical treatments and providing habitat for bees [Pocol, C. B*et al*;2021]. Furthermore, agroforestry, organic farming, and regenerative agriculture are a few other sustainable land management practices that beekeeping can support. Bees benefit from extra feeding and nesting locations in agroforestry systems that include bee-friendly tree species because they improve soil health, water retention, and carbon sequestration. Rural communities can reap a number of environmental and socioeconomic benefits, such as livelihood stability and climate resilience, by combining beekeeping with diverse farming methods.

Benefits and challenges beekeeping:

Economic diversification, poverty reduction, environmental sustainability, and social empowerment are just a few advantages of incorporating beekeeping into rural development plans. To achieve beekeeping's full potential as a tool for rural development, however, this integration also brings with it certain obstacles that need to be addressed [. Yusuf, S.F.G *et al*;2018]. Rural communities can become less dependent on a particular industry or crop by diversifying their economies through beekeeping. In addition to typical agricultural revenues, farmers can augment their income by selling honey, beeswax, royal jelly, and other products from their hives. Economic diversity reduces poverty and promotes sustainable development by strengthening household resilience to shocks and price swings in the market [Hayatu Ibrahim, K *et al*;2021].

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Return generation:

For rural households, beekeeping provides a reliable source of income, especially in places with few other possibilities for a living. In addition to seasonal agricultural revenue, the selling of honey and other hive products can offer a consistent source of income all year round (Kamala, I.M; *et al,* 2021). Additionally, beekeeping can stimulate local economies and provide jobs in rural areas by opening up work possibilities along the value chain, including hive construction, honey extraction, processing, packing, and marketing.

Environmental advantages:

By fostering sustainable land management techniques, increasing biodiversity, and supporting pollination services, beekeeping supports environmental sustainability. As pollinators, bees are essential to the health of ecosystems and the production of agriculture. In order to pollinate crops, fruits, and wildflowers, managed honeybee colonies and wild bee populations both help to increase yields and enhance food security [Patel, V*et al*;2021]. Furthermore, by improving soil health, conserving water, and sequestering carbon, beekeeping techniques that place a high priority on habitat conservation and agro-ecological principles might lessen the effects of climate change [Singh, R.P. *et al*;2013]

Soci*et al* empowerment:

Beekeeping encourages social empowerment by providing opportunities for community engagement, information sharing, and capacity building. In order to pool resources, exchange information, and more successfully access markets, beekeepers frequently gather together into associations, cooperatives, or self-help groups. These collective arrangements encourage social cohesion, solidarity, and collaborative decision- making among rural communities. Moreover, bee-keeping may empower underrepresented populations, like women, youth, and indigenous people by providing them with chances for economic engagement, skills development, and leadership [Gring-Pemble, L *et al*;2020].

Conclusion:

Beekeeping offers a range of economic options for rural development, including revenue generation, employment creation, market development, and value chain integration. Rural communities can enhance their standard of living, lessen poverty, and accomplish sustainable development objectives by utilizing the economic potential of beekeeping. But in order to actually reap these benefits, policies that are supportive, infrastructure and training investments, and coordinated initiatives to solve obstacles like market accessibility, technical expertise, and climate change adaption are needed. Beekeeping has the potential to be a potent instrument for fostering resilience and economic success in rural communities through thoughtful interventions and cooperative partner ships. There are several advantages to incorporating beekeeping into rural development plans, such as socioeconomic empowerment, environmental sustainability, income production, and economic diversity. But in order to overcome the difficulties involved in beekeeping, coordinated efforts are needed to offer technical assistance, resource availability, pest and disease control, market access, and prospects for beekeepers to offer value. Beekeeping can become an effective tool for fostering rural development, resilience, and prosperity in communities all over the world through cooperative action and focused interventions.

Beekeeping benefits agriculture, society, the environment, and beekeepers who augment their income, whether it is their primary or only source of income. Bees enable cross-pollination of flowers, which encourages genetic dissemination and plant variety, by traveling from blossom to bloom. Ecosystem resilience and functionality arise from this genetic diversity. It should be mentioned that pollination is thought to have a significantly higher economic value globally than bee products, both for natural ecosystems and for ensuring food security and livelihoods. Nevertheless, bee products are frequently the source of the beekeeper's motivation and contribute to food security, health, revenue and other neighbourhood services. In addition to their remarkable intelligence and organization, bees are remarkable animals because they are vital to both the natural world and humankind through pollination. For many beekeepers, raising bees is a source of joy as well as food and money. To be sustainable, beekeeping must incorporate the environment for the mutual benefit of both bees and the ecosystem.

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Honey bees- Overview

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Honey bees are long-term models for behavioral studies. This is particularly true for the Western Honey Bee (Apis mellifera L) but the honey bee genus contains several other species that are behaviorally quite interesting and differ in some fundamental aspects from the A. mellifera model. Honey bees are categorized into cavity nesting species that are intermediate in size and typically nest inside hollow trees, and dwarf and giant honey bees that nest openly on a single wax comb suspended from branches, cliffs, or similar overhangs. Although all species of honey bees are exploited by humans, most species live in the wild and only A. mellifera and A. cerana, the Eastern Honey Bee, are actively managed and domesticated to varying degrees. For brevity, we restrict this essay to A. mellifera and refer to this species in the following as honey bees. Apicultural practices date back to ancient Egypt and honey bee products have been utilized in many cultures for a long time. Predominantly honey stores are collected, but also beeswax, pollen, propolis, and even the bees themselves are harvested as food or basis for commercial products. Most importantly, honey bees serve as crucial pollinators in many agricultural ecosystem's, improving yield and market value of over 100 different crops grown for food, feed, and fiber. In the U.S. alone, the annual value of honey bee pollination has been estimated to exceed $14B per year. Over the past decade, honey bees have experienced a sharp increase in public and scientific interest in the wake of reports on unsustainable population losses and considerable health problems. Many of these studies relate to sublethal stress effects that affect behavior and life expectancy giving the study of honey bee behavior a remarkably applied perspective in recent years.

Overview of Honey Bees

Honey bees, belonging to the genus Apis, are social insects renowned for their vital role in pollination and honey production. They are integral to ecosystems and agriculture, contributing significantly to biodiversity and food production.

Species and Classification

The most common species of honey bee is the Western honey bee, Apis mellifera. There are several other species, including Apis cerana (Asian honey bee) and Apis dorsata (giant honey bee). These species exhibit variations in behavior, habitat, and adaptability to different climates.

Social Structure

Honey bees live in highly organized colonies, typically consisting of three castes:

1. **Queen**: The sole reproductive female, responsible for laying eggs and maintaining the hive's social structure through pheromones.
2. **Workers**: Non-reproductive females that perform various tasks, including foraging for nectar and pollen, caring for larvae, and maintaining the hive.
3. **Drones**: Male bees whose primary role is to mate with a queen during the breeding season.

The social dynamics within a colony are complex, with effective communication facilitated through pheromones and the famous "waggle dance," which helps foragers locate food sources.

Life Cycle

Honey bees undergo a complete metamorphosis, progressing through four stages: egg, larva, pupa, and adult. The duration of each stage can vary based on environmental factors and the caste of the bee. The queen can lay thousands of eggs in a single day, ensuring the colony's growth and survival.

Pollination and Ecological Impact

Honey bees are among the most important pollinators, aiding in the reproduction of numerous flowering plants. This activity is crucial for the production of fruits, vegetables, and nuts, making honey bees essential for global food security. It is estimated that one-third of the food consumed by humans relies on pollination, with honey bees responsible for a significant portion of that work.

Honey Production

Honey bees convert nectar into honey through a process of enzymatic action and evaporation. The resulting honey serves as a food source for the colony, particularly during winter months. Humans have harvested honey for thousands of years, and it is valued not only for its sweetness but also for its potential health benefits, including antimicrobial properties and antioxidants.

Threats and Conservation

Despite their importance, honey bee populations are declining due to various factors,

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including habitat loss, pesticide exposure, climate change, and diseases such as colony collapse disorder (CCD). Conservation efforts are crucial to protect honey bees and their habitats, including promoting sustainable farming practices, reducing pesticide use, and restoring native plant populations.

Important of honey in agriculture

Honey bees are vital to agriculture, serving as one of the most effective pollinators for a wide variety of crops. Their contribution goes beyond mere honey production; they play a crucial role in the pollination of approximately one-third of the food we eat, including fruits, vegetables, nuts, and seeds. This natural pollination process significantly boosts crop yields and improves the quality of produce, which is essential for both farmers and consumers.

Pollination Efficiency

Honey bees are particularly effective at pollination due to their foraging behavior. They collect nectar and pollen from flowers, transferring pollen from one bloom to another as they move from plant to plant. This action not only fertilizes plants, enabling them to produce fruits and seeds, but also enhances genetic diversity, which is critical for the resilience of crops. Some studies indicate that crops pollinated by honey bees yield 30% to 50% more fruit than those that are not.

Economic Impact

The economic implications of honey bee pollination are significant. It is estimated that the global economic value of pollination services provided by honey bees amounts to billions of dollars annually. For many farmers, especially those growing specialty crops like almonds, apples, and blueberries, honey bees are indispensable for achieving profitable harvests. Without their pollination services, many crops would experience drastic declines in yield and quality, leading to higher prices and reduced availability in the market.

Biodiversity and Ecosystem Health

Honey bees also contribute to overall biodiversity and ecosystem health. By pollinating a wide range of flowering plants, they support the growth of various crops and wild plants, which in turn provide habitat and food for other wildlife. Healthy ecosystems are essential for sustainable agriculture, as they help maintain soil health, water quality, and pest control.

Challenges and Threats

Despite their importance, honey bee populations face numerous challenges, including habitat loss, pesticide exposure, climate change, and diseases. The decline in honey bee populations poses a significant threat to agricultural productivity and food security. Farmers and researchers are increasingly recognizing the need for conservation efforts to protect these pollinators, such as promoting sustainable farming practices, creating pollinator-friendly habitats, and reducing the use of harmful chemicals.

Conclusion

Honey bees are remarkable creatures that play an indispensable role in our ecosystem and agricultural systems. Their complex social structures, critical pollination services, and honey production underscore their importance. Protecting honey bee populations is vital for maintaining biodiversity and ensuring food security for future generations.

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A Review on Problems and Progresses of Beneficial Microorganisms for Honey Bee Health and Productivity

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Numerous biotic and abiotic stresses exist nowadays that may partially affect both the pollination and hive production of honey bees. The hunt for natural alternatives has been restricted by government on antibiotics used as therapeutics against infections that affect bees. Research on using gut bacteria to enhance bee health has been prompted by growing understanding the roles of the bee gut microbiota as well as the relationship between a healthy gut microbiota and overall health. In some way, we are helping to bring the probiotic idea into the field of bee science.In this study, we look at how the gut microbiota of honey bees affects their health and discuss the various ways that beneficial microbes may be used to help honey bee health and manage pests. The majority of the strains, which mostly come from the genera *Lactobacillus, Bifidobacterium*, and *Bacillus,* are isolated from the guts of honey bees or from their crops; however, certain applications involve formulation for use in food for humans and animals or environmental strains.Overall, the results demonstrate that applying microbial strains has a positive impact on bee health and production, especially when strains with bee origin are employed. It is simply impossible to say for sure at this point if this tactic will ever be effective. Specifically, a number of factors pertaining to the general design of the studies, the dosage, the timing, and the length of the therapy must be improved, taking into account the microbiological safety of the products produced by the bees (pollen and honey, for example). Furthermore, a thorough examination of the impact on host immunity and physiology is planned. Finally, it is important to consider the beekeepers who will ultimately utilize the formulations in order to provide high-quality, reasonably priced, and user-friendly solutions.

Key words: *Beneficial microorganism, honey bee health, probiotic, gut microbiota.*

Introduction

One of the most significant functions that insects perform is pollination, which has a significant influence on the environment, the economy, and culture.*Apismellifera*, the European

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honey bee, is recognized as the most important pollinator, even if they make a big contribution originates from lesser-known *Apoidea* species as well, like such as wild bees (*Macropis* spp.) and bumble bees (*Bombus spp*.), both *Xilocopa* and *Osmia* species). This “free” ecosystem service, whose preservation also depends on human actions, unquestionably assures and satisfies the maintenance of genetic diversity in plant populations, the productivity of crops and orchards for human nutrition, and the floral variety in the environment (Gill *et al*. 2016).A multitude of biotic and abiotic stressors impact the health and productivity of honey bees nowadays. Apart from pesticides, diseases, and insufficient flowering, which have been extensively researched in relation to insect health (Porrini *et al*., 2016), invasive species, habitat loss, and climate change are also becoming increasingly important for maintaining the integrity of beehives (Bond *et al*., 2014). In recent decades, the parasite Varroa destructor and the *MicrosporidiumNosemaceranae* have migrated from *Apiscereana*, their native Asiatic host, to Europe in search of a more favorable environment for growth (Higes *et al*. 2010).Furthermore, as the mite prevalent in *A. mellifera* is a less resistant host, the presence of V. destructor in every colony appears to put a significant strain on bee health (Le Conte *et al*. 2010). The use of veterinary medications in the beekeeping industry is severely restricted because of the significant worries over the acquisition and transmission of antibiotic resistance, antibiotic residues in goods derived from beehives, and, to a lesser degree, the possibility of upset gut microbiota in bees. Antibiotics were consequently outlawed in EU nations, however some acaricides are still legal (European Commission 2010).According to Kwong and Moran (2016), the gut microbiota of honey bees shares a high degree of affinity with that of mammals. A vast array of host-adapted species that inhabit specific gut niches, ranging from the honey crop to the rectum, are representative of the bacterial symbiont population and contribute to host defense, nutrition, and physiology (Hamdi *et al*. 2011). In order to restore a disbiotic insect gut population and stop the spread of disease, commensal gut bacteria and the secondary metabolites they produce are being considered more and more (Berasategui *et al*. 2016). Insects are arguably an easier system to study, but because social bees have numerous variables to take into account such as the environment, genetic variety, and high levels of hive complexity such applications may be more challenging to monitor. In an effort to better understand host-microbiota interactions and apply knowledge gained from studying humans and animals to bees, researchers are concentrating on the microbial residents of the microbial guts of honey bees.

Inside the honey bee gut microbiota

With an emphasis on the functional side of host-symbiont interaction, scientists have been studying microbial gut symbionts during the past ten years thanks to the development of new tools. Thanks to Next-Gen Sequencing (NGS), it is now possible to identify cation of a unique colony of gut bacteria, comprising eight dominating groupings, accounting for more than 95% of the total community, as outlined by Kwong and Moran (2016). The Gram-negative *Gilliamellaapicola* and

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Frischellaperrara, belonging to the Gammaproteobacteria class, and the *BetaproteobacteriumSnodgrassellaalvi* are predominant in the midgut. The rectum is preferentially colonized by the clades Firm-4 and Firm-5, including different Lactobacillus species (e.g. *Lactobacillus mellis, Lactobacillus mellifer, Lactobacillus helsingborgensis, Lactobacillus kullabergensis, Lactobacillus melliventris and Lactobacillus kimbladii*) and two species belonging to the genus *Bifidobacterium (Bifidobacteriumasteroides and Bifidobacteriumcoryneforme*). Alphaproteobacteria (related to the genera *Bartonella/Brucella* and the *Acetobacteraceae*family) have been described but they are less abundant (KwongandMoran2016). Within three to five days after pupae hatch, the microbial gut community, which has been evolving, reaches its definition (Anderson *et al*. 2016). The same authors postulated that a large number of Lactobacillus Firm-5 strains are pioneer species, being especially prevalent within the hive, and that early behaviors such as cell cleaning are essential for promoting the composition of the adult gut microbial community in newly emerging bees. In addition to this fundamental microbiota, caste disparities can be observed in relation to the social roles that honey bees fulfill in their lifetime (Kapheim *et al*. 2015). Furthermore, a recent study (Rokop *et al*. 2015) indicates that the hive environment, which includes the food that the bees prepare, may be the catalyst for the development of the gut core microbiota due to the existence of a "non-core" microbiota group.

The role of gut microorganisms in honey bees Nutritional support

Social insects create a partnership with the microbial gut symbionts as they possess genes encoding for enzymatic activities (i.e. cellulases, hemicellulases and lignase) essential for the energy uptake from a plant-based diet (Newton *et al*. 2013). Additionally, the microbial consortium generates essential nutrients and metabolites such as fatty acids and amino acids.

Additionally, honey bees need vitamins, especially the B complex, and gut microbes may be an appropriate supply of these nutrients (Brodschneider and Crailsheim 2010). A synopsis that outlines the primary functions of gut microbiota is presented in Table 1. It was discovered that some species of fructobacillus, which were isolated from bee bread, brood cells, and larval stomach, used the plant complex chemical lignin, a component of pollen, to start the breakdown of this significant high-protein plant-derived diet (Rokop *et al*. 2015). The presence of a full folate (vitamin B9) biosynthesis pathway was also confirmed by B. asteroides genome sequencing, but not for other B vitamins (Bottacini *et al*. 2012). Overall, the research mentioned above demonstrated once more that some gene sets are present in species that have been isolated from various hosts, indicating host-specific adaptation. Although bifidobacteria are known to be exclusively anaerobic microorganisms, *B. asteroides*, a bacterium found in the hindgut of honey bees, has genes linked to a respiratory metabolism that enable the bacterium to adapt to the oxygen-rich environment of the bee gut (Bottacini *et al*. 2012).

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Immunity support

Host protection is another important aspect that is frequently associated with a balanced gut microbiota. It is a fact that different stress factors, such as parasites/pathogens, deficient nutrition and pesticides, can cause immunosuppression (Di Prisco *et al*. 2013).As was previously mentioned, honey bees have a simpler immune system than other model insects. Instead, they rely on more practical and affordable social defense strategies that integrate a combination of behavioural, physiological, and spatial mechanisms with prophylactic and activated responses. However, the gut microbiota's antagonistic activity and its connection with humoral and systemic immunity play a significant role in host protection (Jaenike *et al*. 2010).Concerning the production of antimicrobial compounds for host protection, Saraiva *et al*. (2015) found a relative high presence of genes involved in the biosynthesis of streptomycin and secondary metabolites in the gut microbiota of honey bee, which could play a role in shaping the microbiome. A considerable amount of information also derives from the LAB community and bifidobacteria, which are well-known antimicrobial compound producers.As was previously mentioned, honey bees have a simpler immune system than other model insects (Barbeau *et al*. 2015). Instead, they rely on more practical and affordable social defense strategies that integrate a combination of behavioural, physiological, and spatial mechanisms with prophylactic and activated responses (Cremer *et al*. 2007). However, the gut microbiota's antagonistic activity and its connection with humoral and systemic immunity play a significant role in host protection (Jaenike *et al*. 2010).Vásquez *et al*. (2012) analysed the interaction of some LAB symbionts with the honey crop by SEM and fluorescence microscopy. The resulting images evidenced biofilm formation and structures resembling extracellular polymeric substances (EPS), which are known to be involved in host protection/ colonization and cellular recognition (Flemming and Wingender 2010). A further support comes from the work of Ellegaard *et al*. (2015), which evidenced at genome level the presence of gene clusters associated with the biosynthesis of cell wall exopolysaccharides in both “Firm4” and “Bifido” groups.According to Martinson *et al*. (2012), honey bee workers have genes in *G. apicola* and *S. alvi* that encode a significant number of activities linked to host interaction and biofilm development. activity (outer membrane proteins, secretion, and Type IV pili), whose words might be significant in establishing a microniche resistant to infection colonization. Ultimately, the Within the *Bacillaceae* family are spore- forming bacteria, isodated from the surroundings of the hive and the bee stomach, demonstrating a potent antibacterial action against infections that affect bees in vitro. Decades of research have demonstrated that inhibitory activity is mostly as a result of the synthesis of antibiotic compounds (lipopeptides and lipopeptides that resemble iturin) (Yoshiyama and Kimura 2009).

The “probiotic concept” in honey bee

It is clear that a balanced gut microbiota offers a wide range of metabolic, trophic and

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protective functions, which confer health benefit to honey bees. In this perspective, the FAO/ WHO probiotic definition (FAO/WHO 2002), which encom passes strain specificity (Sanders *et al*. 2014), is more than appropriate. However, the transfer of the probiotic concept from vertebrates to invertebrates still requires further consider ations, and several questions still need to be investigated and debated. In particular, beyond the health aspect, probiotic microorganisms fulfill a list of biological requirements and safety criteria, e.g. to be non-toxic and non- pathogenic, to have an accurate taxonomic identification, to be normal inhabitants of the targeted host-species, to adhere to the gut epithelium (Gaggìa*et al*.2010). For these rea sons, in the present review, authors will refer to "beneficial microorganisms" rather than to probiotic microorganisms, since honey bee gut symbiont characterization is far to be com pleted.There have already been attempts to modify the gut microbiota in a few insect species (Robinson *et al*. 2010), demonstrating the significance of the endogenous gut microbial community. The primary use of beneficial bacteria in honey bees will be discussed and illustrated in the following part, along with tests conducted on adults and larvae in both the lab and the field.

Conclusions

The European honey bee, *A. mellifera*, must be preserved. Without pollinators, the beekeeping industry and ecosystems suffer from low productivity and missed pollination, which eventually leads to a loss of biodiversity. In an attempt to boost disease resistance, beekeepers these days far too frequently rely on subspecies hybrids; yet, the resistance mechanisms against parasites and bee diseases are typically the outcome of co-evolution in local ecosystems.Overall, the described applications offer to some extent a picture of the favorable influence of beneficial microorganisms on bee health, in particular their potential activity against some pathogens. However, information is scarce and limited to specific investigations. It could be useful, as in human and animal applications, to define some guidelines in order to standardize the studies and draw up appropriate protocols. The dose, the timing, the duration of the administration and the number of strains may influence the efficacy of the treatments.Accurate determination of the number of experimental replicates and their replication across time is necessary. Additionally, uniformity in research procedures (e.g., *N. ceranae* spore number detection) is necessary to maximize trial comparison and output accuracy. The research on gut symbionts extracted from healthy honey bee guts with QPS status must be addressed, and probiotic use for human and animal consumption must be avoided.

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TRENDS IN AGRICULTURE SCIENCE
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Organic And Bio diversified Farming on Crop Improvement Ecosystem

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Organic and biodiverse farming practices play a crucial role in crop improvement and the overall health of ecosystems. Agrobiodiversity is an important aspect of biodiversity that is directly influenced by different production methods, especially at the field level. It can also supply several ecosystem services to agriculture, thus reducing environmental externalities and the need for off-farm inputs. Organic farming is considered an environmentally-friendly agriculture practice. The biodiversity measures (i.e., hedgerows, insectary strips, crop rotation, or the retention of semi-natural areas) in agri-environmental programmes that are also aimed at conventional agriculture. Incorporating organic and biodiverse farming practices not only enhances crop improvement but also promotes ecological balance, sustainability, and resilience in agricultural systems. By focusing on holistic approaches, farmers can contribute to healthier ecosystems while improving productivity.This was similar in organically managed fields and in semi-natural species rich grasslands, but significantly fewer communities were found in conventionally managed fields. Their richness increased significantly over time from the point of a conversion to organic agriculture.

Keywords: *Organic farming, productivity, Biodiversity, Farming practices*

Introduction:

Organic agriculture refers to a farming system that enhances soil fertility by maximizing the efficient use of local resources, while foregoing the use of agrochemicals, genetically modified organisms and the many synthetic compounds used as food additives. Organic food's superior quality and additional value are derived from a variety of ecologically oriented farming techniques that minimize the food industry's negative environmental effects, protect soil sustainability over the long term, and use as little non- renewable resources as possible. [Reeves and Richards,2022].

Organic farming practices have been promoted as reducing the environmental impacts of agriculture. The results of meta-analysis of studies that compare the environmental impacts of organic and conventional farming in Europe show that organic farming practices generally have positive impacts on the environment per unit of area, but not necessarily per product unit. Significant differences between the two farming systems include soil organic matter content, nitrogen leaching, nitrous oxide emissions per unit of field area, energy use and land use. Most of the studies that compared biodiversity in organic and conventional farming demonstrated lower environmental impacts from organic farming [Jayakodi*et al 2021*]. Furthermore, organic farming appears to perform better than conventional farming and also provides other important environmental advantages such as halting the use of harmful chemicals and their spread in the environment and along the trophic chain, and reducing water use [Tuomisto*et al 2012*]. n winter wheat and spelt production, a life cycle analysis method measuring the ecological footprint of several production systems indicated that organic farming practices performed 8.5 and 5.9 times better environmentally than conventional farming methods.[Jayakodi*et al 2021*].

Biodiversity loss and the degradation of ecosystems have important implications for the environment and are costly for society as a whole [6]. The decline of many plant species and the extinction of local and ancient plant types are the main indicators of plant biodiversity loss in Europe. In order to stop the loss of biodiversity and the deterioration of ecosystems, the European Parliament enacted the EU Biodiversity Strategy to 2020 in 2011. In addition to preventing invasive alien species from endangering biodiversity, the strategy aims to increase by 2020 the EU's contribution to raising awareness of the loss of biodiversity worldwide by highlighting the beneficial contributions made by the European agriculture, forestry, and fisheries sectors to biodiversity conservation and sustainable use. [Tuomisto*et al 2012*]. The World Trade Organization notes a crop variety loss of 75% during the past 100 years, even of 90% in the EU. Only 17% of species and habitats assessed under the Habitats Directive have been deemed to be in good status and the degradation and loss of natural capital is jeopardizing efforts for attaining the EUs biodiversity and climate change objectives [Bavec ,2012], which did not reach its 2010 biodiversity target [Tuomisto*et al 2012*].

Reasons for the adoption of organic agriculture

Millions of small farmers in developing nations lack the financial resources to purchase high- yielding seeds as well as the fertilizers and herbicides required for their production. A large number of them have chosen to keep or restore organic farming systems that are based on conventional agricultural practices. These encourage the utilization of cultivars that are more suited to the biotic and abiotic circumstances unique to the area (e.g. biological control of pests and diseases, climatic stress).

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It is not hard to persuade farmers to use organic agricultural practices. In addition to growing high-yielding cultivars that demand a lot of inputs from outside the farm, many farmers have continued to use natural ways to cultivate a portion of their land for crops for their own consumption.

Numerous organizations or individuals have adopted this technique to preserve genetic, species, and ecological variety in industrialized countries due to the significance that organic agriculture plays in the restoration and maintenance of species, variations, and breeds that are in danger of going extinct. However, in centers of diversity, the importance of conservation efforts through organic management is considerably greater. Cultivating populations with significant genetic variety in these regions is essential to agriculture and, consequently, to the security of food supply for future generations.

Biodiversity and resource efficiency have an economic benefit due to the price advantages that organic products fetch (and, in Northern countries, the compensation received for organic agriculture). Because of the high demand for organic products, some farmers choose to cultivate organically. Converting to organic farming is a means for these farmers to increase the value of their output and to get higher market prices. To receive the organic designation, these farms must apply a minimum degree of biodiversity. Actually, increasing agricultural biodiversity begins with crop rotation. Both financial support programs and organizations that certify organic products want this technique. In order for the biological system to yield

By choice or by necessity, organic farmers do not make use of synthetic agricultural inputs. They rather rely on the “natural inputs” by enhancing biodiversity through in situ conservation and sustainable use of genetic resources. Independent of the motives that farmers have for the adoption of organic agriculture, in every case a marked increase in biodiversity is visible. Many of these empirical systems have given satisfactory results and have since become the focus of study in research centres.

Crop biocultural diversity

The biodiversity of direct relevance to crop improvement is a small but economically and nutritionally highly relevant subset of the Earth's total biodiversity — agrobiodiversity (Figure 1) — which arose initially from domestication during the transition from hunting- gathering to agriculture some 12 000–10 000 years ago. The ‘domestication triangle’ (Figure 1) includes the three major factors that affect the process of domestication and, therefore, domesticated or crop biodiversity: (1) the biological characteristics of the organism, (2) the biotic and abiotic environmental characteristics, and (3) human influence [Gomiero*et al.*, 2011].

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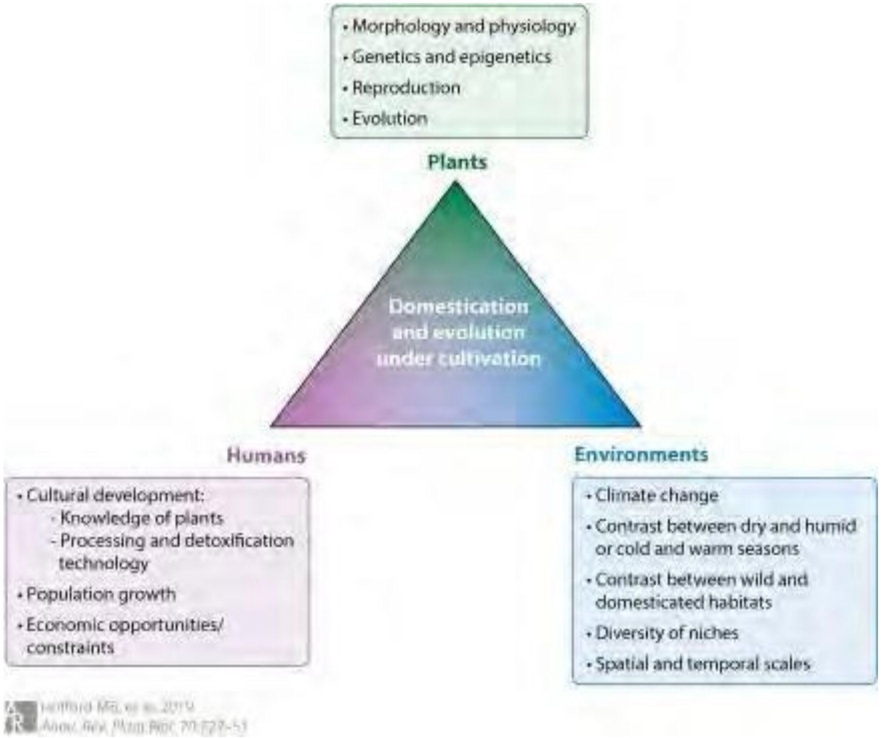

Figure :1

Biodiversity Important in Organic Systems

When diversity is encouraged, locally adapted plant and animal breeds which are more appropriate to local ecosystems can be used. Most importantly, agricultural genetic diversity is a basic insurance against crop and livestock disease outbreaks.

In low-input growing circumstances, organic farmers cultivate varieties that prioritize quality, nutrition, resistance, and yield. Studies have indicated that older native cultivars are more likely to possess these traits. Specifically, open-pollinated cultivars provide a wider range of locally appropriate traits that make them more suitable for organic farming. Open pollinated cultivars are quickly going extinct, while being a vital supply of genes for low- resource farmers in marginalized and stressful environments. Very few hybrid varieties replace them; these depend on big seed firms and require inputs that are unavailable to impoverished farmers. In developing nations, pastoralists and traditional livestock owners continue to care for a sizable number of the native breeds (e.g., pigs in China, cows in India, and poultry in Asia).

Organic systems encourage the preservation and expansion of older, locally bred and indigenous varieties and breeds. Farmers who save their own seeds can gradually increase crop resistance to pests and diseases by breeding for "horizontal resistance". Horizontal resistance is the ability of a crop to resist many or all strains of a particular pest (which differs from breeding for "vertical resistance" to have a gene to resist one specific strain of a disease). By exposing a

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population of plants to a certain disease or pest (or to several pests at one time), then selecting a group of the most resistant plants and inter-breeding them for several generations, a given population becomes more resistant than the original population. Horizontally resistant cultivars are well adapted to the environment in which they were bred, but may be less suitable for other growing conditions.

Numerous indigenous cultures are very knowledgeable about the biodiversity of their own regions. These communities have historically shared, enhanced, and conserved genetic resources in accordance with their dietary habits, socioeconomic status, and environmental circumstances.

CONCLUSIONS

In organic agriculture is making a significant contribution to the in situ protection, restoration, and preservation of agricultural biodiversity nearly entirely independent of governmental agencies. An egalitarian system of benefit sharing from genetic resources for food and agriculture is being shaped by the spontaneous formation of participatory research and development systems. This system is straightforward and practical.

This contribution is probably going to rise considerably more, based on the global development pattern of organic agriculture conversion. Given the part organic farming plays in preserving agricultural biodiversity, it is advised that public institutions—particularly research centers and universities—take the following steps:

- The systematic dissemination of data regarding agricultural biodiversity on organic farms, as well as the documentation of current cases
- Creation of collaborative methods for assessing, choosing, and propagating breeds and varieties that are more suited to low-potential and low-output environments, specifically on organic farms.
- The creation of appropriate registration and access control mechanisms for genetic resources created for organic farming;
- Establish proper systems for compensating the maintenance activities and breeding efforts of organic farmers.

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Bee keeping in India

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Beekeeping in India is a vital agricultural practice with deep cultural roots and significant economic potential. The practice of maintaining bee colonies for the production of honey, beeswax, and other hive products, as well as for the vital ecological role of pollination. Beekeeping provides numerous benefits, including enhanced agricultural productivity through effective pollination, economic opportunities for rural communities, and the production of a wide array of honey types. However, challenges such as pesticide exposure, lack of awareness among potential beekeepers, and the impacts of climate change pose significant risks to bee health and productivity. The introduction of modern beekeeping techniques, particularly the use of movable-frame hives like the Langstroth hive, has transformed the industry. Increased awareness of the benefits of pollination and honey production has encouraged more farmers to adopt beekeeping. The country's diverse flora and favorable climate support a variety of bee species, notably the Indian honey bee (*Apis cerana*) and the European honey bee (*Apis mellifera*).

Keywords: *beekeeping, honey, hive, agriculture, pollination.*

Introduction:

Beekeeping is an art and a mesmerizing science. In India, beekeeping is mostly practiced as a full-time occupation and an engrossing hobby to produce handsome income and table honey. Honeybees are a special gift to mankind because beekeeping can be done for both their pollination services and their cherished products such as honey, beeswax, propolis, bee venom, etc. These products have their widespread use in different small- and large-scale industries in India. The only bitter part of beekeeping is the bee sting. Honeybees sting to defend their colony, but this bitterness will be only in the initial stage of beekeeping, and after one gets habituated to keep bees, he will only taste the sweetness of honey. Most beekeepers develop a tolerance for bee venom over time and have reduced sensitivity to pain and swelling. So, understanding honey bee science is to know and unravel nature's most industrious as well as most fascinating insects.

As of now seven species of Apis have been described; India is an exclusive country which habitats four of these; two domesticated species, viz. *Apis cerana* (oriental honeybee) and *A. mellifera* (occidental or European honeybee) and two wild species, viz. *Apis dorsata* (giant/rock honeybee or

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dumna) and *A. florea* (dwarf honeybee). Among the four species, *A. mellifera* is an introduced species to India because it is resistant to Thai sacbrood virus (TSBV) and also highly suitable for commercial beekeeping.

Because of the different climatic zones in India, there is a massive multiplicity of flora which helps in potential beekeeping. People of India have a long connection with beekeeping and honey since ancient times. Ancient Indians gifted some records about beekeeping as paintings or carvings on rocks. Honey and its medicinal uses were mentioned in the old Ayurveda books of India. After independence, the government of India took policy decision to revive various traditional village industries and an All India Khadi and Village Industries Board (KVIB) was formed in 1954. Through harmonized efforts of well joined organizations like KVIC (Khadi Village Industries Commission) and State KVIBs, Beekeepers' Cooperatives and Public Institutions, the beekeeping industry came into limelight of village industries in India within two decades. In view of the budding importance of beekeeping, in 1981, an All India Coordinated Research Project (AICRP) on Honey bee Research and Training was launched by ICAR involving Agricultural Universities (Ramchandra et al. 2012; Sivaram 2012). Later a Central Sector Scheme entitled "Development of beekeeping for improving crop productivity" was launched by the Ministry of Agriculture in 1994–1995 during the eighth 5year plan. The scheme targets production and distribution of honeybee colonies, organizing trainings and awareness programmes. A Beekeeping Development Board also worked to organize the beekeeping activities. The scheme was approved for continuation during the ninth 5year plan. However, the scheme got incorporated under the Macro Management Scheme. Right now approximately there are about 1.5 million bee colonies in India, which produce 55,000 tonnes of honey annually. India is one of the honeyexporting countries. The major markets for Indian honey.

Honeybee Species in India

Rock Bee (*Apis dorsata)*

They are huge and ferocious bees that construct a single comb in the open, usually about 3-4 feet tall. They can be seen all over the subcontinent, mainly in the forests and also in concrete jungles. In hilly regions, they construct their nests up to an altitude of 2700 m. Rock bees habitually shift their places. Nearly 50–80 kg of honey can be squeezed from a single colony of rock bees per year (Mishra 1995). Its north-south distribution ranges from the southern part of China to Indonesia; it is found neither in New Guinea nor in Australia. The giant honeybees of Nepal and the Himalayas have recently been reclassified as belonging to another species of Apis, as A. dorsata laboriosa (Akratanakul 1990). Apis dorsata binghamii is another subspecies of dorsata distributed in restricted areas of the northeast, namely, in Khasi Hills, Sikkim, and Meghalaya (Allen 1995; Otis 1996). These bees construct their combs at a height of more than 20 ft from the ground, but in some cases, we can also see the colonies hanging from branches just above 2 ft from the ground. Colonies of A. dorsata may occur singly or in groups. The lower part of the comb is the energetic area in which the foraging and scout bees will take off and land. As these bees are aggressive, they will attack intruders (Ramchandra et al. 2012), and every so often, they will chase even up to 100 m. Sometimes, these bee stings can turn fatal to humans.

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Because of the danger involved in harvesting rock bee honey, it is generally priced high locally. Some trained bee hunters prefer to work at night. Smoke is used to pacify the bees, and in some places, professionals add chicken feathers to the smoke produced by burning charcoal, which irritates the rock bees and causes them to move out due to the odor produced from the addition of chicken feathers, allowing easy honey extraction. There is general concern that the total number of A. dorsata nests all over Asia is declining, partly due to shrinking forest areas, the use of toxic pesticides in foraging farmlands, and bee hunting.

Little Bee (*Apis florea*)

Apis florea or dwarf honeybee is also a wild honeybee spp., but these bees are small and less ferocious when compared to the rock bees. These bees build single vertical combs (Hepburn and Radloff 2011; Wongsiri et al. 1996). They also construct palm sized combs in the bushes, hedges, buildings, caves, empty cases, etc. The major difference between the rock bee and little bee comb is that the little bees construct combs encircling the twigs while the rock bees construct the comb on the undersurface of the branch. The honey produced by these bees is dramatically less when compared to the rock bee as these bees produce only about half a kilo of honey per year per hive. However, in the Kutch area of Gujarat, large quantities of honey fromA. florea are harvested (Soman and Chawda 1996). As these bees also have a habit of shifting their colonies frequently, they are also non-rearable, but attempts in India have brought partial success (Mishra 1995). These bees are found only in plains and not in hills above 450 MSL. Compared to other honeybees, these bees are attractively coloured with red to brown colouration having white bands. They are excellent pollinators, which give them an important ecological role in the places they inhabit. These bees are well known for their distinctive defensive behaviours and camouflage in dense forests. A more touching example is the specific behavioural response they exhibit against their chief predator *Oecophylla smaragdina* (weaver ant); when these ants are in close proximity, the bees produce adhesive barriers toobstruct the ant’s path. *Apis florea* is also identified for their hissing sounds when they see a predator. This hissing sound is audible to human ear.

Indian Bee (*Apis cerana*)

Indian honeybee or Eastern honeybee is a wellknown bee species in India. Prior to the introduction of Italian bee, this was the only rearable Apis bee spp. in India. It is also found and has been domesticated in Pakistan, Nepal, Burma, Bangladesh, Sri Lanka and Thailand. These are comparatively nonaggressive and rarely shift locations. These bees construct multiple parallel combs in dark places such as clay pots, logs, wall, tree openings, etc. and produce 7–9 kg of honey per colony per year. Ruttner (1988) classified Apis cerana into subspecies based on the living habitats and genetic diversity; of these Apis cerana indica and Apis cerana cerana occur in India. In India, the subspecies Apis cerana indica is recognized into two morphotypes like “hills bee” (black coloured) and plains bee (yellow coloured) (Ramchandra et al. 2012). Presently beekeeping with Indian bees is mostly done in south India and particularly in Kanyakumari district of Tamil Nadu, with more than 50,000

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beekeepers involved.

Since these bees have built their colonies in dark cavities, it enables man to keep them in specially constructed movable frame hives. The combs of *A. cerana* colony are built parallel to each other and at uniform distance known as the “bee space”, which is respected between them. Compared to rock bees and Italian bees, these are small in size but bigger than the dwarf bees. Brood comb consists of cells of two sizes: smaller for the worker brood and larger for the drone brood. The queen cells are built on the lower edge of the comb. Like other bee species, these bees also store honey in the upper part of their hive. Because of this behaviour, the bee boxes are designed in such a way that the super chamber or the honey chamber is in the upper part of the hive where these bees store honey which helps in easy honey extraction.

European Bee/Italian Bee *(Apis mellifera ligustica)*

Italian bee *(Apis mellifera ligustica)* is one of the sub species of *A.mellifera* and is not native to India and was introduced from Europe during the second half of 20th century. The introduction was primarily because the native Indian bee colonies were vanishing because of the Thai sacbrood virus. Presently they are well established in India and mostly present in northern India because of the rich flora such as mustard, safflower, sun flower, etc. As rice is the major crop in south India, these bees don’t get enough amount of food they need. In south India, beekeeping with Italian bees is hardly practised; for commercial beekeeping, these Italian bees have to be migrated by floral mapping. They are also similar in habits to Indian bees, which build parallel combs in dark places and store honey at the upper portion of their colony (Akratanakul 1976; Maa 1953; Otis 1990; Tirgari 1971). They are bigger than all other honeybees except Apis dorsata. They produce 25–40 kg of honey percolony per year. Probably these bees are the one of the most studied animals. The introduction of A. mellifera to India created problems such as the interspecies transmission of bee pests and diseases. But the introduction of these bees to India can be recorded as success story because it created employment for many people in India with profitable income and also by the pollination service these bees done to Indian flora.

Stingless Bee

Stingless or dammar bees are of smallest size compared to other honeyyielding bees (less than 5 mm). They belong to the family Apidae and subfamily Meliponinae. It consists of two genera Melipona and Trigona. Meliponinae includes eight genera, having 15 subgenera and more than 500 species (Wille 1983). These bees are widely known as dammar bees in India (Rasmussen 2013) (dammar is a resin from among dipterocarp trees) with additional local names commonly applied, e.g. “putka” in Sikkim and Nepal (Gurung et al. 2003; Singh et al. 2011; Lepcha et al. 2012); “ngap siwor”, “ngap hamang” and “ngap khyndew” in Khasi language (Pugh 1947); and “cherutheneecha” and “arakki” in Kerala (Nair 2003). As the name implies, these bees can’t sting as their stingers are highly reduced, but they try to defend their colony from intruders using their mandibles (Michener 2000).

The stingless bees are important pollinators of various food crops and can be domesticated. But the honey yield per hive per year is very low approximately 100 g. As in other regions where stingless bees occur, colonies can be kept in tree logs, wooden boxes and clay pots for harvesting small quantities of highly prized medicinal honey, wax and propolis, used for its household and curative properties. The materials used for nest building are mainly pure wax or cerumen, a mixture of wax and propolis, resins, plant fibres and clay (Rasmussen and Camargo 2008).

Biology and Society

Honeybees are one of the most brilliant products of nature. One of the most superior characters which honeybees demonstrate is eusociality in which they take care of their young ones with cooperative brood care and have other advanced ways of communications and defensive mechanisms. Honeybees have three developmental stages (egg, larvae and pupa) and an adult stage. In adult stage there are three castes (single queen, hundreds of drones and thousands of workers). The queen is a fertile, functional female that can produce males and females, the worker is an unfertilized female capable of only producing males (due to the haplodiploid sex determination system found in honey bees) and the drone is male (Tribe and Fletcher 1977; Winston 1979). The food they are fed during larval stage decides their caste; queen larvae is fed with royal jelly by nurse bees throughout its larval period. Recently, Kamakura (2011) found that a 57 kDa protein royalactin, present in the royal jelly, is a reason for the larvae to become queen.

The Queen

Queen bee is the mother of all other bees in the colony. It can be identified with its long abdomen and short wings. The duty of the queen is to lay eggs. The queen maintains the colony by its pheromones. Her productivity depends on the amount of food the workers bring in and the amount of brood space in the colony. She can lay more than 1500 eggs a day. If it is a honey flow season and if there are enough cells available, she will lay up to 2500 a day (Winston 1992). Queen emerges from queen cell which is situated at the bottom portion of the comb and looks like a small cup, and in India it is famously known as cow's teat because of its structural resemblance. After emergence the newly emerged queen destroys the remaining queen cells in the colony and fights any other queens she finds. The virgin queen will typically stay in the colony for a few days in order to feed and gain strength and allow her reproductive organs to mature a little further (Mackensen 1943; Winston 1992; Woyke 1963, 1969, 1973). After 6–8 days, the queen will leave the colony for her nuptial flight, which occurs 30 m above the ground where she mates with many strong drones who can fly with the queen as she flies better than drones. Postmating, the queen returns to the hive to lay the eggs (Mackensen 1943; Winston 1987, 1992). Average life span of queen is about 5 years, but the egg laying capacity will be only up to 2 years.

The Worker

There are thousands of workers in a colony, and they perform all the duties in the colony

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including foraging, defending, brood rearing and cleaning activities. They are smaller than the queen and drones. There are about 8000–25,000 workers in A. florea colony, 40,000–50,000 workers in A. mellifera colony, 20,000–40,000 workers inA. cerana and 50,000–80,000 in A. dorsata colony (Winston 1992; Wongsiri et al. Wongsiri et al. 1991; Wongsiri et al. 1996). For defending the colonies, worker bees possess sting which is a modified ovipositor, and venom is pumped out at the time of stinging. Workers may lay eggs, under certain conditions, which develop into drones since workers never mate and they have no sperm to fertilize their eggs (Anderson 1963; Mackensen 1943). However, in a normal queen right colony, worker regulation occurs and workers consume eggs produced by other workers (Ratnieks 1993). In A. cerana, unlike A. mellifera, there can be a relatively large number of egg laying workers (Partap and Verma 1998). Workers at their young stages perform indoor duties, and they will get license to go out for foraging only when they are old enough (normally after 21 days) (Winston and Fergusson 1985).

The Drone

Drones can be easily identified by their dark colour and eyes touching at the top of their head. Their only function is to fertilize the queen and enjoy the food inside the hive. They do not sting as they lack stingers. Drones are "haploid", and they onlypossess onehalf of the pairs of genes found in the "diploid" workers and queen (Anderson 1963; Mackensen 1943; Winston 1992). In a colony there are about hundreds of drones, drone cells differ from worker cells with enlarged cappings, and in India commercial beekeepers decap these drone cells as drones consume the stored honey. They have excellent navigation abilities when compared to the other two castes because they have around 75–80 % more facets in their compound eyes than the workers or queen (Gary 1963; Koeniger 1969, 1970; Ruttner 1966; Winston 1992).

Honeybee Foraging

India is a vast country with different climatic zones providing rich flora for honey- bees. By foraging, honeybees collect pollen and nectar where pollen is a protein source and nectar is carbohydrate source which together fulfils their nutrient requirements (Seeley, 1985 and Winston 1987). As the honeybees have division of labour, foraging will be only performed by the forager bees (Von Frisch 1967; Suwannapong 2000). Among the foraging bees, there are two types: nectar collectors and pollen collectors. For collecting the full load of nectar or pollen, they have to visit hundreds of flowers (Akratanakul 1976). In addition to these, the foragers also collect water (Farnesi et al. 2009; Marcucci 1995; Bankova et al. 1983, 2000) and propolis (plant resins) in case of Italian and stingless bees. Bees are the most effective pollinators of crops and natural flora and are reported to pollinate over 70 % of the world's cultivated crops. It has also been reported that about 15 % of the 100 principal crops are pollinated by domestic bees (Kenmore and Krell 1998; Abrol 2012). Table 3.1 lists some commercial crops benefitted by honeybee pollination in India.As the honeybees in India have vast floral diversity, shortlisting of the flora is difficult, and these are some of the crops with rich source of pollen and nectar from which bees were benefitted.

Anacardium occidentale, Nephelium litchi, Azadirachta indica, Callistemon citrinus, Glycine max, Cajanus cajan, Hevea brasiliensis, Acacia catechu, Dalbergia sissoo, Eucalyptus sp., Syzygium cumini and Nephelium litchi are some of the rich nectar sources. Zea mays, Psidium guajava, Sesamum indicum, Sorghum bicolor and Helianthus annuus are some of the rich sources of pollen. *Citrus sinensis, Coriandrum sativum, Cucumis melo, Eucalyptus spp., Musa spp. and Pongamia pinnata* are some of the plants that provide high levels of pollen and nectar to bees. Carica papaya, Cocos nucifera and Musa spp. provide food source to bees throughout the year (Kishan et al. 2014).

Foraging Distances

Foraging distance of A. cerana is around 200–300 m from the hive (Pratap, 2011 and Koetz 2013). Some studies showed that the Indian bee can forage up to 900 m (Hyatt 2011). Maximum foraging range of A. cerana is 1500–2500 m (Dhaliwal and

Table 3.1 Some of the commercial crops benefitted by honeybee pollination in India

Fruits and nuts	Almond (*Prunus dulcis*), apple (*Malus spp.*), apricot (*Prunus armeniaca*), peach (*Prunus persica*), strawberry (*Fragaria spp.*), citrus (*Citrus spp.*), and litchi (*Litchi chinensis*).
Vegetable and vegetable seed crops	Cabbage *Brassica oleracea* var. *capitata*, cauliflower *Brassica oleracea* var. *botrytis*, carrot *Daucus carota*, coriander *Coriandrum sativum*, cucumber *Cucumis sativus*, melon *Cucumis melo*, onion *Allium cepa*, pumpkin *Cucurbita* spp., radish *Raphanus sativus*, and turnip *Brassica rapa* subsp. *rapa*.
Oilseed crops	Sunflower *Helianthus annuus*, niger *Guizotia abyssinica*, rapeseed *Brassica napus*, mustard *Brassica juncea*, safflower *Carthamus tinctorius*, gingelly *Sesamum indicum*
Forageseed crops	Lucerne *Medicago sativa* and clover *Trifolium* spp. (Ragumoorthi et al., 2007).

Sharma 1974). Apis mellifera have a great foraging range and can go even up to 10 km (Abrol 2011). But most of the foraging range of A. mellifera is below 6 km (Visscher and Seeley 1982).

Beekeeping Equipment:

As beekeeping has changed over the centuries, the related equipment has also changed.

Traditionally beekeepers in India used to practice beekeeping in baskets, wooden logs, underground beehive, clay pots for keeping stingless bees, etc., but the Langstroth bee space (1851), Johannes comb foundation (1857) and honey extraction techniques by Frang von Hruschka concepts had a great impact on beekeeping in India which made a dramatic change and urged the beekeepers of the subcontinent to switch over to movable frames, as beekeeping with movable frames is userfriendly and also the modern beekeeping equipments make work easy for commercial handlers. (Mishra 1995; Ramchandra et al. 2012; Singh 2014).

Honeybee Hive :

A beehive is a place in which a single colony of honeybee exists containing and performing various functions for their livelihood; it contains various parts like hive stand, bottom board, brood chamber, super chamber, inner and outer cover. The hive stand consists of a wooden pole or iron stand fixed to the ground; it may be of single legged made up of PVC (polyvinyl chloride) or iron or fourlegged stand made up of iron. Each had their advantages and limitations as it is easy to attach an ant pan for single stand, while the fourlegged stand is easy to carry from one place to another because it is not completely fixed to the ground like single legged stand. The bottom board rests on the stand and is separable from the hive stand. Above the Bottom board, one can find the brood chamber that consists of brood frames whichis a home to honeybees where they rear their larvae in the comb constructed in the brood frames; it also contains pollen and some honey for their daily consumption; these frames are also made of wood and are arranged vertically and parallel to one another. A brood box normally contains one queen bee. The queen lays eggs, placing one each inside a cell of the comb. The eggs hatch to larvae and the larvae mature into the adult bees. When the brood chamber is well populated with bees, the beekeeper fixes a super chamber on the top of the brood chamber. Like the brood chamber, the super chamber also consists of frames arranged parallel and vertical, and it is the place of our interest as it is a honeystoring place for bees. Queen excluder is placed between the brood and super chambers for prevention of queen to enter into the super chamber. However, if the queen is a prolific egg layer, the beekeeper can use the option of fixing a second brood chamber to the first before fixing the super chamber. In such cases there will be great yield of honey because of more number of worker bees gathering nectar. The honey and pollen stored in the brood chamber are meant only for the developing larvae and not for extraction by the beekeeper. The standard height of the super chamber is threefourth of the brood chamber. The number of super chambers will increase in the honey flow season as the bees will collect more nectar in that season. If the beekeeper extracts honey from the hive at short intervals, there is no need for fixing a second or third super chamber to the first. Over the super chamber, there will be top cover which acts as roof to the hive (Fig. 3.1).

Types of Beehives:

There are different types of hives used in India such as Langstroth hive for *A. mellifera*, BIS hive (Bureau of Indian Standards) for *A. mellifera* and *A. indica* and Newton hive and Marthandam

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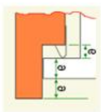
hive for *A. cerana*.

Langstroth Ten-Frame Hive:

Stand: Any four-legged stand 15–25 cm high will do. Its upper dimensions should be such as to support the bottom board properly (Fig. 3.2).

Bottom board: It can be made either by taking a piece of wood 550 mm long, 406 mm broad and 22 mm thick or by joining two wooden boards together, nailed in position with wooden rods. Along each end of the longer side is nailed a wooden rod 550 mm long, 22 mm broad and 22 mm thick, and another wooden rod 363 mm x 22 mm is nailed at the back. The front is provided with entrance rod which is 363 mm x 22 mm x 22 mm, and this has an entrance 75 mm long and 22 mm deep in its middle. Two wooden blocks, to be used for shortening the entrance, when necessary, should also be prepared, each block being 75 mm x 38 mm X 22 mm.

Brood chamber: It is a rectangular box without top and bottom and is made of 22 mm thick wood. Its length on the outside is 500 mm and on the inside 456 mm, its breadth on the outside is 406 mm and on the inside 363 mm and its height is 238 mm. A rabbet 16 mm deep and 13 mm wide is cut along the entire length of its width planks.



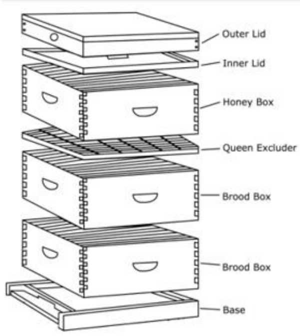


Fig.3.1 Componentsofastandardbeehive

Fig.3.1 Components of a standard beehive

Frame: Consists of top bar, two side bars and a bottom bar.

Top bar: 475 mm long, 25 mm wide and 22 mm thick. It is cut to 9 mm thick- ness on both sides for a length of 25 mm. It has a groove in the middle of its lower side for fixing the comb foundation sheet.

Side bar: Each is made of 9 mm thick wood and is 226 mm long. The upper part of each is 34 mm wide and lower part 25 mm wide. Each is cut out from the middle portion at either end to accommodate the top and the bottom bars, respectively. There are four holes in each side bar for wiring the frame.

Bottom bar: 440 mm long, 19 mm wide and 9 mm thick. The outside measurements of the frame are 440 mm x 228 mm.

Two 15 mm staples should be driven into the top bar on its opposite side so that the frames stand 34 mm apart. One should make all frames either Hoffman or staple-spaced type.Tinned wire of 28 gauge

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should be used in wiring the frame.

Super: The dimensions of the super and the super frames should be the same as those of the brood chamber and the brood chamber frames, respectively.

Inner cover: This is wooden board to cover the brood chamber or the super as the case may be. It is 500 mm long, 406 mm broad and 9 mm thick wood. It has 9 mm thick and 22 mm wide wooden bar nailed onto each of its four sides.

A. Cornerof10-framehivebody,showingconstruction and position of frames
B. Part of end of hive body, showing rabbet,whichshouldbemadeoftinorgalvani

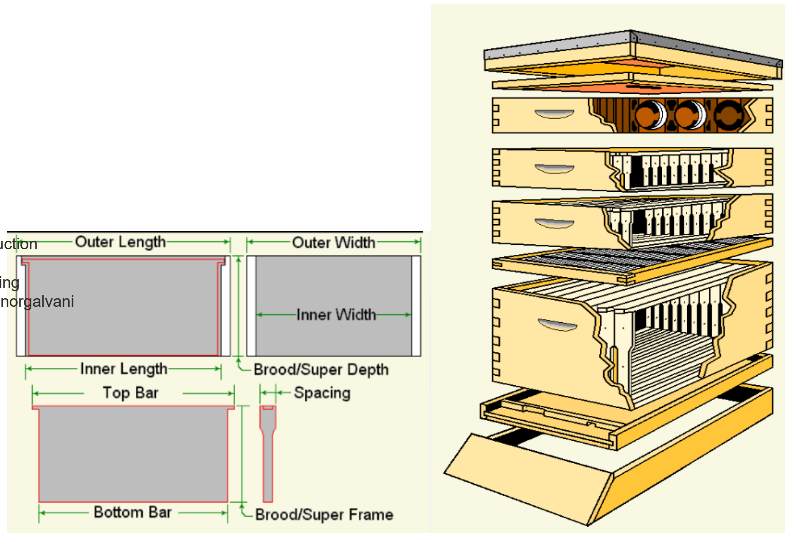

Fig.3.2 Langstrothten-framehive

Top cover: It is made up of 9 mm thick wooden board nailed to a rectangular frame50mmhigh,allcoveredoverwithametallicsheetsoastomakeitimpervious to rainwater. Its inside measurements are 525 mm x 425 mm. It rests loosely over the hive.

Newton Hive (Fig. 3.3)

Stand: A log of wood of about 10 cm in diameter and well soaked in wood preservative is buried deep into ground. A length of about 20–30 cm is left above the ground, and a board 40 x 30 cm is fixed on its top with long nails and screws. The hive is placed on this platform on the log.

Bottom board: It is a plank slightly wider and 25 mm longer than the brood chamber with beadings on three sides into which the hive body fits in tightly. The extension of the front serves as the alighting board.

Brood chamber: It is a box without top and bottom and is made of 22 mm thick planks with outer dimensions 278 mm x 256 mm x 160 mm and inner 234 mm x 225 mm x 160 mm. Along the top of the front and rear planks, a groove of 6 mm depth and 9 mm width is made for resting the frames, and a clearance of about 6 mm is provided between the lower extremity of the frames and the bottom board. The front plank has an opening 88 mm x 9 mm at its lower side to serve as an entrance.

Brood frame: Self-spacing (i) top bar breadth 22 mm, length 250 mm and thick- ness 3 mm; (ii) side bar height 144 mm, width at the top 28 mm and width at the bottom 12 mm; and (iii) inner length of frame 206 mm and inner height of frame 144 mm.

An extension of 3 mm is given on either side of the side bar, and a clearance of 6 mm is ensured when two frames are kept side by side. There are seven frames in a brood chamber.

Super and super frame: It has the same length and breadth as the brood chamber, but its height is 78 mm. The dimensions of the super frame are those of the brood frame, but the internal height is 62 mm.

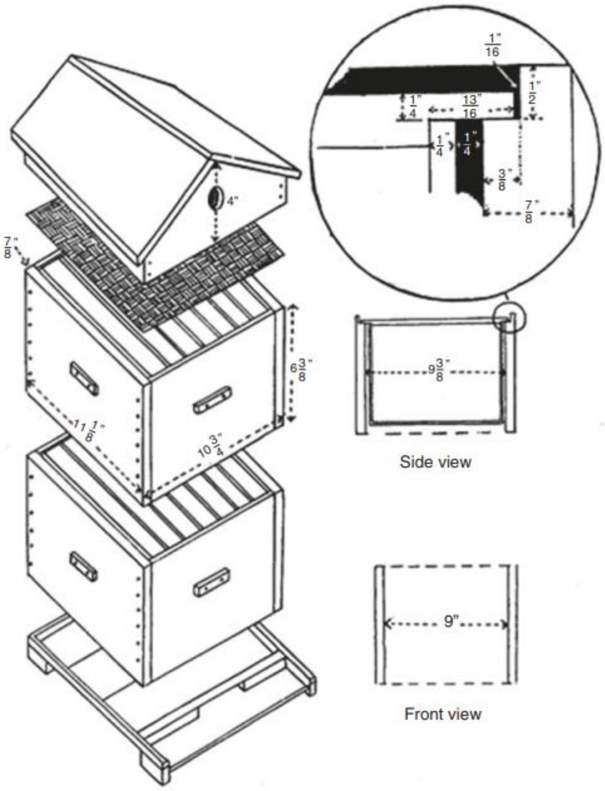

Fig.3.3 Newtonhive

Fig.3.4 Beekeepingtools

Top cover: It has sloping planks on either side. An opening of 87 mm square, fitted with wire gauge, is made on the low ceiling plank to provide ventilation. Two holes in the front and rear planks of the top provide the necessary draught. Care should be taken to provide a clearance of about 6 mm between the ceiling plank and the frames below.

For the manufacture of hives, light, well-seasoned, good quality timber should be used. The wood used should not have a strong smell. Kail (*Pinus excelsa*), teak (*Tectona grandis*) and toon (*Toona ciliata*) are some of the woods suitable for the purpose. The hives should preferably

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be painted white or aluminium on the outside to protect the timber from weathering agents. The hive parts should be accurately cut so that they may be interchangeable throughout the apiary and the particular part of the country.

Other Beekeeping Equipments (Fig. 3.4)

Smoker:

The smoker is a metal cylinder in which smoke is produced by igniting fire. The smoker is attached with a bellow to blow air into the fire. The regulated smoke that comes out of the nozzle is directed into the hive to make the bees docile and less prone to stinging.

Honey Extractor:

It consists of a metal drum with a centrifugally rotating device for the extraction of honey from the frames. Four frames filled with honey from the super chamber can be placed in the extractor at one time to extract honey by rotating it with the help of a handle, and the honey gets dislodged through a pipe attached at the bottom of the extractor. The honey can be collected in a jar, cylinder, etc. The use of the extractor does not cause any damage to the combs, and they can be placed back in the super chamber after honey extraction. A two-frame extractor is also available in which only two frames can be placed at a time; it will be helpful for small-scale and household beekeeping.

Comb Foundation Sheet:

In nature, bees build new combs from beeswax secreted by them and make parallel combs which are attached to the ceiling of the cavity or box. The combs may be built in the direction of the entrance, at right angles to it or in an oblique fashion. In the movable frame hive, it is imperative that straight combs be built in the frames so that when shifted from hive to hive, they may maintain the correct bee space between them. These comb foundation sheets are prepared by using a comb foundation mill which uses wax sheets. These comb foundation sheets will save the energy of honeybees for building their combs as we are providing the basement.

Decapping Knife:

Honeybees seal the cells in honeycomb once the honey is stored in it, so for extracting the honey by using the extractor, we have to decap the sealed portion by means of a decapping knife. The decapping knife may be a normal plain steel knife or an electric heated knife.

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Hive Tool:

It is a piece of flattened iron with hammered down edges and is used for prying apart the frames in the hive and for scraping bee glue and superfluous pieces of comb from the various parts of the hive.

Bee Veil:

It is worn over the face for protection against stings. It should be made of black light material such as nylon netting so that we can get a better picture. Veils should be made to fit snugly around the hat and to fit tightly to the shoulder leaving enough space between the veil and face.

Gloves:

They give much protection as the honeybees mostly sting on the fingers and hands while handling them. They may be made of heavy canvas or rubberized cloth and are useful for beginners to develop confidence.

Bee Brush:

A bee brush or a whisk broom is often employed to brush off bees from honeycombs before it is used for honey extraction.

Feeders:

Various kinds of feeders for feeding sugar syrup to bees are used by beekeepers. The division board feeder, a wooden trough of the regular frame dimensions with shoulders so made that it may hang in the hive just like any other frame and with a wooden strip to serve as a float, is a useful appliance. A sugar syrup-filled tin with holes in the lid is also a good type of feeder.

Queen Cell Protector:

It is a cone-shaped structure made of a piece of wire wound spirally. It fits around a queen cell. A queen cell which may have to be introduced from a queen-right to a queenless colony is often protected in a queen cell protector until its acceptance by the bees.

Dummy or Division Board:

It is a wooden partition which serves as a movable wall and helps to reduce the size of the brood chamber so that bees can keep the hive air-conditioned and well protected from bee enemies or inclement weather.

Embedder:

It is a small tool with a spur or round wheel on the top. It is used to fix the comb foundation sheet on the wires of the frame. Electric wire is also used for this purpose, which is useful to reinforce the comb and give extra strength to the comb.

Drone Trap:

It is a rectangular box with one side open. The other side is fitted with a queen excluder sheet. At the bottom of the box, there is a space for movement of worker bees. There are two hollow cones at the bottom wall of the box. Drones entering through the cones into the box get

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trapped. The narrow end of the cone is wide enough to let the bees pass out but not large enough to attract their attention or re-entry. This device is used at the entrance to reduce the drone population inside the hive.

Pollen Trap:

Pollen-trapping screen inside this traps scrapes pellets from the legs of the returning foragers. It is set at the hive entrance. The collected pollen pellets fall into a drawer-type receiving tray. Besides providing the treasured pollination services, honeybees gift some valuable merchandise to mankind. As the name indicates, the first and foremost gift by honeybees is honey; other products which the honeybee provides include beeswax, pollen, royal jelly, propolis, and bee venom.

Honey

Honey is the substance made when the nectar and sweet deposits from plants are gathered, modified, and stored in the honeycomb by honeybees (Singh et al. 2012). The quality of honey varies depending upon the types of floral and extrafloral nectar. The honey gathered can be classified as unifloral and multifloral. Though monofloral honeys are not common, yet honeys can be categorized on the basis of floral sources such as litchi honey, berseem honey, eucalyptus honey, Brassica honey, etc. (Mishra 1995). Honey is a rich carbohydrate source which mainly contains fructose and glucose. Water is the other main constituent of honey, and it also contains numerous other types of sugars, acids, vitamins, proteins, and minerals (White 1980). Honeybees seal the honey in comb cells after evaporating the excess moisture to reduce it to less than 20% (Mishra 1995). The average composition of honey is shown in Table 3.2.

Water	17.2
Fructose	38.2
Glucose	31.3
Sucrose	1.3
Maltose	7.3
Higher sugars	1.5
Free acids	0.43
Lactone	0.14
Total acid	0.57
Ash	0.
Nitrogen	0.(
pH	3.91
Diastase value	20.8

Table 3.2 Average composition of honey (White 196?

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Honey is harvested in two ways: in case of *Apis dorsata* by squeezing the combs, which contains some impurities like pollen and larvae, but in case of domesticated bees (*A. mellifera* and *A. cerana*), honey is extracted with a honey extractor without impurities using centrifugal force. Honey may remain in liquid form or may crystallize and hence can be presented to consumers as liquid honey or granulated honey (Mishra 1995). Honey is processed by a two-step process. First, the honey is indirectly heated in a water bath and kept at 60°C for 30 minutes to kill the yeast cells responsible for fermentation of honey. Later, it is filtered while still warm through a two-layer cloth filter (when the viscosity of honey is lesser), cooled, and bottled in glass bottles.

Beeswax

Wax is the other product produced by honeybees. The wax is produced by the wax glands when the worker bee is about 14–18 days old. The wax is used for building their nest by bees, and the normal color of the wax is white, but the color may change because of the influence of pollen source. The specific gravity of beeswax is 0.95 and the melting point is 65°C. Beeswax contains complex esters of monoatomic alcohols, 70.4–74.7% of fatty acids, and 13.5–15.0% and 12.5–15.5% of saturated hydrocarbons (Phadke and Phadke 1975). Normally, wax is obtained from the damaged combs. Wax extraction can be done by two methods: extracting wax using a hot water bath is the most common method in India, and solar extractors are also in use, which use sun energy for melting of wax. Wax is used in preparing comb foundation sheets, candles, polishes, furniture, pharmaceutical industry, and perfume industries, and it is a vital constituent of cosmetics like cold creams, lipsticks, and rouges because it adheres better to the skin (Mishra 1995).

Bee Venom

The main components of bee venom are proteins and peptides. Urtubey (2005) mentioned the use of bee venom in apitherapy in China, India, Egypt, Babylon, and Greece. Bee venom is present in the venom sac and will be injected using the sting. The bee venom can be collected using a venom extractor, which possesses a mild electric current. The bees get irritated with this current, so they try to sting, and the venom will be collected in the bottom glass plate. The USA is the leading producer of venom and had produced only 3 kg of venom in the past 30 years (Mraz 1982; Abrol 2012). Apitherapy is an age-old practice followed in India and some other countries for curing joint pains, in which bees are made to sting the patient by holding the bee from its wings with the thumb and index. The venom collected by the above method can be made for subcutaneous injections. Ointment made by mixing apitoxin, Vaseline, and salicylic acid (1:10:1) can be applied on the affected areas. The salicylic acid makes the skin soft and increases penetration (Mishra 1995).

Propolis

Propolis is used in construction and adaptation of the honeybee nest and also to cover the cracks and crevices of the hive; it is a sticky dark-colored material (Burdock 1998). The color of the propolis may vary in temperate climates; it ranges from a light yellow or brown to a dark-brown color, often with a reddish hue. Propolis tends to become darker the longer it is in the hive. The color of propolis also varies according to the trees and plants from which it is harvested (Fearnley 2005). It can be used to treat wounds, infections, dermatitis, and cancer. It is a strong fungicide and disinfectant (Ghisalberti 1979). It has an inhibitory activity against bacteria, fungi, and yeast (Aspay 1977 and Olivier et al. 1981). Among the *Apis* spp., only *A. mellifera* is known to forage for propolis. The tropical stingless bees do collect a resinous substance similar to propolis, which they use to seal up the hive and to create honey and pollen storage vessels (Fearnley 2005).

Royal Jelly

Royal jelly is a milky white cream. It is strongly acidic and rich in protein, sugars, vitamins, RNA, DNA, and fatty acids and is secreted by the nurse bees at the age of 6–12 days (Abrol 2013). It is also a very nutritious food for human beings as it increases vigor and vitality. Royal jelly is rich in amino acids such as alanine, arginine, aspartic acid, glutamic acid, glycine, isoleucine, lysine, methionine, phenylalanine, tryptophan, tyrosine, and serine. Eight of the essential amino acids required for human beings are present in royal jelly. Besides this, it also contains vitamins A, B, and C, iron, copper, phosphorus, silicon, and sulfur. It can be harvested by the Doolittle or grafting method in which artificial queen cell cups made from pure wax are attached to a brood frame that consists of bars holding small wax blocks. Then, one- or two-day-old larvae will be placed in the queen cell cups and kept inside the hive. The nurse bees feed the larvae with royal jelly, which can be harvested (Mishra 1995). As the royal jelly is more nutritious, it can be helpful to mankind in many ways.

Rearing Methods and General Management of Honey Bees

The apiary or the place where bees are kept must be dry without dampness. A natural or artificial water source in the vicinity for honeybees, shade such as trees or artificial structures under which the beehives will be placed, and sufficient bee forage or plants that provide pollen and nectar to honeybees are essential prerequisites.

Hive inspection must be carried out at least twice a week to look for the presence of the queen, eggs and brood, honey and pollen storage, and bee enemies like wax moth, mites, and diseases. Brood net expansion must be done by providing comb foundation sheets in empty frames during the honey flow period. Sugar syrup feeding must be provided inside the hive during the dearth period by dissolving sugar in water at a 1:1 dilution. Supering or the addition of frames in the super chamber is done when the brood chamber is covered with bees on all frames. Comb foundation sheet or constructed comb is provided in the super chamber. At the time of honey extraction, the bees are brushed away using a brush, cells are uncapped using an uncapping knife, and honey is extracted using a honey extractor, and the combs are replaced in the hive for reuse.

Swarming is a natural method of colony multiplication in which a part of the colony migrates to a new site to make a new colony. Swarming occurs when a colony builds up a considerable strength or when the queen’s substance secreted by the queen falls below a certain level. When bees swarm, it is possible that a beekeeper may lose a part of his colony, and hence swarm management must be done by removing brood frames from strong colonies and providing them to weak ones, pinching off the queen cells during inspection, dividing strong colonies, and trapping and hiving the primary swarm.

Indian Bear (*Melursusursinus*)

The apiaries located near to the hilly regions are more susceptible to bear attack. Hangingofbeehivestotreebranchescanbedonetocontrol.Besideshangingnor- mal hives, top bar hives can also be used.

Viruses

Honeybees in India are affected by Apis iridescent virus, Thai sac brood virus (TSBV), and Kashmir bee virus. Among them, TSBV was an introduced virus and a major one. TSBV was first detected in Meghalaya in 1978 (Kshirsagar et al. 1982). This virus caused a disastrous outbreak and devastated more than 90% of ***A. cerana*** colonies in India (Mishra 1995; Devanesan and Jacob 2001). Both the larval and pupal stages are susceptible to this disease, but the adult is an immune stage (Ramchandran et al. 2012). Because of the viral attack, brood will die in the prepupal unsealed stage; dead larvae can be seen with the tip of the head capsule turned upwards. Dead prepupae turn into a saclike structure, and the color of the affected larvae also changes from white to yellow or grey (Mishra 1995). There are no packed materials for the virus control. The disease can be avoided to a certain extent by avoiding, replacing, or mixing bee colonies and hive equipment from TSBV-affected apiaries. Recently, an RT-PCR-based method of diagnosis of TSBV has been developed (Aruna et al. 2016).

Bacterial Diseases

American foulbrood (AFB) disease caused by *Paenibacillus larvae* and European foulbrood (EFB) caused by *Melissococcus pluton* are the dangerous bacterial diseases infecting honeybee colonies (Nakamura 1996; Oldroyd and Wongsiri 2006; Bailey and Collins 1982).

American Foulbrood Disease

AFB is one of the most widely spread bacterial diseases (Gochnauer 1981). AFB-infected larvae normally die after their cell is sealed. Caps of these dead brood cells are usually darker than the caps of healthy cells. The entire population of the hive gets infected. For control of the disease, sterilization of equipment can be done using formalin at 6 ml per liter, and Terramycin at 250–400 mg in 5 liters of sugar syrup can be fed to the diseased colony twice at weekly intervals for effective control (Mishra 1995).

European Foulbrood Disease

European foulbrood is less harmful compared with American foulbrood, and it infects the midgut of infected bee larvae (Suwannapong et al. 2011). In India, it was first observed in Maharashtra in 1971 by Diwan and his coworkers on *A. cerana indica*. The honeybee colonies which are attacked by the *Varroa* are highly susceptible to EFB disease, as this bacterial disease is a stress-related disorder (Bailey and Collins 1982). Young larvae of 4–5 days old are highly susceptible to EFB, and the color of the larvae also changes from shiny white to yellow or brown in color. For control of the EFB disease, Terramycin and formalin can be used as mentioned in AFB control. Other mechanical methods, namely shook swarm (where the adult bees are shaken into new hives, discarding the infected brood combs), can be adopted to avoid the use of antibiotics.

Mite Enemies of Honeybee

Mites are important adversaries of honeybees in India; they spread from one place to another as the beekeeper moves the colonies to floral-rich sources and also because of migratory beekeeping (Anderson 1999, Boecking et al. 2000; Oldroyd and Wongsiri 2006). Tewarson et al. (1992) was the first person to study the lifecycle of *Varroa destructor* on *A. cerana* in India.

Varroa jacobsoni

The mite was first reported in India by Phadke et al. (1966) from Delhi. It is a native pest to *A. cerana* in India, but after the introduction of *A. mellifera* to India, it started affecting the Italian bee colonies also (Mishra 1995). The mite is reddish-brown in color, and the female mite is about 1.1 mm in length and 21.6 mm (Sammataro et al. 1994; Sammataro 1997). It can pierce and tear open the host’s integument and feed on the hemolymph of the honeybee (Suwannapong et al. 2011; Delfinado and Baker 1987). The symptoms are called varroasis, and the larval stage of honeybees is the most susceptible stage. For controlling, sugar powder can be dusted over the honeybees and in the frames; as the bees tend to groom, the Varroa mite can be dislodged. Other than sugar dust, sulfur and *Acorus calamus* (sweet flag) powder can also be dusted. Ritter (1981) and De Jong et al. (1982) suggested synecar, a mixture of sugar powder + chloropropylate or bromopropylate at the rate of 50–100 mg per colony, depending upon the strength, which can be dusted in passages between the frames. Presently, some commercial products are available, such as Coumaphos®, Bayer Bee Strips®, or CheckMite® (Suwannapong et al. 2011; De Jong 1997; Gerson et al. 1988; Le Conte et al. 1989), which are hardly practiced in India.

Acarapis woodi

Acarapis woodi was first reported in India (Singh 1957) from *A. cerana* colonies. This mite was first named as *Tarsonemus woodi* (Rennie 1921; Rinderer et al. 1999), but later it was renamed as *Acarapis*, Acar from Acarus (mite) and Apis from bee (Suwannapong et al. 2011). This mite attacks the tracheal system of honeybees; it attacks all three castes of honeybees. The typical symptom is “K”-winged condition, where the bees cannot fly and the wings are disjoined. This mite also feeds on hemolymph, and the lifespan of the honeybee is reduced (Hirschfelder and Sachs 1952; Mishra 1995). For controlling this mite, formic acid, menthol, or thymol can be applied; fumigation using Folbex strips can be done (Atwal 1971).

Tropilaelaps clareae

It was first reported in India from *Apis dorsata* (Bhardwaj 1968). This mite species attacks all five species of honeybees but is primarily found on *A. dorsata* and *A. mellifera* (Atwal and Dhaliwal 1969; Laigo and Morse 1969). It was first discovered in the rat (Delfinado and Baker 1961). The mite attacks the pupae and prepupae stages of bees. Mature female mites attach to and suck the hemolymph from the larvae and adults. Infected honeybees have poor wings, and irregular brood patterns are a typical symptom of this mite (Mishra 1995; Suwannapong et al. 2011). Sulfur dusting is an effective control method (Atwal and Goyal 1971). The use of organic products like formic acid, oxalic acid, and other essential oils at the right time can be effective for all mite species (Cramp 2008). *T. clareae* is difficult to control compared to other mite species, as this mite is readily available with *A. dorsata* colonies, but professional beekeepers remove the brood frames from their hives so that the female mite will starve to death, as this mite can live only 7 days without food.

Migratory Beekeeping in India

Migratory beekeeping provides good returns to the beekeeper, as the returning bees to the hive are maximum due to the abundant flora in that region. For commercial migratory beekeeping, the beekeeper has to map the available floral resources and plan the migration accordingly.

In northern India, commercial beekeepers shift the colonies between plains and hills for migratory beekeeping. During **October–November**, colonies are migrated to the plains of Uttaranchal, Uttar Pradesh, Haryana, Punjab, and Rajasthan to exploit **rapeseed** and **mustard**. During **December–January**, colonies are migrated to eucalyptus plantations in Uttar Pradesh and Haryana. Bee colonies will also be migrated to **litchi orchards** at Ramnagar and Dehradun from **February to March**. Some beekeepers will also migrate to **sunflower fields** of Punjab and Haryana. Beekeepers will also migrate to forest plantations of Uttar Pradesh for **shisham** until May.

In southern India, migration of bee colonies from southern **Tamil Nadu** (mainly Marthandam of Kanyakumari District) to Kerala during **January–March** is a renowned practice. The commercial beekeepers migrate the colonies to **rubber plantations** which are spread over about 0.40 million hectares. During that period, beekeepers will harvest tons of honey and store it to sell when they get a better price. Rubber is considered the third major source of honey next to **rapeseed/mustard** and **sunflower** in India. Beekeepers from Kerala and Tamil Nadu migrate their colonies mainly to Quilon, Kottayam, Changanacherry, Trichur, Palghat, Kozhikode, and Cannanore districts for **rubber–honey flow**. In Tamil Nadu, during **May–June**, beekeepers migrate the colonies for harvesting nectar from **tamarind flowers**. Colonies are also migrated to high ranges of **Devikulam, Peermedu, Idukki**, and other districts to **cardamom estates**.

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Pesticide Usage and Honeybees

Pesticide use has become inevitable in modern agriculture. With pesticide consumption increasing several folds over the last four decades, the side effects are also increasing, one of which is the toxicity to honeybees. Pesticides, alone and in combination with other factors, have had a devastating effect on honeybees and wild pollinators. Pesticides commonly found in lawn and garden products and used in agriculture are known to be hazardous to bees, some killing bees outright and others with subtle effects that reduce a bee's ability to thrive. Besides increasing agricultural production, they cause undesirable environmental effects, including the impact on non-target species, such as honeybees and other pollinators. Hence, the safety of poisonous agrochemicals must be ensured.

The use of pesticides for pest control on the one hand and the use of honeybees for cross-pollination are not always compatible, as honeybees are susceptible to many of the commonly used pesticides for the control of insect pests (Johansen 1977; MacKenzie and Winston 1989; Poehling 1989; Stark et al. 1995; Russell et al. 1998; Cunningham et al. 2002; Sundararaju 2003). The major constraint confronting pollinator–plant interaction is the indiscriminate and excessive use of pesticides for controlling insect pests (Bisht et al. 1983; Rana and Goyal 1991; Zhong et al. 2004). The loss of honeybees directly affects beekeeping through loss of honey production and indirectly affects crop production due to inadequate pollination. The reduction of the population of these beneficial insects due to insecticides, therefore, incurs significant environmental, ecological, and economic costs (Pimental 1980; Crane and Walker 1983).

Impact of Pesticides on Bees

- The use of **herbicides** eliminates the weed flora, which serves as a very good food source for bees, especially during the dearth period.
- Direct exposure to **insecticidal sprays** results in the death of bees and sometimes leads to the total destruction of bee colonies.
- **Contamination of water resources** affects water carriers.
- **Contamination of nectar and pollen** causes brood mortality.
- Widespread use of chemicals also contaminates the **hive products**.
- Indiscriminate use of pesticides threatens the integrity of the **bee–flower mutualistic system**.

Minimizing Pesticide Hazards to Bees/Management Practices

A proper understanding of the above-mentioned principles can go a long way in reducing pesticide hazards to honeybees. The basic principle, of course, is that honeybees should not get exposed to the toxic effects of insecticides as far as possible. Reducing pesticide injury to honeybees requires communication and cooperation between beekeepers and farmers, since both mutually benefit from honeybees—the beekeeper in terms of its products and the farmer in terms of increased production of crops. While it is unlikely that all poisoning can be avoided, a balance must be struck between the effective use of insecticides, the preservation of pollinators, and the rights of all—the beekeeper, farmers, and the community.

Guidelines to Beekeepers

- It is most desirable that bee colonies should be maintained where the use of pesticides or drift from pesticides is minimum. For this, the beekeeper should be fully conversant with the type of pesticides used in their locality, which in turn depends upon the cropping pattern and the pest complex. He/she should also be aware of normal wind currents prevalent in that area to protect against the harmful effects from drift.
- If ever disinfestation of beehives becomes necessary, he/she should use only the recommended chemicals, safe to the bees, for the purpose.
- During bloom, if the crops in the surrounding areas are being sprayed with insecticides, it is always advisable to confine the bees within the hives. If it is apprehended that the spray program will continue for a longer period, it is better to move the hives away to a safe location free from the drift in advance.
- Apiarists and farmers should have close cooperation so that the beneficial activity of bees is not jeopardized by the irrational use of pesticides by the latter.
- Feeding of colonies with sugar syrup following pesticide application to reduce bee foraging may help substantially in reducing the exposure of bees to pesticides.

Guidelines for Farmers

The golden principle for the farmers is to use insecticides only when necessary. For this purpose, integrated pest management approaches are available on most crops, which should be strictly practiced. It is in the mutual interests of both that the farmer should intimate the spray program in advance to the beekeeper:

- If there is a choice for insecticides, the use should be restricted to the chemicals in the less hazardous groups.
- The spray operation in the evening is always preferable as it not only gives better deposit and distribution but also bee activity subsides.
- Apply granules or sprays in preference to dusts. Baits used for fruit fly control should be discouraged as far as possible during the crop in bloom.
- Examine fields and field margins before spraying to determine if bees are foraging on flowering weeds. Where feasible, eliminate weeds by mowing or tillage.
- Give careful consideration to the position of bee colonies relative to wind speed and direction. Changing spray nozzles or reducing pressure can increase droplet size and reduce spray drift.

Constraints in Beekeeping in India

As discussed above, indiscriminate use of pesticides poses a major threat to honeybees (Shinde and Phadke 1995; Kaur 1998; Kumar 2000). Lack of honeybee professionals and trained bee laborers results in poor management of colonies. Many commercial beekeepers face problems, including interference from police and octroi personnel during the migration of their colonies. A survey conducted in Punjab showed that 37.5% of beekeepers are facing these problems. The transport costs are also high in migratory beekeeping (Kaur 1998; Sharma et al. 2014).

Depletion of floral resources due to the growing concrete jungles is one of the major concerns in beekeeping, as the bee boxes are placed in fields where 24-hour care is not possible. The theft of boxes is a common issue (Bansal et al. 2013). Many beekeepers report that the cost of the equipment is too high, which discourages entrepreneurs in this field. There is no separate market for honey, and beekeepers sell their honey to local markets. For exporting honey, most commercial beekeepers are troubled by international standards, as they have poor knowledge of the standards (Bansal et al. 2013; Sharma et al. 2014). Honey from the rubber plantations is the major source in southern India, and the beekeepers from this part cannot export their honey as it has a high moisture content. The producer price for honey and other products from beekeeping is very low compared to the retailer price, which irritates the beekeepers (Singh 2000).

Overcoming the Constraints

As per FAO (2016), the world total honey production during 2013 was 2.13 million tonnes. China ranks first in honey production with 466,300 tonnes, while India ranks seventh with 61,000 tonnes. India has vast potential for beekeeping. The diversity in flora provides more opportunities for the development of the beekeeping industry. It is said that based on the area under cultivation in India and bee forage crops, India has the potential to have about 100 million bee colonies, while the current figure is less than one million colonies.

Beekeeping should be recognized as an important agricultural activity for increasing the productivity of agricultural/horticultural crops, and a section of beekeeping should be developed within the line departments of the states. The forest department should take an initiative for planting bee flora and should allow beekeepers to use it. Free training on beekeeping with the latest improvements can help beekeepers update their knowledge. Effective cooperation among beekeepers, traders, exporters, extension agencies, and the government should be established.

Intensive efforts should be made to improve the domestic consumption of honey by developing honey-based food/consumer products and intensive generic promotion of honey through media. There is a need to conduct effective promotional and awareness campaigns to remove the myths about honey and bees. The government must take steps to ensure the sale of honey at the best price, which helps improve the beekeeper's economy. The concept of the effect of pesticides on honeybees should be understood by farmers so the beekeeper will be forewarned

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by the farmer before spraying. Presently, the government is encouraging organic farming (recently, Sikkim was declared the first organic state in India), which is a good initiative for saving bee health and consuming organic honey (Bansal et al. 2013; Sharma et al. 2014).

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Fungal, Bacterial and Viral Diseases of Honeybee *(Apis mellifera)*

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Honeybees, important pollinators crucial for ecosystem health, are susceptible to a range of bacterial, fungal, and viral diseases that pose significant threats to their colonies. Two examples of bacterial diseases include European Foulbrood (EFB) caused by *Melissococcusplutonius* and American Foulbrood (AFB) caused by *Paenibacillus larvae*. Whereas EFB mostly affects young larvae, AFB causes the death of honeybee larvae and the formation of spores that contaminate the hive. AFB results in the death of honeybee larvae and the production of spores that contaminate the hive, while EFB primarily affects young larvae. Fungal diseases like chalkbrood are caused by *Ascosphaeraapis*, Chalkbrood transforms larvae into chalk-like mummies Nosemosis is caused by two pathogenic spores *Nosemaapis*, and *Nosemaceranae,* which infects the midgut of adult honeybees and viral diseases such as Deformed Wing Virus (DWV), Israeli Acute Paralysis Virus (IAPV), and Chronic Bee Paralysis Virus (CBPV) further weaken honeybee colonies, DWV and IAPV lead to deformed wings and premature death, and CBPV causes shivering hair loss, and paralysis. Beekeepers use a variety of methods for managing these diseases, such as antibiotic treatments, genetic selection for resistance, Integrated Pest Management (IPM) approaches, and maintaining hive health. Effective disease prevention and control, as well as the preservation of honeybee populations and the vital ecosystem services they provide, depend on continuous study, monitoring, and education.

Keywords: *honeybee, bacterial, fungal, viral, diseases.*

1. Introduction

1.1 Bacterial diseases in honeybee

1.1.1 European foul brood

The disease known as "European foulbrood" affects bee larvae worldwide and is mainly harmful to capped brood (Charriere et al., 2011). It is caused by the Gram-positive bacterium

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Melissococcusplutonius (Ellis *et al.*, 2005). The bacteria in these deposits remain alive for extended periods of time, and even when the cells are cleaned, some germs may still be present and infect new individuals, which is how the infection spreads inside the hive (Belloy*et al.*, 2007). Bacteria can be transferred between hives and apiaries by adult bees and honey working as vectors (Forsgren*et al.*, 2010).

When bees consume food contaminated with the bacteria, the infection process proceeds. After entering the bee's midgut, the bacteria proliferate and causes physiological harm to the peritrophic matrix and epithelial cells (Mantilla Salazar *et al.*, 2012). Furthermore, because the bacteria compete with one another for resources, this infection has been linked to malnutrition in larvae. Within the bee colonies, infected larvae display aberrant dispersion and gradually change color from white to yellow to brown as they approach the ultimate stage of decomposition (Erler*et al.*, 2017). The mortality of larvae caused by M. plutonius infection holds significant importance, yet there remains limited knowledge regarding the pathophysiological mechanisms and virulence factors of this pathogen (Gaggia*et al.,* 2015). It has been suggested that variations in the genotypic structure of the bacteria contribute to the differences in virulence factors among different strains, which play a critical role in the development and severity of the disease. Therefore, understanding the molecular epidemiology of the bacterium and its association with the severity of pathophysiological processes is crucial for timely disease diagnosis and effective control in apiaries (Perez-Ordonez *et al.,* 2021).

1.1.2 Symptoms

The disease can be characterized by several distinctive symptoms. As the condition becomes more severe, infected larvae show atypical color changes; they initially appearing pearly white but eventually turn yellow, brown, or even dark brown (Govan *et al.*, 1998). Furthermore, the impacted larvae sink and eventually break down inside the cells, which causes them to decompose. Additionally, twisted, or deformed larvae are seen, which is a defining sign of EFB.

The bottom of cells or the walls of destroyed larvae may have scale-like remnants stuck to it. A bad smell coming from infected colonies, akin to rotting or decomposing broods, is another sign that EFB is present. Additionally, the sickness results in a patchy brood pattern within the colony, which interferes with normal brood growth and ultimately leads to death. On cell walls or debris inside the hive, chalk-like scales from disintegrating larvae may be evident (Genersch*et al.*, 2010).

EFB weakens honeybee colonies, leading to reduced population size, decreased honey production, and an overall decline in colony strength. Severe EFB infections can increase adult bee mortality, further contributing to colony weakness. Unlike American foulbrood (AFB), EFB does not exhibit rope-like structures when the brood is stretched with a toothpick or matchstick. Early and accurate diagnosis of EFB is vital for effective disease management. Beekeepers and inspectors should closely observe these symptoms and, if necessary, confirm the presence of the bacterium M. plutonius through laboratory analysis (Figure 1).

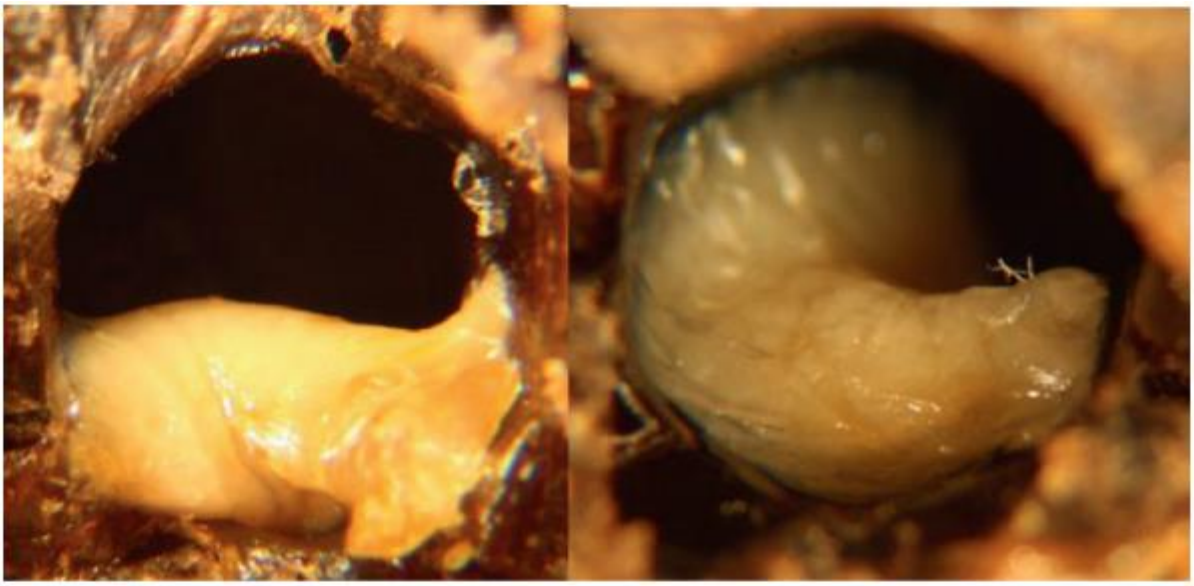

Figure 1. A melted larva in its cell from a hive infected with European foulbrood and larvae curled upwards, flaccid, and brown or yellowish dead larva in its cell.

1.2 American foul brood

American foulbrood (AFB) is one of the serious bacterial larval diseases of honeybees Apis mellifera (Genersch*et al*., 2022) caused by spore-forming, Gram-positive bacteria (Paenibacillus larvae).The bacteria has extremely aggressive pathogenic behavior, which causes bee colonies to collapse catastrophically. Food exchange or feeding amongst larvae by nurse bees occurs when bacterium spores are ingested; specifically, honey, pollen, and royal jelly (Gillard *et al*., 2008).

1.2.1 Pathogenesis

After hatching, the larvae are extremely vulnerable to pathogen infection. The infectious stage pathogen is larval, but symptoms develop in the pupal stage and eventually collapse the entire colony. Vegetative cells infect the haemolymph and break through the protective membrane; spores only infect the midgut of honeybee larvae and grow quickly (Yue *et al*., 2008). The vegetative cells then sporulate, turning into dry flakes that contain millions of spores.

1.2.2 Symptom

Capped brood that is sunken, perforated, or discolored, with a dark, coffee-like appearance", and "Dead larvae that exhibit a rope-like consistency when probed with a matchstick or toothpick". The presence of foul-smelling, decaying larvae that may emit a sour or putrid odor".

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Presence of spore-contaminated debris at the bottom of cells and on the hive floor". Following the initial diagnosis, a bacteriological examination is necessary to isolate and identify the bacteria responsible for the infection (Andrade *et al*., 2019). Molecular biology techniques like real-time PCR have become commonly used for identifying the specific bacterial strains causing the infection (Figure 2).

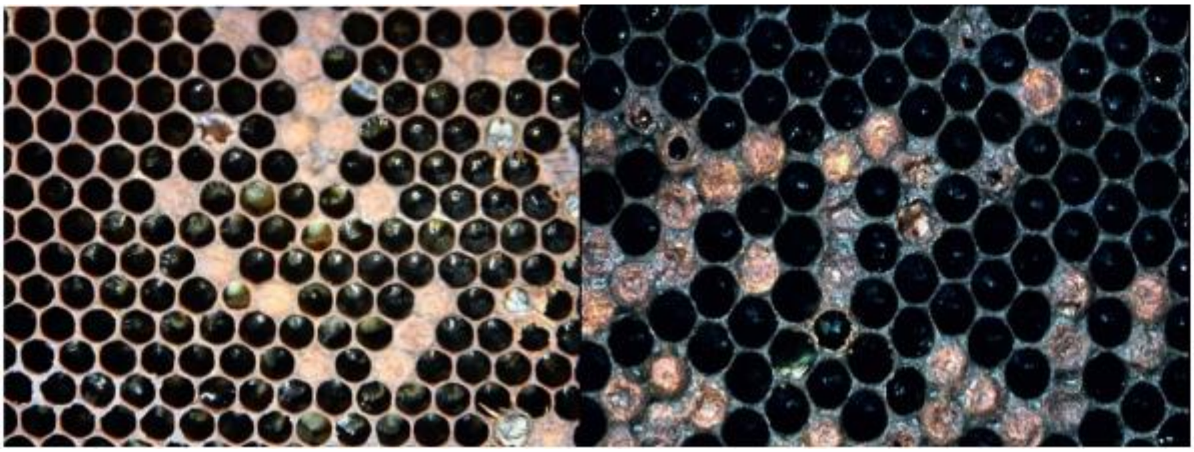

Figure 2. The earlier stage infection and later stage infection of American foulbrood.

2. Fungal diseases in honeybees

2.1 Chalk brood

One of the most common pathogenic agents that damage bee colonies is the fungus Ascosphaeraapis, which causes ascospherosis, also known as chalk disease, and has spread to various countries worldwide. The invasive mycosis known as A. apis infection impacts growing larvae. It is produced when the fungus's spores are consumed by the larvae along with their food source. After closing the cells, the hyphae proliferate in the midgut and reach the surface, creating a microaerophilic environment that supports the growth of fungi and ultimately results in mummified carcasses that resemble chalk (Tejerina *et al*., 2021).

The fungus A. apis doesn't affect adult bees; it only infects brood larvae. The spores of A. apis are dependent on the larvae consuming the spores along with their food, as opposed to other entomopathogenic fungi that can enter insects through their cuticles. After being consumed, A. apis spores require a lot of CO_2 for initial germination. This process takes place in the anaerobic environment of the larval intestine, where the tissues of the larvae make CO_2.

The optimal temperature for germination is 35°C. The spores expand and form germ tubes that mature into dichotomous hyphae when they are activated. These hyphae then break through the larvae's peritrophic membrane and extend into the body cavity, finally reaching the posterior end. Spore cysts are an undesirable result. Ascospores are the infectious units that cause chalk disease; they develop inside spore balls that appear in resistant cysts. The two nuclei which make the spores are the larger one in the center and the smaller one near to the tip (Mraz *et al*.,

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2021). The main component of the three-layered spore wall, chitin, is the component that makes ascospores viable over the long term.

2.1.1 Symptoms

One of the initial clinical signs of chalk disease is the presence of dead larvae that are covered in white fungal growth and usually appear swollen. Over time, these larvae shrink and change color to black, gray, or white, depending on the presence of reproductive structures. The infected larvae become mummified as the fungal development cycle advances (Heath *et al*., 1985). Observing mummified bee brood, often known as plaster brood or plaster mummies, on the bottom board of beehives and in exposed cells makes it easier to identify chalk disease. Because worker bees destroy the brood of infected bees, low-level infestations of the disease (less than 12% infection) are difficult to find (Figures 3 and 4).

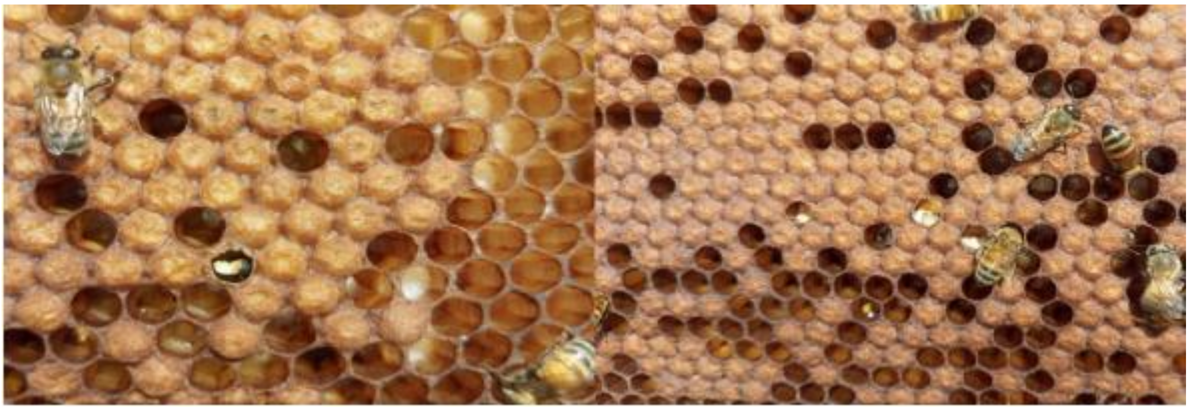

Figure 3. White fungal growth and usually appear swollen. Over time, these larvae shrink and change color to black, gray, or white.

Figure 4. Mummified bee brood, commonly referred to as plaster brood or plaster mummies, on the bottom board of beehives.

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2.2 Nosemosis

2.2.1 Microsporidian of honey bee

Nosemosis is an adult honeybee disease that affects the adult bees' intestinal epithelial cells, destroying the integrity of the gut and disrupting the digestive system. This results in several atypical significant behaviors in the worker bees. Bee behavior polymorphisms, i.e., early development of adult behavior, reduced capacity to feed larvae, reduced life span, and increased overwintering mortality, should be developed more quickly (Botias*et al.,* 2013). resulting in decreased viability, fecundity, and productivity of bee colonies. The pathogen's evolution will be influenced by its geographical environment.

2.2.1.1 Nosemaapis

Nosemosis A is a disease caused by N. apis. The high incidence of N. apis is from the autumn months, being during the winter because of increased colony mortality or collapse (Forsgren*et al*., 2013). It frequently shows apparent signs of the disease, caused by N. apis such as brown fecal stains with a peculiar acid odor observed on the frames and at the entrance of the hive. As a result of high mortally and weak bees at the entrance of hives or swallow's abdomens.

2.2.1.2 Nosema ceranae

Nosemosis C is a throughout the year caused by N. ceranae that does not exhibit clinical indications of N. apis infection, such as fecal deposits or dilated abdomen. N. ceranae is a pathogen with a higher virulence than N. apis. According to Kurze*et al.,* (2016), N. ceranae affects nutritional metabolism and cellular defense processes. The hormone vitellogenin, which affects the bee's longevity, immune system function, and response to stress, is expressed less frequently. It is involved in the manufacture of royal jelly.

2.2.2 Effects on colonies

It has been demonstrated that type A and type C nosemosis are both very harmful to honeybee hives. The strange excrement and dead bees surrounding infected hives, the enlarged abdomens of the affected bees, and the seasonality of the infection—with infection maximum in the spring and fall—are the most prominent symptoms of type A nosemosis. Because of its long initial incubation period and the imbalance of polytheism that results in bees, type C nosemosis is thought to be asymptomatic, which speeds up the hive's beginning. At early ages, have favored its relationship with the decline of bee hives (Goblirsch*et al*., 2018) and with Colony Collapse Disorder (CCD), in different regions of the world.

The host's reaction to the spore load provided to bees in experimental infections has been linked to the distinct pathogenicity of nosemosis. Usually, the impacts on fertility and host survival increase with the dose of infection. In experimental infections with N. apis and N. ceranae, this

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phenomenon has been verified; bees infected with larger doses showed increased mortality and increased consumption of sugar.

There is clear evidence that N. ceranae affects various aspects of individual physiology (metabolism and immune response), morphology, and behavior of infected bees (Benvau*et al*., 2017). For all these reasons, the infection unfavorably affects the viability and survival of the bees, and compromises the health of the hives, decreasing their productivity (Figure 5).

Figure 5. Dysentery at the entrance of Nosema-infected bee hive.

3. Viral disease of honeybee

Single-stand RNA viruses are highly infected pathogens of honeybees (McMenamin *et al*., 2016) about 20 bee-identified viruses, that is, Sac-brood virus (SBV), Deformed-wing virus (DWV), Kashmir-bee virus (KBV), Israeli-acute-paralysis virus (IAPV), Chronicbee-paralysis virus (CBPV), Acute-bee-paralysis virus (ABPV), and Black-queen cell virus (BQCV), and KBV, IAPV, and ABPV complex viruses reported last year caused several colonies losses and bee mortality.

Aspects of pathogenicity, virulence, and impacts (both individually and socially) on honeybees are not fixed characteristics nor host-specific because of the wide variety of virus species. For instance, adult bees of any caste can contract aberrant conditions on their wings and abdomens from the DWV and VDV-1 viruses, which belong to the same viral complex as DWV type A and DWV type B, respectively. These diseases can result in early mortality (Brettell *et al.*, 2017). The BQCV virus, on the different, can infect honeybees of any caste, but it only causes sterility in queen larvae.

3.1 Symptoms

IAPV infect bees having the following symptoms as paralyzed bee, decrease flying ability, crawling, changing in orientation, and shaking of wings (Chen *et al*., 2014). ABPV caused loss of

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hair from the bee thorax, and paralysis. KBV declined bee population. CBPV can paralyze bees, No fling ability, loss of hair from the abdomen, trembling, and the bee to black in color. DWV as the name indicates the deformed bee wings, shortened abdomens, and hypoplastic glands (Figures 6 and 7).

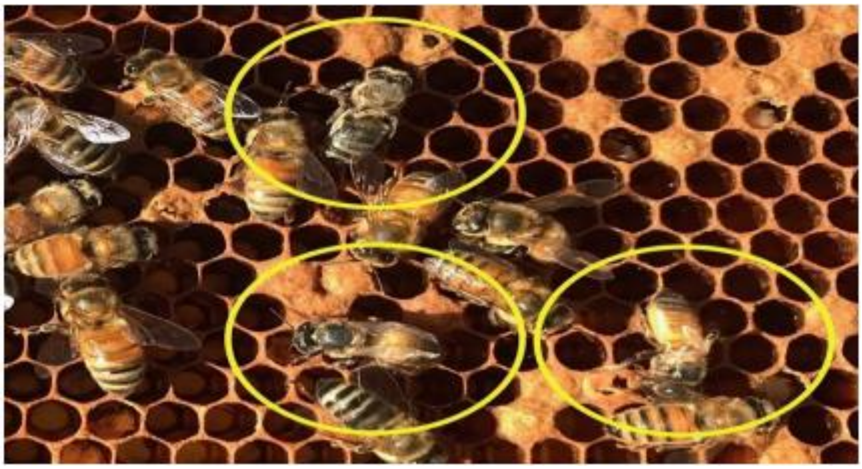

Figure 6. The deformed bee wings, shortened abdomens, and zero fling ability.

Figure 7. IAPV infect bees are paralyzed bee, decrease flying ability, crawling, changing in orientation, and shaking of wings, and CBPV can paralyze bees, loss of hair from the abdomen, trembling, and the bee to black in color.

from different colonies steal resources from each other, can contribute to the transmission of viruses. According to Dainat*et al.* (2012), robbing bees containing the infection may spread viruses into colonies that were previously healthy, hence propagating the disease. Moreover, some beekeeping techniques may unintentionally promote the spread of viruses. Viral transmission can occur through the sharing of beekeeping tools between infected and healthy colonies or using contaminated equipment (Forzan*et al.*, 2014).

Bee-to-bee transmission through direct contact is another important pathway for virus dissemination. Bees in proximity can transmit viruses to each other, such as when Nosema-infected bees pass viruses to healthy bees through mutual grooming behaviors(Di Prisco*et al.*,

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2016). Pollination activities involving honeybees can contribute to virus transmission between different colonies. Bees may carry viruses on their bodies or in their honey stomachs, transferring them to flowers and subsequently infecting other colonies during pollination. Fecal-oral transmission also plays a role, as viruses present in infected bees' feces can contaminate hive surfaces and resources. Healthy bees can encounter the contaminated surfaces or ingest the infected feces, leading to virus transmission. Additionally, environmental factors, including temperature and humidity, can influence the survival and transmission of viruses in honeybees. Higher temperatures and increased humidity can enhance viral replication and increase the likelihood of virus transmission.

4. Conclusion

In conclusion, bacterial, fungal, and viral diseases pose serious risks to honeybee populations. Bacterial infections such as American (AFB) and European (EFB) foulbrood cause hive contamination and larvae death. A fungus called chalkbrood turns larvae into mummies that resemble chalk. Two spore-forming parasites induce nosemosis, which damages adult honeybees' midguts. Viral diseases that weaken colonies and cause malformations, early death, and paralysis include the Chronic Bee Paralysis Virus (CBPV), Israeli Acute Paralysis Virus (IAPV), and Deformed Wing Virus (DWV). External factors like Varroa destructor mites, which also function as viral vectors, aid in the spread of these diseases. To control these diseases, beekeepers use a variety of techniques like as antibiotic treatments, genetic selection for resistance, integrated pest management (IPM), and hive maintenance. However, continued research, monitoring, and education are essential for effective prevention and control, ensuring the preservation of honeybee populations and the critical ecosystem services they provide.

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Comparative studies on Biophysical and Biochemical Basis of Resistance in Brinjal and Chilli against Aphid (*Aphis gossypii*)

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Abstract

Investigations on studies of aphid on brinjal and chilli and host plant resistance studies were carried out during 2022 in vallampadugai village, tamil nadu, India. Significant difference was observed between the brinjal and chilli local variety in length, thickness, breath was positive correlated and trichome density and trichome length and types were negatively correlated. Biochemical component of resistant plants is sugar, nitrogen was positively correlated and phenol, potash and silica were negatively correlated with aphid feeding preference.

Key words: Resistance, Biophysical, Biochemical, *Aphis gossypii*

INTRODUCTION:

Brinjal (*Solanum melongena* L.) is an important vegetable. In India it is cultivated in 73,300 hectares with an annual production of 12,510 million tonnes and productivity of 26.68 metric tonnes [4]. However, China stands first with 35.97 metric tonnes. Chilli (Capsicum annum L.) is a popular vegetable and condiment crop grown throughout the world. India is the world leader in chilli production followed by China. In India it is cultivated throughout the country in about 31,600 hectares with an annual production of 3,634 million tonnes and productivity of 16.43 metric tonnes.

MATERIALS AND METHOD:

Estimation of leaf length, width and thickness

The length and width of the Solanaceous plant (brinjal, tomato and chilli) was measured and expressed in centimetre (cm).

Trichome length and density

Density of trichomes present in the adaxial and abaxial surface of leaf was estimated. One mm long transverse section of leaf was cut from leaves of 50 days old plants and the sectioned sample of brinjal was placed transversely on a clean glass slide and the trichomes length and density per mm were counted with the help of stage and ocular meter using a microscope [10]. Similar procedure was followed to estimate the trichome length and density of tomato and chilli plant leaves.

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Biochemical factors of resistance on Brinjal and chilli crops

The biochemical constituents *i.e.,* total sugars, nitrogen, total phenols, potash, silica were estimated in 50 days old leaf samples of brinjal and chilli plant. Collected samples were preserved by using freeze dryer and powdered leaf samples were analysed.

Estimation of sugar

Total sugars present in leaves of brinjal, tomato and chilli plant were estimated by calorimetric assay described by Sadasivam and Manikam (1992). 200 mg of leaf sample of respective test plant was taken in a conical flask and 5 ml of 2.5 N HCL was added and hydrolyzed by boiling the sample on mantle heater for 3 hours. The sample as cooled to room temperature and the volume was, made up to 100 ml by adding distilled water and supernatant was collected and aliquots of 0.5 ml and 1.0 ml were used for estimation. Aliquots of 0.5 and 1.0 ml were pipette out in to different test tubes, after making up the volume to 10 ml in each tube with distilled water. 1.0ml of 5 per cent volume to 10 ml in each tube with distilled water. 1.0 ml of 5 per cent phenol was added followed by 5.0 ml 96 percent sulphuric acid, after incubating the samples for ten minutes to room temperature. The absorbance was read at 490 nm [11.20] The amount of total sugars reagent present in samples was calculated from the standard glucose calibration curve established with different concentration (20-100 mg) of glucose. The data were represented as per cent.

Estimation of total phenol

The total phenols present in leaves of brinjal, tomato and chilli were estimated as per the method developed by Sadasivam and Manickam (1992). From each sample 0.5 g material were weighed and were added with ten times volume of 80% ethanol and the homogenate was centrifuged at 10,000 rpm for 20 minutes. The supernatant was collected and residues were extracted with five times the volume of 80% ethanol, then centrifuged and the supernatants were pooled and evaporated to dryness. The residue then dissolved in 5ml distilled water and different aliquots ranging from 0.26 to 2.0 ml were pipette out in to the test tubes and the volume in each tube was made up to 3 ml by adding distilled water [15.11]. To this extract, 0.5 ml of folin-ciocalteau reagent was added and after 3 minutes 2 ml 0f 20% sodium carbonate solution was added to each tube. The material was mixed thoroughly and tubes were placed in boiling water exactly for one minute. The tubes were then cooled and the absorbance was measured at 650 nm against a reagent blank in spectrophotometer [1,3,5]. The standard curve was prepared by plotting the catechol concentrations on X-axis and absorbance values on Y- axis. From the standard curve, concentration of total phenols in terms of mg phenols/100 gm of test plant's leaf material was

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estimated and converted to per cent (%).

Estimation of Silica

Estimating silica content as per the method, 0.5g of dried leaf sample of brinjal, Tomato and chilli plants were individually weighed and transferred to 50 ml Erlenmeyer flask which was thoroughly cleaned with hot alkali followed by acid and distilled water. Ten ml of triple acid mixture was added and the contents were digested over a hot plate [13]. The digestion was continued till the brown fumes ceased and the volume of the acid was reduced to about 2ml which took about 30 min. overheating and drying were avoided. The resultant solutions from the digestion were then carefully transferred with repeated washing into tall stainless-steel beakers containing 1-1.5g anhydrous sodium carbonate in suspension such that there was sufficient alkali in excess after boiled for 3-5 min to ensure complete dissolution of silica. The resultant solution after cooling as made up to 250 ml and stored in polyethylene bottles [13]. Two ml of aliquots were treated with 2ml of 1:1 HCl and agitated for a while to remove the CO2 evolved. This was followed by addition of 2ml of 10 per cent Ammonium molybdate and the content in the flask were allowed to stand for 5 min. the interference of iron was then removed the addition of 0.5ml of 5 per cent solution of hydroxylamine HCl and of phosphorous by the addition of 1 ml of 10 per cent oxalic acid. The resultant silica molybdate complex after dilution to volume as reduced by the addition of 2 ml of 0.5 per cent ascorbic acid and the volume made up to 50 ml. The blue color developed was kept on standard for 15-20 min and read at 650nm in a Bauchand Lomb spectronic calorimeter [8,9,10]. Reagent blank as also employed for minimizing the error. The unknowns were calculated from standard prepared with sodium meta silicate.

Estimation of nitrogen

The leaf samples of brinjal, tomato and chilli were analyzed for nitrogen content by micro kjedahl.

Estimation of potassium

The potassium content of the brinjal, tomato and chilli leaf samples were estimated by flame photometer using the tri acid mixture as suggested by Jackson.

RESULT AND DISCUSSION:

Biophysical factors of resistance on brinjal and chilli:

Various biophysical factors of resistance operative in the test Solanaceae crops were investigated. Among the biophysical factors, trichome density on the foliage was found to influence the insect activity. Trichomes detected in the leaves, flower stalk and petioles of the selected crops. With regard to the distribution and density of the trichomes on their foliage, a wider variation was observed among the test crops. Trichome density was more predominant in adaxial surface of brinjal (33.5 no/mm^2) and tomato (37.6 no/mm^2) and followed by abaxial surface of brinjal (18.45

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no/mm^2) followed by chilli (0.56 cm). Trichomes density on flower stalk on brinjal (12.87 no/mm^2) and chilli (5.11 no/mm^2) Leaf length and width on brinjal was highest (20.57 & 9.49 cm). Brinjal leaf thickness (242. 23 µm) was more when compared chilli (170.70 µm). Among the biophysical factors, trichome density on foliage influence aphid population more on brinjal whereas, chilli have less trichome density and thickness of leaf.

Biochemical factors of resistance in brinjal and chilli:

The sugar and nitrogen content of the foliage favour the sucking pests on the selected Solanaecae crops. The sugar content was higher in brinjal (10.74%) and nitrogen content in brinjal (7.32%). The phenol content of the foliage was maximum in chilli (7.08) followed by in brinjal (5.64). Similarly, potassium and silica content were more on chilli potassium (4.83) and silica (6.40) which exhibits the resistance against sucking pests. Aphid feeding on brinjal positively correlated with the biophysical factors. Trichome length (0.826), trichomes adaxial density (0.910) trichomes abaxial density (0.967), in addition, trichome on flower stalk, trichome density in petiole, leaf length, leaf width, leaf thickness was positively correlated (0.970), (0.989), (0.911), (0.936) respectively. Whereas, estimation of biochemical components in the leaf samples concerned, sugar (0.902) and nitrogen (0.855) were positively correlated in brinjal but phenol (-0.988), potash (-0.900) and silica (-0.970) were negatively correlated with preference of aphids feeding. Aphid feeding on the leaves of chilli was positively correlated with the biophysical factors *i.e.,* trichome length (0.515), trichomes adaxial density (0.437) trichomes abaxial density (0.283), whereas trichome in flower stalk, trichome density in petiole, leaf length, leaf width, leaf thickness was also positively correlated (0.937), (0.570) (0.640), (0.563), (0.326) respectively. Whereas, correlation of biochemical component in chilli sugar (0.402) and nitrogen (0.380) was positive correlated but phenol (-0.290), potash (-0.854) and silica (-0.377) were negatively correlate

Conclusion:

The evaluation of biophysical factors of brinjal and chilli leaves showed that, the trichome length and density was significantly high on brinjal followed by chilli leaf. The leaf thickness was high on brinjal when compared to tomato and chilli. Trichome length and density on brinjal was positively correlated with population of aphids. Analysis of biochemical constituents of brinjal and chilli showed that sugar and nitrogen were higher in the leaves of brinjal when compared to chilli. Whereas, phenol, silica and potassium contents were more in the leaves of chilli when compared to brinjal. The chemical constituent in the leaves of brinjal and chilli revealed sugars and nitrogen content were positively correlated with the incidence of aphids whereas, silica and potassium were negatively correlated in the preference of above test host

Table1: Correlation between biophysical and biochemical constituents with feeding of aphid on brinjal

	Feeding Choice	No Choice	Trichome Length	Trichome Density – Adaxial	Trichome Density- Abaxial	Trichome Density in Flower Stalk	Trichome Density in Petiole	Leaf Length	Leaf Width	Leaf Thickness	Sugar	Nitrogen	Phenol	Potassium	Silica
Feeding choice	1														
No choice	0.266	1													
Trichome length	0.826	-0.32	1												
Trichome density –adaxial	0.910**	-0.15	0.985	1											
Trichome density-abaxial	0.967**	0.015	0.941	0.985	1										
Trichome density in flower stalk	0.950**	-0.04	0.960	0.993	0.998	1									
Trichome density in petiole	0.970**	0.489	0.667	0.783	0.879	0.848	1								
Leaf length	0.989**	0.124	0.898	0.960	0.993	0.985	0.925	1							
Leaf width	0.911**	0.638	0.522	0.659	0.779	0.739	0.983	0.843	1						
Leaf thickness	0.936**	0.088	-0.971	-0.997	-0.994	-0.999	-0.825	-0.977	-0.710	1					
Sugar	0.902**	-0.17	0.988	0.999	0.981	0.991	0.772	0.955	0.646	-0.996	1				
Nitrogen	0.855	-0.27	0.998	0.993	0.958	0.974	0.706	0.921	0.568	-0.982	0.995	1			
Phenol	-0.998**	-0.318	-0.794	-0.886	-0.952	-0.932	-0.982	-0.980	-0.933	0.916	-0.877	-0.82	1		
Potash	-0.900**	0.179	-0.989	-0.999	-0.98103	-0.99102	-0.76994	-0.953	-0.643	0.995	-0.99	-0.995	0.875	1	
Silica	-0.970**	-0.02	-0.937	-0.982	-0.999	-0.997	-0.885	-0.995	-0.787	0.99326	-0.979	-0.954	0.9558	0.978	1

** Significant at 0.01 probability level

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Table2: Correlation between biophysical and biochemical constituents with feeding of aphid on chilli

	Feeding Choice	No Choice	Trichome Length	Trichome Density –Adaxial	Trichome Density- Abaxial	Trichome Density In Flower Stalk	Trichome Density In Petiole	Leaf Length	Leaf Width	Leaf Thickness	Sugar	Nitrogen	Phenol	Potassium	Silica
Feeding choice	1														
No choice	0.607	1													
Trichome length	0.515	-0.368	1												
Trichome density –adaxial	0.437	-0.44	0.996	1											
Trichome density- abaxial	0.283	0.585	-0.968	-0.986	1										
Trichome density in flower stalk	0.935**	0.287	0.784	0.726	-0.604	1									
Trichome density in petiole	0.57	0.300	-0.997	-0.987	0.947	-0.826	1								
Leaf length	0.64	-0.219	0.987	0.970	-0.917	0.8711	-0.996	1							
Leaf width	0.563	0.313	-0.998	-0.989	0.952	-0.819	0.999	-0.995	1						
Leaf thickness	0.326	-0.554	0.977	0.992	-0.999	0.637	-0.960	0.933	-0.964	1					
Sugar	0.402	-0.483	0.991	0.999	-0.992	0.699	-0.980	0.9602	-0.982	0.996	1				
Nitrogen	0.380	0.50	-0.988	-0.998	0.994	-0.682	0.975	-0.953	0.978	-0.998	-0.999	1			
Phenol	-0.290	0.936**	-0.670	-0.733	0.835	-0.066	0.61	-0.547	0.627	-0.810	-0.759	0.774	1		
Potash	-0.854	0.114	0.881	0.836	-0.734	0.984	-0.91	0.944	-0.907	0.763	0.814	-0.80	-0.24	1	
Silica	-0.377	0.965**	-0.59	-0.667	0.780	0.026	0.540	-0.467	0.551	-0.753	-0.695	0.712	0.99	-0.149	1

** Significant at 0.01 probability level

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Studies On the Interactions Between Angiosperm Plants and Three Bees (Honey Bees, Bumble Bees, Mining Bees) As Effective Pollinators

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Introduction

Plants classified as angiosperms are those that bloom and carry their seeds in fruits. With roughly 300,000 species, they are the largest and most varied group in the kingdom Plantae. Roughly 80% of all known living green plants are represented by them. The primary reproductive organ of the plant is the flower. Since most flowers have both male and female parts, they are hermaphrodites. Others could be either male or female and only have one ofthe two parts. There are countless ways to combine color, form, size and anatomical arrangement in flowers. They play crucial roles in ecosystems and draw pollinators to produce seeds, which aid in plant reproduction and generation formation. For a vast array of animals, floral nectar, pollen, and even petals serve as vital food sources. Some birds and insects feed on their nectar, which aids in the movement of pollen from one flower to another.The traits of flowers that draw particular pollinator groups and are themselves pollinated are known as pollination syndromes. Although they are known as pollinators, bees are actually herbivores that gather food for their young. They are the main agents that pollinate. They are responsible for about 85% of insect pollination. Bees are helpful tools for plants in their efforts to proliferate and disperse pollen. Millions of acres of crops depend on the pollination services provided by honey bees (*Apis mellifera*), which increases biodiversity and sustainability. To increase the quality and quantity of seeds produced. They have been widely utilized for commercial pollination of fruit and vegetable crops. They are critical to agriculture's long-term viability. There are more than 250 species of bumblebees (Genus *Bombus*), which belong to the bee family Apidae. They are crucial pollinators for agriculture. Pollinators include mining bees (Genus *Andrenidae*).

Materials And Methods

STUDY AREA: The pollination study was undertaken in the Chromepet area, Chennai, Tamil Nadu, India. The photographs were taken at different location of above- mentioned area.

DATA COLLECTION: The plant and pollinating insects were identified through the literature Online Entomology Dictionary (Douglas Harper, 2006). The details of information like binomial name, family and mode of pollination were recorded using the Textbook of Botany (Vidyarthi, 1985) and Taxonomy of Angiosperms (Pandey, 1969).

Results And Discussion

In order for angiosperms to produce seeds, pollination is a necessary process. Over an extended duration, they have evolved in tandem to fulfill each other's requirements forfruitful procreation. Pollen from one flower of the same species will hopefully reach another through cross-pollination, leading to successful reproduction. They might help with hybrid vigor or faster, more thorough growth. Many crops have been found to be male sterile, and plant breeders take advantage of this trait to create hybrids that require cross-pollination to thrive. Insect-borne pollination is known as entomophily. They might act as pollen vectors. Flowers that are pollinated have a close relationship with pollinators. In agricultural and horticultural crops as well as their natural habitats, bees are efficient and good pollinators. They visit many different kinds of flowers. They are divided into three groups: mining bees, bumblebees, and social honey bees. In order to feed on pollen, nectar, oil, breed, or find shelter, they visit flowers. The abdomen of honeybees has multiple stripes including several grey ones (Wild, Alex, 2011). They primarily pollinate open flowers because they have short tongues. Their sizes vary widely, even among the same species. They move from the antherto the stigma of another flower, gathering pollen on their body. One honey bee visits several thousand flowers on twelve or more trips out of the hive in a single day. It visits only one species of plant per trip and gathers only one type of pollen. They have excellent vision and can detect depth, count petals. Their movement within the floral reproductive structures is extremely vigorous. Soft hair covers the round bodies of bumblebees. They are in flight, theirproboscis folds under their heads, allowing them to consume nectar with their long, hairy tongues. They collect pollen to feed their young and nectar to replenish the nest's supplies. They use color and spatial relationships to find flowers to feed on during foraging. Certain

bumblebees steal nectar by drilling a hole close to a flower's base so they can get at the nectar without transferring pollen. They are crucial pollinators for agriculture. They differ in appearance, with a larger, broader, stouter body and a more rounded tip to their abdomen. Broad color bands are present in many species, and these patterns aid in the identification of various species. Certain species gather nectar from flowers that are sealed into tubes using their long tongues. They have a portion of their bodies covered

They are distributed throughout most of the world. As effective pollinators, they are crucial (Gurr, 1974). They help other conspecific plants by spreading pollen. They stop pollen from becoming stuck in stigmas and being lost during interspecific flights. They enhance the easily identifiable and readily available productive flowers. Their mouthparts, eyes, and many branched body hairs are perfectly adapted for locating food sources, consuming nectar, and gathering and dispersing pollen. Their maximum speed is seven miles per hour, and they must beat their wings at a rate of 190 beats per second. They are widely used for agricultural crops and greenhouses. The moderately sized mining bees have depressions on the head near the upper edge of the eyes and scopa on the basal segments of the legs. Bees are pollinators. The following are represented in the table: *Brownea coccinea* Jacq. (Fabaceae), *Tridax procumbens* L. (Asteraceae), *Mimosa elnegi* L. (Sapotaceae), *Justicia procumbens* L. (Acanthaceae), *Solanum torvum* L. (Solanaceae), Euphorbia *hetrophylla* L. (Euphorbiaceae), *Murrya paniculata* L. (Rutaceae), *Sida rhombifolia* L. (Muntingiaceae), *Muntingia calabura* L. (Muntingiaceae) and *Euphorbia occidentalis* L.(Anacardiaceae) are displayed in (Plate.1; Table 2). Cucumbers, squash, melons, strawberries, and many other crops were planted commercially by them. A specific kind of pollinator that flowering plants draw to their blooms uses less energy. Pollination syndromes are a useful tool for predicting the kind of pollinator that will help a flower reproduce successfully. These flower traits are designed to trap pollinators through specialized mechanisms, thereby increasing their effectiveness. The flower's size, color, scent, reward type, quantity, composition of nectar, and flowering time. They are used to pollinate the desired flowers because they simultaneously provide plenty of viable, compatible pollen (Faegri and van der Pijl, 1966; Proctor *et al.,* 1996). Flowers that are scented, landingplatforms, bilaterally symmetrical or tubular, blue or yellow, with a reduced number of floral parts, claw-shaped or bi-lipped corollas, nectar guides and edible pollen are all pollinated by bees. The medium-length, short- tongued bees' proboscis is drawn to white and yellow flowers. Plants produce sweet, fragrant liquid called nectar. Amino acids, sucrose, glucose, fructose, and natural sugar are all present. It is located close to the base of the flower, where

the petals begin to form around the ovary. They are reabsorbed by the plant after pollination. Insects are captured by the glandular trichomes to aid in pollination (Tables 1 and 2). Changes in the pollinator Bees are known for their hairy bodies, keen sense of smell and vision, and ability to "count petals," or sense depth. The characteristics of bee pollination flowers include their irregular shape, reduced number of floral parts, landing platform, deep tube or spur for nectar, markings that serve as guides for nectar, and strong UV light patterns. The flowers are also frequently blue or yellow in color. The warning colors vary from total black to bright yellow, red, orange, white and pink, depending on the species and morph (Williams and Paul, 2007). According to Walther-Hellwig and Frankl (2000), they visit flower patches that show signs of the bee pollination syndrome, which can be found up to 1-2km away from their colony. As long as they

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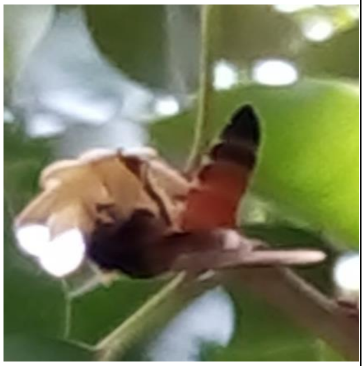
can consistently find flowers or nectar andpollen, they will likely return to the same flower patches each day (Dramstad *et al.*, 2003). They can travel up to 54 km per hour on the ground while foraging (Osborne *et al.*, 1999). Todetermine which flowers to forage from, they employ a combination of color and spatial relationships (Blackawton *et al.*, 2010). Their body hairs get a dusting of pollen from the anthers as it enters a flower. Both crops and wildflowers depend on them for pollination (Modelling bee pollination, 2015). They are being raised more and more as pollinators in agriculture.

Table 1: Bees Pollinating Syndrome

S. NO.	**TRAIT**	**BEES**
1.	Color	Bright white, yellow, blue or UV
2.	Nectar Guides	Present
3.	Odor	Fresh, mild, pleasant
4.	Nectar	Usually present
5.	Pollen	Limited; often sticky and scented
6.	Flower Shape	Shallow; have landing platform; tubular

Plate 1. Bees Pollination in Angiosperms

Portulaca grandiflora L.	*Tridax procumbens* L.	*Mimosa elengi* L.
		
Muntingia calabura L.	*Brassica napus* L.	*Brownea coccinea* Jacq.

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Justicia procumbens L.	*Sida rhombifolia* L.	*Solanum torvum* L.
		
Anacardium occidentalis L.	*Murrya paniculata* L.	*Euphorbia hetrophylla* L.
		

Table 2: Flowering Plants Pollinating Syndrome

S. NO.	Plant Name	Flower Shape	Flower Colour	Odour	Nectar
.	*Portulaca grandiflora* L.	Rosaceous	Orange	Pleasant	Yes
.	*Tridax procumbens* L.	Head	White	No	Yes
.	*Mimosa elnegi* L.	Star-shape	Creamy white	Aromatic	Yes
.	*Muntingia calabura* L.	Star-shape	White	Slightly malodorous	Yes

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				smell	
.	*Brassica napus* L.	Crucifom	Yellow	No	Yes
.	*Brownea coccinea* Jacq.	Tubular	Bright scarlet	No	Yes
.	*Justicia procumbens* L.	Bilipped	Pink to white	Unpleasa nt	Yes
.	*Sida rhombifolia* L.	Star-shape	Creamy to orange yellow	No	Yes
.	*Solanum torvum* L.	Tubular	White	Pleasant	Yes
0.	*Anacardium occidentalis* L.	Tubular	Pale green toreddish	Sweet, Aromatic	Yes
1.	*Murrya paniculata* L.	Star shape	White	Pleasant	Yes
2.	*Euphorbia hetrophylla* L.	Cup shape	Yellowish green	Pleasant	Yes

Conclusion

Flower is the main reproductive part of the plant. Angiosperm plants grow vibrant flower petals and strong fragrance. Bees are winged insects included in the superfamily Apoidea. They are classified into 4000 different genera. There are 3 types of bees are the most common pollinators Honey bees (*Apis mellifera*), Bumblebees (Genus *Bombus)* and Mining bees (Genus *Andrena*) are the most common pollinators. Honey bees with excellent pollination skills visit a diverse range of flower types. Pollination syndrome is close relationship with one or a select few specific pollinators. They essential for pollinating

flowering plants to increase yield of seed and fruit and also improve the quality inagricultural crops, horticulture plants, fiber and nut.

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Climate and Environment induced diversity in Arthropod Sustenance and Spread

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Climate induced environmental changes induce far reaching consequences on Arthropod diversity. Temperature, rainfall, relative humidity, erratic weather, sea level increase, etc., induce long term impact on the distribution of insects especially butterflies, moths, bees and wasps, ants, spiders ticks and mites. Climatological impact more pronounced in tropics, Arctic and Alpine ecosystems, coastal areas and isolated island ecosystems. To mitigate climate induced impacts on arthropods and its diversity, it is essential to address the root causes of climate change. Further on analysis, conservation to be implemented as per specific need and location-based strategies. Climate induced resistance breeding is one of the strategies for tackling pest incidence induced by outbreaks. The effect of climate change not only affects crop growth and its yield but percolates deep to change the architecture of the plants and creates risk of infestation and infection by pests and diseases. Increase in heat and subsequent drought reduce the resistance nature of plants against pest invasion. Elevated Co2 levels increase leaf numbers, its area, thickness and biomass (Anonymous, 2008). Similarly elevated oxygen levels modify the host resistance against pest invasion.

Climate change

The average earth surface temperature hike induced by climate change is referred as Global warming. The greenhouse gases reaching atmosphere also increase surface temperatures. By 2100, it was assessed that the global mean temperature could raise 0.9 to 3.5 degrees celcius, if corrective measures not followed. Global precipitation also assumed to be influenced substantially due to greenhouse gas emission by O3 and Co2. The arthropod diversity is highly influenced by these climate disorders, leading to either increase or evolving resistant pests in many crops. Pest movement and spread to non pest incident areas is another perspective of global warming. The ramifications of these climatic factors on insect pest biology and ecology are profound, given that these pests depend heavily on these factors. Since crop productivity is tightly connected to both insect pests and these climate variables, changes in these factors can significantly impact crop yields. Therefore, it is imperative to comprehend the impact of climate change on insect pests to manage them effectively and ensure sufficient food production (Bijoy Subedi ,2023).

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Impact of climate on the migration of insects and natural enemies

Changes in temperature facilitate the spread of the insect over a larger geographical range. Temperature is one of the crucial factors involved in insect migration. Temperature threshold for the flight activity of the insect vary among different species and even within species based on the seasonal changes. As 1 celcius degree rise in temperature, the spread of the insect could be even to 200 km northwards or 140m upward in altitude. Optimum temperature for aphid *Aphis fabae* for their take off is 17 degree C, and 15, 13 and 6.5 C are found as the optimum temperatures for their upward, horizontal flight and for their wing beatings (Srikanth,2013).

Variation in climate also affects the predatory insect fauna. Temperature also affects the predatory searching capabilities of the predators. Larval and pupal development of the Mexican rice borer (*Eoneuma lofitini*) parasitoid, *Lydella Jalisco* is retarded by increase in temperature. The egg predator *Cyrtorhinus lividipennis* of rice brown plant hopper has increased the attack rates and decreased handling times, as temperature increases until 32 C. At 35C, the attack rate and handling time decreased drastically. This implies that the predator activity is likely to increase with increasing temperatures up to a critical level of 35C (Rajendran, B etal., 2016).

Effect of global warming on the activity and abundance of natural enemies

The majority of insects are benign to agro-ecosystems, and there is considerable evidence to suggest that this is due to population control through interspecific interactions among insect pests and their natural enemies – pathogens, parasites, and predators (Price 1987). Oriental armyworm, *Mythimna separata* (Walk.) populations increase during extended periods of drought (which is detrimental to the natural enemies), followed by heavy rainfall because of the adverse effects of drought on the activity and abundance of the natural enemies of this pest (Sharma et al. 2002). Aphid abundance increases with an increase in CO_2 and temperature; however, the parasitism rates remain unchanged in elevated CO_2. Temperatures up to 25°C will enhance the control of aphids by *Coccinellids* (Freier and Triltsch 1996). Temperature not only affects the rate of insect development, but also has a profound effect on fecundity and sex ratio of parasitoids (Dhillon and Sharma, 2008, 2009). The interactions between insect pests and their natural enemies need to be studied carefully to devise appropriate methods for using natural enemies in pest management.

Effect of climate change on expression of resistance to insect pests (Hari C.Sharma.2010)

Host plant resistance to insects is one of the most environmentally friendly components of pest management. However, climate change may alter the interactions between the insect pests and their host plants (Bale et al. 2002; Sharma et al. 2010). Global warming may also change the flowering times in temperate regions, leading to ecological consequences such as introduction of new insect pests, and attaining of a pest status by non-pest insects (Parmesan and Yohe 2003: Fitter and Fitter 2002: Willis et al. 2008). However, many plant species in tropical regions have the capability to withstand the phenological changes as a result of climate change (Corlett and LaFrankie 1998). Global warming may

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result on breakdown of resistance to certain insect pests. Sorghum varieties exhibiting rresistance to sorghum midge, *Stenodiplosis sorghicola* (Coq.) in India become susceptible to this pest under high humidity and moderate temperatures near the Equator in Kenya (Sharma et al. 1999). There will be increased impact on insect pests which benefit from reduced host defenses as a result of the stress caused by the lack of adaptation to sub-optimal climatic conditions. Chemical composition of some plant species changes in direct response to biotic and abiotic stresses as a result, their tissues less suitable for growth and survival of insect pests (Sharma 2002). However, problems with new insect pests will occur if climatic changes favor the introduction of insect susceptible cultivars or crops. The introduction of new crops and cultivars to take advantage of the new environmental conditions is one of the adaptive methods suggested as a possible response to climate change (Parry and Carter 1989). Insect - host plant interactions will change in response to the effects of CO2 on nutritional quality and secondary metabolites of the host plants. Increased levels of CO2 will enhance plant growth, but may also increase the damage caused by some phytophagous insects (Gregory et al. 2009). In the enriched CO2 atmosphere expected in the next century, many species of herbivorous insects will confront less nutritious host plants that may induce both lengthened larval developmental times and greater mortality (Coviella and Trumble 1999). The effects of increased atmospheric CO2 on herbivory will not only be speciesspecific, but also specific to each insect-plant system.

Ecological models serving climate change studies

Ladanyi and Horvath (2010) listed widely applied ecological models of insect population. Some of the models include,

- Forest vegetation simulators (FVS)-USA
- Phenology and Population SIM (INSIM)
- Agro Ecosystem Management and Optimization Model (ECOTOPE)
- Boundary Layer model (BLAYER)
- Boll weevil dispersal model (BWDISP)
- Northern corn root worm model (ROOTWORM)
- Predictive models-Climate Matching (GIS software)
- CLIMEX-*Plutella xylostella* –shift to 300 km in Japan

Management of Climate change effects on Arthropods diversity

The issue of climate change and its ramifications on arthropod diversity cannot be assumed for easy mitigation within a short span of time. Climate change itself is a phenomenon of long-term cumulative result, management strategies remain in the hands of respective Governments of countries and their joint efforts to nullify them through proper actions. Anyhow , the prospective of the management of climate induced pest attack on crops could be focused through the following principles.

-Integrated Pest Management strategies with least dependence on pesticide strategy.

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-Bio control and cultural techniques of management need to be given priority.

-Pest monitoring and forecast to be adopted in vulnerable areas.

-Host plant resistance to insects though conventional need to approached with dedication for long-term tackling of climate change effects on crops and pests.

Methods for generating pest resistant varieties through Resistance Breeding

-Classical Breeding

-Mutagenesis

-Forward genetic techniques

-Reverse genetic techniques

-Combinatorial mutagenesis bioinformatics tools

-Biotechnology and Genetic Engineering techniques.

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Short-term juvenile hormone (JH) activity screening assay in *Daphnia magna* exposed to Pyriproxyfen 0.5% GR

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Daphnia magna is a small planktonic crustacean that belongs to the subclass Phyllopoda which is found in shallow ponds and lakes and rich in organic matter sediment. *Daphnia magna* is used in different field of research and plays a vital role in the field of ecotoxicology and recommended by OECD test guidelines as one of the test organisms (Test systems) in which toxicity data are generated for agrochemicals. In this study, the juvenile hormone activity was screened by exposing the female parent Daphnids to Pyriproxyfen 0.5% GR for 7 days which induced male offsprings reproduction. The present study reveals that the insecticide Pyriproxyfen 0.5% GR induced male offsprings reproduction at the concentrations of 4 mg/L and 12 mg/L when compared with control female parent daphnids. Due to increase in male offsprings reproduction, further reproduction of female daphnids could be affected which leads to decrease in population of *Daphnia magna*. As it is a natural feed for fish, use ofthis insecticide should be minimized so that *Daphnia* reproduction and population could not be affected.

Key words:*Daphnia magna, Pyriproxyfen 0.5% GR, Offpsrings, reproduction*

Introduction

Daphnia magna is widely used in aquatic eco-toxicity assays for the risk assessment of different agrochemicalssince it issuitable for laboratory testing such as relatively small, short life cycle, parthenogenetic reproduction, high fecundity, ubiquitous occurrence and ease of laboratory handling (l). *Daphnia* is a filter-feeding planktonic crustaceans in various types of freshwater ways in which they filter out bacteria, alga and other small particles which are present in water. It also plays an important role in aquatic food chain as a primary consumer as they pose a feed for fish and other predatory invertebrates (2).

The life span of *Daphnia magna* is relatively short i.e. 7 - 8 weeks and it reaches sexual maturity within 8 days of leaving the brood chamber. *Daphnia* populations main consist of parthenogenetic females. Male daphnids are produced due to environmental stress such as high density in population, lower temperature, variation in light cycles and decrease in food (3). *Daphnia* is a keystone species and freshwater ecosystems which serves as a main food source for fish and other aquatic species. Therefore, its response to contaminants could lead to cascading effects in food web, which makes it a crucial indicator of environmental health (4).

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Pyriproxyfenis a juvenile hormone analog, and it is used as insect growth regulator for controlling a variety of other crops includingbroad range of insect pests *viz*., whitefly, bollworm, pepper, citrus, cotton, tomato, etc. (5). According to the New York State risk assessment, the aquatic systems contain 93 ng/L concentration of Pyriproxyfen. Even though Pyriproxyfen poses low toxicity to mammals and birds, it is potentially toxic to other aquatic organisms such as crustaceans and fish (6).

In this present investigation, we aimed to assess the juvenile hormone activity of*Daphnia magna* exposed to Pyriproxyfen 0.5% GR for 7 days and its reproductive output, parent mortality under controlled environmental conditions based on OECD 253 guideline (7). The ratio of male offsprings produced by parent daphnids treated with Pyriproxyfen 0.5% GR was compared with control parental daphnids at the end of 7 days exposure.

Materials and Methods

The mature female daphnids at the age of 10 - 12 days old with developing embryos in their brood chambers were exposed to three concentrations of commercially procured Pyriproxyfen 0.5% GR such as 1.3, 4 and 12 mg/L and control (M4 medium) for 7 days. These test item concentrations were fixed based on acute immobilization test results (8). Ten replicates (each vessel containing 1 mature female) were used for each concentration and control with 50 mL of M4 medium in each vessel. The test was conducted in a semi-static method andthe renewal of test solutions was performed thrice in a week. During the renewal of test solutions, daphnids were fed with 50 µL of concentrated green algal feed (*Raphidocelissubcapitata*). Concentration of the alga was achieved by centrifugation followed by re-suspension in *Daphnia* culture medium. When the medium was renewed, a second series of test vessels were prepared and the parent daphnids were transferred to using Pasteur pipette.

The temperature of the test medium was in the range of 18-22°C and the photoperiod was maintained as 16 hours-light and 8-hour dark cycle maintained by an automatic timer. The first brood offspring produced by each parent animal was recorded and removed daily to prevent them consuming food intended for the parent. The second brood offsprings were counted and subjected to identification of sex. The numbers of living offsprings from the second brood were counted and the presence of aborted eggs and dead offsprings were recorded. Mortality among the parent daphnids was recorded daily.

After the exposure start, male ratio of the living offsprings from the second brood was confirmed. Male and female offsprings were identified by observing under an inverted microscope at 20X. The first antennae of male offsprings were longer when compared with female offsprings. The dissolved oxygen concentration, temperature, and pH values were measured at one renewal period, in fresh and used (old) culture media, in the control and in the highest test item concentration.

Female *Daphnia magna* **Male *Daphnia magna***

Figure 1: Represents Male and Female *Daphnia magna* offspring. Male (Right) can be distinguished from females (Left) by the length and morphology of the first antennae as shown in the circle.

Results

No mortality was observed in female parent daphnids in control and all test item concentrations (1.3, 4 and 12 mg/L) up to day 7 of experiment. The mean number of live offsprings produced from the second brood in control parent daphnids was found to be 27. The mean number of live offsprings produced from the second brood in parent daphnids exposed to the test item concentrations of 1.3, 4 and 12 mg/L were found to be 19,17 and 15. There was no male offsprings produced in control and 1.3 mg/L whereas 4 male offsprings were observed in the concentration of 4 mg/L and 9 male offsprings were observed in the concentration of 12 mg/L, respectively. The male ratio of the living offsprings from the second brood was calculated as 23.5% at the concentration of 4 mg/L and 60.0% at the concentration of 12 mg/L.

Table 1. Mean no. of Offsprings produced in control and treatment at the end of 7 days exposure period

Test Item Concentration (mg/L)	Mean no. of live offsprings produced		Male ratio
	Female	Male	
Control	27	0	0%
1.3	19	0	0%
4	13	4	23.5%

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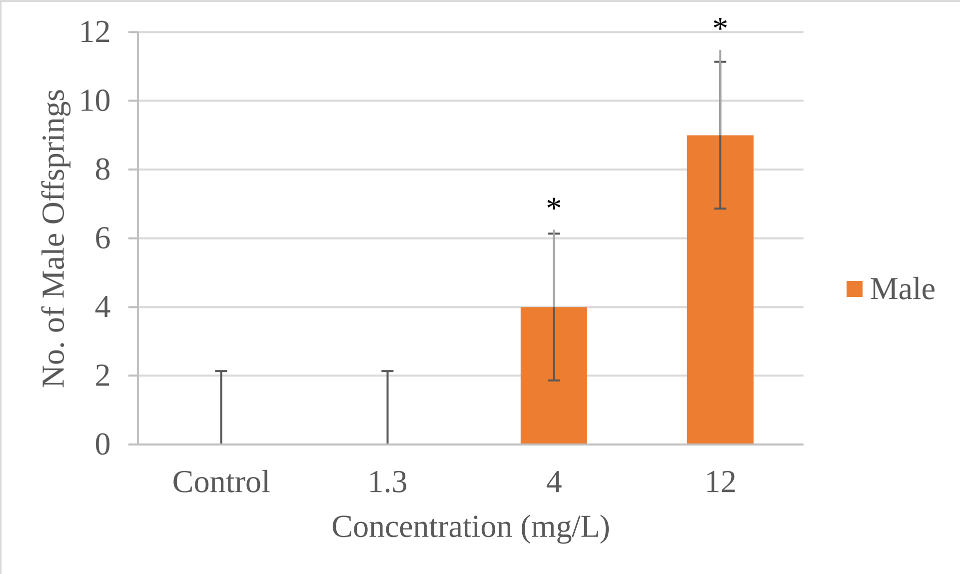
12	6	9	60%



* -Denotes Significant change (P>0.05). The values were compared using Nonparametric one-way ANOVA (Kruskalwallis with Post hoc Mann whitney U Test was compared between the control) and the significance was calculated

Figure 2.No. of male offpsrings produced between control and treatments at the end of 7 days exposure period

Discussion and Conclusion

Pyriproxyfenis an insect growth regulator and a juvenile hormone analog whichhas been used to control a wide range of arthropods, which are pests and vectors of economic and public health importance (9). In the presentstudy, there is no mortality observed in the parent female daphnidsbut increase in the production of male offsprings and decrease in the production of female offsprings were observed in the highest test concentration which is supported to the findingsby another author(10). Pyriproxyfen insecticide caused adverse effects in early developmental stages of other important aquatic species zebra fish also which is similar to our present investigation in which the female offsprings production were significantly decreased (11).

The toxicity of insecticide may vary between technical and formulated products. Pyriproxyfen technical is found to be severely toxic to *Daphnia magna*on an acute basis (12) and for formulated products, it was found to be moderately toxic to non-toxic in *Daphnia magna.* In the present study also, the observed 48 hour-EC_{50} was found to be 24 mg/L which is almost to non-toxic category. Though it is less or non-toxic on an acute basis, when exposed to a long time particularly in chronic study, the reproduction is getting affected in higher concentrations and increase in male offsprings were observed. Hence the pyriproxyfen 0.5% GR which is a formulated product also induced male offsprings production due to juvenile

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hormone activity which is similar to Technical pyriproxyfen. Due to increase in male offsprings reproduction, further reproduction of female daphnids could be affected which leads to decrease in population of *Daphnia magna*. As it is a natural feed for fish, use of this insecticide should be minimized so that *Daphnia* reproduction and population could not be affected.

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The Role of Honey Bees in Ecosystem Services: Beyond Pollination

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Honey bees (*Apis mellifera*) play a critical role in ecosystem services that extend far beyond their well-known function as pollinators. While their contribution to the pollination of crops and wild plants is paramount, honey bees also influence biodiversity, ecosystem stability, and agricultural productivity. This paper explores the multifaceted roles of honey bees in ecosystems, including their contributions to nutrient cycling, soil health, and habitat provision. Additionally, we examine their impact on food webs and interactions with other species, highlighting how their presence can enhance ecological resilience. By integrating perspectives from ecology, agriculture, and conservation, this study underscores the importance of protecting honey bee populations not only for agricultural yield but also for the overall health and functionality of ecosystems. The findings emphasize the need for comprehensive conservation strategies that recognize the broad spectrum of services provided by honey bees, advocating for their preservation as a cornerstone of sustainable ecosystem management.

Keywords:- *Pollination, Biodiversity, Colony dynamics, Eusocial insects.*

Honey bees (*Apis mellifera*) are often celebrated as the quintessential pollinators, yet their significance in ecosystems extends well beyond this vital function. As keystone species, honey bees play a multifaceted role in sustaining biodiversity, enhancing agricultural productivity, and supporting the overall health of various ecosystems. Their intricate relationships with flowering plants not only facilitate the reproductive success of numerous species but also contribute to the complex web of life that defines healthy ecosystems.

The importance of honey bees is especially evident in the context of global food production. They are responsible for pollinating a vast array of crops, which are essential for human nutrition and economic stability. The decline in honey bee populations in recent years has raised alarms worldwide, prompting a deeper exploration of their contributions beyond mere pollination. This decline threatens not just agricultural yields but also the intricate ecological balances that depend on these industrious insects.

Moreover, honey bees serve as indicators of environmental health, reflecting the impacts of habitat loss, pesticide use, and climate change on biodiversity. Their well-being is intrinsically linked to the health of the ecosystems they inhabit, making their conservation imperative for both ecological and agricultural resilience.

In this exploration, we will delve into the diverse roles honey bees play in ecosystem services, examining their contributions to pollination, food production, genetic diversity, habitat formation, soil health, and cultural significance. Understanding these roles highlights the critical need for effective conservation strategies to protect honey bees and the vital ecosystems they support. By appreciating the broader implications of honey bee ecology, we can better advocate for their preservation and the sustainability of the environments we all rely on. Honey bees play a crucial role in ecosystems that extends far beyond their well-known function as pollinators. Here's a closer look at their contributions:

1. Pollination Services

While pollination is their most recognized role, honey bees are essential for the reproductive success of many plants, which in turn supports entire ecosystems. They help sustain biodiversity by facilitating the growth of fruits, nuts, and vegetables.

2. Food Production

Honey bees are vital to agricultural productivity. They enhance yields of crops such as apples, almonds, and blueberries. Their activities contribute to food security and economic stability for farmers and communities.

3. Genetic Diversity

By pollinating a variety of plants, honey bees promote genetic diversity within plant populations. This diversity is critical for ecosystem resilience, enabling plants to adapt to changes in climate and disease.

4. Habitat Formation

Many plants that rely on honey bee pollination provide habitat and food for a wide range of wildlife. Healthy ecosystems with diverse plant life support numerous species, including birds, insects, and mammals.

5. Soil Health

Plants that flourish through bee pollination contribute to soil health. Their roots help prevent erosion, enhance nutrient cycling, and improve water retention, all of which are crucial for maintaining ecosystem integrity.

6. Cultural and Economic Value

Honey bees are also integral to cultural practices and local economies. Beekeeping fosters community engagement and can provide livelihoods for many individuals. Honey and beeswax are valuable products that have been used for centuries.

7. Indicators of Ecosystem Health

Honey bee populations can serve as indicators of environmental health. Declines in their numbers can signal problems like habitat loss, pesticide use, or climate change, prompting conservation efforts.

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8. Support for Other Species

By pollinating a wide range of plants, honey bees indirectly support other animal species that depend on these plants for food and shelter, creating a more balanced and functional ecosystem.

Conclusion

The role of honey bees in ecosystem services is multifaceted. Their contributions to biodiversity, food production, and ecological health underscore the importance of protecting these essential pollinators and their habitats. Effective conservation strategies can help ensure their survival, benefiting both natural ecosystems and human communities.

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The Rise of Women in Apiculture: From Tradition to Innovation

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This paper explores the transformation role of women in the field of apiculture, tracing their journey from traditional practices to innovative approaches that redefine the beekeeping landscape. Historically marginalized in agricultural sectors, women have increasingly embraced apiculture, leveraging their unique perspectives and skills to enhance sustainability, biodiversity, and economic empowerment. Through qualitative interviews and case studies, we highlight the contributions of women beekeepers, their strategies for overcoming challenges, and the impact of community-based initiatives that support their involvement in this vital industry. Additionally, we examine the intersection of gender and environmental sustainability, showcasing how women's leadership in apiculture fosters resilience against climate change and promotes ecological stewardship. Ultimately, this study underscores the significance of women's contributions to apiculture, advocating for greater recognition and support of their innovative practices in the global beekeeping community.

Keywords: *Sustainable Agriculture, Economic Empowerment, Beekeeping Innovations, Gender Equality, Community Initiatives, Environmental Sustainability, etc.*

The role of women in apiculture has evolved significantly over time, becoming an integral part of modern beekeeping and sustainability efforts. In various regions around the world, women are now leading beekeeping enterprises, contributing to rural development, promoting sustainable agricultural practices, and enhancing food security. Below is a detailed exploration of the role of women in apiculture, highlighting their contributions, challenges, and opportunities.

Beekeeping can enhance agricultural yields by 30 – 60%, surplus crops can translate in to improved food security for the household as well as cash earnings from crops sold. After a year an additional income stream can be created from the sale of honey and beeswax.

1. Introduction: Women and Apiculture

Historically, apiculture (beekeeping) has been perceived as a male-dominated activity, largely due to its association with agriculture and the physical demands of traditional hive management. However, over the past few decades, the narrative has changed. Women have increasingly taken up roles in beekeeping, playing a vital part in the economic, social, and environmental aspects of apiculture. From rural communities to urban areas, women are contributing to both small-scale and commercial beekeeping operations, providing a source of income, empowerment, and environmental stewardship.

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2. Women's Contributions to Apiculture

2.1 Economic Empowerment

For many women, particularly in rural areas, apiculture serves as a significant source of income and financial independence. Beekeeping requires relatively low startup costs compared to other forms of agriculture, making it an accessible enterprise for women. By selling honey, beeswax, royal jelly, and other bee products, women can generate income to support their households, improve their living conditions, and even fund education for their children.

In many countries, organizations and cooperatives have been established to support women beekeepers. For example, in parts of Africa and Asia, women's beekeeping cooperatives have created opportunities for women to collaborate, share knowledge, and access larger markets. This collective approach has allowed women to scale their operations and increase their profitability.

2.2 Sustainable Agriculture and Environmental Stewardship

Women beekeepers play a crucial role in promoting sustainable agriculture and biodiversity conservation. Bees are essential pollinators for many crops, and by maintaining healthy hives, women contribute to improving crop yields and ensuring food security. Many women-led beekeeping initiatives emphasize organic practices, reducing the use of harmful pesticides that negatively affect both bee populations and ecosystems.

Women are often seen as stewards of natural resources in their communities, and their involvement in apiculture aligns with their roles in preserving biodiversity. By integrating beekeeping with other sustainable farming practices, women contribute to maintaining ecological balance while supporting livelihoods.

2.3 Knowledge Transfer and Community Leadership

In many regions, women have become leaders in beekeeping education and knowledge transfer. They teach other women and community members the skills needed to manage hives, harvest honey, and produce value-added products like beeswax candles or medicinal honey infusions. This role as educators has empowered women to become change agents in their communities, fostering a culture of shared learning and collaboration.

Women-led beekeeping projects often focus on intergenerational knowledge transfer, where older women pass down traditional beekeeping techniques to younger generations. This ensures the continuity of sustainable practices and strengthens community resilience.

3. Challenges Faced by Women in Apiculture

3.1 Gender Stereotypes and Social Barriers

Despite the growing number of women in apiculture, gender stereotypes remain a significant challenge. In some cultures, beekeeping is still viewed as "men's work," and

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women may face resistance from family members or the broader community when they try to enter the field. This social stigma can limit women's opportunities to participate in training programs, access credit, or join beekeeping associations.

3.2 Access to Resources

Women beekeepers often face challenges in accessing the necessary resources to scale their operations. These challenges include limited access to financing, land, equipment, and beekeeping education. Without access to credit, women may struggle to invest in modern beekeeping tools such as advanced hives or honey extraction equipment, which could increase their productivity.

3.3 Climate Change and Environmental Threats

Climate change poses significant risks to beekeeping, as changing weather patterns can affect flowering cycles, bee behavior, and hive productivity. Women, particularly those in vulnerable rural communities, are often disproportionately affected by these environmental changes. The loss of bee populations due to habitat destruction, pesticide use, and disease also threatens the sustainability of women's beekeeping initiatives.

4. Opportunities for Women in Apiculture

4.1 Empowerment through Training and Education

Expanding access to training programs in apiculture is key to empowering more women to enter the field. Women's beekeeping cooperatives and NGOs can offer specialized courses that provide technical skills, business management training, and knowledge about sustainable beekeeping practices. By investing in women's education, organizations can unlock new opportunities for women to thrive in apiculture.

4.2 Value-Added Products and Entrepreneurship

Women beekeepers can increase their income by diversifying their product offerings beyond honey. Value-added products such as beeswax candles, honey-based skincare products, and medicinal royal jelly can tap into growing markets for natural and organic goods. With the right training and resources, women can become entrepreneurs, creating artisanal products that cater to niche markets both locally and globally.

4.3 Policy Support and Gender Equality Initiatives

Governments and international organizations are increasingly recognizing the importance of supporting women in agriculture and apiculture. By enacting policies that promote gender equality, provide women with access to credit, and support women-led agricultural cooperatives, policymakers can help remove barriers that prevent women from reaching their full potential in beekeeping.

Up to 150 million more people would be fed if women had access to the same resources as men. Women constitute half of the agricultural workforce in developing countries. If women had the same access as men to productive resources, they could increase their farm's production by 20 to 30%. On average, when women manage the household budget, they spend up to 90% of it on food, health care and education for their families, compared with only 30% for men. A child has a 20% greater chance of surviving if the mother controls the family budget. In too many countries, women leave school at an early age. But statistics show that just 2 extra years in school can bring salaries up by near 25%.

4.4 Technological Advancements

New technologies in apiculture, such as smart hives and automated honey extraction systems, present opportunities for women to manage their hives more efficiently. Access to these innovations can reduce the physical demands of beekeeping, making it easier for women to manage larger operations and increase their productivity. Technology can also help women access new markets through online platforms that connect rural beekeepers with urban consumers.

5. Case Studies:

5.1 Women Beekeepers in Africa

In countries like Kenya, Uganda, and Ethiopia, women beekeepers have formed cooperatives to scale their honey production and access larger markets. These cooperatives provide training, mentorship, and access to beekeeping resources, empowering women to become financially independent and contribute to their communities.

5.2 Female Entrepreneurs in Urban Beekeeping

Urban beekeeping is growing in cities around the world, and many women are at the forefront of this movement. Female-led urban beekeeping initiatives in cities like New York, London, and Paris focus on producing local, sustainable honey and promoting biodiversity within urban environments.

Conclusion

The future of women in apiculture is bright, with growing opportunities for leadership, entrepreneurship, and environmental stewardship. As more women enter the field, they are not only contributing to the economic development of their communities but also playing a vital role in the conservation of bee populations and the promotion of sustainable agriculture. Modern apiculture involves easy-to-perform practices like the use of box hives that can be easily be managed by women. There is need for adjusting cultural norms and beliefs to attract women and young people in the industry. By addressing the challenges, they face, such as limited access to resources and persistent gender stereotypes, the global beekeeping community can further empower women and support their contributions to the future of apiculture.

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The Queen's Essence: Royal Jelly and Its Future in Apiculture

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Royal jelly, often referred to as the **"queen's essence"** is a substance produced by honey bees that plays a vital role in the development of queen bees, setting them apart from worker bees in size, longevity, and fertility. This conference explores the biological, nutritional, and commercial significance of royal jelly within apiculture and beyond. The latest research on the production, composition, and molecular mechanisms of royal jelly, focusing on its unique properties that influence queen development. We will also explore how advancements in understanding royal jelly can enhance bee health and sustainability in beekeeping practices. This will address its expanding applications in fields such as human health supplements, cosmetics, and pharmaceuticals, as well as its potential to revolutionize beekeeping efficiency and productivity.

As apiculture faces challenges such as colony collapse and climate change, the future of royal jelly presents opportunities for innovation. Join us as we explore how this remarkable substance can shape the future of beekeeping and contribute to global agricultural sustainability.

Keywords: *Bee Nutrition, Apiculture Innovation, Beekeeping Sustainability, Colony Health, Bee Hive Productivity, Nutritional Supplements etc..*

Introduction

India became self-sufficient in food grain production due to huge investment in agricultural research and development during the initial plans. Intending to maximize farm-income and self-employment, special emphasis has been given to developing various agro-based enterprises like dairy, poultry, goat, fish farming, beekeeping, sericulture, and lac cultivation. Beekeeping is only an enterprise which does not only improves the economic conditions of the beekeepers but also restricts the migration of rural youth to urban areas, thus helping holistic development of rural society by different means *viz.* management of hives, migration of honey bee colonies from one field to another, harnessing honey and other bee-hive products such as pollen, royal jelly, beeswax, propolis, and bee venom.

Nowadays, it becomes a fashion among beekeepers to produce a huge quantity of honey than the promotion of production of other bee-hive products; because they are not well aware of the scientific package and practices of hygienic honey production and other bee-hive products. Some

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of them try to extract each drop of honey from their hive. On the other hand, the other hive products such as wax, propolis, pollen, and royal jelly are also losing their qualitative value due to the unscientific production methods. The time has come, the technique of producing other valuable hive product like royal jelly, etc. should be given top priority in beekeeping besides honey production. Royal jelly is a secretion product of the cephalic glands of nurse bees and served as the most important part of honeybee larvae diet, exclusive food of the queen honeybee (*Apis mellifera*) and plays a major role in caste determination. Due to its complex composition (water, proteins, lipids, carbohydrates, amino acids, mineral salts, vitamins, enzymes, hormones, oligo-elements, natural antibiotics), it has a multitude of pharmacological activities: antioxidant, neurotrophic, hipoglicemiant, hipocholesterolemiant and hepatoprotective, hypotensive and blood pressure regulatory, antitumor, antibiotic, anti-inflammatory, immunomodulatory and anti-allergic, general tonic, antiaging, etc., the production of royal jelly in our country and state is still scanty. China is the world largest royal jelly producing country of which total production of royal jelly reaches to 3,500 tons that account for over 85% of the world total production. Being the 8th leading the country in the world in honey production, India has very few agencies/ organizations involved in royal jelly production. India is also importing value-added products of royal jelly from China and other countries. Likewise, the honey production business in the beekeeping sector, production, and marketing of royal jelly needs to be encouraged for its commercialization and bestow the new opportunity to the beekeepers and unemployed rural people. Similarly, Bihar becomes one of the leading states of our country in honey production since last many years. But, as far as our knowledge no attempts have been made in the state by any of the agencies/ beekeepers/organization for the promotion of production of royal jelly. The main provable reasons for that may be the unavailability of modern and scientific facilities in the state, lack of technical knowledge of the production of precious products produced by bees, lack of suitable market and appropriate prices of the hive products, etc. make the beekeeping industry less profitable. Keeping in view of the above facts, the present experiment was aimed to evaluate queen cell cups prepared from combs of different bee species to develop a suitable technique for royal jelly production using *Apis mellifera* bees.

1.1 The Role of Royal Jelly in Apiculture

Royal jelly is secreted by worker bees and is the sole food source for queen larvae, allowing them to develop into reproductive queens, unlike worker bees. The importance of royal jelly extends beyond queen development, as it is pivotal to the overall health of the colony. Without a healthy queen, the colony cannot thrive.

1.2 Historical Use of Royal Jelly

Royal jelly has long been used in traditional medicine, valued for its supposed vitality-enhancing properties. In recent decades, research has revealed the unique nutritional composition of royal jelly, and its applications have expanded into industries such as cosmetics and pharmaceuticals.

2. Biological Composition of Royal Jelly

2.1 Chemical Composition

Royal jelly contains a complex mixture of proteins, sugars, lipids, vitamins, and minerals. The most important components are the Major Royal Jelly Proteins (MRJPs), which contribute to the growth and development of the queen bee. Other components include fatty acids, amino acids, and various trace elements that provide its unique biological properties.

2.2 Molecular Mechanisms

The differentiation between queens and worker bees is a result of the nutritional and hormonal effects of royal jelly. Key molecular pathways activated by royal jelly include epigenetic changes that turn on or off specific genes, leading to the queen's development. These processes influence queen morphology, longevity, and fertility.

2.3 Unique Properties of Royal Jelly

Royal jelly exhibits antibacterial, anti-inflammatory, and antioxidant properties, which make it beneficial not only for bee health but also for human health. These properties explain its widespread use in health supplements and skincare products.

3. Royal Jelly and Queen Bee Development

3.1 Influence on Queen Bee Morphology and Lifespan

Royal jelly causes dramatic differences in the queen's size, reproductive abilities, and lifespan compared to worker bees. Queens, who are exclusively fed royal jelly throughout their lives, live significantly longer and have fully developed reproductive systems, allowing them to lay thousands of eggs.

3.2 Mechanisms of Action

The proteins and fatty acids in royal jelly directly affect hormone production in queen bees, influencing their physical and reproductive development. The MRJPs also play a crucial role in switching on genes that regulate cell growth and development, resulting in a fertile and long-lived queen.

3.3 Environmental and Genetic Factors

External factors, including the environment and colony health, influence the production of royal jelly and queen development. Stressors such as pesticides, poor nutrition, and environmental changes can affect the quantity and quality of royal jelly, ultimately impacting the colony's success.

4. Production of Royal Jelly in Apiculture

4.1 Techniques for Royal Jelly Harvesting

There are two main methods for harvesting royal jelly: traditional beekeeping and intensive production. Traditional methods involve using hives to encourage the bees to produce small amounts of royal jelly. Modern techniques involve larger-scale production, which increases output but may come with ethical and ecological challenges.

4.2 Factors Affecting Yield and Quality

The quality and quantity of royal jelly depend on several factors, such as the bee breed, environmental conditions, and hive management practices. Beekeepers must carefully balance hive health with royal jelly production to avoid overharvesting, which could stress the bees and reduce colony productivity.

4.3 Ethical Considerations

Intensive royal jelly production can be detrimental to bee health if not managed properly. Overharvesting can stress colonies, weakening their ability to produce a healthy queen and jeopardizing colony survival. Sustainable practices are critical for the ethical production of royal jelly.

5. Applications of Royal Jelly

5.1 Human Health Benefits

Royal jelly has gained popularity for its potential health benefits. It is believed to boost immunity, enhance vitality, and promote overall well-being. Scientific studies suggest that royal jelly may have antioxidant and anti-inflammatory effects that contribute to its positive impact on human health.

5.2 Royal Jelly in Cosmetics

Royal jelly is widely used in skincare products, particularly for its anti-aging properties. It is commonly found in moisturizers, serums, and creams. Its ability to promote cell regeneration and hydration makes it a sought-after ingredient in the beauty industry.

5.3 Pharmaceutical Applications

Ongoing research is exploring the potential of royal jelly in treating conditions such as diabetes, high cholesterol, and inflammatory diseases. Early findings suggest that royal jelly's bioactive compounds may have therapeutic effects, though more research is needed to confirm these applications.

6. Challenges Facing Royal Jelly Production

6.1 Colony Collapse Disorder (CCD)

Colony Collapse Disorder has had a devastating impact on bee populations worldwide. While the causes of CCD are multifactorial, the role of royal jelly in bee health could provide insights into mitigating this issue. Strengthening queen bee development through royal jelly could help maintain colony stability.

6.2 Environmental Stressors

Pesticides, habitat loss, and climate change pose significant challenges to bee populations. These stressors reduce the availability of natural forage and can compromise royal jelly production. Mitigating these environmental risks is essential for the future of beekeeping and royal jelly

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production.

6.3 Economic Barriers

The cost of royal jelly production remains high, and fluctuations in bee populations can affect market prices. Additionally, synthetic alternatives to royal jelly are being explored, which could disrupt the natural royal jelly market.

7. The Future of Royal Jelly in Apiculture

7.1 Innovations in Hive Management

New technologies, such as smart hives and automated monitoring systems, offer ways to improve hive health and royal jelly production. By using sensors and AI-driven tools, beekeepers can optimize the conditions for royal jelly production and monitor colony health in real time.

7.2 Breeding Programs for Enhanced Royal Jelly Production

Selective breeding of honey bee species for higher royal jelly production could offer a solution to the growing demand for royal jelly. However, these efforts must be carefully managed to avoid negative ecological impacts and ensure the health of bee populations.

7.3 Expanding Research Frontiers

Future research will likely explore epigenetic and molecular biology aspects of royal jelly to better understand its potential applications in human health and agriculture. Advancements in biotechnology may lead to new methods of royal jelly production that are both efficient and sustainable.

Conclusion

Royal jelly remains one of the most valuable resources produced by honey bees, not only for its role in queen development but also for its applications in human health, cosmetics, and pharmaceuticals. As challenges such as colony collapse disorder and environmental stressors threaten bee populations, innovations in hive management and royal jelly production will be key to sustaining both bee health and global food systems. The future of royal jelly in apiculture looks promising, with ongoing research and new technologies poised to unlock its full potential.

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Role of Insects as Bio Indicators in Environmental Health

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Abstract

Environmental contamination research has been quite interesting in bioindicators recently. The basic objective of bioindicator research is to find species that can reliably detect environmental disturbances and demonstrate how those disturbances affect other species or biodiversity as a whole. Since they frequently come into contact with the harmful substances found in soil, water, and air, insects are particularly valuable for evaluating how human activities affect the terrestrial ecosystem, the aquatic system, and the atmosphere. In this review article, we've emphasized the use of insects as a resource for assessing contaminants and monitoring environmental contamination. Insects have been our main focus since they are key indicators of changes in soil, water, and air quality. The majority of insects, including beetles, ants, honey bees, and butterflies are employed in this study as biological indicators since they are sensitive to even the slightest environmental changes and are also used to monitor different environmental toxins.
Keywords: *Insects, Monitoring, Climate Change, Environmental Pollutants, Ecosystem, Bioindicator*

1 Introduction

Climate extremes, such as rising temperatures, higher levels of CO2 and other GHGs, and changed patterns of precipitation represent a serious threat to global food supply (Shrestha, 2019). Global warming is a major problem that the world is experiencing right now. The remarkable rates of rise in sea level and air temperature indicate that it has reached previously unheard-of levels (Field et al., 2014). The World Meteorological Organization (WMO) reports that the global temperature has risen by around one degree since the onset of major industrialization. As stated by the Intergovernmental Panel on Climate Change (Field et al., 2014; IPCC, 2022), each of the past three decades has gotten warmer, with the 2000s being the warmest. Many climate model projections and development scenarios predict that the Earth will warm by 1.4°C to 5.8°C during the next century (Pachauari and Reisinger, 2007). One of the main causes of global warming is the sharp rise in greenhouse gas concentrations during the last 200 years in comparison to the pre-industrial period (Rogelj et al., 2018). The most common anthropogenic activities, like burning fossil fuels and changing land use, produce carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) in the atmosphere (Yoro and Daramola, 2020). The increase in atmospheric CO2 during the last 50 years

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has been one of the most noticeable changes to the environment (Prentice et al., 2001). Its atmospheric concentration is estimated to double in 2,100 years, having rapidly grown from 280 ppm recorded for the pre-industrial period to 416 ppm (Pachauari and Reisinger, 2007; Anonymous, 2023). Since the atmosphere absorbs a large amount of heat-infrared radiation from the Earth's surface, CO2 is categorized as a greenhouse gas. More radiation is released from the atmosphere towards the Earth's surface in proportion to the amount of atmospheric gases that absorb thermal infrared radiation from the planet's surface (Mahlman, 1997). At the Earth's surface, the long-wave balance is less negative because there is more energy available for sensible and latent heat change. The air's temperature rises as the amount of energy available for heat flux increases. (Streck, 2005). Changes in extreme weather and climatic events have been noted since the mid-1900s. Anthropogenic influences have also been linked to other changes, including increased warm temperature extremes, decreased cold temperature extremes, faster sea level rise, and more frequent heavy precipitation events in a number of locations. It is anticipated that in certain regions, the frequency and intensity of weather extremes, such as heat waves and extended periods of intense precipitation, will increase (Field et al., 2014). Even while ecology faces many challenges due to the speed and complexity of global change, this does not exclude action to address the underlying causes of this phenomenon (Yang et al., 2021).

Criteria for the selection of bioindicator

It is essential to maintain healthy ecosystems in order to protect biodiversity. Because ecosystems are so complex, it is crucial to use indicator taxa to evaluate the health of ecosystems. Using indicator taxa, assessments have been made of ecosystem health, biodiversity, target taxa status, endemism levels, and resource availability (Faith and Walker, 1996). Selecting an indicator for a study of an area's biological variety, habitat loss, climatic change, or a polluted area are examples of criteria that are flexible and significantly impacted by the goals of the investigation. An indication must meet a number of criteria in order to be considered decent. One popular and affordable way to detect and track environmental changes is through the use of bioindicators. A good bioindicator should be widely distributed over a wide geographic area, have well-established taxonomy and ecology, be specialized to certain habitat requirements, provide early warning of change, be easy and affordable to survey, be largely independent of sample size, have a response that is representative of other species, and be able to distinguish between cycles or trends brought on by natural cycles or stress and those brought on by anthropogenic stress (Noss, 1990). The major criteria for the selection of bio indicators are shown in Figure 1.

Based on domestic and global studies on the selection of bio indicators, eleven selection standards have been established (Han et al., 2015) viz.

i. Species (or species groups) with clear classification and ecology
ii. Species (or species groups), those are distributed in a geographically widespread area.
iii. Species (or species groups), those show clear habitat characteristics

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iv. Species (or species groups), those can provide early warning for a change
v. Species (or species groups), those can benefit promptly and economically from the investigation
vi. Species (or species groups), those are not adversely affected by the size of individual groups and have numerous independent individual groups

Moreover, there are 19 selection criteria can be categorized into four main groups: baseline information, location information, niche and life history attributes, and others (Hilty and Merenlender, 2000).

Classification of bioindicator

A bioindicator monitors the development of biological or non-biological elements in an environment, sometimes concentrating on a living thing. It acts as a metaphor for understanding and assessing the condition of the ecosystem. The effects of environmental change on a species or group of species that reflect the condition of living things or inanimate items in the environment are also more generally or particularly referred to by this term. Similarly, it could be used to characterize live creatures or groups of living things that demonstrate the diversity of a taxonomic group in a particular region or the diversity of the entire taxonomic group (Gerhardt, 2002). There are numerous approaches to classify bioindicators (Mc Geoch, 1998). categorized them according to their various origins and applications into three groups: biodiversity, ecological, and environmental indicators. Pesticide resistance levels are associated with the species' overwintering range, according to a meta-analysis of global data sets. Climate change can encourage and spread pesticide resistance of this damaging species worldwide by supporting local persistence throughout the year (Ma et al., 2021).

3.1 Environmental indicator

An environmental indicator is a species or collection of species that exhibits predictable, easily observable, and quantifiable responses to environmental disturbances or changes in the environment. It is employed to identify environmental changes.

3.2 Ecological indicator

The species or group of species serves to track long-term changes in biota caused by stressors and illustrates how a stressor affects a biotic system (including habitat alteration, fragmentation and climate change).

3.3 Biodiversity indicator

A biodiversity indicator is a group of taxa (e.g., a genus, tribe, family, or order, or a specific group of species from a range of higher taxa) or a functional group that reflects the diversity of other taxa in a habitat through diversity (character and species richness, or level of endemism) (Mc Geoch, 1998; Stewart et al., 2007). According to their taxonomic status, the term "bioindicators" can also refer to a variety of indications, such as microbial, plant, and animal indicators (Figure 2).

3.4 Plant indicator

In this era of urbanization, pollution still poses a threat to people's health and well-being. The

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plant exhibits a great sensitivity to identifying and anticipating environmental stress. Using sensitive plant species for biomonitoring is an efficient way to mitigate this issue. Lichens are disappearing from forest regions due to elevated levels of contaminants such as nitrogen and sulfur (Holt and Miller, 2010). Changes in the diversity of phytoplankton species, including Euglena clastica, Phacus tortus, and Trachelon anas, are signs of pollution of marine ecosystems (Jain et al., 2010).

3.5 Animal indicator

Changes in specific characteristics of an organism have been used as indicators with success. Toxin levels in an animal's tissues can be ascertained with the help of animal indicators (Khatri and Tyagi, 2015). Alona guttata, Mesocyclops edax, Cyclops, and Aheyella are zooplankton that are zone-based indicators of pollution (Jain et al., 2010; Hosmani, 2014). They serve as indicators of contaminated water, eutrophication, and water quality. It is common practice to employ amphibians, particularly anurans like frogs and toads, as biological markers of the buildup of contaminants in a particular habitat (Zaghloul et al., 2020). According to the type of organic residues, earthworms—a vital species for the soil system—can be extremely important to the development and breakdown of soil aggregates (Al-Maliki et al., 2021). As a bioindicator of the condition of soil, earthworms are more sensitive to temperature fluctuations than to moisture content. Additionally, invertebrates are trustworthy bioindicators; insects are essential ecological indicators. There are various scales at which environmental stress can be evaluated, ranging from the individual animal to the entire community of invertebrates.

3.6 Microbial indicator

When subjected to environmental disruptions, microorganisms may be utilized as indicator species to identify environmental pressures. They are extremely sensitive to changes in their surroundings. Toxins in water can be detected by changes in the digestive system or changes in the physiological system of microorganisms, such as the production of stress protein (Khatri and Tyagi, 2015) (Uttah et al., 2008). Foraminifera are a class of eukaryotic microorganisms that are employed in coral reef monitoring (Hallock et al., 2003). Additionally, biofilms and Autonomous Reef Monitoring Structures (ARMS) techniques are used to assess the health of coral reefs (Roitman et al., 2018). Bacterial orders that may serve as bioindicators of high P or nutrient-rich areas include the opitulales, chitinophagales, cytophagales, and saccharimonadales (Mason et al., 2020). Several molds are utilized as biological markers for pollutants, such as Trichoderma sp., Exophiala sp., Stachybotrys sp., Aspergillus fumigatus, A. versicolor, A. niger, Phialophora sp., Fusarium sp., Ulocladium sp., Penicillium sp., Candida albicans, and some yeasts. Dokulil (2003) suggests that blue-green algae could be employed as a biological indicator to identify changes in pH levels in different habitats.

4 Insects used as a bio indicator of climate change

The effects of climate change on living things are among the most significant ecological

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challenges of our day. According to Wilson et al. (2007), Bellard et al. (2012), Grimm et al. (2013), Menéndez et al. (2014), and Sheldon (2019), these effects are widespread and usually detrimental. Numerous other studies have shown that species relationships, range, abundance, and phenology can all be impacted by climate, both directly and indirectly. It also has an impact on biodiversity, the composition of biological communities, and the dynamics and structure of ecosystems. Numerous observations indicate that depending on their physiological tolerances for temperature, animals may move northward in reaction to climate change (Parmesan, 1996; Root et al., 2003; Menéndez, 2007; Menéndez et al., 2014; Sheldon, 2019). Climate change influences the biology and ecology of species as well as several ecological processes. Therefore, selecting a bioindicator to monitor these effects becomes crucial, even though selecting the appropriate species can be difficult. Accordingly, some researchers have proposed selection criteria for species (Groot et al., 1995). Additionally, because the climate directly affects their survival, reproduction, and development, they have been cited as useful bioindicators of climate change (Menéndez, 2007; Gerlach et al., 2013) Figure 3 (Bale et al., 2002).

5 Bioindicator insect groups to monitor environmental changes

5.1 Beetles as bioindicator

Coleopterans, which primarily belong to the families Curculionidae, Staphylinidae, and Carabidae, are considered to be potential bioindicators. The ground beetle is the most widely used insect in environmental biomonitoring, particularly for assessing environmental contaminants and forest management (Ghannem et al., 2018). They are gathered using pitfall traps from areas where persistent heavy metal contamination has caused a buildup of different heavy metals in the soil. Elytra length, body size, and other morphological characteristics are evaluated to track heavy metal contamination (Lagisz, 2008). Adult carabids' locomotory behavior has changed as a result of copper's toxic effects, and there is a high rate of larval death. It is thought that exposure to copper during larval development is linked to behavioral alterations (Bayley et al., 1995). According to studies on Pterostichus oblongopunctatus (Simon et al., 2016), this species is preferred in metal pollution evaluation because of its high BAF (bioaccumulation factor) values for copper (Cu) and zinc (Zn). Conti et al. (2017) have also shown that the carabid sp. Parallelomorphus laevigatus is a trustworthy indicator of harmful chemicals.

5.2 Lepidopterans as bioindicator

Butterflies are significant bioindicators on account of their sensitivity towards the slightest alteration in environmental conditions. They have been extensively used as heavy metal and environmental pollution bioindicators that are close to industrial states and even inside metropolitan zones (Da Renato et al., 2010). Butterflies are particularly sensitive to climate changes. The temperature has a substantial impact on butterfly range shifts, oviposition sites, egg-laying rates, larval development, and survival rates (Sharma and Sharma, 2017). Pupal size of Noctuidae and Geometridae species fluctuates with levels of industrial air pollution (Heliövaara et al., 1989).

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According to (Kyerematen et al., 2018), different environmental stressors in Sierra Leone's wetlands affect butterfly communities, and the higher the stress, the smaller the diversity of butterflies in a specific place.

5.3 Ants as bioindicator

Ants are found in almost every trophic level of the food chain, the web, and other ecological processes. They are being used as an effective bioindicator group for a number of pollution types (Kaspari and Majer, 2000; Andersen et al., 2002), such as aerial phthalate pollution (Lenoir et al., 2014), land rehabilitation (Khan et al., 2017), and soil-heavy metal contamination (Gramigni et al., 2013; Khan et al., 2017). Heavy metals like aluminum (Al), cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), nickel (Ni), lead (Pb), and zinc (Zn) are accumulated by red wood ants (Formica lugubris) in both worker ant bodies and nest material (Skaldina et al., 2018). The use of ants as bioindicators to track the health of ecosystems is growing (Akhila and Keshamma, 2022). The other invertebrate taxa present in an area are also partially reflected in the ant fauna (Majer, 1983). Because of their ecological relevance (Tibcherani et al., 2018) and sensitivity to disturbances caused by species invasion, grazing, forest thinning, forest conversion, forest fragmentation, and other disturbances, ants are commonly used as effective disturbance bioindicators for managing ecosystems and restoring biodiversity (Underwood and Fisher, 2006) (Da Renato et al., 2010).

5.4 Bees as bioindicator

While foraging, social insects can consume contaminants, which they might either transfer to their larvae or incorporate into the materials they use to construct their nests. Bee pollutant can also get up in stored food, like honey or bee bread (Feldhaar and Otti, 2020). Because they indicate ambient chemical impairment due to a high mortality rate and are able to catch particles dispersed in the air or flowers, honey bees are dependable and effective biological indicators. Their tremendous mobility made them extremely successful in ground surveys. Honey bees are employed to keep an eye on radionuclides, heavy metals, and insecticides (Porrini et al., 2003). The amounts of various elements, including beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), nickel (Ni), lead (Pb), copper (Cu), and vanadium (V), in both urban and rural locations were examined by Di Fiore et al. (2022). They then came to the conclusion that honeybees are able to gather environmental toxins and offer information on how pollution is changing over time and space.

5.5 Parasitic wasps as bioindicator

Parasitic wasps have recently been used as woodland habitat bioindicators (Hilszczanski et al., 2005). When compared to coniferous woodlands, the parasitoids were more common in habitats of mixed woodlands with a range of species. Forest type and deadwood characteristics had a greater impact on the parasitoid assemblage, suggesting that maintaining the diversity of deadwood habitats is crucial for parasitoid conservation. Parasitic wasps are complicated and highly specialized because of their limited host ranges, complex biology, and high trophic position (Maleque et al., 2009). Both social and solitary aculeate wasp species are capable of precisely measuring the diversity of all arthropod species within an ecosystem, and certain social wasp species have also been discovered to be trustworthy markers of heavy metal pollution (Brock et al., 2021).

5.7 Syrphid flies as bioindicator

Syrphid flies' extensive geographic range makes them a potent bioindicator of landscape-level forest management techniques (Maleque et al., 2009). The bodies of Eristalis and Sphaerophoria species absorb heavy metals from the industrial zone, such as Mn, Pb, and Cd (Markova and Alexiev, 2002). Flies are also the finest instrument for evaluating the richness of landscapes because of their rapid adult movement (Sommaggio, 1999).

5.9 Dragonflies as bioindicator

Dragonflies are considered the most accurate ecological indicator in aquatic and riparian habitats. Particularly in lakes and flooded drainage areas, they react significantly to habitat disturbance and heavy metal deposition (Shafie et al., 2017). Any water body that contains them is free of manufactured contamination (Azam et al., 2015).

5.10 Termites as bioindicator

Termites are "ecosystem engineers," and by comparing the physicochemical characteristics of termite mound soil to chemically treated soil, they serve as bioindicators of soil fertility (Nithyatharani and Kavitha, 2018). Additionally, termites exhibit the ability to serve as indicators for soil ecosystem services such biodiversity, hydrological processes, chemical fertility, and macro-aggregation (Duran-Bautista et al., 2020). Heavy metals like Ca, Mg, Al, Fe, Zn, Cu, Mn, Be, Ba, Pb, Cr, V, Ni, and Cd were all found in significant concentrations in termites. Although there was a substantial indirect link for Ba, Cr, Ni, Co, and Fe, Alajmi et al. (2019) found a significant direct relationship between termite presence and concentrations of Al, Cu, Zn, Be, Cd, Mn, Ca, Mg, Pb, V, and Mo.

6 Insect as bioindicators of different ecosystems

The major bioindicator insects in different ecosystems are depicted in Figure 5.

6.1 Insect as bioindicators of agricultural ecosystem

Climate change, the need for increased productivity, and shifting consumer demand are all putting pressure on agricultural landscapes. Decisions about land management will affect the animals that are important to the environment that live on agricultural land and its environs. Hundreds of solitary bee species, bumble bees, flies, beetles, and butterflies are examples of insect pollinators. These are primarily hymenoptera groups that are frequently used for pollination in agricultural settings. Additionally, by serving as biocontrol agents, predatory insects including wasps, flies, midges, lacewings, true bugs, and certain beetles support important ecological processes. Furthermore, insects contribute significantly to the improvement of agricultural land through their interactions with it. In comparison to chemicals, dung beetles increase the soil's level of nitrogen,

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phosphorus, potassium, calcium, magnesium, and total protein, which raises crop output (De Groot et al., 2002).

6.2 Insect bio indicators of forest ecosystem

A possibly beneficial technique for Sustainable Forest Management (SFM) is bio indicators. Significant alterations in the ecosystem may be indicated by a rise or fall in the number of insect species. Unsanitary environmental conditions are indicated by the prevalence of houseflies and mosquitoes. Because of their ability to adapt to variations in moisture and topography, butterflies are recognized as trustworthy ecological indicators. According to Weiss et al. (1988), butterflies are an indication of a healthy environment. Various arthropod indicator species have been used in a comprehensive investigation of the effects of forest fragmentation. For instance, Fujita et al. (2008) found that the richness of carabid species in urban forest remnants rose as fragment area increased but stayed relatively constant as isolation distance from major forests increased. Forest fragmentation also has a greater impact on dung beetles, whose species richness and quantity were positively correlated with the size of the fragments (Feer and Hingrat, 2005). Because of their high species richness and adult mobility, syrphid flies are the ideal instrument for evaluating biodiversity at the landscape level (Maleque et al., 2009).

6.3 Insect bioindicators of aquatic ecosystem

Aquatic invertebrate insect species belonging to the Ephemeroptera, Plecoptera, Trichoptera, and Diptera (EPT&D) are highly sensitive to variations in water quality and can only thrive in streams with low pollution levels, cold temperatures, and well-oxygenated waters. Following an anthropogenic disturbance, Chironomidae (Diptera) and Baetis and Paraleptophlebia (Ephemeroptera) show a significant increase in abundance and, consequently, density (Relyea et al., 2000). Although members of the genus Halobates are well suited to detect Cd and Hg, insects are less frequently used as biological indicators of metal contamination (Nummelin et al., 2007).

6.4 Insect bioindicators of mountain ecosystem

Anthropogenic environmental degradation is still common in alpine locations. Invertebrate populations are distributed over these steep altitudinal gradients according to their individual environmental tolerances, and they react appropriately to changes in their surroundings. To monitor the changes in the alpine environment, only a small number of trustworthy invertebrate biomonitoring systems are often and widely used, especially those that concentrate on terrestrial invertebrates. The spittlebug species Neophilaenus lineatus exhibits rapid, frequently annual variations in their upper altitudinal limit in response to fluctuating mean temperatures. If appropriate alpine habitats are lost, the high-elevation species Craspedolepta schwarzi may go extinct. C. nebulosa and C. subpunctata, two lower-altitude species, may be anticipated to demonstrate an upward extension of their overlapping ranges, however, C. nebulosa always inhabits an elevation that is slightly higher than C. subpunctata (Hodkinson and Bird, 1998).

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7 Conclusion

For environmental monitoring, indicator species are crucial as ecological indicators. The primary attributes and traits of a bio indicator include dependability, ecological faithfulness and fragility to tiny environmental changes, ease of handling, cost-effectiveness, species richness and variety, and ease of assessing environmental changes. The class Insecta has all of them. Insect serves as a crucial indication of changes in the quality of the soil, the air, and the water. Although it can be difficult to choose a particular indication and then recognize it, as well as the relationship between the indicators and their specialized uses, these modifications have an impact on many species' physiological characteristics and abundance. This insect will be highly useful in the future as an indicator species because we can use it to detect pollution in the soil, water, and air. By doing so, we will be able to prevent habitat loss and reduce pollution in the future.

Author contributions

SC and VKD initiated and wrote the manuscript. All the authors reviewed the manuscript, contributed to consulting references, and agreed for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Living Soil: How Arthropods Boost Soil Health

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Abstract

Soil is an ecology or part of ecology. It shelters more biodiversity in number and kind than all other biota together. A soil that is able to optimally sustain its native/acquired productivity potential and render ecological services is said to be in good health. Improving soil health and quality can lead to more productive and resilient agricultural systems. The capacity to define soil quality and soil health has become extremely important in recent years due to the dramatic increase in soil degradation. Natural soils are a complex mixture of clastic and biological materials, heavily influenced by a vast array of living organisms. In fact, a high-quality soil can be regarded as largely living due to the immense biodiversity it hosts. While earthworms have historically received significant attention for their crucial role in soil health, arthropods are equally important. Their abundance, diversity, and the variety of ecological niches they occupy highlight their significant contributions to the soil ecosystem, complementing the roles of other organisms and enhancing soil function and fertility. Arthropods comprise a large proportion of the meso- and macrofauna of the soil, animals with body lengths ranging from about 200 µm to 16 cm or more. Arthropods play crucial roles in soil ecosystems, particularly in maintaining soil fertility through various processes viz. Soil aeration, Decomposition, Nutrient recycling, Biodiversity and Resilience. Arthropods function on two of the three broad levels of organization of the soil food web: they are "litter transformers" or "ecosystem engineers." Soil arthropod diversity, distribution and abundance are determined by several factors such as organic matter content, soil features, cover vegetation, soil disturbance (mechanical soil tillage), fire, and pollution. By supporting these processes, arthropods are essential for maintaining healthy soils, which in turn supports plant growth and overall ecosystem health.

Key words: Soil Health, Arthropods, Soil Fertility, Nutrient Recycling, Biodiversity and Resilience.

Introduction

Soil is the most precious but limited basic natural resource on which depends the security of food, nutrition, employment, livelihood, biodiversity and environment. The Green Revolution indeed brought significant advancements in agricultural productivity, but the long-term effects

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on soil health are now becoming evident. Issues like soil degradation, erosion, and loss of nutrients can threaten future food production and biodiversity. To address these challenges, sustainable agricultural practices are essential. Strategies such as crop rotation, organic farming, reduced chemical use, and conservation tillage can help restore soil health and ensure its productivity for future generations. Additionally, integrating agroecological approaches can enhance biodiversity and resilience in farming systems. It's vital to recognize soil not just as a medium for crops, but as a living ecosystem that requires careful management and protection.

The challenges facing Indian soils are significant and multifaceted. The low organic carbon content, coupled with widespread nutrient deficiencies—particularly nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and essential micronutrients—has serious implications for agricultural productivity and sustainability. Addressing these issues requires a comprehensive approach that combines improved agricultural practices, education for farmers, and investment in research to develop sustainable solutions tailored to local conditions. The growing population increases demand for food, while the declining land-to-man ratio and smaller farm sizes limit agricultural productivity. Additionally, declining soil health impacts crop yields, making it challenging to sustain agricultural output (Patra, 2021).

Soil is an ecology or part of ecology. It shelters more biodiversity in number and kind than all other biota together (Blum 2002). Man has a dominating role in influencing the native web of soil life by changing its living environment. A soil that is able to optimally sustain its native/acquired productivity potential and render ecological services is said to be in good health. "Soil health" and "Soil quality" are often used interchangeably, but they can have slightly different connotations.

Soil health generally refers to the ability of soil to function as a living ecosystem that sustains plants, animals, and humans. It emphasizes the biological aspects of soil, including microbial activity, biodiversity, and overall ecosystem resilience.

Soil quality, on the other hand, tends to focus more on the physical and chemical properties of soil, such as texture, structure, nutrient availability, and pH. It is often assessed based on specific criteria or indicators that reflect the soil's capacity to perform its intended functions.

Both concepts are crucial for sustainable agriculture and land management, as they impact plant growth, water retention, and ecosystem services. Improving soil health and quality can lead to more productive and resilient agricultural systems.

The capacity to define soil quality and soil health has become extremely important in recent years due to the dramatic increase in soil degradation. Natural soils are a complex mixture of clastic and biological materials, heavily influenced by a vast array of living organisms. In fact, a high-quality soil can be regarded as largely living due to the immense biodiversity it hosts.

While earthworms have historically received significant attention for their crucial role in soil health, arthropods are equally important. Their abundance, diversity, and the variety of ecological niches they occupy highlight their significant contributions to the soil ecosystem, complementing the roles of other organisms and enhancing soil function and fertility (Thomas Culliney, 2013).

Arthropods

Soils may harbor an enormous number of arthropod species, which may rival or exceed the numbers estimated to inhabit the canopies of tropical forests (Andre *et al.*, 1994). By one recent estimate, the soil fauna may represent as much as 23% of all described organisms, or about 360,000 species, with arthropods comprising 85% of that number (Decaens *et al.*, 2006).

Arthropods comprise a large proportion of the meso- and macrofauna of the soil, animals with body lengths ranging from about 200 µm to 16 cm or more. Of the hemiedaphon and euedaphon, those organisms that live within the litter/humus boundary and lower in the soil profile, five groups are chiefly represented: Isopoda, Myriapoda, Insecta, Acari, and Collembola, the latter two being by far the most abundant and diverse. Species of Protura, Diplura, and Pauropoda are of lesser importance in the soil community, and have little influence on soil processes (Eisenbeis and Wichard, 1987).

Arthropods play crucial roles in soil ecosystems, particularly in maintaining soil fertility through various processes. Key roles include:

1. **Decomposition**: Arthropods, such as beetles and earthworms, aid in breaking down organic matter, enhancing nutrient availability.
2. **Soil Aeration**: Through their burrowing activities, arthropods help improve soil structure and aeration, which is vital for plant root health.
3. **Nutrient Cycling**: They contribute to the cycling of nutrients, ensuring essential elements are accessible to plants.
4. **Predation and Pest Control**: Many arthropods act as natural predators of pest species, helping to regulate populations and maintain ecological balance.
5. **Microbial Interactions**: Arthropods can influence microbial communities in the soil, promoting biodiversity and enhancing nutrient processing.

This review highlights the interconnectedness of arthropods with other soil organisms and emphasizes their significance in sustaining soil health and productivity.

Microarthropods

Oribatida, Prostigmata, and Mesostigmata, along with Collembola (springtails), play crucial roles in soil health and nutrient cycling. They help decompose organic matter, enhance soil structure, and contribute to the overall biodiversity of various habitats. Their presence in a wide range of environments—from equatorial to Polar Regions—highlights their adaptability and ecological importance (Thomas Culliney, 2013).

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As part of the mesofauna, the microarthropods comprise the important middle links of soil food webs, serving, in their role as both predator and prey, to channel energy from the soil microflora and microfauna to the macrofauna on higher trophic levels.

Among soil microarthropods, Collembola and Acari are the two most important groups in terms of abundance and diversity, and are also the most investigated taxa. Both groups are often investigated at the family, genus or species level, and a non-taxonomic different approach considers functional groups or functional traits. Others' microarthropod taxa that are often used to define soil quality are:(i) insects such as Coleoptera adults and larvae, Hymenoptera (ants especially), Diptera larvae, (ii) Araneae and (iii) Isopoda. However, other groups, such as Protura, Diplura, Pseudoscorpionida, Symphyla and Pauropoda, have been investigated only a little, and, when considered, they are generally discussed with a genetic, taxonomic, or ecological approach rather than as soil health indicators.

Functional Roles of Arthropods in enhancing Soil Fertility

Arthropods function on two of the three broad levels of organization of the soil food web: they are "litter transformers" or "ecosystem engineers." **Litter transformers**, of which the microarthropods comprise a large part, fragment, or comminute, and humidify ingested plant debris, improving its quality as a substrate for microbial decomposition and fostering the growth and dispersal of microbial populations. **Ecosystem engineers** are those organisms that physically modify the habitat, directly or indirectly regulating the availability of resources to other species. In the soil, this entails altering soil structure, mineral and organic matter composition, and hydrology (Lavelle *et al*., 1995).

Role of Arthropods on Nutrient Cycling

Plant litter is a mixture of labile substrates (e.g., sugars, starch) easily digested by soil biota, and other components (cellulose, lignins, tannins) more resistant to breakdown. Decomposition of this material results from an interaction between physical and biological processes (Crossley, 1977). Litter first must be physically weathered before it becomes suitable for further degradation by the soil microflora and fauna. Fungi are the important initial colonizers of plant litter (Harley, 1971). With increasing disintegration and solubilization of the substrate, bacteria increase in importance. After this initial microbiological phase, the breakdown process slows, and might come to a halt altogether were it not followed by animal activity (Burges, 1965).

Saprophagous arthropods affect decomposition directly through feeding on litter and adhering microflora, thus converting the energy contained therein into production of biomass and respiration, and indirectly, through conversion of litter into feces and the reworking (re-ingestion) of fecal material, comminution of litter, mixing of litter with soil, and regulation of the microflora through feeding and the dissemination of microbial inoculum. With the exception of some termite groups, only a small proportion of net primary production is assimilated by soil arthropods (e.g.,

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<10% in oribatids, 4%–20% in millipedes and isopods. Thus, the indirect influences of these consumers on decomposition and soil fertility are considered, in general, to be of greater importance.

The influence of the soil fauna on decomposition processes is greatest in the humid tropics, where plant litter decomposition occurs most rapidly. This is due largely to the actions of the microarthropods. In cold temperate zones, rates of biological turnover are curbed by low winter temperatures and the slow breakdown of toxic plant secondary compounds. However, most of the studies concerning the contribution of arthropods to nutrient cycling have focused on soils in temperate regions; comparatively little information is available from the tropics.

Litter Feeding and Comminution

A major contribution of arthropods to the decomposition and humification processes is through the comminution of plant debris. The physical fragmentation involved destroys the protective leaf cuticle, exposes cell contents, and increases water-holding capacity, aeration, and downward mobility of particulate and soluble substances. Comminution of plant litter is brought about largely by the feeding activity of saprophagous animals, and, during passage through the digestive system, is accompanied by catabolic changes. The unassimilated residue from the communitive and catabolic processes is excreted as feces, typically smaller in size and of different chemical composition than the ingested food. The plant matter passing out in feces also presents an increased surface area to attack by micro-organisms.

Coprophagy is common in these arthropods, and may be crucial to ensuring proper nutrition. Collembola may assume a much greater role in the physical breakdown of organic matter.

Mineralization of Nutrient Elements

Mineralization is the catabolic conversion of elements, primarily by decomposer organisms, from organic (i.e., bound in organic molecules) to inorganic form, such as the generation of CO_2 in the respiration of carbohydrates and breakdown of amino acids into ammonium (NH_4^+) and ultimately nitrate (NO_3^-). The direct or indirect actions of arthropods in processing plant litter, which may be nutritionally poor or resistant to decomposition, increase available nutrient concentrations in the soil.

The microbial mineralization of nutrients may be stimulated by arthropod grazing. Grazing by Collembola has a strong stimulatory effect on fungal growth and respiration. Collembolan grazing on fungi can result in increased mobilization of available N and Ca, with implications for nutrient availability in particular environments, such as acidic forest soils, in which large nutrient pools tend to be immobilized in stores of accumulated organic matter (Ineson *et al*., 1982). Isopod (P. scaber) feeding on oak and alder litter colonized by the microflora increased microbial respiration 10- and 20-fold, respectively, over that in plots, in which isopods

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were absent, and resulted in increased availability of the macronutrients, C, N, P, K, Mg, and Ca, in the topsoil, attributable to the increased availability of feces as substrates for further decomposition (Kautz and Topp, 2000). Arthropod grazing on the microflora also acts to regulate the rate of decomposition, preventing sudden microbial blooms, with the result that nutrients are mineralized and released from detritus, and made available for plant uptake, in a controlled and continuous fashion and their loss from the system minimized.

Significant amounts of K^+, PO_4^{3-}, N, Na^+, and Ca^{2+} may be stored in soil arthropod (Collembola, Oribatida, Isopoda, and Diplopoda) biomass, these animals constituting an important nutrient pool in the soil, which temporarily immobilizes ions and prevents them from being leached. Arthropod remains also may constitute a significant portion of the total pool of elements, particularly Ca, found in soil, rivaling that of the living standing crop.

The nests of termites provide ideal conditions to support populations of a variety of microbial species instrumental in the mineralization of litter-derived nutrients. Termite-derived materials used in the construction of the nest center (hive or habitacle), galleries, and runways, such as carton, a mixture of excreta, soil mineral particles, and undigested, comminuted plant tissues, and saliva, may have appreciable nutrient content (Wood, 1988). Clearly, termites and their constructions function importantly in the replenishment of soil nutrients in natural ecosystems. “The combination of foraging for food over a wide radius from the nest and returning it to the nest…intense degradation of the plant tissue collected, and use of the excreted end products of digestion for mound-building resulting in their removal from participation in the plant/soil system for long periods, sets termites apart from other soil animals in their influence on soil organic matter”.

Ant nests also may contain higher concentrations of nutrients than surrounding soil. Large amounts of organic matter from plant and animal (prey, carrion) sources accumulate in refuse dumps within nests. This material, combined with metabolic wastes and secretions from the ants themselves, which may become incorporated into nest soil, undergoes decomposition and mineralization by the microflora, leading to an accumulation and local concentration of nutrients.

Influence of Arthropods on Soil Structure

Arthropods affect the structural properties of soils in various ways.

- Soil Mixing and the Development of Pores and Voids
- Formation of Soil Aggregates

Feces of Collembola and other microarthropods constitute a significant proportion of the humic material in developing sand dunes, and are thought to contribute to dune consolidation and stabilization by binding sand grains into larger aggregates. Arthropod feces generally play a larger role in the formation of the more types of humus and in the formation of primitive soils (Baratt, 1962).

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Indices of Soil Quality Based on Soil Arthropods

Several indices based on soil fauna have been developed and proposed. Among them, numerous studies have used arthropods as bioindicators, generally focusing on low taxonomic level (species or genus) or on specific group, typically Collembola and Acari. The ratio between these two major groups has been used as soil indicator in some studies. Generally, the greater abundance of Acari compared to Collembola suggests good soil quality and habitat stability (Santorufo *et al*., 2012).

Conclusion

Soil arthropod diversity, distribution and abundance are determined by several factors such as organic matter content, soil features, cover vegetation, soil disturbance (mechanical soil tillage), fire, and pollution. The different taxa respond differently to a variety of environmental factors. Some groups are more sensitive, while others are ubiquitous and more able to react to soil degradation. In addition, different species belonging to the same taxonomic group can respond differently. Acari and Collembola are the two groups which are generally considered in soil quality evaluation approach. Other groups, such as Coleoptera, Diptera and Araneae, are often involved in studies aimed to evaluate soil quality/degradation/pollution, while other groups, typically Symphyla, Pauropoda, Pseudoscorpionida and others, are generally little discussed in soil quality monitoring or discussed together with other soil arthropods taxa.

Arthropods play a crucial role in maintaining soil health through various ecological functions. Here are some key contributions:

1. **Soil Aeration**: Many arthropods, such as ants and beetles, burrow into the soil, which helps aerate it. This improves water infiltration and root penetration, promoting healthier plant growth.
2. **Decomposition**: Arthropods, including decomposer species like earthworms and certain beetles, break down organic matter such as dead plants and animals. This process releases nutrients back into the soil, enhancing fertility.
3. **Nutrient Cycling**: By consuming organic materials, arthropods help recycle nutrients, making them available for plants. Their waste products often contain essential nutrients that benefit soil health.
4. **Predation and Pest Control**: Arthropods like spiders and predatory beetles help control populations of harmful pests. This natural pest management can reduce the need for chemical pesticides, promoting a healthier ecosystem.
5. **Symbiotic Relationships**: Some arthropods form symbiotic relationships with plants, aiding in nutrient uptake. For example, certain ants protect plants from herbivores in exchange for shelter or food.

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6. **Soil Structure Formation**: The activities of arthropods contribute to the formation of soil aggregates, improving soil structure. This enhances water retention and reduces erosion.
7. **Biodiversity and Resilience**: A diverse community of arthropods supports a resilient ecosystem. Biodiversity contributes to stability, allowing soils to recover from disturbances.

By supporting these processes, arthropods are essential for maintaining healthy soils, which in turn supports plant growth and overall ecosystem health.

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Evaluation Of Anticancer Activity OF *Plumbago zeylanica* Against Mcf-7 Human Breast Cancer Cells

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Abstract:

Natural products have always been an important part of health treatment. Recent studies have disclosed that plant extracts exhibit anticancer activity through various mechanisms. *Plumbago zeylanica* plant belonging to family Plumbaginaceae, has been known for its beneficial effects against various types of cancers. The primary goal of this study is to determine the cytotoxic effect of *Plumbago zeylanica* ethanolic extract on MCF-7 cells which is analysed with MTT assay, morphological studies under light microscope & Fluorescence microscope, and LDH measurement. The study focuses on the preliminary investigation of *in vitro* anticancer efficacy against breast cancer utilising MCF-7 cells. The findings of this study demonstrate anticancer effect of *Plumbago zeylanica* against MCF-7 cells in a dose dependent manner.

Keywords: Plumbago zeylanica, MCF-7 cells, Breast cancer, MTT, AO/EB stain.

1. Introduction:

Breast cancer is the second most common cause of cancer in the world, according to the World Health Organization (WHO). Breast cancer affects majorly women's of about one out of every ten women at some point in their lives [Caffarel, et al., 2016]. According to data from the International Agency for Research on Cancer (IARC) and Globocan for 2018, breast cancer caused 0.62 million deaths and 2.08 million new cases (about 11.6 percent of all cancers diagnosed) [Bray, et al., 2018]. By 2040, if current trends continue, the mortality troll will have risen to a nerve-wracking peak of 6.99 million [Ferlay, et al., 2018]. According to epidemiological data, the incidence of breast cancer is steadily increasing in emerging countries [Rice,S, et al.,2006].

The majority of the Breast cancers morbidity and mortality are responsible by its cell tissue invasiveness and metastatic dissemination. [Mansoori GA., et al., 2010]. Substantial research., et al., 2006 has been conducted to better understand breast cancer and identify novel ways to combat it. Chemotherapy, which involves the use of cytotoxic drugs, is the most common therapeutic option. Although it has been demonstrated to be beneficial in certain circumstances, it is frequently

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accompanied by risk factors or adverse effects that range from minor to life-threatening [Weinberg., et al., 2015]. The lack of specificity of drugs for cancer cells is the main cause of side effects associated with chemotherapy [Ekor, et al., 2014]. Natural products have long been a cornerstone of health care. It has been estimated that nearly 80% of the population uses natural medicine systems for primary health care [Cragg, et al., 2000]. Natural products, such as medicinal plants, are becoming increasingly important in primary health care, particularly in developing countries. Many pharmacological studies are conducted in order to discover new medications or lead structures for the development of novel therapeutic agents for the treatment of human diseases such as cancer. [Sun YF, et al., 2013]. As a result, due to their low side effects, the identification of naturally occurring phytocompounds from medicinal plants to battle cancer has become more sought after in recent decades [Malaviya, et al., 2014].

Medicinal plants are high in phytochemicals, which are used to treat a variety of human ailments and aid in the healing process. A wide range of plants and their separated compounds have been demonstrated to have anticancer properties. They are a great source of new cytotoxic agents and continue to play an important role in public health. [Richa Tyagi, et al., 2014]. Herbal plants have consistently proven to be the principal source of synthetic medicines. Plumbago zeylanica is one among them which is frequently used in traditional medicine for its therapeutic properties. [Borhade, et al., 2014]. It is an ancient plant that has been utilized in Ayurveda for thousands of years to treat a variety of ailments. This plant, also known as chitrak, is a member of the Plumbaginaceae family which is a well-known Ayurvedic medicine. Chitramala and chitrak are two prevalent names for it. This perennial plant can be found in Sri Lanka and sections of India, including Bengal, Uttar Pradesh, and Southern India [Vishnukanta, et al., 2010]. In the Charaka Samhita (an important text on Ayurvedic system of medicine), P. zeylanica has been classified as an appetizer, anti-saturative, anti-anorexic, anti-haemorrhoidal, tumor negating and anti-dyspeptic and pain-reliever [Liu,Y, et al., 2017]. Plumbagin, a bioactive naphthoquinone found in Plumbago zeylanica, has anticancer properties through a variety of molecular pathways, including the induction of apoptosis and autophagy, cell cycle disruption, invasion and metastasis suppression, and anti-angiogenesis [Pant, et al., 2001].

2.Materials and Method:

2.1. Plant Collection and Extraction:

The *Plumbago zeylanica* plant was gathered from the kanyakumari district, Tamilnadu. To eliminate dust, the whole plant was rinsed in fresh water and then shade dried. The dried powdered plants were extracted with ethanol in a soxhlet. The successive extracts were stored for further analysis**.** The extracts were diluted in dimethyl sulfoxide (DMSO) for bioassays.

2.2. Cell culture:

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MCF-7 (human breast cancer cell line) was used to assess the cytotoxic potential of ethanolic extracts of Plumbago zeylanica. The cell line was obtained from National centre for cell Science (NCCS). Cell line was grown as monolayer cultures maintained in Dulbecco's modified Eagle's medium and was facilitated by heat-inactivated fetal bovine serum (10%), 2 mM L-glutamine and mixed with antibiotics (100 units/mL penicillin and 100 µg/mL streptomycin). The MCF-7 cells were cultivated at 37ºC in a CO2 incubator [Cardile, et al., 2004].

2.3.MTT assay for cytotoxicity assessments:

The viability of the cells was determined using the 3-(4, 5-dimethyl thiazol-2-yl)-2, 5-diphenyl tetrazolium bromide (MTT) assay, which is based on the reduction of MTT to a purple formazan product by mitochondrial dehydrogenase in intact cells. Cells were seeded in 96-well microplates (1 $\times 10^4$ cells/well in 180µl medium) and routinely cultured in a humidified incubator (37ºC in 5%co_2) for 24 hours. EEPZ were added in a serial concentration (20, 40, 60, 80 and 100µg/ml) and reincubated for 24h. Then the medium was discarded and 30µl of tetrazolinium dye (MTT) solution (5mg/ml in PBS) was added to every well and re-incubated for 4 hours. After removing un-transformed MTT reagent, 100 µl of DMSO was added to dissolve the formazan crystals formed. Amount of formazan was determined by measuring the absorbance at 540 nm using an ELISA plate reader. [Khazaei S, et al., 2017]

2.4. Morphological analysis

The variations in the morphological characteristics of the MCF-7 cells after treatment with EEPZ at varying concentrations (100-500 µg/mL) was observed under light microscope at 20X. Images were captured and examined after cells were treated with EEPZ incubated for 24 hours.

2.5. Acridine Orange and Ethidium Bromide Dual Staining Studies:

Using MCF-7 Cell, 25 µL (approx. 1 $\times 10^5$ cells) of treated and untreated cells were taken separately in a micro centrifuge tube and stained with 5 µL of AO-Et Br (acridine orange and ethidium bromide) for about 2 min followed by gentle mixing. Place 10 µL of cell suspension onto a microscopic slide, covered it with a glass cover slip and examined it with a fluorescence microscope using a fluorescein filter. Dual staining was examined under a fluorescent microscope. [Chen Q, et al., 1998]

2.6. ASSAY OF LACTATE DEHYDROGENASE:

The cells (1×10^6/ml) were seeded and treated with various concentration of EEPZ for 24 hours in 37ºC in a 5% CO2. The cell's suspended media was collected. 0.1 ml of suspended media, 1.0 ml of buffered substrate were added to the tubes and incubated at 37ºC for 15 min. The incubation was continued for another 15 min, after adding 0.2 ml of NAD+ solution. The reaction was arrested by the addition of 1.0 ml of 2, 4-DNPH reagent and allowed to incubate for 15min at 37ºC. To the blank, 0.1 ml of suspended media was added after arresting the reaction with 2, 4- DNPH. Now 7.0ml of 0.4

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N sodium hydroxide solution was added and the color developed was measured at 420nm in a UV-spectrometer. [Malaviya, et al., 2014]

2.7. STATISTICAL ANALYSIS:

The findings were analyzed by SD+/- mean and they were subjected to Non-linear regression, One-Way ANOVA, in PRISM program version 9.3.1.(Graph Pad Software Inc, USA).

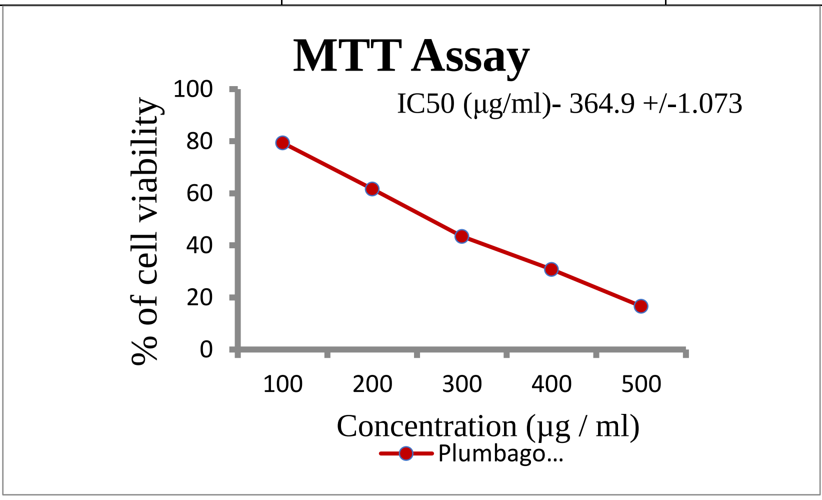
3.RESULT:

3.1.MTT assay for cytotoxicity assessments:

The MCF-7 cells were exposed to varying concentrations of EEPZ for 24 hrs and the cytotoxicity was measured by the MTT assay. The cytotoxic profiles are displayed in Figures 1, and the half maximal inhibitory concentration (IC50) values are presented in Table1 & Graph1. The addition of EEPZ to the cell culture medium exhibited a moderate cell killing effect. Results are statistically significant ($P < 0.005$). It shows that the exposure of different concentrations of EEPZ for 24hrs resulted in decreased cell proliferation in a dose dependent manner when compared with control cells.

Table 1: *In vitro* Cytotoxic activity of *EEPZ* Treated MCF-7 cells after 24 h of exposure

	Concentration (µg / ml)	% of Cell Viability
Plumbago zeylanica (Ethanolic extract)	100	79.39
	200	61.74
	300	43.48
	400	30.86
	500	16.64
IC 50	-	364.9 +/-1.073
R2	-	0.9767



Graph 1: *In vitro* Cytotoxic activity of *EEPZ* Treated MCF-7 cells after 24 h of exposure

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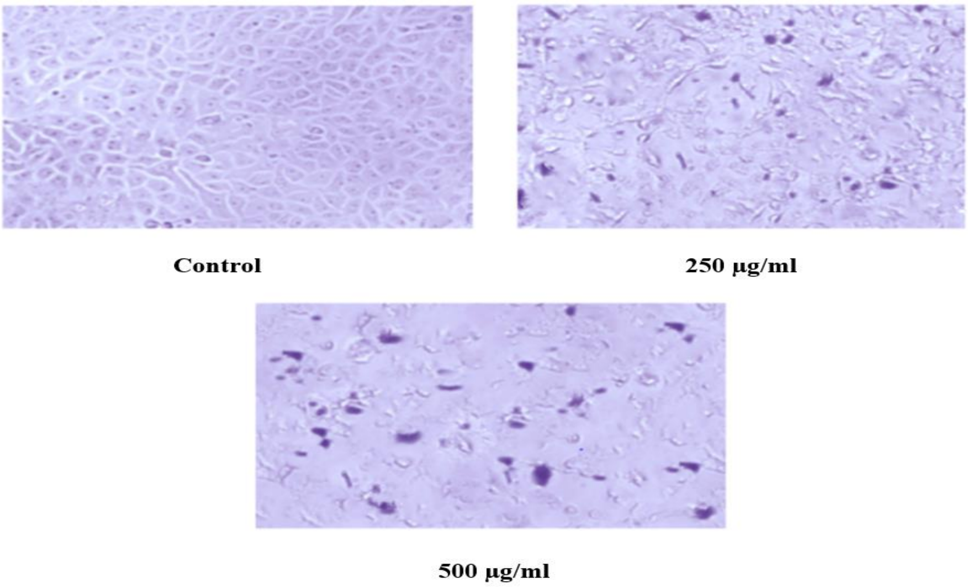
3.2. Morphological study:

In this study, light microscopic observation of the MCF-7 cell treated with EEPZ showed typical morphological features of marked cell death, cell shrinkage whereas control cells observed to be normal. It is represented in Fig1.

Fig1: *In vitro* Cytotoxic activity of *EEPZ* Treated MCF-7 cells after 24 h of exposure



3.3. Acridine Orange and Ethidium Bromide Dual Staining Studies:

The fluorescent microscopic picture of control and *EEPZ treated* MCF-7 cells at the concentration of 250 and 500 µg/ml after 24 hrs of exposure are represented in Fig 2. In the present study, normal live cells were appeared bright green in colour whereas *EEPZ* treated groups of apoptotic nuclei of dead cells appeared bright orange. In addition to this, normal nuclei show chromatin with an organized structure, while apoptotic nuclei show highly condensed chromatin in MCF-7 cells.

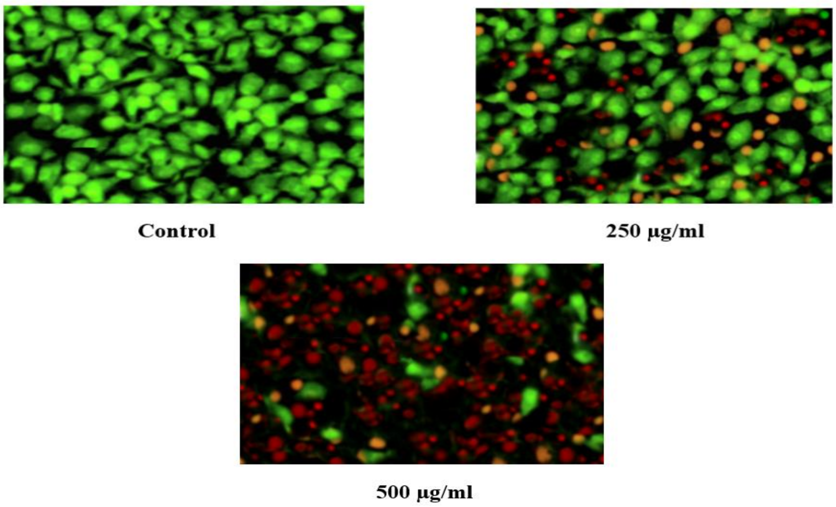


Fig 2: Fluorescent microscopic picture of MCF-7 cells after 24 hrs of exposure

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3.4. Lactate dehydrogenase Assay:

Lactate dehydrogenase is an enzyme that involved in the energy production mechanism. The elevated LDH indicates the tissue damage. So, the percentage of LDH leakage are measured. The 24hour MCF-7 cells treated with EEPZ are elevated more percentage of LDH when compared to control cells. The graph2 indicates the tissue damage takes place high level in 24 hours of MCF-7 cells. The half maximal inhibitory concentration (IC50) values are represented in Table2.It also shows significant of $P < 0.005$.

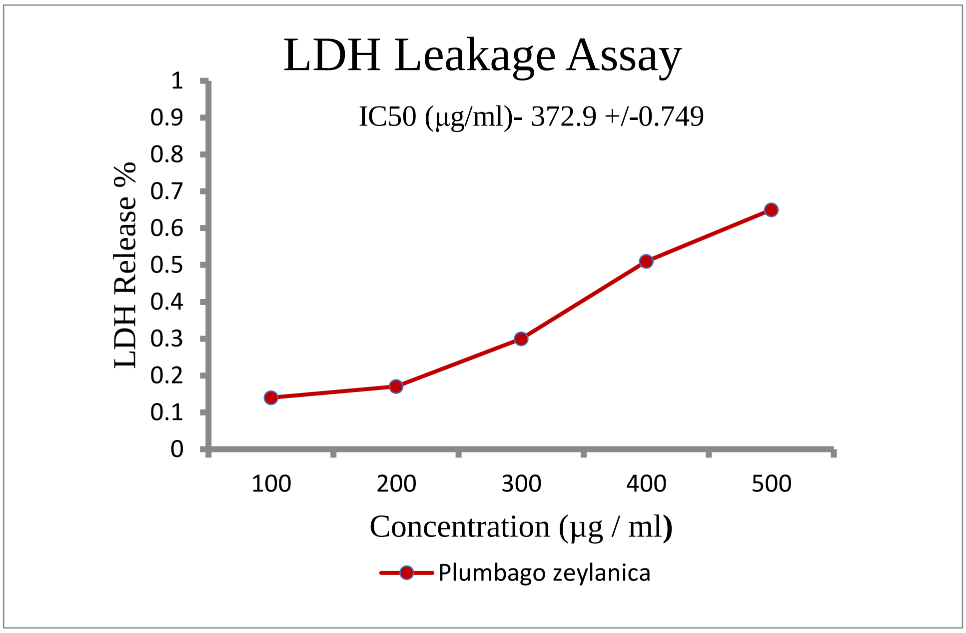
Table2: LDH Leakage in control and *EEPZ* Treated MCF-7 cells after 24 h of exposure

	Concentration	LDH activity (µ mol of NADH / per well / min.)
Control	-	0.12 ± 0.003
DMSO	1% (v/v)	0.13 ± 0.007
Plumbago zeylanica (Ethanolic extract)	100 (µg / ml)	0.14 ± 0.007*
	200	0.17 ± 0.01*
	300	0.30 ± 0.02*
	400	0.51 ± 0.02*
	500	0.65 ± 0.02*

Each values represents mean +/- SD

* P < 0.005 Vs Control

IC50 (µg/ml) - 372.9 +/-0.749



Graph2: LDH Leakage in control and *EEPZ* Treated MCF-7 cells after 24 h of exposure

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4.DISCUSSION:

Medicinal plants are used to treat a variety of human ailments and also have a part in healing. A wide range of plants and their separated compounds have been found to have anticancer activity. They are a valuable source of novel cytotoxic agents and continue to play a better part in health concerns [Sun YF, et al., 2013]. Phytochemicals derived from medicinal plants are thought to be promising medicines for the clinical treatment of breast cancer [Maurya, et al., 2010]. These phytoconstituents acts against cancer cells by suppressing the development and progression, as well as blocking the onset of the carcinogenic process [Bacanli, et al., 2017]. PZ, one of the medicinally important plants of Plumbaginaceae family contains higher concentration of various bioactive phytoconstituents. It has also been documented for its beneficial effects against various types of cancers. This study was carried out to screen the in vitro cytotoxic effects of Ethanolic extract of PZ against human breast carcinoma cell line (MCF-7).

The anticancer activities of EEPZ were measured by using MTT assay, morphological analysis, Fluorescence microscopic view, DNA fragmentation and LDH measurement. MTT assays were utilized in this investigation because they are simple, reliable, and sensitive, and they have been used to assess the cytotoxicity and anticancer effects of plant extracts [Tihauan, et al., 2020]. It is a colorimetric assay that assesses the reduction of mitochondrial succinate dehydrogenase and form formazan product. The cells are then solubilized and quantified using spectrophotometry. MTT can only be reduced in metabolically active cells, the level of activity is a measure of the viability of the cells [Kothai Ramalingam, et al., 2021]. In this study, EEPZ showed depletion of cell viability which in turn states that the cells are degrading in the presence of EEPZ. Thus, results promising cytotoxic activity in a dose-dependent manner. Morphological observations revealed the proportion of dead cells and type of cell death. The findings demonstrated that the morphological changes observed after cell death were consistent with cell apoptosis characteristics. [Yazan, et al., 2011; Liang, et al., 2014].

From our observation, EEPZ treated MCF7 cells shows cell death which were consistent with cell apoptosis. Thus, EEPZ induce apoptosis in MCF7 cells and leads it to death. To better understand the mode of cell death, researchers used fluorescence microscopy. After 24 hours of treatment with MCF7, the cell displayed typical morphological changes which indicates the hallmarks of apoptosis, including nuclear degradation, as evidenced by Acridine orange and Ethidium bromide staining [Khazaei S, et al., 2017]. In this study, EEPZ treated MCF7 cells shows degraded nucleus which results from apoptosis. Thus, EEPZ trigger the apoptosis in MCF7 cells which leads to cell death. LDH, a cytoplasmic enzyme released when the cell membrane deteriorates, is measured in cell culture supernatants [Saad B, et al., 2006]. Our result shows the significant increase in LDH which indicates the cell membrane degradation.

Thus, EEPZ involves in the membrane degradation process. [Sharma, et al., 2015]. From the results of the present study, PZ have high potential activity against cell proliferation and possess

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anticancer activity. Hence, also be used as sources of potent agents for anticancer drug development [Paras Jain, et al., 2016].

5.CONCLUSION:

Plumbago zeylanica is a potent herb with numerous therapeutic properties. From the study it could be concluded that Plumbago zeylanica has great cytotoxic effect against MCF-7 cells which has been analysed using MTT, LDH leakage assay and morphological studies. It could be used as sources of potent agents for anticancer drug development. As such Plumbago zeylanica could be further investigated for its detailed analysis on antineoplastic effects and the mechanism of growth inhibition. It can be integrated into conventional medical practice for the breast cancer treatment.

6. CONFLICT OF INTEREST:

While analysing biological activity in *Plumbago zeylanica,* we understand that it has an impressive beneficial medicinal activity, being an excellent remedy in treatment of numerous diseases. So, in future we suggest that the analysis in separating out potent bio active compounds from the plant extract and study the detailed in vivo anticancer activity which will be helpful in modern therapy.

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A Review of Honey Bees and Positive Externality to Attain Social Optimum in India

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This study describes a positive externality in detail: beekeepers raise and care for bees in order to harvest and market honey to the broader population. They are players in the market for honey. In order to make honey, bees must travel around and pollinate plants, enabling them to flourish. This is quite beneficial for people who grow vegetables and flowers for a living. If bees weren't there, these vegetable and flower farmers would have to develop hybrid plants that self-pollinate or manually pollinate their plants, which is an incredibly labor-and time-intensive process. These are both costly undertakings. The existence of bees is actually necessary for these businesses to survive; without them, the cost of their goods would increase, and the advantages of bee pollination are known as spillover effect and the additional advantage received by farmers who grow nearby fruits and vegetables must be fairly distributed by rewarding beekeepers for safeguarding biodiversity and agricultural output, which ensures food production in the direction of achieving societal optimum.

Introduction

Pollination makes a very significant contribution to the agricultural production of a broad range of crops, in particular fruits, vegetables, fibre crops and nuts (e.g. Levin, 1984; Costanza et al., 1997; Gordon and Davis, 2003). For instance, the value provided by the pollination service with respect to US agriculture alone is estimated at between US$ 6 and 14 billion per year (Southwick and Southwick, 1992; Morse and Calderone, 2000). In India 50 million hectares of land is under bee dependent. One hundred and fifty million colonies are needed to meet this, at the rate of 3 colonies per hectare. In India at present, there are only 1.2 million colonies exist

Crops benefited by bee pollination are **almond**, apple, apricot, peach, strawberry, citrus and litchi, Cabbage, cauliflower, carrot, coriander, cucumber, melon, onion, pumpkin, radish and turnip, Sunflower, niger, rape seed, mustard, safflower, gingelly, Lucerne, clover.

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Sl. No	Crops	Yield increase (percent)
1	Mustard	43
2	Sunflower	32-48
3	Cotton	17-19
4	Lucerne	112
5	Onion	93
6	Apple	44

Some production has accidental benefits to society. Thus, producing more of these products is better. If the firm, which is the origin of the positive effects, were rewarded for these spillovers, then it would do more. Without the reward, the market amount of the activity is too low. By accounting for the extra benefits, we can find the optimal amount, which occurs at a higher price for the firm, and everyone is better off.

Methodology

A deadweight loss is a $-cost to society, that is created by market failure, when supply and demand are out of equilibrium. In this case, the reduction in social efficiency arises from a lower amount of social costs as compared to private supply costs. the prominent change observed with honey bee pollination in the flowering stage of crops the producer of bees not compensated for increased crop yield . The yield increases due to pollination always above 10 percent which guarantee the profit maximize which can be compensated to honey bee growers.

$$SMC(Q) = MC(Q) - MEB(Q)$$

$$DWL = \frac{[P^M - SMC(Q^M)](Q^* - Q^M)}{2}$$

Marginal social cost reflects the impact that an economy feels from the production of one more unit of a good or service.

Results

The main objective of this paper to show the relevant literature that contributes to the benefits and effects of pollination by insects with special regard to honey bees. The canonical example of a positive-producer externality is beekeeping. As bees produce honey, wax, and other bee-related products sold in the market, they also pollinate plants in the area, improving the biodiversity, agriculture, and the

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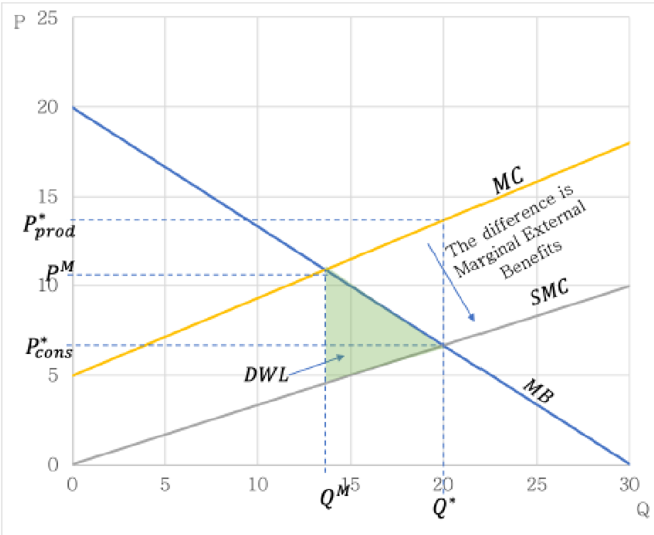
aesthetics that we get from looking at plants. The pollination services are so valuable that a new market evolved: payments for pollination, which rewards the beekeepers and increases quantity produced toward the social optimum. Another positive externality occurs with research and development (R&D); as firms gain knowledge and create new technologies, the information and benefits of their discoveries can spillover into other markets.



The number of colonies of honeybees required per hectare very much depends on the strength of foraging bees in the colony, the crops and prevailing weather conditions. The optimum number of colonies of average strength may range from 3 to 9 colonies per hectare, since the bees usually forage within a radius of about 1 to 2 km to harvest their nectar and pollen loads, and then return to their own hive.

Conclusion

Bee pollination provides a wide variety of benefits to humanity, contributing to food processing, raw materials, medicines, fibers, social, cultural values, and the maintenance of biodiversity and environmental protections. Bees' pollination has direct effects on the profitability and productivity of a substantial amount of global crop varieties, including most vegetables, seeds, and nuts, and some high-value agricultural products, such as coffee, cocoa, and rapeseed. Currently, 5–8% of all global crop production would be lost without the pollination services provided by bees, necessitating changes in the human diet and the expansion of agricultural lands to resolve shortfalls in crop production. Bees are facedwith many challenges that can distort their lives, including shifts in land use, climate change, pesticides, genetics and cultivation management.

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Desk Research on Water, Soil & Troposphere Pollutants for Eco Friendly Environmental Researchers

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Abstract

Substances of foreign origin are called pollutants, plays a main part in alarming health hazards. The essentiality of Water is being used without considering the dreadful contaminants. Arsenic, the most potential and dreadful element is always ignored whenever there is a need for purification of water for the purpose of drinking. Rehabilitation of any affected area in view of health issues is highly mandatory as per the international provisions of Environmental legislations. In this work, we have tried to identify the potential pollutants, their sources and contamination limits toward hazardous health effects.

Keywords: Pollutants, Toxicants, Turbidity, Inorganic, Organic, Acidity and Alkalinity.

1. INTRODUCTION

Natural Water always mingles with many a dissolved organic and in organic matter due to its pathway through rock, soil and environment.

1.1 Inorganic materials in natural water

Sea water contains higher salt level (35grm / liter) than that of Rain water that contains only traces of dissolved matter like oxidized forms of sulfur, Nitrogenous toxicants from fuel combustion and Vegetation.

1.2 Organic materials in water

Organic contaminants get purifies when it is passing through the ground water system. Main souses of organic pollutants are live organisms, decomposing matter, drainage, industrial pollution and atmospheric fall out.

1.3 Dissolved Organic substance

This is the source of biological pollution such as proteins, Amino acids, Fats, Lignin, sugar, chlorophyll etc. These are drawn from natural and synthetic compounds (pesticides), decaying plants and animals.

1.4 Standards of water pollutants

Parameters describing Natural Water Quality involve many a factor. Different territories have different standards and factors in deciding the natural water quality. European system uses about 64

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factors while rules established by Polish require only 51 factors in deciding the natural water quality. The stringent rules as framed by Environmental Protection Agency (EPA 1995) do require around 120 factors.

1.5 Indication by Colour of water

Colour of water is the better indicator of toxic contents that is mostly due to stains from textile industrial waste. Apparent colour indicates dissolved particles in colloidal state and dissolved platinum (Potassium Hexa - Chloro platinum IV - K2PtCl6) along with complex of Cobalt.

1.6 . Various techniques to determine pollutants in water.

Photometry

This is a technique of light measurement using principle of absorbance of light by liquid. The photo detector is placed on one side of the sample solution when a monochromatic light is passed through the other side. The light absorbed by sample is calculated based on Beer-Lambert's law. Appropriate wavelength filters are suggested based on colour of the sample. Based on the absorbance of light, the amount of ingredients can be determined.

Coagulation and sedimentation

By coagulation and sedimentation of pollutant particles using alum the levels of toxic ingredients can be determined by analytical methods of analysis on sediment.

Turbidity

Turbidity is the principle of measurement of scattered light by turbid solution to determine the quantity of elementary and complex contents in the sample. Turbidity in water is due to the suspending organic and inorganic particles, staining complexes of aluminum, manganese and iron, Zooplankton and tiny life forms like pathogenic bacteria and Clay particles. Acceptable turbidity of drinking water is from 20 to 50mg / dm3.

Sources of pollutants in water.

- Suspended solids
- Colloidal & Dissolved
- Dry residues
- Inorganic chemicals can affect taste but not cause any odor
- Inorganic chemicals usually affect both taste and odor
- compounds are detectable @ extremely low concentration
- Organisms most often linked with taste and odor
- Rust
- Plant Fibers &
- Algae and
- Are – an indicator of bacterial or
- Hazardous contamination (filtration)

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Colloidal & Dissolved

Dry residues

- Is a residue left after evaporation of water (drying in 105 ^{0}C)
- Mass of dissolved and insoluble inorganic and organic substances.
- Taste and Odor

Inorganic chemicals (pollutants) can affect taste but not cause any odor

- Salt (NaCl)
- Minerals and
- Metals
- Iron
- Zinc
- Manganese and
- Copper

Inorganic chemicals usually affect both taste and odor

- Humic substances
- Hydrophilic Acids,
- Carboxylic Acids,
- Peptides,
- Hydro Carbons,
- Biological Decay Products,
- Petroleum Products and
- Pesticides

These compounds are detectable @ extremely low concentration

- Chlordane
- Dichlorobenzene
- Trichloroethylene
- Phenol
- Chloro Phenol
- Hydrogen Cyanide

Organisms most often linked with taste and odor problems

- Actino myocytes and
- Various types of algae
- Aquatic organisms such as
- Protozoa and

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- Fungi

Earthy musty tastes and odors are produced by

- Cyanobacteria (Blue – Green Algae)
- Actino myocytes and
- Few Fungi

Growing algae produce numerous volatile & Nonvolatile organic Substances

- Aliphatic alcohols
- aldehydes
- Ketones
- Esters
- Thioesters and
- Sulphides

Occasionally, taste and odor problems in water are caused by

- Other Bacteria
- Fungi
- Zoo plankton and
- Nemathelminths
- Ferro bacteria
- Some species of pseudomonas

Sulphur – containing amino acids

- Hydrogen Sulphide (H_2S)
- Methyl thiol and
- Dimethyl ploy sulfide
- (H2S decomposition of sulphide minerals + CO2)
- Physicochemical Parameters
- pH (ranges from 0 to14).
- Acidic water is highly corrosive

Table 2.1: pH Value of different type of Water

Type of Water	Values in pH
Surface Water	6.5 – 8.0
Ground Water	5.5-7.5
Acid Rain	< 3.0
Drinking water	6.5 – 8.5

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Temperature of surface water depends on

- Water origin
- Climatic Zone
- Season
- Altitude
- Degree of riparian Coverage
- Inflow of Industrial (Power plants, Industrial Cooling) and
- Municipal Sewage
- Temperature can exert great control over aquatic, communities,
- Especially influence on biological activity and growth.
- An increase of 10 ^{0} C in water temperature almost doubles the speed of chemical and biological reactions Occurring in water.
- Temperature increase leads to
- Decrease the amount of dissolved oxygen (DO).
- Increase biochemical Oxygen Demand (BOD)
- Acceleration of Nitrification and Oxidation of ammonia to nitrates III and V which leads to Oxygen deficit in water.
- High Temperature increases

Toxicity of many substances (Pesticides, heavy metals a susceptibility organism to toxicants)

- Organisms (including fish) are also sensitive to temperature
- Acceptable temperature of water in Poland is 22 ^{o} C to 26 ^{o} C (Surface water)

Alkalinity

- Refers to the capability of water to neutralize acids
- Basic species responsible for alkalinity in water are
  - Bicarbonate ion
  - Carbonate ion and
  - Hydroxide ions
  - Calcium Carbonate or
  - Magnesium Carbonate (Compounds)

Minor contributors to alkalinity

- Ammonia and
- Conjugate bases of
- Phosphoric,
- Silicic,

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- Boric and
- Organic Acids

Alkalinity often related to hardness of water because, the main sources of

- alkalinity is usually from
    - Carbonate rocks (lime stone), mostly $CaCO_3$
    - Sodium Carbonate and
    - Potassium Carbonate (do not contribute to hardness)
- **Alkalinity (as well as pH)** can be determined using inexpensive test strips.
- More sophisticated electromagnetic measurement is performed by Computer
- Aided Titrimeter (CAT) and the pH electrode Alkalinity is important for
    - Fish and
    - Aquatic life (best functions @ pH range of 6.0 to 9.0)
- Acidity of natural water system is the capacity of the water to neutralize
- **hydroxide ions (OH-)**
    - Acidity is due to presence of weak acids such as,
    - $H_2PO_4^-$
    - H_2S
    - Proteins
    - Fatty Acids and
    - Acidic metal ions particularly Fe^{3+}
    - Originate from atmosphere
    - Co_2
    - Soil (Co_2 and humic acids)
    - H_2SO_4 and HCl in water
    - Hydrated metal ions
    - Pickling liquor (to remove corrosion from steel)
    - Acidic metal ions
    - Excess of strong acids
    - Conductivity is a measure of the capacity of an aqueous solution to carry an
- **Electric current**
    - Conductivity depends on the presence of ions
- **Cations (+) And anions (-) in water**
    - Their total concentration
    - Mobility and valence
    - And on temperature of water
    - Conductivity good with amount of salt in water

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- Calcium,
- magnesium,
- sodium,
- Potassium,
- Carbonate,
- Bi-Carbonate,

- Sulphate,
- Chloride,
- Nitrate
- and others
- It is commonly used to determine salinity
    - High Salinity interfere with growth of aquatic vegetation
    - Salt decreases the osmotic pressure
    - May cause leaf tips
    - Marginal leaf burn,
    - Bleaching or
    - Defoliation
    - Hardness
- **Cations of Ca2+**
- **Mg2+ (Magnesium), iron Fe3+ and Mn2+ (Manganese)**
- **Dissolved Oxygen (DO)**
- Volume of oxygen present in water
- Basic indicator of ecosystem health
- **Bio Chemical Oxygen Demand (BOD)** is a measure of the quantity of

Oxygen consumed by

- Micro Organisms during decomposition of organic matter
- BOD indicates poor water quality
- **Chemical Oxygen Demand (COD)** is the amount of oxygen required for degradation of the organic compounds of waste water to occur
- Potassium Permanganate ($KMnO_4$)
- Potassium Dichromate ($K_2Cr_2O_7$)
    - Mercury Sulphate ($HgCl_2$) n or $HgCl_4$
    - Carbon dioxide (CO_2) is present in air the atmosphere and all kinds in natural water are
    - $CaCO_3$
    - Mg ((OH) $_2$)
    - Chlorine Present in water is toxic for living organisms

- In elemental form does not exist in natural water
- Sewage undergone
- Chlorination with
- Chlorine or
- Chlorinated compounds

- **Ammonium Nitrate**
- Presents in water reaction will lead to chloramines NH_2Cl, $NHCl_2$,
- **NCl_3**
  - Chlorine causes Oxidation of Iron II compounds
  - Manganese II
  - Nitrates III
  - Sulphides and
  - Sulphates (IV) and forms
  - Aliphatic and
  - Aromatic chloro-derivatives
- **Chlorides**
- HCl
- AgCl
- **Sulphur**
  - In natural water, sulphur is present in the form of dissolved
  - Hydrogen,
  - Sulphide ,
  - Hydrogen Sulphides (HS-) or
  - Soluble and insoluble sulphides S2-
- **Sulphates**
  - Sulphates VI commonly occurs in natural waters
  - Sulphates rarely present in natural water
  - Sulphates are least toxic anions
  - Health disorder to occur (diarrhea type symptoms)
  - Bitter taste
- **Silica**
  - ColloidalSiO2,
  - Silica metal compounds like
  - Na2SiO3,
  - Ca2SiO3,
  - Mg2SiO3,

- K2SiO3 and
- Poly nuclear Silicate species such as
- Si4O6 (OH) 62-or
- Silicic acid H4SiO4
- Sources of silica (in water)
- Sodium feldspar albite (NaAISi3O8)

- **Calcium**
  - Cations found in most fresh water system, has highest concentration
  - Different mineral forms of $CaCO_3$
  - $CaSO_4$. $2H_2O$
  - Anhydrite,
  - $CaSO_4$
  - Dolomite
  - CaMg (CO_3) and
  - Calcite
  - Aragonite
- **Magnesium**
  - Mg like Calcium is a compound commonly found in natural water presents as Mg2+ ion Main source
  - Dolomite,
  - Mg (CO_3) $_2$
  - Mg2+ similar properties of Ca2+
- **Sodium**
  - Main sources of sodium in natural waters are
  - Hydrolytic decomposition of magma rocks
  - Presents in the form of
  - Nacl - Sodium Chloride
  - Sulphates (Na_2SO_4)
  - Salts of Carbonic Acid ($NaHCO_3$, Na_2CO_3) or
  - Nitrates ($NaNO_3$)
  - Well soluble in water
  - Sodium hydrocarbons – Hardness
- **Potassium**
  - Main sources of potassium in natural waters are hydrolytic decomposition of magna rock
  - Erosion of sedimentary rocks (mineral matter as feldspar KAISi3O 8
  - Due to weathering

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- Forest fire runoff
- Municipal, industrial and agricultural sewage
- Potassium Chloride (KCl) rarely in the form of Sulphates
- K 2SO 4
- Salts of Carbonic Acid (KHCO3, K2CO3) or
- Nitrates (KNO3)
- All are very soluble in water

- **Aluminium**
  - Al ions Al_3+ weak solubility, lower concentration in water
  - Sources industrial sewage etc.
  - Corrosion of aluminum tanks and
  - Water treatment process
- (coagulation) with the use of alum
  - $(Al_2(SO_4)_3)$
  - Aluminium salts are harmful to humans
- Microbiological Parameters
- **Decease – causing (Pathogenic) organisms** including
  - Bacteria
  - Viruses
  - Protozoa
- Water has been polluted with feces of humans or other warm blooded animals
  - Coli count Coli bacteria count present in water
  - Faucal Coliforms Indicates the presence of pollutions from animal or human feces
  - Raw sewage or
  - Untreated river water contains high levels of these bacteria
  - Chlorine used in water treatment process kill these bacteria
- Parameters concerning substances undesirable in excessive amount
- **Nitrates**
  - Some studies have shown that there may be a relation between the presence of nitrates in water and
  - gastric cancer methemo globinemia, which in case infants are often referred to have
  - blue baby syndrome.

Nitrites Nitrite NO_2

- can be organic or
- inorganic origin

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- **Ammonia**
  - Organic origin
  - Easily under goes nitrification
  - Pollution if excess use of ammonia fertilizers, atmosphere and sewage
  - Ammonia is toxic for aquatic organisms
  - Increase body pH
- **Total Organic Carbon (TOC)**
  - Carbon enters bio sphere during photo synthesis
  - $Co_2 + H_2O$ □ $C_6H_{12}O_6 + O_2 + H_2O$ and
  - Is returned to the biosphere in cellular respiration
  - $O_2 + H_2O + C_6H_{12}O_6$ □ $Co_2 + H_2O$ + energy
- **Hydrogen Sulphide**
  - Inorganic origin –
  - bio chemical decomposition of plant and animal proteins
  - Gives nuisance rotten egg smell and taste
  - Presence in drinking water known to cause nausea, illness and in extreme cases death
- **Iron**
  - Main sources of Iron in natural water is erosion of minerals from rock sand soil
  - Sewage from metallurgical dyeing and galvanizing plants, erosion pipelines etc.
  - Fe II and Fe III
- Essential nutrition for blood formation
- Large quantities in water cause turbidity
- Yellowish colour and an unpleasant taste
- **Manganese**
- Mn^{2+}, Mn^{4+}
- Source – Magna rock and sedimentary rocks
- $MnO_2 . H_2O$ □ and its further sedimentation
- **Phosphorus**
  - Anions of Orth phosphoric acid
  - H_3PO_4,
  - $H_2PO_4^-$
  - HPO_4^{2-}

are predominant in normal water pH range also

- present as organic phosphorus
- Phosphates some time added to drinking water to reduce corrosion

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- precipitation of certain compounds
- **Fertilizer runoff form** agricultural human activity erosion of rocks (also mining) with
- domestic waster due to use of detergents industrial waste
- result of decay organic matter (plants and animal's origin)
- Copper
- Fluoride
    - Present in minerals soils and naturally found in natural waters
    - Industrial sewage agricultural runoff and due to burning of coal
    - Fluoride in drinking water, leads to a substantial reduction of dentalcavities
    - Harmful to bones and teeth
- Dissolved in emulsified hydro carbons mineral oils
- Crude oil is a complex mixture of hydro carbons (90% Carbonatoms)
- Minor properties of Sulphur,
- Nitrogen and
- Oxygen
- **Phenols**
    - Phenol,
    - O-cresol,
    - M-cresol, P-cresol,
    - I-naphtol,
    - Hydrochinon and
    - Chlorophenol
    - Phenols are easily bio degradable substances, unless they are in
- Concentrations of toxic for micro organisms
- Acute Toxicological effects of phenol, effects central nervous system and death can occur as soon as one half hour after exposure cause
- Severe gastrointestinal, disturbances, kidney mal function, circulatory
- system failure, lung oedema convulsions
- **Surfactants** (surface active agents)
    - Synthetic detergent – component
    - 2 groups - Hydro phobic or
    - Hydro philic (water liking)
    - Harmful aquatic environment – fish, plankton, plants, human as well (higher concentration)
    - Parts of surfactants containing phosphates and poly Phosphates

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- **Trihalomethanes (THMs)**
  - Group of 4 chemicals
  - Parameters concerning toxic substances
  - Affected by those toxicants can have serious influence on the aquatic ecosystems
  - and unsuitable for human consumption Causes of cancer,
  - such as carcinogenic substances,
  - exposure to irrigation and viruses and internal factor,
  - lowering of immune functions caused by
  - heredity,
  - agedness and
  - change in life style
  - According to report from World Health Organization (WHO) 35% of carcinogenic substances are derived from food and drinks and
  - 30% are from smoking as the IInd rank
- **Heavy Metals**
- **Arsenic (III & V)**
- Low concentration of Arsenic in drinking water – higher incidence of lung or bladder cancer
- **Cadmium**

  There is permissible acceptable concentration by WHO
- **Chromium**

  There is permissible acceptable concentration by WHO
- **Lead**

  Excess quantity of lead may impact human health
- **Cyanides**

  Cyanide is a deadly poisonous substance which exists in water as **HCN** (Very Weak Acid)
  - Used in Industry for metal cleaning and electro platting
  - **Cyanide** in water is indicative serious pollution problem
- **Selenium**
  - Naturally occurs in earth's crust- found in sedimentary rocks
  - Selenium in rocks combined with
  - **Sulfide** minerals or with
  - **Silver**
  - **Copper**
- **Lead** and
- **Nickel** minerals
- **Inorganic form**

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- Different oxidation states
- II selenide
- Elemental Selenium
- +IV Selenite SeO_3 2-
- VI Selenate SeO32-
- **Organic form**
    - Organic compounds and Methylated derivatives (used differs from their nutritional and toxic impact)
    - Less toxic form – volatile methylated selenium compounds –
    - DimethylSelenide (DMSe), Dimethyldusekebude (DMDSe).
- **Radio active compounds**
    - Radio Activity is spontaneous
    - nuclear transformation of nuclide into another nuclide – by emission of nuclear radiation
    - Natural radio activity is caused by 226Ra, 222Ru, 239U, 230th, 210Pb, 40K and
    - Isotopes from atmosphere 3H and 14C
    - Acquired radio activity caused by water pollution with radioactive
- **Isotopes**

  90Sr, 89Sr, 90Y, 91Y, 131I, 132I, 137Cs, 141Cs, 144Ca, 32P

- **Radio Isotopes found in Sewage**

  24Na, 32P, 40K, 60Co, 85Zn, 90Sr, 131I, 137Cs
- **Mercury**
- **Most toxic Isotopes**

  90Sr, 90Y, 210Pb, 210Po, 226Ra, 238U
- **Persistent Organic Pollutants (POPs)**

  PAHs, PCBs (include 200 different compounds in water environment, 60were determined)
- **Pesticides**
    - 3 Groups
    - Insecticides
    - Herbicides
    - Fungicides
- **Di Oxins**

  In Industrial Sewage.

Key Water Facts

Aquatic species ceases every year due to increased toxic pollutants from river following into the bay. A study from 1983 to 1993 showed a reduction of aquatic species from 840% to

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75%. About 85% of the total pollutants by the rivers are flowing into the bay. Rivers clutch 90% of the earthly source of contaminants and nutrients into the Bhai Bay. Since 1990 up to2010 worsening of sea water quality both the extent of pollution and affected are increased continuously. In Singapore, recycling the unwanted used (polluted) water into purified drinking water as New Water. Assessment of waste water recycling in Kuwait and its blow on amount of pollutants released into the ocean. Kuwait has recently implemented a rigorous campaign that aims to reclaim and reuse all treated waste water and to preserve sea water quality. It has greatly reduced the number of pollutants discharged into the sea. Results showed 50% reduction in volumes to waste water discharged into the sea has been achieved from year 2000 to 2010. In the year **2020**, due to shortage of storage capacity for reclaimed waste water around **880 million** people may lack access to safe water. **About 3.6 million** people die every year due to illness originated through polluted water. Around 80 per cent of water borne casualties is in children. About 14 Percent of this casualty are due to diarrhea. On an average about **65 billion** People are at peril of **arsenic toxicities** in **India, Bangladesh, and Nepal.**

Conclusion

Earth is covered about 79% of water of which 94.2% is in oceans and only 4.13% in the ground. Arsenic was a cumulative poison claiming loss of live due to cancer, cardiac ailments and other symptoms. Research works claims that as small as 3 parts per billion (ppb) of arsenic is a dreadful weapon causing loss of life. Arsenite (As3+) is the more toxic than Arsenate (As5+). 6 kilometers is the typical distance Africans and Asians walk to carry water. 98 % of casualties arise due water borne ailments the world. Waste water reuse is restricted for agricultural applications. The Ministry of Public Works (MPW) is expected to overcome this problem to a zero discharge of waste water into the sea. Ultimate aim in future development would be rehabilitation of polluted water and reuse of waste water project implementation in Tamil Nadu, India as like in Kuwait and Singapore. Arise due water borne ailments the world. Waste water reuse is restricted for agricultural applications. The Ministry of Public Works (MPW) is aiming at nil release of waste water into the sea. Ultimate aim in future development would be rehabilitation of polluted water and reuse of waste water project implementation in Tamil Nadu, India as like in Kuwait and Singapore.

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ORGANIZED BY
SCHOOL OF AGRICULTURE
VENUE : SEMINAR HALL, ECE BLOCK / DATE : 23.10.2024
GUEST SPEAKERS
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Former Dean, TNAU.
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Special Issue on

"BEES AND OTHER ARTHROPODS: INFLUENCE SUSTAINABLE CROP YIELD"

23rd October 2024

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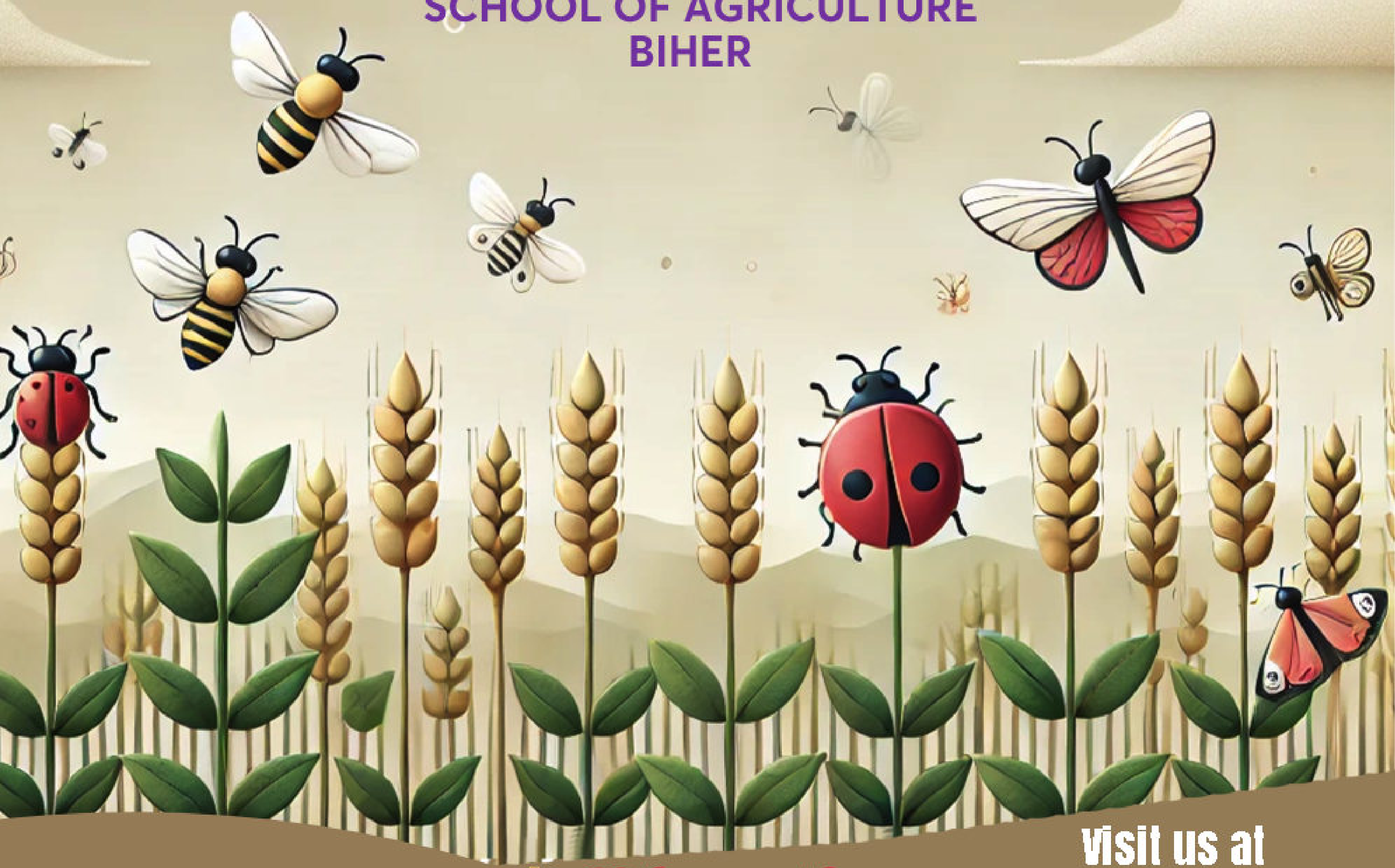

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