Proceedings of the Workshop

on

PROMOTION OF HONEYBEE KEEPING IN HARYANA

held on June 24, 2014 at Panchkula

HARYANA KISAN AYOG

Anaj Mandi, Sector 20, Panchkula -134116

Government of Haryana

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Edited By:

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FOREWORD

Apiculture is an important component of our farming systems which helps in achieving sustainable agriculture. It is an exclusive non-land based activity which does not compete with other farming systems for resources. It also helps in the conservation of forest and grassland ecosystems because honeybees are one of the most efficient pollinators. Inputs for apiculture are mostly simple and locally available. Yet another significant, but not widely recognized role, is that honeybees enhance the productivity of agricultural, horticultural and fodder crops because of effective cross pollination. It has been estimated that the value of honeybees as pollinators is about 18-20 times more than their value as producers of honey and other hive products.

In India, besides food security, the concern to improve livelihood of small holder farms has become a dominant issue. We need to provide farmers additional options for increasing their income. International demand for speciality products such as mushroom, baby corn, strawberry and honey etc. are some of the emerging highly potential options for increased profitability and income. Since, apiculture is a non-land based activity and does not require much input can help in generating income opportunity for the weaker sections of the society. Despite considerable advancements in the science of apiculture, challenges confronting us are still many.

It thus pleases me to see that stakeholders (scientists, extensionists, farmers, scientists from Haryana, Panjab, Delhi and Himachal Pradesh have participated and presented papers in the workshop and discussed a wide range of issues covering almost all aspects of honeybee keeping. I believe that the compilation of this workshop proceedings held on June 24, 2014 along with power-point presentation and recommendations will undoubtedly have enormous use. This timely initiative on promotion of honeybee keeping in Haryana shall provide valuable directions and pave the way for use by concerned stakeholders towards increasing production and productivity of agriculture and horticultural crops in the state and will be a step forward in raising the income of small and marginal farmers not only through the production of honey but also through the sale of many other hive products.

I congratulate Dr. R.S. Dalal, Dr. S.K. Garg, Consultant and the team of Consultants of Haryana Kisan Ayog for taking a timely step in the right direction by holding this workshop.

(R. S. Paroda)

Member Secretary
Haryana Kisan Ayog
Anaj Mandi, Sector 20, Panchkula

ACKNOWLEDGEMENT

This proceeding is an outcome of the workshop held on June 24, 2014 as part of the exercise of the 'Working Group on promotion of honeybee keeping in Haryana'. The generous help and guidance provided by Padama Bhushan Dr. R.S. Paroda, Chairman, Haryana Kisan Ayog is highly appreciated. I take this opportunity to express a deep sense of gratitude to him.

I on behalf of Haryana Kisan Ayog would like to express sincere thanks to Dr. S.P. Singh Chairman, Working Group on promotion of honeybee keeping in Haryana for his guidance from time to time in organizing this workshop and also to Prof. V.K. Mattu, and Dr. C.J. Juneja both members of this working group for their kind help and cooperation.

Our special thanks are due to Dr. Arjun Singh Saini, Director General Horticulture, Dr. B.S. Sehrawat, Principal, HTI Karnal, Dr. S.S. Siwach, Director Research, CCS HAU Hisar, Dr. R.K. Saini HOD Entomology, CCS HAU Hisar, Dr. R.K. Thakur, Project co-ordinator, AICRP on Honey bees, IARI, New Delhi, Officers of Horticulture and Agriculture Department, Dr. S.S. Bains, Consultant Punjab Kisan Ayog, Mohali and honeybee farmers for their sincere and valuable suggestions and actively participating in the deliberations of the workshop.

I on the behalf Haryana Kisan Ayog, member of the working group on promotion of Honey bee keeping in Haryana and on my own behalf extend a very hearty thanks to all the distinguished speakers for sharing with us their findings and opinions. It is because of their scholarly talk that the workshop was a grand success.

Last but not the least, my sincere thanks and appreciation to the consultants of Haryana Kisan Ayog Dr. K. N. Rai, Dr. R.B. Srivastava, Dr. S.K. Garg, and Research Fellows Dr. Gajender Singh, Dr. Monindar Singh Jakhar, Ms. Vandana, and Dr. Jitender Kumar for their sincere efforts and help in making this workshop a great success.

My special thanks to Ms. Meenakshi computer programmer of the Ayog for kind help in meticulously organising the manuscripts so that the proceedings could take a shape. We also thankfully acknowledge the efforts put in by the technical and non-technical staff of the Ayog for helping in organising this workshop successfully.

(R. S. Dalal)

On the CD

The attached CD contains power point presentations made during the workshop on promotion of honeybee keeping in Haryana on June 24, 2014.

Presidential Address by Dr. R. S. Paroda

At the onset Dr. R. S. Paroda, Chairman, Haryana Kisan Ayog explained to the participants as to why a working group on promotion of honeybee keeping in Haryana has been constituted and why this workshop including all stakeholders has been organised.

While addressing the various constraints the bee industry is facing, he informed that the bee keepers do not have option to park their bee colonies in the forest area or in the horticulture farms of the Government during summer hot periods. He suggested that there should be some honey Bee Parks or identified gardens where farmers could park their bee colonies during hot season as well as during lean crop periods. He suggested that Directorate of Horticulture could spare a few gardens in relatively cool or at higher elevation for this purpose.

He also pointed out that at present there is no practice by the farmers for processing and packaging of honey. One cannot buy honey in small pouches for daily/immediate consumption. The honey processing plant installed at Murthal has still remained underutilized since farmers do not use it for honey processing even though the cost of processing is very meagre. He stated that with the processed honey farmers can get higher price.

He also stressed the need to create awareness among the farmers/bee keepers about the importance of beekeeping not only as a source of honey production and a variety of beehive products but because it enhances the productivity of crops due to better pollination and seed setting.

The unscientific beekeeping in the State is mainly due to lack of trained manpower. There is an urgent need for capacity building in this field. Government of Haryana must allocate more resources for this aspect while formulating schemes to promote bee keeping.

He also talked about an earlier workshop on Honey bees conducted in collaboration with Department of Horticulture at Karnal where large number of farmers participated and evinced great interest in bee keeping.

While concluding he stressed on the following:

- That bee keeping is a profitable preposition and that the use of bees to ensure better pollination in agriculture/horticulture crops be promoted.
- Profession of bee keeping can provide opportunity in increasing income of small holder farms as it requires no land but only proper excess to technology.
- More Research is needed in the area of bee keeping, including that on bumble bees in protected cultivation.
- We should recognize threats to bee keeping industry and provide insurance against risks.
- Too much of pesticides in crops unsuitable for honeybees be avoided.
- Progressive farmers be further encouraged and suitably rewarded.
- Farmers be advised to go for value addition to increase their income.
- Public awareness for use of honey and capacity building for scientific production of honey be given high priority.
- We must have a roadmap for further growth of honey bee sector in Haryana.

Introduction to Beekeeping

Dr. S. P. Singh, Chairman Working Group

Honeybees and honey find special mention in the Indian epics and bee hunting for honey dates back to some 2000 to 2500 years. Presently there are four species of honeybees i.e., Giant or Rock honey bee, *Apis dorsata*; Little honey bee, *Apis florea*; Indian honey bee, *Apis cerana indica* and European honey bee, *Apis mellifera which* are available in India. In addition, Stingless bee, *Tetragonula iridipennis* is also found. Today most of the countries practise beekeeping with the European honeybee, *A. mellifera* which surpasses the Indian honeybee, *A. cerana* in almost all the departments.

Beekeeping provides excellent source of employment for the rural unemployed, enhances income of farmers, and the landless beekeepers. It enhances the productivity levels of agricultural, horticultural and fodder crops through pollination services.A number of small scale industries depend upon bees and bee products. Honey and bee products find use in several industries which are under; pharmaceuticals, bees wax industries, bee venom, royal jelly, bee nurseries, bee equipment and hives etc. Beekeeping covers over 4 00 000 villages providing part time employment to 2 50 000 persons.

At present there are about 1.6 million bee colonies in India, with estimated annual production of around 65,000 metric tons of honey including honey from wild honey bees. The total honey production in Asia is only to the tune of about 2 50 000 M. tons. India has the potential of accommodating 5 million colonies and a potential of producing 6 00 000 M tones of honey. At present China is the world's largest producer and exporter of honey.

Mahatma Gandhi realised the importance of beekeeping industry and included it in his rural development programme. Several freedom fighters were trained in his Ashram at Wardha in the art of maintaining honeybee colonies. These Freedom fighters from all over the country initiated beekeeping industry in their respective States.

During 1930's and 1940's some beekeeping stations were established in different parts of the country and some research was initiated at places like Coimbatore, Pusa, Lyallpur (now in Pakistan) and Nagrota (now in H.P.).

Until 1953, the beekeeping in Indian subcontinent was in a disorganised shape until this activity was taken over by All India Khadi & Village Industries Board and subsequently by the Khadi and Village Industries Commission (KVIC) in 1957.

A Bee Research Centre was started at Mahableshwar in 1952, which was upgraded as Apiculture Research Laboratory in 1954. KVIC with the help of Maharashtra State Khadi and Village Industries Board established Central Bee Research and Training Institute (CBRTI) in Pune on 1st November 1962.

CBRTI was supposed to be developed as a primary National Centre for Honey and

Honeybee Research & Training. All India Beekeepers Association was established in Nainital in 1937.

In July 1981 All India Coordinated Research Project on Honeybee Research and Training was initiated by ICAR with eight different cooperating centres. Presently it has 16 cooperative centres with its current headquarters located at IARI, New Delhi. There are several organisations which help in promotion of beekeeping i.e. State Universities, National Bee Board, National Horticulture Mission, State Departments of Agriculture, Horticulture, Forestry, etc.

Historically efforts were made to introduce *A. mellifera* the European honeybees in India since 1880.The success was finally achieved in 1964 at Nagrota where imported European queens were introduced to young brood of *A. cerana* which was gradually replaced by *A. mellifera* cell size foundations. *A. mellifera* was initially introduced in Punjab, Jammu & Kashmir at the individual level as well as by Punjab Agricultural University, Ludhiana. After its successful introduction *A. mellifera* bee was popular and it was taken up in Punjab on commercial basis and has now spread to most part of the country.

Being entirely an agro based industry, bee keeping is feasible only in areas with adequate bee flora at least for a period of 6 to 8 months with one major honey flow season. Now the leading states are U.P., Bihar, Bengal, Punjab and Haryana.

Three thousand plant species have been found useful as bee plants. More than 300 spices and plants have been given to forest/ agricultural department. Bee forage plants may be fruits, vegetables, oil seeds, ornamental crops, herbs, shrubs, bushes, forest and avenue trees and weeds in the field. Honeybees in India are estimated to be availing about one fourth of the floral resources available in the country. Information on different aspects of bee forage is essential for the efficient management of honeybee colonies.

Migratory beekeeping is practised by many commercial beekeepers in states like Himachal Pradesh, Bihar and south India but micro regional survey of bee forage would be required for planning short and long distance migration schedules. General benefits by bee pollination are put at about 20 times the value of honey and beeswax.

Honeybees are affected by large number of viral, bacterial and protozoan organisms, ecto and endo parasitic mites, insects and non-insect enemies. For bacterial diseases antibiotics and for mite pests control measures are available. Any known diseases in the West can be expected to appear in epidemic form in India. Quarantine studies should be initiated on bee viruses not found in India.

Tropical and subtropical climate of India presents suitable conditions for the outbreak and appearance of many pest problems in crops. Weedicides are used to control the weeds and hence lead to starvation of pollinating insects. The indiscriminate use of pesticides leads to the destruction of bee colonies in the field. Only pesticides that are not harmful to bees should be used and should be propagated with farmers. Coordination between the beekeepers and the farmers by any Government decree is lacking and therefore measures to save bees cannot be taken.

There is a vast scope for expansion of beekeeping in India because we need at least 3 colonies/ha in crops and 5/ha in forests for pollination.

Future Needs

- Artificial queen bee insemination technique is now available and mating in the open can be bypassed. By artificial queen bee insemination method the parentage can be controlled.
- Availability of genetically superior queens for increased honey production should be ensured.
- Lack of Infrastructure at the grass roots and national level for beekeeping and availability of trained field workers in beekeeping at the village level is the major constraint.
- Poor quality control for the production of honey and lack of proper pricing policy for honey and those engaged in packaging, processing and storage of honey are serious constraints.
- Scientific methods of extraction of honey from wild colonies be evolved and promoted, particularly in forest ecosystem.
- There is vast potential and scope for diversification in apiculture i.e. besides honey, it offers scope for production and marketing of other bee products like pollen, propolis, royal jelly, bees wax and bee venom, which can add to the overall income from the bee hive. In China each *A. mellifera* colony produces from 300 to 500 grams of Royal jelly per year which sells at premium.
- Disease prevention, control and analysis are the major constraint for the development of beekeeping in India. We need to have regional and also central bee disease analysis laboratories. A registration process of apiaries should be in place to certify and declare the apiaries as disease free for migration. Similarly such apiaries should only be allowed to sell queens and bees all over India.
- Sufficient financial help from government and lending institutions for the development of beekeeping should be provided.
- There is no control on the use of pesticides by farmers leading to death of bee colonies in field locations. This problem should be addressed on priority basis.
- Efforts should be conducted for developing bee vector technology for the management of insect and fungal pests of field crops.
- Pollination studies should be conducted in each of the beekeeping areas.
- There is urgent need for perfect coordination between all agencies engaged in promotion of beekeeping.
- For training future beekeepers, Farmer Field School approach may be adopted.
- Finally country needs a full-fledged Bee Research and Training Institute with network arrangements with existing stake holders.

Remarks by Dr. R.K. Thakur, Coordinator AICRP Honeybee

Asian sub continent is very rich in honeybee diversity having Indigenous honeybees which have co-existed through centuries and kept on going without inter specific transfer of diseases and parasites. The beekeeping is possible in all those areas which have sufficient floral resources. The success of beekeeping depends upon proper understanding of the biology and behaviour of honeybees, their scientific management techniques including methodologies to combat various maladies like diseases and enemies. Research on Apiculture, honey and other by-products has been continuing for many years in our country; however the potential of biotech intervention for improving quality and quantity of products has not been fully exploited. Therefore, there is a need to develop a network programme which will look at the Biotechnological interventions, which can contribute to the improvement of both Honey Bee and Honey products.

He also emphasized the need for Development of breeding and mass rearing of honeybees. If we have to meet the target of number of Honey bee colonies required for meeting pollination needs along with projecting India as the leading producer of hive products. Standardization for assessing the quality of honey, improvement in the production of other by-products such as propolis, royal jelly, bees wax, venom, bee pollen etc. are also required to be given priority. More than 50 per cent of the existing species of plants propagated by seeds are dependent upon insects for adequate pollination. In India 50 million hectare of land is under bee dependant crops. If three colonies are accommodated in a hectare, India requires more than 150-200 million colonies, but presently we have about 1 million honey bee colonies in the country. Despite the fact that India has a very rich floral diversity and ideal climate for beekeeping, the overall honey production is far less (55 thousand metric tons), which is about one fifth of the total production of China. The average honey yield is just 15-20 kg per colony per year as compared to 40 kg in China. The decrease in productivity is due to declining mountain land resources, scarcity of floral resources, decreased productivity and unfair practices, pers, out-break of various pests and diseases. The problems can be mitigated by improvising beekeeping technology, adopting scientific beekeeping practices, diversifying apiculture, broadening food base for honey bees, conserving natural resources having multifarious use. Such planting systems shall provide nectar and pollen to honey bee colonies during different times of the year and will sustain beekeeping, increase productivity, provide additional income and an alternate livelihood options. Organic farming should be integrated with the organic honey production. Organic honey can be produced by a countrywide campaign to explore the forest flora for honey production in various geographical zones. Exploring the forest areas for beekeeping will help in bio-diversity conservation in the long run. Lack of scientific knowledge of different apicultural aspects by our beekeepers is one of the major impediments in beekeeping development. Seasonal management practices are required to be followed by the beekeepers in order to have stronger colonies for maximizing the productivity. The concept of supering the colonies during honey flow periods is utmost important for extracting well ripened quality honey. Quality bee wax should be used for preparation of comb foundation sheets. The use of very old drawn combs should be discouraged to ensure the production of light coloured honey which is widely preferred by consumers. The queen rearing technique is required to be popularized to ensure quality and prolificness in the colonies as they are required to be requeened every year. Queen rearing and use of instrumental insemination need to be popularized for rejuvenating the existing stock by importing paternal genetic material of other races existing elsewhere in the world since the cross breeds are better honey producers. Sustenance of bee keeping depends upon different agri–horti and forest ecosystems. Apiculture is required to be diversified for production of honey, pollen, bee wax, propolis and royal jelly. Technology for the production of various hive products is available in the country but its implementation and commercialization is vital in order to properly harness and tap the agricultural, horticultural and forest wealth in terms of nectar which otherwise remain unutilized. While applying pesticides, safety to the honey bees becomes very important. From time to time beekeeping industry is threatened by various diseases and enemies. Worldwide beekeeping with *Apis mellifera* is now endangered by the mite, *Varroa destructor*. *Varroa* can be controlled chemically, but this has resulted in the contamination of hive products. Honey packaging is needed to be delicately handled during purification and processing so that the purest honey produced by the bees is not deteriorated. All concerned should note that "least processing is the best processing."

The quality honey is possible by following scientific management practices, implementing IPM strategies in the crop ecosystems, combating pests and diseases of honey bees by using safe methods, improvising beekeeping technologies and educating beekeepers regarding scientific technical know-how. Honey is needed to be popularized as food and not only as medicine. This approach shall expand the domestic market of the honey and will give boost to the apiculture industry, thereby paying good price to the beekeepers. Widespread promotional efforts are required to expand domestic market. India will need more than 5 lakh ton of honey for domestic consumption if average per capita consumption increases to about 500 grams per year. It is worth mentioning that in USA and Germany the honey consumption is 1.0 to 1.8 kg per capita per year respectively. It will be of great advantage to the beekeepers and honey traders if domestic market expands since higher price can be fetched in domestic market. Quality honey can be produced if beekeepers get higher price for their produce. Honey is required to be graded and then priced like other commodities. It is worth mentioning that companies get 3-5 times more price in comparison to the price given to beekeepers. Unified market concept for procurement and grading of honey is vital to ensure quality honey. Different nectar corridors, particularly the honey hubs existing in different states are supposed to be exploited for monofloral honey production and this will help in fetching better prices. Plant origin honey has better scope of market acceptance as compared to blended one. Even comb honey production can be encouraged and monofloral comb honey with intact or preserved aroma is most suitable for marketing to the elite class, five star hotels, roadside restaurants and fast food corners.

He further stressed, that Haryana should create Haryana Honey board to watch the interest of state Beekeepers. Government of Haryana should create Pollinator Garden at CCS HAU Hisar to create awareness and conserving pollinators. Even after 25 years of establishment of AICRP centre in Department of Entomology, the villagers around Hisar are still not convinced about the role of honey bees in crop pollination and increased productivity. Regular workshops be conducted/organized on the pattern of Punjab by involving scientists from AICRP (HB&P), CCS HAU, Hisar for updating the knowledge and experiences of beekeepers of the state. Haryana is strategically located and there is every scope for marketing the bee hive products or after post harvest handling the finished products to the neighbouring states. Existing parks and roadside plantations should constitute the melliferous plants or plants having multifarious uses to sustain Beekeeping industry in the state in mission mode. In the past a lot, of Eucalyptus trees were felled which gave a big set back to beekeeping industry.

Attention is required to produce monofloral honey which can be packed in attractive pouches. Purity of honey can be retained if comb honey production and its marketing are encouraged at various outlets. Such innovations can help in faster adoption of honey as a complete food. Honey should be served in youth festivals, sports meets and should be major dietary component of food. At school level and governments sponsored schemes, the children should be educated regarding the bee behaviour and use of hive products. The HAIC Agro R&D Centre is a registered society which has a centre at Murthal, where two activities are being carried out, one on mushroom and other on bee keeping. In the last eight years 4239 youths/farmers have obtained training on bee keeping from this centre. This Centre has a Honey Processing Unit having the capacity of one MT daily. This centre has signed an agreement with HAFED (Haryana Govt. federation) to market honey which is to be procured and processed by this centre with the brand name of Haryana Madhu.

Bee keeping is being adopted in Haryana with interest. Bee keepers are harvesting good quantity of Honey but they are mostly selling raw honey only as they have not come forward to get their honey processed. Other than honey, progressive Bee keepers wish to extract Royal Jelly, Bee venom and prepare other products from wax, pollen etc. If this centre is upgraded by creating other lab facilities for bee keepers, it may prove to be a boon to bee keepers.

Certificate course for Para – apiarists be organized at regular intervals. Beekeeping development, artificial insemination technology is required to be popularized in the country for the fast multiplication of the existing stock to meet the requisite targets which can be well supported due to diverse plant resources across the country offering abundant nectar and pollen sources successively. Because of fear of spread of diseases and enemies, the only possibility is to import the semen of other races of *Apis mellifera* to initiate hybridization work. In this direction sole attempt was made during 1987 when semen sticks of different races were imported and were infused in the existing stock through artificial insemination.

Strengthening the apiculture industry require quality produce of bee hive products and stronger processing and marketing strategies. One very important issue in the Indian beekeeping is non-adoption of scientific beekeeping resulting in the deterioration of hive produce. They should avoid blending and processing to an extent that honey in bottle look like a syrup without flora specific aroma and colour. Exporters should pay better prices for the ripened quality honey and honey extracted from supers.

The melliferous flora is getting depleted day by day due to mass scale deforestation leading to monoculture or conversion of forest areas into orchards or Agriculture, or urbanization and creation concrete jungles. The effluents of factories and dust from illegal or legal mining are the other major factors responsible in depletion of plantations providing nectar and pollen. All these activities are contributing immensely in declining pollinators population and ultimately declining crop productivity. It is the need of the nation to protect and propagate the melliferous resources alongside the roads. All municipalities should pass a resolution to plant few multifarious plant species while approving the construction of colonies or individual houses. The landscape wing of public work departments across the country should propagate the plantations alongside the roads. Such plantations will open possibilities of roof top beekeeping in NCR's and other metropolitan cities and can act as an important recreational and hobby venture. This will open up new vistas for landless and marginal farmers to adopt beekeeping as livelihood option.

The agricultural practices need to be designed to incorporate the protection and sustainable management and use of pollinator's populations in crop ecosystems. Evaluation of effects of alternative practices and technologies like the use of pesticides in agricultural production on pollinators conservation and their effects is the need of the hour. Conserving and promoting traditional beekeeping is important as is practiced on *Apis cerana* and stingless bees in other states like Himachal Pradesh, Jammu and Kashmir, North Eastern states, Kerala, Tamil Nadu, Chhattisgarh, Maharashtra and Andhra Pradesh respectively. These pollinators are required to be conserved, en-mass multiplied and utilized for the purpose of pollination under varied planting systems.

The economic and ecological importance of pollinators and the issue of their decline in India have not been realized. To effectively address this issue it is necessary to bring pollination concerns into the policy, research and development mainstream. There is a dearth of non-technical literature for promoting awareness among planners and policy makers. Public outreach is the key to pollinator protection, conservation, and restoration.

In spite of great potential of beekeeping in India, apiculture research in India and its gainful utilization has not yet received the required impetus and is far below the available resources. This is possible only if a full-fledged National Level research institute is established to take up work on all these issues. The proposed centre should be made responsible to improve the health and productivity of honey bee colonies focusing on honey bee husbandry, ecology, behaviour, and conservation. Though All India Coordinated Research Project on Honey bees and pollinators has contributed immensely for creating data base on Honeybees, standardizing rearing technologies of natural pollinators in AICRP Centres located in different states and expansion of beekeeping throughout the country, but only AICRP (HB&P) cannot alone suffice the need and requirement of the country with meager budgetary provisions and limited Scientific force as compared to the leading countries of the world.

At the end he concluded that there is a need for undertaking scientific beekeeping in increasing honey production and pollination of crops. He also gave an idea for promoting region specific unifloral honeys which will fetch higher price.

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RESEARCH AND DEVELOPMENT IN BEEKEEPING IN INDIA

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ABSTRACT

Beekeeping has been practiced in India since ages by rural people with wild honey bee species (*Apis dorsata* Fabricius and *Apis florea* Fabricius) for honey hunting and with *Apis cerana* Fabricius in semi-domesticated conditions in wall hives, log hives and as underground beekeeping. Honey from these species was extracted by cutting the honey combs and squeezing them. However, taking the clue from development of modern technologies in the West, during 1910 Rev. Father Newton in Southern India designed a smaller movable frame wooden hive (Newton hive) for A. *cerana* and successfully maintained it. In 1937 Shri. R.N. Mattoo founded the All India Beekeepers' Association (AIBA) in Uttar Pradesh for popularizing modern beekeeping and bringing about awareness to extract honey from *A. cerena* colonies, using centrifugal honey extractors. At that time, AIBA published Indian Bee Journal, beekeeping books, other literature, like beekeeping charts etc. After independence, Govt. of India took policy decision to revive various traditional village industries and an All India Khadi and Village Industries Board (KVIB) was formed in 1954. Through coordinated efforts of well-knit organizations like KVIC, State KVIBs, Beekeepers' Co-operatives, Public Institutions, etc. the beekeeping industry came on the map of village industries of India. In 1962, Central Bee Research and Training Institute (CBRTI) was established by KVIC at Pune for more comprehensive research work and training on beekeeping which later on, was recognized by BIS and AGMARK.

However, till 1960s, the country had not made any breakthrough in the field of apiculture due to the reason that the Asiatic hive bee (*A. cerana*) was a poor honey yielder along with absconding, robbing, swarming traits and was prone to bee diseases and wax moth. Efforts made since 1880 till 1960 by various experts across the country to introduce *A. mellifera* Linnaeus into India did not succeed. Hence, renewed efforts were made by Punjab Agricultural University (PAU), Ludhiana to introduce, acclimatize and establish high honey yielding, European honey bee (*A. mellifera*) in India. Scientists like Dr. A. S. Atwal, and Dr O. P. Sharma finally achieved the success to introduce and establish *A. mellifera* first in early sixties at Nagrota Bagwan (now in Distt. Kangra of H.P) and then in mid sixties at Ludhiana (Punjab).

During 1981, ICAR launched All India Coordinated Project on Honey Bees Research and Training. The Project started functioning with the Project Coordinating unit located at Central Bee Research & Training Institute, Pune with six centres including one in an ICAR institute. Five more centres, four in SAUs and one in an ICAR institute, were sanctioned in 1983. Project coordinating unit was shifted to Haryana Agricultural University, Hisar in 1987. There were nine university based coordinating centres during the X Five Year Plan at Solan (Himachal Pradesh), Ludhiana (Punjab), Vijayarai (Andhra Pradesh), Jorhat (Assam), Pusa-Samastipur (Bihar), Vellayani (Kerala), Hisar (Haryana), Pantnagar (Uttarakhand) and Bhubaneswar (Orissa). The objectives were redefined and the title of the project was re-

designated as All India Coordinated Research Project on Honey Bees & Pollinators in July, 2007. During the XI Five Year Plan, five more SAU based regular centres and two SAU based voluntary centres were added at Bangalore (Karnataka), Kanke-Ranchi (Jharkhand), Kumarganj-Faizabad (Uttar Pradesh), Medziphema (Nagaland), Raipur (Chhattisgarh), Jammu (Jammu & Kashmir) and Kota (Rajasthan). Currently there are 16 centres (14 regular + 2voluntary) working under this project. During XII Five year plan, three more regular and 10 more voluntary centres are added which are in the process of approval.

1. Honey Bee Diversity In India

Under super family Apoidea, out of the nine families (as per Michener classification) covering the bees with various degrees of socialization, only the tribes Apini and Meliponini belonging to family Apidae cover honey bees which store surplus honey in their combs. In Apini, at least nine species of honey bees belonging to genus *Apis* have so for been reported the world over viz. *Apis dorsata* Fab. (Rock bee/ Dammer bee), *Apis florea* Fab. (Small bee/ Little bee), *Apis cerana* Fab. (*A. indica, A. cerana indica*) (Asiatic bee/ Indian bee/ Pahadi bee), *Apis mellifera* Linn. (European bee/ Western bee), *Apis laboriosa* Sakagami *et al*. (sympatric to *A. dorsata*), *Apis andreniformis* Wongsiri *et al*. (sympatric to *A. florea*), *Apis koschevnikovi* Buttel-Reepen (sympatric to *A. cerana*), fossil honey bees (*Apis armbrusteri* Zeuner and *Apis oligocenia* (Meunier)). Among these, the first four are the traditional true honey bees and all these are present in India. *A. laboriosa* has also been reported from Sikkim. The first two species are wild ones and have strong absconding instinct and are ferocious. These make single combs in open and honey is stored in anterior and upper part of the combs, respectively. *A. cerana* and *A. mellifera* are the hive honey bees which produce multiple parallel combs and are docile can be hived in movable frame hives. Till 1975, only *A.cerana* was hived in India and beekeeping was restricted only to hilly regions of northern, eastern and southern part of the country. It is low yielder, more prone to absconding, swarming and low propolizer, more prone to wax-moth attack, and thus could not be commercialized in the country extensively. *A. cerana* which has four sub-species/ races in the world over three of these occur in our country which has clear-cut geographic zonations. *A .c. cerana* exists in northern India, *A. c. himalayas* in north-eastern India and *A. c. indica* in southern peninsula. Due to the above limitations of beekeeping with *A. cerana*, the exotic European/Western honey bee species, *A. mellifera* was introduced into India in early sixties of the last century. It is docile, less prone to swarming, with negligible absconding instinct and suitable and productive even in hot plains of the country, besides relatively less prone to wax-moth attack. Under Meliponini, several species of *Trigona* have been reported from southern and eastern part of the country (Chunneja, 2011).

2. Indian Honey Production Scenario

There are 45,000 species of plants and shrubs, which comprise seven percent of the world's flora. As all the four species of honey bees found in Indian subcontinent and the major portion of honey comes from the wildbee, *Apis dorsta*. Only 10 percent of the existing potential has been utilized so far. India has a potential to keep about 120 million bee colonies that can provide self-employment to over 12 million rural and tribal families. In terms of production, these bee colonies can produce over 1.2 million tons of honey and about 15,000 tons of beeswax. Organized collection of forest honey and beeswax using improved methods can result in an additional production of at least 120,000 tons of honey and 10,000 tons of beeswax. China is the largest producer (40%) and exporter (35%) of honey of the world followed by US, Argentina and Ukraine. Mexico supplying 20 per cent, whereas, Argentina supplying 15 to 20 per cent. Germany on the other hand is world's largest consumer, importing 90,000 tonnes of honey products annually with per capita consumption 1.5 kg/person as compared to 3gm in India. In India, **Honey production is about 70,000 tonnes / year**, and Exports 25,000-27,000 tonnes/yr to > 42 countries e.g. EU, Middle East and the US). The major honey producing states include Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. The Foreign exchange earned amounts to Rs 200 crore (2002-03). Organized collection of rockbee and other forest honey and beeswax using improved methods can result in an additional production of at least 50,000 tons of honey and 5,000 tons of beeswax. This can generate income to about half a million tribal families. India has immense potential for development of beekeeping. It has been estimated that the Indian forests could provide shelter and food to over 120 million bee colonies. Even if we consider reduction in the forest area in recent years, due to deforestation, etc., the country can still hold over 100 million bee colonies, providing self-employment to over 10 million rural and tribal families. In terms of production, these bee colonies can produce over 700,000 tons of honey and about 30,000 tons of beeswax. If the potential that exists in the country is taken into account, then bee-keeping has never taken off. We do have about 15 million colonies at present. Ninety per cent of the potential remains untapped due to insufficient livestock. The *Apis mellifera* beekeeping is concentrated mainly in states like Punjab, Jammu & Kashmir, Himachal Pradesh, Haryana, Uttar Pradesh, Bihar and West Bengal. India is basically an agricultural country and copious amount of plant resources available for commercial beekeeping and quality honey production. Though, India has 678,333 Km^2 of forest cover (20.55% of the geographical area), commercial exploitation of bee plant species for honey production is considerably very less (Sivaram and Anita, 2000). In India, beekeeping covers 40,000 villages and provides part time employment to more than 2, 50,000 persons.

3. Pollinator Decline - Indian Scenario

India is still predominantly an agrarian country in which 50 million hectare of area is under entomophilous crops, cross pollinated by different abiotic and biotic agents. Considering the fact that there are indications of pollinator decline impacts in the world, the same aspect requires a closer interest in India which has undergone over four decades of pesticide dependent agricultural intensification and is also undergoing fast change in land use due to urbanization and industrialization. The decline in pollinator population and diversity presents a serious threat to agricultural production and conservation and maintenance of biodiversity in many parts of the country. One indicator of the decline in natural insect pollinators is decreasing crop yields and quality despite necessary agronomic inputs. Examples can be found in Himachal Pradesh in northwest India, where, despite all agronomic inputs, production and quality of fruit crops, such as apples, almonds, cherries and pears, is declining. Extreme negative impact of declining pollinator populations can be seen in other areas, for example several farmers in Jammu and Kashmir are disappointed with the very low yields and quality of apples as a result of poor pollination they have chopped off their apple trees (Partap 2003).There is every possibility of such declines and impacts in other crops also. Despite its economic usefulness, biodiversity of Asian hive bee *Apis cerana* is suffering precipitous decline and is threatened with extinction in its entire native habitat. For example, in Japan, beekeeping with this native bee species has been completely replaced by European honeybee, *Apis mellifera* and only a few beekeepers and research institutes are raising *Apis cerana* colonies (Sakai, 1992). In China, out of more than 8.5 million colonies of bees kept in modern hive, 70 percent are exotic *Apis mellifera* (Zhen-Ming et.al., 1992). Similarly, in

South Korea, only 16 percent beekeeping is with native *Apis cerana* and remaining has been replaced by exotic *Apis mellifera* (Choi, 1984)

What should be done now?

1. Educate the public on the importance of pollinators and raise awareness of the pollination crisis.
2. Train the next generation of researchers and taxonomists.
3. Support national plans for the conservation of bees and increase the awareness of governments, industry and the public.
4. Undertake research on alternative pollinators.
5. Farmers survey have revealed that more than 90% of the farmers had no knowledge of pollination.
6. There is a need for national policy on pollinators. Pollination has not only been underplayed by the planners, government authorities and also the agriculturists have ignored altogether.
7. There is need for zonation for European and Indian hive bees

There is a need for conservation of pollinators by providing nesting sites and good forage, and protecting them from pesticides.

4. Management of Diseases and Enemies

Asian sub continent is very rich in honeybee diversity having Indigenous honeybees (*Apis ceana*, *Apis laboriosa*, *Apis dorsata*, *Apis florea*) have co-existed through centuries and kept on going without inter specific transfer of diseases and parasites. The beekeeping is possible in all those areas which have sufficient floral resources. Among these, *A. cerana* is the only species that can be managed in hives, but the single combs of the other two are collected by honey hunters. Efforts have been made throughout the Asian sub continent to manage *A. dorsata* and *A. florea*. The success of beekeeping depends upon understanding of the biology and behaviour of honeybees, their management techniques including knowledge of their diseases and enemies (Fig. 1, 2, 3) for handling them. The emergence of a serious and widespread disease necessitates the need to protect and sustainably manage native pollinators for the pollination service. The pollinator crisis exemplifies the intimate relationship existing between the welfare of natural environments and their biodiversity and the needs of sustainable agriculture. The agricultural practices need to be designed to incorporate the protection and sustainable management of pollinator's populations. Evaluation of positive and negative effects of alternative practices and technologies in agricultural production on pollinator conservation and effectiveness is the need of the hour.

Fig. 1. : *Varroa destructor*

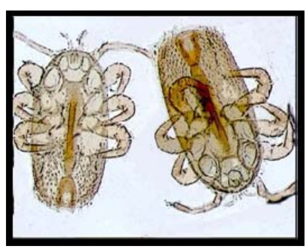


Fig. 2.: *Tropelaelaps clareae*

Fig. 3.: Crippled adults with *Rudimentary wings*

5. Conserving Traditional Beekeeping

- Traditional beekeeping with *Apis cerana* is practiced in Jammu and Kashmir, Himachal Pradesh, Nagalang and other states in wall hives, log hives and as underground beekeeping. In Nagaland the farmers have earmarked the forest area for the underground *Apis cerana* rearing with zero tolerance to other Agricultural activities.
- *Apis cerana*, the Asian hive bee, and its various sub-species, is threatened throughout Asia. The research suggests that the North Indian strain (subspecies *cerana*) is not only larger but also higher honey-yielding than other Himalayan strains.
- Many households have honeybees *A. cerana* integrated into their home, with holes built into the exterior walls leading into hives stored in wooden containers. Honey is extracted using smoke and water to repel the bees. Most honey is used within the household, though excess honey is sold. One household, for example, extracts between 10-15 kg per year from four small house hives.
- Conservation of this genetic resource is being tackled by in situ promoting and conservation of traditional beekeeping.
- Integration of the traditional method with the modern concept of movable frames would add to the ease of management operations in the field making the modernized log/wall hive (Fig. 4) an eco-friendly, readily acceptable, economically viable and environmentally sustainable technique for the future.


Fig. 4: Wall hives in Himachal Pradesh and Traditional hives in Jammu & Kashmir

6. Promoting Migratory Beekeeping for Sustainable Beekeeping Development

- Beekeeping is a technology that is simple, easily accessible and affordable, especially in rural areas. It utilizes only the naturally available resources which otherwise go waste. The bee foraging of both individual plants and of a specific vegetational unit or ecosystem are essential pre requisites in formulating strategies for honey production and bee management. If the income from honeybee pollination of crops of economic importance were taken into account, the social returns would be many times more than from honey and other hive products.
- Unlike beekeeping with *A. cerana*, commercial beekeeping with *A. mellifera* is possible only by adopting migration as a regular management practice. The productive efficiency can be achieved only when a large number of colonies are maintained in an apiary in good strength. It is difficult to get adequate bee forage for these colonies in one location throughout the year. It is necessary therefore for *mellifera* beekeepers to have detailed information on the availability of different

floral sources near their apiaries, seasons of their availability and migration schedules for optimal utilization of the available floral resources.

- Promotion of migratory bee keeping through promotion of mass planting of bee flora: The problem of depleting floral resources has reduced the bee keeping potential in India. A beekeeper cannot afford to grow bee flora exclusively for honeybees. But social forestry programme, which advocates growing of good bee forage trees, such bee plants should be identified and their plantation be undertaken in wastelands of low agricultural value.
- Preparation of extensive floral calendars for different ecological zones: The relatively brief periods during which some plants secrete pollen and nectar and the localized distribution of others are the fundamental causes for migratory beekeeping. A given locality may have a heavy, brief flow of pollen and nectar at one season and may be practically devoid during remainder of the year.
- The bee flora for subtropical, intermediate and temperate areas reveals that the state has a rich vegetation which provides opportunities by (i) protection and better conservation of existing forest stands, (ii) systematic reafforesation of barren hills by designing mixed stands of arboreal species which provide bee forage along with timber and other economic products, (iii) plantation of such species of plants which could fill floral gaps and acute dearth periods, (iv) regeneration of local pastures which provide cattle forage as also bee forage and prevention of uncontrolled grazing by cattle through a rational system of rotational grazing, (v) inter-cropping of fruit orchards with short duration autumn and spring season legumes, (vi) introduction, trial and extension of better bee plants in the local cultivated and wild flora.
- Surveillance of bee diseases, pests and predators in various eco-geographical zones in South Asia. Enforce strict quarantine, isolation, certification of disease free status measures through legislation. Create a network of laboratory facilities for the identification, testing and control of bee diseases and pests
- Capacity building and awareness training programmes should be organized in terms of management plans and training manuals, honey festivals, seminars, conference for farmers, fruit growers, extension workers, NGOs and policy makers to promote migratory beekeeping as full-time occupation among rural people and beekeepers.
- In order to induce beekeepers to migrate colonies during prolonged dearths, or for different flows or for pollination, a subsidy should be provided to cover the expenditure of migration.

7. Biodiversity and Conservation of *Non Apis* Bees

- Considering the increasing global need of insect pollination and decline in the pollinator community, non-*Apis* bees along with honey bees hold immense importance. In order to formulate the conservation policy of any species, one needs considerable amount of available information regarding its habit and habitat.
- Keeping this fact in mind, there is an urgent need to generate a baseline source of overall information regarding non-*Apis* bees providing ecosystem services as effective pollinators of various plant species. Documentation of diversity and occurrence of non-*Apis* bees across different landscapes may help understand the insect pollinator services in various ecosystems across the area.
- Management protocols are needed to increase the use of wild pollinator species as alternatives to honey bees, either through domestication of alternative pollinator

species and/or habitat management to encourage the presence of wild pollinators like Bumble bees and Stingless bees.

8. Biotech Intervention in Apiculture

Research on Apiculture, honey and other by-products has been continuing for many years in our country. however the potential of biotech intervention for improving quality and quantity of products has not been fully exploited. Therefore, there is a need to develop a network programme which will look at the Biotechnological interventions which can contribute to the improvement of both Honey Bee and Honey products. The following priorities need to be examined:

i. Genetic diversity:

Morphometric and molecular analysis and characterization to study the diversity of all honey bees including non *Apis* species.

ii. Pollination studies:

a. Bee colonies are rented in parts of H.P. for pollination services in apple orchards. The same may be replicated in other parts of the country as per the requirement.
b. Studies may be initiated to study the pollination (Fig.5) capability of different species including non-honey producing bees which are smaller in size.
c. Studies on using pheromones to attract honey bees for increased pollination of selected crops.

Fig.5: Honey bees pollinating various crops.

iii. Development of breeding techniques/mass rearing of honey bees:

a. Standardization of artificial insemination technique for different bee species for hybridization studies for which expertise is currently lacking in our country.
b. Since recombinant DNA technique is not a possibility, other techniques to be utilized for introducing a gene of interest for example introduction of a gene which codes for a protein (Cecropin which gives resistance against several pests).

c. Breeding/rearing of different species of bee in the different ecosystem as per their behaviour.
d. Breeding of selected disease and pest resistance and also pesticide resistant bees for higher yield, better pollination ability and other desired characters.
e. Breeding rearing of different species – stingless bees, other species of Apis, Mass rearing of queen bee.
f. Management practices/Harvesting and conservation for rearing of honey bees as for, *e.g.* Hive designing is not perfected, directed nectar harvesting for a particular crop.
g. Studies on disease/pest resistance including development of immunological diagnostic tools.

iv. Honey products:

a. Value addition and Quality studies, certification etc.
b. Standardization for assessing quality of honey. Improve production of other by-products such as propolis, royal jelly, bees wax, venom, bee pollen etc (Fig 6 a,b,c).



Fig.6: (a) Porpolis (b) Pollen (c) Roya Jelly

v. Molecular markers:

a. Development of molecular markers for *Apis cerana* and other Apis and non-Apis species. No work on development of molecular markers has been done for any of the Indian species. The genome size of *Apis mellifera* is about 200 mbp organized in 16 chromosomes. New set of genetic markers to study diversity in honey bees. Basic analysis for comparative genomics like hygienic behavior, foraging behavior etc.
b. Screening of population for specific traits such as disease and pest resistance, higher yield and quality, role in pollination, foraging behavior, hygienic behavior etc.
c. The technologies for production of hive products other than honey are existing in the country.

9. Mass Promotion of Pollinators

- The economic and ecological importance of pollinators and the issue of their decline around the world have not been recognized in most mainstream research and development efforts. Apparently most people, including farmers and policy makers, are generally unaware of the services pollinators provide to natural and agro ecosystems.

- To effectively address this issue it is necessary to bring pollination concerns into the policy, research and development mainstream through promoting their integration into agricultural research policies, extension and outreach activities. There is a dearth of non-technical literature for promoting awareness among planners and policy makers.
- Public outreach is key to pollinator protection, conservation, and restoration. Develop and communication outreach capacity in the form of multilingual manuals on pollinator conservation and restoration for farmers. Dissemination of information on pollination in agricultural environments through data bases, websites, and networks etc.
- Establishing a national advisory group on pollinator conservation and to create an information network on pollinator conservation and a directory of pollinator experts. Development of guidelines for policy makers and for farmers is the need of the hour.
- There is a need to assess the state of scientific and indigenous knowledge on pollinator conservation and to develop and update global and national lists of threatened pollinator species.

10. Green Accounting

- A way to help policy makers recognise the importance of pollination services, and thus guide their decisions, is to promote the inclusion of ecosystem services, such as watershed and non-timber forest values, which include pollination services, in national accounting practices. These services could then be given visible economic value for understanding national wealth; for example the gross domestic product (GDP).
- Developing 'greener' national accounting methods holds the promise of introducing environmental problems into a framework that key economic ministries, governing bodies and heads of state could understand.
- Rarely are ecosystem services included in accounting spreadsheets or economic equations and models. Policy choices that keep a natural resource base intact or encourage 'free' ecosystem services, such as native bee pollination of crops, should make a country wealthier.
- Pollination services, if they are to enter into green accounting, should be considered in the first component of the methodology for developing natural resource asset accounts. This requires measuring 'opening stocks' of natural resources at the start of a given year, and 'closing stocks' at the end of the year. If pollination cannot be entered into such 'national stock-taking' by itself, it should be factored in as 'added value' to wild lands and forest 'stock', along with other values such as carbon sequestration and soil fertility.

11. Sustainable Use Of Pollinators

- Disseminate information on pollination in agricultural environments through data bases, websites, and networks
- Establish a roster of existing pollination and pollinators experts to serve as a pool for consultations in technology transfer
- Promote applied research on pollination in agricultural ecosystems through training of post-graduates to work on gap issues
- Protect natural habitats, within agricultural landscapes, as sources of wild pollinators for crop improvement

- Evaluate positive and negative effects of alternative practices and technologies in agricultural production on pollinator conservation and effectiveness
- Evaluate impacts on pollination of practices and technologies used in agricultural production
- Improve the knowledge on the real needs of pollination of agricultural crops and forest trees
- Gather and disseminate/exchange information of best practices
- Conduct risk/impact assessments of main causes of pollination decline
- Develop guideline for policy makers and for farmers

To undertake above mentioned basic and applied studies there is an urgent need to establish a ICAR institute on beekeeping and pollination in NCR region of the country.

12. Vision for A New Bee Research Center

Inspite of great potential of beekeeping in India, apiculture research in India and its gainful utilization has not yet received the required impetus and is far below the available resources. This is possible only if a full-fledged ICAR institute is established to take up work on all these issues. The proposed centre is to improve the health and productivity of honey bee colonies focusing on honey bee husbandry, ecology, behaviour, and conservation. The proposed research institute shall maintain an active research program focused on native pollinator ecology and conservation and communicate the research programmes to clientele groups via targeted and multi-faceted extension efforts, thereby enhancing the sustainability of beekeeping and native pollinators and the agricultural/ ecological communities. Finally, undergraduate and graduate students can receive mentoring, training, and instruction in many areas related to honey bee and native pollinator research, thus ensuring a future generation of educators, researchers, conservationists and many more.

Our vision is to create research and discovery facilities to showcase the beauty and complexity of the bee society and their direct connection to food, agriculture, floral landscapes, and medicine. Honey bees, our nation's most vital pollinators of natural, urban and agricultural ecosystems, are being threatened by diseases, parasitic mites, pesticides and habitat destruction, which in turn threatens our nation's food supply.

The current bee research facility is no longer adequate to accommodate the growing and urgent need for increased bee research and beekeepers training. A new state-of-the-art Research and Teaching facility will be transformative for bee research. This facility will efficiently combine research and teaching space to improve bee health and biodiversity, train new undergraduate and graduate students, mentor new beekeepers and assist commercial and small beekeepers. The new research facility will showcase the importance of bees to agriculture and to human nutrition, health and food safety. And it will expand and enhance our internationally recognized research program and provide substantial benefits through increased funding and interdisciplinary and international collaborations.

In few SAUs in India, there is a separate Apiculture Division, aimed at offering education to under-graduate students. It is high time to establish a new College of Apiculture that would offers a four year graduate course to educate and train B.Sc. (Apiculture) graduates. A "demand and supply" GAP analysis of Agricultural Graduates performed at NAARM, Hyderabad (Table 1) showed no position of Apicultural graduates in India. As per the GOI census, there are 593 districts in 35 states of India. As such, at the rate of 2 graduates per state, there is a requirement of at least 1186 Apicultural graduates for development of Apiculture and undertake conservation priorities of pollinators.

Table 1.: Demand and position of Agricultural Graduates in India Demand Supply Gap

Discipline	Supply-2010	Demand-2010	Gap
Agriculture	15949	25000	9051
Horticulture	1465	8618	7153
Forestry	716	1832	1116
Veterinary	2683	7672	4989
Fishery	433	2614	2181
Dairy	310	3315	3005
Agril. Engineering	734	1039	305
All	**23797**	**53346**	**29549**

Source Rama Rao, *et al* 2011, NAARM, Hyderabad

Apiculture or Bee keeping is the art and science of collecting or procuring honey bee colonies of desired species, hiving them in specified and standard boxes, installing at appropriate sites, managing optimum number of colonies scientifically round the year and harnessing both direct and indirect benefits of the activities. As such, a degree or high qualification is not essential in order to work in this profession. **Para apiarists** can be developed and trained to handle the enterprise. A "Para apiarist" is a person, preferably a literate rural youth, educated on various aspects of bee keeping to assist the apiculture professionals for promotion of bee keeping and managed bee pollination in the country, barring their entitlement to acquire license to practice the activity independently as professionals (Thakur and Satapathy 2013) (Thakur and Satapathy 2014). However, one can facilitate his/her income based on experience, education, and type of employment related to promotion of bee keeping. Additional income may be earned if he/she produces and markets honey, beeswax and bee colonies. Furthermore the knowledge, awareness and practice of scientific bee keeping can be augmented through:

- Establishment of **School of Apiculture** at state level in all the 35 states and UT
- Introduction of one year course in education system to produce **Para apiarist,**
- To attain better proficiency, about ¼ th of the course should be offered in class room while ¾th of the course should be offered as practical in the field on various aspects of bee management and exploitation of honey bees for pollination support through managed bee pollination.
- Establishment of bee nurseries by the para – apiarists

The mission shall be to conduct research and develop education on a broad array of topics concerning honeybees, the most important insect in natural resource entomology, and to promote general interest in honeybees and their useful products. To complete this mission, activities such as a) research in bee biology, behavior, genetic and molecular aspects, and other fields related to bees, including non-*Apis* species, b) research on various bee products like honey, royal jelly, and propolis, c) research on various pollinators in the scene of natural and practical pollination, d) holding meetings and workshops for research and education, e) international exchange and f) publishing the periodical magazine. The institute is proposed with following divisions to undertake studies (Table 2).

Table 2: Justifications of different divisions

S. No	Division	Justification
1.	Division of pathology	to undertake research on diseases and enemies of bees and other pollinators
2.	Division of systematics	to identify plants and pollinators
3.	Division of palyonology	to undertake studies on pollen resources, and identify plant resources
4.	Division of bioprospecting	to study bioprospecting of different hive products
5.	Division of genetics and breeding	molecular and genetic studies and breeding of selected strains
6.	Division of honeybee management	to work out management practices for management of honeybee colonies, to develop technology for managing honey bees
7.	Division of Engineering	to fabricate new equipments and standradise/modify existing ones as per needs of bees
8.	Division of pollination studies	to undertake pollination studies using honeybees and all other pollinators developing and implementing integrative, multidisciplinary approaches for improving pollinator health, conservation, and management for ecosystems services through research, education, outreach and policy
9.	Division of toxicology and pesticide residues	To undertake studies on pesticides in relation to honeybees and analysis of residues. focusing on synergistic and sublethal effects of multiple pesticides on the chemical senses and chemically mediated behaviors of honeybees
10	Division of marketing and extension	To help marketing and extension

13. Apicultural Research

Basic research and applied Research constitute two principal components of apicultural research. Basic research will pave a pathway to formulate the possible means to plan for the applied research and the extension machineries will be educated on outcome of the applied research for efficient transfer of the technology for utilization by the ultimate users.

i. Basic Research

At present the scenario of basic Apicultural research is abysmally low in our country. Though honey bee is the most studied insect, further basic research in Indian context need prioritization. Decline in pollinators population, CCD etc. have created havoc in the European countries and the same cannot be ruled out in India in the near future. Unfortunately the exact reason for such situations has not been unveiled.

In order to address many such issues relating to apiculture, attention of the rulers and mentors of the country needs to be focused on -

1. Establishment of a well equipped, sophisticated **National Research Centre on Apiculture** (NRCA) with its head quarters in a suitable location.
2. There should be 2-3 Regional centers of the NRCA in other agro climatic conditions to deal with different species of pollinators and different species of honey bees in particular.

The NRCA needs to concentrate on the following areas of research

a) Molecular studies relating to apiculture
b) Characterization of species, subspecies and ecotypes
c) Studies on Bee genetics of Indian species
d) Studies on bee breeding and multiplication
e) Behavioral attributes
f) Bee Pathology

ii. Applied Research

Lot of work had been done on applied aspects on apiculture in the country under All India Co-ordinated Research Projects 9AICRP). The projects are working on various aspects of apiculture viz.

1. Bee Pollination
2. Bee Species (*Florea*, Stingless bees etc.)
3. Selective Breeding
4. Bee Management
5. Disease AND Natural enemies of honey bees and their management
6. Palynology
7. Capacity building
8. Bioprospecting

14. Apicultural Extension

Transfer of technology and motivation for its adoption is far more important than technology generation. The technology developed by the AICRPs on Honey bees and Pollinators should reach the ultimate users i.e. Farmers/Bee Keeper for hygienic honey harvest and augmented pollination. The best machinery with wide spread net work in this context developed by the ICAR is the KVK (Krishi Vigyan Kendra) system. At present there are about 637 KVKs operating in 593 districts in the country. The marvelous results obtained in the dissemination of technologies by the KVKs in the field of agricultural and allied sectors (Animal sciences, Fisheries, Agricultural engineering etc.), it is imperative for the ICAR to sanction a higher proportion of KVKs per district as against the initial proposal of one KVK per district.

In a KVK system, the Subject Matter Specialists (SMS) take up the responsibility of technology transfer on a particular subject depending upon its regional importance. In this context the KVK in potential districts of the country for bee keeping should have SMS (Apiculture) in case the as apiculture graduates produced through the proposed Graduate course on Apiculture. The SMS (Apiculture) will be the district level nodal technocrat officer responsible for planning and execution of the apicultural activity in the district. He/she should establish strong liaison with the nearest center of AICRP on Honey bees and Pollinators, the Regional Center of the NRCA as well as with the NRCA headquarters.

Pending availability of potential Apiculture graduates, the Plant Protection SMSs available with nearly 320 out of 637 KVKs in the country should be made the trainers' trainees on Apiculture for their respective district. Since apiculture is a very specialized science with skillful activities, the SMS (PP) should undergo training under AICRPs (nearest center) or Central Bee Research and Training Institute (CBRTI), Pune or from the apiculture division of SAUs. The following principles should be adhered to for effective HRD in field of Apiculture.

1. The SMS (PP) of the KVKs should undergo training on apiculture in a structured manner to acquire complete practical knowledge on apiculture.

2. A complete training programme should be comprised of 4-5 phases, each of a 3-7 day duration based on the facet of apiculture dealt with in a particular phase/period. Further, the training should be offered by the same Institute.
3. Refresher training cum exposure visit to other Institutes will enable to develop confidence and competency level of the SMS (PP) of the KVKs.

The trained SMS (PP) through KVK activities will popularize the Apiculture in the district in the following ways:

1. SMS (PP) being trained as trainer's trainee should impart training to the interested farmers.
2. Popularize bee keeping in KVK adopted village through Front Line Demonstration.
3. Popularize the benefits of bee pollination in enhancing crop yield through Open Pollination Trials.
4. Establish Apiculture unit /Small apiary in KVK
5. Develop individual entrepreneur from rural youths.
6. Popularize apiculture among the Women Self Help Groups (SHGs)

A comprehensive course outline (encompassing the generic aspects of apiculture, irrespective of category of students/researcher/trainees) needs to be developed. However, based on the level of the student/trainees the volume of the course content pertinent should be discharged. Further, the course content must be modified suitably depending upon bee species used, seasons, geographical region in question etc.

Salient Achievements of Apicultural Research Done Under The Aegies of All India Coordinated Research Project on Pollinators:

Sr. No.	Field/ Sub field	Technologies Developed
1.	**Pollination Requirements**	• Bee colony requirement for different important crops of different state like mustard, sunflower, berseem, litchi, radish, guava, apple, almond, cherry, kiwi, apricot, strawberry, citrus, cauliflower, radish, cucurbits etc. have been standardized.
2.	**Floral Maps**	• Beekeeping map of the different states and floral calendars of different districts have been prepared. • Important bee flora of different states were also evaluated.
3.	**Pollinators Database**	• Database of pollinators on different crops has been prepared. Pollination studies have been carried out in different cross pollinated crops and pollination requirements have been worked out in Apple, Litchi, Rose apple, Guava, Sweet Orange, Assam Lemon, Strawberries, Ber, Pear, Plum, Peach, Onion, Cucumber, Fennel, Coriander, Carrot, Cauliflower, Bitter gourd, Ridge gourd, Snap Melon, Radish, Winged bean, Rapeseed and mustard, Sunflower, Niger, Egyptian clover, etc.
4.	**Honey Bee Management**	• Performance of *Apis mellifera*, a new introduction in Kerala, Andhra Pradesh, Orissa and Assam was evaluated and management practices have been standardized. • Techniques refined for Mass Queen Bee Rearing to produce quality queens. • The average honey yield potential of *A. cerana* could be enhanced from 2-3 kg to 15-20 kg / year / hive by adoption of scientific management technologies in Kerala. • One and two years old raised combs were most acceptable over three and four years old combs to queen bees for egg laying due to ideal cell measurements.

		• Improved colony division technique for small beekeepers, in which division of 1/3rd of their best performing colonies is to be done to cater to the need of sealed gyne cells for the rest of the 2/3rd of the colonies and prevent any negative bearing of colony division on honey production.
5.	**Queen Rearing Techniques**	• For mass queen bee rearing of *Apis mellifera* (Fig.7), 20 bee frame strength cell builder colonies resulted in better acceptance of grafts and gyne emergence than in 10 bee frame strength using a total of 40 graft both under queenless and queenright conditions. • Requeening in queen right colonies was recommended to do away with drudgery and make the process cost and labour effective • Protocol for selection of better performing *A. mellifera* stock was developed and used. • Highest gyne emergence was recorded in case of Cupkit apparatus • Less than 24 h old larvae from Cupkit apparatus cells transferred to queenless cell builder colonies resulted in raising of maximum number of queen bees which also minimize losses occurred while grafting a young larva in Doolittle method of larval grafting. • To facilitate queen bee replacement in queenless colony arising under unnatural death of the queen, queen bee bank/ reservoir technique was standardized in which a maximum survival (60 %) up to 18th week was achieved by using wooden queen cages with wire mesh screen, followed by 50 % in plastic hair curler cages and 20 % in wooden cages with queen excluder.
6.	**Diseases**	• Enzyme-Linked Immuno Sorbent Assay (ELISA) kit prepared to detect the Thai Sac Brood Virus of *A. cerana*, European Foul Brood and sacrood of *A. mellifera*. • Management of European foulbrood using 'shook swarm' and colony management technologies developed. • Studies on the biology and population dynamics of the mite, *Varroa destructor* indicated that there was an increase in population of the mite along with an increase in worker brood. Stronger colonies have an ability to resist the infestation by the mite. • For control of *Tropilaelaps clareae,* four dustings of precipitated sulphur@ 200 mg/ frame at an interval of 7 days were recommended. For control of *Acarapis woodi* mite, formic acid (85 %) @ 5ml/day/ colony for 21 days was recommended. For the control of Varroa, fumigation with formic acid (85%) @ 50 ml/colony along with other management practices on campaign basis at 10 days interval has been recommended in package of practices of the University. • Bt. formulation *var. kurstaki* @ 0.5 gm per litre of water per hive has been recommended for the control of *Galleria mellonella*, a serious enemy in weak colonies and stored combs of honey bee. Protection of stored combs was achieved best by fumigating the stored combs with sulphur @ 250 g/m^3. • Technique for minimizing wasp population in apiary has been developed using ripe jack fruit skin with jiggery and few grains of granular insecticides in an earthen pot. • In both the hive bees, European foul brood disease was controlled by feeding oxytetracyclin (5%) or ciprofloxacin (5%) in sugar syrup (50%) @ one dose of 200mg/ 500ml syrup/ *A. mellifera* colony and 4 doses each of 200 mg/ 300ml syrup at 3 days interval / *A. cerana* colony. The treatment controls the disease in 10 days and 20 days in former and latter species, respectively.

7.	**Stingless bees**	• Stingless bee, *Trigona irridipennis* has been domesticated and recommended for Meliponiculture in homesteads of Kerala, Orissa, Nagaland and Uttar Pradesh. bamboo hive with 1500 c.c. capacity is recommended for its rearing. • Four stingless bee species, *T. canifrons, T. irridipennis, T. atripes* and *T. laeviceps* from North East India have been identified. • In Kullu area of H P, in apple orchards having low proportion of pollinizer (10-15%), 49.89 % fruit set was obtained by using self designed (with front strip of 2 cm height) pollen insert hive entrance as compared to 18.53 % fruit set in orchards where bee colonies were kept without pollen insert (2.5 % higher). In the insert, 4 g pollen/ day (@ 2g / 2h) collected from suitable pollinizer variety was used. The pollen remained viable for 7 months at 4^oC.
8.	**Granulation**	• Honey heated in water bath at 60^0C for 30 min and stored at 5^0C has been recommended as the technique for delaying honey granulation. Granulation is a major problem with honey to check/ slow down the rate of granulation. Indirect heating of toria honey to 70^0C for 30 mins. or at 77^0C for 20 mins. produced good results in checking granulation. Increasing moisture content from 17.8 to 25.0 per cent combined with heating to 70^0C for 5 mins also completely checked granulation. Heating at 70^0C and at 50^0C for 5 mins. sunflower and litchi honeys, respectively checked granulations.
9.	**Non Apis Bees Bumble Bees**	• Laboratory rearing of non-apis pollinator, *Bombus heamorrhoidalis* for one complete cycle like natural ones was done for the first time in the country. Different pests and diseases of bumble bees like nematodes, *Sphareularia* sp, conopid fly wax moth and nosema spores *etc.* were also studied.
10.	**Feeding/ Pollen substitute/ Supplements**	• Sugar syrup can be provided to the bees by placing the syrup filled polythene bag of 0.05 mm thickness, with four holes pricked in it, on the top bars of combs in the honey bee colony and covering it properly using crown board and outer cover. Four feedings of sugar (1/2 kg/ feeding) at 10 day interval increased colony strength, brood rearing and storage of surplus honey by 101, 359 and 360 per cent, respectively. • Bee hives of *Eucalyptus* wood were heaviest (27.175 kg), followed by Hollacq and Mango (24.700 and 24.250 kg), whereas, Poplar and Kail wood hives (18.875 & 18.475 kg) were lighter. Various wood types did not have any adverse effect on mortality and foraging activity of honey bees. • Studies on relative preference of pollen by *Apis mellifera* revealed that *Brassica* pollen was consumed maximum, followed by mixture of *Brassica* + *Helianthus annuus* (1:1 ratio w/w) and *Helianthus annuus* alone. Chemical analysis revealed that *Brassica* pollen had maximum content of crude protein (26.17 %). • The effect of various vitamins on development of honey bee colonies was studied. • Pollen substitute / supplement for *A. mellifera* and *A. cerana* for dearth period management and colony development have been evaluated.
11.	**Extension Activity**	• Dissemination of technologies on bee keeping through technical bulletins / brochures, package of practices, enrichment circulars, TV and radio talks. • Advisory on good beekeeping practices prepared and circulated to all stakeholders. • Training courses conducted for bee keepers including farm women, rural unemployed youth, beginners, State Governments officials, extension specialists, scientists and other officials of organizations involved in beekeeping programmes.

Fig.7: For mass queen bee rearing of *Apis mellifera*

15. Technology Developed

- Seasonal management of *A. mellifera* colonies including management of bee enemies and diseases.
- Criteria for selection of better performing *A. mellifera* stock for bee breeding.
- Modified Doolittle technique for mass queen bee rearing, establishment mating nuclei and realizing selective mating of queen bees.
- Mass queen bee rearing using queen-right cell builder colonies.
- Enhancing drone brood rearing for mass rearing of queen bees.
- Maintaining queen bee reservoir/ queen bee bank for prolonged maintenance of mated queen bees.
- Requeening under queen- right conditions.
- Pollen substitutes/ supplements for enhanced worker brood rearing and augmentation of drone brood.
- Package bee technology for economical and distant transportation of more number of *A. mellifera* colonies.
- Royal jelly production technology.
- PAU royal jelly extractor (Fig.8).

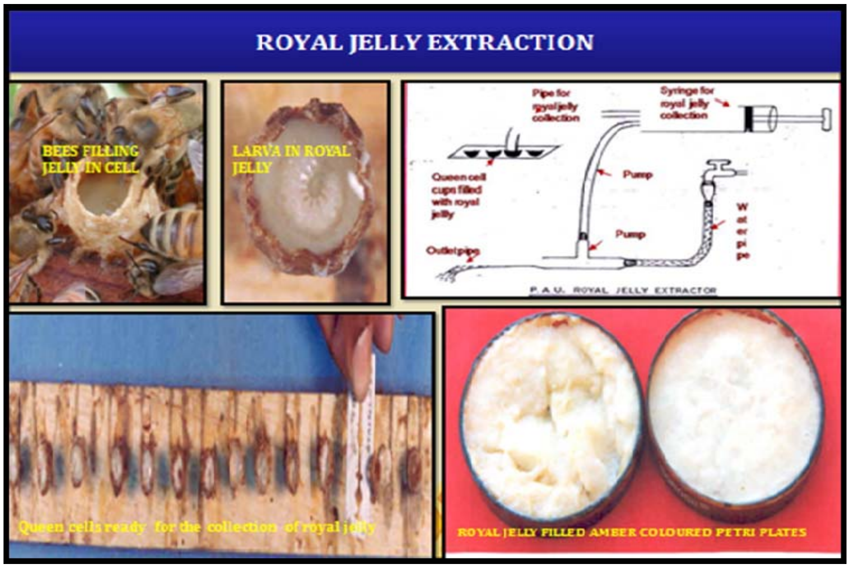


Fig. 8: Royal Jelly Extraction.

- PAU stainless steel 8- frame radial honey extractor.
- Pollen trap (Fig.9).

Fig.9: Pollen Trap

- PAU battery operated smoker.
- Pollen insert with dimensions of 375 cm x 49 cm x 2 cm (l x b x h) was designed to pollinate the apple orchard having low proportion of pollinizer (Fig.10).

Fig.10: Pollen dispenser

- Specific antiserum (1: 200 titre) and ELISA kit (1: 1000 titre) were prepared for the detection of Thai sacbrood disease of *A. cerana* and sacbrood disease of *A. mellifera*.

- For the detection of European foul brood diseases of *A. cerana* and *A. mellifera* through serological reactions, specific antiserum (1: 400 titre) and ELISA product were prepared.
- For the collection of propolis from *A. mellifera*, 5 mesh double plastic trap was designed.
- For the safe and maximum collection of bee venom, duration (5 min) and strength (18-22 V) of electric stimulation of Helix make Bee venom Extractor was standardized.
- Pollen substitute for *A. mellifera* consisting of defatted soyabean flour and wheat flour in equal proportion (1:1) and mixed with deactivated Brewer's yeast (3:1) was standardized.
- Bumble bee (*Bombus heamorrhoidalis*) rearing technology (Fig. 11, 12, 13). was standardized (Thakur 2008)
- Hiving technology for stingless bees *Trigona laeviceps* is being standardized.

Fig.11:(a) Nest Entrance (b) Digging Of Nest (c) Single Entrance of Nest

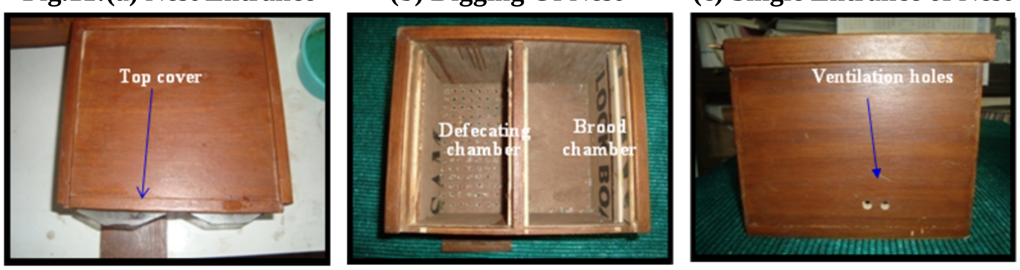


Fig. 12: Different types of domiciles and refinements incorporated, used for the rearing of bumble bees in captivity

Fig. 13: (a) Rice shaped eggs (b) Brood Development (c) Fully Developed Colony

16. Beekeeping Scenario in Haryana

The Haryana state presents two distinct zones for beekeeping. One is north zone and another is south west zone. District like Sirsa, Hisar, Bhiwani, Rewari, Mahendergarh, Faridabad, Gurgaon, Rohtak, Jhajjar, Jind and Sonipat constitute the south west zone. Here high temperature (48^0 C) and low humidity (15 % or less) prevails during summer dearth. North zone is comprised of districts like Panchkula, Ambala, Yamunanagar, Kurukshetra, Karnal, Kaithal and Panipat, where relatively lower temperature (upto 44 C) and higher humidity (above 30%) are witnessed during dearth. Due to the difference in types of soil, irrigation facilities, ambient temperature and R.H. conditions, cropping pattern is different and so are the practices.

The agro-climatic conditions prevailing in the state are quite favourable for beekeeping with *Apis mellifera*. The winter season is not severe to hamper their brood rearing and food collection activities which continue at the normal pace. Thus, there is no problem of over wintering to *A. mellifera*. Although the summer season is quite severe but these bees have the potential to regulate their temperature and work under these conditions, provided some suitable arrangement of shade and water be made available in the apiary. The food availability is scanty and a dearth period is experienced during monsoon but it can be overcome through artificial feeding of sugar syrup and pollen substitute. In Haryana state, about 250 plant species have been identified as bee forage from which bees collect nectar and pollen for their growth and development. Of the total bee flora, 29 spp. are source of nectar, 21spp. pollen and 200 spp. are the source of both pollen and nectar. According to the relative utility of the bee flora, the plant species have been grouped into four categories. Nine plant species included in the major category are very rich source of nectar, pollen or both. Their acreage is quite high in the state. Of these, major sources are mustard, Eucalyptus, berseem, sunflower, bajra, cotton, pigeon pea, Acacia and neem. Multiple honey extraction is possible in the state where these sources are available in succession. Twenty plant species, comprising the medium utility bee flora are rich source of nectar, pollen or both and have abundant occurrence in the state. These sources are mainly utilized for maintaining the colony strength throughout the year. The minor and poor utility category bee flora contains 45 and 95 plant species, respectively. These plant species are either poor/very poor source of nectar and pollen or their intensity is very rare. These sources are comparatively of lesser importance to honey bees and prove useful only as subsistence food sources.

In Haryana state, commercial beekeepers are keeping *A. mellifera* bees whose queen is highly prolific and lay about 1500-2000 eggs per day during honey flow season. Therefore, the colonies always remain in good strength. To maintain their strength during dearth period, these colonies are regularly migrated in those areas where plenty of bee floras are available during that season. In Haryana there are two main zones i.e. north and south west zone. In north zone *Eucalyptus*, toria, pigeon pea, sunflower etc. are grown in plenty whereas in south west zone the crops like mustard, *Acacia*, ber, bajra and cotton are grown in large areas (Table 3). Most of the beekeepers migrate their colonies from 15th Sept. to 15th Nov. in north zone and from 15th Nov. to 15th Feb. in south west zone to exploit the different bee flora available there. Again from 15th April to 15th June bee colonies are migrated in north zone to take the advantage of berseem and sunflower bloom. During July and August colonies are fed sugar syrup and pollen substitute to overcome the dearth period in the state.

At present Haryana is one of the leading states in India in honey production as shown in table 1. In the year 2004-05 there were only 28000 colonies from which about 275 MT of honey was extracted. Today Haryana state is having about 150000 bee colonies (Table 4) from which about 900 MT honey is produced annually. It was estimated that keeping in view of the availability of bee flora continuously for eight months from October to June, Haryana could sustain about 4 lakh *A. mellifera* colonies from which about 15000 MT honey could be harvested annually. Besides this, there is vast scope of employment generation of about 4000 unemployed youth in the State. In addition to this, additional job of 100 men days can be created for about10000 persons in a year. The rural artisans such as carpenter, black smith and other beekeeping equipment manufacturers will also get additional source of income. This shows that there is tremendous scope of beekeeping in the state with *A. mellifera* bees

Table 3: List of Crops Benefited by Bee Pollination in Haryana

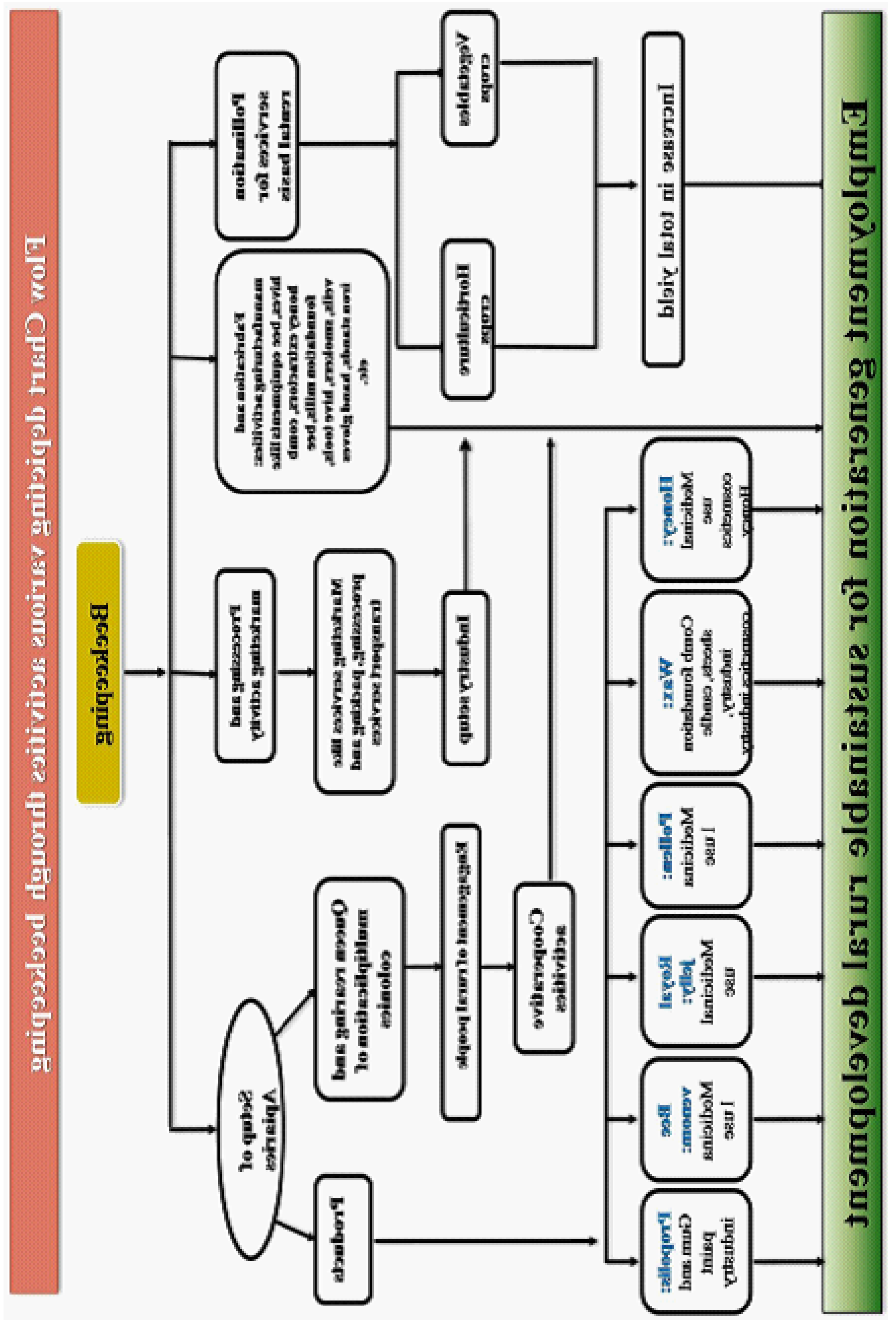
Fruits	:	Citrus, ber, phalsa, papaya, datepalm, litchi, pear, plum, peach, jamun, bel, aonla, mango, *etc.*
Vegetable seed crops	:	Carrot, onion, radish, turnip, colecrops and cucurbits.
Seed spices	:	Fennel, coriander and fenugreek
Oilseeds	:	Rapeseed, mustard, sesamum, sunflower and castor.
Fodder seed crops	:	Berseem and afalfa
Fiber crops	:	Cotton and sunhemp.
Pulse crops	:	Pigeonpea, chickpea, moong, pea, soybean *etc*.

Table 4: Growth of Beekeeping with *A. mellifera* Bees in Haryana

S.N.	year	No. Of colonies	Honey production (MT)
1	2004-05	28,000	275
2	2005-06	30,000	300
3	2006-07	42,000	465
4	2007-08	65,000	650
5	2008-09	80,000	800
6	2009-10	1,50,000	900

17. Scope of Diversification of Beekeeping for Entrepreneurship Development

There is vast potential and scope from diversification in apiculture i.e. besides honey; it offers scope for production and marketing of other bee products like pollen, propolis, royal jelly, and bee wax and bee venom. Besides, sale of package bee, the rearing and sale of pedigree queens offers a tremendous scope as entrepreneuring activity. Honey bees can also be managed as and when required for pollination of field and horticultural crops and for hybrid seed production in vegetables and other bee pollinated crops. Thus, renting out bee colonies for pollination can also be another source of income to the beekeepers. Increasing colony productivity by adopting apicultural diversification will help making our beekeeping internationally competitive and pave way for the country to enter into the global market of other bee products too, thus, enhancing the income to the beekeepers. Apart from direct employment to the beekeepers, there would be need for good artisans, hive manufactures, apicultural equipment and machinery manufactures, transport system for irrigation of colonies, traders, product quality experts, packers, sellers, raw material dealers etc. and allied industries. This industry has, so far, remained unexplored and offers tremendous scope. Technologies for the production of different products i.e. royal jelly, bees wax, pollen, propolis, bee venom, queen bees, package bees etc. are now available in India (Thakur, 2008, Thakur and Yadav 2013).


Flow Chart depicting various activities through beekeeping
Beekeeping
Setup of Apiaries
Processing and marketing activity
Fabrication and manufacturing activities
Pollination services for rental basis
Products
Queen rearing and multiplication of colonies
Marketing services like processing, packing and transport services
Industry setup
Horticulture crops
Vegetable crops
Employment of rural people
Cooperative activities
Increase in total yield
Propolis: Gum and paint industry
Bee venom: Medicinal use
Royal jelly: Medicinal use
Pollen: Medicinal use
Wax: Comb foundation sheets, candle industry, cosmetics industry
Honey: Medicinal use, cosmetics
Employment generation for sustainable rural development

18. Constraints in Development of Beekeeping Industry

- The honey resources and beekeeping areas have not been fully exploited.
- Non – availability of essential materials and bee colonies at the proper time.
- Lack of bee training facilities and bee nurseries.
- Lack of disease investigation facilities.
- No organized system of marketing bee products.
- Problem of migration to hilly areas due to disturbances in the state.
- Indiscriminate use of pesticides.
- Rising cost of beehives and lack of diversification of bee products.
- Using the Correct Species for Beekeeping
- Availability of Genetically Superior Queens for Increased Honey Production
- Lack of Technical Knowledge for Efficient Management of Colonies for High Honey Yields
- Lack of Infrastructure at the Grass Roots and National Level for Beekeeping
- Poor Quality Control for the Production of Honey
- Emphasis on Production of Honey instead of other Bee Products, e.g. (a) Bees Wax (b) Pollen (c) Propolis (d) Bee venom(e) Royal Jelly
- Disease Prevention, Control and Analysis
- Lack of Sufficient Financial Help from Government and Lending Institutions for the Development of Beekeeping
- No Tax or other Monetary Benefits for Beekeeping
- No Control on the Use of Pesticides by Farmers Leading to Death of Bee Colonies in Field Locations
- Pricing Structures for Honey Promotion of mass planting of bee flora
- Lack of proper management of bee colonies
- Promotion of migratory beekeeping

19. Development of Beekeeping Industry

It is estimated by the statisticians that the population of India will stabilize at about 1.4 billion by 2030. The planners will have to face two formidable challenges in the coming decade, viz., (1) generating employment for about 250 million youth and (2) providing enough and nutritious food to all. Agriculture is the biggest private enterprise in our country. As 70 per cent of our population lives in rural areas and depends on agriculture and agro-based industries, agriculture sector alone can address this uphill task. Beekeeping industry in its own humble way can contribute in this endeavour by providing part-time employment to about a million of the rural and tribal population. In addition it can produce thousands of tons of honey from the nectar of the flowers which otherwise dry-up in nature and go waste, and more importantly boost crop productivity substantially through bee pollination. Beekeeping has to be integrated with agriculture for mutual benefits and development. Apiculture and agriculture are interdependent and cannot develop in isolation. All the institutions working for promoting beekeeping such as AICRP HB&P, KVIC, NHM etc should work in collaboration for mutual benefits and rapid development of the industry.

20. Overcoming Constraints /Solutions

Beekeeping is a non-traditional activity. It needs awareness, change in attitude and administrative will. In the present context it also needs positive and technological attitude of all beneficiary sections, *viz*. beekeepers, traders and exporters *etc*. Extension agencies, Govt.

Departments and Scientists also need to think in totality and come out of their water tight compartments. With this in view following actions are suggested for immediate consideration:-

- One major problem while planning strategies for beekeeping development in India is a lack of accurate scientific database. Different national organizations involved in beekeeping R&D programs give different and contradictory figures about potential and present status and future prospects of the beekeeping industry in India. Unfortunately so far beekeeping has not been included in national census held either in 1991 and or in 2001. It is recommended that this important activity should find a place in next national census.
- Beekeeping should be recognized as an important agricultural activity for increasing the productivity of Agricultural / Horticultural crops and a section of Beekeeping should be developed within the line Departments of the states.
- A comprehensive roadmap for beekeeping development (as an Agricultural activity) and commercial production of honey should be prepared based on the biodiversity (honey and floral) and other resources with an emphasis on pollination of crops and organic honey production.
- Concerted efforts should be made to enhance the domestic consumption of honey through developing honey based food / consumer products and intensive generic promotion of honey through media. There need to be an effective promotional and awareness campaign to remove the myths about honey and bees.
- Different Honey Standard is laid under different organizations in India, namely, Agmark, BIS, PFA and Export (Q.C & Inspection) Act 1963. The multiplicity of liberal standards in the country is creating problems for the beekeeping industry. This facilitates the inflow of poor quality honey in the domestic market locally as well as through imports. Therefore, only one domestic standards of honey at par with international (Codex & EU) standards should be formulated. This will improve the quality of honey in the domestic market and help stop import of poor quality honey in to the country. The BIS standard / with MRL included could be adopted by all the enforcing agencies.
- The quality control facility of honey in the country is extremely insufficient. Therefore, one 'National (Central) Honey Laboratory' (with referral lab facilities) and five regional laboratories should be established. A proposal had already been approved by National Horticulture Mission in 2006.
- The main constraint in the development of beekeeping industry in agricultural belts is the absence of forage to the bees for a long period. Forage is available only during the flowering of Kharif (summer or monsoon) and Rabi (winter) crops. But absence of forage during the other periods coupled with inhospitable heat of summer poses problems in maintaining bee colonies on agricultural plains throughout the year.
- Beekeeping and pesticides are both essential inputs for modern agriculture management technology. Ignoring either would seriously impair food production. But at the same time pollination of crops is seriously affected by the indiscrimination use of insecticides and other chemicals. This has reduced or even destroyed the populations of useful insects and indirectly has affected the farm production and the crop yields are therefore poor. Application of pesticides may be inevitable, but this can be done judiciously by avoiding the sprays during the flowering period of the crops.

- While recommending various IPM schedules for various crop pests, it should be made mandatory to highlight their effects on honey bees and pollinators. Only practices safe to bees and pollinators should be considered for inclusion in packages of practices. No pesticide recommendations should be made during honey flow season
- In the face of increasing human population and urbanization, the area under forests is not likely to increase. It will have to be seen that the flora useful to bees does not diminish in the coming decade. In fact it should increase in view of our plan to increase the number of honey bee colonies. Multipurpose tree species that provide food to bees during their flowering besides having other economic utility should be considered for afforestation. Great emphasis is now given on agro-forestry, farm forestry, roadside forestry, canal side forestry, social forestry, etc. All these projects can have mixed plant species useful for fuel, food, fodder, shelter, medicine, etc., and also useful to honey bees during their flowering. Drumstick, *Emblica officinalis* (amla), Indian beech (karanj), soapnut, shikakair soap pod, chebulic myrobalan (harad), copper pod (Peltophorum), neem, and jamun, for example, are a few multipurpose tree species which flower in different months and provide nectar and pollen to honey bees continuously (Suryanarayana *et al.,* 1983).
- Different forest areas and hills in India show different climatic and floristic conditions. Fortunately, it so happens that when there is acute floral dearth in forest areas in monsoon or winter, there are Kharif or Rabi crops on adjacent agricultural plains. And when there is dearth of flora on agricultural plains there is abundant bee flora in hills and forests. Thus bee forage seasons in forests and agricultural plains alternate. Advantage of this fact can be taken by inter-migration of bee colonies between farms and forests and to utilize bee colonies for honey production, colony multiplication and pollination of crops.
- Organic farming should be integrated with the organic honey production. Organic honey can be produced by a countrywide campaign to explore the forest flora for honey production in various geographical zones. Product from such local niches may be labelled as produce of a particular niche. Such an approach will definitely give quality honey and better price for the beekeepers.
- The beekeeping research facilities are very meager. AICRP centers should be established in all the potential States, every Agricultural University and major Agriculture Institutions.
- Beekeeping should be diversified by using the bees for pollination; by developing package bees and queen trade and by adding production of Pollen, Propolis, Royal jelly and Bee venom in the apiary.
- India is richest country in the world in bee genetic resources with four to seven species of honeybees. Although, native *A. cerana* has many valuable characteristics of biological and economic importance, yet much encouragement has been given for large-scale importations and propagation of exotic *A. mellifera* in recent years. Due to this, further research for improving beekeeping with *A. cerana* is being neglected, which may have serious consequences in long run. Moreover, native bee species are suffering a precipitous decline and is threatened with extinction throughout its entire range. Therefore, there is a need to tackle following issues:
    - Exploration and evaluation of different races/strains of *A. cerana*
    - Development of productive bee strains through selective breeding
    - Conservation of native bee genetic resources
    - Zonation of beekeeping areas for *A. cerana* and *A. mellifera*

- Farmers and beekeepers are to be educated about the mutual benefits they derive. Beekeeping is of great value to beekeepers for the honey, wax and other products they get from the bee colonies and to the farmers for the pollination service the honey bees offer. The insecticide application schedules should be so adjusted that they are least harmful to honey bees. The crop rotation or cropping patterns can also be modified so as to provide forage to bees for a long period.

21. There is A Need at Government Level

Marketing:

1. Marketing of other bee products like beeswax, propolis, bee collected pollen etc to be encouraged.
2. Quality control of bee products should be assured.
3. Export market for bee products be explored
4. To fix support price of bee products.
5. Marketing organization and marketing channels may be established to avoid excessive stocking of honey in any region.
   - To provide financial assistance for migration of colonies to hilly areas and proper permits to bee keepers due to disturbances in the state.
   - To provide subsidy to the bee keepers for purchase of bee equipments/colonies.
   - Quarantine organizations may be developed/ strengthened to prevent entry of diseases / enemies.
   - To provide insurance facilities to beekeepers.

22. Future Thrust

1. Use of Standard Bee hive in Indian Beekeeping, specially with *A. mellifera* bees:

The hives used in India are not the standard hives with all needed components. Most of the *Apis mellifera* beekeepers do not use supers. This has created several problems, including contamination and high moisture content in honey. Through we have BIS standards for hive but none of the hive manufacturer is using this standard. **Financing Institutions do not enforce the use of standard hive clause.** The standard of C- Dimensions of C type (Langstroth) hive has some discrepancy in measurements. Improvement in the use of hive is an essential aspect to save Indian Beekeeping and is primary need no. 1. Even standard seasoned wood is not used for manufacturing of the beehives which results in appearance of cracks within a year.

2. Improvement of HIVE HYGENE and prudent control of Bee ailments:

Beekeepers **have no knowledge of bee diseases and pests**. The beekeeper neither has the inclination to consult an expert nor does he have the knowledge as to where and when to consult. **There is no accredited bee pathology laboratory in the country where from right diagnosis and advice can be obtained.** The beekeeper relies on the trader who is near to him and aims at unscrupulous tendency for earning. As a matter of fact this practice is the main source of contamination in honey. This is a very serious matter to be taken note of ‘Bee Pathology Lab and Beekeepers’ Advisory System are the primary need no. 2.

3. Unification of Honey Standards:

We have 3 different standards for honey, PFA (now FSSAI), AgMark & BIS. We have to follow **International standards for export**. This discrepancy has to be removed in the interest of Indian Beekeeping Industry.

4. **Beekeeping Laws**:
Through we have a **Bis Code of Conservation & Maintenance for Honey Bees**: It has no sanctity as the other BIS standards in Apiary Industry section. However, Indian Beekeeping desperately needs the protection of law. We need to act for transforming the BIS Code in Law & rules.
5. **Revision of the Pattern of Assistance under DAC, GOI:**
The pattern of Assistance under NHM (DAC) **is not only inadequate but also incomplete**. A beekeeper not only needs the bee hive and the colony, he also needs other appliances and tools also. There is a dire need to revise the pattern quantitatively as well as qualitatively.

Conclusion

Beekeeping is a vast scientific subject, related to agriculture, food, nutrition, medicine, industrial product and environment. India has a large unrealized potential for the production of honey and other bee products in the field of beekeeping. By utilizing all this advantages there will be a unique opportunity for rural development through the promotion and extension of beekeeping. Beekeeping is a good profitable venture requiring small investment of capital and skilled labours and high yield enterprise in comparison to other poverty reduction activities. Nevertheless, for rural development bee keeping can play a vital role as one of the economic activities. Conservation of existing bee colonies, their rapid multiplication, increasing their productive efficiency, diversification of bee products and utilizing the bee colonies for planned pollination should be the theme of beekeeping development programme. We have seen the first phase of the Green Revolution; we have seen the White Revolution; let us see the second Green Revolution in association with honey bees and a Golden Revolution in honey production in apiary industry.

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STATUS AND PROSPECTS OF BEEKEEPING IN HARYANA

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ABSTRACT

Beekeeping plays an important role in sustainable agriculture since it contributes significantly as an allied industry. Bee farming provides supplementary and sometimes major source of income to the farmers, especially to the small farmers. Enterprises like poultry, piggery, dairy, mushroom growing, *etc*., require higher initial costs than beekeeping. Due to its low cost and higher returns, farmers prefer beekeeping as an important subsidiary occupation as compared to other agro-based industries. Majority of the beekeepers want to increase their level of business but they could not adopt this entrepreneur because of the factors such as indiscriminate use of pesticides, bee diseases and enemies, weather conditions, low price of hive products, *etc*. affecting the honey production adversely. The susceptibility of honeybees to different diseases, pesticide hazards and marketing of bee products are found to be the major limiting factors in the expansion of beekeeping in India. Government should take serious steps to revive this cottage industry and sort out the problems faced by the beekeepers and promote small farmers for beekeeping, so that they may obtain higher returns from this industry.

Keywords: Beekeeping, hive products, problems, prospects

Introduction

Haryana State represents one of the most important beekeeping areas in India as the state is having different agro-climatic conditions and crop diversity in different zones with temperature range from -2.5 to 48ºC. Such diversity of geographical features plays a major role in determining the climate and plant species present in different zones and offers great potential for both migratory and stationary beekeeping. Beekeeping with *Apis mellifera* is the main profession of commercial beekeepers in the state. Based on beekeeping, this state represents two distinct zones, *i.e*., (i) north zone, comprising Panchkula, Ambala, Yamunanagar, Kurukshetra, Karnal, Kaithal and Panipat, where relatively low temperature (up to 44ºC) and high humidity (> 30%) are witnessed during dearth and (ii) south west zone, constituting Sirsa, Hisar, Bhiwani, Rewari, Mahendergarh, Faridabad, Gurgaon, Rohtak, Jhajjar, Jind and Sonepat districts, where the temperature is high (around 48ºC) and humidity 15% or less during hot summer months. The different cropping pattern due to different soil types, irrigation facilities, temperature and relative humidity and the agro-climatic conditions prevailing in the state are quite favourable for beekeeping with *Apis mellifera*. In the state, winters are not so severe that may hamper their brood rearing and food collection activities. Thus, there is no problem of over wintering to *Apis mellifera*. Although the summers are quite severe but this species has the potential to regulate its temperature and works under such ruthless conditions, provided some suitable arrangements of shade and water be made in the apiary (Plate-1).

During monsoon, the food availability becomes scanty and a dearth period is experienced but it can be overcome through artificial feeding on sugar syrup as nectar substitute and soya sugar patties as pollen substitute. Besides, the beekeepers also face several other problems in the state, which are discussed below in this article:

Problems of Beekeeping:

Indiscriminate use of pesticides

Beekeeping is an important input in agricultural system for enhancing the yield of cross-pollinated crops but indiscriminate use of pesticides on the crops in the state causes heavy loss to honeybee colonies, which ultimately discourages beekeeping. Some researchers have reported that this problem of pesticide sprays is faced by majority of the respondents, resulting in killing of honeybees, which causes huge loss to crop yield and honey production (Shende and Phadke, 1995; Kaur, 1998; Kumar, 2000).

Poor management of honeybee colonies

Poor management of honeybee colony is a major constraint in honey production in the state due to the poor knowledge of the beekeepers regarding scientific beekeeping methodology, hence, they are unable to manage their hives during dearth periods when besides bee flora scarcity, they are unable to manage various pests and predators in the apiaries, which result in dwindling of bee colonies (Trehan, 1986; Abrol, 1997; Sharma and Kumar, 2011).

Honeybee diseases and enemies

The problem of bee diseases and natural enemies is a major constraint in beekeeping industry. Sometimes, the diseases remain undetected for a long time and when they appear, cause catastrophic destruction. Treatment of bees against diseases is a challenge even for the pathologists. The spread, intensity and control of diseases are influenced by climatic factors, forage availability and its quality (Sharma, 1998). While studying the problem of bee pests and diseases, Kaur (1998) found that 55% of the respondents were bothered by the attack of bee enemies and reported bee enemies including all major pests like green bee-eater, wax moth, wasps, mites and diseases (especially European Foul Brood) to be detrimental to beekeeping.

Complications in the migration of honeybee colonies

Migration of honeybee colonies is generally a practice with commercial beekeepers. Hobbyists or marginal beekeepers generally have tough time during dearth period, hence, a beekeeper may need to move his honeybee colonies to long distances to abridge the floral dearth period (Sharma *et al*., 2011) to exploit different bee floral sources/honey flows, send his colonies for the pollination of crops/orchard plants, or to establish a new apiary at a new location (Gatoria *et al*., 2007). Migration of bee colonies to potential bee flora areas throughout the year is also one of the major problems faced by the beekeepers. High transport charges, mortality of bees during transportation, interference of police and octroi people, *etc*. during migration of bee colonies is also a major impediment for honeybee keepers. This problem was faced by 37.5% of the respondents in a study conducted in Punjab (Kaur, 1998).

Depleting floral resources

The forest cover is gradually declining due to urbanization and fragmentation of land. The plantation of bee flora is not being taken up either by the forest department or individually, and depleting floral resources has reduced the beekeeping potentials in the country. Beekeepers cannot afford to grow bee flora exclusively for honeybees. However, social forestry programme, which advocates growing of multipurpose trees, can be augmented to grow those trees that are also good for bee forage. About 20% of the beekeepers face colony migration constraints due to lack of bee flora and financial facility, harassment of migratory beekeepers by the state administrators and non-cooperative attitude of the forest department officials and also the problem of increasing dearth of bee flora due to decrease in area under bee plant species (Kaur, 1998).

Adverse weather conditions

Unfavorable weather conditions are also a major setback to beekeeping. Extreme hot or cold weather conditions reduce the bee population. Cloudy atmosphere and rainy season also affect bee population adversely. In honey production, natural factors are the great limitations in the expansion of beekeeping (Tonapi, 1988) and bad weather is a major constraint (Singh *et al*., 2002).

Cost of equipments

Many beekeepers says high cost of equipments as the main problem in beekeeping expansion since equipments, particularly the beehives (boxes) and bee frames are progressively becoming costlier, which put negative impression on entrepreneurial spirit of new comers as well as of those who want to expand their business.

Marketing

Marketing of honey is another major constraint that discourages the producers. Without proper marketing, the beekeeping industry cannot flourish to its maximum. Bulk honey collected from different producers is often of the poor quality and fails to meet the national and international standards. In export markets, there is great competition and importing countries have strict quality norms, *i.e.*, aroma, colour, consistency and floral source, requirements. However, most of the producers are not aware of these standards, and thus, they fail to meet these international standards. Hence, marketing is one of the major constraints in beekeeping as stated by 65% of the beekeepers in Punjab respondents (Kaur, 1998). Non-fixation of minimum support prices for beekeeping products, variant prices and unorganized market are the other troublesome factors in the marketing of bee products. The other constraint in the selling of honey is that there is no specific market for the sale of honey, and the beekeepers are selling their produce mostly locally or in nearby areas without any brand name (Sharma, 1989; Gatoria *et al*., 2003) as about 65-70% of the beekeepers have highlighted the problem of honey marketing and low price of their bee products (Kumar and Singh, 2002; Bansal *et al*., 2013).

Administrative and financial constraints

Farmers face problems in getting loans and non-availability of insurance policy in the state as majority of the respondents have reported that they face difficulty in getting loan for beekeeping enterprise (Kaur, 1998; Sharma, 1989; Gatoria *et al*., 2003; Kumar and Singh, 2002). During migration of honeybee colonies, harassment of beekeepers at the barriers including impositions of taxes, octroi, *etc*. and non-cooperation of government agencies especially the forest department for setting the migratory apiaries on vacant government land or forest areas along the canals, roads, railway tracks, etc are some of the other problems being faced by bee farmers.

Lower price of hive products

Lower price of bee products (honey, bee wax, *etc*.) are the second major problem faced by 77% of the beekeepers. Actually, there is a big gap between producer's price and retail price, which irritates the beekeepers a lot. Low price of honey and its products have affected 90% of the producers and 70% of the intermediaries (Singh, 2000).

Lack of involvement of extension personnels

There is lack of social welfare organizations, women clubs, tribal development Institutions and missions to take modern beekeeping to remote and interior areas. In addition, there is less interaction between local beekeepers and extension staff to evolve new techniques and management practices (Abrol, 1997).

Prospects of beekeeping in India

In India, the production and consumption of honey is very low as compared to China, the leading producer, exporting 80,000 tonnes annually as against 27,000 tonnes by our country. Honey production in India is only about 85,000 tonnes a year as at present only about 20-25% of the bee flora is being exploited and Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal are the only honey producing sates. Germany is the world's largest consumer, importing 90,000 tonnes of honey products annually. The per capita consumption of honey in Germany is 1.5 kg as against 3 g in India. According to a survey, there is a Rs. 1,500 crore world's market for healthy foods but India's share is stated to be negligible. In the world market, the demand for honey is around one million tonnes. There is an immense possibility for India to increase its export share from 27,000 tonnes to 3 lac tonnes if more people invest in honeybee colonies.

The present trend in the beekeeping industry tells us for raising the number of colonies to around 4 millions, and thereby, increasing honey production to one lac tonne in another decade. A major portion of the honey produced in the country is used in medicines and only a small quantity finds its place as food on the table. Bee venom has been used as medicine for many decades in Europe and Russia, especially in the treatment of muscular diseases. Bee wax is a high value product and its consumers are cosmetic, candle and paint industries. Quality testing facilities are also not easily available to beekeepers and packers in India.

The European Union will not import honey from countries where the use of pesticides is not regulated and where the samples are not specifically tested for insecticidal residues. Some honey importing countries also insist on a certificate to the effect that the honey has been procured from disease-free colonies. However, there is no arrangement for disease surveillance in the state. Honey is often stored in undesirable and inappropriate containers that deteriorate the quality for the product.

Above all, the processing of honey has to be of high standards so that quality deterioration may be minimal. Imports from China and Argentina, the two large exporters, are now being avoided due to the poor quality of honey and many countries are turning towards new exporters like India. Europe, the United States of America and Japan are the major honey importers. India needs to build the confidence of world buyers. Price, supply, purity and service are the major determinants in the honey industry.

Future projections and expansion of *Apis mellifera* in Haryana

In India, at present Haryana is the leading state in honey production as shown in Table 1. In the year 2004-05, about 275 tonnes of honey was extracted from 28000 colonies. Today, Haryana state is having 250000 bee colonies, from which, 3000 tonnes honey is being produced annually.

Table 1: Growth of beekeeping with *Apis mellifera* bees in Haryana

Sr. No.	Year	No. of colonies	Honey production (MT)
1.	2004-05	28,000	275
2.	2005-06	30,000	300
3.	2006-07	42,000	465
4.	2007-08	65,000	650
5.	2008-09	80,000	800
6.	2009-10	1,50,000	900
7.	2010-11	1,75,000	1200
8.	2011-12	2,00,000	2500
9.	2012-13	2,50,000	3000

A wide gap exists between the number of bee colonies which are available and the number of colonies that could be supported in the state. Keeping in view of the availability of bee flora (Table 2 and Plate 2 and 3) continuously for eight months from October to June, it was estimated that Haryana could sustain about 4 lac *Apis mellifera* colonies, from which, about 15000 MT honey could be harvested annually. Besides, there is a vast scope of employment generation in the state, and thus there may be additional jobs available for 100 men days for about 10,000 persons in a year. The rural artisans such as carpenters, black smith and other beekeeping equipment manufacturers may also get additional source of income. This shows that there is tremendous scope of beekeeping in the state with *Apis mellifera* bee species in the coming years.

Table: 2 important bee flora of Haryana

Sr. No.	Scientific Name	Common Name	Family	Flowering period	Source type
Field crops					
1.	*Oryza sativa*	Rice	Poaceae	9-10	P_1
2.	*Pennisetum tyhhoides*	Pearl millet	Poaceae	11-10	P_2
3.	*Sorghum bicolor*	Sorghum	Poaceae	9-10	P_2
4.	*Zea mays*	Maize	Poaceae	1-12	P_3
Legume Crops					
5.	*Cicer arietinum*	Bengal gram	Fabaceae	12	N_2P_2
6.	*Dolichos biflorus*	Horse gram	Fabaceae	10	N_1P_1
7.	*Medicago sativa*	Lucerne	Fabaceae	3-4	N_2P_2
8.	*Phaseolus mungo*	Black gram	Fabaceae	8-10	N_1
9.	*Phaseolus radiatus*	Green gram	Fabaceae	8	N_1P_1
10.	*Pisum sativum*	Peas	Fabaceae	8-9	N_1
11.	*Sesbania gradniflora*	*Dhiancha*	Fabaceae	6-7	P_1
12.	*Trifolium alexandrium*	Bersem	Fabaceae	3-4	N_3P_2
13.	*Vigna unguiculata*	Cowpea	Fabaceae	8	N_1P_1
Oilseed Crops					
14.	*Arachis hypogea*	Groundnut	Fabaceae	8-9	N_2P_2
15.	*Brassica campestris* var. sarson	Mustard	Brassicaceae	10-11/10-1	N_1P_1
16.	*Brassica campestris* var. toria	Indian rapeseed (toria)	Brassicaceae	10-11	N_1P_1
17.	*Brassica juncea*	Raya, Indian mustard	Brassicaceae	12-2	NP
18.	*Brassica napus*	Rapeseed	Brassicaceae	12-3	N_1P_1

19.	*Brassica nigra*	Black mustard	Brassicaceae	8-9	N_3P_3
20.	*Brassica rapa*	Safflower (Canola)	Brassicaceae	2-4	N_2P_2
21.	*Eruca sativa*	Taramira, Rocket	Brassicaceae	12-8	N_2P_2
22.	*Helianthus annuus*	Sunflower	Asteraceae	1-12	N_1P_3
23.	*Ricinus communis*	Castor	Euphorbiaceae	8-9	N_1P_1
24.	*Sesamum indicum*	Sesamum	Pedaliaceae	4-9	N_3P_3
Fiber Crops					
25.	*Gossypium arborium*	Cotton	Malvaceae	4-1	N_1P_1
26.	*Crotolaria juncea*	Sun hemp	Malvaceae	8-11	N_3
Vegetable crops					
27.	*Abelmoschus esculentus*	Okra	Malvaceae	1-12	N_3P_2
28.	*Allium cepa*	Onion	Liliaceae	5-7	N_3P_3
29.	*Brassica oleracea. capitata*	Cabbage	Brassicaceae	2-4	N_3P_2
30.	*Brassica oleracea botrytis*	Cauliflower	Brassicaceae	2-4	N_3P_2
31.	*Capsicum annuum*	Peppers	Solanaceae	1-12	N_3P_1
32.	*Coccinia indica*	Little gourd	Cucurbitaceae	1-8	N_3P_2
33.	*Coriandrum sativum*	Coriander	Apiaceae	2-3	N_1P_1
34.	*Cucumis melo*	Muskmelon	Cucurbitaceae	3-4	N_3P_2
35.	*Cucumis sativus*	Cucumber	Cucurbitaceae	10-11	N_3P_2
36.	*Cucurbita maxima*	Winter squash	Cucurbitaceae	2-3	N_3P_1
37.	*Daucus carota*	Carrot	Apiaceae	3-4	N_2P_2
38.	*Laginaria siceraria*	Bottle gourd	Cucurbitaceae	1-12	N_3P_2
39.	*Luffa acutangula*	Ridge gourd	Cucurbitaceae	11-2	N_3P_1
40.	*Lycopersicum esculentum*	Tomato	Solanaceae	1-12	P_1
41.	*Memordica charantia*	Bitter gourd	Cucurbitaceae	4-7	N_2P_2
42.	*Phaseolus vulgaris*	French bean	Fabaceae	1-12	N_1P_1
43.	*Raphanus sativus*	Radish	Brassicaceae	2-4	N_3P_1
44.	*Trigonella foenumgracum*	Fenugreek	Fabaceae	1 -12	N_1
Fruit Crops					
45.	*Carica papaya*	Papaya	Caricaceae	7-9	N_3P_2
56.	*Citrus spp.*	Citrus	Rutaceae	2-3	N_1P_1
47.	*Litchi chinensis*	Litchi	Sapindaceae	3-4	N_1
48.	*Prunu spersica*	Peach	Rosaceae	2-3	N_2P_2
49.	*Psidium guajava*	Guava	Myrtaceae	2-4	N_3P_3
50.	*Punica granatum*	Pomegranate	Punicaceae	4-7	N_1P2
51.	*Pyrus communis*	Pear	Rosaceae	2-8	N_2P_2
52.	*Grewia* spp.	Phalsa	Teliaceae	7-11	N_2P_1
Trees					
53.	*Acacia arabica*	Babul	Mimosaceae	7-11	N_1P_1
54.	*Acacia catechu*	Khair	Mimosaceae	7-9	P_1
55.	*Aegel marmelos*	Bael	Rutaceae	5-6	N_2P_2
56.	*Albizia lebbeck*	Siris tree	Mimosaceae	2-4	N_1P_1
57.	*Azadirachta indica*	Neem	Meliaceae	3-4	N_2
58.	*Bauhinia purpurea*	Khairwal	Fabaceae	2-8	N_1P_1
59.	*Bombax ceiba*	Samuel	Malvaceae	1-3	N_1P_2
60.	*Butea monosperma*	Dhak	Fabaceae	2-3	N_1P_1
61.	*Callistemon lanceolatus*	Bottle brush	Myrtaceae	1-12	N_3P_1
62.	*Dalbergia sissoo*	Sissoo	Fabaceae	3-4	N_1
63.	*Datura stramonium*	Thorn apple	Solanaceae	11-6	P_1

64.	*Ehretia acuminate*	Puna	Boraginaceae	4	N_1
65.	*Eucalyptus* spp.	Safeda	Myrtaceae	11-4	N_1P_1
66.	*Eugenia* spp.	Bhedas, Gudda	Myrtaceae	2-4	N_1
67.	*Leucaena leucocephala*	Subabul	Mimosaceae	1-12	P_1
68.	*Madhuca longifolia*	Madhua	Sapotaceae	2-3	N_1
69.	*Morus alba*	Mulberry	Moraceae	2-6	P_1
70.	*Peltophorum ferrugineum*	Copper pod	Caesalpinaceae	5-7	N_2P_3
71.	*Phyllanthus emblica*	Amla	Euphorbiaceae	2-4	N_1P_1
72.	*Pithecollovium dulce*	Manila	Caesalpinaceae	2-4	N_1
73.	*Polygonum glabrum*	Polygonum	Polygonaceae	12-3	N_1P_1
74.	*Pongamia pinnata*	Karanj, Sukhchain	Caesalpinaceae	3-4	N_1P_2
75.	*Pterospermum personatum*	Pterospermum	Bignoniaceae	4i-5	N_1P_1
76.	*Rubinia pseudoacacia*	Rubinia	Fabaceae	9-4	N_1P
78.	*Tamarindus indica*	Tamarind	Caesalpinaceae	5-6	N_1P_1
79.	*Tecoma stans*	Tecoma	Bignoniaceae	1-12	N_1P_1
80.	*Terminalia arjuna*	Arjun	Combretaceae	3-5	N_1
81.	*Thelepaepale* spp.	Whayati	Acanthaceae	4-1	NP
82.	*Toona ciliata*	Tun	Meliaceae	3-4	N_1P_3
83.	*Zizyphus jujuba*	Wild Ber	Rhamnaceae	5-6	N_3P_2
84.	*Ziziphus mauritiana*	Ber	Rhamnaceae	3-5	N_1P_1

N= Source of nectar; P= Source of pollen; Flowering Period (Month) = January to December (1-12)

Source: 1- Major, 2- Medium and 3- Minor

Conclusion

Haryana has vast resources of bee flora, thus, there is a great scope for further expansion of beekeeping in the state. In Haryana where land holding is less than 0.75 ha, beekeeping can provide better food, balanced nutrition and employment to small and marginal farmers. It can also provide the unemployed and underemployed persons with full employment and extra income.

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Plate-1


PIGONPEA


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BERSEM


COTTON


JAMUN


PEACH

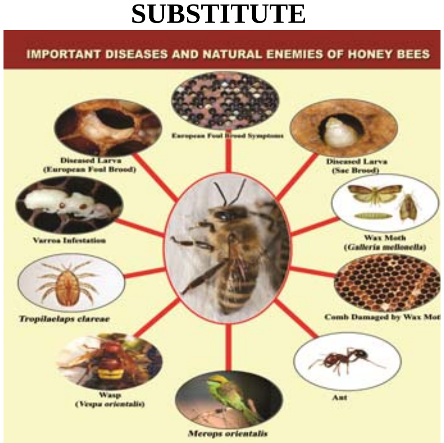
Plate-2

APIARY

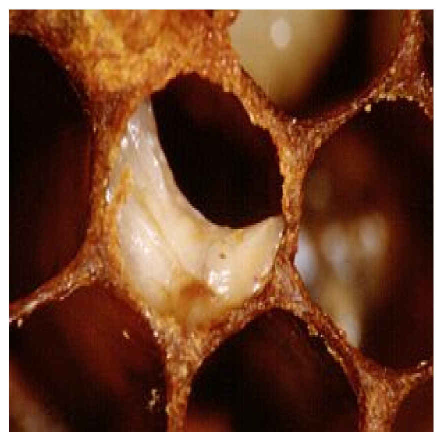
SUMMER MANAGEMENT

FEEDING POLLEN SUBSTITUTE

WINTER PACKING



HONEYBEE DISEASES & ENEMIES

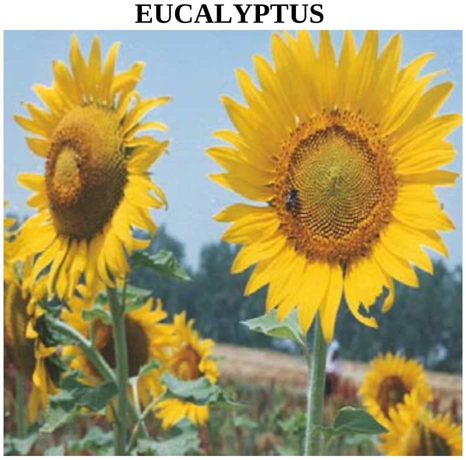


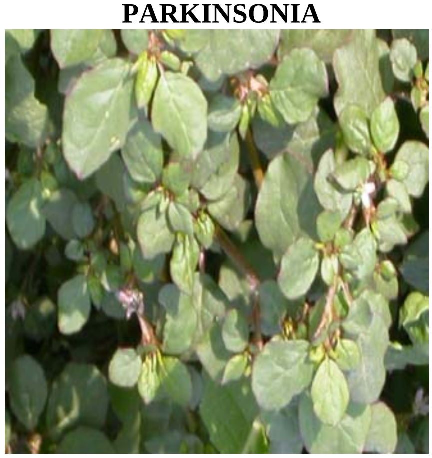
EUROPEAN FOUL BROOD

Plate-3

MUSTARD **PEARL MILLET**

EUCALYPTUS **PARKINSONIA**





SUNFLOWER **SANTHI**

CONSTRAINT ANALYSIS IN BEEKEEPING INDUSTRY

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ABSTRACT

Beekeeping is a non-traditional industry where 2 living organisms – honeybees and flowering plants interact with weather to affect cross pollination of crops and give a sweet byproduct - honey. Once a Sunrise industry, beekeeping has now degraded appreciably and become synonymous with constraints. Problems generally begin with ridiculous nomenclature of a miniscule industry, woefully inadequate technical manpower, decreasing profits, eroding ethics and lack of leadership. On administrative front, complete institutional failure is attributable to lack of vision, non-inclusive approach, multitude of agencies working in isolation, and poor tax structure. This low priority enterprise is bereft of a national policy, national institute, cadre of experts and low consumer awareness. There is an urgent need to prioritize research in consultation with stock holders especially in the field of bee breeding, pollination in enclosures, wild bees, etc. Beekeeping schemes needs to be thoroughly reworked as they have utterly failed to deliver envisaged goals, are lopsided, poorly monitored and resulted in creation of idle infrastructure. Investing in human resource and adoption of futuristic technologies may turn it into a highly professional enterprise capable of fighting the emerging menace of global warming and pest threats. This export oriented industry is now producing worst quality honey laced with contaminants, sugars, etc. and if not administered properly, may lead to re-imposition of export ban. Diversification into hive and value added products, with adequate marketing support and conservation of honeybees and plants holds the key to its profitability and sustainability.

Key words: Honeybees, beekeeping, constraints, futuristic technologies, policy support.

Before analyzing the constraints of beekeeping, it is important to know that it is a highly technical and scientific, multi-disciplinary but non-traditional industry; generally practiced by poor, tribal and illiterate people in forest/villages or remote places; where two living materials -honeybees and flowering plants interact for the sole purpose of pollination and produce honey as a byproduct. Beekeeping in India is greatly diverse due to floral and weather variations. Once was a blessed profession, it has almost become synonymous to constraints thanks to the wisest creature on the earth – the man. It is relevant to discuss and analyze the constraints under various heads and suggest remedial measures/action plan to realize the ultimate potential of beekeeping.

A. General Constraints

1. Nomenclature: Name reflects our ideology, thoughts, orientation and efforts. In Khadi and Village Industries Commission (KVIC), that patronized beekeeping in India, named it as "Beekeeping Industry" after the dream of Bapu Gandhi to empower rural masses with self sustaining village industries. It was truly treated as an industry by providing complete end-to-

Note- This paper was not presented during the Workshop, however, it is being included in the proceedings

end support to the sector. In purely scientific parleys at state agricultural universities (SAU's), it is called Apiculture, restricting its scope mainly to Entomology component of broader discipline of Apiculture. In the realms of Indian Council of Agricultural Research (ICAR) and union ministry of Agriculture, its scope has been further confined to a limited sub branch of "pollinators" as if pollination can be achieved automatically without the basic concept of beekeeping. For beekeepers, it is purely beekeeping, the *art* of rearing honeybees with little scientific inputs and sole aim of producing honey. For exporters, it purely is a commercial activity of procuring honey (commodity) for profit maximization bereft of the ethics.

Honeybees as creature are epitome of symbiosis and can't be delimited by narrow physical, geographical and thought barriers. In India, we are hell bent to narrow down the very scope of honeybees and beekeeping. In fact, we are fighting with and not for the bees. It is time not only to perfect the nomenclature but also our approach, thought process and course of action.

2. Huge unexplored potential: Tremendous scope of beekeeping growth exists in India. Bees have direct bearing on production of crops sown in 48.5% area of India besides substantial indirect pollination support. Shockingly, only 98.3% of beekeeping potential remains unexplored and gigantic national resource is being allowed to go waste (Chaudhary unpublished).

3. Social stigma to be a beekeeper: An enterprise grows when its members take pride and satisfaction. Unfortunately, beekeeping is taken up by that strata of society who are either marginal, deprived (of land or resources), un or under privileged or by those who are already in trade and can't leave it for want of alternatives. Society considers beekeepers as an outcast, living a nomadic life, scientist take them as ignorant and exporters as 3rd grade citizen. Younger, educated generation will not adopt it even if it is a paying proposition due to hard nature of job, working conditions and social stigma attached. They may only be allured to the subsidiary benefits attached but not to the core beekeeping, unless the enterprise is made more attractive.

4. Census: It really is a shame but true that after 1995 (when KVIC was providing real time ground statistics), there is no data base/census available for beekeeping at national and state levels and we are really planning in the air! There is great variation in the reported number of beekeepers, honeybee colonies, honey/wax production, etc. sometimes to the factor of ten. Even in a small state of Haryana, estimates about number of beekeepers range between 600-6000. A complete census is a must and it is not difficult to physically gather such data.

5. Technical manpower engaged in beekeeping in India: Technical strength of Central Bee Research and Training Institute (CBRTI), Pune and KVIC has dwindled from more than 2000 in 1980's to about 50 (only handful technical, rest extension staff). ICAR has only one scientist (PC) mostly engaged in administrative and coordinating activities. In Haryana, only 2 scientists deal with research and 2 ADO's with the development aspects. It is a pity that in India with 1.25 billion people and 1.3 million honeybee colonies, there are no more than 30 scientists (Entomologists) and 85 development staff, meaning 1 scientist per 40,625 colonies and 1 development staff for 15,662 colonies. There is an urgent need to substantially increase this manpower.

6. Low priority, miniscule industry with no role of sector management organizations: In terms of government priority and resource allocation, beekeeping is a miniscule segment of 2.42 lakh beekeepers maintaining 1.3 million colonies and producing about 52,000 MT honey. Absolute lack of a powerful lobbying group and sector management organizations (associations/ federations) failed to provide beekeeping its rightful place at national level. In contrast, it is provided highest priority in agriculturally developed countries like US, EU, etc.

7. Profit analysis of beekeeping enterprise: Beekeeping once was a highly profitable activity but increased cost of production (labor, migration, medication, feeding, rentals, etc.) made it really unsustainable. Cost of honey production has exponentially negative relationship with productivity. At a higher productivity level (25 kg/hive/year), cost of production is a factor of 2.72 and at moderate level (20 kg) grows 1.6 times to 4.25. However, at a lower productivity of 12 kg, as recorded during 2013-14, it leaped exponentially by 4.3 times (11.75) the production cost, coupled with other negative traits. There is thus, an urgent need to improve profitability by adopting **specially designed management aspects**, technological innovations and diversification.

8. Ethical erosion of beekeeping segments: Beekeeping till 1980's was scientifically driven but in late 1990's it turned exporter centric when mustard honey exports to EU and USA began. Exporters wanted more honey, adopted unethical means and even encouraged beekeepers to adopt wrong practices of extraction of unripe honey without supers. Beekeepers after 2004-05 *Varroa destructor* epidemics turned their energies to cost reduction to offset exorbitantly higher cost of medication. Scientists failed to predict the catastrophe and provide inputs at crucial time. However, exporters and beekeeper's combination proved disastrous as Indian honey was banned in EU due to poor quality and contaminations. After lifting of ban in 2011, policy makers failed to frame rules and implement them. Instead of learning from past mistakes, it was free for all. Exporters exploited the beekeepers without investing anything to good beekeeping practices (GBP). Exporter wanted more profit, beekeeper wanted more money and labor wanted to do no extra work. The honey production and productivity reached lowest ebb and honey quality deteriorated alarmingly. Today, almost all these segments of the industry are at fault.

B. Administrative Constraints

1. Non-technical persons heading beekeeping: An industry takes the shape of the thoughts and actions of its leaders. Gandhi ji had the vision to incorporate beekeeping in his *swa-rojgar* moment and laid the foundation of a holistic beekeeping industry under Khadi and Village Industries Commission (KVIC). Directorate of Beekeeping Industry handled development and marketing while CBRTI, Pune headed by eminent and dedicated scientists lead the research front. Declaration of beekeeping as non-core industry by KVIC and its subsequent leadership by non-technical heads lead to its down fall.

All India Coordinated Research Project on Honeybees (AICRP) mandated with a gigantic national approach lost its way due to faulty declaration of its guiding research principles and approach. Instead of natural transformation into a "National Institute", it remained mere a data gathering center and failed to provide leadership. Similar is now the fate of research in state agricultural universities (SAU's) as beekeeping is the least priority of Entomologists due to dirty nature of the job and lack of training. National Bee Board (earlier Beekeeping Development Board) established in 1993 by joint efforts of author, KVIC and All India Beekeeper's Association (AIBA) in union Ministry of Agriculture and Cooperation failed to become a fully autonomous body. It was later converted into a private entity, run mainly by exporters for their narrow gains and subsequently was headed by a non-beekeeping Executive Director thus, losing the direction. National Horticulture Board (NHB) and later National Horticulture Mission (NHM) were entrusted with the implementation of centrally sponsored schemes, are doing so without technical manpower.

Department of Horticulture, Haryana is establishing “Center of Excellence in Beekeeping” under Indo-Israel project to provide highly technical and specialized services to beekeepers. It is expected that it will be headed by a technical person passing a wide experience in scientific beekeeping.

Rise and fall of these mighty beekeeping institutions reflects the blurred and narrow vision of leaders. There is thus an urgent need to involve real beekeeping persons into these bodies.

2. Integrated and inclusive approach is missing: Beekeeping is an inter-disciplinary science involving disciplines of Apiculture, Bee Botany, Melissopalynology, Pollination, Genetics, Bee Breeding, Honey Chemistry, Quality control of honey and hive products, Wild bees, Entomology, Zoology, Pathology, Engineering, Extension, Training, Information Technology, Honey Processing and Marketing, etc. are wrongly considered part of Entomology. It is high time beekeeping is treated as it is by making it holistic, integrated and inclusive.

3. Multitude of implementing agencies working in isolation: Honeybees are the most coordinated creatures and its policy makers and implementers must learn this art. There is multitude of organizations at national and state level but no one knows what others are doing. Pooling and coordinating vast resources, manpower and efforts could create a giant body capable of providing gigantic growth and employment opportunities.

4. Abolition of VAT on honey and other equipments: It is strange that an agrarian and progressive state like Haryana levies 4% VAT on honey, which in turn provides meager revenue to the state and even proves counterproductive. Honey produced in the state is, not reflected as its own production but is rather sold off to neighboring states like Punjab which wrongly claim to be the major honey producing state at the cost of Haryana. VAT needs to be immediately abolished. Likewise, VAT on other beekeeping equipments should also be abolished.

5. Compensation of colony loss by disasters: Beekeepers now consistently incur severe colony losses due to failure of honey seasons and disasters like, rain, hail storm, fire, flood and theft etc. Government compensates farmers of their crop losses and beekeepers must also be extended this cover. Even loss of productivity in terms of lost yields needs be compensated for beekeepers as is done in many foreign countries including USA through a revolutionary Farm Bill, 2014.

6. Compulsory registration and insurance of beekeepers: To provide relief to beekeepers from calamities like fire, theft, etc. their registration with state association and insurance should be mandatory. Government should ensure special insurance schemes for beekeepers.

C. Policy Constraints

Sectoral policy formulation is done without the involvement of target groups and is influenced by dominant group of exporters. A comprehensive policy formation for sector is the need of hour.

1. Consider beekeeping as legal agriculture activity: Beekeeping is 100% agro-forestry based activity but wrongly considered otherwise. It is rather an “orphan” discarded by Ministry of Industries and abandoned by Ministry of Agriculture to which it actually belongs. It should be declared an agriculture activity for all legal purposes.

2. National honey or beekeeping policy lacking: There is an urgent need of framing “National Honey/Beekeeping Policy” followed by state policies. It is a long pending demand by the beekeeping fraternity and imprints were suggested as far back as 1993 to the Union

Ministry of Agriculture during first National Conference on Beekeeping and also later on many other occasions (Chaudhary, 1993 a,b; Chaudhary and Taori, 1993; Shende and Phadke, 1993; Taori, 1993 a,b; Taori and Chaudhary, 1993; Taori *et al*., 1993). It is high time that such an inclusive policy is framed that shall encompass the guiding principles of the industry and the realistic action plan. It shall also encompass:

a) **National beekeeping medication policy:** In the absence of a uniform policy for treatment against insect-pests and diseases of honeybees, beekeepers resorted to cheaper, un-recommended and unethical remedies, thus increasing substantially the cost of medication and production of contaminated honey. Such a policy shall include all gamuts like quarantine, use of recommended chemicals, their time and method of application, waiting period, supervisory authority, etc. State should bear this miniscule cost of treatment
b) **National marketing policy for honey and value added products:** (discussed later)
c) **National policy on organic honey production:** India has vast designated organic areas (even states like Sikkim) with potential to produce premium "organic honey" but remains unutilized for want of policy support. India must step into this niche sector.

3. Comprehensive and integrated beekeeping plan for Haryana: There is an urgent need to formulate integrated beekeeping planning (IBP) for Haryana with realistic and workable action plan.

4. Beekeeping be declared priority sector by government: Realizing the yeomen service rendered by honeybees in increasing crop production and productivity, it should be declared the top priority sector of country. But unfortunately, except by inserting a line "honeybees as an input to agriculture", precious little has been done by the government. Our governments should be extra sensitive as it directly touches farming community and influences agro-based industries.

5. Creation of cadre of experts: There is an urgent need of a cadre of scientists in different disciplines of beekeeping by identifying their interests and potential and ameliorated through advanced trainings and experiences along with a similar cadre of field officers and beekeepers.

6. Separate division of Apiculture in SAU's: As discussed earlier, an Entomologist may not be an ideal apiculturist. A separate functional division of Apiculture needs to be created in SAU's with scientists drawn from different disciplines.

7. Increased curriculum in universities: As honeybees touch almost every gamut of our life, it is important to introduce more courses in curriculum of universities. Even in SAU's, there is a need to make beekeeping courses as mandatory at UG level and more courses at PG level.

8. Increased awareness: Being a low profile industry but with immense benefits to humanity at large. All segments of society needs to be sensitized especially leaders, planners and farmers about pollination benefits and consumers about honey and other products through electronic and print media, honey festivals/days, workshops, promotional events, etc.

9. Publication of literature relevant to Indian conditions: It is strange that the only beekeeping journal (Indian Bee Journal) is defunct for years. There are scanty authentic books pertaining to Indian beekeeping (most being cut and paste jobs from foreign books). There is an urgent need to publish a general magazine along with literature in Hindi and also in other vernacular languages.

D. Research Constraints

1. Prioritization of research: Beekeeping in India reached its pinnacle due to untiring and selfless work of beekeeping scientists of KVIC and later on at Himachal Pradesh and PAU, Ludhiana. Presently, the research priorities are more academic and less beekeepers or industry oriented and thus needs complete reorientation. In SAU's, Entomologists are mainly engaged in pollination research (without Botanists), but there is no field adoption in any crop (except apple) as package of practices, economics and colony requirement studies are worked out. Even the pollination studies in enclosures are the least priority. Other important aspects are: effect of global warming on honeybees and pollinators; mechanization; hives and value-added products, apitherapy; residues; disease resistant, bee breeding, development of equipments, etc.

2. Large scale death of honeybees: Alarming bee deaths have become a global phenomenon with more than 50% colony loss in US and EU due to CCD (Colony Collapse Disorder) primarily due to newer pests and pesticides like neonecotinoids. Annual winter and summer stands at 30 and 12.5%. CCD will also reach India and we shall again be caught unaware due to lost priorities.

3. Beekeeping is a missionary work: Beekeeping is not a 9-5 job, it is a missionary field work. That's why it is on the lowest priority of scientists or field functionaries. There has to be special incentives to them and freedom of working hours, if results are to be achieved.

4. National Beekeeping Institute (NBI): A country or industry's success is mapped by its scientific institutes. It is a matter of great concern that in India, we have no national level institute of beekeeping now (as CBRTI, Pune is almost defunct). In Germany, there are 18 institutes of beekeepers.

5. Bee Breeding: An absolutely essential but entirely neglected aspect of Genetics. Bee Breeding is not even practiced by apiculturists in India, however the work on bee breeding has already been initiated in another laboratory. Top priority has to be accorded by ICAR and SAU's to breed pest resistant and higher productive lines. Beekeepers should be provided with this nucleus stock for further multiplication and distribution under critical scientific supervision.

6. Research on wild bees: India is home to two most important commercial species of wild bees viz. rock bees and dwarf honeybee, former being the largest source of honey and pollination. There is rapid decline of these species and practically there is no research on these bees is being done in India.

E. Beekeeping Schemes- Myths and Realities

The schemes are framed for community at large but their success or failure depends on implementation. Following statement about beekeeping projects is made without any prejudice and comment on authority/technical competency/integrity, etc. and may not be taken otherwise. Here are some prominent beekeepings schemes are discussed and evaluated.

1. Centrally sponsored scheme "pollination support through beekeeping": Presuming bees are primarily for cross pollination of crops. This scheme was initiated in 1993 providing 50% subsidy on honeybee colonies (bee hove + live material). Let us analyze its important facets:

a) Real vs. envisaged pollination benefits: Beekeeper's apiary size (depending upon holding) is generally consulting of 225-250 colonies or a truck load that are dumped at one migratory site for ease of operation and another at least 3 kilometers away, actually affecting "spill-over pollination". However, for planned pollination, colonies are required to be evenly spread over a designated area. Such dumping actually leads to over exploitation of a limited area and non pollination of majority areas. In a 9 km^2 area with 3 apiaries spaced equidistantly at 3 km and one apiary in center result in 33.3 and 11.4% area being optimally pollinated, respectively, defeating the very purpose of the scheme. There is an urgent need to work out the strategies to evenly pollinate the crops/areas to avoid precious national resource wastage.

b) Subsidized distribution of honeybee colonies through so called "Bee Breeders" through NHM: Under this scheme, up to 50 disease free honeybee colonies headed by high quality queens at 4-frame strength in standard LT bee hives are distributed to new beekeepers by bee breeders at 50% subsidy. Various state government agencies without scientific norms and criteria have arbitrarily designated many beekeepers as "Bee Breeders" to provide high quality, colonies to the beekeepers of the state. They altogether lack technical competency and are mere suppliers or commission agents. Bee improvement is a highly skilled, labor, time and equipment intensive approach. Scheme looks very attractive on assumptions, but its critical analysis show a completely different picture when following points are considered.

i) Honeybee colonies were sold at a fixed price at Rs. 340 per frame with a subsidy component of Rs. 170/frame (set by nodal agency through tendering). Colony prices are dynamic and are governed by distribution time and market price of honey.
ii) Prices is generally high from October to December (range Rs. 225-265/frame), low during February to July (Rs. 135-150/frame) and also during August-September vary from Rs. 175-180.
iii) Distribution period is August to March and maximum delivery is done from end of February to March. Colonies supplied after mid February has very little chances of growth and survival.
iv) Mean yearly colony growth index is 35%, meaning a bee breeder with 100 colonies is generally capable of supplying 35 eight frame colonies.
v) If a beekeeper instead of 8-frame colony, purchases 4-frame colonies, there is a net loss of Rs. 500/colony (to half the colonies) being the cost of quality queen.
vi) A standard LT (Langstroth Honeybee Hive -bee box named after the scientist) bee hive with super and inner cover is priced at Rs. 1340 (subsidy of Rs. 670). What generally supplied is "wooden box" where bottom board is nailed to brood chamber and is without super and inner cover. Its equivalent is available in market at Rs. 500-700.
vii) Market value of a 4-frame colony with "wooden box" in major delivery period is almost equal to the total subsidy amount. Prospective bee keepers pays his share (50% cost) to the bee breeder in advance. Subsidy benefits goes to whom?
viii) Why a beekeeper always buy full quota of 50 boxes even if his capacity is lower?

There is thus, an urgent and thorough need to rework this whole scheme so that benefits actually reach the target.

c) Improving efficiency of the so called Bee Breeders: To usher this advanced system and technology of mass queen rearing, following points are suggested to improve this scheme:

i) **Selection of Bee Breeders:** As described earlier, there is an urgent need to rework the selection procedure. Based on scientific criteria, competent beekeepers should be selected afresh.

ii) **Provision of high pedigree material from the Bee Breeders of SAU's**

iii) **Provision of specialized equipments and infrastructure grant:** Once new breeders are selected, provide them with one-time grant for specialized equipments and infrastructure.

iv) **Proper utilization of resources:** Earlier also, state government gave one-time lump sump grant to these bee breeders for technical upgrade, but there seems to be no improvement. Instead, a realistic component wise grant pattern should be framed and its monitoring and implementation assured.

v) **Intensive practical Training to Bee Breeders:** Training on the techniques related to mass queen rearing, queen mating, etc. followed by periodic updating at state's cost at national and international avenues is necessary.

vi) **Regular monitoring of schemes:** Devise proper procedure of marking, documentation and verification of bee breeders and their colonies at regular intervals by technically competent person/team to ensure they really provide services they are being paid for.

2. Proper monitoring and evaluation of scheme: Seeing the nature of industry, recirculation and bogus distribution can't be ruled out and there is urgent need to make system water-tight.

3. Ground reality about projects: Majority of projects funded by financial institutes are either non-functional or are not on ground and only add to idle capacity/infrastructure, e.g. large capacity in terms of honey processing plants, buildings, etc. at KVIC institutions (Yamunanagar, Ambala), government (HAIC, Murthal) or beekeepers projects alike. The guiding principle of growth and development has perhaps been overshadowed by subsidy component. The reasons of failure are many like non-marking or recirculation of bee hives/colonies; technical or marketing competence; will of implementing agencies; lack of monitoring, etc. thus required thorough discussion as this low-input and high return industry has no apparent reasons to fail.

4. Project patterns needs upgrade: Beekeepers are generally from marginalized and weaker (economically) section and there are many target oriented government sources of finance (DRDA, NHM and special segment schemes for SC/ST), while others like KVIC, KVI Board, National Horticulture Board etc. are project based. It is very difficult for a poor or less resourced person to formulate a project and get financing. To improve financing to real beneficiaries, following points are suggested:

- There is little objective public display of information about schemes and still they are fully or over-subscribed.
- There are huge and unrealistic variations in project components and needs uniformity.
- There are many unrealistic conditions of lease agreement of land (in NHB) even when beekeeping is a landless enterprise.
- Thorough monitoring and follow-up of projects is must.
- Financing pattern for projects needs thorough up-gradation.

F. Human Resource Development

Every segment of industry needs training, but where and by whom is the question.

1. Beekeepers: Beekeepers are generally privy to a 3-day "general beekeeping course" run by SAU's, HTI, etc. where they are taught only the basic concepts of beekeeping with very low practical exposure. This course enables them to acquire a certificate which is an essential pre-requisite to purchase honeybee colonies at subsidized rates under centrally sponsored scheme. Some graded training courses are run at CBRTI and some other places. There is an urgent need to enhance the scope and tenure of need-based (customized) trainings with more hand-on practical components. These must be work-driven and ready for private sector uptake.

2. Scientists: Scientists are self possessed and believe that being trainers they are supposed to know everything. A true scientist on introspection will know how little he actually knows about true beekeeping. There is thus, urgent need to hone their skills periodically at international level as we have no center of excellence for beekeeping in India.

3. Implementing agencies: Concerned persons need thorough training on various aspects of project formulations, evaluation, implementation and monitoring. They need be exposed to practical beekeeping as it is operationally an entirely different from other branches/industries.

G. Technological Constraints

Beekeeping differs in western countries and India. Beekeepers in west go for scientific techniques and standardized equipments, whereas Indian beekeeper's priority is cost reduction. In India, there is hardly any use of modern technology in beekeeping, except in honey processing and packaging. Some technological constraints are discussed here.

1. Poor information system: For a beginner, first step is the information about beekeeping, its benefits, economics, feasibility, projects, etc. Even in this seem-less world of high technology, all such information is not available at one place. All one gets is scattered information.

2. Communication channels: Beekeepers use non-conventional communication ways and conceal information from fellow beekeepers, as required information is not in public domain.

3. Web site: There is no Indian web site catering to the beekeeping and the foreign web sites have contents not entirely suitable to Indian conditions. The portals of implementing agencies show only a skeleton as if to hide more than to disseminate.

4. Sources of colonies: To start beekeeping enterprise one has to search for the source of good quality honeybee colonies and such information on sources is not available even though government also approves these sources.

5. Quality equipments: It is really a matter of concern that 99.99% of bee hives used today are non-standard (wooden boxes) and so are the other equipments. The wood used and manufacturing is faulty. This unhygienic box is the root cause of many ill effects faced by the honeybees.

6. Non renewal of old combs: Most of the combs in colonies are almost black with shorter cell space leading to small size of worker honeybees.

7. Supers and queen excluders: Adoption of the best practice of honey extraction from supers using queen excluder is almost non-existent in India and Haryana with only 0.17% supers (Chaudhary, 2005). Supers in fact are considered excess inventory and beekeepers feel it difficult to work with them. There is an urgent need to reverse this practice to get best quality honey.

8. Availability of quality queens: Queen is the life-line of colony. This concept of mass queen rearing to get quality and prolific queens was never attempted in Haryana the necessary know how on this aspect is available at the apiary of the author at College of Agriculture, Kaul. To improve production and productivity of honeybee colonies, mass availability of good quality queen is made mandatory with quality germplasm coming from SAU's.

H. Need to Adopt Futuristic Technologies

1. Real time pollination service approach (RTPSA): Government is worried about declining production, productivity and quality of crops/products but in reality it provides lip-service only. Barring apple crop in Himachal Pradesh (that too is a farmer-beekeeper initiative), there are no contractual "pollination services" between farmers and beekeepers- this otherwise is the universal concept worldwide. Author proposes a "Real Time Pollination Service Approach (RTPSA)" in collaboration with government agencies and stake holders that encompasses i) determination of annual "pollination cycles", ii) resource availability iii) establishing contractual obligations, iv) resource allocation, v) timely establishment, vi) impact analysis, etc.

2. Identification and trekking of bee hives: Beekeeping being migratory in nature, the basic requirement of a subsidized colony distribution system is marking of bee hives, followed by their trekking and monitoring over time and space – a component till now been compromised with. In absence of such a system, a very high probability of bogus hive distribution and their re-circulation exists. Effective means exist of permanent branding of not only the bee hives with scientific coding system but also of its parts (even frames) by embossing. It is essential to trek bee hives of beneficiaries and bee breeders following traceability procedure.

3. Mechanization: Indian beekeeping is entirely labor dependent who are illiterate and are in acute short supply. Their cost has doubled over the years. Without segmental mechanization, it will be difficult to run beekeeping enterprise in future. Immediate semi or full mechanization in fields of migration, honey extraction, honey transportation, medication, feeding, etc. is needed.

4. Turning beekeeping into a highly professional enterprise through HTIBS approach: Honeybees are most specialized and professional creatures, but in India, this enterprise is run in most unprofessional ways. The author has devised a "High-Tech Integrated Beekeeping System (HTIBS)" to usher professional and scientific approach in sectors of colony inspection, medication, survey, trekking, certification, queen rearing, collection/preservation of hive products (pollen, propolis, etc.), traceability, etc. in order to have uniformity (time, methods, chemicals, etc.) and efficacy. Centrally monitored system has commercial potential. A team of few dedicated and trained professionals can effectively perform all such end-to-end functions in a state like Haryana and even at national level at a fraction of cost.

5. Record keeping of apiary using integrated system - Honeybee colony and apiary are so dynamic that fortunes may fluctuate in a week. Proper record keeping allows daily as well as seasonal planning. There is no operational record keeping by beekeepers. More surprisingly, such records are not generally maintained for research and development apiaries. Many detailed colony growth parameters mainly for scientific work are reported which are of little help to the beekeepers. Author has devised a unique system of stock taking, colony inspection and advisory report for an apiary called STCIARS that involve complete stocking, random sample colony inspection followed by evaluation and advisory report.

6. Effect of climatic change and persistent failure of honey crops: Global warming and other weather related factors have disastrous effects on plants and honeybees, resulting in complete to partial failure of most copious honey plants like eucalyptus, rubinia, *pahari kikar¸ Delbergia sissoo,* litchi, *Accacia catechu*, ber, cotton, *Plectranthus rugosus*, pigeon pea, coriander and most importantly the mustard (in last 3 years), making beekeeping a losing enterprise. Author has envisaged following two MIS based integrated systems for beekeepers to plan and coordinate their activities in advance:

a) **Advanced information system of area-wise crops and densities (ISFMMP):** There is an urgent need for a web-based information management system about cropping densities of honeybee forage crops up to village level allowing advanced migration planning for beekeepers to ensure optimum crop pollination. Presently, the crops are either grossly unutilized or highly exploited – resulting in resource wastage in both the scenarios.

b) **Weather forecasting system (WFBOAS):** Beekeeping of late has become a totally weather dependent industry. An integrated weather forecasting-cum-beekeeping operations and advisory service (WFBOAS) for various beekeeping regions of state/country may guide beekeepers to perform timely operations to maximize their productivity and save their colonies.

7. Disease survey, forecasting, diagnosis and management system (DSFDMS): Honeybees in India has befallen to many threats like "Thai sac brood virus" in *Apis cerana*" and epidemic of "*Varroa destructor*" on *A. mellifera.* Indian scientists on all occasions were found wanting in their prediction and management and same lethargic attitude continues from impeding disasters like of CCD (Colony Collapse Disorder), neonicotinoid insecticides, etc. It is suggested to put in place a centrally coordinated system with state-wise branches and international cooperation proposed by the author called DSFDMS consisting of 4 units, the first essentially in government sector and other three may be in private sector:

a) **Immediate establishment of Disease diagnostic laboratory**.
b) **Highly qualified disease diagnostic officials/inspectors**
c) **Colony loss surveys:** Periodic survey of honeybee colonies in liaison with stake holders to the quantum and cause of such losses.
d) **Cadre of trained persons:** A strong professional technical cadre has to be raised to operationalize findings and recommendations of above 3 units at beekeeper's apiaries.
e) **"National beekeeping medication policy":** Discussed earlier.

I. Honey Production, Value Addition, Diversification and Quality Control

1. Deteriorating Honey Quality: The quality of honey being produced now is really worrisome due to contamination by antibiotics, lead, etc. Some of the reasons are extraction of unripe honey from brood chambers and not from supers (99.99%); storage in tin containers (though plastic buckets were introduced but later almost withdrawn); use of un-recommended chemicals applied using wrong methods and time; low production, etc. Though traceability system is in place but has been breached completely by exporters and days may not be far off when another ban could be re-imposed on India.

2. Adulterated and fake honey: Recent reports of large scale adulteration of honey with sugar by beekeepers and especially traders coupled with import of fake/spurious honey entering Indian market may prove disastrous and kill this enterprise which is entirely export oriented. Recently, large imports of invert/corn syrup, etc. have been reported and there is a strong fear that it may enter into honey industry. A strong and immediate action from government is solicited.

3. Export and domestic marketing: Honeys confirming to international quality standards are exported mainly to US, EU and middle-east but rest finds way to domestic market as proposed domestic honey standards (at par with international standards) are still not promulgated. Indian customer can't be put to such great risk and government has to act fast and decisively.

4. Honey testing lab: With a great magnitude of contaminants in Indian honeys, its export is jeopardized owing to policy of "zero-tolerance of contaminants" in importing countries. To analyze such an array of contaminants, highly sophisticated testing facilities is essential involving fixed assets of nearly Rs. 15 crores in addition to trained manpower, running cost, etc. There is no accredited honey testing lab in India and all samples are sent to Germany for analysis and export certification. It is not only time consuming but also economically exorbitant involving a cost of about Rs. 20,000 per sample. It is absolutely necessary to establish a centralized testing lab by the government with free testing facilities. The most state of the art testing lab in food sector in India is in the private sector (Kashmir Apiaries Export) and till the establishment of government laboratory; possibilities to use its services may be explored.

5. Diversification: Tremendous scope exists and it is the need of the hour in present times of declining profitability to diversify beekeeping into many full-fledged industries like – hive bee products (royal jelly, pollen, bee venom, propolis, etc.), manufacturing (equipments and tools), marketing (honey); value added products (honey and hive products), research, pollination (high-tech and high-value crops, enclosures, general crops), bee rearing (specialized), apitherapy, ayurvedic/naturopathy and pharmaceuticals, transportation (migration), food industry, confectionary/bakery, cosmetic industry, etc. No other industry has potential to diversify into such great independent variants.

6. Production of specialized hive products: To make beekeeping really sustainable and profitable, it is pertinent to diversify into the production, processing, storage and marketing of specialized hive bee products like royal jelly (RJ), pollen, propolis, bee venom, etc. These are highly skilled initiatives with immense export potential. As proposed earlier for bee breeders, provision of specialized trainings, specialized equipments and infrastructure package along with marketing support, needs to be provided.

J. Marketing Constraints

Honey marketing is in unorganized sector and mainly export oriented. It is a specialized field and best left to professional. Product margin could go even beyond 200% for traditional products and astonishingly for specialized products. A sharp increase in domestic consumption in India is witnessed from 8.4 grams per capita in 1993 to 25.6 g now (Chaudhary, 2014, pc).

1. Marketing ventures: There are many examples of development of wonderful products by many companies (Honey Bee Natural Products, Kashmir Apiaries, etc.) and their subsequent failures only due to faulty marketing strategies. In contrast there are successful marketing ventures also that included first "Honey Parlour" in India at CBRTI, Pune developed by the author and honey marketing network in KVIC, "Honey Hut", Dabur, etc. There are successful ventures of private labeling by the exporters for international clients as well as Indian marketing chains.

2. Comprehensive marketing policy and support for honey and value added products: Beekeepers are poor and due to many factors like low product retention capacity, lack of capital, lack of knowledge, etc. and are unable to market their product which is slow moving and have seasonal consumption pattern. A comprehensive support system right from crop forecast, trends, prices, procurement, processing, value addition, advertisement, awareness, sale, etc. is urgently required involving government, beekeeper, honey exporter, etc. to safeguard the interest of the beekeepers. The real players have to be private entrepreneurs and the government at best can provide infrastructure and policy support. Demand of government's support in fixing "minimum prices" or direct marketing support are ill advised, failed previously and out dated as the prices are governed by production (domestic and international), demand, export orders, pooling strategies of honey exporters, etc which are outside the influence/purview of government.

K. Conservation of Bee Plants, Pollinators and their Habitat

A global problem with more pronounced results in developing countries, demands holistic approach with natural resource conservation in response to rapidly declining pollinator population threatening the productivity and even survival of important commercial crops.

1. Conservation of wild bees: The most endangered honeybee species are rock bees and dwarf bees whose population has dwindled alarmingly and no efforts are being made to conserve these species.

2. Propagation and conservation of bee plants: The propagation efforts should supplement prioritization of bee plants over purely woody/timber species in the forest (social forestry), ornamental spaces, barren areas, etc. and needs coordination between various departments like forests, wasteland, environment, agriculture and rural development, etc.

3. Permission to utilize government farms/land by beekeepers: Presently there is no policy to utilize vast tracts of forests, plantation and farm land of government for beekeeping (temporarily during flowering period only), wasting valuable resources and hindering biodiversity enrichment.

It could be concluded that besides facing endless constraints beekeeping has potential not only to full the bellies of Indians and the world through increased production and productivity but can make it nutritionally perfect in the most sweeter way. The only thing required is little attention and the way we look at this tiny but most magnificent friend of humanity.

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Plate-1: Commercial Production of Royal Jelly in Bench-Mark Setup

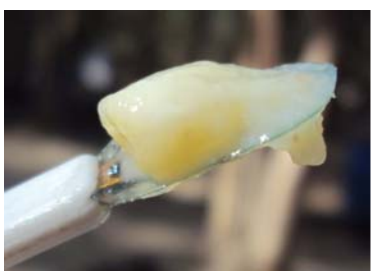

Thousands of queen cells produced using mass queen rearing technique

Queen larvae floating in Royal Jelly

Removing larva

Scooping Royal Jelly

Extracting Royal jelly in Factory-like setup



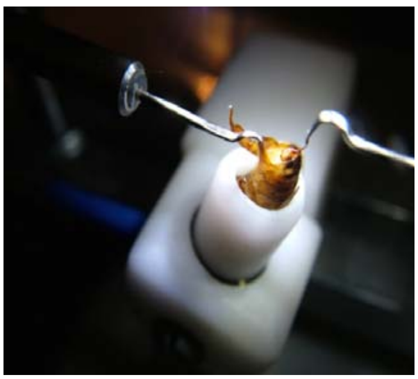

Commercial production of more than 4000 human doses of Royal Jelly

Plate-2: Instrumental Insemination of Queens

Dr. O.P. Chaudhary inseminating queens

Squeezing drone to get semen

Drawing semen into micro-pipette



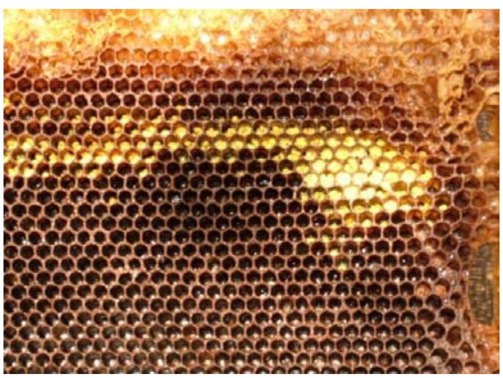
Opening vagina of unconscious"gyne"

Inseminating "gyne" with drone semen

Plate-3: Pollen Collection and Pollen Feeding


Universal easy to use POLLEN TRAP developed by Dr. O.P.Chaudhary


Easiest way of feeding pollen to colonies is to pour collected and dried pollen into cells




Sprinkle fine sugared water and place in colony

ROLE OF HONEYBEES AND OTHER POLLINATORS IN CROP PRODUCTIVITY AND IMPACTS OF CLIMATE CHANGE

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ABSTRACT

Most of the agricultural and horticultural crops and flowering plant species rely mainly on animal pollinators. Of the hundred or so animal-pollinated crops which make up most of the world's food supply, at least 80% are pollinated by wild bee species, honeybees and other forms of wildlife. Most of the 25,000 to 30,000 species of bees are effective pollinators, and together with moths, flies, wasps, beetles and butterflies, make up the majority of pollinating species. Current understanding of the pollination process shows that, while interesting specialized relationships exist between plants and their pollinators, healthy pollination services are best ensured by an abundance and diversity of pollinators. Thus, honeybees and other pollinators are essential for diet diversity, biodiversity and the maintenance of natural resources.

Threats to honeybees and others pollinators and the services they provide are perceived to be increasing around the world and are largely man-made in origin. Climate change could be a major factor in weakening the bees and has affected the pollination of crops in many agricultural areas. Climate change has the potential to affect the distribution of pollinators and the plants they pollinate, as well as the timing of flowering and migration. It is recognized that agricultural production, agro-ecosystem diversity and biodiversity are threatened by declining populations of pollinators and honeybees. Many pollinator population densities are being reduced below those levels at which they can sustain pollination services in agro-ecosystems, natural ecosystems, and maintain wild plant reproductive capacity. Ecological dangers of pollinator decline include the loss of essential ecosystem services (particularly agro-ecosystem services) and functions that pollinators provide.

In this paper, an attempt has been made to know the role of honeybees in crop pollination; causes of decline of their population especially in relation to climate change, their conservation and management practices and impact of declining pollinator population on crop productivity.

Keywords: Pollination, honeybee, foraging, *Apis cerana, Apis mellifera*

Introduction

Pollination is the transfer of pollen grains from male to the female part of the flower with the help of abiotic and biotic pollen dispersing agents. Wind, water and gravity are the important abiotic agents, whereas, insects, birds, bats and small mammals are the primary biotic agents. Among insects, honeybees are considered as the most efficient pollinators of cultivated crops because of their floral fidelity, potential for long working hours, presence of pollen baskets, maintainability of high populations, micromanipulation of flowers and adaptability to different climatic conditions. It is not only the self-sterile varieties which require cross-pollination, but self-fertile plants also produce more seeds of a better quality if pollinated by honeybees and other insects (McGregor, 1976; Mattu and Mattu, 2003, 2010).

The efficiency of a bee colony as a pollinator of agricultural crops depends on numerous factors like colony strength, number and time of placement of colonies, distribution of colonies in the fields/orchards, weather conditions, attraction of bees to blooming crops, etc. If all these factors could be managed properly, the productivity of cultivated crops could be enhanced several times through bee pollination **(**Verma, 1992; Mattu *et al.*, 2012**)**.

The vital role that honeybees play in enhancing the productivity levels of different agricultural and horticultural crops has often been underestimated especially in developing countries, but bee pollination research carried out in western countries has revealed that the main significance of bees and beekeeping is in cross-pollination, whereas, hive products like honey and beeswax are of secondary value. Cross-pollination of entomophilous crops by honeybees is one of the most effective and cheapest methods of increasing their yield. Other agronomic practices like manuring, pesticides, fertilizers etc. are quite cost effective and these may not yield the desired results without the use of honeybees for enhancing the productivity levels of different crops by pollination. Although it is difficult to quantify the non-consumptive benefits of increasing crop yield through cross-pollination by honeybees, yet the value of bee-pollination, based crop production in the United States has been estimated at 20 billion US Dollars per year. A FAO report indicated that direct contribution of pollination to increase farm harvest was 3.2 billion in developing countries and 5.2 billion US Dollars per year in 20 Mediterranean countries (Verma, 1992; Verma and Jindal, 1997). A recent study by ICIMOD revealed that of different crop categories, fruit crops have the highest EVIP (Economic Value of Insect Pollination) estimated at US Dollars 2.3 billion followed by oilseed crops (USD 233.1 million) and vegetable crops (USD 78.5 million). Pulses (2.68 million) and spice crops (5.49 million) have significantly lower EVIP values (Partap *et al.*, 2012).

Pollinators which evolved over millions of years, are eroding at a fast rate from the globe. During the past few years, many pollinators especially honeybees have been dying across the globe in unprecedented number and, no one has so far been able to prove beyond a reasonable doubt what the causes may have been. The economic implications of these deaths are immediate because honey bees are integral to the pollination of tens of millions of dollars of cash crops in the world (Gallai *et al.*, 2009; Mattu and Mattu, 2014). Despite much of the world’s agriculture relying on pollination by honeybees, especially European honeybees, their number across the globe has also declined. Many other pollinators such as digger bees, sweat bees, alkali bees, squash bees, leafcutter bees, carpenter bees, mason bees, and shaggy fuzzy foot bees could also be on decline, but data providing unambiguous documentation of trends are simply not available. Threats to pollinators and the services they provide are perceived to be increasing around the world and are mainly man-made in origin. Climate change could be a major factor in weakening the bees and has affected the pollination of crops in many agricultural areas.

1. Diversity of Pollinators

Majority of wild crops and flowering plant species depend upon animal pollinators for fruit and seed production. Of the hundred or so animal-pollinated crops which make up most of the world’s food supply, at least 80% are pollinated by honeybees, wild bees and other forms of wildlife. Bees are the most dominating pollinators of agricultural crops. The diversity of pollinators and pollination systems is striking. Most of the 25,000 to 30,000 species of bees are effective pollinators, and together with moths, flies, wasps, beetles and butterflies, make up the majority of pollinating species. Vertebrate pollinators include bats, non-flying mammals (several species of monkey, rodents, lemur and tree squirrels etc.) and birds (humming birds, sun birds, honey creepers and some parrot species). Current understanding of pollination process shows that, while interesting relationships exist between plants and their pollinators, healthy pollination services are best ensured by an abundance and diversity of pollinators. Approximately 73% of world's cultivated crops, such as cashews, squashes, mangoes, cocoa, cranberries and blueberries are pollinated by bees, 19% by flies, 6.5% by bats, 5% by wasps, 5% by beetles, 4% by birds, and 4% by butterflies and moths. Of the hundred principal crops that constitute most of the world's food supply, only 15% are pollinated by domestic bees (mostly honeybees, bumble bees and alfalfa leafcutter bees), while at least 80% are pollinated by wild bees and other wildlife forms (Gallai *et al*., 2009; Mattu and Mattu, 2007, 2010).

In agro-ecosystems, pollinators are essential for orchard, horticultural and forage production, as well as the production of seed for many root and fibre crops. Pollinators such as bees, birds and bats affect 35 percent of world's crop production, increasing outputs of 87 of the leading food crops worldwide, besides many plant-derived medicines for pharmacies. Food security, food diversity, human nutrition and food prices all rely strongly on animal pollinators.

2. Honeybee Diversity and Crop Pollination

At present four or more species of honeybees are found in the Indian sub-continent. Of these, *Apis cerana* F., *Apis dorsata* F. *laboriosa* and *Apis florea* F. are native to this region, whereas, the European honeybee, *Apis mellifera* L. was introduced in the northern India during mid-sixties for increasing honey production and crop productivity. *A. cerana* is considered equivalent to *A. mellifera* because both of these species build parallel combs and can be domesticated**.** The genetic diversity of *A. mellifera* has been organized into 24 sub-species having varied economic usefulness. These sub-species are adapted to a wide range of ecological conditions and occur at latitudes ranging from 0^{o} (equator) to 50^{o} N and 30^{o} S **(**Verma, 1990**)**. With regard to native bee species, *A. cerana,* our research group at Himachal Pradesh University, Shimla has successfully identified and recognized three sub-species of *A. cerana viz*., *A. cerana cerana, A. cerana himalaya* and *A. cerana indica* corresponding to the geographic distribution in the Northwest, Northeast Himalayas and South India respectively **(**Verma *et al*., 1994; Mattu and Mattu, 2010**)**. There may be similar geographic populations of *A. cerana* in different parts of the country. Such tremendous biodiversity of honeybees can be utilized for increasing crop productivity in India and may help in providing food and nutritional security to millions of poor people below poverty line **(**Mattu and Mattu, 2007, Mattu *et al.*, 2012**)**.

3. Principles of Bee Pollination

Most of the investigations of crop pollination have been carried out in developed countries where the European honeybee, *Apis mellifera* has been extensively utilized to increase the yield of different cultivated crops. However, there is very little information available on the role of the Asian hive bee, *Apis cerana*, in pollinating agricultural crops in the developing countries of South and Southeast Asia. Both these species of honeybees, however show remarkable similarities in foraging behaviour, thus the basic principles involved in crop pollination by these two species of honeybees should not differ significantly (Verma, 1992; Verma and Jindal, 1997; Mattu and Mattu, 2007, 2010). The efficiency of a bee colony as pollinator would depend upon the following factors:

Colony Strength

Larger and stronger colonies are four to five times better pollinators than smaller and weaker ones because the former have a higher percentage of older bees as foragers. Good honey yielding colonies are better and more efficient pollinators also. It has been estimated that one colony of *Apis mellifera* with 60,000 worker bees produces one and a half times more honey than four colonies with 15,000 bees each. The same is true for pollination activity also. The strength of a colony depends upon the honeybee breed, the availability of nectar and pollen plants as food resources and the management practices employed and also upon the season. In the Western Himalayan region, during winter, the colony strength is poor because of low temperatures and dearth of bee flora. In early spring, when honeybee colonies are required for the cross-pollination of apple blossom in this region, these colonies do not build up enough strength for effective pollination. Keeping in view this constraint, apple growers in Himachal Pradesh move their colonies to lower altitudes, where winters are warmer and there is no dearth of bee flora, so that in spring, at the time of the apple blossom, they are available in adequate strength for effective pollination.

Number and Time of Placement of Colonies for Pollination

The number of colonies required for the pollination of different cultivated crops depends upon the following factors: density of plant stand; total number of flowers in inflorescence of one plant; number of flowers over an area of one hectare of land; duration of flowering and strength of bee colonies. In general, two colonies of *Apis mellifera* per hectare of crop in blossom are proposed for sufficient and efficient pollination. Keeping in view the smaller colony size of *Apis cerana* and also its shorter flight range, three colonies per hectare are recommended (Verma, 1990; Verma and Jindal, 1997).

Distribution of Colonies in the Field/Orchards

Honeybees, as a rule, primarily visit those sources of nectar flow which are within 0.3 to 0.5 km/radius from the apiary. At a distance of more than 0.5 km, pollination activity diminishes significantly. In the Western Himalayas, because of the small size of farm holdings and also due to the practice of mixed cropping, spacing of colonies and their optimum arrangement do not pose a serious problem as in developed countries, where mono-culture in farming systems is a common practice. For effective pollination, *Apis cerana* hives should be placed singly instead of in groups. Honeybees always tend to forage in the area closest to the hive, particularly when the weather is not favourable.

Time and Placement of Colonies in the Field/Orchard

Bee colonies should be placed in the field or orchard when 5 to 10 per cent crop is in bloom. Earlier placement of colonies would result in foraging of the bees on other weeds and wild plants present in the vicinity of the orchard and would ignore the crop in bloom. If the bees are moved late, they only pollinate the late and less vigorous flowers.

Weather Conditions

Weather plays an important role in determining the success or failure of pollination programmes, as it affects both bee activities as well as seed/fruit setting. For example, in the temperate climate of the northwest Himalayas, apple trees are in bloom in early spring when the temperature is low. Flower buds may be killed by frost injury and also adversely affect the foraging activities of bees. As reported earlier, native hive bee *Apis cerana* can forage at lower temperatures than its European counterpart, *Apis mellifera*. Wind velocity of 15 miles per hour or more also adversely affects the foraging behaviour of bees. It is, therefore, recommended that a wind-break around the crop field/orchard should be provided.

Attracting Bees to a Crop in Bloom

Russian bee scientists have strongly advocated the theory that bees should be fed flavoured syrup of the flowers required to be pollinated in order to attract large numbers of them for effective pollination. Theoretically, this seems to be a logical approach, but in practice it does not always yield the desired results. In Sweden, Canada and U.S.A., various research workers have also tried essential oils or flavours, especially from apple flowers, and their results are inconclusive (Verma and Jindal, 1997; Mattu and Mattu, 2007).

Another method of attracting bees to a particular crop in bloom is by sowing a high nectar-yielding crop among other crops which are poor in nectar secretion. For example, sweet clover requires cross-pollination by bees for good seed yield. But this crop is not very attractive to bees due to poor or very low quantity of nectar in the nectaries of this plant. However, by sowing other nectariferous plants such as buckwheat, a larger number of bees are attracted to this crop. A crop to be pollinated can also be made more attractive to honeybees if nectar production in the nectaries is increased by breeding techniques or by improving other agronomic practices such as addition of fertilizers and manure, or better irrigation facilities.

4. Honeybees and Sustainable Crop Productivity

a. Temperate fruit crops

Temperate fruit crops, popularly known as 'Hill fruits' are grown in the Himalayan region at an altitude of 1400 m or above. Important temperate fruits of the Western Himalayan region are: apple (*Malus domestica* Borkh), cherry *(Prunus avium* L.*)*, peach *(Prunus persica* Batsch*)*, almond *(Prunus amygdalus* Batsch*)*, apricot *(Prunus armeniaca* L.*)*, plum *(Prunus domestica* L.*)* and pear *(Pyrus communis* L.*)*. Most of these temperate fruits are self-incompatible in nature and need the services of different insect visitors for successful pollination (Verma and Jindal, 1997; Mattu and Mattu, 2003, 2007, 2010).

Our research group at Himachal Pradesh University, Shimla has made comprehensive studies on the pollination ecology of temperate fruit crops (Figs. 1, 2, 4) on the following lines:

Diversity, Distribution and Abundance of Insect Pollinators

Relative abundance of insect visitors on the bloom of different crops depends upon the geographical distribution, climatic conditions, availability of natural sites for resting and hibernation and relationship between the plant and the insect species. Our Sociobiology research group has made detailed studies on number of insect visitors and their relative abundance on the bloom of apple, plum, cherry, pear, peach and almond crops (Verma and Dulta, 1986; Mattu and Chaudhary, 1993; Mattu *et al*., 1994, 1996, 2012; Rana *et al*., 1995).

These studies indicated that a total of 70 species of insect pollinators visit temperate fruit crops. Of these, 44 were on apple, 20 on plum, 34 on cherry, 22 on pear, 37 on peach and 29 on almond bloom. *A. cerana* and *A. mellifera* were the most abundant species on all the temperate fruit crops. Other important pollinators were: *Bombus* spp., *Vespa* spp., *Halictus* spp., *Eristalis* spp., *Syrphus* spp., *Pieris* spp., *Coccinella* spp. etc. (Table 1). These studies suggest that hymenopterans were the most abundant insect pollinators on apple, plum, pear and almond crops, whereas, hymenopterans and dipterans were almost equally predominant on peach and cherry crops.

Table 1: Diversity of insect species visiting temperate fruit crops with their taxonomic status

Order HYMENOPTERA	**Order DIPTERA**	**Order LEPIDOPTERA**	**Order COLEOPTERA**	**Order HEMIPTERA**	**Order THYSANOPTERA**
Family APIDAE 1. *Apis cerana* 2.*Apis mellifera* 3. *Apis dorsata* **Family BOMBIDAE** 4. *Bombus tunicatus* 5. *B. haemorrhoidalis* 6. *Bombus* sp. **Family VESPIDAE** 7.*Vespa mandarina* 8.*Vespa velutina* 9.*Vespa flaviceps* 10.*Vespa magnifica* 11.*Vespa auraria* 12. *Vespa* sp. 13.*Polistes maculipennis* 14. *Polistes* sp. **Family HALICTIDAE** 15. *Halictus dasygaster* 16. *Halictus* sp. **Family ANDRENIDAE** 17. *Andrena* sp. **Family XYLOCOPIDAE** 18.*Xylocopa fenestrata* **Family FORMICIDAE** 19. *Camponotus* sp. 20. *Holocomyrmex* sp. **Family CERETINIDA**	**Family SYRPHIDAE** 25. *Eristalis tenax* 26.*Eristalis himalayaensis* 27. *Eristalis cerealis* 28. *E. angustimarginalis* 29. *Eristalis arvorum* 30. *Eristalis* sp. 31. *Metasyrphus* sp. 32. *Macrosyrphus* sp. 33. *Episyrphus balteatus* *34. Episyrphus* sp. 35. *Scaeva opimius* 36. *Scaeva* sp. 37. *Melanostoma*sp. 38. *Syrphus* sp. **Family MUSCIDAE** 39. *Musca domestica* 40. *Musca* sp. 41. *Fannia domestica* 42. *Orthelia* sp. **Family CORDYLURIDAE** . *Scathophaga stereoraria* **Family CALLIPHORIDAE** 44. *Calliphora vicina* 45. *Lucilia* sp. **Family SEPSIDAE**	**Family PIERIDAE** 49.*Pieris canidia* 50. *Pieris* sp. 51. *Delias* sp. 52. *Gonepteryx rhamni* **Family NYMPHALIDAE** 53. *Pyrameis indica* 54. *Vanessa cance* 55. *Vanessa* sp. 56. *Neptis* sp. **Family NOCTUIDAE** 57. *Heliothis* sp. 58. *Plusia*sp. 59. *Agrotis flammatra* 60. *Agrotis* sp. 61. Sphinx moth **Family LYCAENIDAE** 62. *Heodes* sp. 63. *Heliophorus* sp. **Family ZYGANIDAE** 64. *Zyganea* sp.	**Family COCCINELLIDAE** .*Coccinella septumpunctata* 66. *Coccinella* sp. **Family CHRYSOMELIDAE** 67. *Altica* sp.	**Family CIXIIDAE** 68. *Nysius* sp. 69. *Adolenda typicaic*	**Family THRIPIDAE** 70. *Thrips* sp.

Order HYMENOPTERA	**Order DIPTERA**	**Order LEPIDOPTERA**	**Order COLEOPTERA**	**Order HEMIPTERA**	**Order THYSANOPTERA**
E 21.*Ceratina hieroglyphica* **Family TENTHRIDINIDAE** 22. *Athalia* sp. **Family ICHNEUMONIDAE** 23. *Fileantha* sp. **Family SCOLIIDAE** 24. *Elis thoracica*	46. *Sepsis* sp. **Family ASILIDAE** 47. *Promachus* sp. **Family DOLICHOPODIDAE** 48. *Dolichopus* sp.				

Foraging Behaviour of Indian and European Honeybees in Pollinating Temperate Fruit Crops

Based on the extensive foraging studies conducted by our research group (Mattu and Mattu, 2007, 2010) on temperate fruit crops (Table 2), it seems that *A. cerana* has several advantages over *A. mellifera* for the pollination of these fruit crops:

- *A. cerana* commences its activity earlier in the morning at lower temperature and ceases later in the evening than *A. mellifera.*
- The average daily duration of foraging activity of *A. cerana* is longer than that of *A. mellifera*. Thus, *A. cerana* may ensure adequate pollination in less time period than *A. mellifera.*
- *A. cerana* seems to have better foraging speed and foraging rate than *A. mellifera* on temperate crops.
- Both the species of honeybees showed diurnal fluctuations in the percentage of pollen, nectar and pollen plus nectar collectors. Pollen collectors were significantly more in the morning hours on all the temperate fruit crops whereas, nectar collectors outnumbered pollen collectors in the evening.
- Both *A. cerana* and *A. mellifera* preferred to forage on middle and top heights of fruit trees.
- The flight range of *A. cerana* is less as compared to *A. mellifera,* thus, *A. cerana* could be better suited for the pollination of specific crops grown on smaller plots.
- Foraging activity of honeybees showed a significantly positive correlation with temperature and a significant negative correlation with relative humidity
- *A. cerana* requires low maintenance costs in comparison to *A. mellifera* which needs expensive technology.
- Over and above, *A. cerana* has co-evolved with a large number of fruit crops of the Himalayan region, hence this native bee may prove better pollinator than *A. mellifera.*

Table 2: Comparative foraging behaviour of *A. cerana* and *A. mellifera* on temperate fruit crops in Northwest Himalayas

(Values are R.V. of Means)

Parameter	*A. cerana*	*A. mellifera*
Commencement of foraging (Time of day)	0559-0706	0616-0756
Cessation of foraging (Time of day)	1835-1913	1758-1856
Duration of foraging activity (h)	11.30-13.10	09.85-12.40
Peak foraging hours:		
Apple	0900-1130	1100-1320
Plum	1000-1300	1100-1300
Cheery	1000-1400	1100-1300
Peach	1200-1300	1200-1400
Almond	1300-1400	1200-1300
Duration of foraging trip (min)	13.93-15.11	14.51-17.92
Time spent per flower (sec)	05.56-10.95	06.63-20.50
Number of flowers visited per minute	05.60-10.74	03.74-08.00
Pollen load carried per bee (mg)	08.99-14.60	07.76-16.60
Percentage of unifloral / multifloral loads		
(UF)	72.65-97.86	55.90-97.33
(MF)	02.14-27.35	2.67-44.10
Preference to different heights of tree		
Apple, cherry, plum	Middle	Middle
Peach	Top	Top
Almond	Top & Middle	Top & Middle

b. Vegetables Crops

Availability of the desired quantity of quality seed is one of the most important aspects for a successful vegetable industry. For the production of such quality seeds, sufficient or adequate cross-pollination of vegetable crops is essential. Further, many of the vegetable crops are completely or partly self-incompatible and incapable of pollinating themselves. Cross-pollination by honeybees is, therefore, very important. Vegetable flowers in return are excellent sources of pollen and nectar to bees (Verma, 1990; Sihag, 1995a, b; Atwal, 2000; Abrol, 2010).

Recently in some parts of the Western Himalayan region, a large area of land is coming under off-season vegetable production which brings to the farmer four to five times higher income than the normal seasonal vegetables (Verma, 1990, 1992). Similarly, in other parts of the northern India, vegetable cultivation is expanding rapidly because of the change in the food habits of the people and also because it is a source of cash income (Sihag, 1995a, b). Keeping this in view, the demand for high quality vegetable seed at a cheaper rate will increase tremendously in the future. One way to meet such demands will be through the utilization of pollination services of honeybees and including beekeeping as an essential component of vegetable seed production technology.

It is now well-documented that cross-pollination by honeybees helps in increasing the yield and quality of vegetable seeds (Atwal, 2000; Abrol, 2010). This activity of honeybees also hampers pure seed production in such crops due to intercrossing. This problem can be solved by providing the necessary isolation distance between different cultivars of the same crop in order to avoid crossing and contamination. Foraging areas of the adult worker bees are always limited and they keep their foraging activities confined to this particular area only during their successive field trips to collect pollen, nectar or both. In cases where fields with compatible varieties/cultivars are quite adjacent, chances of intercrossing or contamination will be more. However, in distant fields with compatible varieties or cultivars, foraging areas of bee visits will not overlap and pure seed production is possible. Such actual isolations distance would depend upon the degree of the purity of seed required (Verma, 1990).

c. Oilseeds Crops

Oilseeds play an important role in the national economy of many countries. Oils and fats derived from oilseeds not only constitute an essential part of human and animal diet, but are also indispensable. It has been noticed that oilseed production in some parts of the country is either stagnant or declining gradually (Verma, 1990; Mishra and Garg, 2002; Abrol, 2010). Efforts are being made by different Government agencies of the region to bring more area under oilseed production in order to meet the growing demand. One way of increasing oilseed production is by introducing a planned honeybee pollination programme as one of the essential inputs which has not been so in this region. The main reason for which is ignorance on the part of the agriculture extension agencies and farmers.

Among the important oilseed crops, groundnut, mustard, sesame, safflower, niger and sunflower are extensively grown in India. Since most of these crops, except groundnut, are cross-pollinated, adequate pollination is vital for increasing the yield per unit area of the land. It is also now well-documented that pollination by honeybees ensures uniform maturity and early harvest of these oilseed crops, thus facilitating timely sowing of the next crop in rotation (Tables 3, 4; Fig. 3). In view of such encouraging results, farmers in India are being given honeybee pollination demonstrations by different extension agencies in various parts of the country to create awareness of the beneficial effects of honeybee pollination.

d. Fodder and other Miscellaneous Crops

Improvement of animal products such as beef, pork, poultry, lamb or dairy products, is strongly dependent upon improving the quality and quantity of fodder and livestock ration feed. Availability of such quality fodder in sufficient quantities would depend upon reliable, cheap and good quality seed supplies. Three conventional components of seed quality (i.e. physical, genetical and vital quality) are greatly improved if the flower in bloom is pollinated by honeybees. Many of the fodder crops are dependent on or benefited by honeybee pollination. Major fodder crops grown in India are: alfalfa, clover, trefoil, vetch and sainfoil. For all these crops, cross-pollinating is either essential or beneficial to enhance their seed production (Table 3).

Besides fodder crops, some miscellaneous crops like buck wheat, coffee, cotton, field beans and cardamom (Tables 3, 4), which is one of the world's costliest seed species and a cross-fertilized crop, also depends exclusively upon honeybees for pollination. A large number of insect pollinators such as different species of honeybees, wild bees, dipterans, coleopterans lepidopterans etc. help in pollination of above crops (Verma, 1990; Sihag, 1995a, b; Abrol, 2010). However, honeybees are the main pollinators constituting more than 88 per cent of the total insect pollinators and help in increasing their crop productivity (Table 4).

Table 3: Percentage increase in yield of some crops due to bee pollination

Crop	Increase (%)	Crop	Increase (%)
Fruit crops		**Fodders and legumes**	
Apple	18.00-69.50	Alfalfa	23.00-19,733
Almond	50.00-75.00	Berseem	193.00-6,800
Apricot	5.00-10.0	Clovers	40.00-33,150
Cherry	56.00-1000	Vetches	39.00-20,000
Citrus	7.00-223.00	Birds foot	3.00-1000
Grapes	23.00-54.00	**Miscellaneous crops**	
Guava	12.00-30.00	Buck wheat	63.00-100.00
Litchi	453.00-10,246	Coffee	17.00-39.00
Plum	536-1,655	Cotton	2.00-50.00
Vegetable crops		Field beans	7.00-90.00
Cole crops	100.00-300.00	**Oilseed crops**	
Radish	22.00-100.00	Mustard	13.00-222.00
Carrot	9.00-135.00	Safflower	4.00-114.00
Turnip	100.00-125.00	Sunflower	21.00-3,400
Cucumber and squashes	21.00-6,700	Sesame	24.00-40.00
Onion	353.00-9,878	Niger	17.00-45.00
Cabbage	100-300.00	Linseed	2.0-49.00

Source: Compiled from multiple sources

Table 4: Pollination data on management of different crops with the help of honeybee colonies

Crop	Blooming period of the crop	Number of *A.mellifera* colonies/ha	Number of *A.cerana* colonies/ha	Time of placement of colonies
Fruit crops				
Almond	Mid - February to mid- March	5-8	10-12	5-10% bloom
Apple	April (7-10) days	5-8	10-12	5% bloom
Apricot	Mid - February (2-3 weeks)	2-3	4-6	5-10% bloom
Avocado	April -May	5-8	10-12	10-15% bloom
Cherry	February (7-10) days	2-3	4-6	5% bloom
Citrus	March-April	2-3	4-5	5-10% bloom
Kiwifruit	March-April	8-9	16-20	5-10% bloom
Litchi	March-April	2-3	4-6	5-10% bloom
Mango	February	2-3	4-6	5-10% bloom
Peach	February - March (3-4 weeks)	1-2	2-3	5-10% bloom
Persimmon	March-April (2 weeks)	2-3	4-6	5-10% bloom
Plum	February (l-2 weeks)	2-3	4-6	5% bloom
Strawberry	February to April (2 months)	>15	25	5-10% bloom
Vegetable crops				
Cabbage	February -March	5	8-10	10-15% bloom
Carrot	March-April	5-8	10-12	10-15% bloom
Cauliflower	March-April	5	8-10	10-15% bloom
Cucumber	June -September	1 for	2-3 for	10-15% bloom

		monoecious 8 for dioecious	monoeious 12-16 for ioecious	
Cucurbits (pumpkin, squash gourd)	June -September	5-8	10-12	10-15% bloom
Okra	June -September	1-2	2-3	10-15% bloom
Onion	April	5-8	10-12	5-10 % bloom
Radish	March-April	2-3	4-6	10-15% bloom
Turnip	February -March	2-3	4-6	5-10% bloom
Oilseed crops				
Mustard and rape	December-January- February-March	3-5	5-8	10-15% bloom
Niger	August-September	3-5	6-8	5-10 % bloom
Safflower	March-April	5	4-6	5-10% bloom
Sunflower	June	5	8-10	5-10% bloom
Spice crops				
Cardamom	March-April	2-3	4-6	10-15% bloom
Chilli	July-September	2-3	4-6	10-15% bloom
Coriander	February-April	2-3	4-6	10-15% bloom

Source: Compiled from multiple sources

e. Decline Of Honeybees And Other Pollinators

Pollinators which have evolved over a very long period, are declining at a very faster rate throughout the world. Currently many important pollinators especially honeybees have been dying across the globe in an unprecedented manner and no proper reasons for this declining trend have been suggested so far by different authorities (Tables 5, 6). This constant decline in honeybee and other pollinators population will have serious ecological and economic implication in the long run because they are integral to the pollination of most of agricultural, horticultural and cash crops in the world (Gallai *et al*., 2009; Mattu and Mattu, 2007, 2010). Many other pollinators such as digger bees, sweat bees, alkali bees, squash bees, leafcutter bees, carpenter bees, mason bees and shaggy fuzzy foot bees are also declining, but data providing unambiguous documentation of trends are simply not available.

Table 5: Population decline of honeybees in world scenario

Country	Percentage decline	Duration
Germany	57	Last 15 yrs.
U.K	61	Last 10 yrs.
U.S.A	>50	Last 20 yrs.
Poland	>35	Last 15 yrs.
India	>40	Last 25 yrs.
Brazil	>53	Last 15 yrs.
Netherlands	58-65	Last 25 yrs.
China	>50	Last 20 yrs.

Source: (Gallai *et al.,* 2009; Mattu and Mattu, 2007)

Among wild pollinators, patterns of population change are clearest for large, warm-blooded species such as bats. Decline in bat populations has been so dramatic that two of the three U.S. pollen-feeding species are now listed as endangered under the U.S. Endangered Species Act.

Table 6: Data on decline in honeybee population and other pollinators in U.S.A.

Pollinators	% Loss in population
Honeybees	>50
Bumble bees	36
Solitary bees	30
Bats	14
Humming birds	16
Monarch butterflies	28

Source: (Kevan and Philips, 2001; Mattu and Mattu, 2007, 2010)

Causes of Decline of Wild and Domesticated Pollinators

No scientific facts are yet available on decline of the pollinators, however, based on our own observations (Verma, 1990, 1992; Mattu and Mattu, 2003, 2007, 2010, 2014) and experiences, it can be concluded that population of the pollinators especially the insect pollinators such as the honeybees, bumble bees, dipterans etc. is declining in the entire Indian sub-continent. Major factors responsible for the decline of pollinators are as follows:

- Excessive and indiscriminate use of chemical pesticides
- Land use changes, monoculturing and deforestation
- Conventional methods of honey extraction from wild bee colonies
- Minimal efforts for conservation of the native pollinators
- Agricultural intensification and promotion of high yielding composite and hybrid varieties
- Global warming/climate change
- Introduction of exotic vegetables
- Destruction of natural pasture lands
- Unawareness among the farmers and general public about significant role played by pollinators
- Natural calamities and perpetual forest fires
- Lack of promotional policies

Strategies for Conservation of Pollinators and Honeybee Diversity

Following strategies can be adopted for the conservation of honeybees and other pollinators:

- Use of broad spectrum pesticides should be avoided; only selective and relatively environmental friendly (REF) pesticides should be used where necessary.
- Recommended dose and concentration of pesticides should be used.
- Pesticidal application should be avoided during the blooming period of crops.
- It is useful to keep bee colonies as far away from the pesticides treated fields as possible.
- Pesticidal applications if possible, should be done in early morning or late evening hours.
- There is a need to create awareness among farmers and orchardists regarding pesticide application schedules and insecticidal poisoning of pollinators.
- Greater stress should be given on integrated pest management programmes so as to minimize the use of poisonous chemicals.
- Floral diversity should be conserved and maintained to encourage the wild pollinators
- To develop a technique for mass rearing of insect pollinators and survey of their natural nesting sites.

- Like other agro-inputs, managed pollination should be included in programmes of agriculture and horticulture departments
- Adoption of pollinator-friendly management practices
- Pollinator awareness programmes should be launched among farmers and general public.
- Enhanced integration of pollination issues into sectorial policies, including agriculture and environment.

5. Impacts of Climate Change on Honeybees and Other Pollinators

Climate change could be a major factor in diminishing the honeybee populations and is affecting the crop pollination in many agricultural zones. It could be the result of numerous factors, but historical records show that there are fluctuations in beehives every seven to eight years due to changing weather conditions and this in turn affect crop yields. Climate change also influences the distribution of pollinators and also the plants they pollinate, as well as the flowering time and migration. For migratory pollinators such as bats, humming birds and monarch butterfly, the identification and protection of nectar corridors is important. If nectar is unavailable anywhere along their migratory route at the time of migration, it could result in the death of a part of the population (Buchmann and Nabhan, 1996).

As climate changes, the habitats suitable for survival of pollinators may change with some areas being lost and others are being newly created. When a habitat disappears or the pollinator is unable to move to a new habitat, then local extinction can occur (Travis, 2003). Climate change may also disrupt the synchrony between the flowering period of plants and the activity season of pollinators (Price and Waser, 1998; Mattu and Mattu, 2007).

Influence of Declining Pollinator Population and Climate Change on Crop Productivity

It has been noticed that agricultural production, agro-ecosystem diversity and biodiversity are threatened by declining populations of pollinators and climate change. Many pollinator population densities are being reduced below certain levels at which they cannot sustain pollination services in agro-ecosystems, natural ecosystems and for the maintenance of wild plant reproductive capacity. Ecological dangers of pollinator decline include the loss of essential ecosystem services (particularly agro-ecosystem services) and functions that pollinators provide. Ecosystem services in turn have their own value not only biophysical, but also economical, for example, for the entire biosphere the value of ecological services (most of which is outside the market) was estimated to be in the range of US$ 16-54 trillion per year, with an average of US$ 33 trillion per year (Costanza *et al.*, 1987). The value of annual global contribution of pollinators to the major pollinator dependent crops is estimated to exceed US$ 54 billion. In the Canadian prairies, the value of pollinators to the alfalfa seed industry has been placed at about CAD 6 million per year (Kevan and Phillips, 2001).

Investigative studies from Asia show a linkage between declining natural insect population and decreasing crop yields - as a result, people have begun to manage crop-associated biodiversity (i.e. pollinators) in order to maintain their crop yields and quality. For instance, farmers in Himachal Pradesh, a northern Indian state, are using honeybees to pollinate their apples (Partap, 1999; Mattu and Mattu, 2010). Due to declining pollinator populations and changing cultivation practices, an increasing number of farmers around the world are now paying for pollination services and are importing and raising non-native pollinators to ensure crop production i.e. managed crop pollination. In many developing countries, however, external pollination services are not available and rural communities have to survive with reduced quantity, quality and diversity of foods (Partap and Partap, 2002;

Mattu and Mattu, 2007). In fruit orchards in western China, the decline of useful insect populations has led farmers to pollinate by hand, thus acting like human bees. Despite a general recognition of the impacts of declining pollinator population on ecosystem functioning and economy, certain bottle necks and constraints hinder the conservation and management of pollinators for sustainable agriculture (Partap *et al*., 2012; Mattu and Mattu, 2014).

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Plate-1: Insect pollinators on apple crop in Shimla hills

Apis dorsata

Apis cerana

Apis mellifera

Pieris indica

Plate-2: Insect pollinators on apple crop in shimla hills

Syrphus sp.

***Calliphora* sp.**

Musca domestica

***Vespa* sp.**

Plate 3: Insect pollinators on *Brassica* and *Cassia* crops in Haryana state

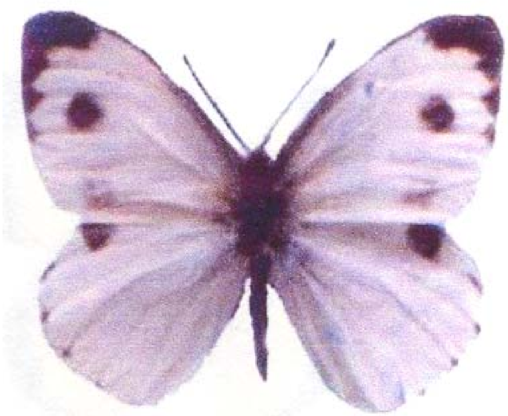
***Syrphus* sp. on on *Brassica* sp.**

***Eristalis* sp. on *Brassica* sp.**

***Apis dorsata* on *Brassica* sp.**

***Bombus haemorrhoidalis* on *Cassia* sp.**

Plate- 4: Lepidopteran pollinators of temperate fruit crops in H.P.



Pieris canidia

***Gonepteryx rhamni* female**

***Gonepteryx rhamni* male**

***Pieris* sp.**

HONEY BEE MANAGEMENT

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Key to success in beekeeping lies in proper management of honey bee colonies. As weather and floral conditions in Haryana and surrounding states vary a lot, management practices in different seasons also vary. Therefore, effective management of honey bee colonies during different seasons will boost colony development and productivity which ultimately improves profitability (Abrol, 2010). The management practices required, in general, to be undertaken during different seasons has been briefly discussed below.

I. Management Of Colonies In Spring Season

During this time, rapeseed, mustard and *Eucalyptus* are the major bee flora available apart from peach, pear and plum in certain areas. Weather also normally becomes favourable for bee activity and with the increase in temperature, foraging period of bees increases thereby resulting in increase in their total working hours in the field. Availability of plenty of nectar and pollen stimulate brood rearing resulting in rapid increase in bee population in honey bee colonies. This season is considered one of the best season to start beekeeping. Examine the colonies at the beginning of the season and do the needful for maximizing colony development and honey production. The various management operations needed to be undertaken during this period are as under:

Examination of honey bee colonies

Examine honey bee colonies on a warm and sunny day to avoid exposure of bees and brood to chilly weather. Following activities are to be undertaken generally during first examination of colonies this season:

i) Remove inner winter packing to make room for providing more combs or frames to cope-with the increased brood rearing/ egg laying activity.
ii) Clean the hive thoroughly and burry or burn the debris.
iii) Replace worn out hive parts.
iv) Inspect the colonies for availability of honey and pollen. The colonies in need of honey, may be provided with honey combs taken from colonies having surplus honey. Alternatively feed sugar syrup. The colony should also be examined for the availability of stored pollen and if found lacking it should be fed on stored pollen/ pollen substitute/ pollen supplement in early spring period. It would boost brood rearing and hence help in population build up well in advance so as to exploit the available/ ensuing bee flora to the maximum.
v) Check for the presence and performance of the prevailing queen bees. Lack of egg and larval brood in a colony indicates absence of queen bee. In such a situation, preferably provide good quality queen bee to the colony or unite it with another colony.
vi) Provide space to the colonies in the form of combs or comb foundation fitted frames.
vii) Presence of dead bees in colonies should be examined carefully and if some disease is suspected, the colonies should be shown to the experts and managed accordingly.

Stimulative Feeding

In those regions where rapeseed, mustard, temperate fruits and *Eucalyptus* flora is not available or bees are unable to exploit it due to unfavourable weather conditions, or sometimes because of non-availability of honey inside the colony, bees do not go out for foraging. Under these situations feeding of sugar syrup as stimulative feeding ensures that the colony attains optimum strength by the time the main honey flow starts or the bees take to foraging of available flora. The stimulative feed is generally prepared by dissolving sugar and water in 1:2 ratio.

Swarm Management

Swarming is a natural process of multiplication of honey bee colonies. During this process the old queen bee leaves the colony along with about half of the colony population, leaving behind a cross-section of the bee population and a few queen cells from which the new queen bee emerges. If such colonies are not managed properly, these may issue secondary and tertiary swarms thereby resulting in tremendous financial loss to the beekeeper. Sometimes, when bees swarm at the end of the breeding season the new queen bee in the mother colony remains unmated resulting in dwindled bee strength. Even if the new queen bee mates successfully within few days, the colony is unable to build up to a desirable strength for the full exploitation of that honey flow season.

Over-crowded condition in the colony and presence of drones and queen cells with coarse surface on the periphery of the comb also indicates that the colony is preparing to issue a swarm.

Control of Swarming

a) Preventive measures: Prevention of swarming in a colony means the measures to be taken to prevent over-crowding and queen cell construction in the honey bee colony.

i) Removal of congestion: A beekeeper should always remain ahead of bees in providing space to the bees in the form of combs, foundation sheets or super chamber, as per situation. If available, combs should be provided otherwise frames with comb foundations are added. These new frames should be put in between the middle bee frames having honey or brood so that these are immediately accepted. The colonies which are already full with 10 bee frames may be provided with super chamber. While providing super, baiting in the form of one or two bee frames with honey or brood should be provided in between newly provided combs or frames in the super to make the bees accept super chamber easily.

ii) Reversing : When the colonies are at super, reversing the brood chamber with super and vice versa at fortnightly interval is very effective method of swarm prevention. The queen bee has a tendency to restrict her activities in one chamber only, due to which that chamber usually becomes over-crowded with the brood and sometimes with food. By reversing the chambers, more space becomes available for laying, the queen bee in the due course of time will shift to the lower chamber, thus relieving the immediate congestion.

b) Remedial measures: i) These measures such as clipping of queen which involves cutting the wings of the queen by half; caging the queen by putting wire entrance guard or by placing queen excluder in between bottom board and brood chamber and destruction of queen cells can delay the swarming but cannot completely prevent the colony from issuing a swarm.

ii) Division of colonies also reduces the urge of swarming. The beekeeper can make more colonies either for his own apiary or to sell them out to beginners. However, if the aim of a beekeeper is not the multiplication, then the divided colonies can be re-united just before the start of honey flow. By that time the swarming urge gets subsided.

Capturing a Swarm

The newly issued swarm first tries to settle at a favourable place in the near vicinity of the apiary on a lower branch of a tree, bush etc. An effort should be made to capture and re-hive such a swarm. A captured swarm can be re-united with the parent colony before the start of main honey flow or a new colony can be formed. The bees in newly issued swarm hover in the air at a height of 10-15 feet. To make it settle at a lower height, sprinkle water over the bees. The water should be thrown upwards with a tumbler etc. but never with an insecticide contaminated spray pump. The water wets the wings of the flying bees. They will try to settle on a suitable place at a lower height so it becomes easy to capture them. To hive the swarm, the hanging cluster of bees is shaken into small box or nucleus hive. The hive containing some brood and honey frames is placed just beneath the swarm. The branch of the tree is shaken so that the bees along with the queen fall into the hive. In case the tree branch is too thick the bees could be brushed to fall in the hive. If swarm settles at a higher place, a comb of honey is tied to a bamboo and is raised close to the settled swarm to attract bees to the honey comb, these bee combs are then shaken in a hive placed below.

Colony multiplication

Spring season is the most suitable for colony multiplication. Colony division for multiplication can be taken up, if honey and pollen is available to bees and colonies have already started drone brood rearing. To improve the existing stock, selective division should be preferred over general division of colonies. Alternatively, mass queen bee rearing can also be undertaken.

Control of ectoparasitic mites

During spring season, the brood rearing activity is very high and the ectoparasitic mites *Tropilaelaps clareae* and *Varroa destructor* may also start multiplying with the availability of larval/ pupal brood as their host. Even if the mite attack is not prominent, sulphur dusting @ 1g/com should be done on the top bars of the frames to prevent the attack of the parasite. Excessive and direct dusting on the brood is detrimental which should always be avoided. Alternatively use Formic acid fumigation @ 5ml/colony daily for a fortnight (see Chaudhar, 2014).

Honey extraction

- Select sealed honey combs and place these in an empty hive and cover it with an inner cover.
- Never select honey frames having sealed/unsealed brood.
- Dislodge bees from honey combs with the help of bee brush.
- Uncap the wax seals of honey comb with uncapping knife by placing the combs in the drip tray
- Put these uncapped honey combs into the honey extractor (Tangential or radial).
- Gradually increase the speed of rotation of the honey extractor, honey from one side gets extracted.
- After extracting honey from one side change the side of the combs if tangential honey extractor is in use, and extract honey from the other side.
- When using radial honey extractor, direction of frames need not be changed, only rotate the machine in the reverse direction.
- Filter the honey through double fold muslin cloth immediately after extraction.

- After honey extraction, return these emptied combs back to the honey bee colonies.

Uncapping of sealed honey comb

Placing uncapped honey combs in tangential honey extractor

II. Management Of Colonies In Summer Season

In northern plains, the climate starts warming up from the month of March and reaches to its peak in May-June. In these latter months, the temperature sometimes rises even to 45°C which is quite unfavourable for the bees. By the month of April–May, the bee activity usually attains its peak and the bee population increases tremendously. Therefore, a special care is required to maintain the colony activity to exploit the main honey flow which mainly coincides with the *berseem* bloom. During this hot climate, the colonies can mainly be helped through maintaining low temperature in and around the hive, thus increasing colony production by conserving colonies' energy sources in lowering colony temperature and engaging more bee population for foraging to exploit the available honey flow. The following steps may be undertaken in this endeavour :

Alleviating heat effects

i) Provision of fresh water: Water is used by the nurse bees to dilute the honey before feeding it to the larval brood and also for lowering the hive temperature. Provide water to honey bees in the form of running water channel inside or near the apiary, water tanks for tube wells and pitchers with hole etc. Earthen bowls placed underneath the legs of the hive-stands also serve as a good source of water but needs to be refilled frequently.

ii) Provision of shade: Colonies should be shifted to shady place so that more of water collecting bees may be made to work for honey collection. This shifting should be done by following the thumb rule of 3 ft or 3 km. It is advisable that the beekeepers must arrange for planting quick growing shady trees such as peach, plum, etc. during the proper season which may provide additional flora for bees.

iii) Provision of Space: Adequate space should be made available in the colony for brood rearing and later on for storing the incoming nectar. A beekeeper should always remain ahead of bees in providing the ample space and avoid the risk of suffering bees owing to the lack of space. If available, combs should be inserted otherwise frames with properly embedded comb foundations should be used. The colony which is already full with 10-frame bees be provided with a super. While providing a super, one or two bee frames from the brood chamber should be shifted to the super chamber in between the newly provided frames. The gap created in the lower chamber should also be filled with frames having comb foundations. Always avoid adding frames without comb foundations to save bees' labour to minimize construction of drone cells.

iv) Provision of Ventilation: Widening the hive entrance, removal of the entrance rod as a whole or provision of an additional entrance will help in improving ventilation of the colonies. Ventilation may also be improved by staggering the supers in such a way that a slit between the two adjacent chamber is created, but care should be taken that the gap created due to staggering of supers does not allow the bees to escape. Placing thin sticks between the bottom board and the chamber, and between the two adjacent chambers to create a narrow slit, is another way of improving ventilation of the colony. Use of nine frames instead of 10 frames in the super not only helps in improving ventilation but also encourages bees to draw out thicker honey combs. Improved ventilation will also helps in faster ripening of the collected nectar into honey.

Curbing Drone Population

As a drone consumes 5-6 times more than a worker bee, the colonies should, therefore, be managed in such a way that the drone brood rearing is curbed during this period. This is necessary during summer as stock multiplication or queen bee replacement are not undertaken during this period and hence drones are no longer required. Moreover, it would help in higher honey yield from blooming flora. The important steps required to curb drone bee population are:

- Substitute old and depleted drone layer queens with freshly mated queen bees to reduce drone rearing
- Use combs with worker brood cells to encourage worker brood rearing
- Use comb foundations to minimize construction of drone cells
- Use wire entrance guards and drone traps to keep away the already existing drone bees

Preparing colonies for maximum honey gathering

Preparation of the honey bee colonies for the full exploitation of the main honey flow i.e. of *Berseem* blooms in May-June, is very important. For maximum collection of honey, the main aim should be to build the required population of bees in the colonies because the percentage of foraging bees in a strong colony is much higher than that of a weak colony. Following points may be kept in mind to maximize honey production:

i) Unite weak colonies with the strong ones before the start of honey flow
ii) Maintain young and prolific queen bees in the colonies.
iii) Provide adequate space with good quality combs or frames with comb foundations
iv) Place horizontal queen excluder between brood and super chambers to avoid brood rearing in the honey chamber, thereby, getting brood free honey combs.
v) Provide adequate shade and fresh water to the colonies
vi) In case of scarcity of food availability, provide feed to the honey bee colonies to sustain brood rearing.

Honey Extraction

Surplus honey collected from the main honey flow is extracted in the May end or June beginning. All the necessary precautions during extraction and post honey extraction must be followed.

III. Management Of Colonies In Monsoon Season

Monsoon is very harsh period for bees because of scare availability of bee flora, continuous rains/ cloudy weather, bees consume their stores. Brood rearing activity is much reduced, resulting in dwindling of colony population. Weak colonies are more prone to the attack of bee enemies like wax moths, wasps, black ants, bee predatory birds etc. Hot and humid conditions lead to suffocation as a result of which large population of bees form barbate at the alighting board. Manage honey bee colonies during monsoon as given below:

- Clean and burry deep the debris (including wax moth larvae) lying on the bottom board of the honey bee colonies.
- Keep the surrounding of the colonies clean by cutting the unwanted vegetation which may hamper free circulation of the air.
- Provide artificial sugar feeding by mixing sugar and water in 1:1 ratio.
- In case of pollen dearth, provide stored pollen or pollen substitute or pollen supplement can be given to the colonies.
- Regularly visit apiary and check for robbing.
- Unite weak/ laying worker colonies with the average strength queen-right colonies.
- Control wax moth, wasps and bee eating birds.

Robbing

Robbing in the apiary may be intra-specific, during which worker bees of stronger colonies start robbing the food from the weaker colonies of the same species, or may be inter-specific during which worker bees of one species rob colonies of other species. Inter-specific robbing of *A. mellifera* colonies by *A. florae*, *A. dorsata* and *A. cerana* has been reported. During rainy season, this problem becomes more serious because of scarcity of nectar available from the field. During robbing, fight takes place between the robbers and the guard bees at the entrance of the colony being robbed. During this process, the intruding bees try to kill the queen bee so that the remaining bees get demoralized and surrender themselves completely to the robbers. To take care of this menace the following management measures should be adopted:

Preventive measures

1. The hives should be made bee proof, except the main entrance, using mud etc. so that no cracks and crevices are present in the hive to allow the robber's side entry into the colony.
2. Entrance of the colony should also be narrowed down to single bee space so that only one bee enters or leaves the hive at a time.
3. If need be, feeding should be given only late in the evening in some suitable feeders inside the hive. During feeding, take care not to spill sugar syrup on or around hives.

Checking of robbing

If robbing process starts in the apiary, adopt following points to manage robbing:

1. Reduce entrances of all the colonies to one bee space but take care that the hives is sufficiently ventilated.
2. Place a bunch of grass etc. soaked in crude carbolic acid, kerosene oil or phenol in front of the entrance of the colony being robbed. Alternatively place a slanting wooden plank in front of the hive entrance to deter the entry of robber bees.
3. In case of heavy robbing, close the entrance of colony being robbed, with wire guage, and sprinkle 1% solution of carbolic acid around the hive so that the robbers get repelled from the colony.
4. If the robbing does not stop even after following the above measures, spot the robber colony. This can be done by dusting wheat flour or sulphur powder over the bees at the entrance of the colony being robbed. This flour or sulphur will get dusted

on the body of the robbers also. Such robbers can then be followed to locate their colonies/hives and as a last resort the robber-colony should be removed about 3 km away from the apiary or its site should be exchanged with the colony being robbed.

Uniting of honey bee colonies

Unite weak honey bee colonies using newspaper method, sugar sprinkling method, camphor method or smoke method.

IV. Management Of Colonies In Autumn Season

Autumn season is the second breeding season for honey bees and honey flow period under north Indian conditions. By the time monsoon retreats climate becomes mild and days are clear. Autumn season flora like pigeon pea, millets, maize, cotton, *toria* and in hill regions of H.P. and J.K. *Plectranthus* is available. Bee activity is also increased and colonies start rearing drone brood. Important operations to be undertaken during this period are:

- Provision of space
- Strengthening the colonies to stimulate them for drone brood rearing
- Control of ectoparasitic mite, wax moth and wasps
- Extraction of autumn honey before the winter sets

V. Management Of Colonies In Winter Season

Normally winter extends from December to February but this period may vary from region to region. *Brassica* comes in bloom some time during December. To perpetuate the colonies through winter, following operations need to be taken up.

Colony examination: Examine the colonies on a sunny day for presence of queen, brood and food reserves. Open the colony for minimum time. Weak colonies should be united with stronger ones so that strong unit over winters well.

Feeding: If there is food scarcity, feed concentrated sugar syrup (sugar and water in 2:1 ratio) by filling in the drawn combs as because of low temperature, the bees may not pick it up from the feeders.

Shifting / migrating the colonies to sunny places: In plains the colonies should be shifted to the sunny places with hive entrances facing towards sun.

Protection from the chilly winds: Ensure plantation of wind breaks in the apiary site with combination of bushes, hedges etc. Plug all cracks and crevices in the hive body and narrow down the entrance of the hive.

Unite the weak colonies with stronger one: Unite weak honey bee colonies using newspaper method as described under monsoon season management.

Removal of extra combs and winter packing: Remove the extra empty combs and store them properly to save these from mice/ rats. Depending upon the strength of the colonies and severity of winter, provide one- or two-sided winter packing combined with outer packing, if needed.

One-side inner winter packing

Two-sides inner winter packing

Drifting of bees and its prevention

The drifting of bees from one hive to another is generally because of wind or confusion. The effect of drifting may be negated by exchanging the position of colonies that have become strong with those that have been weakened only during the period of nectar flow. Young bees drift frequently during their play flights because of wind.

To avoid drifting of bees, do not place colonies close together in very close straight rows or in regular fashion in the apiary. Honey bee colonies should be placed at 6 to 8 feet distance from one another in the rows which are at least 10 feet apart. These colonies should be placed in such a way that the colonies in the adjacent rows are not placed right behind the previous row colonies. , thus, staggering the positions of the colonies. It will have a tendency to reduce the extent of drift. In windy and exposed places, a good wind-break will also reduce drifting. Painting alighting boards/front plank of chambers differently also reduces the chances of drifting of bees.

Queenless and laying worker colonies

Honey bee colonies may lose their queen bee due to various reasons and thus become queenless. Management of such colonies in different seasons (breeding and non-breeding seasons) is different. Such colonies, if not managed properly and timely particularly during non-breeding seasons, may develop into laying worker colonies. Population of such laying worker colonies dwindles because lack of normal brood rearing thereby causing a great loss to the beekeeper. Problem of queenless condition of a colony may also occur even during breeding/ normal brood rearing season, and such colonies need to be handled very skillfully to requeen them without adversely affecting the colony productivity.

Symptoms of queenless colony

- Absence of functional queen bee in the colony.
- Absence of eggs and very young brood in the comb cells.
- Presence of queen cells anywhere in the middle of the combs rather than on the margins.
- Colony behaviour is more aggressive.
- Brood rearing reduced and may finally stops.
- Pollen collection by these colonies decreases and finally ceases.
- Number of guard bees at the entrance of such colonies increases.

Minimizing queen losses

- During colony examination, the comb with queen bee should be least disturbed and in no case be taken out and placed outside the hive.

- The comb being examined should always be held over the hive body, so that if queen bee falls accidently, it will drop into the colony only. Otherwise the queen which falls out of the hive may get accidently crushed under feet.
- Take care of the queen bee while removing honey combs for honey extraction and dislodging of bees from these combs with the help of bee brush.
- To avoid crushing of queen bee in between two adjacent combs while placing the combs back into the colony, it is advised to spot the queen bee and place this comb at the end.
- Scare away bee predatory birds by the use of dummy, reflective tape or bird scarer near honey bee colonies.
- Never use any insecticide near the colonies to avoid mortality of queen bee due to insecticidal toxicity.
- Take all precautions during feeding, to avoid the menace of robbing. Even then if robbing begins follow recommended management measures to stop it at the earliest.
- Pack the honey bee colonies properly before transportation and place these colonies length-wise along the long axis of a suitable vehicle for transportation to minimize chances of mortality of queen bees during transportation.
- Take necessary steps to avoid loss of queen due to swarming and drifting.

Management of the queenless colonies

Handling of queenless colonies mainly depends upon the period and stage of the queenless condition and the season. The best option is to provide a mated queen bee, if available. If a sealed mature queen cell is present in one of the better performing colonies, provide this cell on a brood comb in the queenless colony. Generally during the breeding season, queenlessness may be managed by the colony itself, if either eggs or young larvae are present, by raising queen cells. As the new queen may get mated in this season, if mature drones are present, and may start laying eggs. Keep checking the colony for the queen bee. If the new queen fails to emerge or mate or lay eggs normally, provide a comb of eggs or very young larvae to this colony for raising of new queen cells. Another option is to unite the queenless colony with a queen-right colony. During non-breeding season, only option available to the beekeeper is to provide either a mated queen bee or to unite this colony with a queen-right colony.

The queenless colonies, if not requeened naturally or by the efforts of the beekeeper for too long, at least by the time no brood is left, become imperceptibly laying worker colonies.

The laying workers are imperfect females which develop from the normal workers of the colony. Their ovaries get a little developed in the absence of queen substance and these bees start laying infertile eggs which give rise to drones of smaller size.

Symptoms of laying worker colony

- Unfertilized eggs by laying worker bees are laid in worker brood cells and even in honey cells and are placed in a haphazard manner.
- In one cell, usually more than one egg is seen because many workers lay eggs in the same cell irrespective of the fact whether egg is already present or not.
- The eggs are also mostly seen attached to the cell wall rather than at the base unlike in the normal queen-right colony.

- The pattern of brood also looks uneven, irregular and scattered in such a colony. It has been observed that in laying worker colonies, the honey and pollen is stored below the brood contrary to storing of the formers above the brood in a queen-right colony.

Management of laying worker colonies

Sometimes, the queenless conditions of the colony continue for a longer duration either due to lack of timely management of such colonies by the beekeeper or due to non-breeding season. Generally this stage is reached after almost all the brood of the previous queen bee has emerged as adult bees.

First of all, get rid of the laying worker bees so that the colony accepts any help provided by the beekeeper. To get rid of the laying workers, dislodge all the bees from all the combs of the colony, a few meters away from the hive. The normal worker bees will fly back to the hive, whereas the laying worker bees will not be able to return into the hive because of their heavier bodies. Then destroy the drone brood of laying worker bees by scrapping with hive tool or provide these combs to a strong queen-right colony. After this provide combs with normal brood from healthy colony and adopt following practices to make the colonies queen-right:

(a) Providing normal eggs: During breeding season, if mature adult drone bees are present, provide the colony with a comb of normal eggs and dislodge nurse bees from unsealed brood combs from healthy colonies to ensure raising of queen cells.

(b) Transplanting queen cells: During breeding season, a sealed queen cell from a healthy colony is removed and is transplanted into the queenless or laying worker colony and is covered with queen cell protector.

(c) Provision of mated & laying queen: After getting rid of all the laying worker bees, introduce a mated and laying queen bee, caged in a queen cage, by following recommended practice.

(d) Uniting laying worker colony: If spare mated and laying queen bee is not available, unite this colony with a strong queen-right colony and if the laying worker colony is very strong, it is better to unite these bees with two or more queen-right colonies.

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HONEY BEE DISEASES, THEIR DIAGNOSE AND MANAGEMENT

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Honey bees in India suffer seriously from many diseases, mites, wax moths, predatory wasps (Morse and Flottum**,** 1997). They are also attacked and devoured by a number of birds and mammals.

Based on their damage to life stages of honeybees can be broadly classified into – brood and adult diseases with the exception of *V. destructor*, *T. clareae* and Kashmir bee virus (KBV) which affect both the stages.

A. Diseases: The important disease of honey bees are:-

1. Thai sacbrood virus
2. Sacbrood virus
3. Apis Iridescent Virus
4. Kashmir Bee Virus
5. American foul brood
6. European foul brood
7. Chalk brood
8. Stone brood
9. Nosema

1. Thai Sacbrood Virus Disease (TSBV): Thai Sac Brood Virus (TSBV) disease has been described by Bailey (1982). First found in Thailand in 1976 (Aemprapa and Wongsiri 2000), TSBV spread to the state of Meghalaya in 1978 and in Bihar in India by 1979 and hence from East to West within Northern India during the 1980s (Kshirsagar et al., 1984). It killed 95 % of the colonies and presently negligible in the country.

Causative organism: The causative virus is isometric in shape with 30 nm diameter

Spread: - exchanging food, feeding brood and cleaning the dead brood. TSBV accumulates and multiplies in hypophyaryngeal glands of the bees which acts as continuous source of infection through royal jelly

- through robbing, drifting, absconding, manipulation and migration.
- also spreads from the queen to brood through eggs.

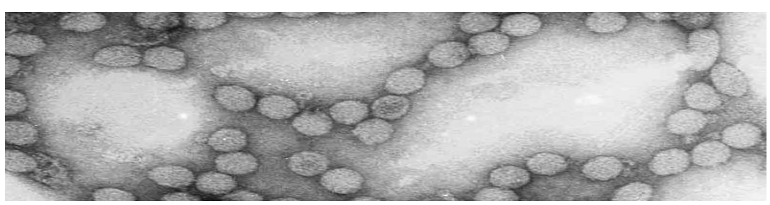


Fig.1: EM of TSBV

Note- This paper was not presented during the Workshop, however, it is being included in the proceedings

Field diagnosis

- Colonies with scattered and perforated brood
- Brood mortality occurs in prepupal stage

Fig. 2: Healthy sealed brood

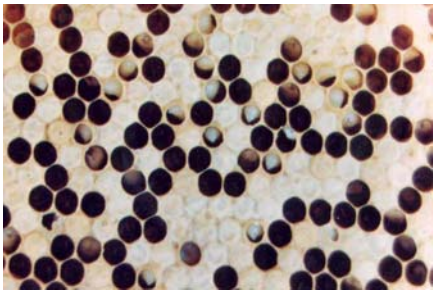


Fig. 3: TSBV

- Dead prepupa lies straight with tongue like projection of the head in perforated cell Dead brood emits no peculiar odour
- Sac-like appearance of the dead prepupae which can not be drawn to rope
- Brood colour changes from white to yellow, brown and finally black. Then dries down to a soft boat shaped scales in the cells.
- Colonies show reduced brood rearing, foraging and cleanliness activities which results in weakening of the colonies.
- *A cerana* colonies show high tendency to abscond than *A. mellifera*. In severe stage of infection, 2-3 colonies come together and form a single colony by killing the queens.

2. **Sacbrood Virus (SBV):** Sacbrood virus (SBV) infects larvae of the honeybee (*Apis mellifera*), resulting in failure to pupate and death.

Fig. 4: SBV

- Widely reported from *A. mellifera* L. but not serious like TSBV.
- Noticed for the first time in 1913 from USA and 1998 from India.

Management of TSBV and SBV: No specific and control measure for TSBV and SBV because virus becomes part of the host cell. However, following measures can help in minimizing the possibilities of further spread of the disease:

- Keep colonies strong and exercise check on robbing, absconding, drifting and exchange of combs and equipment.
- Adopt general colony hygience like frequent cleanliness of hives, handling of diseased and healthy colonies separately during manipulation, honey extraction, etc.
- Avoid hiving stray swarms.
- Isolate healthy colonies from infected ones.
- Create broodlessness in colony by caging queen for 15 days.

- Check the colonies periodically for any abnormality
- Destroy the severely infected colonies and combs.
- Multiply disease resistant colonies.
- Replace queens from diseased colonies with newly mated ones.
- Disinfect empty equipment and combs by soaking in a detergent (surf excel, 1%) solution containing 1% formalin for few hours. Then wash them with fresh water, dry and use.

or

- Disinfect the empty and dry combs with UV- rays each side for 20 min in protected chamber.
- Feed a dose of oxytetracyclin or ciprofloxacin @ 200 mg (5 % a.i., vet. grade) per colony in sugar syrup (50 %) to prevent secondary infection.

3. Apis iridescent virus

Apis iridescent virus was reported in adult individuals of *Apis cerana* from sick colonies in Kashmir and Northern India. It is only known to occur in adult bees. It causes an easily detectable iridescence in the fat body and most other internal organs. AIV multiplies in *Apis mellifera* also.

4. Kashmir bee virus (KBV)

Kashmir bee virus (KBV) infects many types of bees including *Apis mellifera*, the European honey bee (de Miranda et al., 2004) The virus effects both brood and adult bees. Infected adults die within a few days of exposure to the virus but infected larvae may survive and develop into seemingly unaffected adults.

5. American Foul Brood Disease (Goodwin & Van Eaton**,** 1999)**:**

- Most dreaded and highly contagious diseases of *A. mellifera* brood
- Reported for the first time in *A. mellifera* from America in 1907.
- One report from India in 1961 on *A. cerana*.

Causal organism- Caused by a rod shaped (2.5-5 X 0.5-0.8 µm), peritrichous flagellate, spore forming and gram positive bacterium, *Paenibacillus larvae.*

- Spores resistant to heat, chemical disinfectants and desiccation.
- Remain viable indefinitely on beekeeping equipment, so the disease is usually diagnosed during the active brood rearing season.
- Spores can remain dormant upto 35 years.

Spread- In the colony from adults to brood and vice-versa by the bees engaged in cleaning combs and nursing brood activities.

- Colony to colony and to apiaries through robbing, drifting, absconding, manipulation and migration.

Field diagnosis

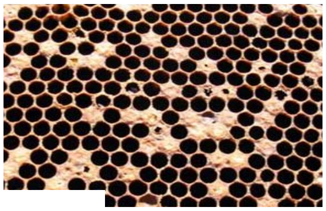


Fig. 5: AFB

Fig.6: Tongue formation

- Irregular pattern of sealed and unsealed brood.
- Perforation in sealed brood
- Death of brood at prepupal stage.
- Dead brood lies upright with their heads pointing outwards.
- Brood cappings appear initially discoloured, moist, sunken and finally dark in colour.
- Colour of the brood changes from pearly white to dark brown and finally black.
- Decaying brood emits rotten flesh like odour.
- Finally the brood dries down to a brittle scale which adheres tightly to a cell wall.
- The scale exhibits a pupal tongue which protrudes upwards
- The body of decaying larva if picked up with the help of a tooth-prick stretches into a rope of 2-3 cm rope.

Management

- Keep colonies strong with good egg laying queens.
- Isolate healthy colonies from diseased ones.
- Maintain colony hygiene. Prevent robbing, absconding, migration and drifting of bees.
- Create broodlessness for 15 days by caging queen.
- Select and multiply diseased resistant colonies.
- Kill the heavily infested colonies with about half pint of petrol by pouring in the top of the closed hive. Burn these alongwith brood combs in a pit (45 cm deep and wide enough) and afterwards fill it with soil. Remove the debris by scratching bottom boards, hive bodies, inner covers or outer covers, collect and burn in a pit. Flame the hives and equipments with blow torch.
- Disinfect the hives, combs and equipment (for 24 hrs) with ethylene oxide (1 g/ lit) for 48 hours at 43^0 C in fumigation chamber. Reuse the material after proper aeration

or

- Sterilize the empty and dry infested combs with UV- rays for 20 minutes.
- Dust tylocin tartarate or lincomyacin hydrochloride @ 200mg in 20 mg sugar powder /hive between the combs at weekly interval.

or

- Feed oxytetracyclin @ 250-400 mg / 5l sugar syrup (50%)/ colony.

6. European Foul Brood Disease:

- First reported in 1885 from U.K in *A. mellifera*.
- In India, during 1970 in Maharashtra from *A. cerana* and in 1998 from *A. mellifera* colonies of Himachal Pradesh and Karnataka.
- Presently it is prevalent throughout the country in both the hive bees.

Causal organism: by a non- spore forming, lanceolate, gram positive bacterium *Melissococcus pluton* (= *Streptococcus pluton*).

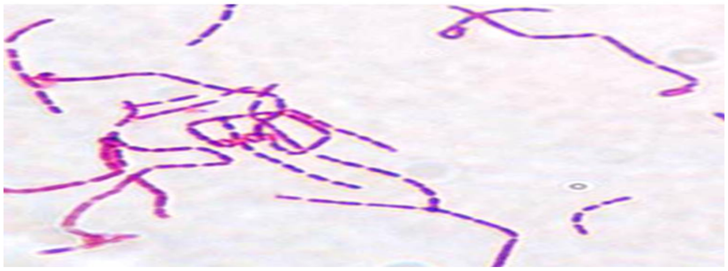


Fig. 7: *Melissococcus pluton*

Spread:

- Within the colony from adults to brood and vice-versa by the bees engaged in cleaning combs and nursing brood activities.
- Infected queen also spread the disease through eggs.
- Colony to colony and other apiaries through robbing, drifting, absconding, manipulation and migration.

Field diagnosis

- Colour changes from glistening shiny white to pale yellow
- Infected larvae appear somewhat displaced upward or downward direction.

Fig. 8: Healthy brood

Fig. 9: EFB

- The brood die at 3-5 days age (coiled stage). In *A. mellifera*, death of the brood occasionally occurs at pupal stage whereas, in *A. cerana* it dies generally at pupal and sometimes in prepupal stages. The disease at this stage, appears similar to Thai sac brood virus disease and mite infestation.
- The rotten larvae emitted sour or vinegar like smell.
- On drying, the larvae convert to rubbery scales.
- At serious stage of infection, combs show scattered pattern of sealed and unsealed brood.
- *A. cerana* colonies show high tendency to abscond.

Management

- Keep colonies in open, clean and dry with shade area.
- Maintain colony hygiene by cleaning the bottom board frequently.
- Keep the bee colonies strong by feeding honey / sugar syrup, uniting weak colonies, adding healthy young bees and brood combs.
- Supply good prolific queens to the colonies.
- Isolate the diseased colonies from healthy ones.

- Prevent robbing, drifting absconding and avoid migration of diseased bee colonies to other areas
- Maintain disease resistant stocks through selection and multiplication of honeybee colonies
- Create broodlessness in colonies by caging the queen for 15 days
- Check the colonies periodically for any abnormalities in brood / behaviour of bees.
- Replace the contaminated combs with fresh ones or comb foundation sheets
- Sterilize by treating the contaminated equipment and combs with detergent (surf excel, 1% solution) containing 1% formalin for 1- 2 hrs. Wash with water and dry the material before use.

(or)

- Treat the dry and empty contaminated equipment and combs with UV- rays for about 15- 20 minutes.

Feed the colonies with oxytetracyclin (5% a.i, vet. grade) @ 200mg /300ml sugar syrup (50% w/v) /colony just at the appearance of disease atleast more than one month before the start honey flow season or during long dearth period.

7. Chalkbrood

The entrance to this beehive is littered with chalkbrood mummies that have been expelled from the hive by hygienic worker bees. It is caused by *Ascosphaera apis* , which infests the gut of the larva. The fungus compete with the larva for food, ultimately causing it to starve. The fungus will then go on to consume the rest of the larva's body, causing it to appear white and 'chalky'. . Hives with chalkbrood can generally be recovered by increasing the ventilation through the hive.

8. Stonebrood

Stonebrood is also a fungal disease caused by *Aspergillus fumigatus*, *Aspergillus flavus*, and *Aspergillus niger*. It causes mummification of the brood of a honey bee colony. The fungi occurs in soil and are also pathogenic to many other insects, birds, and mammals. When a bee larva takes spores, they may hatch in the gut, growing rapidly to form a collar-like ring near the head. After death, the larvae turn black and become difficult to crush, hence the name stonebrood.

9. Nosema Disease:

- Disease of adults of both the hive bees.
- Recorded first time in *A. mellifera* in 1909.
- Prevalent through out the world.
- All three casts of honey bees are susceptible.

Causative organism:

- Caused by a spore forming protozoan, *Nosema apis*.
- Spores are microscopic bacilliform with bright and fluorescent edges.

Field diagnosis

- Heavy bee mortality
- Infected bees become dysenteric with distended and swollen abdomen.

Fig. 10: Heavy bee mortality

- Wings become disjointed and bees are found crawling in the hive and in front of the hive.
- Droppings of loose yellow coloured excreta are found on the combs or on alighting board or on other hive parts
- Infected queen stops egg laying due to degeneration of ovaries land colony become weak as death rate of worker bees exceeds the birth rate.
- Nurse bees stop rearing brood as their hypopharyngeal glands deteriorate and shift to foraging duties.
- Life of worker bees reduce to half.

Spread:

- Spores spread in faecal matters of infected bees which are taken by house or cell cleaning or polishing bees.
- Queen and drone bees get infected during feeding by infected nurse bees.

Management

- Prevent prolonged confinement
- Overwinter the colonies with good strength and adequate food reserves.
- Keep the colonies in open sunny sites.
- Provide fresh and clean water in the apiary.
- Re-queen the colonies with newly mated queens.
- Give temperature treatment to the empty equipment at 49^{o}C and 50% RH for 24 h for destroying spore.

Or

- Sterilize the equipment and empty combs by fumigating with 80% acetic acid @ 150 ml/hive space in stacks for few days. Reuse them after proper aeration.
- Feed dependal – M @ 500 mg/l sugar syrup (50%) at an interval of 15 days to each colony.

B. Mites:

Mites are tiny relatives of insects and they can be a serious pest problem for bees. One mite, the honey bee tracheal mite, lives in the breathing tubes or trachea of worker honey bees. A second mite, the Varroa mite, is of greater concern. It was discovered in the U.S. in 1987. It lives on developing bees and kills or deforms them. It also feeds on adult bees. Miticide control is widespread

1. Endoparasitic mite

Caused by a endoparasitic mite *Acarapis woodi* in adults of hive bees.

Fig. 11: Acarine disease

Spread

- First report from *A. cerana* of Kullu H.P. in 1957.
- Enters and multiplies in tracheae.
- Spreads through through robbing, drifting, absconding, manipulation and migration.

Field Diagnosis

- Bee crawlers in front of hives.
- 'K' condition of wings and bees can't fly.
- Confirmed through microscopic examination of dissected thorax of crawlers.

Management

- Keep colonies strong.
- Check robbing, drifting, absconding, manipulation and migration.
- Maintain proper spacing.
- Fumigate colonies with Formic acid (85%) @ 5 ml/colony for 15 days.

Or

Fumigate with Folbex (chlorobezilate) at weekly interval (5-7 fumigations).

Warning: Chemical treatments to the colonies should be avoided. If necessary, it should be given only when there is a long dearth period (>30 days) and honey should not be extracted from the treated colonies.

2. Ectoparasitic mite

i. *Varroa destructor*

Prevalent throughout the country (Wilde,2000).

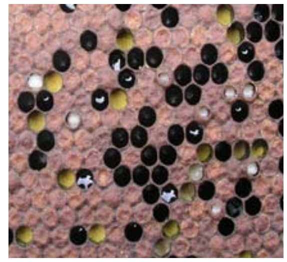
Fig. 12: *Varroa destructor*

Symptoms

- Mites on thoraces of the bees, inside the capped brood, brood combs and on bottom boards.

- Dead pupae and crawling bees with shorter abdomen, deformed legs and wings present in front of the hive.
- Spotty brood pattern.
- White droppings on the walls of empty brood cells, depressed brood capping or uncapped pupae.





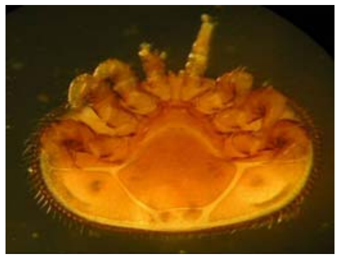


Fig.13: *Varroa destructor*

Management

- Maintain apiary/colony hygiene.
- Keep colonies strong
- Creating broodlessness for ten days to prevent mite multiplication.
- Introduction of drone brood for attracting mites in the colonies and later destroying.
- Use of sulphur powder @ 200mg/frame.
- Fumigate the colonies with 85% formic acid @ 5ml/day for 15 days

Or

- Spraying of oxalic acid dehydrate (3.2%) in 50% sucrose solution, 3 treatments @ 10 days interval (50ml/treatment).
- Fumigate with Apistan (fluvalinate).
- Use of sticky paper on the bottom board for trapping mites and then destroy by burning.
- Follow above strategy in to as a campaign and not as an individual.
- Keep check on other diseases.

ii. *Tropilaelaps clareae*

The mites in the genus Tropilaelaps are parasites of honey bee brood. Feeding on bee larvae and pupae causes brood malformation, death of bees and subsequent colony decline or absconding (woyke,1987, 1993).

it is a parasite of the native honey bee *Apis dorsata and also* a parasite of the introduced honey bee species *A. mellifera (* Atwal and goyal(1971).

The short life-cycle, as well as a very brief stay on adult bees, explains why populations of *T. clareae* increase faster than those of *Varroa* mites. When both *T. clareae* and *Varroa destructor* infest the same colony, the former may out-compete the *Varroa* mite.

Fig.14: T. Clareae

C. Wax moth:

This can be a terrible problem to bee hives if allowed to get out of hand and will destroy brood comb in a very short time if unchecked. A normal healthy hive will keep wax moth under control by ejecting the larvae, but weakened hives with small populations can be overcome by wax moth infestations destroying the brood comb, ultimately destroying the hive.

Following two are the most common varieties of wax moth which affect honey bee combs:

a) Greater wax moth (*Galleria mellonela)*

b) Lesser wax moth (*Achroia grisella*)

Fig. 15: Wax moth

D. Predatory Wasps

Hornets and yellow jackets may frequently be found around bee colonies. They may attack both single foraging bees in the field or an entire colony. They are after the bee and not usually the honey. Yellow jackets may claim dead and dying bees before the colony entrance and enter fall colonies to rob a meal of honey. Other wasps, may also capture bees in the field or at the hive entrance**.**

Fig. 16: Predatory Wasps

E. Birds

Various types of birds such as shrikes, titmice, kingbirds, swifts, martins, thrushes, mockingbirds and others may eat honey bees. They consume very few bees and most bee colonies can suffer the occasional loss of a worker bee to a bird. If the bird happens to get a virgin queen on a mating flight the loss is more serious but only beekeepers who are queen breeders need to be concerned. Wood peckers may locally become a pest. a colony, or the apiary site moved to alleviate the problem. There are mainly 2 groups of birds, the honey guides and the bee-eaters that can be classified as major bee pests because they selectively search for and consume bees.

Fig. 17: Predator Birds

F. Mammals

1) **Bear:**

Bear can be a serious pest of honey bee colonies. An individual bear that discovers bee colonies returns night after night to feast on brood and honey. The bear pounds and smashes the hive equipment to get to the beeswax comb and quickly destroys a bee hive beyond repair. Stings apparently are of little deterrent.

Skunks and other night-time foraging animals may find bee colonies an easy food source.

Fig. 18: Bear

2) Pine martin:

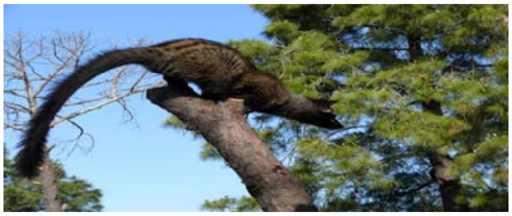


Fig. 19: Pine martin

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PRESENT STATUS OF PESTS AND DISEASES OF HONEYBEES *APIS MELLIFERA* L. IN INDIA AND INNOVATIONS IN THEIR MANAGEMENT

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ABSTRACT

Beekeeping was once a very flourishing industry with very few minor diseases and insect pests. With the advent of ectoparasitic mite *Varroa destructor* on *Apis mellifera* L., the situation has changed for the worst as it caused extensive colony losses. The conditions further aggravated with the appearance of more complex symptoms resembling many other diseases and stresses collectively called as parasitic mite syndrome (PMS). Many other problems like European foulbrood, mites and viruses also became prominent entailing continuous monitoring and regular medication. Beekeepers in distress started using a cocktail of unrecommended chemicals at grossly inappropriate doses, methods and varying periods, which lead to severe contamination of honey with pesticides, chemicals and antibiotics, etc. leading to ban on the export of honey by European Union. Many innovations adopted by the author in *Varroa* detection like square counting method, reusable plastic sheets, new wire mesh bee hive and *boora* method helped in taking decisions to initiate control measures. Similarly, for its control, biotechnical methods like the use of iron and wooden mesh floor board frame inserts and organic methods like Chaudhary's formic acid glass/plastic dispensers, formic acid pouches and *boora* method proved to be a boon to the beekeepers. These technologies / equipments are very effective, cheap and made from locally available material. It helped greatly in the revival of beekeeping industry in India. An “integrated Varroa management (IVM)” program developed is capable of producing contamination free honey.

Key words: *Apis mellifera, Varroa destructor*, parasitic mite syndrome, innovations.

European honeybee (*Apis mellifera* L.) ushered “yellow revolution” in India. As late as 2004, *A. mellifera* based beekeeping was by and large free from any major pests. The only pests encountered were mite *Tropilaelaps clareae* and wax moth and the only treatment beekeepers used was occasional application of sulphur powder. But hell broke out in 2004 with the epidemic of Korean haplotype of ectoparasitic mite *Varroa destructor* giving a severe blow to a flourishing beekeeping enterprise. Thereafter, beekeeping industry changed a lot and demands enhanced level of monitoring and management, resulting in a manifold increase in the cost of medication and honey production.

1. Status Of Insect-Pests Of *A. mellifera*

Honeybee diseases and pests based on their damage to life stages of honeybees can be broadly classified into – brood and adult diseases with the exception of *V. destructor*, *T. clareae* and Kashmir bee virus (KBV) which affect both the stages. The present status of

Note- This paper was not presented during the Workshop, however, it is being included in the proceedings

insect-pests and diseases inflicting *A. mellifera* in India is reviewed in Table 1 along with their symptoms, diagnostic methods and management strategies. In India as also in Haryana, *V. destructor*, is the major problem (that has been separately dealt with), followed by European foulbrood (EFB) and wax moth. EFB caused by bacterium, *Melissococcus plutoni* was till recently
regarded as a "stress disease" but has assumed a serious proportion following a regular pattern. The disease appears in a pronounced seasonal cycle beginning from mid February and continue up to August but the severity from March to June. Colonies that are small, weakened, malnutritioned or migrated are more prone to its attack.

2. *Varroa Destructor* and Parasitic Mite Syndrome (PMS)

External parasitic brood mite, *V. destructor* is the most dreaded enemy of honey bees the world over and its infestation is commonly known as Voroosis. The recent outbreak caused by Korean haplotype of *V. destructor* on *A. mellifera* was started in 2004 in the North Indian states, devastating up to 70% colonies in some states and now has spread to all areas where *A. mellifera* beekeeping is practiced (Chaudhary, 2005 and Gatoria *et al.*, 2005).

Symptoms and effects of *Varroa* attack: *Varroa* mite feeds on the haemolymph of worker and drone brood in the cells resulting in white spots on feeding sites and walls of those cells from which adult honeybees have emerged. After 5 days of egg hatching, the cell of a healthy worker larva is sealed from which a healthy adult worker bee emerges. But cells of many mite infested pupae are not sealed. Such "naked" pupae are seen on a comb in patches and are referred to as "patchy appearance". These pupae finally die and adults do not emerge from them. The pupae fail to develop fully in these cells and generally die, but from many of these capped pupae, adults emerge. The emerging adults are lazy, weak, with deformed wings and abdomen. *Varroa* attack even reduces life span of workers considerably and such workers are unable to perform their normal duties efficiently. The colony has very few workers and adult bees and colony strength dwindles steadily. Colonies show increased tendency of robbing and absconding. Such colonies become prone to infection by other diseases and secondary infections.

Parasitic mite syndrome (PMS): For the last many years, a range of abnormal symptoms of *Varroa* infestation in combination with that of different diseases and tracheal mite are being observed in the colonies which are collectively termed as "Parasitic Mite Syndrome" or PMS (Chaudhary, 2011). Adult workers are seen fallen, shivering and moving away from the hives. On inspection of the hive debris, adult *Varroa* mites are found scattered among the debris and also on the adult honey bees. On microscopic inspection after dissecting their trachea, endoparasitic tracheal mite, *Acarapis woodi* may also be observed. Some colonies exhibit repeated supersedure tendency even when the young prolific queen is present. In some queenless colonies, workers repeatedly kill unmated queens. Typical symptoms of European Foul Brood (EFB) like C-shaped larvae lying at the bottom of the cell, American Foul Brood (though AFB has not yet been reported from India) or Sac Brood (SB) alone or in combinations are also observed but with negative results when tested clinically. Colour of some of the larvae changes to brown, grey and finally black and larvae turn into a scale at the bottom of the cell. These scales can be easily removed, which are tough and rubbery when pressed between finger and the thumb. Such larvae with PMS symptoms, when analyzed clinically for various fungi, bacteria and viruses do not reveal any dominant specific causative agent responsible for PMS. Chaudhary (2005) found that beekeeping practices played a major role in wild fire spread of *Varroa* and PMS in India. Majority of beekeepers did not maintained optimum colony-to-colony (91.2%) and row-to-row distance (84.4%) in apiaries. The concept of supers- a sign of populous and healthy colonies producing quality honey was almost missing as only 0.7% colonies were recorded with supers. Similarly, the percentage of beekeepers adopting proper treatment against these ailments was only 4 %.

Why western control techniques proved ineffective in India?

Varroa has extensively been studied in many developed countries of the world and many effective control technologies and methods have been developed. But these methods cannot be used in India as such because of basic difference in beekeeping techniques. In western world, beekeeping is based on scientific techniques and all the equipment is of standard quality and measure, whereas, the priority of Indian beekeepers is cost reduction and not the quality. Majority of the hives (>99.9%) used for *A. mellifera* beekeeping in India are not the standard LT hives, but unhygienic "general box hives" where brood chamber and the bottom board are nailed together. Temperate west adopt 4-5 months of "wintering", a period of broodlessness, but in India, winter is the most productive season. For these reasons, the western *Varroa* management strategies proved ineffective here.

V. destructor has put enormous economical and social burden on poor beekeepers. Adoption of western *Varroa* management modules consisting of expensive and sophisticated application equipments and methods is simply beyond the reach of majority of the beekeepers of Indian subcontinent and other poor and developing countries of the world. It is important that these techniques be modified and developed to suit our conditions and of beekeepers.

Table 1: Status of insect-pests and diseases of *A. mellifera* in India, symptoms, diagnosis and management

Disease	Causal organism	Symptoms	Diagnosis	Status	Management
A. Adult diseases					
Tracheal Mite	***Acarapis woodi***	Affected bee has disjointed wings (K-wings), unable to fly and have a distended abdomen. Only mites found in the bee tracheae.	Microscopic examination of the tracheae, ELISA	Major	
Ectoparasitic mite	***Tropilaelaps clareae***	Somewhat similar to *V. destructor*	Comb jarring, magnifying glass	Major	Menthol Formic acid
Nosema Disease	**Protozoan** *Nose apis*	No single symptoms. Presence of stains of fecal material on bottom board and combs coupled with unhooked wings, distended abdomens or disoriented or paralyzed behavior.	Examining ventriculus which is white, soft and swollen with obscured constrictions and microscopic analysis.	Minor	
Chronic Bee Paraly Virus	**Virus**	Affected bees turn black, hairless and shiny and are usually found on top bars of the combs. Bees tremble uncontrollably, are unable to fly crawl out of the hive entrance.	By observing symptoms of individual bees and colony behaviour but confirmed only through serological techniques.	Minor	No
Acute paralysis bee virus (APBV) and Kashmir bee virus (KBV)	Dicistroviridae	No specific gross symptoms reported to either virus. Both are serlogically related viruses.	Immunodiffusion tests and molecular methods	Minor	No

Disease	Causal organism	Symptoms	Diagnosis	Status	Management
Deformed Wing Virus	Iflaviridae	Mite *V. destructor* acts as its vector. Emerging worker bees with deformed or atrophied wings, shortened and bloated abdomen and miscolouring. Bees are not viable and die within less than 67 h of emergence.	**-do-**	Minor	No
B. Brood diseases					
European Foulbrod	Bacteria *Melissococcus pluton*	Affects young unsealed larvae up to 48 hours old that are killed at 4-5 day age. But occasionally, older sealed larvae are also infected with discolored sunken, or punctured cappings. Dead brood is dull white that turns yellowish white to brown or almost black and non- ropy. Patchy brood appears associated with foul smell. Finally, larvae turn into a rubbery, black scale lying at the base of the cells in a twisted position.	Staining with carbol fuchsin, ELISA, polyclonal antisera or polymerase chain reaction.	Major	1. Uniting weak colonies 2. Isolation of infected colonies 3. Restriction on exchange of infected materials 4. Shook swarm method followed by requeening and use of uninfected combs 5. Proper care during dearth being a "stress diseases"

Disease	Causal organism	Symptoms	Diagnosis	Status	Management
Sac brood		This virus affects only the bee larva whose colour changes from pearly white to gray and finally black. Head turns darker and affected larvae appear like a sac filled with water. It dies just before pupation in an upright position generally in capped cells. Finally it turns into a scale which is brittle but can be easily removed. No characteristic odor is associated with this disease.	Laboratory diagnosis is based on gross symptoms and the absence of bacteria but for positive confirmation, special antiserum or molecular techniques are required	Minor	No
Kashmir bee virus (KBV)	**Both adult and larva**				
Ectoparasitic mite	*Varroa destructor* (Korean haplotype)				Discussed separately
Wax Moths	*Galleria mellonella* & *Achroia grisella*	Damage occurs during warm climate by larvae who while obtaining nutrients from honey, castoff pupal skins, pollen, and other impurities found in beeswax, tunnel and damage older wax combs	Visual	Major	Strong colonies Stored equipment may be treated with paradichlorobenzene, freezing, carbon dioxide

3. Economics Of *Varroa* Control In India

As per an estimate by Chaudhary (2008, 2009), *Varroa* treatment has entailed an additional minimum expenditure of Rs. 9810 per unit of 100 colonies with formic acid application, Rs. 5115 with oxalic acid and Rs. 6626 with oxalic acid with efficiency varying from 75-90%. *Varroa* thus, has put an additional burden of Rs. 5.12 to 9.81 million in Haryana state alone depending on the treatments chosen. In two states, viz., Haryana and Punjab, additional burden is to the tune of Rs. 12.8-24.5 million. In India, the minimum cost of treatment thus, varied from 5.15 to 9.81 crores which the poor unorganized beekeepers are unable to afford and sustain the business. The wrong methods of application, repeated application and under/over dosing has further compounded the problem.

4. Innovations in Management ff *V. destructor* (see plate 1)

It was prudent to develop low cost management strategy against *Varroa* for the poor and developing world. Author developed and/or improvised many such equipments and strategies suited specially for Indian conditions to detect and manage *Varroa* which are discussed here (Chaudhary (2007 and b). These have largely been adopted in India and have given the poor beekeepers effective and cheap alternatives. More importantly, these could be easily assembled and can be made from locally available materials and costs only a fraction.

A. Innovations in *Varroa* Detection Methods

V. destructor can be found on adult bees, on the brood, and in hive debris. World over an economic threshold level (ETL) of about 2500 mites/colony is used but such studies lack in India. Beekeepers in reality are treating their colonies only on the basis of subjective estimates. To determine ETL and population estimates, following new techniques have been developed:

i. Improvised square counting method: Every day, a certain number of mites fall on bottom board called “natural mite fall”. At low populations, it is easier to count them but very difficult and time consuming at higher population. A new and efficient “square counting method (Chaudhary, 2007 a,b) has been developed and is described below:

Take a butter paper of sticky sheet and mark lines horizontally and vertically at a distance of 2 inches. Remove and place colony debris on this sheet, spread it uniformly, count the number of mites in each square and find out the total number of mites. This method requires no additional material and estimates can be made in a single visit of the apiary.

ii. Reusable plastic sheets: World over white paper, cardboard, etc. are being used (one time application) to prepare sticky sheets/pads/boards and on them sticky material is applied to trap falling adult mites. A reusable thin, transparent polythene sheet measuring of size 17 x 14½ inches smeared either with mustard oil or grease was developed and proved equally effective (Chaudhary, 2007 a,b). Moreover, these sheets can be easily cleaned, stored in bundles, reused any number of times and can’t be nibbled by bees.

iii. *Boora* or Icing sugar: By using finely sieved *Boora* powder, used traditionally in Indian dishes, accurate mite estimates can be made without killing bees (Chaudhary, 2007 a,b). In this procedure, sample of about 300 worker bees from 3 brood frames is taken in a glass bottle, to which is added one tea-spoon of *boora*, and the mouth is closed with a tin cap. Bottle is rotated slowly for 3-5 minutes and then tin cap is replaced with wire mesh cap (12 mesh size). Contents are then sieved through this cap on a white paper and the fallen mites are counted. Thereafter, the bees are released into the colony.

iv. Wire-mesh bee hive: Author developed a new bee hive where a wire mesh of size 8-12 inches was fixed at the bottom of brood chamber, which is stretched down by an inch and has a slit running across the entire length on its both sides (Chaudhary, 2007 a,b). In these slits, a plywood bottom board is slid from the front in such a way that it closes the hive from beneath. Bottom board is extended in the front by 2 inches to act as landing board also. There is a provision of placing sheet on this bottom board for mite count.

vi. Comprehensive season wise guide on mite detection techniques under Indian conditions: After evaluating various detection methods over beekeeping seasons and years, author developed comprehensive season-wise guidelines that provide information on application time, ETL, effectiveness and special operational procedures for different detection methods. These are presented in Table 2 and provide many options to beekeepers (Chaudhary, 2007 a,b).

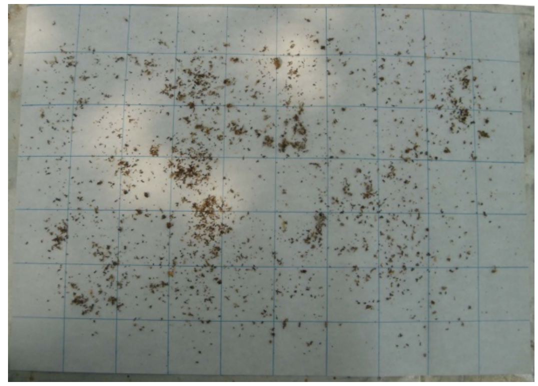
B. Biotechnical Control Methods

These encompass all the non-chemical control methods that have the potential to reduce *Varroa* population and are considered important component of "Integrated *Varroa* Management", organic certification or when beekeepers do not want to use synthetic chemicals. In western countries, separate mesh bottom boards are used on the principal of "natural mite fall", creating a mesh barrier between fallen mites and honeybees. They cost Rs. 300/colony and more importantly these can't be used in Indian hives. In the new method, following two inserts with universal application were developed by the author that cost a fraction to the mesh bottom boards and even have a provision to place sticky sheets.

i. Iron Mesh Floor Board Frame Insert: It consists of a 17x14½ inches of rectangular iron frame of 7 mm width, covered with 12 iron mesh (size 18 x 15½ inches), folded at the corners (Chaudhary, 2008). It has provision of hooks for proper handling. Costing only Rs. 30/-, it is capable of being used in all types of hives. In standard hives, it is inserted from the front by lifting the brood chamber and in general hives, is placed on the bottom board after removing the frames.

ii. Wooden Mesh Floor Board Insert: It is made by using a ¼ inch thick wooden frame measuring 17x14½ inches and provided with an extra arm in the center for additional support (Chaudhary, 2007 a,b). An iron mesh of size 8-12 size is nailed on it. This insert is used in the same way as the iron frame.

<u>Plate 1: Innovations in *Varroa* Mite Detection Techniques</u>

Collection of hive debris and mite it counting on by "square counting method"

Reusable plastic sheet

New wire mesh bee hive



Detecting mites in a bee sample using "*boora* ´method

Table 2: Comparison of different *Varroa* detection methods

Sr. No.	Detection method	Time of application	Sample size (No. of bees)	Economic Threshold Level (Mites/day)	Effectiveness	Remarks
	A. Inspecting hive debris					
1	Hive debris on bottom board	Whole year	-	-	Very low, only estimate	
2	Sticky sheet on bottom board	Whole year	-	8	Accurate	
3	Wire mesh bottom board	Whole year	-	10	Accurate	Use sticker sheet or simple white paper
	B. Visual inspection of adult honey bees					
		Whole year	-	-	Just estimate	Not accurate
	C. Inspection of adult honey bee sample					
1	Soapy water	February, June	300	10	100%	Sampled bees die
2	Ether roll	February, June	300	15	100%	Sampled bees die
3	Heating honey bee	February, June	300	15	100%	Sampled bees die
4	*Boora* or powdered sugar	February, June	300	12	80%	Most ecological safe, no bee kill
	D. Visual inspection of brood	February	200pupae	Mite in 10 drone pupae	Precise	Pupa gets killed
	E. Estimating mite in whole colony					
1	Tobacco smoke	February, June	-	-	Accurate	Bee poisoning or kill
2	Wire mesh bottom board	February, June	-	8	Accurate	
3	Sticky board	February, June	-	10-12	Accurate	
4	Formic acid	February, June	-	12	Accurate	
5	Fluvalinate and other strips	February, June	-	12	Very accurate	Estimate only after 24 hours,expensive

C. Using Organic Chemicals to Control *Varroa*

Three organic acids viz. formic, oxalic and lactic acids are used to control *Varroa*.

I. Formic acid (FA): FA is used at 85% or as 65%. Generally, after removing the frames from a bee hive, a 10 ml injection vial is placed on the center of bottom board opposite to hive entrance and filled with 5 ml formic acid daily for 14 days. Every day, central frames are removed to pour the acid, making the procedure more cumbersome.

Following innovations have been developed by the author (see Plate 2 and 3 also):

a) Chaudhary's Formic Acid Glass/Plastic Dispensers (CFAGD or CFAPD): In CFAGD (Chaudhary, 2006 a), a 10-ml used injection glass vial having absorbent cotton at the bottom is taken. A plastic soft-drink straw is inserted in this vial. After placing CFAGD in colony (mentioned above), measured amount of formic acid is poured with 10 ml graduated plastic syringe from its popping end between the top bars and the colony is closed. For the next 13 days this treatment is continued. Just lift the top and inner cover from the rear side of the colony, release the acid through straw and close the colony. Another dispenser called CFAPD was developed, where glass vial is replaced with a plastic cap used to cap honey tins. This cap is filled with cotton and covered with muslin cloth which is held in position with the help of a rubber band. Through a small hole made in the cloth a straw is inserted. This CFAPD costs Rs. 0.40 only.

b). Formic acid absorbent pouches (FAP): A single application FAP was developed using locally available material (Chaudhary, 2007 a,b). Cut news paper into 21x10 cm size pieces and pack them in 23 x 10 cm polythene bags as per Table 3. Pour required amount of formic acid and seal them. First inspect the apiary to ascertain the strength of bee colonies (no. of frames) and make FAP's as per the need. Select appropriate pouch, cut a 1.5x16 cm strip with a pencil cutter and place FAP in the center of bottom board with cut side facing upwards (in summer). In winters, place FAP on top bars with cut end facing downwards.

Table 3: Formic acid and papers required in different strength colonies

Colony strength (No. of frames)	Amount of formic acid required (ml) of strength		No. of news paper strips required	
	85%	**65%**	**85%**	**65%**
Up to 5 frames	40	50	15	20
6-10	70	85	25	30
10-15	100	125	30	40
16-20	140	175	45	50

II. Oxalic acid (OA): Commercially available OA (71.4%) is generally used at 3.2% solution by mixing 40g OA in 500g sugar and 500ml water. This solution is applied @ 5 ml/ frame on adult honeybees between the frames using a syringe. To treat a colony of 10 frames, the syringe is refilled many times. Treating an apiary of 250 colonies, make the work tedious, repetitive and slow. A new way of using a plastic bottle (500 ml or even a one liter capacity) with a lid provided with a 12 inches long curved plastic tube with narrowed distal tip to regulate the flow of solution was developed. The flow regulator at its tip makes oxalic acid application easier. In one fill, as many as 10 to 20 colonies can be treated with 500 and 1 liter capacity bottle, respectively saving a lot of time and drudgery.

III. Lactic acid (LA): It is used as 15% solution @ 5 ml/frame by spraying with small agriculture spray pump on the adult honey bee frames at an angle of 45^0. Two combs are sprayed outside the colony and the rest inside by providing space. A new way of LA application using a 5 liter pneumatic pump with very fine nozzle was developed (Chaudhary, 2007 a,b), treating the colony in just about 4 minutes.

IV. Thymol or *Ajwain*: It is used both as oil and as synthetic crystals. Liquid formulation is applied using two foam/absorbent pads, sanitary pads or potholders (6x5 cm and 0.5 cm thick) placed in brood chamber in two opposite directions and applied with 4 ml of thymol/pad using a syringe. Thymol crystals are applied directly in a colony using two shallow plastic caps of 5-7 cm diameter on which 4 g of thymol crystals are placed.

V. Chaudhary's multi-purpose dispenser (CMPD): A new multi-purpose dispenser for application of formic acid and thymol in solid as well as liquid formulations is developed which is planned to be patented (Chaudhary, 2014 personal communication).

VI. *Boora* or finely powdered sugar or icing sugar: Aliano and Ellis (2005) in USA isolated adult honeybees of a colony (using bee repellent) into a separate "bee box" where they were dusted with 225 g powdered sugar, confined for 5-10 minutes and bounced against white paper to recover mites. Bees are then rereleased near the hive entrance.

In a new innovation, finely ground and sieved *boora* or powdered sugar is dusted on adult honeybees between the combs @ 15 g/ colony 4 times/day at 3-day interval. These finer particles are supposed to interfere with the activity of the sticking pads present on the mite leg, thus dislodging them from the honeybees. *Boora* is the cheaper alternative at Rs. 1.50 only for full 14 day treatment with 70-80% efficacy. *Boora* method is the most ecologically sound method of control of mites with no adverse effect and can be applied in any season and leaves no residues in honey or wax and thus very effective tool of IVM program against *Varroa*.

D. Chemical Methods ff *Varroa* Control

Synthetic chemicals are the most effective and reliable methods of control. However, they cannot be used for organic honey production and result in many problems like pesticide residues, pollution, development of resistance to chemicals, etc. As per the Insecticide Act, no synthetic chemical can be used in India without registration. But the plain reality is that beekeepers are using a variety of chemicals. The most widely used products are strips of synthetic pyrethroid fluvalinate, flumethrin and other chemicals which are illegally imported from China. They are hanged from the top bars between brood frames for a period of 6-8 weeks. They are the most wrongly used products in terms of method, duration and seasons. These are fat soluble and adsorbed into wax and honey. Their extensive and continuous use has resulted in development of resistant mites in Europe and USA with resistance index of up to 440.

Strip hangers: To overcome these problems related with the use of plastic, paper or wooden strips, five types of strip hangers have been developed (Chaudhary, 2012).

a) **Comb piercing hangers (CPH):** Strips are hanged using match stick, wire or twig between the frames costing almost nothing.

b) **Wire Multi Purpose Strip Hanger and Spacer (W–MPSHS):** Three types of hangers using 3 mm iron, nickel coated or stainless steel wires were developed that help in hanging the strips without touching the frames and can be made by any beekeeper.

c) **Plastic Multi Purpose Strip Hanger and Spacer (P- MPSHS):** This molded plastic hanger is the further refinement of above type of hangers. It has a top support, two side supports and a V-bend to hang the strips. It has all the advantages mentioned above with perfect frame spacing and uniformity and costs only Rs. 0.20.

5. Evaluation of Miticides for The Management of *Varroa*

In one of the most comprehensive studies (Chaudhary (2006 b) with a view to find effective control of *Varroa*, 17 treatments/products including biotechnical, organic insecticides and organic acids were evaluated under two sets of colony strengths (up to 5 frame and up to 10 frame colonies).

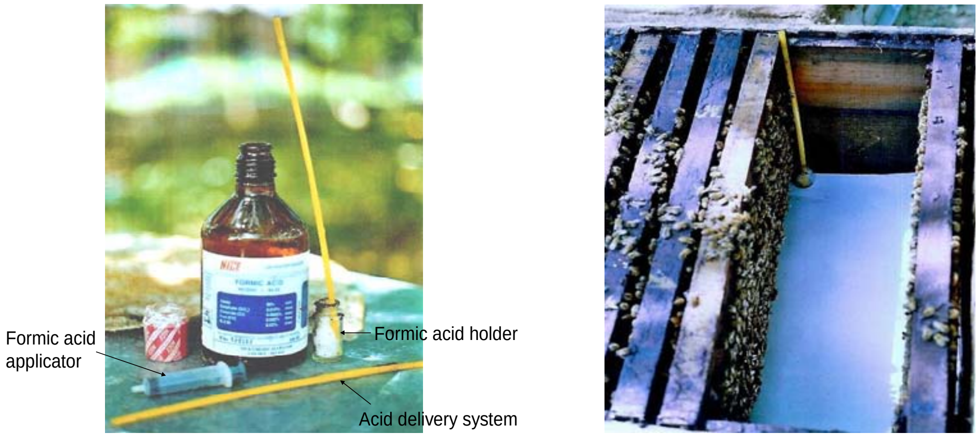
a. Use of Formic acid: In this method formic acid (85%) can be applied in three different ways:

i) Chaudhary's Formic Acid Plastic Dispensers (CFAPD) @ 5 ml/day

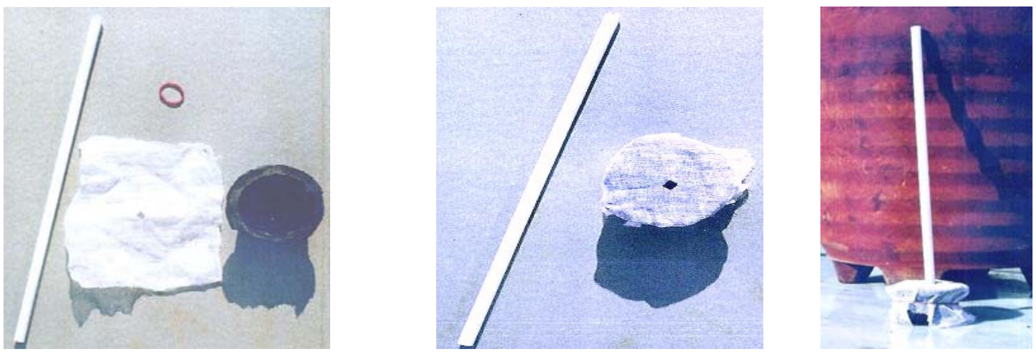
ii) On the bottom board using a syringe (15 and 30 ml/day at 4 day intervals) and

iii) Use of formic acid pouches (50, 70 and 100 ml/pouch/colony).

Plate 2: Formic Acid Dispensers



Chaudhary's formic acid glass dispenser (CFAGD)



Chaudhary's formic acid plastic dispenser (CFAPD)

Applying formic acid in single colony and in supers- the easiest way

Plate 3: Innovations in Varroa Mite Management

Placing Formic Acid Pouch (FAP) in hive

Iron Mesh Floor Board Frame Insert

Pouring oxalic acid with plastic bottle

Spraying lactic acid with pneumatic pump

"*Boora* "or powdered sugar method

Multi-purpose plastic strip hanger & spacer

b. Use of lactic acid and oxalic acid: In this method lactic acid (15%) is sprayed on frames and oxalic acid (3.2% solution) is trickled on the bees in between the frames @ 5 ml/frame.

c. Use of Fluvalinate strips: In this method fluvalinate strips (1/ 5 frames) and the *boora* or powdered sugar is applied on the adult bees between the frames @ 15 g/colony.

Efficacy of various treatments was evaluated on the basis of "daily natural mite fall" for a treatment period of 14 days along with behavioural response of honeybees and colonies like agitation, cluster formation, swarming, brood removal, effect on queen bees etc. Results have revealed that small strength colonies were more prone to *Varroa* damage despite the application of control measures and registered substantial reduction in colony growth (Table 4). Formic acid application through CFAPD, fluvalinate strips and application of *boora*/powdered sugar were most effective methods and had little ill effects on honey bee colonies. *Boora* method had no adverse effects at all. Formic acid pouches @ 50 ml for low strength colonies and 70 ml for 10-frame colonies were equally effective but at higher doses, bees became agitated, formed clusters outside, removed brood from the frames and even killed queens and colonies.

Based on these various studies and experience, author has proposed an "integrated Varroa management (IVM) program for A. mellifera beekeeping (Table 5) which has a potential to produce honey and other products absolutely free from any contaminants.

It could be concluded that with the passage of acute phase, Varroa and PMS has now stabilized due to biotic factors but will flare up again in cyclic manner, thus, beekeepers can't become complacent. Appropriate technological interventions in integrated manner can even organically manage these menaces. But still we have to go a long way in managing these diseases and pests and newer challenges facing our beekeeping.

Table 4: Efficacy of various miticde treatments against *Varroa destructor*

Treatments	**Dose/ concentration**	**Daily mite fall days after treatment in colonies of**			
		5 Frame colon		**10 Frame**	
		7	**14**	**7**	**14**
Formic acid with CFAPD	5 ml/day	29.0	11.8	8.8	3.7
Formic acid pouches (FAP)	50 ml	58.0	8.2	-	--
Formic acid pouches (FAP)	70 ml	51.0	2.7	36.0	11.1
Formic acid pouches (FAP)	100 ml	-	-	40.0	12.2
Formic acid on floor	15 ml	17.0	7.9	19.0	18.7
Oxalic acid	3.2%	23.0	9.3	51.0	18.3
Lactic acid	15.0%	23.7	20.8	24.0	222
Sticker sheets	-	11.0	8.1	15.0	7.2
Fluvalinate strips	1/colony	50.0	2.1	53.0	0.9
Boora/ Powdered Sugar	15 g	4.7	3.1	6.8	3.8
Control	--	9.6	10.9	18.2	19.6

C.D. ($p<0.05$) 7 DAT = 31.0
14 DAT = 8.7

Table 5: Proposed integrated *Varroa* management (IVM) program

Sr. No.	Control method	June-September	October-December	January-February	March-May
1	Monitoring	√	√	√	√
2	Optimum distance between apiaries/colonies	√	√	√	√
3	Prevention of robbing	√	√	X	√
4	Drone trapping	X	X	√ (twice at monthly interval)	X
5	Wire mesh bottom board / inserts	√	√	√	√
6	Sticker sheets	√	√	√	√
7	Strong colonies on supers	√	√	√	√
8	Selection and development of *Varroa* resistant populations	√	√	√	√
9	Organic chemicals	*Boora*, FA, oxalic, lactic acid	X	X	Formic acid
10	Synthetic chemicals	?*	X	X	?*

* Only when *Varroa* population is high and never repeat treatment

** Always try to use organic chemicals

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SCIENTIFIC BEEKEEPING FOR APICULTURE DEVELOPMENT

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ABSTRACT

The history of scientific beekeeping in India is not too old though it was known in India since ages and its references are made in ancient Vedas and Bodh scripts. The scientific principles to Indian traditional beekeeping were started to be applied at the end of nineteenth century. There is vast potential and scope for diversification in apiculture i.e. besides honey, it offers scope for production and marketing of other bee products like bees wax, royal jelly, propolis, bee venom and pollen. Besides there is tremendous scope for utilization of honey bees for increasing quantity and quality of crops produce through pollination. The present paper provides information on the present status of beekeeping in India, potentialities for honey production for sustainable livelihood in India. Moreover, the paper emphasizes on the constraints for beekeeping development and future strategies for faster development. The unscientific methods adopted by the beekeepers and their remedies have been included. The paper also suggests that India has tremendous scope for commercial beekeeping and use of honey bees for pollination of agri-horticultural crops and wild flora.

Key words: Honey bees, scientific beekeeping, constraints, pollination.

Apiculture (Beekeeping) is a scientific method of conservation and rearing honey bees for the production of hive products like honey, beeswax, royal jelly, bee venom and propolis and for pollination of agricultural crops. Beekeeping can play an important role in the upliftment of economy as it is an important income generating activity for the people. It also helps in conservation of forests and grassland ecosystems and does not compete with other farming systems. Therefore, beekeeping is becoming an important component of present day strategies for agricultural development and integrated rural development programmes. As apiculture has always been linked with the cultural and natural heritage of rural communities, therefore, the role of beekeeping in providing, nutritional, economic and ecological security to these communities in developing countries cannot be overlooked. Honey bees live in almost all parts of the world, except the polar region. Even the range of commercial and hobby beekeeping, particularly with *Apis mellifera*, extends throughout the world from tropics to the Arctic Circle. In India, although special efforts were made after independence to develop various agro-based industries but beekeeping industry received inadequate attention resulting in its slow development. As a matter of fact, beekeeping in India remained badly a disorganized sector till 1953 where after it was included in the schedule of Khadi and Village Industries Commission (KVIC). This commission established Beekeeping Directorate in 1956 with the aim of strengthening honey bee research in the country. The KVIC with the help of Maharashtra State Khadi and Village Industries Board established Central Bee Research and Training Institute (CBRTI) at Pune in 1962 and the institute worked through a network of regional bee research laboratories, field stations and experimental apiaries all over the country (Gupta and Dogra, 1998). In India till 1962, beekeeping was solely practiced with indigenous honeybee, *Apis cerana* when exotic bee, *A. mellifera* was successfully introduced in the country. However, the introduction of *A. mellifera* in India also brought some controversies about the lurking fear of spread of diseases specific to these bees which of course now stands settled. Even though beekeeping in India is now being practiced with both indigenous *A. cerana* and exotic *A. mellifera*, yet beekeeping industry is still in infancy, compared to the neighboring country, China.

The potential for beekeeping in India is yet to be realized and according to a rough estimate this figure is a mere 10 per cent. It is also well documented that there is still a lot of significant untapped diversity of scientific and practical knowledge which is available within the country. Several aspects have been studied in much details but this knowledge has not been widely disseminated. In general, very little is known about the overall status of research, training and extension systems. Primarily, because of lack of coordination amongst the various implementing agencies and lack of database on different aspects especially of organic beekeeping. Pollination and its practical application are still knowledge for insiders and a broad level outreach of this aspect is lacking. There is thus an obvious need for reorienting policies and programs in the country for revitalizing the beekeeping industry thereby resulting in a paradigm shift towards more productive and sustainable apiculture.

As per the estimates given by different sources/organizations, presently there are about 1 million bee colonies of native *Apis cerana* F. and exotic *Apis mellifera* L. kept in traditional and modern beehives in India . Beekeeping covers 40000 villages and provides part time employment to more than 250000 persons. National Commission on Agriculture (NCA) has earlier set a production target of 60000 tons of honey and 6 million colonies of bees by the year 2000 AD, but this could not be achieved because of various constraints and lack of knowledge on the status and prospects of beekeeping region-wise. In order to achieve the targets of NCA, it is imperative to quantify the current status of beekeeping industry in India for its sustainable growth. Moreover, a comprehensive survey of honey production, processing and marketing in different eco-geographic regions of the Country is needed (Mattu, 2011).

Constraints and Strategies for Beekeeping Development

An assessment of potential and present status of beekeeping in India indicates that there is indeed an enormous scope for apicultural development in the country and it can be brought at par with that in developed countries through some of the following strategies that need biotechnological interventions.

Apiary Features

In India, importance of beekeeping is for honey production and a little importance has till now been given to the primary biological and economic role played by bees in the pollination of cultivated and wild plants. Honey bees have helped mankind in maintaining biological diversity through hybrid vigor by cross pollination and saved a number of botanical sources from extinction by providing free ecosystem services in the form of cross pollination and propagation of many cultivated and wild plants. Though it is established that bee pollination increases yields in many cultivated crops, but still beekeeping remains to be recognized as a low or no cost input along with fertilizers, irrigation, pesticides etc. Beekeeping industry also offers many other important products like royal jelly, pollen, bee venom, beeswax and propolis which have in general been neglected in India. Beekeeping can be a side line, subsidiary, semi-commercial or commercial business. But in India beekeeping is considered a side business and each beekeeper often handles quite a low number of bee colonies as compared to his counterparts in other countries. The statistics on the development of beekeeping industry in India shows that on an average a beekeeper has less than five colonies. The main disadvantage with small number of colonies is that these are left to themselves for fending and not at all managed. These ill or mismanaged colonies give very poor yield. The low yields necessarily do not highlight the production potentials of the colonies. However, Indian beekeeping has undergone a change during the recent past and there is also a definite trend towards commercial beekeeping, especially with *A. mellifera*. In European countries, a beekeeper normally looks after 100-300 colonies and in Australia the figure is still higher. The most mechanized beekeeping is in California (USA), where a beekeeper manages an apiary of 1000 or even up to 2000 hives. On the other hand, in China apiaries are generally small and most are family apiaries of 30 to 80 colonies; even then it has earned number one position in the world export market.

Socio-Economic Factors

Beekeeping is an enterprise which can be practiced by anyone irrespective of sex and age. It is a non-land based activity which does not exert any pressure on agricultural land for raw materials and also does not compete with other resources of farming systems. This, being a forest and agro-based decentralized industry, does not displace artisans from their villages. Beekeeping can be taken up as a commercial enterprise or single-family business or still smaller side line business to supplement income from other sources and is most suitable for integrated agriculture. In developing countries, it can be used in rural development programmes designed to increase the income of individuals as well as of the group and thus has great potential in raising the economic and social status of rural communities. However, lack of education, remoteness, poverty and lack of apicultural traditions are hindrances in the development and promotion of beekeeping in these countries. There is wrong notion that beekeeping is a no investment profit giving activity. This has been so with *A. cerana* and especially in remote and tribal areas. Small beekeepers never used to invest on hives, comb foundation sheets and above all on managing the colonies. The beekeepers in some areas, even now depend on swarms and their capturing for raising the colonies but to allow the colonies to swarm is against the cardinal principles of scientific beekeeping.

As discussed above, beekeeping has great potential for the upliftment of national economy. But the development of apiculture should take care of the background of the people also. In areas where education level is high and transportation is easier, beekeepers can learn to work at higher technological level but in areas which are poor we should promote low level technology which suits to the general way of life of the people. Resources are required for bee hives, other equipments, maintenance and management of apiaries as also for migration and transportation etc.

Deforestation, Monoculture and Indiscriminate Use of Pesticides

Due to changes in agro-climatic conditions and various socio-economic factors, beekeeping development has been hindered to great extent. Deforestation of many areas, monoculture and indiscriminate use of pesticides has rendered several areas uneconomical for beekeeping. Increasing cost of bee hives and other bee equipments has also discouraged the adoption of modern beekeeping by the poorer section of the society. If due attention is given to apiculture, it has a good scope in the country to develop as a prime agri-horticulture and forest based rural industry. It can generate self-employment to over 22 million rural and tribal families and can produce annual income of over Rs 4.5 billion by producing 150,000 tons of honey (Shende, 1992 ;Chhuneja,2011).

Lack of Beekeeping as Recreational Activity

In many countries beekeepers keep honey bees for recreation and in some areas recreational beekeepers far outnumber the commercial beekeepers. In such areas commercial beekeepers earn much of their living by supplying queens, bee colonies and other bee materials and by rendering advice to the hobbyist beekeepers. In India also beekeeping can be advertised for recreational purposes.

Awareness for Pollination

Earlier due to naturally occurring wild pollinators in the country, need for managed pollination was not realized. But now due to large scale deforestation and indiscriminate use of pesticides, the population of natural pollinators has declined to be great extent and thus there is necessity for the propagation of hive bees to meet pollination requirements. There exists a great potential for expansion of apiculture in the country due to vast area of land under crops and forest plantations. In India, cropped area is estimated to be 160 million hectares out of which 55 million hectare is under crops requiring cross pollination by bees and other insect pollinators. Thus for pollination alone the number of colonies required would be more than 150 million against the present strength of only one million colonies in the country (Verma, 1990). Crop growers need to be made aware about the benefits of honey bee pollination and to be awakened to place honey bee colonies near to their fields by paying rent to beekeepers. This cost will be many times lower than the benefits due to pollination, specially in cross pollinated crops.

Bee Diseases, Enemies and Import of Honey Bee Colonies

It is obvious that high yielding germplasm always attracts the farmer. For this reason, *A. me1lifera* is becoming more and more popular amongst beekeepers in India. But we have to be careful so that the beekeeper is provided with appropriate knowledge regarding its management as well as to remove doubt and fear about the introduction of new diseases and enemies of *A. mellifera* which cropped up without any experimental evidence or scientific data (Chahal and Gatoria, 1983). It is now a well accepted fact that with the introduction of *A. mellifera*, no new diseases and enemies except a few, have been introduced in the country. Many a times wrong notions do result in such confusions and controversies. Maskey (1992) has pointed out that 'Thai Sacbrood' might have appeared possibly due to import of *A. mellifera* in Nepal, whereas it is well known that 'Thai Sacbrood' is specific to *A. cerana*. It has been observed by the author that *A. mellifera* kept even in the same apiary with *A. cerana* remained unaffected. Although there are instances where honey bees introduced in new areas of the world have brought new pest problems. Introduction of *Varroa*, an ectoparasitic mite into Europe is a glaring example. Such introductions of bee diseases and pests cannot be ruled out if importations are made in a haphazard manner. Land contiguity with other countries also plays an important role in the spread of bee diseases and pests and we have to be vigilant while introducing new genetic material in the country. Khan (1992) in his article on Honey bee resources in north-west frontier province of Pakistan has mentioned that due to lack of bee specialists, improper and non-existence of bee disease laboratory in Pakistan, many diseases have been introduced inadvertently and the situation worsened when Afghan refugees brought bee colonies along with their belongings into Pakistan during 1980-81. This resulted in destruction of 85 per cent colonies of *A. cerana* and 55 per-cent colonies of *A. mellifera* in 1982. Hundreds of *A. mellifera* colonies from Australia were imported and distributed among Afghan refugees (Shahid, 1992). Such importation and distribution of bee colonies in our neighboring country can be a warning signal to beekeeping industry in India.

Management of Colonies for Higher Honey Production

First and foremost step in the management of honey bees is to select high yielding stock from the existing colonies and breed the selected stock. Such a work has already been undertaken in different parts of the world and well known hybrids of *A. mellifera* are available for commercial beekeeping. Work in this direction is badly needed in India. Work on selective breeding of *Apis mellifera* and breeding through artificial insemination by import of semen is also required to be undertaken.

Honey Stores

Another aspect in the management of *A. mellifera* colonies in India is poor food stores with the colonies. A colony should always have at least 5-8 kg of stores. Many a times the beekeepers extract honey from the combs in the brood chamber which is a bad practice. The food stores are never left up to this level in most of the colonies resulting in poor development of colony strength for availing the honey flow. Beekeepers should leave sufficient honey stores in the colonies at the time of honey extraction. If the stores are poor, artificial feeding should be done to raise the food stores but this needs lot of care to avoid robbing which in turn leads to spread of diseases and enemies from diseased to healthy colonies.

Regulation for Migratory Beekeeping

Beekeepers in India need to be educated regarding colony hygiene. Due to poor and unhygienic conditions of colonies, there is always a danger of spread of bee diseases in the apiary. Since we do not have restrictions on the movement of bee colonies in the country, there is always a chance of spread of bee diseases. Therefore, there is an urgent need to have some central agency to look after this important aspect of beekeeping and only disease free colonies should be allowed to be moved. There is also a necessity of periodical surveillance of bee diseases and pests.

Diversification in Beekeeping

At present beekeeping in India is essentially for honey production which results in comparatively low income to beekeepers. In order to generate more income, it is important to diversify beekeeping by exploiting honey bees to produce royal jelly, pollen, propolis, bee venom and beeswax which will add to the income of beekeepers. Though at present there is no market for these products in India because of their non-availability, yet these are in great demand in the world market.

Package Bees

The concept of package bees is also new to beekeeping industry in India and so far meager work has been undertaken in this direction. In many countries this is a well developed industry and the bees are sold by weight in packages of 2 or 3 pounds. Package bees are shipped either by express or parcel post. To prepare a package of 2-3 or more pounds of live bees are shaken into small shipping cages each of which has a queen in queen cage with sugar candy. In advanced countries many commercial beekeepers prefer to kill the bees at the end of honey producing season and replace them with package bees during the following spring. In such cases all the honey is extracted during fall, the bees are killed and hives are stored empty for the next season. Package bees can also be used to keep the colonies strong and availing honey flow in areas where the buildup period is short. Package bee concept also acts as a check on spread of bee diseases and enemies as only adult bees along with queen but no brood is transferred in such packages.

Propagation of Bee Flora

Decline in bee flora due to deforestation and cleaning of waste lands for extensive agriculture has been one of the serious setback for Indian beekeeping. Propagation and mass plantings of bee flora through a forestation should be done on the principle of planting flora having multiple uses, since it is not practically possible to plant melliferous plants for honey bees alone. These plantations can be undertaken along highways, railway lines as well as in waste lands with the help of some central agencies. People can be encouraged to take up plantation of bee flora under social forestry and agroforestry schemes.

Quality Control and Appropriate Storage of Honey

Quality of honey is most important to compete in the international market. Due to poor quality control, Indian honeys do not come up to international quality standards for the export market. It is a general tendency of the beekeepers to extract honey even from unsealed frames along with the sealed ones. Such honeys contain high moisture content and the honey extracted from such frames is also of poor quality as bees take some time for ripening and sealing of honey containing cells which adds to the colour, flavor and quality of honey by enzymatic conversion of sugars. Honey from unsealed frames eventually gets fermented. Honey extracted/squeezed from the wax cappings should not be mixed with the honey extracted by centrifugation, since squeezed honey from cappings contain lots of foreign bodies including wax and air bubbles which affect the quality of the honey. Extracted honey needs processing for killing of sugar tolerant yeasts to prevent its fermentation as well as granulation. Heating of honey is the only answer but this should be minimum and controlled, because uncontrolled heating results in loss of flavor, aroma, enzymes and darkens the colour. Hence, honey processing plant be installed by government and co-operatives. For this purpose, Government may help beekeepers/co-operatives by providing loans and subsidies. For storage of honey, beekeepers generally use old tins which are mainly used for storing oil and ghee. Such tins get rusted and impart black colour to honey which also loses its flavor. Therefore, for storage of honey stainless steel or galvanized containers should be used, although these are expensive. These containers should be moisture proof and should have tight fittings. Aluminum milk cans have also been found suitable for storage of honey. Even plastic containers have been used for honey storage but the plastics should be of good food grade quality as poor grade plastic also impart odour to honey. Government may help in this matter through loans and subsidies.

Beekeeping as an Agricultural Activity

Beekeeping in fact should have been included in the schedule of agriculture and only then it would have acquired the needed impetus. At present it is neither considered as an industry nor an agriculture activity. As a result there is lack of sufficient financial help available from government and other lending institutions for the development of beekeeping. It also requires long term loans at easy rates of interest. This was the procedure adopted by China to take up beekeeping on a commercial scale. Beekeeping is a long term developmental activity and needs to be given some tax incentives for people to take it up in a big way. Furthermore, it is a high risk activity, depending upon favorable weather conditions for heavy production. Therefore, beekeepers need financial support during season of bad honey harvest to sustain the colonies for next season.

Domestic Honey Consumption

In India there is a general lack of consumers' awareness of uses of honey and bee products. It is mainly used as medicine and its value as food by the general consumers has not been realized. The per capita consumption of honey in India vary between 3 to 10 g in some years. General interest and awareness about beekeeping and bee products can be created amongst the consumers by beekeeping societies and national bodies by organizing honey festivals, honey beauty queen competition and award to beekeepers for high honey production. Presently few National bodies are engaged for the purpose but the number of such bodies need to be increased.

Apiculture as Specialization

How can scientific beekeeping be expected without grooming the science of Apiculture which with booming beekeeping is losing its base and qualified manpower and expertise. Earlier **Apiculture** specialization placed under Entomology is no longer in existence and no such specialization exists for those willing to pursue M.Sc. or Ph.D. in the field only research component may be taken up with few compulsory academic courses in apiculture during post graduation. How can apicultural development be expected from ones who have studied only plant protection and when intricacies of the subject are unknown to him/her? Presently, there is only one university in Bangalore where there is separate department of Apiculture but unfortunately M.Sc (Apiculture) degree holders are not allowed by many agricultural universities for admission to Ph.D. (Entomology) programme. This issue needs specially attention of those at the top position in universities and Indian Council of Agricultural Research.

Multiplication of Bee Colonies

For the expansion of the beekeeping industry in the country, it is essential to increase the number of bee colonies for distribution amongst farmers. To achieve this goal, a time bound mission mode programme should be started in all the potential beekeeping regions. Each of these regions should have beekeeping extension centres with sufficient technical and extension functionary manpower for multiplication/distribution of bee colonies. Each extension centre should have a fixed target of raising bee colonies every year.

Beekeeping Extension Work

Need based and location specific appropriate beekeeping technologies have been evolved through assessment and refinement of existing ones. However, mass scale dissemination and use of these technologies amongst grass root stakeholders (farmers) has not been adequately attempted. In this context, there is a need to create a force of technical and extension functionary force so as to give an impetus to beekeeping.

Beekeeping is a highly specialized, scientific and technical activity in comparison to other branches of agricultural sciences such as crop husbandry, horticulture, livestock, sericulture etc. There are more than 60,000 individual bees in a bee hive, through their social life act as a micro-manipulator of pollen and nectar in nature and produce a diversity of bee-products for use by mankind. In order to make a bee colony more productive, it needs special care, management and manipulation by the beekeepers. The present Policy of distribution of bee colonies to the farmers and little subsequent follow up for their management in terms of food resources, abiotic and biotic stresses of colonies in these hives leads to absconding. Therefore, a network of well-trained beekeeping extension staff is needed to monitor the behavior and strength of bee colonies as this industry requires more intensive extension services than other farming activities. With beekeeping being treated as an insignificant ancillary activity, the present tendency is to depute inefficient or unwanted staff to look after beekeeping and many such personnel have no knowledge or training in beekeeping. There is a need to create a cadre of well-trained and skilled beekeeping extension experts for proper monitoring and management of bee colonies by farmers, otherwise all other beekeeping inputs provided by development agencies would be wasted. Experienced beekeepers can even act as a good extension agent and some mechanism need to be evolved to utilize their services.

Co-ordination amongst beekeeping Research and Development organizations

There are at present more than one dozen R&D organizations engaged in beekeeping program. Amongst these, two major ones are KV1C and National Bee Board, Ministry of

Agriculture and Co-operation, Govt. of India. Both these organizations have different priorities as well as assigned functions for the promotion and development of beekeeping industry in the country and lack co-ordination. For example, KVIC perceive beekeeping as an income and off-farm employment generating activity through production and sale of hive products for the weaker section of rural society. On the other hand, the primary focus of the Ministry of Agriculture and Co-operation, GOI is on increasing productivity of agricultural crops through pollination activities of honey bees. Both these activities are complimentary to each other. The Ministry of Environment and Forests, GOI, is yet to realize the role of bees and beekeeping in conservation of biodiversity as a decline in population of wild honey bees, in nature would lead to extinction of several important wild plants and animal species. A coordination between different research and development organizations is thus very important.

Computer Assisted Scientific Database on Beekeeping

In the modern era of computer and information technology it is very important to have scientific databases and networking facilities for the growth of any scientific discipline. Thus, there is a need to establish a network of web sites with databases on different aspects of beekeeping.

Scientific Beekeeping Requirements

Many very basic and petty things in beekeeping which are quite tangible have gone unscientific. To put the beekeeping on sound footings, it is high time that beekeeping is recognized as highly specialized field and scientific principles of beekeeping are promoted to make it more remunerative.

A few points from simple beekeeping point of view have to be pondered upon:

Bee Space

In bee hive all components are just separable and rather have to be separable for efficient and productive beekeeping. A successful apiculturist first learns the full scale bee behavior which is out of the scope of those from the other agricultural disciplines. Lorenz Lorraine Lang troth (an American) after studying the bee behavior gave the basic principle of bee hive viz. ‘bee space’. However, does attention is paid to observe that this bee space is ensured everywhere in hive for the efficient working of the bees.

Bee Hive

While teaching about the hive, certain characteristics of the wood are always stressed upon, including, it has to be lighter to facilitate movements and transportation, it has to be porous to not permit condensation of exhale vapors preventing build-up of the higher humidity - an another abiotic enemy, it has to withstand nails owing to their frequent use during transportation, it should not open at the joints even on absorption of moisture during monsoons to prevent giving way for enemies and robbing, and it should withstand extreme temperature conditions. Do we observe such things while planning policies, purchasing and supplying to the beekeepers and do we advise beekeepers to look for these things? My long practical experience working closely with beekeepers found it otherwise. The frames are seen as twisted, wooden planks torn, wood swollen at joints and giving way to biotic fauna and triggering robbing, a layer of moisture along the inner side of the planks and on the bottom board particularly during low temperature conditions and seen as distorted and much heavier. So far so, even use of inferior wood is defended.

It is astonished to see ‘bottom board’ just fixed with brood chamber. This is scientifically wrong as the hive is an ‘open system’. A misconception has been created among beekeepers that for migration, their job had been much easier. But the other side of the coin could not be realized as only specialized and professionals would know that. Was it ever realized as to how bottom board would be cleaned to check multiplication of wax moths and other enemies. How the colonies would be united to strengthen them or in the advent of one going queen less in non-breeding season, and how it to be united with queen-right ones. Arousing awareness would help in throwing these misconceptions.

Use of Hessian Cloth

Use of hessian cloth has almost replaced inner cover and many beekeepers do not know this useful part of bee hive. Beekeepers defend this point saying that this would save them about Rs. 100 per hive. But what about the lower productivity. This practice has lead to an increased incidence of diseases, enemies and reduced efficacy of chemicals etc. in reducing the incidence of occurrence of diseases.

Placement of Colonies

Very close placement of the hives, with utter disregard to the minimum 6-8 feet distance between hives and at least 10 feet between rows, is a common sight. This would lead to reduced egg laying by queen bee and low foraging and hoarding of floral rewards and, hence the productivity. Further, this leads to drifting among bees of different colonies and spread of diseases and bee mites. It is generally argued that there was less space available for the apiaries, however on colonies examination, it was found that colonies were very weak and sometimes need uniting to the extent ,reducing the colonies numbers to one-third.

Feeding

Open feeding is becoming common. Feed is given in some container kept in the apiary with grass or some float arrangement and even sometimes, honey cell cappings following honey extraction are kept in open in the apiary in some container for the bees to lick the residual honey. In the world, there is no recommendation of such open feeding anywhere. In this type of feeding, colonies may collect more at the expense of the others. Further, this may trigger robbing and bee diseases.

Weak Colonies

It is quite common to maintain colonies on single chamber against recommendations of taking these to at least one super. It is generally debated that single chamber facilitate frequent migrations. But the argument is untenable. Even colonies on super can be migrated as single unit using ‘travelling straps’ or simply, their divides (with specific numbers) can be migrated and reunited at the new site. The migration involves costs and it must be ensured to realize higher production which is possible to augment many a folds using stronger colonies. The strong colonies are generally self perpetuating and reproductive as they are more efficient in maintaining temperatures, hygienic conditions, etc. thereby also in defending against bee diseases and enemies.

Colony Division

Colony multiplication by division method is still very common even among progressive and large beekeepers. Though on account of easiness, it could be preferred by very small apiary size holders but for large sized apiaries, it is unscientific. Firstly, the colonies division allows the deleterious genes in the stock to perpetuate and, secondly, owing to reduced bee strength following division, the honey production dwindles. Large apiary size holders should take up selective breeding and colonies selected with desirable traits should be used for queen bee rearing.

Honey Extraction

It is generally observed that beekeepers extract honey from brood combs as colonies are maintained on single chamber. Even when colonies are on super, owing to non-use of queen excluder, the combs are though chosen from super chamber, yet they are not free from brood. This leads to loss than any profit. The beekeepers need be advised and convinced on this account. If a comb has half brood and half honey, it would lead to maximum honey production of 1 kilogram which on current whole sale purchase price would fetch only Rs. 80-85. As is well known that half comb will have to result in one and half combs of bees costing Rs. 500-550 which will be lost to earn Rs. 80-85 as the honey extraction from brood frames will result into mortality of such brood. Furthermore, honey extraction from brood chambers will lead to spread of brood menaces as the brood combs would get mixed during extraction process. Sometimes, even unripe honey is extracted which has to be discouraged to enhance its shelf life.

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HONEYBEE COLONY STRUCTURE AND REPRODUCTION

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ABSTRACT

Honeybees are social insects and live in colonies. A honey bee colony typically consists of three kinds of adult bees the queen, the workers and the drones. The social structure of the colony is maintained only by the presence of the queen and workers which depends on an effective system of communication. Division of labour are just some of the behaviours that honey bees have developed to exist successfully in social colonies. The main function of the honeybee queen is to lay eggs, while worker bees which are sexually undeveloped females perform all the duties connected with the maintenance and management of the colony. Drones are the only males; their main function is to mate with the queen during nuptial flight. Queen can lay both fertilized and unfertilized egg. Fertilized eggs hatch into females (either queen or workers) and unfertilized develop into males (drones). Normally, development of the workers' ovaries is inhibited by the presence of brood and the queen and her chemicals. However, when a colony becomes queenless, the ovaries of many worker bees start developing and they begin to lay unfertilized eggs, resulting in the production of drones.

Introduction

Bees of all kinds belong to class insecta, order Hymenoptera. This order comprises of some 100,000 species, which also includes wasps, ants, ichneumons and sawflies. Honey bees belong to the family of social bees which includes bumble bees and the tropical stingless bees. Honey bees are social insects, which mean that they live together in large, well-organized family groups. The social bees nest in colonies headed by a single fertile female, the queen, which is generally the only egg layer in the colony. The sub-family *Apinae* or honey bees, comprises a single genus, *Apis*, which is characterised by the building of vertical combs of hexagonal cells constructed bilaterally from a midrib, using only the wax secreted by the worker bees. The cells are multi functional, being used repeatedly for rearing the larvae and for the storage of honey and pollen. Management and study of honeybees is called apiculture, which has been practiced in Europe and Asia throughout recorded history**.**

Communication, complex nest construction, environmental control, defence, and division of labour are just some of the behaviours that honey bees have developed to exist successfully in social colonies. These fascinating behaviours make honey bees among the most fascinating creatures on earth.

A significant, but not widely recognized role is that honeybees enhance the productivity levels of agricultural, horticultural and fodder crops through cross pollination. Thus honey bees are the only insects which provide food to the human beings. Knowledge on their caste system, functions/duties of each member of the colony and understanding about the ways how male and female sex appears in the colony is an important aspect for undertaking studies on apiculture.

Note- This paper was not presented during the Workshop, however, it is being included in the proceedings

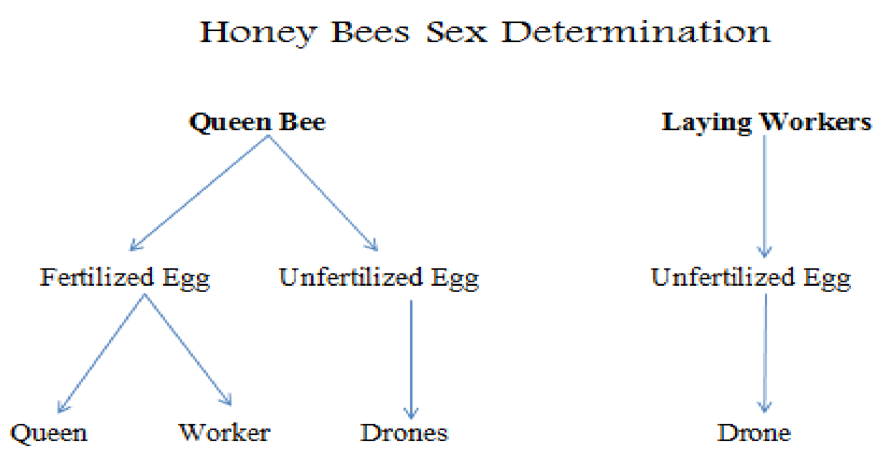
Communication and colony structure

The social structure of the colony is maintained only by the presence of the queen and workers which depends on an effective system of communication. The distribution of chemical pheromones among members and communicative "dances" are responsible for controlling the activities which are important for the survival of the colony. Labour activities among worker bees depend on the age of the bee, which may vary with the needs of the colony. Worker bees perform different duties throughout their lives. Foragers find flowers, locate food source, navigate back home, and share the detailed information about with other foragers. Karl von Frisch received the Nobel Prize in Medicine in 1973 for cracking the language code of honey bees – the waggle dance.

A honey bee colony typically consists of three kinds of adult bees (Stanley, 1960 and Rembold, 1964).

1. The queen,
2. The workers,
3. The drones.

All the three types of adult honey bees pass through three developmental stages before emerging as adults: egg, larva, and pupa. The three stages are collectively labelled brood. Unfertilized eggs become drones, while fertilized eggs develop either workers or queens (Mackensen, 1951; Heimpel and de Boer, 2008). Nutrition plays an important role in caste development. Larvae destined to become workers receive less royal jelly and more a mixture of honey and pollen as compared to the high amounts of royal jelly that a queen larva is fed. In addition to thousands of worker adults, a colony normally has a single queen; several hundred drones and each of these three types have specific duties to perform in the hive.



Honeybee Queen

A queen can be easily distinguished from other members of the colony as her body is much longer than either the drone's or the worker's, especially during the egg-laying period when her abdomen is greatly elongated. Her wings cover only about two-thirds of the abdomen, whereas, the wings of both workers and drones nearly reach the tip of the abdomen when folded. A queen's thorax is slightly larger than that of a worker and she has neither pollen baskets nor functional wax glands. Her stinger is curved and longer than that of the worker, and has fewer and shorter barbs.

Development: Life in the beehive depends upon one bee, the queen. She begins her life as a normal, fertilized egg and hatches into a female larva, which are reared in special cells. These cells hang vertically and get extended as the larva grows. Twenty four hours after the egg hatches, the workers begin to feed the queen-to-be a substance called 'royal jelly'. Feeding on jelly makes the queen grow differently, and turn into a queen. Thus, 16 days after an egg is laid, a queen can hatch. Five to eight days after the queen hatches, she goes on her mating flight. Five to eight days after this, she is ready to lay eggs for another 2-3 years. The queen is constantly surrounded by dozens of worker bees. The queen can live for several years—sometimes for as long as 5 years, but the average productive life span is 2 to 3 years, however, she is normally replaced after 1-2 years.

Each colony has only one queen, except during swarming preparations or supersedure. She lays both fertilized and unfertilized eggs. During peak production, queens may lay up to 1,500 eggs per day. One queen may produce up to 250,000 eggs per year and possibly more than a million in her lifetime. So prolific an egg layer is she, that she can produce her own body weight in eggs in a single day. In fact, she has no time for any other chores, so attendant workers take care of all her grooming and feeding.

Mating/Nuptial flight: Nuptial flight is an important phase in the reproduction of most of the bee species. During the flight, virgin queens mate with males and then continue the succession of an existing hived colony. About one week after emerging from a queen cell, the queen leaves the hive to mate. She must fly some distance to avoid inbreeding from her colony to mate (nature's way of). The queen mates, usually in the afternoon, with seven to fifteen drones at an altitude above 20 feet. If successful, she never needs to mate again. She holds the sperm in her spermatheca and uses it to fertilize eggs throughout her life. A queen bee stores a lifetime supply of sperms. Drones locate and recognize the queen by her chemical odour (pheromone). If bad weather delays the queen's mating flight for more than 20 days, she normally loses her ability to mate and then she will lay only unfertilized eggs, which results in the hatching of drones (males) only. After mating, the queen returns to the hive and begins laying eggs in about 48 hours. She may release several sperms from her spermatheca each time she lays an egg destined to become either a worker or queen. The queen is constantly attended and fed on royal jelly by the worker bees. The number of eggs laid by the queen depends on the amount of food she is fed and the number of the workers attending the queen, preparing beeswax cells for the eggs, caring the larvae that will hatch from the eggs in about three days. When the queen substance (a pheromone known as the queen substance (oxodecenoic acid) secreted by the queen is no longer adequate, the workers prepare to replace (supersede) her. Thus the old queen and her new daughter may both be seen in the hive for some time following supersedure. New (virgin) queens develop from fertilized eggs or from young worker larvae (not more than three days old) under the following three different circumstances:

1. Emergency
2. Supersedure
3. Swarming

When an old queen is killed, lost, or removed, the worker bees select younger worker larvae to produce emergency queens. These queens are raised in worker cells. When an older queen begins to fail (decreased production of queen substance), the colony prepares to raise a new queen. Queens produced as a result of supersedure are usually more fertile /productive than emergency queens since they receive larger quantities of food (royal jelly) during development. Like emergency queen cells, supersedure queen cells typically are raised on the comb surface.

The other major function of a queen is producing pheromones that serve as a social "glue" unifying and helping to give individual identity to a bee colony. One major pheromone termed queen substance is produced by her mandibular glands (Arriault and Mercer, 2012). The characteristics of the colony depend largely on the egg-laying and pheromone production capabilities of the queen. Her genetic makeup along with that of the drones she has mated with contributes significantly to the quality, size, temperament, and productivity of the colony

The Worker

Morphology: They are smallest bodied adults and thus smaller than the queen, the wings are well developed and extend the length of the body. Worker bees are sexually undeveloped sterile females with undeveloped reproductive system, constitute the primary and essential elements of the colony population. They are unable to lay eggs under normal hive conditions. They possess a well developed and long proboscis for nectar gathering, scent, wax and brood food producing glands and pollen baskets, which allow them to perform all the duties connected with the hive. They also possess a well developed sting apparatus with a curved denticulated barb.

The life span of the worker is around 6 weeks in the summer because they literally work themselves to death. They can, however, live up to 6 months during the winter months, allowing the colony to survive the winter and assisting in the rearing of new generations in the spring before they die

Development: The worker begins her life as an egg, then develops into a larva and transforms into the final pupa stage. After hatching, she is fed by other workers and spends a good deal of time standing still on the comb. Twenty one days after the egg is laid, the worker bee emerges from its enclosed cell and begins work.

Functions/duties The tasks undertaken by a worker bee depend partly on its age and partly on the immediate needs of the colony. But surviving and reproducing take the combined efforts of the entire colony. Individual bees (workers, drones, and queens) cannot survive without the support of the colony.

Several thousand worker bees cooperate in nest building, food collection, and brood rearing. Workers gather nectar and pollen, feed young larvae, supply the hive with water, secrete beeswax, build comb, and dozens of other tasks. They clean and polish the cells, care for the queen, remove debris, handle incoming nectar and air-condition and ventilate the hive during their initial few weeks as adults. Later as field bees they forage for nectar, pollen, water, and propolis (plant sap). Propolis is a resinous substance that the bees collect from trees and sticky buds. They use it for sealing small cracks and gaps in the hive. Old bees performing "nurse" duties, and young bees foraging. Nurse bees care for the young, while the queen's attendant workers bathe and feed her. Guard bees stand watch at the door protecting the hive from invasion by robber bees. Construction workers build the beeswax foundation in which the queen lays eggs and the workers store honey. Some worker bees remove the dead from the hive.

Foraging and honey production: After about three weeks of hive duties the worker becomes a forager and spends the daylight hours collecting water, nectar, pollen and propolis and carrying it back to the hive. This work she may continue for about three weeks before she dies. During the summer months, the worker bees travel around 55,000 miles to gather enough nectar to produce just one pound of honey. Each worker can only produce about 1/12 of a teaspoon of honey and 1/80 of a teaspoon of wax in her entire lifetime. The entire colony however, in a good year, can produce up to 200 lbs of honey. It is the number of worker bees that counts**.** From spring to fall, the worker bees must produce about 60 lbs. of honey to sustain the entire colony during the winter. It takes tens of thousands of workers to get the job done. An industrious worker bee may visit about 2,000 flowers per day. As she can not carry all the pollen from so many flowers all at one time, so she visits about 50-100 flowers before heading to the comb. All day long, she keeps repeating these round trip flights to forage, which puts a lot of wear and tear on her body. Foragers must bring back enough pollen and nectar to feed the entire community. A hardworking forager may live up to just 3 weeks.

Environmental control inside the hive: Temperature and humidity inside and outside the hive are important indicators of hive health. Honey bees maintain a constant temperature of about 93º F (about 34 ºC) within the hive year-round. As temperatures fall, the bees form a tight group within their hive to stay warm. Honey bee workers cluster around the queen, insulating her from the outside cold. In summer, the workers fan the air within the hive with their wings, keeping the queen and brood from overheating. Humming sound of all those wings beating inside the hive can easily be heard several feet away.

Production of wax and making nest: Honey bees produce beeswax from special glands on their abdomens. The youngest worker bees make the beeswax, from which workers construct the honeycomb. Eight paired glands on the underside of the abdomen produce wax droplets, which harden into flakes when exposed to air. The workers must work the wax flakes in their mouths to soften them into a workable construction material.

Laying Workers

When due to some unavoidable circumstances, a colony becomes queenless, the ovaries of many worker bees start developing and they begin to lay unfertilized eggs. Normally, development of the workers' ovaries is inhibited by the presence of brood and the queen and her chemicals. The presence of laying workers in a colony usually means the colony has been queenless for several weeks. Laying workers can also be observed in normal colonies during the swarming season and when the colony has poor queen. Colonies with laying workers can be easily identified by to the presence many eggs (5-15) per cell and also small-bodied drones present in worker-sized cells. They scatter their eggs more randomly over the brood combs, and eggs can be found on the sides of the cell instead of at the base, where they are placed by a queen. Some of these eggs do not hatch, and many of the drone larvae that do hatch do not survive to maturity in the smaller cells.

Drones

Morphology and functions

Drones (male bees) are the largest bees in the colony. They have no fathers as they emerge from the unfertilized eggs. About a week after emerging from their cells they become sexually mature and are ready to mate. They are generally present only during late spring and summer. They do not possess structures for pollen or nectar collection, stinger, pollen baskets, or wax glands. They are larger than the workers, yet smaller than the queens. Their head is much larger than that of either the queen or worker, and their compound eyes meet at the top of their head. Their main function is to impregnate the virgin queen during her mating flight and thus provides sperm to the queen. Only a small number of drones succeed in performing this function. They die immediately after mating.

They don't forage (early in life they are fed by workers), they can't feed themselves. Often over looked, drones are still vital to the survival of the honeybees. Without them, the queen would never be able to lay fertilized eggs. Since drones eat three times as much food as workers, and a high population of drones may exert an added stress on the colony's food supply. Drones stay in the hive until they are about 8 days old, after which they begin to take orientation flights. Drones have never been observed taking food from flowers. When cold weather begins in the fall and pollen/nectar resources become scarce, drones usually are evicted from the hive into the cold and left to starve or are die of predation. Queenless colonies, however, allow them to stay in the hive indefinitely.

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RECOMMENDATIONS

More than 100 agricultural crops around the world are pollinated by bees. This means bees are important, if not essential, for the production of many billion worth of agricultural and horticultural crops. Honeybees are the only pollinators that can be easily managed, moved around and are known to exploit a wide variety of crops for pollination and thus seed setting.

In recent times, there has been a growing concern about the decline in the natural populations of honeybees. Among different factors responsible for bee decline are habitat loss and fragmentation, chemical intensive agriculture, invasive species and climate change. Climate change, an emerging global phenomenon, with a potential to affect every component of agricultural ecosystems, is reported to impact diversity of bees at various levels, including their pollination efficiency.

In view of this, a one day workshop on promotion of Honeybee keeping in Haryana was organised by Haryana Kisan Ayog on June 24, 2014. In all, about 60 participants comprising of scientists, administrators, policy makers, extension personnel, farmers, NGOs and small entrepreneurs attended the workshop and had an intensive discussion on various aspects of bee keeping and its promotion in the state of Haryana.

The following recommendations had emerged from this workshop on various aspects of bee keeping and its promotion in the state of Haryana requiring effective implementation by all concerned:

General
Recommendations

1. Frequent beekeeping workshop-cum-training should be organised to update the knowledge of beekeepers, promote scientific beekeeping and feedback for further development of beekeeping. In this platform, beekeepers can share their problems and bee keeping experts can solve their problems on the spot. In addition they can also talk about the latest technologies developed in bee keeping.
2. During migration, a permit/Identity card may be issued by Govt. Agency to registered beekeepers so that policeman and octroi persons do not create any hindrance during migration of bee colonies.
3. Crowding of colonies at one place should be discouraged. There should be at least 5 km distance between the two apiaries.
4. Make beekeepers aware that instead of having large number of weak or average strength colonies they should maintain strong colonies.
5. Beekeepers be encouraged to develop their own domestic and local market for honey and premium for ripe honey should be introduced to encourage beekeepers to produce better quality of honey.
6. Database of number of beekeepers, number of bee colonies and honey production should be prepared to give an estimate of beekeeping industry at a glance in the State. In this regard, registration of beekeepers must be made mandatory in the state and suitable identity cards be issued
7. Self-help groups be created to have common facilities like honey processing, bottling and marketing.

Researchable
Recommendations

1. There is a need of undertaking scientific beekeeping in increasing honey production and pollination of crops.

2. Indiscriminate use of Antibiotics, pesticides and chemicals in bee colonies leaves residues in bee products including honey. These residues are very harmful for human lives. Further, the presence of these residues in honey may disqualify it for human consumption and may be rejected in National & International markets causing ultimate loss to the bee keepers. Therefore, indiscriminate use of Antibiotics/Pesticides/Chemicals in bee colonies should be discouraged.

3. Use of inner cover in bee hives should be encouraged to obtain better management of bee brood mites.

4. For faster development of honey bee colonies, traditional method of division should be replaced with selective division at small scale beekeeping and mass queen bee rearing from selected colonies having high honey production and resistance/tolerance to diseases be adopted.

5. Diversification of beekeeping should be promoted to enhance profitability of beekeeping.

Policy Recommendations

1. It is imperative to promote region specific unifloral honeys to fetch higher prices. For this, a clear strategy at state level be evolved.
2. Most of the beekeepers are rearing honey bees in unscientific way. The training on bee-keeping should be imparted on regular basis by experts on all aspects of bee keeping.
3. For quality honey production and profitable marketing of honey, there is need for scientific beekeeping. For this purpose, the State Govt. should open regional training centers.
4. Already existing honey processing plants in the State should be further strengthened and effectively utilized.
5. Bad weather compensation: In bad honey season (when there is poor honey harvest), Govt. may be requested to compensate the registered beekeepers as Govt. compensate for Agricultural crops during unfavourable seasons like drought, flood etc.
6. Bee keepers/bee breeders be provided loans/ subsidy for buying bee hives and for honey processing by the cooperative societies /self help groups of beekeepers. There should be no limit on subsidy on number of bee hives provided to farmer
7. The issue as to whether collection of bee venom is permissible under the law or not has to be examined and clarified.
8. There is 4% VAT on honey as well as on bee keeping implements in Haryana. It was felt that bee keeping should be treated on par with other Agricultural activities and VAT should be abolished on such items.
9. Government should extend insurance policy/scheme for bee keeping in Haryana.
10. Under NHM scheme, the bee breeders supply bee hives and colonies to the farmers on subsidised rates generally in the months of February – March every year. In this case, the bee colonies have very rare chances of survival during lean/dearth period especially in June, July. It was suggested that bee keepers should be given bee colonies in the months from August to November.
11. There should be a Bee Board consisting of members from scientific community, Government side and bee keeper's association, etc. for the welfare of bee keeping in the State.
12. Bee parking space is an important issue as there is much resistance from land owners There should be some honey Bee Parks or gardens where farmers could keep their bee colonies temporarily during honey flow season as well as during lean/dearth period.

Directorate of Horticulture be approached for sparing two to three gardens for this purpose.

13. Various Govt. agencies particularly Forest and Irrigation Department may be contacted to allow the beekeepers to park their colonies in their land/farms during the lean period.
14. Large scale mass planting of trees under social forestry be planned, which will serve as multipurpose source for fuel, fodder and bee forage.
15. Indo-Israel centre for promotion of beekeeping in Haryana may be strengthened with both scientific and technical manpower so that this centre could cater to the needs of the beekeeping industry in the state.
16. There is an urgent need to create adequate laboratory facilities for disease diagnosis, and testing of quality of bee hive products
17. In Haryana State, there are only few Agriculture Development Officers (ADOs) who are engaged in the development of beekeeping. There is an urgent need to increase their numbers to 10 - 15 for smooth expansion of beekeeping.
18. Written directions from the State Government to forest officials, inter-state barriers, etc will reduce harassment and loss of beekeepers.
19. Intensive and extensive basic as well as advance beekeeping trainings programme throughout the State should be developed to promote beekeeping.
20. A visit of the beekeeping trainees to young successful beekeepers will encourage the rural unemployed youth to take up beekeeping in a big way. It will really helpful to under-privileged youngsters.

Annexure-I

Workshop on Promotion of Honeybee Keeping in Haryana
June 24, 2014
(Venue: Kisan Bhavan, Sector- 14, Panchkula)
Programme of the Workshop

9.30 AM	**Registration**		
10.00AM	**Inauguration**		
	Welcome Address	**Dr. R.S. Dalal**	**10.00-10.05**
	Opening Remarks	**Dr. S.P. Singh**	**10.05-10.20**
	Presidential Address	**Dr. R.S. Paroda**	**10.20-10-40**
10.45-11.45AM	**Technical Session I** **Chair: Dr. S.S. Siwach, Director Research CCS HAU Hisar** **Co-Chair: Dr. B.S. Sehrawat, Principal, HTI, Karnal** **Rapporteur- Dr. V.K. Mattu**		
	Dr. R.K. Thakur	Research and Development in Beekeeping in India	
	Dr. S.K. Sharma	Status and Prospects of Bee keeping in Haryana	
		Discussions	
11.45AM-1.15PM	**Technical Session II** **Chair: Dr. A.S. Saini, DG Horticulture** **Co Chair: Dr. Balvinder Singh, Prof.&Head, Entomology, PAU** **Rapporteur-Dr. C.J. Juneja**		
	Dr. V.K. Mattu	Role of Honeybees in Pollination and impact of climate change	
	Dr. Jaspal Singh	Honeybee Management	
	Dr. B.S. Rana	Honeybee Pests and Diseases	
		Discussions	
1.15-2.15 PM	**LUNCH**		
2.15-3.45 PM	**Technical Session III** **Chair Dr. R.K. Thakur, Project Co-ordinator, AICRP** **Co-Chair Dr. R.K. Saini, HOD Ento., CCS HAU Hisar** **Rapporteur-Dr. Mrs Neelam Mattu**		
	Dr. Yogesh Kumar	Constraint Analysis in Beekeeping Industry	
	S. Jagjit Singh Kapoor	Honey export scenario in India	
3.45- 5.00 PM	**Plenary Session** **Chair Dr. S.P. Singh** **Rapporteur Dr. V.K. Mattu**		
	Reports of the Rapporteurs & discussion	**Session I, II and III**	
	Concluding Remarks by Dr S.P. Singh		
	Vote of Thanks	**Dr. S.K. Garg**	

Annexure II

WORKSHOP ON

PROMOTION OF HONEYBEE KEEPING IN HARYANA

Held on June 24, 2014

Workshop Participation

S.No.	Name and Address	Telephone/Fax	Stake holder category
1.	**Dr. R.S. Paroda** Chairman, Haryana Kisan Ayog, Panchkula chairman@haryanakisanayog.org	0172-2551864 0124-2300789	Haryana Kisan Ayog
2.	**Dr. R.S. Dalal** Member Secretary, Haryana Kisan Ayog, Panchkula rsdalal1@gamil.com	0172-2551864	Haryana Kisan Ayog
3.	**Dr. S.P. Singh,** Former Director, NBAII, ICAR, Bangalore spdoad@gamil.com	0172-2673149 08968840119	Chairman Working Group
4.	**Dr. C.J. Juneja** Sr. Consultant (Bee Keeping), Haryana State Horticulture Development Agency, Kurukshetra juneja.cj@gmail.com	09896890950	Member Working Group
5.	**Dr. V. K. Mattu** Professor, Deptt. Of Biosciences, HPU, Shimla vkmattu@rediffmail.com	0177-2830037 09418701009	Member Working Group
6.	**Dr. A.S Saini** Director General Horticulture, Govt. of Haryana, Udhyan Bhawan, Sector-21, Panchkula horticulture@hry.nic.in, hortharyana@gmail.com	0172-2582322	Department of Horticulture
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18.	**Dr. Rakesh Kumar** APPO, Agriculture, Panchkula	09501079828	Department of Agriculture
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27.	**Mr. S.K. Mahajan** #1490/ 15 Panchkula	09815611561	Entrepreneur
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29.	**Mr. Vijay Kumar** VPO- Khar kara, Kaithal (Haryana Bee Association)	09416094303	Farmer
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Annexure III
Workshop in Progress





HARYANA KISAN AYOG
WORKSHOP
Promotion of Honeybee Keeping
in Haryana
US Prez Obama
launches plan to
save honey bees


HARYANA KISAN AYOG
Promotion of Honeybee Keeping
in Haryana


HARYANA KISAN AYOG
Promotion of Honeybee Keeping
in Haryana

"If the bee disappeared off the surface of the globe then Man would only have four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man"

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