Miranda House

(Under the aegis of IQAC)

in collaboration with

Dyal Singh College, University of Delhi

(Under the aegis of IQAC)

ICAR-All India Coordinated Research Project on Honey Bee and Pollinators (AICRP-HB&P)

GAD-TLC, SGTB Khalsa College, Ministry of Education, PMMMNMTT, Govt of India

Organizes One-Week National Faculty Development Program
and
Training Program for Laboratory Staff

(10th October to 16th October 2023)

Abstract Book and Laboratory-Manual on Apiculture

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10th October to 16th October 2023 (Online and Offline mode)

Venue: New Seminar Hall, Miranda House

"UNVEILING APICULTURE: EXPLORING THE ART AND SCIENCE OF BEEKEEPING METHODS AND APPLICATIONS"

Key Highlights of the FDP

1. Economic Significance of Beekeeping
2. Hands on various mounting and purity testing
3. Basic Beekeeping Technique (Visit to IARI)
4. Entrepreneurship in Apiculture: Employment opportunities

Participants can be faculty members: Permanent, Ad-hoc, Guest and Laboratory Staff

Participants will obtain FDP certificate from GAD-TLC, SGTB Khalsa College, Ministry of Education, PMMMNMTT, Govt. of India.

Registration Fees: ₹ 3500 for Faculty Members and ₹ 1500 for Laboratory Staff

Limited seats available on first come first serve basis

These certificates will fulfill CAS of UGC's promotion

One-week National FDP On

"Unveiling Apiculture: Exploring The Art And Science Of Beekeeping Methods And Applications"

10th October to 16th October 2023 (Online and Offline)

CORE TEAM: UNIVERSITY OF DELHI and ICAR

Professor Yogesh Singh
Hon'ble Vice-Chancellor,
University of Delhi

Professor Payal Mago
Chairperson, SEC Committee
University of Delhi

Sr. Professor Rina Chakrabarti
Head of the Department
Department of Zoology
University of Delhi

Professor Bijayalaxmi Nanda
Principal, Miranda House
University of Delhi

Professor Vinod Kumar Paliwal
Principal, Dyal Singh College
University of Delhi

Dr. Sachin Suresh Suroshe
Project Coordinator
AICRP- HB&P, New Delhi

CORE TEAM: GAD-TLC, SGTB KHALSA COLLEGE, UNIVERSITY OF DELHI

Professor A.K. Bakhshi
Chairman
GAD, TLC

Professor Jaswinder Singh
Director
GAD, TLC

Professor Vimal Rarh
Project Head and Joint Director
GAD, TLC

Registration Link:
https://docs.google.com/forms/d/e/1FAIpQLSexnSZDSZqv3DPtONmY2t-XIffmXoatOibIgQHh65tSIrOLIg/viewform?usp=sf_link

One-week National FDP On
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10th October to 16th October 2023 (Online and Offline)

About the organizers

Miranda House

MH has a rich legacy. Established at dawn of independence it provided a unique opportunity to young women for quality higher education. They set for themselves high goals and ideals. They worked for a new society in which women would enjoy equal opportunity with men in professional and public fields. In this, they were abetted by the founding faculty who were independent minded, and belonged to the select group of highly educated women in independent India with a deep concern for quality of education they imparted. They were also charged with a spirit of adventure, steeped in idealism, and committed to women empowerment and the task of building a nation. Proud of their mission as early pioneers, they worked with single-minded devotion in setting the Miranda traditions. These attributes of total dedication have contributed in a large measure to the position of distinction occupied by the college. Over near seven decades of its existence, the college has grown from strength to strength, continuing to provide an atmosphere of high academic excellence and rich cultural activities to its students. The college has established a niche for itself amongst the globally recognized premiere.

Dyal Singh College

Dyal Singh College (University of Delhi), has a rich history rooted in the extreme generosity and foresight of Sardar Dyal Singh Majithia, the founder of 'The Tribune', Punjab University, and 'Punjab National Bank'. In 1895, he dedicated a substantial portion of his wealth to establish an Education Trust for a truly secular college. The college was first set up in Lahore in 1910 and later expanded to Karnal and Delhi after India's partition. In Delhi, it began its journey at Rouse Avenue in 1952 and later moved to its present location on October 16, 1962, where it now operates as a University-maintained institution under the University of Delhi since 1978. Dyal Singh College offers a range of undergraduate and postgraduate courses across various specializations. The college offers a wide range of undergraduate and postgraduate courses, and the eligibility criteria and selection process vary for each program. The college provides an environment that fosters academic excellence and holistic development, making it an attractive choice for students seeking quality education and diverse co-curricular opportunities.

ICAR-All India Coordinated Research Project on Honey bees and Pollinators (AICRP-HB&P)

All India Coordinated Project on Honeybee Research & Training", which was launched by the Indian Council of Agricultural Research in 1980-81. The coordinating centers of the Project started functioning at different locations under the Project Coordinating unit located at the then Central Bee Research Institute (CBRI), Pune, presently designated as Central Bee Research & Training Institute (CBRTI), Pune with an objective to coordinate, counsel and monitor the activity of cooperating centres. Besides the honey bees, there are many non *Apis* bees, insects and animals which contribute to potential yield enhancement of several cross pollinated crops. Realizing this fact the current project has been up scaled during the XIth plan period (2008-2012) with a new name as All India Coordinated Research Project on Honey bees and Pollinators in July, 2007. The Project Coordinating Unit is functioning at Division of Entomology, IARI, Pusa, New Delhi from November, 2013 with new aspiration and drive to coordinate location specific research on pollinators. Now the project has 18 regular coordinating centers and 6 voluntary centers with sanctioned strength of 26 scientists to undertake the research work over a larger agro-ecological area than before.

GAD-TLC

GAD-TLC is a leading Centre of Ministry of Education, Govt. of India under PMMMNMTT. Since 2016, it has trained more than 80,000 teachers through various FDPs, FIPs, Refresher Courses, workshops, seminars, webinars, conferences, etc. The Core Team of GAD-TLC has expertise of developing more than 50 MOOCs for SWAYAM platform of Govt. of India and the e-content produced by GAD-TLC has been rated as one of the best in quality at the National Level.

COORDINATORS:

Prof. Rita Rath Department of Zoology Dyal Singh College	Dr. Nisha Vashishta Department of Zoology Miranda House	Dr. Kumaranag, K.M. Scientist AICRP-HB&P, New Delhi

CO-COORDINATORS:

Dr. Pooja Suman Department of Zoology Miranda House	Dr. Roopa Rani Samal Department of Zoology Dyal Singh College

ORGANIZING TEAM

Prof. Neeraja Sood (DSC), Dr. Sadhna Gupta (DSC), Dr. Biji Balan (DSC), Dr. Karuna Yadav (DSC), Dr. Deepak Yadav (MH), Ms. Saba Zulfiquar (MH), Dr. Reetuaparna Basak (MH), Dr. Shivani Kumari (MH), Dr. Deepika Rani (MH), Dr. Rohit Jamwal (MH), Dr. Yasha Yadav (HRC), Dr. Pallee Shree (BCAS)

One-week National FDP On

"Unveiling Apiculture: Exploring The Art And Science Of Beekeeping Methods And Applications"

10th October to 16th October 2023 (Online and Offline)

Educational Objectives:

- ✓ A comprehensive understanding of the principles and concepts underlying apiculture, including bee biology, behavior, and ecology.
- ✓ Identification of the key components of a successful beekeeping operation, including equipment, tools, and protective gear.
- ✓ Construct and assemble beehives, frames, and other essential equipment needed for beekeeping.
- ✓ Analyze challenges and risks in beekeeping, such as disease management, pest control, and environmental stressors, and propose effective solutions.
- ✓ Compare and contrast traditional beekeeping methods with modern approaches, considering advantages, disadvantages, and ethical implications.
- ✓ The ethical considerations related to beekeeping, including the responsible use of bee products, hive management, and environmental impact.

Quality Parameters for Certification:

- ✓ Attendance and feedback is compulsory. Only 2 sessions can be taken off only in emergent situation with prior approval from GAD-TLC.
- ✓ After Qualifying in Assignments, Projects and Online Quizzes as per norms (50% or above), Certificate with Grade for CAS will be issued.
- ✓ Those who do not fulfil all requirements or do not score 50% or above, will be given certificate of participation with No grades. This cannot be used for CAS.

Eligibility

Faculty members and Laboratory staff involved in teaching UG and PG courses in Botany, Zoology, Life Science, Microbiology and Biotechnology any subject of biological sciences in various colleges are eligible to apply.

"UNVEILING APICULTURE: EXPLORING THE ART AND SCIENCE OF BEEKEEPING METHODS AND APPLICATIONS"

Titles of SECs being covered in the FDP

1. Biology of Bees
2. Rearing of Bees
3. Diseases and Enemies of honey Bees
4. Bee Economy

Learning Outcomes

Upon completion of the course, faculty should be able to:

1. A comprehensive understanding of the principles and concepts underlying apiculture, including bee biology, behavior, and ecology.
2. Identification of the key components of a successful beekeeping operation, including equipment, tools, and protective gear. Construct and assemble beehives, frames, and other essential equipment needed for beekeeping.
3. Analyze challenges and risks in beekeeping, such as disease management, pest control, and environmental stressors, and propose effective solutions.
4. Compare and contrast traditional beekeeping methods with modern approaches, considering advantages, disadvantages, and ethical implications.

Core Team @University of Delhi and AICRP

Prof. Yogesh Singh, Vice Chancellor, University of Delhi
Prof. Payal Mago, Chairperson, Skill Enhancement Courses Committee, University of Delhi
Prof. Rina Chakrabarti, Head, Department of Zoology, University of Delhi
Prof. Bijayalaxmi Nanda, Principal, Miranda House, University of Delhi
Prof. Vinod Kumar Paliwal, Principal, Dyal Singh College, University of Delhi
Dr. Sachin S Suroshe, Project Coordinator, AICRP on Honey bees and Pollinators

Core Team @GAD-TLC

Prof. A.K. Bakhshi, Chairman, GAD-TLC
Prof. Jaswinder Singh, Director, GAD-TLC
Prof. Vimal Rarh, Project Head and Joint Director, GAD-TLC

Details of Coordinators

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Details of Co-Coordinators

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Organizing Team

Prof. Neeraja Sood (DSC), Dr. Sadhna Gupta (DSC), Dr. Biji Balan (DSC), Dr. Karuna Yadav (DSC), Dr. Deepak Yadav (MH), Ms. Saba Zulfiquar (MH), Dr. Reetuaparna Basak (MH), Dr. Shivani Kumari (MH), Dr. Deepika Rani (MH), Dr. Rohit Jamwal (MH), Dr. Yasha Yadav (HRC), Dr. Pallee Shree(BCAS)

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Schedule

10th October to 16th October 2023

Day	Time	Technical Session	Resource Person
Day 1 (October, 10th 2023) (Tuesday) (Miranda House)	10:00 am- 10:30 am	Registration	
	10:30 am-11:30 am	Welcome Address: Principal, Miranda House, Professor Bijayalaxmi Nanda Address: Chairperson, Miranda House, Professor Rajni Abbi Principal, Dyal Singh College, Professor V.K. Paliwal Head, Department of Zoology, Professor Rina Chakrabarti Chairperson Skill Enhancement Course, Professor Payal Mago Vice Chancellor, Professor Yogesh Singh	

	11:30 am-12:00 noon	**High Tea**	
	12:00 noon -1:00 pm	Apiculture for Income Generation	Dr. Sachin S Suroshe Project Coordinator AICRP on Honey bees and Pollinators
	1:00 pm-2:00 pm	**Lunch**	
	2:00 pm-3:00 pm	Social Organization and Communication in Honey Bee.	Professor A.K. Singh Professor Department of Zoology University of Delhi
	3:00 pm-4:00 pm	Buzz of the Bees: Super Societies of Super Organisms	Dr. Debjani Dey Professor and Principal Scientist ICAR-Indian Agricultural Research Institute
	4:00 pm-4:15 pm	**Tea**	
	4:15 pm- 5:00 pm	**Quiz and Feedback**	
Day 2 (October, 11th 2023) (Wednesday) (Online)	10:00 am-11:30 am	Role of Biomes in Pollination Efficiency	Dr. N.K. Krishan Kumar Former Deputy Director (Horticulture), ICAR and Bioversity International's Regional Representative in South and Central Asia
	12:00 noon-1:30 pm	Ecological importance of bees with special reference to pollination and Pollinizer issues. And Pollinators Conservation	Dr. Sachin S Suroshe Project Coordinator AICRP on Honey bees and Pollinators
	2:30 pm- 3:15 pm	Interaction with Mr. Manmohan Bahel	

	3:15 pm-4:00 pm	Quality standards of honey and other hive products	Dr. Tirthankar Banerjee Principal Scientist ICAR-IARI, New Delhi
	4:15 pm- 5:00 pm	**Quiz and Feedback**	
Day 3 (October, 12th 2023) (Thursday) (Visit to Pusa campus)	10:00 am-11:00 am	Basic beekeeping techniques Basic bee equipment and accessories	Dr. Kumaranag K M Scientist AICRP-HB&P, New Delhi
	11:00 am-11:15 am	**Tea**	
	11:15 am-12:15 pm	Technologies for the production of other hive products	Dr. Kumaranag K M Scientist AICRP-HB&P, New Delhi
	12:15 pm-1:00 pm	Honey-Extraction and processing	Dr. Sachin S Suroshe Project Coordinator AICRP on Honey bees and Pollinators
	1:00 pm- 2:00 pm	**Lunch**	
	2:00 pm- 3:00 pm	Hands on Handling of bee colonies preparation of the dearth period feeding and pollen substitutes And Hands on Record keeping in Apiculture	Dr. Kumaranag K M Scientist ICAR-AICRP-HB&P, New Delhi
	3:00 pm- 4:00 pm	Honey bee species and their distribution Hands on : Identification of the different bee species of Honey bees with Taxonomic keys	Dr. Shashank P.R. Scientist ICAR-IARI New Delhi
	4:00 pm- 4:15 pm	**Tea**	

	4:15 pm- 5:00 pm	**Quiz and Feedback**	
Day 4 (October, 13th 2023) (Friday) (Miranda House)	10:00 am- 11:15 am	Case study of Apiculture Entrepreneurship- A Success Story	Mr. Jagpal Singh Phogat Founder of B-Buzz Honey
	11:15 am- 11:30 am	**Tea**	
	11:30 am- 1:00 pm	Practical's on morphological and anatomical differences in different castes of honey bees And Hands on mounting various parts of worker bee.	Professor Rita Rath Department of Zoology Dyal Singh College And Faculty of Miranda House and Dyal Singh College
	1:00 pm- 2:00 pm	**Lunch**	
	2:00 pm- 4:00pm	Hands on analysis of honey for basic quality parameters Study of bee pasturage through mounting of pollen grain	Professor Rita Rath Department of Zoology Dyal Singh College And Faculty of food technology, Miranda House and Dyal Singh College
	4:00 pm- 4:15 pm	**Tea**	
	4:15 pm – 5:00 pm	**Quiz and Feedback**	

Day 5 **(October, 14th 2023)** **(Saturday)** **(Online)**	10:00 am- 11:00 am	Bee Pasturage and Floral Mapping	Dr. C.G. Kushalappa Former Dean College of Forestry (University of Agricultural and Horticultural Sciences-Shivamogga) Kodagu, Karnataka
	11:00 am- 12:00 noon	Honey bee biology-Caste differentiation, Division of Labour	Dr. Sagar D Sr. Scientist ICAR-IARI New Delhi
	12:00 noon- 1:00 pm	Recent developments in the field of apiculture with respect to equipment, processes and policies	Dr. B.L. Saraswat Former Executive Director at National Bee Board, Ministry of Agricultural, Govt of India. DAC & FW.
	2:00 pm- 3:00 pm	Gut Microbiome of honey bees and their functional role	Dr. S.Subramanian Principal Scientist ICAR-IARI New Delhi
	3:00 pm- 4:00 pm	Retrospect and Prospects of Apiculture in India	Prof. Pradeep K Chhuneja Dean, Postgraduate Studies Punjab Agricultural University Ludhiana, Punjab
	4:15 pm- 5:00 pm	**Quiz and Feedback**	
Day 6 **(October, 15th 2023)** **(Sunday)** **(Online)**	10:00 am- 11:30 am	Role of green pesticides in protecting bees from pesticide poisoning	Dr. Suresh M. Nebapure Scientist ICAR-IARI New Delhi
	11:30 am- 12:30 noon	Role of Honeybees and other pollinators in Agriculture and Human Life	Professor Balraj Singh Vice Chancellor

			Sri Karan Narendra Agricultural University Jobner (Jaipur) Rajasthan
	2:00 pm- 3:00 pm	Government initiatives for Promoting Beekeeping sector In India	Dr. Naveen Patle Additional Commissioner, Department of Agriculture, cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhawan, New Delhi
	3:00 pm- 4:00 pm	Care and Management of bee colonies during honey flow period and dearth period	Dr. Neeraj Dr. Rajendra Prasad Central Agricultural University Pusa, Samastipur, Bihar
	4:15 pm – 5:00 pm	**Quiz and Feedback**	
Day-7 **(October, 16th 2023)** **(Monday)** **(Miranda House)**	10:00 am-11:30 am	Challenges of Woman Entrepreneur in the Indian Ecosystem	Ms. Richa Jaggi Co-founder and Chief Marketing Officer (CMO) of Awshad
	11:30 am-11:45 pm	**Tea**	
	11:45 pm – 1:00 pm	Entrepreneurship in Apiculture	Mr. Rakesh Gupta Beekeeper & Chief advisor Golden Hive Foundation
	1:00 pm- 2:00 pm	**Lunch**	
	2:00 pm- 4:00 pm	**Summary Report Assessment**	
	4:00 pm- 4:15 pm	**Tea**	
	4:15 pm- 5:00 pm	**Valedictory**	

"UNVEILING APICULTURE: EXPLORING THE ART AND SCIENCE OF BEEKEEPING METHODS AND APPLICATIONS"

Preface

Welcome to the captivating world of apiculture! This FDP is your gateway to the remarkable realm of beekeeping, offering a comprehensive guide that covers every facet of this ancient and vital practice.

Apiculture, the science and art of rearing honeybees, has been an integral part of human history for millennia. Bees, those tiny marvels of nature, have not only provided us with the sweet nectar of honey but have played a critical role in pollinating our crops, ensuring our food security.

In the pages of this book, you will embark on a journey through four distinct units, each tailored to equip you with essential knowledge and skills:

We will be delving into the intricate biology and behavior of honeybees. Understanding the lives of these industrious insects is fundamental to becoming a successful beekeeper. Building upon your knowledge of bee biology, we guide you through the practical aspects of beekeeping. Learn how to set up and manage your beehives, handle bees safely, and extract the liquid gold, honey.

Bees, like all creatures, face challenges. Explore the diseases and enemies that can afflict honeybee colonies, and discover strategies to protect and preserve your buzzing companions. And finally, we delve into the economic dimension of beekeeping. Learn how beekeeping can be a sustainable and lucrative venture, offering various products and services beyond honey.

Whether you're a novice eager to embark on your first beekeeping adventure or an experienced beekeeper seeking to deepen your knowledge, this resource material aims to be your trusted companion. Beekeeping is not just a hobby; it's a profound connection to nature's intricate web. We hope this book inspires you to join the ranks of beekeepers and contribute to the well-being of both bees and humanity.

Let's embark on this buzzing journey together!

Team FDP Apiculture

Speakers Abstracts and Biosketches

Dr. Sachin S. Suroshe

Dr. Sachin S. Suroshe is a Project Coordinator at ICAR-AICRP (HB&P), Division of Entomology, ICAR-IARI, Pusa, New Delhi. Dr. Sachin S. Suroshe did his Ph.D from ICAR-IARI, Pusa, New Delhi. Dr. Sachin has significantly contributed in the field of Biological control, IPM, Apiculture, Pomegranate and Vegetable plant protection. Dr. Sachin S. Suroshe has 20 years of research, education and extension experience in Agri. Entomology, and he has attended International and National seminars and conferences and he is a fellow and life member of many Professional Bodies/Societies. He has presented many guest lectures in national and international conferences. His field of interest is Apiculture, Biological Control, Insect Pest Management.

Dr. Sachin S. Suroshe received many prestigious awards, *viz*., DST-SERB Young Scientist-2014; SARP (Society for the Advancement of Research on Pomegranate) Associate Award-2017; Scientist Award-2019 by Dr. B. Vasantharaj David Foundation, Chennai; Outstanding Scientist Award-2020 by New Age Mobilization Society, New Delhi; NESA eminent scientist of the year award-2021 by National Environmental Science Academy, New Delhi; Best Scientist Award-2022 by the Society of Plant Protection Sciences ICAR-NCIPM, New Delhi. Dr. Sachin has 57 research articles, 3 books, 5 book chapters, 15 conference papers, 5 technical reports, 23 manual chapters, 22 extension folders, and over 50 popular articles. Currently, he is looking after the AICRP on Honey bees and Pollinator project of ICAR.

Apiculture for Income Generation

Sachin S. Suroshe[1*] and Kumarnag KM.[2]

[1]Project Coordinator; [2]Scientist, Honey bees & Pollinators, Division of Entomology, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012.

In addition to their pollination services, honey bees produce various valuable hive products *viz*., honey, beeswax, pollen, propolis, royal jelly, and bee venom. Among these, major emphasis had been on honey and to some extent on beeswax. However, hive products other than honey have garnered increasing attention in recent years. Research and development (R&D) efforts related to these hive products have gained momentum globally due to their potential economic, medicinal, and nutritional benefits. India is a major honey producing country in the world, with annual honey production being 1,33,200/- MT during 2021-22. Production technology for honey, royal jelly, pollen, bee venom, propolis and queen bee rearing have already been standardized in India under the ICAR-All India Coordinated Research Project on Honey Bees & Pollinators. However, to further increase productivity, work on genetic improvement of *Apis mellifera*, *Apis cerana, and Tetragonula irridipennis* is going on. Apiculture for bee hive products offers a wealth of opportunities for research and development, spanning from medicine and cosmetics to functional foods and biotechnology. Both India and the global community recognize the value of these hive products and are investing in R&D to harness its potential. As we continue to unlock the secrets of Apiculture for income generation, it is imperative to balance innovation with conservation, ensuring the well-being of both honey bee populations and the environment at large.

Ecological Importance of Bees with Special Reference to Pollination and Pollinizer Issues and Pollinators Conservation

Sachin S. Suroshe[1*] and Kumarnag KM.[2]

[1]Project Coordinator; [2]Scientist, Honey bees & Pollinators, Division of Entomology, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012.

Pollination is the process by which pollen is transferred from the anther to the stigma of flowers. Each pollen grain is a male haploid gametophyte, which is being transported to the female gametophyte in the process of fertilization. Pollinators are the organisms that carry pollen from the stamen to the stigma. Worldwide, more than 20,000 Apoids are responsible for pollination. More than two thirds of the world's agri-horticultural crops need a pollinator to reproduce. Pollinators contribute more than USD 200B each year through pollination services. Pollinizers are plants that serve as the source of pollen for successful pollination and fertilization. The term pollinizer is more often used in pollination management to refer to a plant that provides abundant, compatible, and viable pollen at the same flowering time as the pollenized plant. For example, most crabapple varieties are good pollenizers for any apple variety that blooms at the same time, and are often used in apple orchards for that purpose. Some apple cultivars produce very little pollen; some produce pollen that is sterile or incompatible with other apple varieties. These are poor pollinizers. A pollinizer can also be the male plant in dioecious plant species such as with kiwifruit and holly. Self pollenized plants may or may not benefit much from pollen transfer from male to female flower parts by insects or other pollinators, but in case of self-sterility or dioecious condition pollen from another cultivar or variety is highly needed for successful fertilization. Nearly all apples and most sweet cherries have separately as male and female flowers on the same plant. However, cucurbits, asparagus, kiwi, holly and gingko have separate male and female plants itself. In this case pollinators as well as pollinizers must be deployed for quality production.

Prof. Ashok K Singh

Dr. Ashok K Singh completed his graduation from Magadh University and M.Sc. from Ranchi University. He joined Delhi University for research in 1980 and awarded Ph.D. degree in 1985 on insect-plant-interaction. After Ph.D. he moved to Max-Planck Institute for Biochemistry, Munich Germany where he worked for four years on ecology of insects. He returned from Germany in 1989 and joined as Lecturer at Gaya College. Dr. Singh joined Delhi University as Reader 1992, and became Professor in 1998. He retired as Professor and Head of the Department of Zoology, University of Delhi. He discharged many academic and administrative responsibilities at Delhi University. He was Provost of Gwyer Hall, Member Academic council, Dean, Faculty of Science, Member on the Governing bodies of several colleges. He guided 28 students for the award of Ph. D. degree. He published quality research papers in reputed journals. He worked on the editorial Board of many scientific Journals. He was on the expert panel/committee of University Grants Commission, Zoological survey of India, Ministry of Environment & Forest, Indian council of Agricultural research, Department of Biotechnology, Council of Scientific and Industrial research and many universities/Boards. Prof. Singh earned reputation as an excellent teacher, having more than 40 years of teaching experience.

Social Organization and Communication in Honey Bees

Prof. Ashok K Singh
Department of Zoology, University of Delhi

Honey bees are renowned for their intricate social organization and communication systems. These insects live in large, well-organized family groups, known as colonies. Within a colony, honey bees are divided into different castes, including workers, drones, and a queen. Each caste plays a specific role in maintaining the hive's functionality, with workers being responsible for foraging, nest maintenance, and feeding the young, and while drones are primarily involved in reproduction, and the queen's role is to lay eggs.

Communication among honey bees is vital for the smooth functioning of the colony. Bees use various methods to communicate, with the most famous being the waggle dance. This dance is performed by worker bees to inform others about the location of food sources. Through the angle and duration of their dances, they convey information about the direction and distance of the food.

Additionally, honey bees communicate using pheromones, chemical signals that trigger specific behaviors. These pheromones help in coordinating tasks, maintaining colony cohesion, and regulating the hive's overall health.

The complex social structure and communication mechanisms in honey bees have contributed to their remarkable success as pollinators and the production of honey and other hive products. Understanding these aspects of honey bee behavior is crucial for their conservation and the pollination of various crops.

Dr. Debjani Dey

Dr Debjani Dey has been involved in research and teaching for more than 30 years. She was Head of the Division of Entomology till recently and currently is Professor and Principal Scientist at the Division of Entomology, IARI, New Delhi. During her initial years she had been trained with Commonwealth funding at The International Institute of Entomology, London and British Museum of Natural History, London. She has guided 21 M.Sc and Ph.D students till date. As Incharge of the 110 year old National Pusa Collection is responsible for maintenance and curation of nearly one million insect specimens, many of which are more than 100 year old. She is also Incharge of the Insect Identification Service provided by the Taxomonic unit of IARI. Currently is the Principal Investigator of IARI Institute project, on "Biosystematics of insects, fungi, bacteria and nematodes of economic importance". She has also handled more than a dozen ICAR, DST, DBT and contract research projects including the prestigious "ICAR Network project on insect biosystematics" as P.I . She has also acted as a master trainer for several Training Programmes funded by the NCSTC Division of DST and conducted around a dozen training programs as Course director. Has also been closely associated with IGNOU for development of several courses in their School of Sciences, has acted as an examiner in various capacities of more than two dozen Universities, member of selection committees and committees of Career Advancement of Scientific and technical personnel. Some other important assignments include advisor to UPSC, ASRB, CBIRC, Silk board, Zoological Survey of India, FRI etc. Till date has published 200+ papers, authored 30 book chapters, one book, 50 + popular articles, Technical Bulletins, Training manuals and has delivered more than 50 invited lectures in various training programmes. Also has

Buzz of the bees: Supersociety of Super Organisms

Debjani Dey

Professor & amp; Principal Scientist, Division of Entomology, ICAR I,A.R.I., New Delhi-110012

Honeybees are marvelous insects known to mankind since the prehistoric times. The art of their management scientifically is called as apiculture or beekeeping and the place where hives are maintained is called apiary. India has a long history of honey and bees. Its mention can be found in our ancient epics such as Rigveda, Mahabharata , Ramayana , etc. Honeybees are social insects. A honeybee colony is a complete biological unit and typically consists of several thousand bees that cooperate in nest building, food collection, and brood rearing. Each member has a definite task to perform, but it takes the combined efforts of the entire colony to survive and reproduce. The division of labour in honeybees is based upon sexual and physiological differences in the three castes, viz., queen, drone and worker, which exist within the bee-colonies. Individual queens, workers, and drones cannot survive by themselves. The social structure of the colony is maintained by the queen and workers and depends on "an effective system of communication. The exchange of chemical secretions among members and communicative " dances" are undoubtedly responsible for controlling the activities necessary for colony survival. Division of labor within the worker caste primarily depends on the age of the bee but varies with the needs of the colony. Beekeeping/Apiulture is a decentralized, forest and rural agriculture based industry, which does not require any raw material. The raw material needed is in the form of nectar and pollen, which is freely available from flowers in nature. Bee hives neither demand additional land space nor do they compete with agriculture or animal husbandry for any input. The beekeeper needs to spare a few hours in a week to look after his bee colonies. It is perhaps the only industry, which besides production of honey, royal jelly, propolis, beeswax, bee venom and several medicinal compounds, improves crop productivity through pollination. It maintains the stability of ecosystem and environmental quality, which in turn helps conservation of biodiversity.

Beekeeping has tremendous scope for development of ancillary industries and its untapped potential remains to be explored for increasing opportunities for gainful employment and income in rural areas. Although production of honey has been the major aim of this industry but beekeeping today also includes production of beeswax, bee collected pollen, bee venom, royal jelly, propolis, as also of package bees, queen bees and nucleus colonies etc. The annual economic value of pollination services by different species of insects is estimated to be €153 billion worldwide. This cannot be an exaggeration as 35% of global crop production including 87 of the major food crops are dependent on cross pollination affected by various pollinators. A fact which has been realized only recently. Since bees carry out about 80% of the pollination in the globe, managing and maintaining their biodiversity is crucial. A single bee colony may pollinate 300 million flowers each day. All these are possible only with a proper management of bees, utilization of the local plant resources and adapting to the local climatic conditions. Beekeeping can be started by anyone even with a single colony, which can be increased to hundreds later. It is ideally suited for the rural areas as it utilizes only the available resources which otherwise go waste. A beekeeper needs little investment for beekeeping as no sophisticated machinery is needed.

The honeybees can be obtained from the following sources: (a) Commercial bee-keepers or Government bee farms; (b) Individual beekeepers; and (c) Capturing of stray swarms. Areas with abundant flowering plants eg., forest sites, agricultural farms and fruit orchards are ideal for beekeeping. Installation of the apiary depends on a series of factors like: Vegetation; Water availability; Orientation and setup of the colonies etc.

Beekeeping can transform Indian agriculture. Therefore steps should be taken towards the conservation of the bees by controlling deforestation, taking up measures like afforestation and social forestry, which can in turn create proper habitats for honey bee populations. Insecticide application, which is a regular practice in farm and orchards crops, should be regulated as a measure to conserve bees and protect beekeeping. In certain cases the losses due to killing of pollinators, is several times more than the losses due to pest infestation. Such aspects should be brought to the notice of the farmers and they should be educated in integrated pest control measures that ultimately help him realize better and improved crops. Honey industry in the country can well become a major foreign exchange earner if international standards are met.

Dr. N. K. Krishna Kumar

Former Deputy Director General (Hort. Sci.), ICAR, New Delhi
Former, Regional Representative (Bioversity International), South & Central Asia
Former Director, NBAIR, (ICAR), Bangalore

Dr. N.K. Krishna Kumar, former Deputy Director General (Horticulture), ICAR was born on 5 September 1955 at Mysore, Karnataka State. He was awarded the Ph. D. from USA in 1993 as an East-West Scholar and PDF from UC Davis, California in 2002-03. In 38 years of his illustrious career, he served as Deputy Director General (Horticulture), Director, NBAII, Bangalore (June 2011–August 2012), and Head (Entomology and Nematology) for 8 years. He has made valuable contributions in the field of agriculture, Horticulture, Research management, Biodiversity to India and the region. Dr Kumar contributed significantly to IPM of vegetables, location of source of resistance, management of sucking pests as vectors of plant pathogens etc. As a part of Ph. D under the guidance of Dr. Diane Ullman at Hawaii under the East-West Fellowship, Dr. Kumar contributed to better understanding and management of vector thrips of Tomato spotted wilt virus (TSWV). He continued this work for his post- doctoral studies focusing on the role of TSWV glycoprotein in vector acquisition, pattern of transmission in vector population & relationship between virus replication and transmission efficiency. Dr Kumar is a recognized advisor for post graduate research work at UAS, Bengaluru and Kuvempu University, Shivamogga. Similarly, his students have made valuable contribution on molecular systematics of aphids, whitefly, thrips, role of aphid honeydew, resistance to pesticides in relation to virus transmission etc. Dr. Kumar organized several scientific meetings such as National Meeting on Entomology and IPM, sap sucking insects, focused meetings on leafhoppers, whiteflies, mealybugs, insecticide resistance management, bioinformatics etc. The ORP-Sucking pests were an outcome of one such meeting, a project which contributed invaluable HRD into the national systems besides more than 60 international publications. Under his leadership the team developed DNA barcode for 50 different species of insect-pests of different orders; designed Species-Specific Markers for major insect-pests of horticultural crops; Dr. Kumar worked at Bioversity International (2016-20) with a responsibility to lead research in South and Central Asia and played a key role in organizing The first International Meeting on Agrobiodiversity (2016), two international meetings on Management of Tropical Race-4 of Banana (China 2018 and India 2020). Very recently (2020) as Vice-President of the Entomological Society of India, he organized three meetings on Biopesticides: , phytoplasma in Agriculture, Registration & Quality Assurance and Onion crop and Seed Production in relation to Onion Yellow Spot Virus. At Bioversity International he initiated research on development of an ABD index and valuation of Ecosystem Services in Collaboration with ICAR. He played a key role in organizing the I International meeting on Agrobiodiversity in New Delhi in 2016. As recognition of his scientific and managerial abilities Dr. Kumar, an entomologist was selected as DDG (Horticultural Science), ICAR in 2012. The PG school for Horticulture at IIHR, Bengaluru, and Directorate of Floriculture at Pune besides innumerable scientific meeting etc. speaks for themselves. Under his tenure Horticulture surpassed Grain production is an understatement. I am associated with many national and international professional societies in various capacities. He is the Vice-President of Entomological Society of India. He is a recipient of several awards and honours. Primarily, he is the honorary fellow of Karnataka State Science and Technology (KSTA), Member of the Advisory Board, Foundation for Advanced Training in Plant Breeding (ATPBR), recipient of Nammalvar Award for Conservation of Biodiversity, Dr Vasanthraj David Award for work in Entomology, Dr Roy Choudhary Memorial award from Phytopathological Society of India, Fellow of Society for Promotion of Horticulture, IIHR, Bengaluru, and many more. I am the research advisory committee (RAC) member of Central Silk Board, Chairman, RAC Indian Institute of Spice Research (IISR), Calicut, Central Tuber Crop Research Institute (CTCRI), Tiruvananthapuram, Directorate of Cashew Research, Puttur, Sericulture Biotechnology Research Laboratory, Kodati, Bangalore etc. Dr Kumar has several national and international (110) research papers to his credit. Besides, he has written 5 books/book chapters. Dr. Kumar has edited a book on “Advances in IPM for Horticultural Crops”, and an ICAR publication The Onion.

Conservation of pollinators: Status and plan of action

N K Krishna Kumar

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Pollination Services

Most of us equate honey bees with honey but in reality their role as pollinators of crops is several times more important. Pollination is recognized as the most important ecosystem service that drives both natural and manmade ecosystems by maintaining overall biological diversity. Biodiversity is the essence of our life on earth and of course all other flora and fauna on which our life depends. The importance of pollinators is reflected in the fact that 72 per cent of our cultivated crops require insect pollination and 35 per cent of human food is dependent on animal pollinators (Klein et al 2007). Among animal pollinators' insects are the most important pollinators with more than 20,000 species of pollinating bees alone, not to mention ants, wasps, beetles, butterflies and moths. In economic terms the contribution of pollinators to the global economy through agriculture has been estimated to be about €153 billion.

Global threat of 'Pollinator Decline'

The pollinators, like all other organisms, are critically dependent on both the biotic and abiotic components of ecosystems viz., the 'vegetation' and 'refuge' and the physical habitat. In the last two decades both these components have been eroding due to increasing human activities and changing land-use practices leading to what has come to be known as 'pollinator decline.' The loss of pollinator services can have serious consequence both for maintenance of biological diversity and also human livelihoods, especially in the hot-spots of biodiversity.

Pollinator Initiative: Indian scenario vis-à-vis global action

The crisis of declining activity of pollinators prompted the Conference of the Parties to the Convention on Biological Diversity (CBD COP Decision V/5), to establish an International Initiative for the Conservation and Sustainable Use of Pollinators with the following objectives:

- Monitor pollinator decline, its causes and its impact on pollination services;

- Address the lack of taxonomic information on pollinators;
- Assess the economic value of pollination and the economic impact of the decline of pollination services; and
- Promote the conservation and the restoration and sustainable use of pollinator diversity in agriculture and related ecosystems.

The FAO undertook an initiative to prepare an action plan and launched the International Pollinator Initiative (IPI) in several countries. Africa, Canada, Europe and USA have all implemented IPI and achieved considerable progress in assessment of pollinators, development of adaptive management for conservation of pollinators and capacity building in pollinator conservation. Further, several countries have enacted legislation specifically aimed at making conservation of pollinators and pollinator habitats a top priority in line with CBD action plan. More recently another international effort called the Global Pollinator Species Campaign has been launched under GBIF for 'making taxonomic and related biological data available in standard digital formats for use in scientific inquiry, natural resources management, political decision-making, agriculture and public information.

Indian Scenario

While India is home to at least three hot-spots of biodiversity it is neither a party to the IPI and GSPC nor does it have an independent programme to address the serious issue of pollinator decline. Further the crisis of pollinator decline has not been adequately addressed in India perhaps mainly due to the lack of critical capacity in addressing the issue and also partly to poor understanding of animal pollinator especially the insects. Most work carried out in India on pollinators and their role is confined to the Indo-Gangetic plains (Sihag, 1995) and virtually no information isavailable in this regard from the Western Ghats.

Assessment of the pollinator diversity is the first element in the plan of action of IPI and the first report (Barbara Herren, et al., 2005) clearly underscores our poor understanding of the pollinating bees of the world. According to the report at least two subfamilies of Apidae and one family viz., the Megachilidae are poorly understood from the Indian sub-continent. Since new species of bees are still being described from even well studied groups (Michener et al., 2003) it is our contention that the bee fauna of the Indian sub-continent has been poorly studied and that all the six families of bees listed in the report are likely to have many more species represented in the sub-continent.

We cannot begin to save what we do not know.' However, it is also true that 'by the time we know what we need to know it may be too late.' Any conservation planning therefore has to critically integrate monitoring assessment along with an action plan for saving 'what we know' from decline and parallel step up efforts to 'know what we do not know.' The task therefore with respect to bee pollinators therefore is to simultaneously undertake an 'assessment of the 'taxonomic gaps' in the distribution of bee diversity of the Indian sub-continent for pollinator conservation and also to develop 'recovery plans for the bee pollinator guild' and their sustainable utilization in accordance with the action plan of IPI. The CEPF document identifies plant, birds, fishes and reptiles as being important components of the overall biodiversity that requires immediate attentions so that the gaps can be filled and conservation priorities be laid down. The problem is even more acute for invertebrates despite them being important ecosystem service providers in pollination and recycling. Thus, there is a need to monitor and assess the status of bee pollinators through quantitative sampling in different agro-climatic zones, identify habitat requirements for conservation of the 'pollinator guild', assess the threats faced by bee pollinators, and develop conservation plan for recovery of 'bee pollinator guild'. This will contribute to development of a sound quantitative methodology for monitoring and assessing 'bee pollinator guild' that can be used over the entire country, fill the gaps in our understanding of the diversity and distribution of bee pollinator fauna, achieve a better understanding of the threats faced by the 'bee pollinator guild.' And development of a conservation action plan for 'bee pollinator guild' through participatory approach, which can be replicated. Recently there is a lot of concern on pollination and sustainable development. A major concern has been the use of neo-nicotinoids. Equally indiscriminate deforestation, human intrusion into the forest is responsible especially in the tropics. About 94% of all tropical wild flowering plants are animal pollinated (Ollerton, Winfree, & Tarrant, 2011) and more than 75% of global food crops benefit from (dependence ranging from 1-100% for fruit or seed set) animal pollination (Klein et al., 2007). Wild and crop plants benefit from wild and managed pollinators, and thus are imperative in retention of biodiversity and associated ecosystem services in addition to securing food security. Wild pollinators are heavily dependent on forests for nesting and forage resources. Despite a documented decline in pollinators and negative effects on their role in maintaining biodiversity (directly and indirectly) and food security, little emphasis has been placed on understanding the importance of forest in maintaining wild pollinators. Among pollinators, bees (20,000 species- most are pollinators) are the most frequent flower visitors, followed by flies, butterflies and moths (Winfree, Williams, Dushoff, & Kremen, 2007) Among pollinators, bees (20,000 species- most are pollinators) are the most frequent flower visitors, followed by flies, butterflies and moths. A study conducted in Kodagu coffee landscapes within the Western Ghats biodiversity hotspot reveals that bees contribute to 33% of the total coffee production and wild bees (*Apis dorsata*) are the main pollinators (58% of the total visitors) of coffee which primarily nest in remnant forests called sacred groves.

Forest fragments appear to be necessary for the persistence of *Apis dorsata*, the main coffee pollinator. In the world of pollinators, the role of volatiles and the relationship of volatiles from biomes which influence pollinations visits, impact on other pollinators and rate of pollination success and fruit set is emerging. While a lot is said about pollen, nectar little is understood about stigma and factors influencing stigma receptivity. As decades roll by, the role of stigma receptivity under global warming will come under more focus. How the complex, micro interactions of biome, volatiles and changing behavioural pattern of pollinations in influencing pollination success, fruit set and productivity for a sustainable world is being unravelled though at a slow pace.

Dr. Tirthankar Banerjee

Dr. Tirthankar Banerjee is the principal scientist, division of agricultural chemicals, ICAR-Indian agricultural research institute, New Delhi. He completed his masters and Ph.D. from Indian Agricultural Research Institute, New Delhi, in agriculture chemicals.

He has significantly contributed in the field of multi residue method development, safety assessment and pesticide residue chemistry. He has 20 years of research, education and extension experience in Agricultural chemicals, and he has attended International and National seminars, conferences and workshops. He has presented many guest lectures in national and international conferences, on various topics, one such being Laboratory Accreditation.

He has 48 research papers, 9 books, 11 books chapters, 41 conference presentations, 3 scientific reviews, 3 training manual and over 15 popular articles. Currently he is holds the position of principal scientist, at the division of agricultural chemicals, ICAR-IARI and is in charge of NABL accredited pesticide referral laboratory.

Quality standards of honey and other hive products

Tirthankar Banerjee
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Honey has been valued not only as a sweetener but also as a medicinal remedy throughout history. It was discovered in ancient Egyptian pyramids, maintained by its natural antibacterial and preservation characteristics. Honey is a commodity having huge demands all over the world owing to its medicinal properties. It is also used very often as a healthy and nutritious substitute for sugars. The incidence of corona pandemic has resulted in the introduction of honey as an immunity booster. Small scale production of pure (unadulterated) honey compared to the growing honey demand in the domestic and export market and its commercial value has led to honey adulteration/honey fraud as the major issue of concern. According to the U.S. Pharmacopeia's Food Fraud Database, honey ranks as the third food target for adulteration, behind milk and olive oil, and in Europe it is classed as one of the 10 most faked food products. 30-35% of all honey sold in the world at this stage is fraudulent, according to Interpol. Honey's high value gives a strong economic incentive, putting it at danger of commercial adulteration. Low-cost sugars and commercial syrups are common substances for honey adulteration. Some of the well-known adulterants are from sugar cane and sugar beet such as corn syrup (CS), high fructose corn syrup (HFCS), glucose syrup (GS), sucrose syrup (SS), inverted syrup (IS), and high fructose inulin syrup (HFIS). Adulteration of honey by sugars alters the chemical and biochemical properties of honey, such as the enzymatic activity, electrical conductivity, and specific compound contents. This is a major issue for many people, including beekeepers who produce honey and are undercut by cheaper supermarket items, as well as customers who are ignorant that fake honey exists. Beside the continuous effort to identify the adulterated honey to protect the honey industry, effective awareness programmes related to types of adulterants use, their need and process of detection as well as development of trained human resource for detection of honey adulteration throughout the country is the need of hour.

Dr. Kumaranag, K.M.

Dr. Kumaranag, K.M. Ph. D (Entomology) working as a scientist at the Project Coordinating Unit, AICRP on Honey bees and Pollinators, Division of Entomology, ICAR-IARI, New Delhi-12 from last eight years. He is involved in the coordinating and monitoring the activities of 24 research centres of the AICRP network. He is also serving as faculty of the Division of Entomology, ICAR-IARI involved in teaching of courses like Insect Ecology, Integrated Pest Management and Commercial Entomology. As Co-PI, he has successfully completed three multi institutional projects. He has published 15 research articles in reputed national and international journals.

Technologies for the production of other hive products

Kumaranag K.M. and Sachin S. Suroshe

Project Coordinating Unit, AICRP on Honey bees and Pollinators, Division of Entomology, ICAR-IARI, New Delhi

Honey bees are the source for the many economically valuable hive products besides their vital role in ecosystem as chief pollinating agents. Each of the hive product has its own unique uses and benefits. These hive products are not only valuable to the bees themselves but also to the humans. Royal jelly is a special secretion produced by worker bees and used to feed bee larvae and the queen bee. Royal jelly can be produced in commercial scale though Doolittle method of grafting. Each colony can produce about 300-500 gm of royal jelly annually. Royal jelly used as a dietary supplement due to its potential health benefits. Propolis is the plant resins collected by the bees from tree budsand it is used to seal cracks and crevices in the hive. Propolis has antimicrobial and antioxidant properties and is often used in traditional medicine for its potential health benefits. Commercially propolis is produced by introducing the screens of various types inside the hives below the top chamber. Bee pollen is another product of bee hive. It is mainly used as the dietary supplement. Bee pollen can be easily harvested from the hives by introducing the pollen traps in front of the hives. Another medicinally important product of the hive is bee venom. Bee venom collected from the bee hives by using the bee venom collectors either installed at the front of the hives or on the top bars. Bee venom is highly priced and potential to cure many ailments. Beeswax is another important hive product secreted by worker bees from the special glands on their abdomen. Wax cappings and deserted combs of *Apis dorsata* are the major source for the bee wax. Beekeeping practices vary, and the extraction and processing of these hive products require care to ensure their quality and purity.

Bee Keeping techniques and basic bee equipment & accessories

Kumaranag K.M. and Sachin S. Suroshe

Project Coordinating Unit, AICRP on Honey bees and Pollinators, Division of Entomology, ICAR-IARI, New Delhi

Beekeeping is the art and science of managing the bees in scientific way to harvest honey and other hive products in commercial scale as well as for managed pollination services. Beekeeping practices vary with the location and need of the bees. Basic bee keeping techniques involves choice of the suitable area for the establishment of apiary; placement of the colonies in apiaries, regular inspection of the colonies for monitoring the colony performance parameters; swarm control measures, etc. Hive manipulation with the suitable interventions at the time of need of bee colony. These measures will help in improving the colony performance and productivity. Basic equipment's required for the starting of the beekeeping includes bee hives of BIS standards suitable for the bee species and superior bee stock free from pests and diseases. Frames and comb foundations of prescribed standards and quality. Protective gears such as bee veil and overalls for protection from bee stings and bee smoker for pacifying the bees during hive inspection. Bee management tools like queen excluder, queen gate, hive tool and bee brush for manipulation of bees. Feeders for the feeding of colonies during dearth period. Tools for harvesting of honey like uncapping knife, uncapping tray, extraction nets and honey extractor. Queen rearing kits including queen cell frames, queen cell cups, grafting needles and holders for mass queen rearing. Equipment's and accessories should be of prescribed standards and quality for better durability.

Dr. P.R. Shashank

Dr. P.R. Shashank is a scientist specializing in Entomology, particularly focusing on Insect Taxonomy, Biodiversity, molecular diagnosis, and Invasive species. He works at the ICAR-Indian Agricultural Research Institute in Pusa, New Delhi, India. His research has been quite prolific, with numerous publications in scientific journals. Some of his notable achievements and contributions include:He has published a significant number of research articles, with a total of 102 publications, including 2 books and 1 journal article.

Dr. Shashank has received 24 citations and has an H-Index of 3, indicating his impact in the field of entomology. He holds a Ph.D. obtained from the University of Agricultural Sciences in Bangalore, reflecting his strong academic background. Dr. Shashank has received the DST Inspire Fellow award in 2011, showcasing recognition for his work. He is a member of professional organizations, including the Entomological Society of India and the Society for Biocontrol Advancement. His expertise in entomology and research on various aspects of insect biology makes him a notable figure in the field.

Honey bee species and their distribution

P.R. Shashank and Jyoti Falswal

Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi

Honey bees (*Apis* spp.) are a crucial component of global ecosystems, contributing significantly to pollination and the production of honey and beeswax. This abstract provides an overview of the various honey bee species. The genus *Apis* encompasses all honey bees and stands as the exclusive genus within the Apini tribe. This Apini tribe, in conjunction with the Bombini tribe (bumble bees), Euglossini tribe (orchid bees), and Meliponini tribe (stingless bees), collectively forms a cohesive and evolutionarily related group recognized as the corbiculate bees. In *Apis*, with the Western Honey Bee (*Apis mellifera*) being the most well-known and widely distributed. However, there are over 9 recognized Apis species, each adapted to specific environmental conditions. *Apis dorsata*, also known as the rock bee, can be identified by its large size and distinctive coloring, with wholly orange-yellow abdominal segments I-III/IV, while the rest of the abdomen is black. These gigantic bees are capable of producing an impressive 38 to 40 kilograms of honey per colony. *Apis indica*, often referred to as the Indian bee, is recognizable by its moderate size and partially or entirely black abdominal segments I-III. This species is commonly raised for honey production and is relatively easy to domesticate. Each colony of *Apis indica* typically yields 2 to 5 kilograms of honey annually. *Apis florea*, also known as the little bee, can be distinguished by the presence of white hairs on the metatibia and dorsolateral margin of the metabasitarsus, as well as reddish-orange metasomal terga I-II. It is known for its non-aggressive behavior, rarely stinging. Extracting honey from *Apis florea* hives is straightforward, and each colony produces approximately 1 kilogram of honey per year. *Apis mellifera*, often referred to as the Italian bee, can be identified by its light to dark brown mesoscutum and moderate body size. Despite its common name suggesting otherwise, this species is not native but is commonly raised by beekeepers due to its high honey production.

Dr. C. G. Kushalappa

Dr. C.G. Kushalappa is from the third generation coffee farmer from Kodagu district of Western Ghats, a biodiversity Hot Spot and UNSECO World Heritage Center. After completing Bachelors in agriculture in 1982, post-graduation in horticulture with gold medal in 1985 and Doctorate from University of Agricultural Sciences Bangalore joined teaching carrier in 1988 as Instructor for the first batch of B.Sc. (Forestry) students. In 1996 Promoted as Professor and in 2016 selected as Dean of College of Forestry at Ponnampet one of the five best forestry colleges in the country and superannuated in May 2023. In 34 years of undergraduate, Post graduate and doctoral teaching have guided 18 Masters the 10 doctoral students from Universities within and outside India. In addition to teaching successfully completed 22 research projects in collaboration with reputed partners from within and outside the country. With H index of 23 based on 50 research publications in diverse aspects of natural resources management in peer reviewed international journals and presentations in international conferences in 15 countries I have mainly contributed on research for sustainable development in Western Ghats. Actively involved in outreach activities involving farmers, students and general public in conservation of sacred forests, coffee-based agroforestry and apiculture in Western Ghats. Currently leading two Farmer Producer Companies (FPC) ie. Biota Coorg Farmer Producer Company for coffee and Busy Bee Honey cluster for promotion of apiculture in the region working under the principle of ecological economics to sustain communities and landscape. Hence it is gratifying that as a son of a farmer I not only continue to farm but also could contribute to academic, research, outreach and management activities in one of the most diverse and dynamic landscapes of the world.

Madhu Kranti through Evergreen Revolution

Dr.C.G.Kushalappa

Former Dean College of Forestry, Kodagu district , Karnataka 571216

The objective of the presentation is to share the information on importance of floral resources in sustainable bee keeping.

Key takeaways

The presentation would start with historical and current status of beekeeping in our country. Prospects for bee keeping in India and activities being undertaken by different stakeholders to promote sweet revolution will be highlighted. One of the most critical factors in sustainable honey production is continuous and adequate availability of bee forage resources both natural and cultivated and hence role of bee pasturage management as a key tool in sustainable bee keeping will be discussed. The bee forage in terms of nectar and pollen resources available in different agro climatic regions and in major honey producing regions of India will be highlighted. Case studies related to impact of bee pollination on some important horticultural, agricultural and forest plants will be shared as a win -win strategy in enhancing productivity of crops and improvement of farmers income. One key bee pasturage management tool is development of region-specific floral calendar which will help us to understand the availably of food resources for bees during major, minor and dearth honey production period. Floral calendars developed for important honey producing regions and crops will be shared with the participants. To conclude I will be highlighting the role of floral resources which are not economically quantified for the development

Key points: Sustainable bee keeping, Floral resources, Bee pasturage, Floral calendar.

Dr. Sagar, D

Dr. Sagar, D., is presently working as Senior Scientist (Entomology) at ICAR-Indian Agricultural Research Institute (IARI), New Delhi. Dr. Sagar D was born on 20th November 1985 in Tumkur district of Karnataka, he did his schooling and pre university education in Bangalore, Karnataka and passed B. Sc (Agriculture) in first class with distinction in 2007 and he was awarded with gold medal for his academic excellence. Thereafter he did his M. Sc (Agricultural Entomology) from College of Agriculture, Raichur and passed M.Sc with distinction in 2009 and he was awarded with three gold medals. Later he joined Ph. D. at University of Agricultural Sciences, Dharwad and worked on the "Status of insecticide resistance in leafhopper, *Amrasca biguttula biguttula* (Ishida) in Bt cotton of major cotton growing districts of Karnataka", for his work and based on M. Sc merit he was awarded with prestigious **INSPIRE fellowship for Doctoral research** from Department of Science and Technology (DST), Ministry of Science and Technology, Government of India, New Delhi during 2010-13. In 2012 he cleared All India level entrance examination for Agricultural Research Service (ARS) and stood second in national level and in 2013 after completion of Ph. D. joined as scientist at Entomology Division, IARI, New Delhi. During his ten years of service in research he has worked on bio-prospecting of insecticidal proteins from legumes, stress physiology in insects and insect pest management in chickpea including weather based model development for forecasting of insect pests of chickpea. He is actively involved in teaching the basic and advanced courses of insect physiology, insect biochemistry, host plant resistance and molecular approaches for post graduate students. He has guided seven M. Sc students and presently guiding one M. Sc and one Ph. D student as research guide.

He is editorial board member of five journals and life member of seven scientific societies and also he his fellow of Entomological Society of India and Plant Protection Association of India; he is associated with 5-6 journals as a reviewer. Sagar has published >40 research papers in reputed journals and has awarded with DST INSPIRE fellowship, DST-SERB start up research grant, DST-SERB core research grant, fellow and young scientist awards from professional societies apart from that he is Co-PI in externally funded projects from DST-SERB and ICAR-NASF. He is now continuing is research work on reproductive physiology due to thermal stress in insects using *Spodoptera frugiperda* as a model insect.

Honey bee biology-Caste differentiation, Division of Labour

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Honeybees are eusocial insects belonging to family Apidae of order Hymenoptera. Honey bees are a fascinating model organism with a complex mating and inheritance system, highly evolved social behavior, dance communication language, and mutualistic interaction and evolution with flowering plants. They are vital to agriculture and serve as a model system for many basic questions in biology. All honey bees belong to the genus *Apis* and bees in this genus are the only species to store large amounts of honey and exhibit a perennial life cycle. In the world, there are about eleven species of honey bees are reported, however seven species of bees of commercial importance are found in India; *Apis dorsata* (Rock bee), *Apis laboriosa* (Himalayan Giant bee), *Apis cerana indica* (Indian hive bee), *Apis florea* (little bee), *Apis mellifera* (European or Italian bee), *Tetragonula iridipennis* (Dammer or stingless bee) and *Apis karinjodian* (Indian black honeybee). Like any holometabolus insect, honey bees pass through four distinct life stages: the egg, larva, pupa and adult and this process is called complete metamorphosis. Every honey bee colony comprises of a single queen, a few hundred drones and several thousand worker castes of honey bees. Queen is a fertile, functional female, worker is a sterile female and the drone is a male insect. On the first day, the queen bee lays a single egg in each cell of the comb. The egg generally hatches in three-four days and then develops into larvae that are known as grubs. All grubs are fed royal jelly at first, but only the future queens are continued on the diet. When fully grown, the grubs transform into pupae. Queens emerge in 16 days, workers in about 21 days, and drones in 24 days. There is only one queen in a colony. It is considerably larger than the members of other castes. Her wings are much shorter in proportion to her body. Because of her long tapering abdomen, it appears more wasp-like than other inmates of the colony. The queen is the only individual which lay eggs in a colony and is the mother of all bees. The differentiation in worker and queen is due to the quantity and quality of food fed to the larva. The larva which becomes the queen is fed the royal jelly, a secretion from hypopharyngeal glands of the worker bees.

Drones are male members of the colony; they are somewhat larger and stouter than either the queen or the workers and make up only about five percent of the hive population. The drones could be called the couch potatoes of the insect world. Their only function is to impregnate the young queen, after mating, the drones die. They also help in maintenance of hive temperature. The workers are the smallest inhabitants of the beehive, they form the bulk of the population. The number of workers in a colony varies from 1,500 to 50,000. They are imperfect females incapable of laying eggs. On certain occasions when the colony is in need of a queen, some of the workers start laying eggs from which only drones are produced. These workers, called laying workers, are killed as soon as a new queen is introduced or produced in the colony. The lifespan of workers can be divided into two phases as first three weeks for house hold duty and rest of the life for outdoor duty which includes building comb with wax secretion; feeding the young larvae with royal jelly, older larvae with bee-bread; feeding and attending queen; guarding the hive and collecting nectar, pollen, propolis and water.

Dr. Subramanian Sabtharishi

Dr. Subramanian Sabtharishi is a prominent scientist known for his expertise in the fields of Insect Physiology and Insect Molecular Biology. As a Principal Scientist at the Division of Entomology in the Indian Agricultural Research Institute (IARI), New Delhi, he has made significant contributions to the study of insects. Dr. Sabtharishi's educational journey includes earning a Ph.D. in Entomology from IARI, New Delhi, and post-doctoral training at Oxford University, UK, in Molecular Entomology. His career has been marked by various academic and research positions, from Assistant Professor roles at agricultural research stations to becoming an Associate Professor at Tamil Nadu Agricultural University before assuming his current role as a Principal Scientist at IARI. Dr. Sabtharishi has received numerous awards and recognition for his work, including being a Fellow of the Royal Entomological Society in London and a Research Advisor at the Nanyang Academy of Science in Singapore. His extensive research contributions include a substantial number of publications and involvement in externally funded projects. Dr. Sabtharishi is an integral part of the academic and research community in the field of entomology, playing a crucial role in advancing our understanding of insect physiology and genetics, particularly in relation to insecticide resistance and the gut microbiome of insects.

Gut Microbiome of honey bees and their functional role

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Honeybees are the most dominant group of beneficial insects providing ecological services via pollination in crops and thus ensuring improved agricultural production and food security. Italian honeybee *Apis mellifera*, one of the prominent agents of pollination and benefactor of several bee products has transformed apiculture into a gainful agro-enterprise. The bees during the course of evolution have acquired microorganisms and nurtured symbiosis in their digestive tract. Honeybees are home to eight microbial phylotypes which play a significant role in nutrition and defence. The physiologically active stages of bees have interactions with many microbial groups. The honey bee gut microbiome is a hidden player known to influence essential traits and metabolic pathways by aiding in food digestion, detoxification of harmful molecules, providing essential nutrients, and modulating development, and immunity which affects the physiology of honey bees. Although works have been carried out in other parts of the world on microbial communities associated with the gut of *A. mellifera*, there is limited information on the gut microbiota of Indian populations of *A. mellifera*. Our study attempted to profile the diversity and compartmental distribution of the microbiota in different gut regions of foragers and hive bees in an Indian population of *A. mellifera* by utilizing the PLFA tools. The distribution of different microbial groups varied among the gut compartments of *A. mellifera*. While the foregut was characterized by the dominant presence of microeukaryotes and anaerobes, the midgut was inhabited by anaerobes and microeukaryotes, and the hindgut harboured microeukaryotes and anaerobes. Fungi were detected in a small proportion in the midgut and hindgut regions of forager and hive bees.

Further, we explored the diversity of gut bacteria in the forager and hive bee of *A. mellifera* through culture-dependent approaches by microbial isolation coupled with the generic characterization of using 16S ribosomal RNA probes and culture-independent approaches like next-generation sequencing on Illumina MiSeq platform. The results of our investigation identified a total of 51 and 32 aerobic gut bacteria associated with forager and hive bees of *A. mellifera* respectively. Metagenomics analysis revealed that a complex community of bacteria comprising of Proteobacteria, Firmicutes, Actinobacteria and Bacteriodetes, Cyanobacteria are associated with the hive bees Burkholderiales, Enterobacteriales, Pseudomonadales, Lactobacilliales, Neisseriales, Bifidiobacteriales, Rhizobiales Rhodospirillales, Pasteurellales are the major bacterial orders common to both forager and hive bee. Streptophyta, Xanthomonadales, and Caulobacterales are unique to the hive bees, while, Flavobacterales are unique to foragers. Besides the core group of gut bacteria like α-, β-, γ-proteobacteria, Firmicutes (Lactobacillus), Bifidobacterium

(Actinobacteria) are found to be associated with *A. mellifera*. The presence of these diverse groups of gut bacteria may not be completely ruled out. Hence an enormous amount of further work is needed to profile the complete diversity of Indian *A. mellifera* by sampling bees from different geographical niches of India and across different climatic seasons. Culture-dependent methods offer insights into the prevalence of specific bacterial groups, while metagenomic analyses provide a broader perspective, uncovering a complex interplay of multiple bacterial species that contribute to the overall diversity of the bee gut microbiome. These findings collectively enhance our understanding of the intricate microbial communities inhabiting the digestive systems of forager and hive bees, emphasizing the diverse nature of their gut microbiota.

We have formed a nationwide consortium of researchers to profile the gut bacteriome diversity of major honey bee species such as *A.indica*, *A. mellifera* and stingless bee, *Tetragonula iridipennis* from different agro-ecological zones of India with funding support from National Bee Board under the National Beekeeping and Honey Mission. The profiling and functional characterization of the beneficial bacteria may aid in developing a probiotic consortium specific to Indian populations of *A.indica*, *A. mellifera* and *Tetragonula iridipennis* which would go a long way in enhancing bee health and sustainable beekeeping in India.

Prof. Dr Pardeep Kumar Chhuneja

Prof. Dr. Pardeep Kumar Chhuneja holds the esteemed position of Dean of Postgraduate Studies at Punjab Agricultural University (PAU), Ludhiana. He is the recipient of the Prof. Baldev Singh Dhillon Distinguished Professor Chair award, an honor he has held since 2022. Dr. Chhuneja's reputation as a distinguished Apicultural scientist is well-deserved, with a previous role as the Head of the Department of Entomology at PAU from July 2017 to June 2021. His contributions to Apiculture have not gone unnoticed. He received commendation from the Indian Council of Agricultural Research (ICAR) for his outstanding work in the field. Furthermore, in September 2022 and 2023, Dr. Chhuneja was honored by ICAR at its Annual Workshop and the Annual Group Meeting of the ICAR-AICRP, respectively. Dr. Chhuneja is not only a scholar but also an expert external to ICAR.

Dr. Chunneja serves as a member of ICAR's Project Advisory & Monitoring Committee (PAMC). Additionally, his expertise extends to the National Academy of Agricultural Sciences (NAAS), where he was selected to prepare a strategy paper and lead a Brain Storming Workshop on Apiculture. His academic journey is marked by excellence, having completed his B.Sc. Agric. and M.Sc. Entomology with Gold Medals. With over 32 years of post-doctoral experience, primarily in Apiculture, Dr. Chhuneja has made significant contributions through research, teaching, and outreach programs. His impressive career has been recognized with awards, including the Best AICRP Team Award and Overall Best ICAR-AICRP Centre on Honey Bees & Pollinators in multiple years. Currently, he holds the distinguished position of President in both the Indian

Society for Advancement of Insect Science (INSAIS) and the Entomological Society of India (ESI), New Zealand (NZ). Dr. Chhuneja's international exposure and contributions extend beyond borders, with engagements in various countries and a role as a Technical Consultant in a government Flagship Trilateral Cooperation Programme for apicultural development in Kenya.

Retrospect and Prospects of Apiculture in India

Pardeep Kumar Chhuneja

Punjab Agricultural University, Ludhiana

Honey bees – hive honey bees and wild Apis species (Apini) and also a few belonging to other closely related taxon (Meliponini), elaborate nectar into their fructose (the sweetest sugar) rich, enzymes enriched & supplemented food reserve, the honey – one among the sweetest natural products. Simply put, "Beekeeping is science and art of keeping the bees for the benefit of mankind". In new millennium, however, under business endeavours, "Apiculture covers entire scope of season and region specific scientific husbandry for the bee resources (faunal & floral), harvesting hive products and their usage, pollination services, and their interface with socio-economic, cultural & natural heritage and environmental integrity". Till mid-seventies, Indian Apiculture was based only on one hive bee species, viz. Apis cerana Fabricius (Indian/ Asiatic honey bee) and two wild honey bees (Apis dorsata Fabricius and Apis florea Fabricius), said to be subjected to honey hunting. Apiculture with A. cerana was restricted to hilly/ temperate regions, and low paced colony build-up, smaller population at the onset of nectar flow, low flight range, low honey and pollen load capacity, high swarming and absconding tendencies and being low propolizer subjected to serious wax moth vagaries were the tendencies, compelling apiculture scientists across the nation to introduce the exotic western honey bee, Apis mellifera Linnaeus, the widely distributed, adopted and adapted over the globe and free from above said limitations. In India, Punjab Agricultural University (PAU) is credited with the successful introduction of A. mellifera into India, through a novel technique, named as 'Inter-specific Queen Introduction' and then followed by its multiplication, it was released into the farms of Punjab in 1976. Hive bee species yield ripe honey with maximally low moisture content protecting it from fermentation and further its mechanical extraction, preventing squeezing of brood, results in hygienic honey, in demand over the world, over squeezed high moisture content honey from the wild honey bee species. The commercialization and industrialization of apiculture at the national scenario, in fact, took off in 1976 in the country with the release of the most productive and widely adapted and adopted honey bee race, viz. Italian (A. m. ligustica Spinola) by the PAU. The pace at which the apiculture has leapt, has been exponential. It has been owing to its distinct advantages over the other agro-based/ subsidiary occupations. These include low initial investment, low cost technologies, least labour intensive and low time demanding, not requiring any own land or sheds/ structures making it suitable for marginal and small farmers and even designating landless farm labourers as bee-farmers, yielding profits in the same very year through honey production and multiplication of colonies, amenable to be undertaken by persons from all walks of life (children, ladies, retirees, part-time, school-kids, etc., and of course, including whole-timers) and not competing with agriculture for any resources. India has achieved rarest of the rarest feat by running special trains, known as ‘Honey Trains’ from Ludhiana to Mumbai for honey export – one in 2009 and two in 2011. India under its fast-pace adoption of Apiculture, has made a mark at the global level emerging as a leading (No. 2) honey production country with it production of 133,000 MT after China at 485,960 MT. However, in export, India during 2022 stood at No. 4 with export realize of US$ 229.261 mn (8.7% share).

Beyond honey, various other hive products, viz. bees wax, bee pollen, bee bread, royal jelly, propolis and bee venom greatly widen the scope of Apiculture - the bee and plant origin products elaborated by honey bees find their use in diverse ways in various industries, as food supplements, in pharmaceutical industry, in cosmetic industry, as preservative, disinfectants, etc. and have a great economic value. Europe and many other countries are now increasingly leaping towards apitherapy. According to an estimate, 10,000 honey bee colonies directly and indirectly provide employment to 1,543 persons. Thus, Apiculture holds a great livelihood promise. Role of Apiculture in provisioning livelihood for marginal & small farmers and landless farm labourers and ruralites is well documented and, for this reason, commemorating the outstanding contribution in leading research and development in Apiculture by the PAU at the national front, the Department of Posts, GOI had released special postal cover in 2017 depicting the outstanding achievements of the SAU. The role of honey bees in crops’ pollination is well known owing to their floral constancy and floral fidelity traits. In India, Chaudhary and Chand (2017) reported that out of 211 crops, 108 (51.2%) are dependent on animal pollination, and further that direct contribution of insect pollination to Indian agriculture is 8.72 per cent, monetarily estimated at ₹1,12,615.73 crore (US$ 22.52 billion). Apiculture is a multi-pronged activity which besides employing for core beekeeping, also necessitates to support the raw material manufacturing industry, including hive and apicultural equipment/ tools & machinery manufacturing, transport, packaging material manufacturing, quality, authenticity & safety assessment, and marketing & export guidance/ support, disease diagnostics, bee breeding and queen bee rearing, bee package industry, food industry, and outreach activities including advisory support, etc. In overall, apiculture holds potential in enhancing employment generation and rural development, augmenting agricultural productivity, ensuring nutritional security to resource crunch Indian public and augmenting biodiversity and environmental sustainability.

Dr. Suresh M. Nebapure

Dr. Suresh M. Nebapure is a Senior Scientist in the Division of Entomology at the Indian Agricultural Research Institute, located in New Delhi. His expertise lies in the fields of insect toxicology and semiochemicals, making him a valuable asset in the study of insects' chemical ecology and the impact of toxins on these organisms. Dr. Nebapure has made significant contributions to pest management. He has conducted research on the efficacy of various insecticides, including synthetic and botanical ones, in combating both field crop and storage pests. This work is crucial in addressing agricultural challenges related to pest control and crop protection. His academic journey is marked by remarkable qualifications: B.Sc. (Agriculture) in 2007 from Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri. M.Sc. (Agricultural Entomology) in 2009 from G.B. Pant University of Agriculture & Technology (GBPUAT), Pantnagar, Uttarakhand. Ph.D. (Entomology) in 2013 from the Indian Agricultural Research Institute, New Delhi. Dr. Nebapure's research has also resulted in a substantial number of publications in reputed journals, with over 55 articles to his name. His dedication and expertise have been recognized through various professional awards and fellowships, including: Young Scientist Award from the Agro Environmental Education & Farmers Welfare Society (AEEFWS) in 2022. Best Young Scientist in Agriculture Science by the Manraj Kuwar Singh Educational Society in 2022. Best oral presentation awards and poster awards at national and international conferences. Life fellow of The Entomological Society of India in 2019.Receipt of the INSPIRE (DST) Fellowship from the Department of Science and Technology in 2010. Dr. Suresh M. Nebapure's academic journey, research contributions, and accolades reflect his significant role in entomological research and the field of pest management in agriculture.

Protecting Honey Bees from Pesticide Poisoning

Suresh M Nebapure

Senior Scientist,

Division of Entomology, ICAR-Indian agricultural Research institute, New Delhi

Honey bees and other pollinators provide an indispensable pollination service in agricultural food production. There have been reports of decline in honey bee population from different parts of the world attributed to different causes. Recently, reports of honey bee population decline from various regions around the world have been linked to various factors such as intensification of farming, various pollutants, anthropization, habitat fragmentation, forest fires and climate change. Among these synthetic pesticides are considered to be one of the important factor. Since honey bees are also insects, numerous insecticides employed for pest management can be harmful to them. They may get exposed to pesticides through different routs viz., direct spray on body, contact with treated surface, through pollen, nectar and guttation water and drinking water. Although botanical pesticides are considered as promising and eco-friendly alternative for synthetic insecticides, several reports suggests that these pesticides are also affect survival and behavior of honey bees and other pollinators. To safeguard honey bees from hazardous pesticides and prevent the buildup of pesticides in honey bee products, it is essential for crop growers, beekeepers, pesticide applicators, and government policies to collaborate and play their respective roles effectively. Enhancing the awareness of pesticide labels, understanding pesticide formulations and their modes of action, comprehending crop biology, and implementing integrated pest management strategies among farmers and beekeepers can significantly contribute to reducing pesticide poisoning in bees.

Prof. Balraj Singh

Prof. Balraj Singh serves as the Vice Chancellor of Sri Karan Narendra Agricultural University in Jobner, Jaipur, Rajasthan. He brings a wealth of experience and expertise to this esteemed institution. Prof. Singh's educational background includes a Ph.D. in Vegetable Science, demonstrating his deep knowledge in the field of agriculture.

Before assuming the role of Vice Chancellor at Sri Karan Narendra Agricultural University, Dr. Singh held the position of Vice Chancellor at the Agriculture University in Jodhpur. His contributions and leadership in the agricultural sector have made a significant impact on the academic and research landscape in Rajasthan.

Prof. Balraj Singh's dedication to the advancement of agricultural education and research is evident through his extensive career in academia. His commitment to enhancing agricultural practices and promoting academic excellence continues to benefit students, researchers, and the agricultural community.

As the Vice Chancellor of Sri Karan Narendra Agricultural University, Prof. Singh plays a pivotal role in shaping the future of agricultural education and research in Rajasthan. His leadership ensures the university's continued growth and its vital contributions to the field of agriculture.

Role of Honeybees and other pollinators in Agriculture and Human Life

Balraj Singh

Vice Chancellor

Sri Karan Narendra Agricultural University Jobner (Jaipur) Rajasthan

Honeybees and other pollinators play a vital role in agriculture and human life in several ways. Pollinators, primarily honeybees, aid in the pollination of a wide variety of crops, including fruits, vegetables, and nuts. This process is essential for the reproduction of these plants, leading to the production of fruits and seeds. Pollinators contribute to maintaining biodiversity by facilitating the reproduction of numerous plant species. They help sustain natural ecosystems by ensuring the survival of many plants. The role of pollinators in crop pollination directly impacts food security. A significant portion of the global food supply depends on pollinators. Without them, the availability of fruits, vegetables, and nuts would be severely limited. The economic value of pollinators is substantial. Insect pollination, including that by bees, is estimated to provide billions of dollars in economic benefits through increased agricultural productivity and the production of marketable products. Honey, one of the products of honeybees, has medicinal properties and is used in traditional and modern medicine for its various health benefits. Pollinators are crucial for maintaining the health of natural ecosystems. They contribute to the reproduction of native plants, supporting wildlife and preserving the balance of these ecosystems. Honeybees alone pollinate a significant portion of the world's crops, including over 130 types of fruits and vegetables. This underlines their indispensable role in global agriculture. The presence of pollinators enriches human diets by ensuring the availability of diverse and nutritious foods.

Dr. Neeraj Kumar

Dr. Neeraj Kumar is a distinguished academic and entomologist currently serving as a Professor in the Department of Entomology at the Post Graduate College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, located in Pusa, Samastipur, Bihar. He was born on October 19, 1975, and holds impressive academic qualifications, including a B.Sc. in Agriculture from NDUAT, Faizabad, an M.Sc. in Entomology specializing in Apiculture from RAU, Pusa, and a Ph.D. in Entomology with a specialization in Apiculture, for which he was awarded a University Gold Medal. Dr. Neeraj Kumar has a remarkable employment record, having served as an Assistant Professor, Associate Professor, and currently as a Professor in the field of Entomology. He has made significant contributions to beekeeping committees and standards, playing a vital role in advancing apiculture. Additionally, he has guided numerous students, led various research projects related to bee pollination and apiculture, and has an extensive publication record. Dr. Kumar has received multiple awards in recognition of his excellence in research and teaching and has organized numerous beekeeping training programs for farmers and officers.

Seasonal Management of Honey Bee Hives

Neeraj Kumar

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Apiculture is the study and purposeful management of honey bees. Apiculture is derived from the honey bee's Latin name *Apis mellifera*, meaning 'honey gatherer'. Since bees do not collect honey but nectar from which honey is made, the scientific name should actually be *Apis mellifica* meaning 'honey maker'. Beekeepers calendar starts with the activity of bee colonies in spring after prolonged cold in temperate climate and during winter in tropical climates. Colony build-up and honey flow period is from October to May in various parts of the country. There is a tendency to expand colonies with increased rate of brood production. Brood rearing starts with the blooming of oilseeds and last upto spring honey flow. Four seasons are important in regard to bee management viz. spring, summer, rainy and winter in India.

Winter management

Honey bees live in a thermal environment of their own and maintain suitable temperature between 27-32^{0}C. The bees form a cluster below 10^{0}C. The cluster is composed of inner and outer shells, the later serves as insulation and prevents the heat loss. Bees raise the temperature by muscular movements which are possible by consumption of honey. In cold weather the bees go out on short flights. However, at times, weather may not allow them even for short flights. Strong colonies during winter survive well because large number of bees can produce heat and retain it. Bee colonies can also be helped to sustain the winter by raising nest temperature. Following management practices should be implemented to protect the colonies from cold.

- Plug all cracks, crevices, etc. in the beehive.
- Keep the entrance gate opposite to wind.
- Provide sufficient food store.
- Provide artificial food, if necessary.

- Provide insulation inside beehive-inner packing with finely chopped rice/wheat straw may be used as packing materials inside hive.
- Do not open the beehive unnecessarily.
- Unite weaker colonies.
- Keep the colony strong.
- Cover hive with gunny bags from all sides.

However, the most congenial temperature range is 27-32^{0}C for foraging of honey bees and it remains for longer period whereas adverse temperature below 10^{0}C and above 40^{0}C goes for only a few weeks in the state. Thus, the colonies can thrive well during winter season in Bihar.

Summer management

This period is hard for the survival of bees. In most localities the spring flow is followed by a summer dearth period. There is no pollen, the weather is unfavourable and brood rearing activity is reduced very much. Some bees get exhausted and are lost in keeping the hive well ventilated and cool. The enemies and diseases of bees become active and further they demoralize the colonies. The lack of stores and the presence of enemies and diseases are the most important causes of swarming and absconding.

Absconding is comparatively less in *A. mellifera* but this tendency is very strong in *A. cerana, A. mellifera* colony would rather die because of starvation or due to attack of enemies but show little tendency to abscond. In this season, the bees need proper care and management. The best thing to do during this period is to avoid brood lessness in colonies and stimulate them to rear. The strong colonies with sufficient stores would continue to rear some brood. A young prolific queen will continue to lay eggs. The following management practices should be adopted during summer for proper development of bees.

- Keep the colonies strong.
- Keep the colonies with new prolific queens.
- Place the hive under shade.
- Sprinkle cold water twice in day over hive on gunny bags.
- Provide proper ventilation by removing entrance rod.
- Bee colony requires water for increasing humidity in brood nest and for cooling. To save the energy of water foragers, fresh water can be provided near the apiary. Stagnant dirty water or water in a container is not appropriate because it can spread *Nosema* infection.

- Flowing water near the apiary should serve as a good source but as an alternative, water trickling from a container, set on a stand, and falling on a slanting wooden plank can be arranged in the apiary.
- Provide wind breaks against westerly wind.
- Feed dilute sugar syrup diet.
- Broodless colonies should be given brood from other strong colonies.
- Control bee enemies and disease.
- Check robbing.
- Migrate the colonies to rich floral areas, if available.

Rainy season management

In this period bees are confined to hive for longer intervals because of continuous rains. Large numbers of foragers are lost in storm or downpour reducing the strength of bees in the colonies. High humidity in the hive, coupled with high temperature, creates an unfavourable environment for bees. They become lethargic and often suffer from dysentery. Egg laying capacity of queen is reduced, pollen becomes mouldy and unripe honey may ferment. Bee enemies, on the other hand, grow in number and further weaken the colonies. In most cases it is difficult to make such colonies to accept new queen. Moreover, there are no drones and new queen can not be mated. For survival of colonies in the rainy season the following management practices should be undertaken.

- Maintain new and prolific queen.
- Removal of empty combs from beehive at periodic intervals.
- Provide ventilation properly.
- Artificial diet should be provided and avoid robbing.
- Provide broods to broodless colonies from strong colonies.
- Protection from enemies and diseases must be given.
- Migrate bee colonies to overcome dearth period.

<u>Artificial diets</u>

Preparation of sugar syrup

During dearth period sugar syrup is provided to boost up the moral of bees, to increase egg laying capacity of queen, to construct new combs, and for survival of bees. A normal colony should have at least two kilogram of honey and pollen in Indian bees while 4-5 kg in Italian beehive as store. Below this quantity a colony needs artificial feeding. The sugar syrup should be prepared by boiling sugar in water. Sugar should be mixed by 50 per cent for rainy season, 40 per cent in summer and 75 per cent in winter. The sugar syrup should be allowed to cool then put it in feeder or plastic/steel cup provided with straw in syrup filled pot to sit the bees on it. Sugar syrup should be given in evening at weekly interval or as per need basis in desired quantity depending on colony strength, i.e. 250 - 300 ml per colony.

Pollen substitute

If the pollen store is not available in colony then pollen substitute or pollen supplements should be given and prepared with the following ingredients.

1.	Soybean flour (defatted)	-	35g
2.	Yeast powder	-	10g
3.	Pollen grains	-	15g
4.	Milk powder	-	05g
5.	Sugar	-	25g
6.	Honey	-	10g

Preparation of Pollen supplement

Soybean flour, yeast powder and milk powder mixed in Petri dish and sugar after making powder and pollen grains powder are also mixed with them. Thereafter mix the honey. Thus, a paste will be formed. The paste may be kept in small quantity on top bar of frame alternatively so that the bees could not get over crowed at a place for taking this.

Honey flow period management

To manage the colonies efficiently the beekeeper should have knowledge of honey flow trends and the state of the colonies. The principal function of the beekeeper during honey flow period is to keep the colony morale high. Congestion in the hive must be avoided and surplus house bees are drawn to supers. It must be remembered that more space is required for the evaporation of water from honey, before its final storage. Therefore, drawn combs should be provided liberally. Many times the queen enters in the super chamber and lays eggs, and honey extraction becomes difficult. Atleast three weeks before honey extraction a queen excluder should be placed in between brood and super chamber and queen is confined to brood chamber. An *A. mellifera colony attains* sufficient strength before honey flow and full depth supers on Langstroth hives are used in Bihar. Colony should be examined once a week and frames full of honey should be removed to the sides of the super and such frames can be raised from brood to super chamber. The frames which are three-fourth filled with honey or pollen and one-fourth with sealed brood should also be taken out of brood chamber and in its place empty combs or frames with foundation are added. Often the beekeeper is short of drawn combs and getting more combs raised would lower honey yield. In such cases, the combs which are completely sealed or two-thirds capped may be taken out for honey extraction and again placed to the supers after honey extraction. Such extraction, apparently gives an incentive to the colonies and helps to activate the bees to store more honey. Two or three such extractions are usually possible during litchi honey flow. The extraction of uncapped honey should be avoided because this unripe honey has higher moisture percentage and is liable to ferment. On warm days, bees are noticed to gather in clusters at the entrance. This is a sign of congestion and poor ventilation. This affects the honey gathering instinct. Ventilation can be improved by removing the entrance rod or placing the supers a little backward.

Golden Rule of Beekeeping: It is better to have one strong bee hive than two weak bee hives

Dr. B. L. Saraswat

Dr. B. L. Saraswat is a prominent figure in the apiculture industry in India, closely associated with the National Bee Board (NBB). He holds the esteemed position of President within the NBB, signifying his significant role and contributions to the apiculture sector in the country. Dr. B. L. Saraswat's active involvement in promoting and advancing apiculture and honey-related initiatives is well-documented in various official documents and news reports.

His leadership within the NBB has led to the execution of multiple projects and events geared towards the development of the apiculture sector in India. These endeavors have likely aimed to bolster beekeeping practices, honey production, and sustainable agricultural approaches that involve beekeeping. Dr. B. L. Saraswat's role as the President of the NBB underscores his dedication to fostering the growth of apiculture in India and aligns with the government's initiatives to enhance beekeeping as part of sustainable agriculture practices. His work is instrumental in harnessing the potential of beekeeping for economic and environmental benefits in the country.

Recent Development in the field of apiculture with respect to equipment, processes and policies.

B.L. Saraswat

Former Executive Director at National Bee Board, Ministry of Agricultural, Govt of India. DAC & FW.

Beekeeping is an agro-based activity which is being undertaken by farmers/landless labours in rural area as an integrated farming practice. Beekeeping supplements income & employment generation and nutritional intake of rural population. Though the honeybees are best known for the honey they produce, their economic role in nature is to pollinate flowering plants and assure setting of seed or fruit. Honey Bees have their vital role in sustaining plants bio-diversity resulting in environmental sustainability.

The Ministry of Agriculture launched a CSS entitled 'Development of Beekeeping for Improving Crop Productivity' in the VIII plan (1994-95). The Scheme continued up to IX Plan. A Beekeeping Development Board also functioned to coordinate the Beekeeping activities. However, the scheme got subsumed under the Macro Management Scheme, w.e.f October, 2000. The focus on Beekeeping also got diminished under such arrangement. In view of the tremendous scope for increasing productivity due to cross pollination and increase in income through Apiculture, Beekeeping was included as a supplemental activity under National Horticulture Mission (NHM) for promoting cross pollination of Horticultural Crops, in May, 2005. Further, it was decided to revive Beekeeping activity in the country, exponentially by pooling the resources of all organizations. Accordingly, the National Bee Board (NBB), a Registered Society was reconstituted in June, 2006. The main objective of the Govt. is overall development of Beekeeping by promoting Scientific Beekeeping in India to increase the productivity of crops through pollination and increase production of Honey, Wax, Bee Pollen, Propolis, Bee Venom, Royal jelly for increasing income of the Beekeepers/ Farmers. Presently, Beekeeping is being promoted under MIDH, under the component of 'Pollination Support through Beekeeping', KVIC, MSME, State Khadi Board (SKVIVs), etc. National Beekeeping and Honey Mission (NBHM) is also under

implementation since 2020. Beekeeping equipment have vital role in promoting Robust & Scientific Beekeeping and ensured pollination. For promoting Scientific Beekeeping lots of efforts, including isolated bee-breading yards, processing and testing facilities and other infrastructure facilities, etc. are still to be made.

Key Words:

Robust; Scientific Beekeeping, Pollination, Beehive, Comb Foundation Sheet, Brood chamber, Super/ Honey Chamber, Decapping Knife, Frame, Queen, Honey Extractor, Queen Cage , Feeder, Bee venom collector, Pollen Trap, Royal jelly kit, Propolis jali, Honey, Wax, Honey Bee Colony, Apiary, CFS manufacturing machine, Training , Queen Excluder, NBHM , Traceability, Bee Venom, Bee Pollen, Propolis, Royal jelly, Nectar, Migration, etc.

Ms. Richa Jaggi

Richa Jaggi is the Co-founder and Chief Marketing Officer (CMO) of Awshad – a South Delhi based cannabis wellness start-up. She is a dynamic business leader and an award-winning marketing and strategy specialist with 10+ years of rich cross-category and cross-sectoral experience with various leading global brands. She is one of the leading marketing voices of our country today with the title of 'Top #40under40 Marketers' under her belt – for which she was one of the youngest awardees! Richa is highly passionate about building brands and digital customer journeys; she is skilled in Digital Strategy, Integrated Marketing, Market Research, Brand Management, Social Media Strategy and Management, Digital Tools and Analytics, Influencer Marketing and so on. Following the completion of a graduate degree in Economics and a Masters in Marketing & Advertising, Richa started her career in advertising and PR, and went ahead to work for renowned agencies like Ogilvy, Publicis Groupe and Edelman, while helping some of the world's biggest and most iconic brands like Vodafone, Lakme (Hindustan Unilever), Outbrain and many more along the way with impeccable campaigns and strategies. Her last working stint before founding Awshad was as the Marketing Head of Times Internet until March 2021. At Awshad, Richa leads the marketing and strategy team of the brand, and is responsible for all the creative campaigns, digital marketing and brand building efforts to enable the brand to scale to new heights. She is bringing her comprehensive 360-degree experience across all major paradigms of marketing, and is at the heart of Awshad driving it forward with deep insights, creativity, storytelling and data.

Challenges of Woman Entrepreneur in the Indian Ecosystem

Richa Jaggi

Co-founder and Chief Marketing Officer

(CMO) of Awshad

Join in for a captivating journey into the dynamic world of entrepreneurship, as we delve into the fascinating narrative of Richa Jaggi's path as an entrepreneur and the birth of their innovative CBD startup, Awshad. As the Co-founder and Chief Marketing Officer of Awshad, Richa is redefining the perception of women entrepreneurs and the potential of medical cannabis in India. In an industry that is not commonly associated with women leaders, she stands out as a true innovator and successful entrepreneur. In recent years, India has witnessed a remarkable shift in the role of women entrepreneurs, highlighting their determination to break societal stereotypes and overcome challenges. Women are now making strides in various fields. Despite facing challenges like conservative mindsets and cultural barriers, women are challenging these labels. The startup culture has been a game-changer, empowering urban women to take stronger positions in their companies and disrupt traditionally male-dominated sectors. The COVID-19 pandemic presented both challenges and opportunities. While some women considered leaving their corporate jobs due to increased household responsibilities, many urban women embraced entrepreneurship during this period. The growth rate of women entrepreneurs in India surged during 2020 and 2021. However, there's still a need for more support, training, mentorship, and financial assistance for women entrepreneurs, as well as a supportive ecosystem starting from their homes.

Research suggests CBD can help alleviate anxiety, pain, and inflammation. Additionally, it's being explored for its potential in treating epilepsy and promoting better sleep. Apitherapy like medical cannabis is also hailed as a natural solution for its various properties like pain relief, anti-inflammatory effects, neurological benefits and many more. Though two very different segments of alternative medicines, medical apiculture and medical cannabis overlap when it comes to their benefits. Through a blend of personal experiences, industry insights, and transformative moments, this talk will inspire and inform the audience about the challenges and triumphs of a woman building a business in the rapidly evolving CBD landscape.

Rakesh Gupta (MBA) Agri-Entrepreneur

Mr. Rakesh Gupta is a passionate beekeeper, Rakesh has an excellent understanding of the complex yet simple nature of bees. With nearly twenty years of functional experience as a migratory beekeeper, Rakesh has a vast territorial reach and brings with him experience, exposure and new ideas for beekeeping. Rakesh is always willing to be associated with any Bee initiative. Realising that beekeeping is not only about honey, he visualizes immense possibilities of backward and forward integration too.

As Chief Advisor of Golden Hive Foundation, Rakesh has independently handled multiple training sessions and effectively imparted his bee-keeping know how – perfected over the years. With numerous published articles and innumerable workshops, he has successfully created empathy for these tiny and struggling pollinators.

Entrepreneurship in Apiculture

Rakesh Gupta

Beekeeper & Chief advisor, Golden Hive Foundation

The two most tangible entrepreneurship options with apiculture revolve around HONEY and HONEY BEES. (Although, there are a few more including queen breeding, pollination services, usage of bees wax, production of royal jelly, production of bee venom, forward and backward integration etc.)

However, we will only discuss the above two possibilities:

1. The most tangible output in apiculture is honey. Honey is still considered as an elixir of life. However, degradation of honey starts with unwise human intervention and therefore the honey normally available now is a highly compromised product. It is necessary to understand the dimensions of degradation - the ‘how’ and the ‘why’ too. And, how this quality degradation opens up new issues and challenges and a wonderful entrepreneurship option - of transforming honey from what it is to what it ought to be.
2. Another equally important entrepreneurship possibility is propagating healthy honey bees. As a responsible beekeeper, one has to realize the importance of basic yet correct beekeeping practices to propagate and sell healthy bee colonies to generate revenue. Here also, we will discuss the issues and challenges too.

Manual according to NEP-2020

Unit 1: Biology of Bees

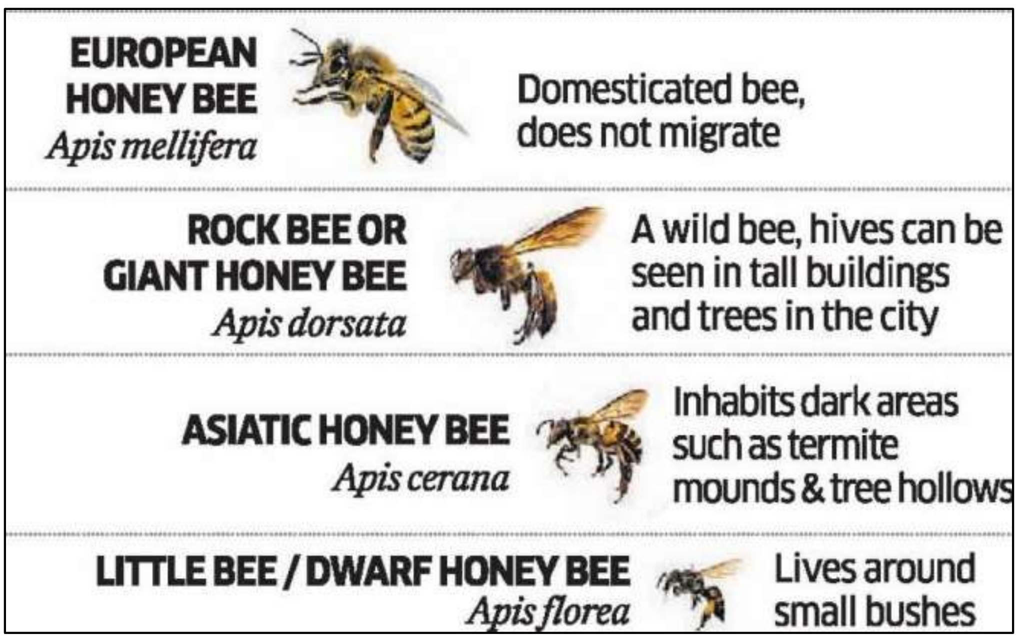
Dr. Roopa Rani Samal and Prof. Rita Rath

Dyal Singh College, University of Delhi

Historical background of apiculture, classification and biology of honey bees, Social organization of bee colony, behavioral patterns (bee dance, swarming).

Practical Exercises:

1. Study of the life history of honey bees: *Apis cerana indica*, *Apis mellifera*, *Apis dorsata*, *Apis florea*, *Melipona sp*. from specimen/ photographs - Egg, larva, pupa, adult (queen, drone, worker).
2. Study of morphological structures of honey bees through permanent slides/photographs– mouthparts, antenna, wings, sting apparatus and temporary mount of legs (antenna cleaner, mid leg, pollen basket).
3. Study of natural beehive and identification of queen cells, drone cells and brood.



Source: https://www.deccanherald.com/state/top-karnataka-stories/state-insect-bees-find-sudden-champion-in-govt-742831.html

Historical background of Apiculture

- Apiculture, the practice of beekeeping, has been a part of human history for thousands of years. The earliest evidence of beekeeping comes from rock paintings in Spain, estimated to be 7000 years old, which depict people gathering honey from wild bees using smoke to pacify them.
- Ancient civilizations such as the Egyptians, Greeks, and Romans also kept bees for their honey and wax, and used them for pollination. In fact, the Egyptians depicted beekeeping in hieroglyphics, and their honey was highly prized for its medicinal properties.
- In the middle ages, beekeeping became more widespread in Europe and the use of movable comb hives was introduced. This allowed beekeepers to manage their hives more effectively and to harvest honey without destroying the entire colony.
- The 18th and 19th centuries saw significant advancements in beekeeping technology, such as the invention of the modern beehive by Lorenzo Langstroth in 1851. This hive design allowed beekeepers to manipulate the colony more easily and increased honey production.
- Today, beekeeping continues to be an important practice for the production of honey and other bee products, as well as for the crucial role bees play in pollination. However, it is also facing numerous challenges such as habitat loss, pesticide exposure, and disease, highlighting the importance of responsible and sustainable beekeeping practices.

Classification and biology of honey bees

- Honey bees belong to the order Hymenoptera, which includes other well-known insects such as wasps, ants, and hornets. They are classified under the family Apidae, which includes over 20,000 species of bees, including bumblebees, carpenter bees, and orchid bees.
- The scientific name for the honey bee is *Apis mellifera*, with "*Apis*" meaning "bee" in Latin and "*mellifera*" meaning "honey-bearing." There are several recognized subspecies of *Apis mellifera*, each adapted to the climate and environmental conditions of their respective regions.
- The biology of honey bees involves a complex social structure, with different castes performing specialized roles within the colony. A typical colony consists of a single queen, several hundred to several thousand female worker bees, and a few hundred male drones.
- The queen is responsible for laying eggs and regulating the behavior of the workers and drones. Worker bees perform various tasks, such as tending to the queen and young, collecting nectar and pollen, and defending the hive. Male drones are primarily responsible for mating with queens from other colonies.
- Honey bees have a complex life cycle that includes several distinct stages: egg, larva, pupa, and adult. The length of time spent in each stage varies depending on the caste of the bee. For example, queens emerge from their cells in 15-16 days, workers in 21 days, and drones in 24 days.

- Honey bees are important pollinators of many crops and wildflowers, and they are also valued for their production of honey and beeswax.

Social organization of bee colony

- The social organization of a bee colony is complex and highly structured, with each individual bee playing a specific role in the functioning of the colony as a whole. The colony is typically composed of a queen bee, thousands of worker bees, and a few hundred drones.
- The queen bee is responsible for laying eggs, which will become the next generation of bees. The queen bee is also responsible for producing chemicals called pheromones that help to regulate the behavior of the other bees in the colony.
- The worker bees are all female and are responsible for many of the tasks that keep the colony functioning. These tasks include cleaning the hive, caring for the young bees, collecting nectar and pollen, and producing honey. As the worker bees age, they take on different tasks within the colony, with older workers typically serving as guards or foragers.
- The drones are male bees and their sole purpose is to mate with the queen bee. Drones do not collect nectar or pollen and do not contribute to the day-to-day functioning of the colony. Once they have mated with the queen, they die.
- Overall, the social organization of a bee colony is highly specialized and efficient, with each individual bee playing a specific role in the survival of the colony as a whole.

Behavioral patterns (bee dance, swarming).

Bee Dance

- The bee dance is a remarkable example of a complex behavioral pattern observed in honey bees. It is also known as the waggle dance or the round dance, and it is used by worker bees to communicate the location of a food source to other members of the colony.
- During the dance, the bee performs a series of movements that indicate the direction and distance of the food source from the hive. The direction of the dance is relative to the position of the sun, with the bee moving in a straight line or a circle depending on the distance to the food source. The duration of the dance is also correlated with the distance to the food source, with longer dances indicating further distances.
- The bee dance is made possible by the highly developed nervous system and sensory organs of honey bees. They have specialized receptors on their legs that can detect the vibrations of other bees performing the dance. They also have excellent vision that allows them to navigate and orient themselves to the position of the sun.
- The bee dance is an important example of how social insects have evolved complex communication systems to coordinate the behavior of large groups. By sharing information about the location of food sources, the colony can efficiently exploit resources and maximize their chances of survival.

- The round dance and the waggle dance are two types of communication dances performed by honey bees to communicate the location of food sources to other bees in the colony.
- The **round dance** is used when the food source is nearby, within about 50 meters of the hive. The dancing bee runs in a circle on the surface of the comb, alternating between clockwise and counterclockwise directions. While running, the bee vibrates its body and touches other bees with its antennae. This dance signals that food is nearby, but does not give any information about its direction or distance.
- The waggle dance is used to communicate the direction and distance of a food source that is more than 50 meters away from the hive. The dancing bee moves in a figure-eight pattern, waggling its body from side to side as it moves forward. The direction of the food source is indicated by the angle of the waggle relative to the vertical axis of the hive, while the distance is indicated by the duration of the dance and the number of waggles per second. Other bees in the colony can decode this information and navigate to the food source.
- The ability to perform these dances is an important aspect of the social organization of honey bee colonies, allowing for efficient communication and foraging.

Swarming

- Swarming is a natural phenomenon that occurs in honey bee colonies. It is the process of colony reproduction, where a large group of bees, including the queen, leave the parent colony and establish a new colony elsewhere. Swarming usually occurs in the spring or early summer when the colony population has grown too large for the existing hive.
- Before the swarm departs, scout bees search for a suitable location for the new colony. The swarm gathers around the queen and waits for the scouts to return with information about the new location. The bees communicate this information through a series of dances, called the waggle dance.
- The old queen leaves the hive with about half of the worker bees, while the remaining worker bees stay behind with the new queen. Swarming is an important natural process that helps to prevent overpopulation in a colony and allows for genetic diversity through the formation of new colonies. However, it can also be a problem for beekeepers as it can reduce honey production and increase the risk of the spread of disease.
- Beekeepers can manage swarming by monitoring the health and population of the colony, providing enough space for the colony to expand, and by manipulating the queen's pheromones to prevent the colony from swarming.

Practical 1 A: Study of the life history of honey bees: *Apis cerana indica*

Honey bees are fascinating insects known for their intricate social structure and honey production. One common species found in India is *Apis cerana indica*, also known as the Indian honey bee.

The life cycle of honey bees begins with the queen laying eggs in the honeycomb cells. These eggs hatch into larvae after three days and are fed with royal jelly by the worker bees. The larvae then spin cocoons and pupate for 12 days before emerging as adult bees.

1. Eggs

- The eggs of *Apis cerana indica*, also known as the Indian honey bee, are a critical stage in the life cycle of this insect.
- The queen bee is responsible for laying eggs, which are then placed in individual cells within the honeycomb.
- The eggs are tiny, cylindrical, and slightly curved, measuring about 1.5mm in length and 0.3mm in width.
- They are almost transparent, making it challenging to spot them inside the comb. The eggs are attached to the bottom of the cell, standing upright and surrounded by a small amount of royal jelly.
- Once the egg is laid, **the worker bees start feeding it with royal jelly**, which is a highly nutritious secretion produced by their glands. This royal jelly helps the egg to develop into a healthy larva.
- The development of the egg takes about three days, after which it hatches into a larva.
- The eggs of *Apis cerana indica* play a crucial role in the life cycle of the honey bee. They are the first stage of development and the foundation of the entire colony. Understanding the development of the egg is essential for beekeepers and researchers, as it provides insight into the reproductive behavior and ecology of these insects.

2. Larvae

- The larval stage is a crucial part of the life cycle of *Apis cerana indica*. After hatching from the egg, the bee enters the larval stage, during which it undergoes significant growth and development.
- The larva is a small, white, grub-like creature with no legs or wings and a curved, segmented body. It is entirely dependent on the worker bees for its survival, as it cannot feed itself or move around.
- ***During the larval stage, the worker bees feed the larva with royal jelly, a highly nutritious secretion produced by their glands. The royal jelly contains all the essential***

nutrients needed for the larva's growth and development, including proteins, carbohydrates, and fats.

- The larval stage lasts for approximately six days, during which the larva grows significantly in size. Towards the end of the larval stage, the larvae covers the top of the hive and enters the pupal stage, where it undergoes metamorphosis to become an adult bee.
  - There are also five larval instars in *Apis cerana indica*, which is also known as the Indian honey bee. The developmental process and growth patterns of *A. cerana indica* larvae are similar to those of *Apis mellifera*, including the molting and shedding of skin during each instar.
  - However, there may be some differences in the timing and duration of each instar, as well as in the specific nutritional requirements of the larvae. Overall, understanding the number and characteristics of larval instars is an essential aspect of bee biology and can provide valuable information for beekeepers and researchers.
  - The worker bees play a vital role in the larval stage, ensuring that the larva receives enough royal jelly to grow and develop correctly. The amount and quality of royal jelly fed to the larva can influence the bee's future as a worker, drone, or queen bee.

3. Pupa

- During the pupal stage, the bee undergoes several changes, both externally and internally. The body of the pupa transforms into the characteristic shape of an adult bee, with the wings, legs, and antennae developing and becoming more prominent.
- The pupal stage lasts for approximately 12 days, during which the bee is entirely enclosed in its shell and immobile.
- As the pupal stage nears its end, the bee starts to break out of its top cover and sheds its outer skin. The fully developed adult bee emerges from the cocoon and begins its life as a worker, drone, or queen bee.

4. Adult

- The adult bees can be categorized into three groups: the queen, the drones, and the worker bees.
- The queen is responsible for laying eggs and can live up to five years. The drones are male bees that mate with the queen and die soon after. The worker bees, which are female, perform various tasks such as caring for the young, collecting nectar and pollen, and defending the hive.
- The worker bees have a relatively short life span of around 6 weeks during the summer months. During this time, they perform different tasks depending on their age. The

younger bees work inside the hive, while the older ones forage for nectar and pollen outside.

- ***Once the forager bees return to the hive, they communicate the location of the food source to other worker bees using a dance called the waggle dance. This helps the other bees locate the food source and collect more nectar and pollen.***
- As winter approaches, the worker bees begin to prepare the hive for the colder months by storing honey and pollen in the comb. The queen bee lays fewer eggs, and the worker bee cluster together to maintain warmth.

In summary, the life history of *Apis cerana indica* is a complex and fascinating process, involving various stages of development and different roles played by the queen, drones, and worker bees. Understanding the life cycle of honey bees is essential for beekeepers and helps us appreciate the crucial role these insects play in pollination and food production.

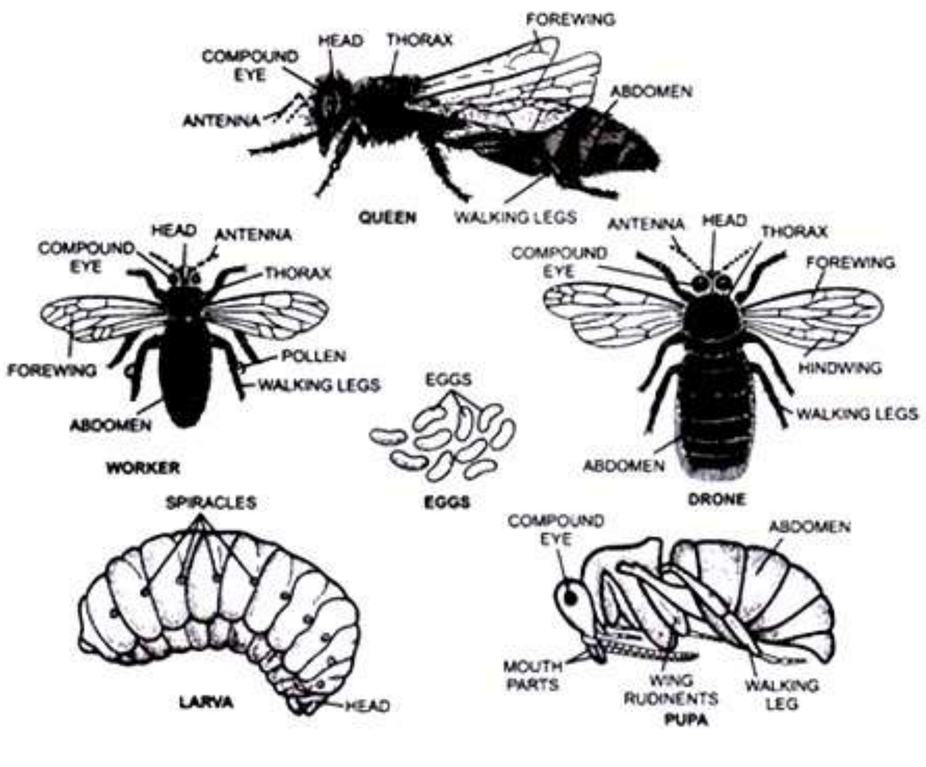


Figure 1: Life cycle of Apis cerana indica

Practical 1 B: Study of the life history of honey bees: *Apis mellifera*

Apis mellifera, or the western honey bee, is one of the most important and widely recognized species of bees. They are native to Europe, Africa, and the Middle East, but it has been introduced to many other parts of the world, including North and South America, Asia, and Australia. They are important pollinator of many crops and wildflowers, making it essential to the world's food supply and biodiversity. *Apis mellifera* populations are threatened by various factors, including habitat loss, pesticide use, and disease. They produces many valuable products, including honey, beeswax, and royal jelly.

1. Eggs

- The eggs of *Apis mellifera*, or the western honey bee, are a crucial part of their life cycle. After the queen bee mates with drones, she begins to lay eggs in the cells of the hive. Each egg is about 1.5 mm long and is attached to the bottom of the cell by a small pedestal.
- The eggs are white and elongated, with a slightly curved shape at one end. They are very small and difficult to see with the naked eye, but beekeepers and researchers use magnifying glasses to observe them.
- The queen bee can lay up to 2,000 eggs per day during peak season, and the eggs hatch into larvae after three days. The queen decides whether to lay a fertilized egg, which will develop into a female worker bee or queen bee, or an unfertilized egg, which will become a male drone.
- The queen bee can control the sex of her offspring by selectively fertilizing the eggs with sperm stored in her body.
- The size and shape of the eggs are important for the beekeeper to assess the health and productivity of the colony. In general, healthy eggs are uniform in size and shape, and the queen bee lays them in a consistent pattern throughout the hive. Irregularly sized or shaped eggs can be a sign of disease or stress within the colony.

2. Larva

- The larval stage begins when the eggs hatch, and lasts for about six days. During this time, the larvae undergo rapid growth and development, as they are fed and cared for by worker bees.
- The larvae are small, white, and have no eyes or legs. They are curled up in a C-shape, and they fill the bottom of the cell in which they are laid. They are unable to move or feed themselves, and are entirely dependent on the worker bees to provide food and care.
- The worker bees feed the larvae a special secretion called royal jelly, which is produced by glands in their head. This royal jelly is rich in protein and nutrients, and helps the larvae grow quickly. After three days, the larvae are switched to a diet of pollen and nectar, which is still provided by the worker bees.

- There are five larval instars in *Apis mellifera*. Each instar represents a developmental stage in the larval growth process, which occurs over approximately six days. The first instar begins when the egg hatches, and the fifth instar ends when the larva pupates. During each instar, the larva molts or sheds its skin to accommodate its growing body and prepare for the next stage of development. The number of instars in bee larvae varies across different bee species, with some having fewer or more instars.
- During the larval stage, the bees undergo several molts, or shedding of their skin, as they grow larger. At the end of the six-day larval stage, the larvae spin a cocoon around themselves and begin to pupate. During this time, they transform into adult bees, including the worker bees, queen bee, and drones.
- The larval stage is crucial for the development of the colony, as it determines the number and type of bees that will be present.

3. Pupa

- After the larval stage, the larvae spin a cocoon around themselves and begin the pupal stage, which lasts for about 12 days. During this time, the larvae transform into adult bees, including worker bees, drones, or queen bees.
- The pupal stage begins when the larvae have fully enclosed themselves in the cell of the hive.
- The pupae are immobile and have no feeding or excretory systems. During this stage, the bees undergo critical physical and developmental changes, including the formation of legs, wings, eyes, and antennae, and the differentiation of male and female reproductive organs.
- As the pupal stage progresses, the color of the bees changes from white to a darker brown. This coloration is due to the development of pigments, which give the bees their characteristic stripes and coloration.
- At the end of the pupal stage, the adult bees emerge from their cocoon and begin their life outside of the hive.

4. Adult

- The adult *Apis mellifera*, is a highly social insect that plays a crucial role in pollination and honey production. The adult bee has a complex anatomical structure, with specialized organs and adaptations that allow it to perform its various tasks within the hive and outside.
- Worker bees are the smallest members of the colony, and they make up the majority of the adult population. They are responsible for tasks such as nursing the young, gathering nectar and pollen, producing wax, building the comb, and guarding the hive.
- Worker bees have a lifespan of around six weeks during the summer months and up to several months during the winter.

- Drones, on the other hand, are larger than worker bees and have a single purpose: to mate with the queen. They have large eyes, which allow them to locate the queen during mating flights, but they lack stingers and other adaptations for foraging or defense. Drones are expelled from the hive during the winter months when resources are scarce.
- The queen bee is the largest member of the colony, and she has a specialized reproductive system that allows her to lay eggs continually. She is responsible for the survival and productivity of the hive, and worker bees attend to her needs and protect her from harm. The queen bee can live up to five years, but her productivity declines after the first year.
- Adult honey bees have a highly specialized mouthpart called the proboscis, which they use to suck nectar and water. They also have specialized pollen baskets on their hind legs, which they use to carry pollen back to the hive.
- Overall, the adult *Apis mellifera* is a highly specialized and complex organism that performs crucial functions within the hive and in the larger ecosystem. Understanding their anatomy, behavior, and ecological role is essential for beekeepers, researchers, and anyone interested in the natural world.

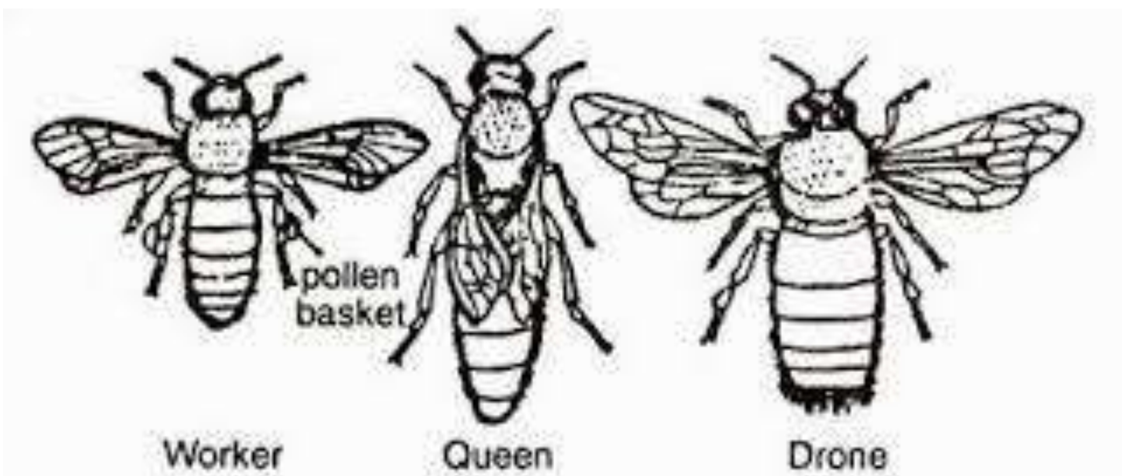


Figure-2: The various caste of Apis mellifera

Practical 1 C: Study of the life history of honey bees: *Apis florea*

The *Apis florea*, commonly known as the dwarf honey bee or red dwarf honey bee, is one of two small, wild honey bee species found in southern and southeastern Asia. Unlike its counterpart, *Apis andreniformis*, *Apis florea* is widely distributed. It was first identified in the late 18th century and stands out for its unique morphology, foraging behavior, and defense mechanisms such as producing a piping noise. *Apis florea* builds open nests and has small colonies, which makes them more vulnerable to predators compared to species that nest in cavities with larger numbers of defensive workers. These bees play an essential role in pollination and are highly valued in countries such as Cambodia. The comb had a unique Marigold color, unlike the typical light yellow color.

1. **Eggs:**

- The worker bees produce and shape a wax honeycomb in which eggs are laid singly. The queen has the ability to choose whether to fertilize the egg during the laying process, typically depending on the cell in which she is laying it. Drones develop from unfertilized eggs, while fertilized eggs give rise to female bees such as queens and worker bees.

2. **Larva:**

- Worker bees produce royal jelly, which they use to initially feed the larvae. The larvae then transition to a diet of honey and pollen. However, if a larva is exclusively fed royal jelly, it will develop into a queen bee. Before pupating, the larva undergoes multiple moltings and spins a cocoon within its cell.
- The larval stage of *Apis florea*, like other honey bees, has five instars. During each instar, the larva undergoes growth and development, shedding its skin as it transitions to the next stage. By the end of the fifth instar, the larva has reached its maximum size and is ready to spin its cocoon and pupate.

3. **Adult:**

- The small size of *A. florea* compared to other honeybees has earned it the nickname "dwarf honey bee." Workers of this species typically measure 7-10 mm in body length and are red-brown in color.
- Colonies of *A. florea* construct a single, exposed comb, usually on tree branches or shrubs. These bees produce honey, which is harvested and consumed in Thailand and Cambodia.
- *A. florea* are excellent pollinators and play a crucial ecological role in their habitats. The drones of this species carry a thumb-like bifurcation called the basitarsus, located two-thirds along the length of the tibia. The fimbriate lobe of *A. florea* features three protrusions, and they use two stylet barbs to deliver their stings.
- When they are young, worker bees primarily focus on cleaning the hive and feeding the larvae. As their glands for producing royal jelly begin to atrophy, they transition to building comb cells. As they mature, they take on other tasks within the colony, such as receiving

nectar and pollen from foragers and defending the hive. Eventually, the worker will take her first orientation flights and venture out of the hive to forage for the remainder of her life.

The development process from egg to emerging bee differs among queens, workers, and drones. Queens emerge from their cells after 15-16 days, while workers take 21 days and drones take 24 days. This honeycomb is from the species of honey bees known as "Dwarf Honey bees" (Apis florea). Their stingers are typically not strong enough to penetrate human skin.

Practical 1 D: Study of the life history of honey bees: *Melipona sp.*

Melipona sp., commonly known as stingless bees, have a fascinating life cycle that involves several distinct stages.

1. **Eggs**

- The queen lays small white eggs in individual cells of the comb. The eggs are attached to the bottom of the cell and are visible to the naked eye. The eggs are laid in a horizontal or vertical pattern depending on the species.

2. **Larvae**

- After about three days, the eggs hatch into tiny white larvae. The larvae are fed with a mixture of pollen and honey, which is secreted by the nurse bees. The larvae continue to grow and molt through several instars over the next six days.

3. **Pupae**

- After the final instar, the larva spins a cocoon around itself and enters the pupal stage. During this time, the pupa undergoes metamorphosis, transforming into an adult bee. The length of this stage varies depending on the species and environmental conditions.

4. **Adult**

- The life cycle of *Melipona sp*. starts with a fertilized queen bee. The queen is responsible for laying eggs that will hatch into workers and drones. She begins laying eggs soon after she emerges from her own cell.
- When the adult bee is fully developed, it chews through the cocoon and the wax cap of the cell to emerge as an adult bee. The emerging bee is usually greeted by the other bees in the colony, who clean and groom it.
- The emerging bee will either be a worker or a drone, depending on whether the queen laid a fertilized or unfertilized egg. Workers are female bees and perform all the tasks within the colony, while drones are male bees that exist solely to mate with the queen.
- During the life cycle of a honey bee colony, the queen mates with a single drone from a different colony and stores all the sperm she needs for egg fertilization during her life. The

mating occurs in-flight, and the queen can mate with multiple drones during a single mating flight. Once the queen returns to her nest, she begins to lay two types of eggs.

- Fertilized eggs are laid and will develop into either worker or queen larvae. Unfertilized eggs develop into drone larvae. The queen determines the sex of the egg by whether or not she fertilizes it with sperm before laying it.
- The fertilized egg hatches into a larva after three days. Larvae that must develop into queens are fed and provisioned entirely on royal jelly produced by the worker bees. The royal jelly is a protein-rich secretion that is fed exclusively to queen larvae throughout their development.
- The worker bees care for the developing larvae by feeding them a mixture of pollen and nectar. They also cap the cells with wax when the larva is fully grown, which signals to the rest of the colony that the cell is ready to be sealed.
- After about six days, the larva spins a cocoon around itself and begins the pupal stage. During this time, the larva metamorphoses into an adult bee. Worker bees emerge from their cells after about 21 days, while queens emerge after about 16 days. Drones, on the other hand, take around 24 days to develop.
- Once the adult bee emerges from its cell, it begins to help with the various tasks within the colony. Workers start with tasks such as cleaning and caring for the young, then progress to other tasks such as foraging, guarding the hive, and storing nectar and pollen. Queens, however, focus on laying eggs and regulating the behavior of the colony. Drones, which are male bees, have only one purpose, which is to mate with a queen from another colony.
- Drones serve as the male members of the colony and play a vital role in the colony's reproduction by mating with virgin queens from other colonies. They originate from unfertilized eggs and are fed with larval food similar to that of the workers. Drones can be easily identified within the nest by their light-colored appearance.

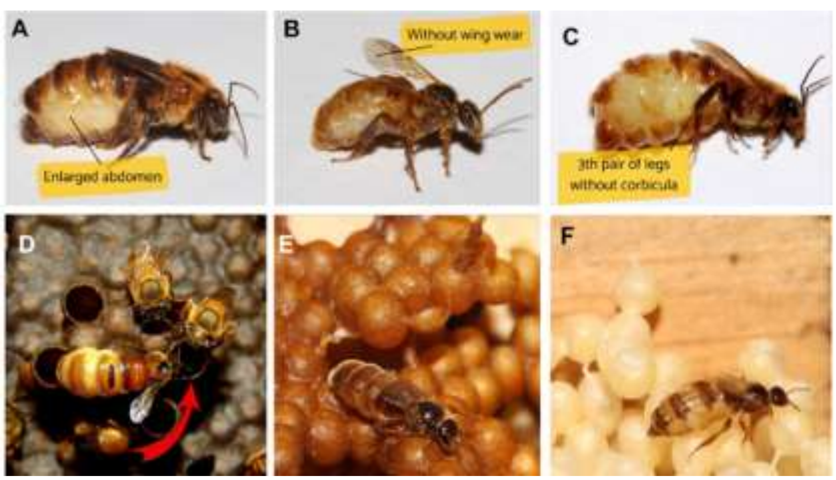


Figure-3: The royal brood cells, represented by white ellipses, can be found in different arrangements depending on the species of stingless bee.

Practical 2: Study of morphological structures of honey bees through permanent slides/photographs–mouthparts, antenna, wings, sting apparatus and temporary mount of legs (antenna cleaner, mid leg, pollen basket).

1. **Mouth Parts of Honey Bee**

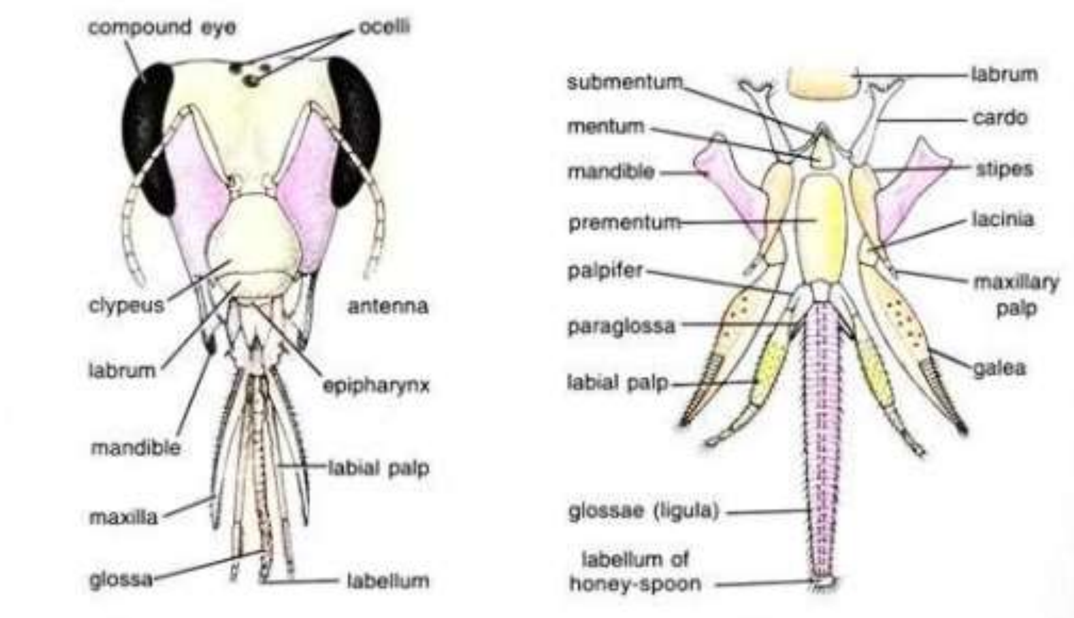


Figure-4: Mouth parts of Honey Bee.

The mouthparts of honeybee are chewing and lapping type. Also bumble-bees also have similar kind of mouth parts. Honey bees have a combined mouth parts than can both chew and suck. This is accomplished by having both mandibles and a proboscis.

- ✓ **Mandibles:** The mandibles are a pair of jaws suspended from the head of the bee. The insect uses them to chew wood when redesigning the hive entrance, to chew pollen and to work wax for comb-building. They also permit any activity requiring a pair of grasping instruments. These paired "teeth" that can be opened and closed to get the work done.
- ✓ **Proboscis:** The proboscis of the honeybee is not a permanent functional organ, but it is formed temporarily by assembling parts of the maxillae and the labium to produce a unique tube for drawing up liquids such as sweet juices, nectar, water and honey. The insect releases it when needed for use, then withdraws and folds it back beneath the head when it is not needed.
- ✓ **Labellum:** The glossae are greatly elongated to form a hairy, flexible tongue. The glossa terminates into a small circular spoon shaped lobe called labellum, which is useful to lick the nectar. Labial palms are elongate and four segmented.
- ✓ **Maxillolabial Structures:** Maxillolabial Structures are modified to form the lapping tongue. The tongue unit consists of the two galeae of maxillae, two labial Palps and an elongated flexible hairy glossa of labium.

Chewing and Lapping mouthparts: Process of feeding

The galeae fit tightly lengthwise, against the elongated labial palps and they in turn roof over the elongated glossae (tongue) to form a temporary food channel through which saliva is discharged. The tongue (glossae) is trusted into flower, which gets smeared with nectar. It is then retracted between labial palps & galeae. Nectar is then squeezed by galeae and is deposited in the cavity formed by the paraglossae. Accumulated nectar is then drawn into oesophagus by the pharyngeal pump.

2. **Antenna of Honey bee**

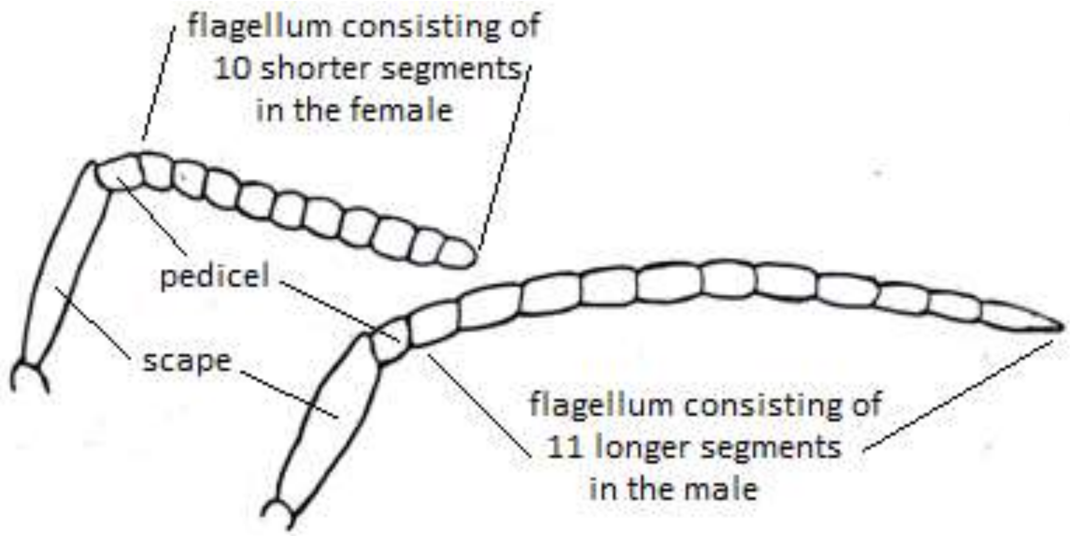


Figure-5: Antenna of male and female honey bee.

- The antenna of a honey bee is a sensory organ located on the head and consists of two main segments: the scape and the flagellum. The scape is the base of the antenna that attaches to the head while the flagellum is the long, thin, segmented part of the antenna that extends outward.
- The flagellum is composed of many individual segments, each covered in sensory organs known as sensilla. These sensilla are responsible for detecting various stimuli, including odors, temperatures, humidity, and vibrations. The length and shape of the sensilla vary depending on their function.
- The honey bee uses its antennae for various tasks, including communication with other bees, detecting food sources, and navigating to and from the hive. The antenna can also detect changes in the environment, such as the presence of predators, which helps the bee to avoid danger. Overall, the antenna is a crucial part of a honey bee's sensory system and plays a vital role in its survival.
- The main difference between male and female honeybee antennae is that the male antenna is longer and has more segments than the female antenna.
- Male bees, also known as drones, have 13 segments on their antenna, while female bees, including workers and queens, have only 12 segments. The male antenna is also slightly curved

and has longer segments than the female antenna. Additionally, the male antenna lacks the specialized structures that the female antenna has for collecting pollen, such as pollen combs and brushes.

- Another noticeable difference is that the tip of the male antenna is blunt, while the female antenna has a more pointed tip. However, these differences may not be visible to the naked eye and may require magnification to observe.

3. **<u>Legs of Honey bee</u>**

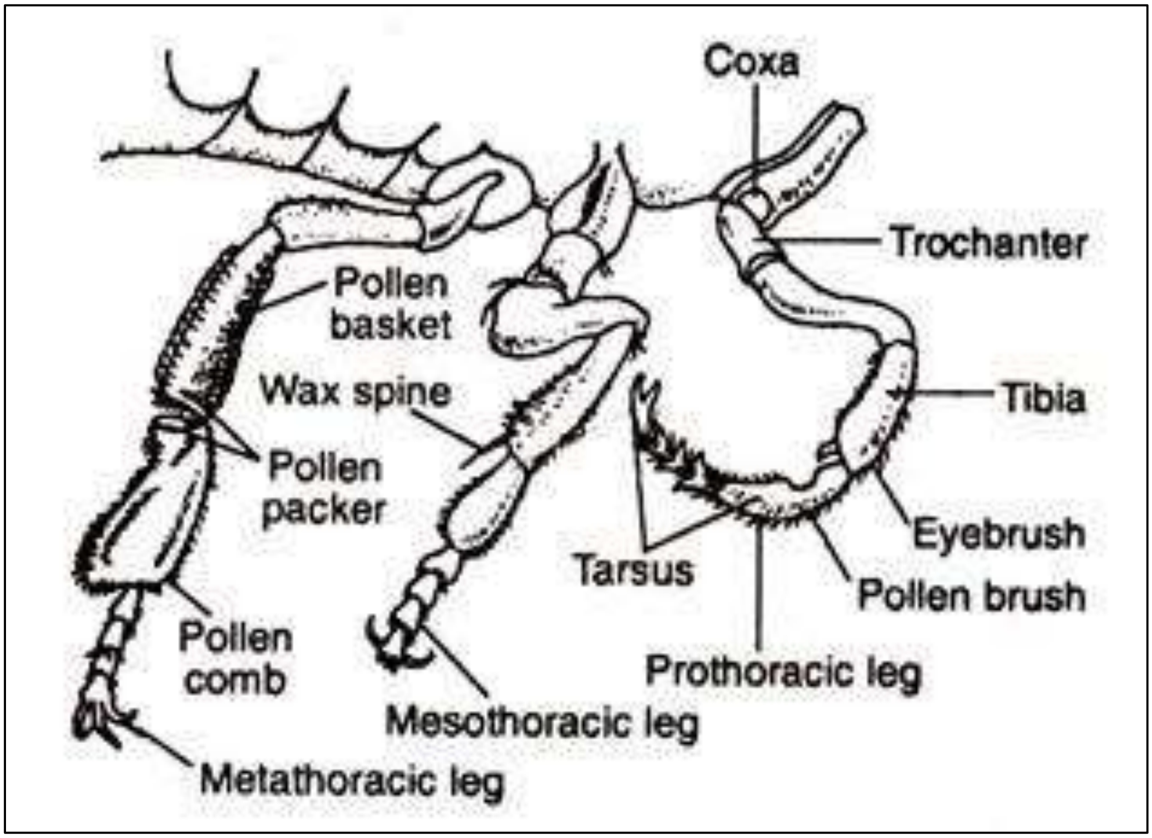


Figure-6: Fore-leg, Mid-leg and Hind leg of Honey bee.

The legs of a honey bee is a complex structure that is adapted for a variety of tasks, including grooming, collecting pollen, and manipulating wax to build honeycomb. Here are some features of the foreleg that can be observed in both male and female honey bees:

- ✓ **Coxa:** The coxa is the basal segment of the leg that attaches to the thorax. It is relatively short and stout, with a groove on the underside that allows the bee to fold its leg close to its body.
- ✓ **Trochanter:** The trochanter is a small segment that articulates with the coxa. It is more elongated than the coxa and has a ball-and-socket joint that allows the leg to move in different directions.

- ✓ **Femur:** The femur is the largest and most muscular segment of the leg. It is relatively straight and provides a stable platform for the bee to stand on.
- ✓ **Tibia:** The tibia is the next segment of the leg, and it is more slender than the femur. It is covered in rows of stiff hairs that the bee uses to brush pollen off its body and collect it for transport.
- ✓ **Basitarsus:** The basitarsus is a thick segment that connects the tibia to the foot. It has a curved shape and is covered in sensory hairs that allow the bee to feel its way around its environment.
- ✓ **Tarsus:** The tarsus is the foot of the leg, and it is made up of five segments. Each segment is equipped with tiny hooks and pads that allow the bee to cling to surfaces and manipulate objects. The final segment, the pretarsus, has two claws and a sticky pad called the arolium that allows the bee to grip surfaces tightly.

Antenna Cleaner:

- The "antenna cleaner" of honey bees refers to a specialized structure found on their front legs. This structure consists of a series of curved bristles arranged in a row.
- The bee uses this structure to clean its antennae, which are important sensory organs used for detecting food sources, communicating with other bees, and navigating to and from the hive.
- To clean its antennae, the bee will run them through the bristles on its forelegs, which help to remove any dirt or debris that may have accumulated.

Pollen Basket:

- Pollen baskets, also known as corbiculae, are specialized structures found on the hind legs of female bees, including honey bees. They are used to carry and transport pollen back to the hive.
- The pollen is collected from flowers and plants and stored in the pollen baskets, which are concave areas located on the outer side of the tibia and tarsus of the hind legs. The baskets are surrounded by long, stiff hairs that help to keep the pollen in place during flight.
- The pollen is moistened with nectar or saliva to make it more malleable and compact, and then packed into the pollen baskets using the bee's mandibles and front legs.
- Once the bee returns to the hive, the pollen is unloaded from the baskets and used as food for the colony. Pollen is an important source of protein, vitamins, and minerals for bees and is essential for the development of larvae.

4. **Sting Apparatus**

- The sting apparatus of a honey bee consists of several components, including the sting itself, a venom sac, and muscles that control the movement of the sting. The sting is a modified ovipositor, which is a structure used by females to lay eggs. In the honey bee, the ovipositor has been modified for defense purposes, allowing the bee to sting potential threats.

- The sting is barbed, meaning that it has backward-facing hooks that can become lodged in the skin of the target. When the bee pulls away, the sting and associated tissues are left behind, resulting in the death of the bee. This is why honey bees are said to have a "one-time use" sting.
- The venom sac, located at the base of the sting, contains venom that is injected into the target when the bee stings. The venom can cause pain, swelling, and other symptoms in humans and other animals.
- The muscles that control the movement of the sting are located in the abdomen of the bee. When the bee stings, these muscles contract, driving the sting into the target and releasing venom from the venom sac.
- The sting apparatus of honey bees consists of several parts, including the venom sac, a pair of barbed lancets, and the sting bulb. The venom sac contains the venom, which is acidic in nature and composed of various peptides and enzymes.
- When a honey bee stings, the lancets and sting bulb penetrate the skin of the victim, and the venom sac pumps venom through the lancets and into the wound. The venom causes pain, inflammation, and other effects on the victim.
- In addition to the venom, the sting apparatus also secretes an alkaline fluid that neutralizes the acidic venom and helps to prevent it from being degraded too quickly by the victim's immune system. This alkaline fluid also acts as a lubricant, allowing the lancets to penetrate the skin more easily.

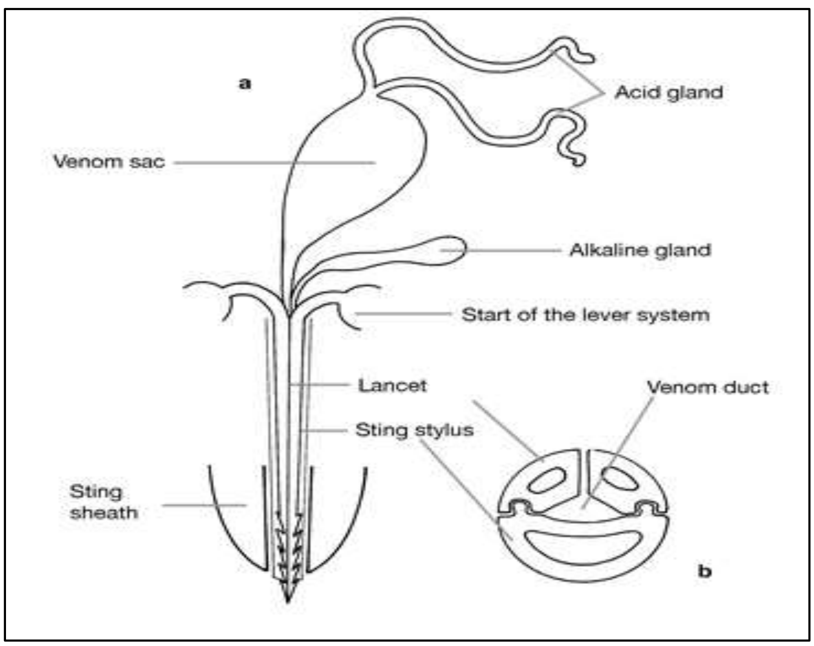


Figure-7: Sting Apparatus of Honey Bee

5. Wings

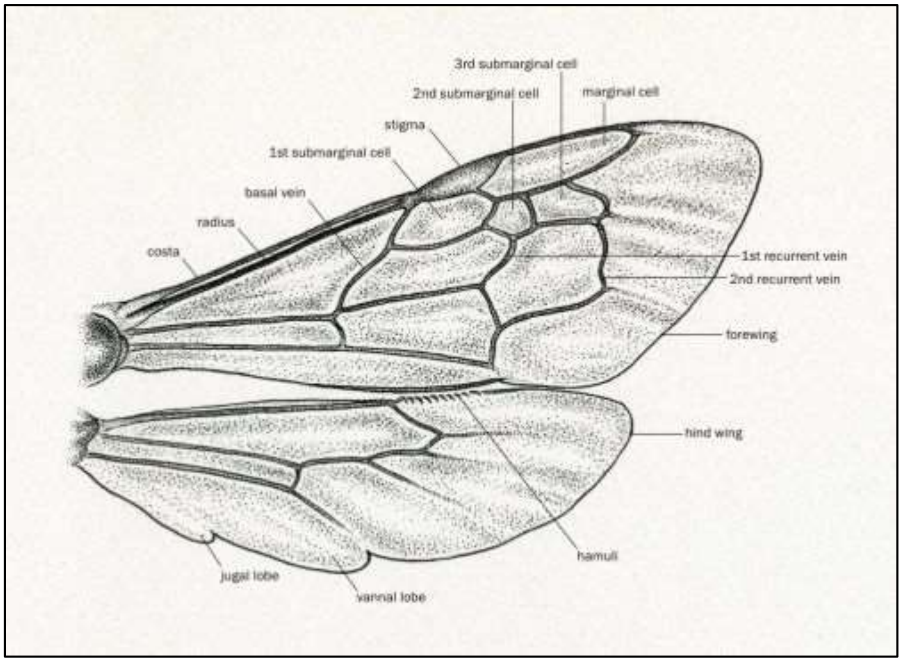


Figure-8: Pattern of fore and hind wing of honey bee.

- Honey bees have four wings in total, with two wings on each side of the body. The forewing and hindwing on each side are connected by a series of hooks called hamuli.
- Hamuli are hook-like structures that interlock the forewing and hindwing of honey bees during flight. This interlocking mechanism allows the wings to function as a single unit, enhancing stability and maneuverability during flight. The hamuli also allow the wings to maintain a flat, aerodynamic profile during flight, which reduces drag and increases efficiency. The interlocking of the wings is a unique feature of honey bees and some other insect species, which enables them to fly with great precision and agility.
- The wings are membranous and translucent, with veins that strengthen and support them.
- The shape and size of the wings vary depending on the species of honey bee, but they are generally long and narrow, with a characteristic pattern of veins.
- The wings are used for a variety of purposes, including foraging for food, defending the hive, and communicating with other bees through the production of specific wing movements and vibrations.

Practical 3- Study of natural beehive and identification of queen cells, drone cells and brood

In nature, honey bees build their nests or hives inside cavities, such as hollow trees, crevices in rocks, or even in buildings. These hives are composed of a series of wax comb cells arranged in a hexagonal pattern, with each cell having a depth of about 1.5 cm and a diameter of about 0.5 cm. The cells are used to store honey, pollen, and brood (developing young).

The cells in a honey bee hive can be broadly classified into three types:

1. **Queen Cells:** These are larger than the regular cells and are elongated in shape. They are built by the worker bees when the colony needs a new queen. The queen cells are used to raise the queen bee and are fed with royal jelly exclusively.
2. **Worker Cells:** These are the regular cells in the hive, and they are smaller than the queen cells. They are used to store honey and pollen and are also used for brood rearing. The eggs laid in these cells develop into worker bees, which form the bulk of the hive population.
3. **Drone Cells:** These cells are slightly larger than the worker cells and are used exclusively for rearing drone bees. Drones are male bees that are produced by the queen bee laying unfertilized eggs. They are raised in the drone cells and are used for mating with virgin queens from other colonies.
4. **Brood Cells:** In addition to these three cell types, there are also some specialized cells in the hive, such as the storage cells for honey and pollen, and the brood cells, which are used to rear the developing young. The brood cells are arranged in a compact pattern in the center of the comb, with the honey and pollen storage cells surrounding them.

Identification of the various cells in a honey bee hive can be done by examining the comb closely. The queen cells are easy to spot, as they are larger and elongated. The worker cells are smaller and hexagonal in shape, and they are usually the most abundant cells in the hive. The drone cells are slightly larger than the worker cells, and they are often found scattered throughout the hive. The brood cells are typically located in the center of the comb, and they can be identified by the presence of developing young inside them.

Figure-9: Natural hive showing queen cells, drone cells and brood cells

Unit 2: Rearing of Bees

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Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth; Bee Pasturage; Selection of bee species for apiculture –*Apis cerana indica, Apis mellifera*; Bee keeping equipment methods of extraction of honey (Indigenous and Modern) & processing; Apiary management - Honey flow period and lean period, effects of pollutants on honeybees.

Practical Exercises:

1. Distinguishing characters of workers of three bee species.
2. Importance of site selection for bee keeping.
3. Study of an artificial hive (Langstroth/Newton), its various parts and beekeeping equipment: draw diagrams of bee boxes proportionate to the body size and measure the body length and wing size.
4. Preparation of mount of pollen grains from flowers.

Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth

Artificial bee rearing, also known as apiculture, is the practice of managing and rearing bees in artificial beehives for various purposes, such as honey production, pollination services, or scientific research. Two popular types of beehives used in apiculture are the Newton hive and the Langstroth hive.

Newton Hive: The Newton hive is a traditional type of beehive that was developed by Reverend Samuel Newton in the early 18th century. It consists of a series of wooden boxes stacked on top of each other. Each box, also known as a super, contains frames where bees build their comb and store honey. The Newton hive is characterized by its simplicity and ease of construction, making it suitable for hobbyist beekeepers.

Langstroth Hive: The Langstroth hive, invented by Reverend Lorenzo Lorraine Langstroth in the mid-19th century, revolutionized modern beekeeping. It is the most widely used hive design worldwide. The Langstroth hive features standardized dimensions and movable frames, which allow beekeepers to inspect and manage the hive more efficiently. The frames can be easily removed, and surplus honey can be extracted without causing significant disruption to the colony. This hive design minimizes bee stress and provides better control over the beekeeping process.

Both the Newton and Langstroth hives have their advantages and disadvantages, and the choice between them often depends on the beekeeper's preferences, management style, and goals.

It's worth mentioning that in recent years, there have been advancements in hive design and beekeeping techniques, such as top-bar hives and flow hives, which provide alternative options for beekeepers. These newer hive designs aim to simplify hive management and honey extraction, making beekeeping more accessible to beginners or those with limited space.

Bee Pasturage

Bee pasturage, also known as bee forage or bee pasture, refers to the sources of nectar and pollen that bees collect from flowering plants. It is the natural food supply for bees and plays a vital role in their survival and productivity. Bee pasturage is essential for honey production, as well as the pollination services that bees provide to plants, enabling them to reproduce.

Bees are opportunistic foragers and will gather nectar and pollen from a variety of flowering plants. Different plants bloom at different times throughout the year, providing a diverse and changing array of food sources for bees. A healthy and abundant bee pasturage is crucial for maintaining strong and thriving bee colonies. Beekeepers often consider the availability and quality of bee pasturage when choosing locations for their apiaries. They look for areas with a diverse range of flowering plants that provide a continuous supply of nectar and pollen throughout the seasons. This ensures that the bees have a balanced diet and sufficient resources to sustain their colony.

Bee pasturage can include a wide range of plants, including flowering trees, shrubs, wildflowers, garden flowers, and agricultural crops. Some popular plants for bee pasturage include clover, alfalfa, sunflowers, lavender, citrus trees, and fruit trees, among others. It's important for beekeepers and landowners to promote and protect bee pasturage by planting bee-friendly flowers and avoiding the use of pesticides that can harm bees.

Selection of bee species for domestication

When selecting bee species for apiculture and domestication, several factors should be considered, including the bee's suitability for the local environment, desired characteristics for honey production or pollination, and the beekeeper's goals and preferences. Here are some commonly selected bee species for apiculture:

Apis mellifera (Western honey bee): This is the most commonly domesticated bee species worldwide. *Apis mellifera* has a strong social structure, excellent honey production capabilities, and effective pollination behavior. There are numerous subspecies of *Apis mellifera* available, each with its unique traits and adaptations to different climates and environments.

Apis cerana (Eastern honey bee): *Apis cerana* is native to Asia and has been domesticated in several regions. It is well-suited to tropical and subtropical climates. This species is valued for its ability to cope with high temperatures and its resistance to certain pests and diseases.

Apis dorsata (Giant honey bee): *Apis dorsata* is known for its large size and the construction of large, exposed nests. They are found in tropical regions, particularly in South and Southeast Asia. Although less commonly domesticated than *Apis mellifera*, they are sometimes utilized for honey production in certain areas.

Apis florea (Dwarf honey bee): *Apis florea* is the smallest of the honey bee species. They build small nests and are adapted to warm climates. While they produce less honey compared to other species, they are efficient pollinators and can be valuable for specific agricultural settings.

It's important to note that the selection of bee species should take into account local regulations, climatic conditions, availability of resources, and the beekeeper's level of experience and knowledge. It is advisable to consult with local beekeeping associations, experts, or experienced beekeepers who are familiar with the specific conditions of your region to determine the most suitable bee species for domestication.

Bee keeping equipment methods of extraction of honey (Indigenous and Modern) & processing

Beekeeping equipment and methods for extracting honey can vary between indigenous/traditional approaches and modern techniques. Similarly, honey processing methods can vary depending on the desired end product and available resources. Here are some commonly used equipment and methods for honey extraction and processing:

Indigenous/Traditional Methods of Honey Extraction:

Traditional Hive or Skep: In indigenous beekeeping, traditional hives made from natural materials such as clay pots, woven baskets, or hollowed logs are used. Honeycombs are harvested by physically removing the entire hive or skep and cutting out the combs.

Crushing and Straining: In this method, the honeycombs are crushed to release the honey, and the resulting mixture of honey and wax is strained through a sieve or cloth to separate the honey from debris.

Modern Methods of Honey Extraction:

I. **Langstroth Hive and Frames**: The Langstroth hive, a modern beehive design, uses removable frames. To extract honey, beekeepers remove individual frames that contain capped honeycombs. The combs are uncapped using a hot knife or uncapping fork, and the frames are then placed in an extractor.
II. **Extractor:** A honey extractor is a machine used to extract honey from uncapped frames. The frames are placed inside the extractor, which spins them rapidly, using centrifugal force to extract the honey. The honey flows out of the frames and collects at the bottom of the extractor, where it can be drained out.
III. **Honey Processing:**
    a. **Settling:** After extraction, honey may be left to settle in a settling tank or bucket for a period of time to allow air bubbles and debris to rise to the top. This helps in achieving clearer honey.
    b. **Filtering:** Honey can be filtered to remove any remaining debris or wax particles. Filtering can be done using fine mesh or cloth filters, which capture impurities while allowing the honey to pass through.
IV. **Bottling and Packaging:** Once the honey is extracted and processed, it is typically poured into jars or bottles for storage and sale. Proper labeling and packaging should be done to meet regulatory requirements and maintain product quality.

It's important to note that the specific equipment and methods used may vary depending on the scale of beekeeping operations, regional practices, and personal preferences. It is recommended to consult with experienced beekeepers or local beekeeping associations for guidance on the most suitable equipment and methods for honey extraction and processing in your specific context.

Apiary management - Honey flow period and lean period

Apiary management involves understanding and managing the various periods in the beekeeping calendar, including the honey flow period and the lean period. These periods play a crucial role in the overall management of bee colonies and honey production. Here's a brief overview:

a. **Honey Flow Period:** The honey flow period is the time when nectar-producing plants are in bloom and abundant, providing a significant source of nectar for the bees. During this period, beekeepers can expect increased honey production as the bees actively collect nectar and convert it into honey. The honey flow period varies depending on the location and the types of plants in the surrounding area.

Managing the honey flow period involves:

i. **Hive Supers:** Beekeepers may add additional hive supers (boxes) to provide extra space for honey storage as the bees bring in more nectar. This prevents overcrowding and encourages the bees to store honey in the supers rather than the brood chamber.
ii. **Regular Inspections:** Frequent inspections during the honey flow period allow beekeepers to monitor honey production, assess hive health, and take necessary actions to prevent swarming or address any issues.
iii. **Honey Harvesting:** When the supers are full and the honey is properly ripened and capped, beekeepers can harvest the excess honey. This usually involves removing the frames containing capped honey from the supers, extracting the honey, and processing it.

b. **Lean Period:** The lean period, also known as the dearth period, is the time when nectar-producing plants are scarce or not in bloom. This period occurs after the honey flow period and typically corresponds to seasonal changes or specific periods when flowering plants are limited. The lean period varies in duration and intensity depending on the region and climate.

Managing the lean period involves:

i. **Supplemental Feeding:** Beekeepers may provide supplemental feeding to ensure the bees have sufficient food reserves during the lean period. Sugar syrup or fondant can be provided as a substitute for nectar and pollen.
ii. **Water Sources:** Providing clean water sources near the hives is essential during the lean period. Bees need water for cooling the hive and diluting stored honey when necessary.
iii. **Pest and Disease Management:** The lean period is an ideal time to monitor and manage pests and diseases in the hive. It is essential to protect the bees' health during this vulnerable period.

Overall, effective apiary management involves understanding the local honey flow and lean periods, adapting hive management practices accordingly, and ensuring the well-being and productivity of the bee colonies throughout the year. Local knowledge, experience, and consultation with experienced beekeepers or beekeeping associations can provide valuable insights into the specific honey flow and lean periods in your region.

Effects of pollutants on honeybees

Pollutants can have detrimental effects on honeybees, impacting their health, behavior, and overall colony productivity. Here are some common pollutants and their effects on honeybees:

Pesticides: Pesticides, including insecticides, herbicides, and fungicides, can be highly toxic to honeybees. They can be present in agricultural environments where bees forage for nectar and pollen. Pesticides can interfere with honeybee navigation, foraging behavior, learning abilities, and overall colony health. Exposure to pesticides may lead to increased bee mortality, reduced brood development, impaired immune function, and colony collapse disorder.

Heavy Metals: Heavy metals, such as lead, mercury, cadmium, and zinc, can contaminate the environment due to industrial activities, mining, and pollution. Honeybees can encounter heavy metals through contaminated water, nectar, and pollen. These metals can accumulate in their bodies and negatively affect their nervous system, metabolism, reproduction, and overall health.

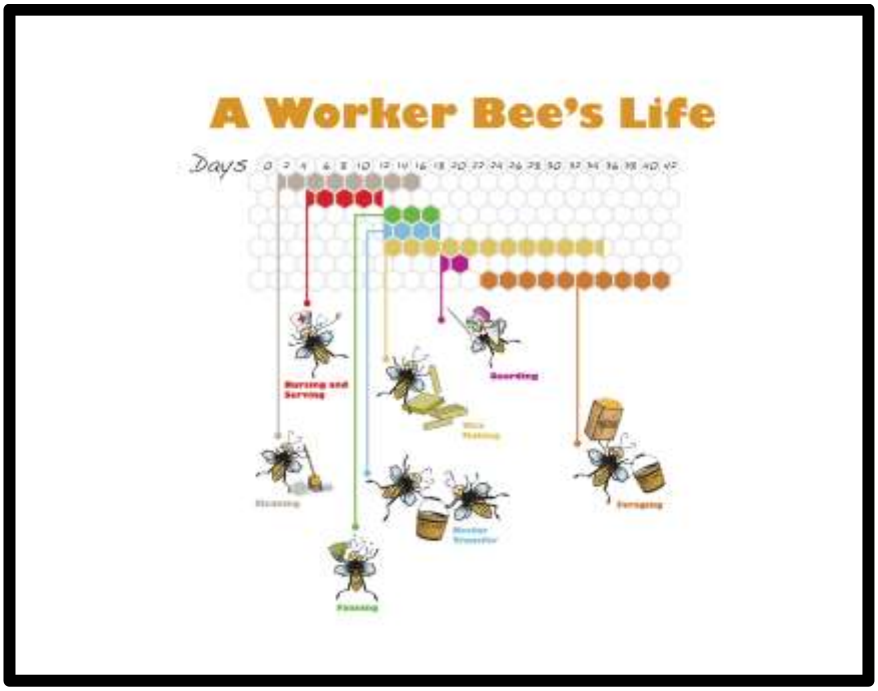
Air Pollution: Air pollution, including particulate matter and chemical pollutants from vehicle emissions, industrial activities, and urban areas, can have indirect effects on honeybees. Pollutants in the air can reduce the availability and quality of floral resources, impacting the bees' foraging efficiency and nutritional intake. Additionally, air pollution can contribute to the deterioration of overall environmental health, which indirectly affects honeybees and their habitats.

GMOs and Genetic Contamination: Genetically modified organisms (GMOs) can introduce novel proteins and genetic material into the environment. When honeybees forage on GMO crops, they may come into contact with genetically modified pollen and nectar. The long-term effects of GMOs on honeybees are still under study, but potential risks include changes in bee physiology, behavior, and interactions with other organisms.

Water Contamination: Water pollution from various sources, including industrial discharge, agricultural runoff, and improper waste disposal, can affect honeybees that rely on water sources for drinking and hive maintenance. Polluted water can contain chemical contaminants, heavy metals, and pathogens that can harm honeybee health and compromise their immune system.

To mitigate the negative effects of pollutants on honeybees, it is crucial to adopt sustainable agricultural practices, reduce the use of pesticides, promote organic farming methods, create buffer zones between agricultural fields and bee habitats, and enforce proper waste management and pollution control measures.

Practical-1: Distinguishing characters of workers of three bee species.



I. *Apis indica*

Apis indica, also known as the Indian honey bee or the Indian hive bee, is a species of honey bee native to the Indian subcontinent. The worker bees of *Apis indica* are an integral part of the colony and perform various tasks necessary for the survival and functioning of the hive. Here are some characteristics and roles of worker bees in *Apis indica*:

i. **Size and Appearance**: Worker bees are the smallest members of the honey bee colony. They have a slender body with alternating yellow and black bands on their abdomen. The coloration and appearance of *Apis indica* worker bees are similar to other honey bee species.

Figure-1: Worker bee of *Apis indica cerna*

Source:https://en.wikipedia.org/wiki/Apis_cerana#/media/File:Apis_cerana,_Asiatic_honey_bee_-_Khao_Yai_National_Park.jpg

ii. **Tasks and Roles:** Worker bees progress through various roles within the colony as they age. The tasks of *Apis* indica worker bees include:

a. **Nursing:** Young worker bees start their lives as nurse bees. They care for the brood (developing larvae and pupae) by feeding them royal jelly, pollen, and honey. They also clean and maintain the hive.

b. **Foraging:** As worker bees mature, they transition to foraging roles. Foragers venture outside the hive in search of nectar, pollen, water, and propolis. They locate and collect these resources, which are essential for the survival of the colony.

c. **Pollination:** While foraging for nectar, worker bees also contribute to the crucial process of pollination. As they visit flowers to collect nectar, they inadvertently transfer pollen from the male parts (anthers) to the female parts (stigma) of flowers, aiding in plant reproduction.

d. **Hive Defense:** Worker bees play a crucial role in protecting the hive. They guard the entrance, identifying and repelling potential threats such as predators or intruder bees from other colonies.

e. **Wax Production:** Worker bees produce wax glands on their abdomen. They use these wax glands to build and maintain the hive structure, constructing honeycomb cells where nectar is stored, and brood is raised.

iii. **Lifespan:** The lifespan of an *Apis* indica worker bee varies depending on the time of year and the tasks they perform. During the busy summer season, worker bees typically have a lifespan of around 4-6 weeks due to the demanding nature of foraging. However, in colder months or during periods of reduced foraging activity, worker bees can live for several months.

II. *Apis mellifera*

The worker bee of *Apis mellifera*, commonly known as the Western honey bee, is a highly organized and industrious member of the honey bee colony. Worker bees perform a range of tasks crucial for the functioning and survival of the hive. Here are some key characteristics and roles of worker bees in *Apis mellifera*:

i. **Size and Appearance:** Worker bees are the smallest bees in the colony. They have a robust body with a fuzzy appearance. The coloration of worker bees can vary, but they typically have alternating bands of yellow and black on their abdomen.

Figure-2: The image showcases European honey bee, belonging to the species *Apis mellifera*.

ii. **Tasks and Roles:** Worker bees progress through various roles as they age. The tasks and roles of *Apis mellifera* worker bees include:

a. **Nursing:** Young worker bees start their lives as nurse bees. They care for the brood (developing larvae and pupae) by feeding them royal jelly, a nutritious substance secreted by their glands. They also clean and maintain the hive, removing debris and dead bees.

b. **Foraging:** As worker bees mature, they transition to foraging roles. Foragers venture outside the hive to collect resources such as nectar, pollen, water, and propolis. They locate and gather these resources from flowers and other sources, bringing them back to the hive for storage and processing.

c. **Pollination:** While foraging for nectar, worker bees play a vital role in the pollination of plants. As they visit flowers to collect nectar, they inadvertently transfer pollen from the male parts (anthers) to the female parts (stigma) of flowers, facilitating plant reproduction.

d. **Hive Defense:** Worker bees are responsible for protecting the hive from potential threats. They guard the entrance, identifying and repelling intruders, such as predators or bees from other colonies. Worker bees may also engage in "balling" behavior, where they form a tight cluster around intruders to generate heat and suffocate them if they pose a significant threat.

e. **Wax Production and Comb Building:** Worker bees have wax glands on their abdomen. They secrete wax to build and maintain the hive's structure, constructing hexagonal cells within honeycomb frames where nectar is stored, and the brood is raised.

f. **Undertaking Tasks:** Worker bees also perform various tasks within the hive, such as removing dead bees, regulating temperature and humidity, and distributing food resources to other colony members.

iii. **Lifespan:** The lifespan of a worker bee in *Apis mellifera* depends on factors such as the time of year and the tasks they perform. During the busy summer season, when foraging activity is intense, worker bees typically live for about 4-6 weeks. However, in colder months or periods of reduced foraging, worker bees can live for several months.

The specific behaviors and adaptations of worker bees in *Apis mellifera* can vary based on factors such as geographic location, subspecies, and environmental conditions. Nevertheless, the roles and characteristics mentioned above generally apply to worker bees in *Apis mellifera* colonies.

III. *Apis dorsata*

The worker bee of *Apis dorsata*, commonly known as the giant honey bee or the rock bee, is a fascinating member of the colony with distinct characteristics and roles. Here are some key features and information about the worker bee of *Apis dorsata*:

i. **Size and Appearance**: The worker bee of *Apis dorsata* is relatively larger compared to other honey bee species. They have a robust body with distinct coloration. The abdomen of the worker bee displays alternating bands of yellow and black, similar to other honey bee species.

Figure-3: Worker bee of *Apis dorsata*

Source: https://www.rekoforest.org/field-stories/*Apis-dorsata*-the-honeybee-of-the-sialang-tree/

ii. **Tasks and Roles:** Worker bees in *Apis dorsata* colonies perform various essential tasks for the survival and functioning of the hive. These include:

a. **Hive Defense:** Worker bees are responsible for defending the hive against potential threats. They exhibit aggressive behavior and engage in defense mechanisms, such as forming a "bee curtain" or "shimmering" behavior, to deter predators and invaders.

b. **Foraging:** Worker bees venture out of the hive to collect nectar, pollen, propolis, and water. They are efficient foragers and can cover long distances in search of floral resources. The worker bees of *Apis dorsata* are known for their ability to forage on tall trees and cliffs, as they build large exposed nests.

c. **Comb Building:** Worker bees construct large, single-comb nests, which can be several feet wide, hanging from cliffs or tree branches. They use wax secreted from their wax glands to build the comb structure and create individual cells for brood rearing and honey storage.

d. **Brood Care:** Worker bees are responsible for caring for the developing brood. They feed the larvae with a mixture of pollen and honey, ensuring their proper nutrition and growth. They also maintain the temperature and humidity levels within the hive to support brood development.

e. **Honey Production:** Worker bees in *Apis dorsata* colonies collect nectar and convert it into honey through the process of regurgitation and evaporation. They store honey in the comb cells, which serves as the colony's food reserve.
f. **Lifespan:** The lifespan of worker bees in *Apis dorsata* can vary depending on factors such as environmental conditions and workload. Typically, worker bees have a lifespan of a few weeks to a few months, with the summer season being the busiest period of their lives due to increased foraging activity.

The behavior and characteristics of worker bees in *Apis dorsata* may exhibit some variations compared to other honey bee species due to their unique nesting habits and ecological adaptations. Local conditions, climate, and available resources can influence the behavior and specialization of worker bees within the *Apis dorsata* species.

Practical-2: Importance of site selection for bee keeping.

Site selection is a crucial factor in successful beekeeping, as it directly impacts the health and productivity of honey bee colonies. Here are some key reasons highlighting the importance of site selection for beekeeping:

I. When selecting an apiary site, it is important to consider the following factors
   a. **Forage Availability:** Choosing a site with abundant and diverse floral resources is essential for honey bee colonies. Bees require a consistent and varied source of nectar and pollen throughout the foraging season to meet their nutritional needs. A suitable location should offer a range of flowering plants that provide ample forage for the bees, ensuring their well-being and productivity.
   b. **Cleanliness:** Choose a clean location free from debris and pollutants to maintain hive hygiene.
   c. **Dry and Shaded:** Opt for a dry area with shade to protect the hives from excessive moisture and direct sunlight.
   d. **Proximity to Fresh Water:** Select a site near a reliable source of fresh running water, which is essential for the bees' hydration and honey production.

II. **Environmental Factors:** The surrounding environment plays a significant role in beekeeping. Some important environmental factors to consider include:

III. **Temperature and Climate:** Bees are sensitive to temperature fluctuations and extreme weather conditions. A site with a favorable microclimate, offering moderate temperatures and protection from strong winds, is ideal for their well-being.

IV. **Water Availability:** Access to a clean and reliable water source near the apiary is essential for honey bees. They require water for hydration, cooling the hive, and diluting stored honey for consumption. Ensuring a nearby water source, such as a pond, stream, or water trough, reduces the bees' foraging distance and supports their vitality.

V. **Shelter and Protection:** Selecting a site that offers natural or man-made barriers, such as hedges or tree lines, can provide windbreaks and protection from excessive sun exposure. It helps create a more favorable and sheltered environment for the colonies.
   a. **Adequate Sun Exposure:** Select a site that receives proper sunshine, particularly in the morning and afternoon, to promote optimal hive activity and honey production.
   b. **Clear of Dry Leaves:** Ensure the area is free from dry leaves or flammable materials to minimize the risk of fire, especially during the summer season.
   c. **Wind Breaks:** Consider the availability of natural features (e.g., trees, hedges) or artificial windbreaks to shield the hives from strong winds, providing a more favorable microclimate for the bees.

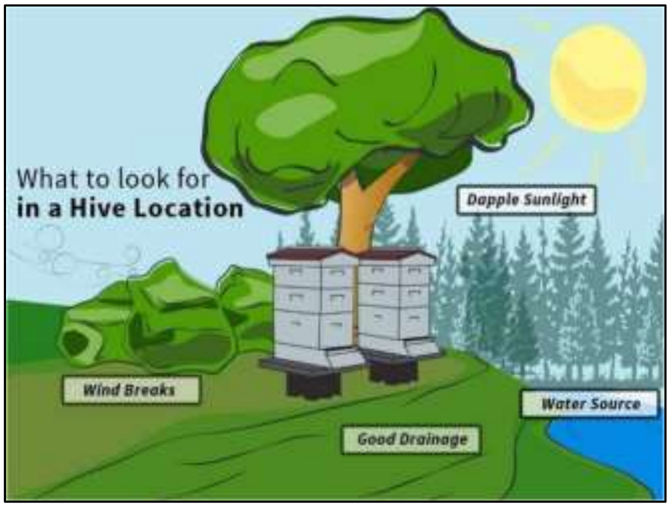


Figure-4: Apiary Site Location

Source: https://blog.superbeehoney.com/beekeeping-selection-of-apiary-site-and-risk-factor/

VI. **Distance to Other Apiaries:** Keep a distance of 2-3 kilometers from other commercial apiary sites to prevent overcrowding and competition among the colonies.

VII. **Documentation of Pollen and Nectar Sources**: Document and ensure that the pollen and nectar sources within a 3 km radius around the apiary are free from contamination risks such as large roads with heavy traffic, industrial areas (chemical or sugar mills), contaminated waters, GMO crop cultivation, or any industries that may pose a risk to the honey produced.

VIII. **Accessibility and Safety:** Accessibility to the apiary site is important for regular inspections, hive management, and honey extraction. Additionally, ensuring the safety of the beekeeper, neighboring communities, and livestock is crucial. Selecting a site that is not too close to residential areas or high-traffic zones helps mitigate potential conflicts and risks associated with bee stings.

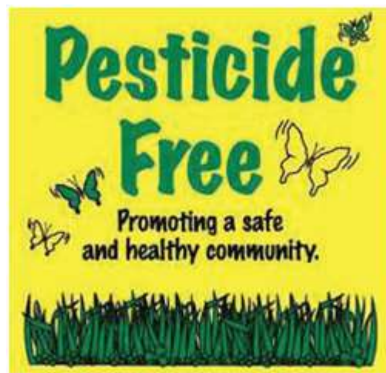
IX. **Land Use and Regulations:** Consider local regulations, zoning laws, and land use restrictions when choosing a site for beekeeping. Some areas may have specific guidelines on hive placement, setbacks from property boundaries, or limitations on the number of colonies allowed per site. Adhering to these regulations ensures compliance and harmonious beekeeping practices.

Overall, careful site selection for beekeeping is essential for providing honey bees with optimal forage, a favorable environment, and protection from harmful factors. It contributes to the success and sustainability of bee colonies, promotes honey production, and supports the vital role of bees in pollination and ecosystem health.

Figure-5: Super bee apiary site

Source: https://blog.superbeehoney.com/beekeeping-selection-of-apiary-site-and-risk-factor/

Risk for Apiary Site selection



- Contamination from the environment
- Heavy metals
- Radioactivity
- Pesticides
- Bacteria
- GMOs
- Antibiotics in waste water from pharmaceutical industry.
- Sugar mills, Sugar cane crushers, country KOHLLU or other foodstuff productions that could attract the bees.
- Pesticide Exposure: Minimizing pesticide exposure is critical for the health and survival of honey bee colonies. It is crucial to choose a site away from areas with heavy pesticide use, such as agricultural fields treated with insecticides or herbicides. Selecting a location that minimizes exposure to harmful chemicals helps maintain the bees' immune system and reduces the risk of colony losses.
- Contaminants can be present on/in the flowers, in the water and in the air and possibly enter the honey produced by the bee colonies.
- Disturbance and annoyance due to power stations, highway, train tracks etc. situated near bee colonies.
- Fire due to lot of dry leaves around the apiary.

Practical-3: Study of an artificial hive (Langstroth/Newton), its various parts and beekeeping equipment: draw diagrams of bee boxes proportionate to the body size and measure the body length and wing size.

I. Artificial/ Modern Hive:

An artificial hive is a man-made structure designed to provide a suitable living space for honey bee colonies. These hives are created to mimic the natural environment of bees, allowing beekeepers to manage and maintain the colonies more easily. Here are some key features and components of an artificial hive: Hive bodies, Frames and Foundation, Supers, Inner Cover, Outer Cover, Bottom bard, Bee spaces and Hive Tools.

Figure-6: Basic structure of artificial hive

Source: https://www.almanac.com/beekeeping-101-types-of-beehives

Artificial hives offer several advantages over natural nesting sites, including ease of management, honey production, disease control, and the ability to monitor and manipulate colony activities. Different hive designs exist, with the most common being the Langstroth hive and the top-bar hive, each offering its own unique features and management techniques.

a. Langstroth Hive:

The Langstroth hive is a type of artificial beehive widely used in modern beekeeping. It was invented by Reverend Lorenzo Lorraine Langstroth in the mid-19th century and revolutionized beekeeping practices. Here are some key features and components of the Langstroth hive:

i. **Hive Bodies:** The Langstroth hive consists of rectangular hive bodies, commonly referred to as "supers." These supers are stacked vertically and house removable frames where bees build comb, raise brood, and store honey. Langstroth hives typically have multiple supers, allowing for expansion as the colony grows.

ii. **Frames and Foundation:** Langstroth frames are suspended within the hive bodies. Each frame holds a removable foundation, which can be made of beeswax or plastic. The foundation provides a guide for bees to build comb, ensuring uniformity and easier management within the hive.

iii. **Bee Space:** Langstroth hives are designed with precise spacing between frames and hive components to maintain the optimal "bee space." Bee space is the gap that allows bees to move freely without creating excessive comb or propolis. This spacing facilitates easy inspection and manipulation of the hive.

iv. **Brood Chamber (Also called: deep super or brood box):** The brood box contains larger frames than the shallow super. Here, the queen lays eggs for the next generation of bees. In this maternity ward, nurse bees care for the young.

v. **Inner Cover:** The inner cover is placed on top of the uppermost super. It acts as an insulating barrier and provides ventilation within the hive. It often features a central hole to serve as an upper entrance for the bees.

vi. **Outer Cover/ Telescoping cover:** The Langstroth hive is capped with an outer cover to protect the hive from the elements. The outer cover provides additional insulation and helps maintain a stable internal temperature.

vii. **Shallow/Honey Super:** Shallow supers are most the commonly used size for honey production.

viii. **Queen Excluder:** Allows only worker bees to pass through, keeping the queen and drones away from the honey. This is an optional piece of equipment that prevents the queen from laying eggs in the honey collection supers. Not every beekeeper uses an excluder.

ix. **Bottom Board:** The hive rests on a bottom board, which serves as the base. It provides an entrance for the bees and helps regulate ventilation within the hive. Some Langstroth hives have removable bottom boards for monitoring and pest management purposes.

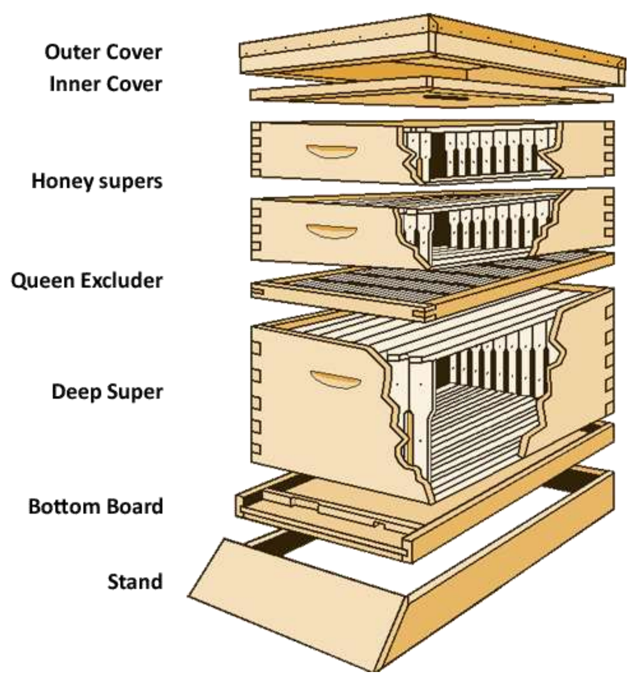


Figure-7: Basic Structure of Langstroth hive

Source: https://www.almanac.com/beekeeping-101-types-of-beehives

The Langstroth hive design offers several advantages, including efficient management, easy access to frames, and the ability to expand the hive vertically. Beekeepers can manipulate frames, inspect the colony, and extract honey without causing significant disruption to the bees. The Langstroth hive has become the most widely used hive type worldwide, making it a popular choice for both hobbyist and commercial beekeepers.

a. **Newton's Hive (**Designed by Fr. Newton)

Newton's hive consists of following parts:

a. Stand made of wood.
b. Floor Board with an extension in front serving as lighting board.
c. Brood Chamber with an entrance, it is mounted over the floor board.
d. Wooden Frames 7-10 in number which are hung in the brood chamber.
e. Super Chamber kept over the brood chamber for the collection of honey.
f. Roof made of two sloping plank of with an opening guarded by wire gauge is kept over the super chamber to provide ventilation.
g. Hives are painted yellow, light blue, green or pink but never red, black or grey. Green or light blue colours are preferred.

SPECIFICATIONS OF BEEHIVES

S.No.	**Type of Hives**	
	Langstroth hives	**Newton's hives**
1	Langstroth hives for rearing Italian bee	Newton's hives for rearing Indian bees
2	Langstroth ten-frame hive	
3	Bottom board (floor board): Bottom part of the hive length 22" long 16.25" broad and 7/8" thick. Another wooden rod 14.5" be nailed at the back and the front be provided with similar rod (entrance rod but having an entrance in the middle) after leaving 2" space so that these nailed rods make a rectangle of 2" x 16.5"	Floor board: 14" x 9.5" in size with an extension in front which serves as an alighting board
4	Alighting board: The 2" space in front of the entrance rod meant for the bees to take off flight or land on it.	Floor Board is the alighting board
5	Entrance: In the middle of the entrance rod is given a cut 3" long and 3/8" deep as a passage for bees to enter or leave the hive	Brood Chamber with an entrance, it is mounted over the floor board

6	Brood Chamber: Is a box, made of wooden planks, without bottom and is placed over the bottom board. It is 20" in length 16.25" in width and 9.5" in height and 0.875" thick. A robbat 0.625"of deep and 0.5" wide is cut along the upper inner length of its width planks. The internal dimensions of the chamber are 18.25" x 14.25".	Brood chamber: 9.75'' x 8.25" x 6.75" in size with an entrance slit of 3.5" x 3/8" at the base; it is mounted over the floor board
7	Frames: Each chamber contains 10 frames and a dummy board. A frame has four wooden pieces – Top bar, bottom bar and two side bars. (i) Top bar: 19" length x 1" width x 7/8" thickness. A groove is present on lower side of top bar to insert comb foundation sheet. (ii) Side bar: 9.125" length x 1.125" (upper half) and 1" (lower half) width 3/8" thickness. There are four holes in each of the side bar for wiring the frame. (iii) Bottom bar: 17.625" length x 0.75" width x 0.375" thickness	Wooden frames: Eight separate wooden frames 8.75" x 5.75" x 6" in size and 7/8" broad: they are hung inside the brood chamber
8	Super Chamber/honey chamber with bee frames: Same as the brood chamber	Super chamber: 9.75" x 8.25" x 3.125" in size: it is kept over the brood chamber.
9	Inner cover: Wooden plank 20" long x 16.25" wide and 0.375". Inner cover is nailed 0.375" thick, 0.875" wide wooden rod on its four sides	
10	Top/Upper cover: It is the top most cover 21" long, 17" wide and 0.375" thick. This plank is provided with a frame, 2" wide 0.875" thick, its top side is covered by G.I/Aluminum sheet.	Top cover: It is board having same dimensions of brood or super chamber. In the centre there is an opening covered with wire gauge. It is kept on super or brood chamber.

Equipment for Apiculture

1. **Comb Foundation Sheet**

- A comb foundation sheet, also known as foundation or beeswax foundation, is a thin sheet made of beeswax or synthetic materials that is used as a guide for honey bees to build comb within the frames of a beehive.
- It serves as a starting point for bees to construct their honeycomb cells in a uniform and structured manner.
- The comb foundation sheet is usually attached to a wooden or plastic frame within the hive.

- It has small indentations or impressions that mimic the shape and size of honeycomb cells.
- These impressions provide a guide for the bees to build their comb, ensuring consistent cell size and proper spacing between cells.

The use of comb foundation sheets in beekeeping offers several benefits:

a. **Time and Energy Efficiency:** By providing a foundation, beekeepers save the bees' time and energy that would otherwise be spent constructing the comb from scratch. This allows the colony to focus on other essential tasks, such as brood rearing and honey production.
b. **Improved Beehive Management:** Comb foundation sheets provide a uniform framework for beekeepers to manage their hives. The presence of predefined cells makes it easier to inspect the hive, manipulate frames, and ensure proper spacing between frames for effective hive management.
c. **Increased Honey Production:** The use of comb foundation sheets promotes efficient honey production. Bees tend to build comb in a straight and organized manner on the foundation, allowing for more honey storage within the hive.
d. **Prevention of Cross-Comb:** Cross-comb refers to the irregular and messy construction of comb that can make hive inspection and management challenging. Comb foundation sheets help guide the bees in building their comb vertically and prevent the formation of cross-comb, making hive management tasks easier.

Comb foundation sheets can be made of natural beeswax or synthetic materials like plastic or wax-coated plastic. Beekeepers often choose the type of foundation based on their specific needs and preferences.

Figure-8: Comb foundation sheet

Source: https://www.exportersindia.com/product-detail/yellow-bee-comb-foundation-sheet-4458577.htm

2. **Queen Cells**

- Freshly built, capped and empty with a cap from with the queen has emerged.
- These cells are made by wax secreted by bee abdomen.
- These are thousands of hexagonal thin walled fragile cells arranged in two opposite rows.

- The rest of hive consist of hexagonal cells.
- These cells cannot be used again.

A

B

Figure-9: A: A frame of newly accepted queen cell grafts; B: Newly accepted queen cell grafts - each larva is very well fed, floating on a deep bed of milky-white royal jelly visible through the clear plastic queen cup

Source:https://www.nationalbeeunit.com/assets/PDFs/3_Resources_for_beekeepers/Rearing_Queen_Honeybees.pdf

3. Uncapping Knife

An uncapping knife is a specialized tool used in beekeeping for removing the thin layer of beeswax that seals the honey cells in the comb. This process is known as uncapping and is typically performed before honey extraction.

Here are the key features and functions of an uncapping knife:

a. **Blade Design:** An uncapping knife typically has a long, narrow blade specifically designed for smoothly cutting through beeswax cappings. The blade is usually heated to aid in the uncapping process.
b. **Heated Blade:** Uncapping knives can be heated using various methods, including hot water, steam, or electric heating elements. The heat softens the wax, making it easier to cut through the cappings cleanly and efficiently.
c. **Handle:** The knife features a handle that provides a comfortable grip for the beekeeper, allowing for precise control while uncapping the honey cells.

Using an uncapping knife involves the following steps:

a. **Heating the Blade:** The uncapping knife blade is heated to the appropriate temperature. This can be done by immersing the blade in hot water or using a heating element, depending on the type of uncapping knife being used.

b. **Uncapping Process:** The heated knife is carefully passed over the surface of the capped honey cells. The heat melts the beeswax cappings, allowing the beekeeper to smoothly and gently remove them, exposing the honey within the cells.
c. **Efficiency and Cleanliness:** The beekeeper repeats the process across the frame, ensuring all the honey cells are uncapped. It's important to maintain a steady and controlled motion to avoid damaging the comb or honey cells.

Uncapping knives are commonly used in conjunction with other honey extraction equipment, such as an extractor or honey spinner, which removes the honey from the uncapped frames. After uncapping, the frames can be placed in the extractor, and centrifugal force is used to extract the honey.

Figure-10: Uncapping Knife

4. **Bee Brush**

A bee brush is a specialized tool used in beekeeping to gently move bees away from specific areas of the hive or to remove bees from frames during inspections. It is designed to be soft and gentle, allowing beekeepers to manipulate the bees without causing harm or agitation. Here are the key features and functions of a bee brush:

a. **Bristles:** The brush consists of soft and flexible bristles typically made of horsehair, synthetic fibers, or other gentle materials. The bristles are designed to be flexible enough to avoid injuring or crushing the bees while effectively brushing them away.
b. **Handle:** The brush has a handle that allows the beekeeper to hold and control the tool. The handle is usually made of wood or plastic, providing a comfortable grip during use.

Used for:

a. **Bee Management:** Bee brushes are primarily used to move bees away from specific areas during hive inspections. For example, if a beekeeper needs to examine a frame or remove excess bees from a super, they can gently brush the bees away using the bee brush. It helps create a clear space for inspection or manipulation without harming the bees or disrupting the hive significantly.

b. **Hive Hygiene:** Bee brushes also serve a purpose in maintaining hive hygiene. For instance, if a beekeeper identifies a diseased or dead bee in the hive, they can use the brush to gently remove it without damaging the comb or causing distress to the other bees.

When using a bee brush, it's important to be gentle and avoid excessive brushing or agitation, as this can stress the bees. The brush should be used with care and only when necessary to achieve the desired effect.

Figure-11: Bee Brush

Source: https://www.beeculture.com/the-bee-brush/

5. **Dummy Division Board**

It is a wooden partition that serves as a movable walls and helps to reduce the size of the broad chamber so that bees can keep the board nest warm and well protected from the enemies or unfavorable climate.

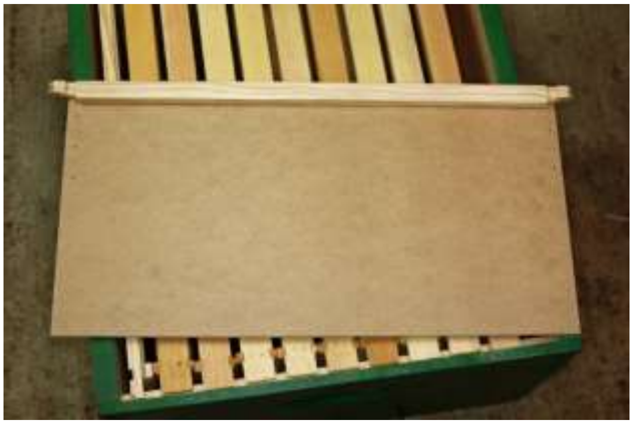


Figure-12: Dummy Division Board

Source: https://www.honeybeesuite.com/how-to-make-follower-boards-for-a-langstroth-hive/

6. **Swarm Trap**

A swarm trap, also known as **a swarm box or bait hive**, is a device used in beekeeping to attract and capture swarms of honey bees. Swarming is a natural reproductive process of honey bee colonies, where a queen and a large number of worker bees leave their original hive to establish a new colony. Beekeepers often set up swarm traps to capture these swarms and relocate them to their own hives. Here are the key features and functions of a swarm trap:

a. **Design:** Swarm traps are typically designed to resemble a traditional beehive. They are often made of wood, similar to regular beehive boxes, and have a hollow interior to provide space for the swarm to establish a new colony.
b. **Entrance and Ventilation:** Swarm traps have an entrance that allows bees to enter and exit. The entrance is usually small and positioned near the bottom of the trap. Adequate ventilation is provided to ensure the comfort and survival of the captured swarm.
c. **Lure:** To attract swarms, beekeepers place a lure or attractant inside the trap. This lure can consist of a combination of pheromones, essential oils, beeswax, or other substances that mimic the scent of an established bee colony. The lure helps attract scout bees and increases the likelihood of capturing a passing swarm.
d. **Location:** Swarm traps are strategically placed in areas where swarms are likely to occur, such as near existing apiaries or areas with high bee activity. The traps are typically positioned at an elevated height, such as on trees or stands, to mimic the preferred location for swarms to settle.
e. **Swarm Capture:** When a swarm encounters the trap and finds it suitable for establishing a new colony, they will enter the trap through the entrance. Once inside, the bees start building comb, and the queen begins laying eggs, initiating the formation of a new colony.

Swarm traps serve as a valuable tool for beekeepers to collect and expand their honey bee colonies. They provide a means of capturing and managing swarms in a controlled manner, allowing beekeepers to increase their bee population and prevent swarms from settling in unwanted locations.

Figure-13: Swarm Trap

Source: https://www.betterbee.com/instructions-and-resources/swarm-traps.asp

7. Bee Escape

The triangle bee escape operates based on the following principle.

- To begin, you position the escape board between your brood boxes and honey supers. As evening approaches, the bees residing in the honey super naturally desire to rejoin the rest of the colony located in the brood boxes.
- To accomplish this, the bees must pass through the central hole of the board and exit through the triangular openings on the other side. The bees, however, do not immediately discern how to return to the supers the following day, resulting in honey supers that are relatively free of bees.
- It is important to plan accordingly and refrain from leaving the bee escape on for more than 24-48 hours, as in many instances, the bees will eventually figure out how to ascend back to the supers given more time.


Figure-14: Bee Escape

Source: https://www.beeculture.com/make-a-triangle-bee-escape-heck-make-one-for-every-hive/

8. Two way spring type bee escape

The two-way spring-type bee escape is a beekeeping tool that facilitates the removal of bees from honey supers before harvesting. Unlike traditional one-way bee escapes, this type of escape allows bees to exit the super while also providing a pathway for them to re-enter the hive if necessary. Here's how the two-way spring-type bee escape works:

a. **Installation:** The escape is installed between the honey supers and the brood boxes, similar to other bee escape boards. It is typically placed above an excluder or queen excluder to ensure that the queen bee does not access the honey supers.
b. **Spring Mechanism:** The two-way bee escape features a spring-loaded mechanism that allows bees to pass through it in both directions. The spring creates a barrier that the bees can push through to exit the supers, but it also acts as a deterrent if they try to re-enter.

c. **Exit and Re-entry:** During the honey flow period, when the supers are full of bees and honey, the bees will naturally move down to the brood boxes. They can easily pass through the spring mechanism and exit the supers. However, if the bees attempt to re-enter the supers after leaving, the spring tension prevents them from doing so.
d. **Harvesting Efficiency:** The two-way bee escape helps beekeepers to efficiently clear bees from the supers before honey extraction. The majority of bees will leave the supers through the escape, reducing the number of bees during the extraction process. However, if any bees remain in the supers after a certain period, they can find their way back through the spring mechanism.

It's important to note that the effectiveness of the two-way spring-type bee escape may vary depending on the specific design and bee behavior. Some bees may still find their way back to the supers, so it's recommended to monitor the supers before extraction to ensure they are mostly free of bees.

Figure-15: Two-way Spring Type Escape

Source: https://beekeepingforum.co.uk/threads/two-way-porter-bee-escape.30292/

9. **Smoker**

A smoker is a vital tool used in beekeeping to manage honey bees during hive inspections and manipulations. It is a device that generates smoke, which is then directed into the beehive. Here's how a smoker is used and its purpose in beekeeping:

a. **Design:** A typical smoker consists of a fire chamber, a bellows or pump mechanism, and a nozzle or spout for directing the smoke. The fire chamber is where fuel, such as wood chips, pellets, or burlap, is burned to produce smoke.
b. **Lighting the Smoker:** Beekeepers usually start by lighting the fuel inside the fire chamber of the smoker. They blow air into the chamber using the bellows or pump to ignite the fuel and create a smoldering fire. This generates the smoke required for beekeeping purposes.

Application of Smoke: Once the smoker is properly lit, the beekeeper directs the smoke into the beehive by squeezing the bellows or pumping the handle. The smoke is typically directed at the entrance of the hive, as well as around the frames and bees inside.

Effects on Bees: The smoke from the smoker has several effects on bees. First, it triggers a defensive response within the hive, causing the bees to go into a state of alertness. Second, the smoke masks the alarm pheromones released by guard bees, which helps to prevent the rapid spread of alarm signals among the colony. As a result, the bees become less aggressive and more docile during hive inspections.

Purpose of Using a Smoker: The primary purpose of using a smoker in beekeeping is to calm the bees and reduce the likelihood of stinging. By puffing smoke into the hive, beekeepers create a temporary disruption in the bees' communication and defensive behavior, allowing them to work more comfortably and safely.

Figure-16: Smoker

Source: https://www.buddhabeeapiary.com/blog/why-do-beekeepers-use-smoke

10. Swarm catching bag

A swarm catching bag is a specialized tool used in beekeeping to capture and transport swarms of honey bees. When honey bee colonies become overcrowded, the queen and a portion of the worker bees may leave the hive in search of a new location to establish a new colony. This is known as swarming. Beekeepers often use swarm catching bags to safely collect and relocate these swarms. Here's an overview of the swarm catching bag:

- **a.** A swarm catching bag is typically made of durable fabric or mesh material that allows air circulation while containing the bees. The bag is usually cone-shaped or cylindrical, with a wide opening at the top and a narrower bottom.
- **b.** When a swarm is spotted, the beekeeper carefully positions the swarm catching bag beneath the cluster of bees. The open end of the bag is held or tied securely to prevent any bees from escaping.
- **c.** The swarm catching bag is positioned directly under the swarm so that when the bees are dislodged or shaken, they fall into the bag. The beekeeper may gently tap or shake the branch or object where the swarm has settled to encourage the bees to drop into the bag.

d. Once the bees have fallen into the bag, the opening is closed tightly to prevent them from escaping. This is usually done by pulling a drawstring or using a clip or tie to secure the top of the bag.
e. The swarm catching bag can then be carefully transported to a new hive or desired location for the establishment of a new colony. It is crucial to handle the bag with care to avoid harming the bees or causing unnecessary agitation.
f. When the beekeeper reaches the intended location, the swarm catching bag can be gently opened, allowing the bees to exit and begin settling in their new hive. It is important to provide a suitable hive with frames, comb, and other necessary components to ensure the successful transfer and establishment of the captured swarm.

Figure-17: Swarm Catching Bag

Source: https://www.alamy.com/the-swarm-catching-bag-full-of-bees-placed-on-the-ground-in-a-garden-image259836513.html

11. Bee Veil

- The Indian Standard institute has standardized some very common equipment for the production of uniform and changeable articles.
- Bee veil is one of them which is worm over the face for protection against the sting.

Figure-18: Bee Veil

12. Honey Extractor

A honey extractor is an essential piece of equipment used in beekeeping to extract honey from honeycomb frames without damaging the comb. It utilizes centrifugal force to separate the honey from the cells in the comb. Here's an overview of a honey extractor and how it works:

a. A honey extractor typically consists of a drum or cylinder-shaped container made of stainless steel or food-grade plastic. It has a removable lid with a central axis or spindle that holds the honeycomb frames.

b. Beekeepers remove the honeycomb frames from the beehive and carefully place them inside the honey extractor. The frames are usually uncapped (removal of the wax covering the cells) prior to extraction to allow the honey to be released easily.

c. Once the frames are loaded, the honey extractor is set in motion. It can be hand-cranked, motorized, or powered by other means. As the extractor spins, the frames are subjected to centrifugal force, causing the honey to be forced out of the cells and collect at the bottom of the drum.

d. The extracted honey flows down the sides of the drum and collects at the bottom. Most honey extractors have a valve or gate at the bottom, allowing beekeepers to control the honey's flow and direct it into containers or storage tanks for further processing.

e. After the initial extraction, the frames are reversed to extract honey from the opposite side. This ensures that all the honey is removed from the frames and maximizes the extraction efficiency.

f. Unlike other honey extraction methods, such as crushing and straining, a honey extractor preserves the integrity of the comb. After extraction, the frames can be returned to the beehive, and the bees can reuse them, saving time and resources.

Honey extractors come in various sizes and configurations, accommodating different quantities of frames and beekeeping operations. They can be radial extractors, which spin the frames horizontally, or tangential extractors, which spin the frames vertically or at an angle.

Figure-18: Honey Extractor

Source: [https://www.aajjo.com/farming-tools-equipment-machines/*Apis-mellifera*-honey-extractor/product](https://www.aajjo.com/farming-tools-equipment-machines/Apis-mellifera-honey-extractor/product) and https://www.researchgate.net/publication/323185027_Application_of_Geothermal_water_for_Honey_Processing/figures?lo=1

13. Feeders

In apiculture (beekeeping), various types of feeders are used to provide supplemental food to honey bee colonies when natural food sources are limited or unavailable. These feeders help ensure the bees have sufficient nourishment to sustain their health and productivity. Here are some commonly used feeders in apiculture:

a. **Boardman Feeder:** This is a simple and inexpensive feeder that is placed directly on the front of the hive. It consists of a plastic or wooden tray with a reservoir for syrup or liquid feed. The tray has small holes or slits that allow bees to access the feed without drowning. Boardman feeders are best suited for small-scale beekeeping operations.

Figure-19: Broad Man Feeder

b. **Entrance Feeder:** Similar to the Boardman feeder, the entrance feeder is placed at the hive entrance. It typically consists of a container, such as a plastic or glass jar, filled with syrup or liquid feed. The jar is inverted and placed inside a feeder cap or an entrance feeder specifically designed to accommodate the jar. Bees can access the feed through small holes or slits in the feeder cap.

Figure-20: Entrance Feeder

c. **Hive Top Feeder:** Hive top feeders are positioned on top of the hive, just below the outer cover. They are larger feeders that can hold a larger volume of syrup or liquid feed. Hive top feeders often have floating platforms or floats that allow bees to access the feed without drowning. They are convenient for feeding larger colonies and require less frequent refilling compared to other feeders.

Figure-21: Hive Top Feeder

d. **Division Board Feeder:** Division board feeders are installed in the hive as a partition between frames. They are shallow containers that can hold syrup or liquid feed. Division board feeders have access holes or notches on one side that allow bees to access the feed while keeping the feed contained within the hive.

Figure-20: Division Board Feeders

The choice of feeder depends on factors such as the size of the colony, beekeeper's preference, and the purpose of feeding. It's important to ensure that feeders are kept clean and free from contaminants to maintain the health of the colony and prevent the spread of diseases.

14. Queen Excluder Sheet

A queen excluder sheet is a specialized component used in beekeeping to restrict the movement of the queen bee within the hive. It is a device placed between the brood chamber and honey supers to prevent the queen from laying eggs in the honey storage areas. Here's an overview of queen excluder sheets and their purpose:

a. A queen excluder sheet is typically a flat, rectangular grid made of metal or plastic. The grid consists of evenly spaced, small openings or slots that are large enough for worker bees to pass through but small enough to prevent the larger queen bee from moving freely.
b. Queen excluders are usually positioned above the brood chamber, separating it from the honey supers. The excluder is placed on top of the brood box or between the brood chamber and honey supers, depending on the beekeeper's preference.
c. The primary function of a queen excluder is to prevent the queen bee from entering the honey supers where honey is stored. The excluder allows worker bees to pass through and store honey in the supers while keeping the queen confined to the brood chamber. This helps maintain cleaner honey, free from eggs, larvae, or brood.
d. Using a queen excluder offers several advantages. It helps ensure that the honey supers remain free of brood, making honey extraction and processing more efficient. It also helps separate the brood area, where the queen lays eggs and the worker bees raise brood, from the honey storage area, improving management and reducing the risk of brood contamination.

Its worth mentioning that queen excluders should be used with caution during specific circumstances, such as honey flow periods or when introducing new colonies, as they may impact the natural movement of the colony and the honey production process.

Figure-21: Queen Excluder Sheet

15. Queen Cell Protector

- The Queen Cell Protector typically consists of a small plastic or metal cage that is placed over individual queen cells. The purpose of this protector is to shield the developing queen cell from potential damage caused by other bees or disturbances within the hive. It prevents worker bees from tearing down or damaging the queen cells, ensuring the survival and proper development of the queen larvae.
- The Queen Cell Protector is usually designed with small openings or mesh that allow worker bees to continue feeding the developing queen larvae and maintain the necessary airflow within the cage. This protective enclosure also serves to mark the queen cells, making them easily identifiable during hive inspections or when moving queen cells to different hives.

- By using Queen Cell Protectors, beekeepers can increase the success rate of queen rearing, as it provides an added layer of protection for the delicate queen cells. It allows the beekeeper to control the development of queen bees and select the desired genetics for their colonies.

Figure-22: Queen Protector

Source:
https://www.researchgate.net/publication/235222402_Standard_methods_for_rearing_and_selection_of_*Apis_mellifera*_queens/figures?lo=1

16. Hand Operated Comb Foundation Mill

- A hand-operated comb foundation mill, also known as a foundation press or embossing machine, is a tool used in beekeeping to create beeswax comb foundation sheets. These sheets serve as a base for honey bees to build their comb and provide a uniform template for the bees to follow. The comb foundation mill allows beekeepers to produce their own foundation sheets, which can save time and ensure consistency in hive management.
- The mill consists of two metal rollers, usually made of brass or aluminum, mounted on a sturdy frame. The rollers have a series of precise parallel ridges or cells engraved on their surfaces, corresponding to the size and pattern of the honeycomb cells.
- To use the mill, beeswax is prepared by melting and filtering it to remove impurities. The beeswax is then molded into a pliable, flat sheet that is slightly larger than the desired size of the foundation sheet.
- The prepared beeswax sheet is fed into the mill between the rollers. By turning a handle or using a crank, the beekeeper manually rotates the rollers, causing them to compress and emboss the beeswax. The ridges on the rollers imprint the pattern of honeycomb cells onto the wax sheet as it passes through the mill.
- As the wax sheet passes through the mill, it is transformed into a comb foundation sheet with the desired pattern of cells. The sheet is then collected and can be cut into smaller sections to fit into frames within the beehive.

Using a hand-operated comb foundation mill allows beekeepers to produce their own foundation sheets with specific cell sizes and patterns, tailored to their needs. It provides control over the quality and uniformity of the foundation, which can influence the bees' comb-building behavior and optimize hive management.

Figure-23: Hand Operated Comb Foundation Mill

Practical-3: To prepare a mount of pollen grains from flowers for microscopic observation.

Requirements: Flowers, acetocarmine, alcohol gradation, Xylene, DPX, cavity slides, coverslip.

Procedure:

1. Choose mature flowers with visible pollen grains. Gently remove the anthers or stamens from the flower using tweezers or a fine brush.
2. Place the collected anthers or stamens in a clean, dry container, ensuring that they are not crushed or damaged during the collection process
3. Anthers with pollen grains are removed from a flower and were stained in acetocarmine for 20mins.
4. Wash in water and then transfer to different alcoholic grades (30%, 70%, 70%, 90% and 100%) for 20 mins each for dehydration.
5. Anthers are placed in xylene for 30 mins for clearing them.
6. Anthers are then taken on a slide and teared to release the pollens and mounted in DPX.
7. Gently place a drop of the prepared mounting medium onto the slide, covering the pollen grains. Carefully lower a coverslip onto the slide to avoid trapping air bubbles. Press down gently to spread the mounting medium evenly and secure the coverslip in place.
8. Allow the mount to settle for a few minutes to minimize air bubbles. Then, place the slide under a microscope and observe the pollen grains using appropriate magnification

Observation

- Pollen Grains with intine and exine are observed.

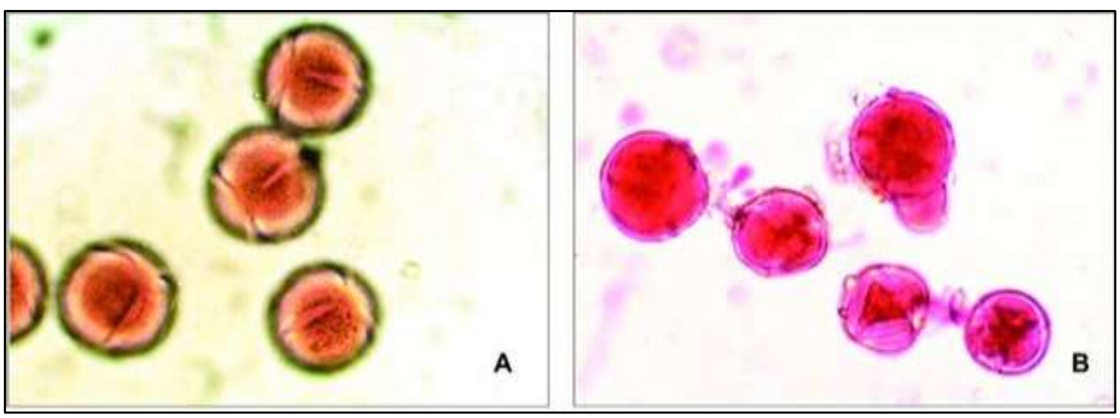


Figure-24: Pollen grain structure A-mature pollen grains not treated with acetocarmine; B-mature pollen grains treated with acetocarmine

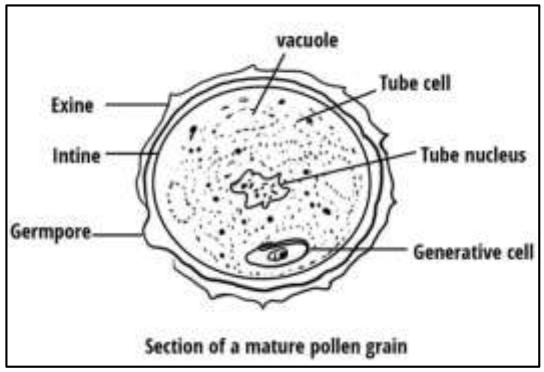


Figure-24: Section of Mature pollen grain

Discussion:

When viewed under a microscope, the structure of a pollen grain can reveal various features and characteristics.

a. **Exine:** The outer layer of the pollen grain is called the exine. It is composed of a tough and resistant substance called sporopollenin. The exine can have various patterns, textures, and ornamentations, which are often species-specific and aid in pollen identification.
b. **Pores or Apertures:** The exine may have one or more openings called pores or apertures. These apertures allow for the release of the pollen tube during pollination. The number, size, and location of the apertures can vary among different plant species.
c. **Intine:** Beneath the exine is a thinner layer called the intine. The intine is typically more delicate and less visible compared to the exine. It surrounds the cytoplasm of the pollen grain and contains various cellular components.
d. **Cytoplasm:** Within the intine, you may observe the cytoplasm of the pollen grain. The cytoplasm contains various organelles, including the nucleus, mitochondria, Golgi apparatus, endoplasmic reticulum, and other cellular structures. These organelles are essential for the metabolic activities and development of the pollen grain.
e. **Vegetative Cell and Generative Cell:** Inside the cytoplasm, you may identify two distinct cells, known as the vegetative cell and the generative cell. The vegetative cell plays a role in producing the pollen tube, which allows the pollen grain to transport sperm cells during fertilization. The generative cell divides to form two sperm cells that are eventually released into the pollen tube.
f. **Size and Shape:** Pollen grains come in a wide range of sizes and shapes, depending on the plant species. Some pollen grains are spherical, while others may be elongated, triangular, or have other unique forms. The size of pollen grains can vary from a few micrometers to several tens of micrometers.

Unit 3: Diseases and Enemies

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Bee diseases control and preventive measures: enemies of bees and their control.

Practical Exercises:

1. Diagnosis of honeybee diseases: Protozoan diseases, Bacterial diseases, Viral diseases (one each)- symptoms, nature of damage and control.
2. Identification of honeybee enemies: Predators-Insects and non-insects.

Maintaining healthy and productive bee colonies is a primary goal for beekeepers. This involves addressing various diseases, pests, and other threats that honeybees face. In India, beekeepers contend with several challenges:

1. **Brood Diseases:** Honeybees can suffer from brood diseases, including American foul brood, European foul brood, Thai sac brood, and clustering disease. These diseases primarily affect the developing brood within the beehives.
2. **Adult Bee Diseases:** Adult bees can also fall victim to diseases such as acarine and Nosema. These illnesses impact the mature bees within the colony.
3. **Pests:** Bee colonies are vulnerable to various pests, including wax moths, wasps, ants, and hive beetles. These pests can damage the beehive structure, capture and kill bees, disrupt colony development, and consume food reserves.
4. **Predators:** Birds, especially those that feed on bees, are a significant concern. Additionally, mites, mice, and even bears can pose threats to bee colonies.

To ensure the health and productivity of bee colonies, beekeepers should implement the following practices:

1. **Regular Monitoring:** Consistent surveillance of bee colonies is essential to detect diseases and pests early.
2. **Non-Chemical Methods:** Beekeepers should consider non-chemical methods for managing bee diseases and enemies to avoid the negative impacts of chemicals on bee health and honey quality.
3. **Pest Population Control:** It's crucial to maintain pest populations below an economic injury level to protect bee colonies effectively.
4. **Protection Measures:** Implement measures to safeguard beehives from predators like bears and skunks.

By adhering to these practices, beekeepers can enhance the well-being of their bee colonies and optimize honey production.

Practical 1: Diagnosis of honeybee diseases: Protozoan diseases, Bacterial diseases, Viral diseases (one each)- symptoms, nature of damage and control.

DISEASES OF HONEY BEES

There are a number of diseases which affect the honeybee in India. Of the major diseases which affect honeybee are the Acarine and No*sema* diseases of the adult bees and the brood diseases of larval stages.

1. Nosema Disease

This disease is caused by a protozoan, *Nosema apis*. The *Nosema* infestation leads to dysentery. The flies are unable to fly and void loose excreta on the combs, frames and ground in front of the hive. It mainly affects the flight during cold weather. An antibiotic known as Fumagillin is useful in controlling the infection. The drug is administered by giving a feed of 100 mg fumagillin per colony in 250 ml of sugar syrup for 10 days continuously.

2. Broad Diseases

Honey bee broods suffer from variety of diseases. Loss of brood affects the colony strength. Adult bees are not affected by brood diseases but they can spread the casual organisms. Brood diseases are more serious than adult diseases. Brood diseases of bees are described below.

- **European foul-brood**
- **American foul-brood**
- **Sac foul-brood**
- **Thai Sac brood virus (TSBV)**
- **Chalk foul-brood and stone brood disease**

Out these brood diseases, the European foul-brood disease and the Thai Sac-brood disease are common in India.

I. <u>European foul-brood disease, *Streptococcus pluton*</u>

Nature of damage: The origin of this disease was initially observed in Mahabaleshwar, India and has since spread widely. It is suspected to have been brought in through the importation of *Apis mellifera* from foreign origins. The disease is triggered by a non-spore-forming bacterium known as *Streptococcus pluton*, with *Bacillus alvei* acting as a secondary invader. Its impact is on the larvae of all castes.

Diagnosis and Symptoms: The progression of this condition in honeybee larvae is as follows:

a) **Larvae Color Change:** Initially, the larvae exhibit a transformation from a watery appearance to a yellow hue, which subsequently darkens.
b) **Visible Tracheal System:** As the disease advances, the tracheal system within the larvae becomes apparent, leading to their demise in a coiled stage, emitting a foul odor.
c) **Formation of Non-Elastic Threads:** In more advanced stages, the disease results in the creation of non-elastic threads with a hemp-like texture.
d) **Location of Dead Larvae:** Deceased larvae are typically discovered in poorly maintained cells, and there is no dominant odor associated with their presence.
e) **Scales and Larvae Position:** Both scales and larvae may be found in various positions within the affected cells.
f) **Timing of Disease Occurrence:** This disease typically manifests during periods of active brood rearing.
g) **Cell Caps and Mixture:** Cells affected by the disease often display inadequate capping and are interspersed with normal cells.

Control: The use of antibiotic terramycin is most effective in treating the disease. Terramycin is given dissolved in sugar syrup @ 100 mg of active terramycin in a litre of syrup. The terramycin syrup (freshly prepared) is fed every seventh day. The disease can also be controlled by fumigation with ethylene oxide. Quarantine is a must to prevent entry of any of the bee diseases.

European foul brood disease

I. American Foul Brood, *Bacillus larvae*

Nature of damage: American foulbrood, caused by Bacillus larvae White, primarily impacts bee larvae. This disease is widespread in numerous tropical and subtropical regions. In the United States, it stands out as the most devastating among bee ailments, leading to annual financial losses amounting to hundreds of thousands of dollars.

Diagnosis and Symptoms:

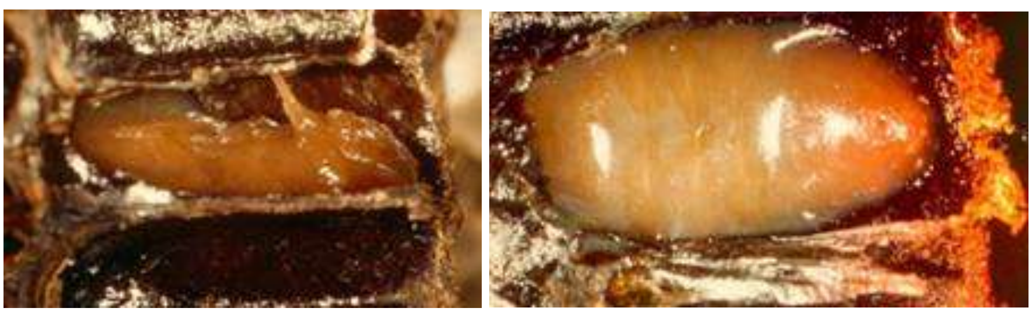
a) The pathogen responsible for this ailment is a robust, rod-shaped bacillus with flagella, displaying exceptional resistance to heat, desiccation, and disinfectants. Infection occurs in larvae of worker bees, drones, and queens when they ingest spores along with their food.

b) Once ingested, these spores germinate in the gut, typically during the pupation stage, and enter the haemolymph, where they undergo rapid multiplication. Among the larvae, the youngest are the most vulnerable to infection.

c) Diseased larvae face two possible outcomes: they are either removed and rejected by the nurse bees or, if not removed, succumb during the prepupal or pupal stage. At this point, their bodies elongate against the cell walls with heads inclined toward the cell cappings. Subsequently, they turn brown, undergo putrefaction, emitting an unpleasant fishy odor. The affected cells dry out, and their cappings become dark and sunken.

d) To exacerbate the situation, nurse bees engaged in cleaning the cells can inadvertently spread the infection. Larvae reared in cells previously occupied by diseased larvae are also at risk of becoming infected. While colonies may recover during periods of abundant nectar flow, the losses incurred during times of scarcity can be substantial.

Control: Controlling this disease involves the complete elimination of the infected colony, which includes the hive, frames, bees, and honey. In some Western countries, certain strains that exhibit resistance to the disease have emerged. To prevent its spread, it's crucial to maintain strong colonies and prevent robbing. Additionally, minimize the exchange of combs between hives and regularly replace three combs in the brood chamber each year with foundation or drawn combs from honey supers. For effective control, bee hives and suspected frames and brood boxes should be disinfected at the NCDA&CS fumigation chamber using ethylene oxide. It's important to note that using antibiotics as a preventive measure is not recommended. This is because antibiotics can mask the symptoms of the disease, potentially leading to its increased spread among hives. Moreover, this practice can contribute to the development of antibiotic-resistant strains of the disease.



American foul brood disease

II. Thai sac brood virus (TSBV)

The causative agent is Thai Sac-brood virus. This virus attacks specifically *Apis cerena indica*. The dead brood is found in propupal but sealed stage. The pupae turn into sac-like structures filled with lemon-coloured liquid at the posterior end. In advanced stage, the larvae change their appearance from yellowish to brownish to black colour. No discernible foul odour is noticed. Many Indian bee colonies were destroyed by TSBV in South India during early 90s and caused severe loss to bee keeping industry. Noeffective method to control this disease is known as yet.

Prevention is better than cure. It is better to isolate the infected colonies. Combs from diseased colonies should not be used for any other purpose and dequeening the colony for a few days followed by requeening with a healthy queen from a strong colony is effective.

Practical-2: Identification of honeybee enemies: Predators-Insects and non-insects.

A. Greater Wax Moth (*Galleria mellonella*)

The greater wax moth, scientifically known as *Galleria mellonella*, is a significant threat to honeybees. These moths have a wingspan of approximately 3 cm and are grayish-brown. The adult female wax moth infiltrates beehives, depositing eggs in cracks, crevices, and directly on the honeycomb. Upon hatching, the wax moth larvae, primarily consume the beeswax comb and occasionally pollen. These larvae progress towards the front of the comb through continuous feeding, creating silken tunnels using their secretions. During their feeding process, they also excrete small, elongated, black, striated pellets. This activity weakens the comb, and severe infestations can reduce it to a web-like mass comprising comb fragments, silken galleries, and excreta. The extent of damage to beehives can be observed.

It's essential to note that wax moths do not directly attack the bees themselves. To complete their life cycle and develop into adults, they require access to older combs or cell cappings that contain essential proteins for larval development. Wax moth infestations are more prevalent in hot and humid conditions and pose a greater threat to weaker honeybee colonies. Additionally, they tend to be more serious for Asiatic bee species compared to European honeybees. Even surplus wax combs stored in super

Control: A robust honeybee colony usually requires no intervention to combat wax moths. The bees naturally eliminate the moth larvae and their webs. Strengthening the colonies, removing excess combs, sealing cracks and crevices, and regularly cleaning the floorboards are effective measures to control wax moth infestation. Chemical treatments for wax moths are not advisable within an active colony.

To manage the wax moth chemically, several methods are effective:

- **Para Dichloro Benzene (PDB) Moth Crystals:** PDB moth crystals can be used to control wax moths. These crystals are known for their effectiveness in keeping these pests at bay.
- **Burning Sulfur Fumigation:** Exposing stored combs to burning sulfur fumigation is another method to control wax moths. This process helps eliminate the pests in empty combs.
- **Aluminium Phosphide Fumigation:** The use of aluminum phosphide fumigation is also helpful in controlling wax moths, particularly in empty combs. After applying these chemical methods, it's crucial to follow these precautions:
- **Airing Out:** The treated combs must be thoroughly aired out for several days before they are reused to ensure that any residual chemicals have dissipated. However, it's important to note that the use of naphthalene balls (moth balls) is discouraged due to several drawbacks:
- **Accumulation in Wax:** Naphthalene can accumulate in the wax, which can have adverse effects.
- **Harm to Bees:** It can harm bees, which is detrimental to the hive.
- **Honey Contamination:** Naphthalene can contaminate honey, making it unsuitable for consumption. Therefore, it is advisable to opt for safer and more effective chemical control methods while avoiding the use of naphthalene balls.

B. Bee Predatory Wasps *(Vespa sp)*

Both *Apis cerana* and *Apis mellifera* colonies are commonly targeted by predatory wasps, particularly Vespa spp. In the case of *A. cerana* colonies, wasp invasions often lead to bees abandoning their hives. Similar behavior is observed in weaker *A. mellifera* colonies when confronted by these aggressive wasps.

The predatory wasps, *Vespa spp*., capture bees both at the hive entrance and inside the hives, significantly weakening the affected colonies. The impact of predation by *Vespa spp*. is typically seasonal, posing a temporary threat to commercial apiaries during certain times of the year.

Furthermore, these pest wasps are known to be active in hot and humid environments, making them a notable concern in regions with such climatic conditions. Their activity can exacerbate the challenges faced by beekeepers and the health of bee colonies, emphasizing the need for effective pest management strategies in affected areas.

Wasp attacks on apiaries peak during the monsoon and autumn months, specifically from July to October. Apiaries located near foothills and tropical forests are particularly vulnerable to these attacks. The process unfolds in several phases:

- **Hunting Phase:** Initially, a 'hunting phase' occurs where a few wasps target slow-flying bees one at a time near the entrance of weak hives. During this phase, individual bees are captured and killed.
- **Slaughtering Phase:** Subsequently, a 'slaughtering phase' ensues, characterized by a coordinated attack by approximately 20 to 30 wasps on a weak colony. These wasps employ their strong jaws to maul the bees. The dying and dead bees are discarded on the ground during this phase.
- **Invasion Phase:** As this phase continues and the colony loses most of its defender workers, the wasps proceed to enter the hive. Once inside, they consume the honey and brood nest.

This pattern of wasp behavior poses a significant threat to bee colonies, especially those in vulnerable geographic locations, resulting in the loss of bees and vital resources within the hive.

Control: The foraging range of Vespa wasps extends to a larger area surrounding their nests. To reduce the wasp population in subsequent seasons, it's effective to eliminate gravid females during the spring. Minimizing damage from these wasps can be achieved through several methods, including bait-trapping, trapping at hive entrances, and using protective screens.

Locating and destroying wasp nests by tracking individual wasps back to their nests is a helpful approach, although it can be time-consuming. If labor costs are manageable, capturing and eliminating individual foraging wasps near apiaries is a useful control method. Tools like fly-flappers or brooms can be employed to kill wasps in front of beehives, especially during the active noon hours when wasp activity is at its peak.

This approach has proven to be quite effective, mainly because the period of the most intense wasp attacks typically lasts for only two to three months. Additionally, the use of wasp bait within the apiary can contribute to minimizing damage caused by these insects.

Unit - 4 Bee Economy

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1. Beekeeping industries -Recent advancements, employment opportunities

In recent years, the beekeeping sector has experienced notable changes because to the growing global demand for honey and other products generated from bees. Honeybees are regarded as highly captivating creatures due to their ability to generate profits. They not only produce honey and other valuable beehive products such as propolis, royal jelly, and bee venom, but they also contribute to the enhancement of crop yield through cross-pollination. Additionally, the multiplication of bee colonies and the sale of surplus colonies serve as an additional source of income in the field of beekeeping. Beekeeping has a minimal requirement for land and infrastructure. The initial cost associated with entering this profession is rather low, and there are several government and semi-government cooperative sectors that offer financial support in the form of loans and subsidies to facilitate the commencement of this occupation. Additionally, there has been an increased acknowledgment of the vital role that pollinators play in agricultural practices. The user did not provide any text. Alongside the advancement of traditional methods in beekeeping, these advances have resulted in a wide range of employment opportunities within the industry. This essay aims to critically examine the recent developments in apiculture, with a particular focus on the various employment prospects it offers.

1.1 Recent advancements in beekeeping

1.1.1 Technical advances in beekeeping

The beekeeping sector has experienced notable changes in recent years, largely due to advancements in technology and the general accessibility of various technical tools that are integrated with cloud-based software systems. The implementation of these technological advancements has significantly transformed the administration of bee colonies, hence streamlining the responsibilities associated with beekeeping. One noteworthy technological innovation is a solar-powered equipment designed to protect bee colonies from parasitic organisms that can hinder the growth of colonies and reduce honey production. In addition, a wide variety of programmes have been designed with the intention of assisting beekeepers in recent years. These programmes give assistance in the identification and selection of plants that are conducive to the well-being of bees by taking into consideration a wide variety of characteristics, such as the location of the plants. As a consequence of this, these sprays contribute to the enhancement of the fodder supply for bee colonies, which is beneficial for beekeepers as well as gardeners. One such unique application makes use of artificial intelligence to remotely monitor the health of beehives and informs beekeepers of potential problems such as the lack of queens, swarming events, and environmental conditions that may have an effect on the colonies. One significant advancement is the implementation of data analytics and sensor technology in beekeeping management. Beekeepers currently use gadgets that are connected to the Internet of Things (IoT) in order to do continuous inspections of the hives (Rosli *et al*., 2022). These sensors keep track of the temperature, humidity, and weight of the hive in addition to the activity of the bees, which provides vital information regarding the health of the colony (Ochoa *et al*. 2019).

One of another strategy being widely used within Precision Agriculture that focuses on efficient management of individual bee colonies is called as Precision Beekeeping (PB) that involves three phases namely, data collection, analysis, and application (Alleri *et al*., 2023). To advance PB, the development of decision support systems (DSS) is suggested as a mid-term goal, with the long-term vision involving specialized electronic devices controlled by DSS. Specific roles for actors within PB systems are proposed for implementing DSS recommendations and diagnostics. Achieving success in PB requires optimizing sensor combinations, ensuring cost-effective DSS solutions, and considering business interests, apiary location, and potential risks (Alleri *et al*., 2023; Zacepins *et al*., 2015). With the help of this data-driven strategy, beekeepers can quickly address any problems, lowering hive losses and enhancing bee health in general (Ho *et al*., 2022). In addition, advancements in hive design have resulted in the production of structures that are more advantageous and successful for bees. Intelligent hives, which feature modular frames and increased insulation, are better able to maintain a steady temperature within the hive and reduce the amount of bee suffering. Advancements in pest and disease control, such as the development of Varroa mite monitoring systems and organic medicines, have significantly augmented the survival rates of bee colonies (Qandour *et al*., 2014). The aforementioned innovations jointly enhance the overall productivity, sustainability, and efficiency of the beekeeping industry.

1.1.2 Sustainable beekeeping and its benefit

In recent years, the significance of sustainable beekeeping practises has escalated due to their crucial role in safeguarding honeybee populations and ensuring the enduring profitability of the beekeeping business. The aforementioned methodologies prioritise the welfare of bees, the general ecological health, and the production of superior bee products, while also aiming to minimise negative environmental consequences. The implementation of responsible hive management is an essential practise for ensuring sustainability. This involves monitoring the well-being of the hive, employing organic methods for pest and disease management, and avoiding the overuse of antibiotics or other chemical substances that may have detrimental effects on bees or the ecosystem (Cota *et al*., 2023; Dsouza, and Hegde, 2023). Sustainable beekeepers place a high value on the preservation of natural forage and habitat, giving bees access to a variety of pesticide-free food sources. Another critical component of sustainable beekeeping is minimizing stress on bees during hive inspections and honey harvesting. Strong and robust colonies can be maintained by using gentle handling and limiting disturbances. It is impossible to exaggerate the value of sustainable beekeeping methods. Because bees are essential crop pollinators, both food production and biodiversity depend on them. Sustainable practices help bee populations as well as ecosystem health, higher-quality bee products, and the future viability of the beekeeping sector.

1.1.3 Market trends and consumer preferences

In recent years, the beekeeping industry has experienced significant shifts in market dynamics and consumer preferences (Pippinato *et al*., 2020). The aforementioned modifications are indicative of evolving societal attitudes towards sustainability, the adoption of health-conscious lifestyles, and the ethical considerations associated with consumption. One trend that is becoming increasingly visible in the business is the growing desire for natural and organic bee products. Honey and other products associated with bees that do not include synthetic chemicals or pesticides are becoming an increasingly popular choice among consumers (Roman *et al*., 2013). This tendency aligns perfectly with a broader drive in the food business towards healthier and more environmentally friendly products. One more significant shift has been the development of new regional and artisanal honey markets. Honey produced by local beekeepers on a small scale might command a premium price from consumers who are willing to pay extra (Wu *et al*., 2015). This movement places an emphasis not only on the aspiration for openness but also on the promotion of regional economies and the savouring of honey with particular flavour profiles. Additionally, there is a growing interest on the part of customers in products that are favourable to bees. Customers are looking for businesses and products that are involved in the protection of pollinators, which highlights the necessity of beekeeping practises that are ethical and environmentally responsible. Recent technological breakthroughs have brought forth a paradigm shift in the realm of beekeeping, characterised by enhanced precision and effectiveness. The utilisation of Internet of Things (IoT) devices and data analytics has facilitated the maintenance of more robust bee colonies and the attainment of higher honey production. Sustainable practises not only serve to save bee populations, but also play a significant role in the conservation of biodiversity and yield superior quality bee products. This phenomenon can be attributed to a growing recognition of the significance of bees within our ecological system.

1.2 Exploring Prospects for Employment in Apiculture

India possesses a rich and diverse flora that is conducive to the practise of beekeeping, offering significant opportunities for entrepreneurial endeavours and the creation of jobs, particularly for the younger generation and women. In India, the phenomenon of increased youth migration to urban regions is primarily attributed to the issue of unemployment. There is an expectation that the establishment of a beekeeping enterprise might perhaps mitigate the issue of unemployment and serve as a deterrent to inter-state migration. There are numerous job prospects in the beekeeping sector. Beekeeping serves as a favourable agro-based subsidiary enterprise, offering an additional source of income to individuals residing in rural regions (Agrawal, 2014). This occupation possesses the potential to serve as a lucrative business venture, requiring minimal exertion while yielding substantial financial returns. Moreover, it has the capacity to enhance the socio-economic standing of rural households, as well as generate work opportunities for future generations (Moniruzzaman & Rahman, 2009). Currently, there is a certain industry that is emerging as a significant sector, with an increasing number of entrepreneurs venturing into it on a commercial level. Beekeeping not only provide honey but also wax or hive products, and beneficial substances such as Royal jelly, venom, and propolis. Honeybees contribute to agricultural cultivation by facilitating efficient pollination, which subsequently enhances farm production. Beekeeping also fosters the development of ancillary enterprises, such as equipment manufacturing, processing, the creation of value-added goods, and marketing. This sector has the potential to augment domestic production by effectively harnessing untapped natural resources, whilst minimising adverse environmental impacts. The comprehensive use of natural resources not only generates employment opportunities for millions but also contributes to the preservation and conservation of the environment (Abrol, 2023). The current state of this industry can be attributed to a significant advancement. Beekeepers play an essential role in the administration and upkeep of bee colonies in order to ensure the continued good health and productivity of the hives they tend. For the purpose of honey processing and packaging, labourers with prior experience in the gathering, processing, and quality control of honey and other products related to bees are required. There is a need for scientists, researchers, and educators who are interested in improving beekeeping practises and the health of bees. Equipment manufacturing firms use production personnel, designers, and sales representatives in order to develop and market beekeeping equipment. These employees are responsible for designing the equipment. Pollinator conservation organisations are searching for individuals with extensive knowledge of pollinator health to assist with the development of initiatives, lobbying efforts, and educational programming. There are a variety of marketing and sales opportunities available for businesses that deal in honey and other bee-related items, including positions for marketing professionals, sales reps, and e-commerce specialists. In addition, there is a demand for teachers and educators who can educate aspiring beekeepers through the delivery of seminars and workshops as part of beekeeping education and training. Because there are so many different job options available, the beekeeping business is appealing to people who have a wide range of interests and skills. The apiculture industry is presently facing a critical juncture characterised by the convergence of opportunity, sustainability, and innovation. Undoubtedly, the beekeeping industry is poised to progress and flourish in the foreseeable future, presenting abundant opportunities for entrepreneurship and yielding favourable ecological effects. In order to sustain its current growth rate and profitability, it will be imperative for the industry to embrace ecologically sustainable business practises and remain updated on developing consumer preferences in the foreseeable future. The practise of beekeeping encompasses more than the mere production of honey. Its broader objectives include the preservation of ecological balance, the provision of a reliable food source, and the establishment of harmonious coexistence between people and bees, devoid of any adversarial dynamics.

2. Scope for women entrepreneurs in bee keeping

The current discourse surrounding the economic empowerment of women has positioned it as a crucial factor in the developmental trajectory of nations. Consequently, the matter of women's economic empowerment has garnered significant attention and is considered very significant. It has been believed by political thinkers, social scientists, and reformers, that women play a significant role in the growth and development of nations as approximately half of the population of country are women. The prevalence of female entrepreneurs has experienced a notable increase throughout a specific time frame, particularly during the last 10 years (Mattis, 2004; Morris *et al*., 2006). Rural women play a significant role in facilitating agricultural development and related sectors, encompassing activities such as crop production, harvest operations etc. Small-scale entrepreneurship has emerged as the exclusive solution for tackling the problem of unemployment, efficiently harnessing human resources and improving the quality of life for women living in rural regions (Mahajan & Bandyopadhyay, 2021). The endorsement of income-generating activities in rural areas is increasingly being embraced by development organizations and professionals in the field of rural development (Matshe and Young 2004). Beekeeping serves as a favorable agro-based subsidiary enterprise that offers both additional and primary sources of income to individuals residing in rural regions. This practice contributes significantly to augmenting income, enhancing socio-economic standing, and facilitating employment generation besides providing nutritional, and sociocultural advantages to impoverished households, without necessitating land ownership or substantial capital outlays (Faud *et al*., 2019). Additionally, it promotes the establishment of subsidiary firms, thereby contributing to the overall enhancement of national production and the creation of employment opportunities for a significant number of individuals.

Furthermore, the practice of beekeeping serves as a means to empower women living in rural regions. Historically, the practice of beekeeping was predominantly pursued by males (Duarte Alonso *et al*., 2021). Multiple studies undertaken at the international level have indicated that the practice of beekeeping is predominantly dominated by males. Nevertheless, recent studies have indicated a notable increase in the interest and participation of women in this field (Pocol *et al*., 2015). The field of beekeeping presents numerous chances for economic empowerment and sustainable living, making it an area with considerable potential for women entrepreneurs. Moreover, the practice of beekeeping necessitates reduced labor and attention, rendering it a viable vocation for women engaged in farming activities. Apiculture is frequently acknowledged as a potential strategy for enhancing the agency and socio-economic status of women residing in rural areas. The initial investment required is relatively low, but the rewards are realized quickly. The promotion of beekeeping has the potential to attract farm women, families, and unemployed young, ultimately leading to its transformation into a lucrative enterprise on a significant scale. Beekeeping exhibits considerable market potential as a productive endeavor, offering greater adaptability to the limitations of low financing and limited land access compared to alternative agricultural industries. It has also been demonstrated that it provides additional benefits to women, such as enhanced community participation and agency (Woldewahid *et al*., 2012). Research examining the involvement of women in the practice of beekeeping on a global scale is progressively shifting its attention towards the challenges encountered by women in this domain, with the aim of providing recommendations for enhancing their participation. In their respective studies, Qaiser *et al*. (2013) and Ejigu *et al*. (2007) have identified several obstacles that impede women's involvement in beekeeping endeavors. These barriers pertain to certain tasks within the beekeeping process, such as colony transfer, queen catching, harvesting, and hive movement, which are found to be less frequently undertaken by women, particularly young women. The provision of training sessions that are specifically tailored to women will help in reducing the gap.

Also, the participation of women in beekeeping operations has been limited due to several cultural taboos and the specific beekeeping methods employed (Olana & Demrew, 2018). A initiative initiated by the United Nations Conference on Trade and Development (UNCTAD) is utilizing the capabilities of bees to enhance the economic well-being of women and promote sustainable development in rural communities within the southern African nation (UNCTAD, 2023).

2.1.1. Benefits of beekeeping to women in India

Beekeeping has the potential to avoid migration to cities and earning a sustainable living is in the hands of women; giving them social and economic empowerment. There are several benefits of bee keeping to women- Several elements make beekeeping a feasible and empowering business opportunity for women entrepreneurs mentioned below: (Mwakatobe, *et al*., 2016; Nagma *et al*. 2021; Verma & Kunjwal, 2019)

- Protecting the environment while boosting incomes
- Enhanced community participation and agency
- Beekeeping does not necessitate a significant amount of financial resources or expansive area. One may commence with a modest scale and progressively broaden their undertakings as they accrue expertise and assurance.
- Beekeeping has the benefit of flexible working hours, which can be particularly helpful for women who may have additional duties such as childcare or home tasks.
- Income generation coupled with household consumption.
- Women’s empowerment and biodiversity conservation.
- Beekeeping is an essential component of sustainable agriculture as it plays a crucial role in facilitating pollination, hence enhancing crop productivity and safeguarding food security. Women have the ability to participate in the practice of beekeeping as a component of sustainable agricultural methods.
- Demand of honey and other value added products -In addition to the production of honey, beekeeping presents prospects for the creation of value-added products such as royal jelly supplements, beeswax candles, and cosmetics and personal care items using propolis.
- Numerous organisations and governmental entities offer training and assistance to women who possess an interest in the field of apiculture, so equipping them with the necessary information and competencies, ultimately fostering their empowerment.

Because of the above mentioned benefits Beekeeping presents a great opportunity for Indian women entrepreneurs to meet the growing demand for bee products while promoting economic independence and sustainable agriculture.

2.1.3 Entrepreneurship by Women

Indian women can start successful beekeeping companies with training, resources, and perseverance. A multitude of governmental schemes and initiatives in India are implemented to foster the practise of beekeeping as an integral component of agricultural development programmes. These programmes frequently offer training, grants, and financial support to women who have an interest in beekeeping. The integration of beekeeping activities into Self-Help Groups (SHGs) is observed among numerous women in India (Gupta & Singh, 2016). Self-Help Groups (SHGs) have the capacity to effectively administer beekeeping enterprises and distribute the resulting income among their members in a collaborative manner (Sharma, *et al*.,2012).

Several Indian women have successful inspiring journey which tells the story that women can do a good job in bee keeping and contribute in national economy. One such story is of Savitramma. Her journey began when she attended an orientation session on beekeeping and turning it into a company at a local mela held in her Gram Panchayat. Driven by the acquired knowledge, she sought financial assistance from the Community Investment Fund (CIF) and allocated the funds towards the procurement of essential equipment and raw materials required for beekeeping. The process began, but while gaining beekeeping experience, she lacked the knowledge to promote her products. Furthermore, because honey is a food product, she realised she would need to follow a variety of standards if she wanted to extend her business outside her tiny neighbourhood. he received training on crucial areas of business operations, laws, and developing market linkages through the State Government's National Rural Economic Transformation Project, which is being implemented in collaboration with the United Nations Development Programme (UNDP). This helped a lot in weaving her successful entrepreneurship career.(*Bee-Lady of the honey-hill: United Nations Development Programme* (2022a)

Another inspiring story is of Anita Kushwaha form Muzaffarpur, Bihar. The area is known for litchis and honeybees are attracted to the litchi flowers. Hence, beekeeping is pursued by many in this area. She thought she can do it and then she joined a course run by the government to learn about this. She was only the girl in the training. But she lacked the money to start the work. She was able to save Rs. 5000 in some time and with this money, she bought two boxes for keeping bees. With the remaining money, she bought the other required items and thus her journey began. A girl from a poverty-stricken family who turned to bee-keeping for a better living and was declared the 'UNICEF girl' has now been hailed as a role model by the National Council of Educational Research and Training (NCERT) (Available at: https://ncert.nic.in/textbook/pdf/deap105.pdf)

3. Economics in small and large scale Beekeeping

Beekeeping is an age-old agricultural practise that has recently gained new significance as a result of the economic potential it possesses, the value it adds to the environment, and the contribution it makes to the maintenance of food safety. In India, beekeeping has evolved from a time-honored hobby into a vibrant commercial industry that provides opportunities for both modest and expansive business endeavours. The purpose of this study is to explore the economics of beekeeping in India, with a particular emphasis on the distinctions between beekeeping on a small scale and on a large scaleIt investigates the factors that influence profitability, the dynamics of the market, and the bigger developmental activities and institutions that serve as a foundation for this essential business. By looking into these many areas, we want to gain a deeper understanding of the complex economic conditions that contribute to the success of beekeeping in India.

3.1.1 Small Scale Beekeeping

The amount of money spent and the number of hives maintained by a small-scale beekeeper are both typically low. It is sometimes considered to be the first step in getting into beekeeping. Small-scale beekeepers are only responsible for a handful of beehives, which makes beekeeping a manageable business for individuals with little resources. Individuals or small farming households make up the majority of them. The initial investment involves bee costumes, beehives, smokers and hive equipments. Honey production serves as the principal source of revenue, supplying communities and local markets with high-quality, handcrafted honey (Hinton,*et al*.,2022). While small-scale beekeeping operations may not yield comparable financial outcomes to larger firms, they often manage to recoup expenses and earn supplementary income. In addition to honey production, small-scale beekeepers have the potential to generate income through the provision of pollination services, particularly in the context of assisting local farmers in pollinating crops, particularly those found in vegetable and fruit orchards. Furthermore, it would be prudent for them to explore the potential of value-added products that have the capacity to enhance profitability. Examples of such products include propolis and beeswax etc. The revenue and profitability derived from small-scale apiculture in India may be low, yet it can nevertheless make a significant contribution to the livelihoods of beekeepers (Thakur and Yadav, 2016).). Small-scale beekeeping plays a crucial role in India's beekeeping sector as it not only contributes to family economics but also fosters the adoption of sustainable agricultural practises and environmental conservation through the provision of pollination services (Gentry,1984). Small-scale beekeepers encounter various obstacles, including the prevalenc of bee illnesses, unpredictable weather patterns, competition from larger-scale beekeeping enterprises, and limited market accessibility.

3.1.2 Large Scale Beekeeping

The practise of large-scale beekeeping in India represents a notable advancement compared to small-scale operations, as it necessitates a greater financial investment and a bigger number of beehives (Sain & Nain, 2017). Typically, individuals engaged in commercial enterprises or experienced apiarists seeking to expand their beekeeping endeavours undertake this endeavour. Economies of scale frequently enable commercial beekeepers to attain increased levels of honey output while simultaneously reducing costs. The economies of scale commonly involve many activities such as honey extraction, processing, and packaging, serving both domestic and international markets (Sain & Nain, 2017). Due to the sheer amount of honey produced, large-scale beekeeping has a much better economic potential than small-scale businesses. Further expanding their revenue streams, large-scale beekeeping operations can offer large-scale agricultural enterprises necessary pollination services. This industry is essential for raising agricultural production, promoting food security, and promoting economic development in rural areas (Kishan Tej, *et al*., 2017). It also comes with more difficulties, such as the requirement for efficient hive management, disease prevention, and marketing plans to take use of the increasing production potential. In India, large-scale beekeeping is essentially a key factor in driving both economic growth and agricultural sustainability (Ubeh *et al*., 2011).

Economics of Beekeeping

Beekeeping offers employment opportunities to individuals who are currently unemployed. The following proposal outlines a framework for the establishment of an apiary consisting of colonies of *Apis mellifera*.

Expenditure for 100 *Apis mellifera* bee colonies:

NON-RECURRING

	Number	Rate/unit	Total amount (Rs)
Bee Hives	100	Rs 2200/hive	2,20,000.00
Bee colonies	100	Rs 350/frame x 4	1, 40,000.00
Honey extractor	1	Rs 2500/-	2,500.00
Smoker, bee veil, Hive tool etc	1 set	Rs 500/-	500
Miscellaneous (honey cans, mating nuclei etc)	-	Rs 7000/-	7,000.00
Total			3,70,000.00 (A)

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

RECURRING (per year)

a. For stationary beekeeping

	Number	Rate/unit	Total amount (Rs)
Labour (full time)	1	Rs 3900/month	46,800.00
Comb foundation sheets	1000	Rs 20/sheet	20,000.00
Sugar for feeding	500 kg	Rs 36/kg	18,000.00
Chemicals for pest control	-	Rs 20/colony	2,000.00
Miscellaneous	-	-	2,000.00
Total			88,800.00 (B)

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

b. For migratory beekeeping

Transportation	No. of trips	cost per trip	Total
Truck	4	Rs 2500/trip	10,000.00
Total cost (a + b)			98,800.00 (C)

Adapted from
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

DETAILS OF EXPENSES

a) Stationary beekeeping:

Interest on non-recurring cost @15%	55,500.00
Recurring cost (B)	88,800.00
Interest on recurring for 6 months @15%	6,660.00
Depreciation on permanent articles except bees @ 10%	23,000.00
Total	**1,73,960.00 (D)**

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

b) Migratory beekeeping:

Interest on non-recurring cost @15%	55,500.00
Recurring cost (C)	98,800.00
Interest on recurring for 6 months @15%	7,410.00
Depreciation on permanent articles except bees @10%	23,000.00
Total	1,84,710.00 (E)

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

INCOME FROM 100 COLONIES

a) Stationary beekeeping:

Commodity	No./average	Quantity	Rate	Amount (INR)
Honey	15kg/colony	1500 kg	Rs80/kg	1,20,000.00
Sale of divided colonies	30 % colonies	30 colonies	Rs1400/colony	42,000.00
Beeswax	2% of honey produced	30kg	Rs 200/kg	6,000.00
Colonies for pollination	10% colonies	10 colonies	Rs 600/colony	6,000.00
Commercial queen production(two breeding seasons)	from 10% colonies	100 queens	Rs 400/queen	40,000.00
Total				2,14,000.00(F)

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

b) Migratory beekeeping:

Commodity	No./average	Quantity	Rate	Amount
Honey	35kg/colony	3500 kg	Rs 80/kg	2,80,000.00
Sale of divided colonies	40 % colonies	40 colonies	Rs 1400/colony	56,000.00
Beeswax	2% of honey produced	70 kg	Rs 200/kg	14,000.00
Commercial queen production(two breeding seasons)	from 10% colonies	200 queens	Rs 400/queen	80,000.00
Total				4,30,000.00(G)

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

NET INCOME

Stationary beekeeping (F-D) 214000-173960= Rs 40,040.00

Migratory beekeeping (G-E) 430000-184710=Rs 2, 45,290.00

Adapted from -
http://ecoursesonline.iasri.res.in/pluginfile.php/17370/mod_resource/content/1/Practical_14.pdf

Factors that exert an influence on the profitability of beekeeping,

Location, bee species, and climate stand out as significant predictors of beekeeping profitability among other essential considerations. First and foremost, location is crucial to the financial success of beekeeping. The amount and quality of nectar and pollen that the bees have access to directly depends on their proximity to various feeding sources, such as flowering plants. The site is crucial for beekeepers since areas with a rich and diverse flora can produce more honey. Second, it is important to consider the species of bees. The ability to produce honey, resilience to disease, and temperament varies across different bee species. Because of its excellent honey yield, versatility, and generally kind temperament, the European honeybee (Apis mellifera) is favoured by many people. Profitability is highly influenced by choosing the best kind of bee for the regional environment and beekeeping objectives. Finally, the weather has a big impact on beekeeping. Bees are extremely sensitive to temperature and weather, which has an impact on both their foraging habits and the health of the hive as a whole. The production of honey can be affected by extremely cold or hot conditions. To ensure profitability in areas with difficult climates, proper hive management and shelter from bad weather are crucial.

Development Programs & Organizations involved in bee keeping in India

India has witnessed a significant surge in the establishment of beekeeping development programmes and the proliferation of many groups dedicated to fostering and advancing this crucial industry. The aforementioned programmes have been specifically developed with the intention of assisting beekeepers in enhancing their skills and fostering the adoption of sustainable practises. Government-sponsored initiatives, including the National Beekeeping & Honey Mission (NBHM), offer beekeepers all around the nation financial aid, instruction, and technical advice. Beekeeping programmes are also managed by state governments, which helps the sector's expansion. In India several NGOs (Himalayan Environmental Studies and Conservation Organization (HESCO) and the Centre for Sustainable Agriculture (CSA), Khadi and Village Industries Commission (KVIC), National Bee Board (NBB) and National Horticulture Mission (NHM) put in a lot of effort to raise beekeepers' awareness, provide them with training, finantial support and help them connect with markets. The Khadi and Village Industries Commission (KVIC) has been actively involved in the promotion and advancement of beekeeping since 1957 and formulating policies and schemes, implementing promotional programmes, organising awareness and training initiatives, and providing technical expertise through its network of State/Divisional Offices, CBRTI (Central Bee Research and Training Institute) in Pune, and State Beekeeping Extension Centres for the advancement of the beekeeping programme. The Honey Mission was launched by the Khadi and Village Industries Commission (KVIC) in May 2017 as a part of the Beekeeping programme, following the clarion cry of the Honourable Prime Minister for a "SWEET KRANTI" (KVIC, 2023). NBB is primarily focused on advancing the field of scientific beekeeping and enhancing the long-term viability of this practise inside India. Consequently, this phenomenon directly influences the enhancement of crop productivity through the facilitation of pollination. The board underwent registration as a "society" in accordance with the provisions outlined in the Societies Registration Act of 1860. The reconstitution took place in June 2006 (NBB, 2023).There are several project run by government for extension of beekeeping. In 1976, the National Commission on Agriculture proposed the initiation of a project called the "All India Coordinated Project on Honeybee Research & Training." This recommendation was made in recognition of the significant role honeybees play as pollinators. The initiation of the project was undertaken by the Indian Council of Agricultural Research in the fiscal year 1980-81 (ICAR-AICRP, 2023). Beekeeping is part of the central government's National Horticulture Mission (NHM). It funds bee colony establishment and beekeeper training. Apart from this several other organisations like Krishi Vigyan Kendra, Indian Institute of Horticultural Research: ICAR, CSR initiative of many banks run, District rural development agency (DRDA), *Rubber*. conduct awareness and beginners *training programme or provide* subsidy for buying *bee*-keeping materials. National Agricultural Cooperative Marketing Federation of India Ltd. (NAFED) engaged in the procurement of honey from beekeepers and its subsequent domestic and worldwide commercialization. The platform facilitates the sale of honey in large quantities for beekeepers. Many Indian states have Beekeeping Development Agencies like Beekeeping Development Agencies (BKDAs) and SBEC (state beekeeping extension centers) to encourage regional beekeeping. Beekeepers receive training, technical advice, and financial aid from these institutions.

Furthermore, these organisations provide assistance in the establishment of infrastructure and the formation of beekeeping clusters. Moreover, India collaborates with international institutions such as the Food and Agriculture Organisation (FAO) to facilitate the implementation of beekeeping development initiatives, which encompass the dissemination of knowledge, provision of training, and enhancement of capacity building. Collectively, these institutions and development initiatives provide a substantial contribution to enhancing the beekeeping industry in India, empowering beekeepers, and ensuring its long-term viability, while simultaneously promoting economic growth and environmental preservation.

In summary, beekeeping in India encompasses a wide range of enterprises, encompassing both small-scale and large-scale activities that significantly contribute to the economic and agricultural sustainability of the country. Location, bee species, and climate all have an impact on how profitable beekeeping is, underscoring the need of making well-informed decisions. In order to promote growth and sustainability within the beekeeping industry, development programmes and organizations—including government initiatives, NGOs, and international partnerships—have been crucial. These initiatives are positioned to further increase the industry's influence as India continues to recognise the economic and environmental significance of beekeeping, assuring a prosperous future for beekeepers and the ecosystem alike.

The mail objectives of all Development Programs & Organizations are (KVIC, https://msme.gov.in/sites/default/files/Beekeeping.pdf):

- Creating reliable employment and providing supplementary income in rural areas

- Judicious use of available natural resources
- Training to beekeepers
- Awarness programme for beekeepers
- Creating awareness about the benefits of beekeeping in cross pollination
- Connecting with like-minded groups
- Identification and selection of potential beekeeping areas
- Organising workshop and skill development programme
- Marketing of Bee products

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Snippets of the Faculty Development and Training Program for Laboratory Staff







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