

HONEYBEES IN MOUNTAIN AGRICULTURE

Editor

L.R. VERMA



Honeybees in Mountain Agriculture

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International Centre for Integrated
Mountain Development, Kathmandu



OXFORD & IBH PUBLISHING CO. PVT. LTD.

New Delhi

Bombay

Calcutta

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© 1992, International Centre for Integrated Mountain Development
(ICIMOD), Kathmandu

ISBN 81-204-0650-8

Published by Mohan Primlani for Oxford & IBH Publishing Co. Pvt.
Ltd., 66 Janpath, New Delhi 110 001. Phototypeset by Laserwords,
Madras, processed and printed at Baba Barkha Nath Printers,
N-48 Kirti Nagar, New Delhi 110 015.

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PROCEEDINGS OF

INTERNATIONAL EXPERT MEETING

ON

BEEKEEPING DEVELOPMENT IN THE

HINDU KUSH-HIMALAYAN REGION

Kathmandu, Nepal.
21st–23rd June, 1989

Organized by
INTERNATIONAL CENTRE FOR INTEGRATED MOUNTAIN
DEVELOPMENT (ICIMOD)
MINISTRY OF AGRICULTURE, HMG, NEPAL

And
FOOD AND AGRICULTURE ORGANIZATION (FAO)
OF THE UNITED NATIONS

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Foreword

Today, the entire Hindu Kush-Himalayan region is facing a near crisis situation, both economical and environmental. National development strategies in this region are therefore being reoriented with major emphasis on food, income, nutrition and ecological security, especially for the unprivileged. In this task, ICIMOD, being the only International Centre for Integrated Mountain Development in the region has a special role to play. The primary objective is to promote economically and environmentally sound programmes for the socioeconomic upliftment of the mountain farmers living at or below subsistence level. Apiculture (Beekeeping) is one such activity which fits very well into the policies and programmes of ICIMOD in relation to sustainable development of mountain agriculture. Apiculture has been closely linked with the cultural heritage of the rural people of the mountain areas and is an excellent source of nutritious food and cash income. This non-land based activity does not require high cost technology and forms an integral part of different mountain ecosystems with positive ecological consequences only. Apiculture and honeybees render essential ecological services through cross-pollination of both wild and cultivated plants and contribute to saving them from extinction.

The central theme of the Expert Meeting held in Kathmandu, Nepal, from 21st to 23rd June, 1989 was mountain apiculture for sustainable agriculture and integrated rural development. It was, therefore, planned and organized in a somewhat different manner than the several international conferences on this subject held in the recent past by different agencies such as FAO, IBRA, APIMONDIA and CIDA. Besides discussing important aspects of bee biology and management in mountain areas, the major emphasis was on creating awareness amongst the policy makers, planners in different Government organizations, and international donor agencies regarding the role of apiculture in solving the different economic, nutritional, ecological, and social problems, of mountain rural communities.

In this Expert Meeting, successful beekeeping experiences of countries such as China, one of the major producers and exporters of honey

and other hive products in the world, have been reported. Similarly, Himachal Pradesh in northern India has taken a lead in utilizing honeybees in apple orchards for pollination purposes to boost production and improve quality. Such success stories can be of help to other countries of the Hindu Kush-Himalayan region where initiatives have been taken to develop apiculture on modern scientific lines.

More than 50 experts from various fields such as development planning, economics, genetic resources, horticulture, and entomology, as well as donor agencies, participated in this meeting, to discuss how apiculture can help mountain farmers in food and income generation, in increasing the yield and quality of different agricultural crops, and in overcoming the problem of malnutrition.

ICIMOD is indebted to the co-sponsors of this Expert Meeting: the Ministry of Agriculture, HMG, Nepal and the Food and Agriculture Organization (FAO) of the United Nations. It was a great honour to all of us that the inaugural session was chaired by Mr. Janak Bahadur Shah, Hon'ble Assistant Minister for Agriculture, HMG, Nepal and Mr. Krishna Charan Shrestha, Hon'ble Minister of Agriculture, HMG, Nepal inaugurated the meeting with a thought-provoking and stimulating address.

I must express my sincere thanks to Prof. L.R. Verma of ICIMOD, who acted as Convenor of this Expert Meeting and also contributed greatly in editing this report. I acknowledge with pleasure the efforts made by the former Director of ICIMOD, Dr. Colin Rosser, for initiating and organizing this meeting. The support received from the professional and administrative staff of ICIMOD is sincerely acknowledged.

E.F. TACKE
Director, ICIMOD

Introduction

L.R. Verma

International Centre for Integrated Mountain Development
Kathmandu, Nepal

Apiculture (Beekeeping) is an important resource base of mountain farming systems and offers specific advantages for developing 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 render essential ecological services such as cross-pollination and propagation of plant species thereby maintaining biological diversity.

The most important aspect of apiculture is that it is an important income-generating activity in the hills for small and marginal farmers, landless labourers, and other weaker sections of society living at, or under, subsistence level. Hive products such as honey, beeswax, royal jelly, and pollen provide both nutritious food and cash income. These are in demand both locally and for export market. Beekeeping is a flexible occupation which creates off-farm employment and diversifies the economy. Inputs for apiculture are mostly simple and locally available. Yet another significant, but not widely recognized, role is that honeybees enhance the productivity levels of agricultural, horticultural, and fodder crops through cross-pollination. It has been estimated that the value of honeybees as producers of honey and beeswax is only a small fraction of its value as crop pollinators.

There are at present four or more species of honeybee in the Hindu Kush-Himalaya. Among these, *Apis cerana*, *Apis dorsata/laboriosa* and *Apis florea* are native to this region, whereas, the European honeybee, *Apis mellifera* has been introduced in some countries of Hindu Kush-Himalayan region. The Asian hive bee, *Apis cerana* and the European hive bee, *Apis mellifera*, can be domesticated but all attempts to domesticate the other two species of honeybees have so far failed. Such a great diversity of honeybee at the species level in the Hindu

Kush-Himalaya is not only the basic source of most of the commercial or domestic honey and other hive products, but they also enhance productivity levels of many cultivated crops through cross-pollination.

Exotic *Apis mellifera*: Problems and Prospects

As a result of continuous research efforts in the area of genetic diversity, selective breeding, and improved management practices, *Apis mellifera* produces three times more honey than *Apis cerana*. *Apis mellifera* is also superior to *Apis cerana* due to its maintenance of prolific queens and less swarming and absconding tendencies. However, many importations of exotic *Apis mellifera* in the Hindu Kush-Himalayan region have proved disastrous. When kept sympatrically, *Apis cerana* and *Apis mellifera* colonies frequently rob each other (Koeniger 1982). Another cause of failure in the co-existence of the two species is attempted intermating which produces lethal offspring (Ruttner and Maul 1983). A new problem is the transfer of parasites from one species to another. A parasitic mite of brood and adults, *Varroa jacobsonii* can co-exist with *Apis cerana* and causes no serious damage to this native bee species. In several parts of Asia, where both the bee species are now kept together, the parasitic mite has infested *Apis mellifera* colonies and become a serious pest to this unadapted host. There is now apprehension that importation of *Apis mellifera* will lead to the decline of *Apis cerana* populations in its native habitat to a level that threatens its existence as a valuable genetic resource. In Japan and China, *Apis cerana*, is now largely replaced by imported *Apis mellifera* colonies. Other Asian countries such as Pakistan and India are now following this trend.

***Apis cerana*: Problems and Prospects**

Apis cerana has many valuable characteristics of biological and economic importance. These include their docile and industrious nature, their being less prone to attacks of wasps and a high level of resistance to nosema disease and the parasitic Asian mites, *Varroa jacobsonii* and *Tropilaelaps clareae* that plague *Apis mellifera*. *Apis cerana* can co-exist with other native bee species and requires little chemical treatment of colonies to control epidemics. However, this native bee species has not yet become popular amongst beekeepers because of several behavioural characteristics. These include the frequent swarming and absconding, the tendency to rob, production of a large number of laying workers and lower honey yields. These negative traits show eco-geographical variations depending upon the sub-species/geographic ecotype and management efficiency of the beekeepers (Verma 1990).

Some of these undesirable behavioural traits, from a beekeeping point of view, may have emerged in *Apis cerana* during the process of evolution as a result of harmful exploitation by man. For example, through traditional methods of beekeeping, which are in vogue even today, most of the bees were killed during honey harvesting and no honey store was left behind in the nest for consumption by bees during dearth periods. As a result, the colonies of *Apis cerana* that survived and propagated in nature developed the traits of frequent migration and absconding to safer and better pastures. In order to reverse such trends, a strategy through development and promotion of beekeeping with *Apis cerana* in modern movable hives is needed where moderate honey harvests are collected in a timely manner without harming the bees. In order to make such strategies successful, the foremost requirement is exploration and evaluation of different sub-species/geographic ecotypes of *Apis cerana*, which has not yet been done in detail in its native habitat.

The expert meeting was organized to discuss methods to overcome some of the above constraints. It is hoped that the recommendations of this meeting will help to raise the status of this rural industry from traditional honey hunting into a viable income-generating activity and a stable occupation for rural communities living in the Hindu Kush-Himalayan region. The major objectives of this workshop were as follows:

- Bring together apicultural experts from the Hindu Kush-Himalaya (and other parts of the world), for an exchange of knowledge, and to focus on relatively successful developments in mountain apiculture, in China and India, as well as on the extent to which they are relevant to other mountain areas in the Hindu Kush-Himalaya.

- Bring awareness to the Governments of the Hindu Kush-Himalayan countries, and international organizations, concerning the importance of mountain apiculture in providing extra food, pollination of crops, employment, nutritional benefits, and cash income to the weaker sections of rural society.

- Explore the possibilities of establishing a regional Apicultural Research and Training Centre, with substantial international funding, in the Hindu Kush-Himalayan region. This would help create a centre of trained experts and generate and deliver improved apicultural management technology, through basic and applied research, primarily on Asian species of honeybees.

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Expert Meeting Discussions

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For three days in late June, 1989, more than 50 leading bee biologists, economists, horticultural experts, development planners, representatives of international funding agencies, and other professionals, participated in an International Expert Meeting on Apicultural Development under the auspices of ICIMOD, HMG/Nepal, and FAO. In accordance with their different professional backgrounds, the speakers approached the topic from many directions. However, the central theme remained the role of apiculture in sustainable mountain agriculture.

In this chapter on Expert Meeting Discussions, are summarized the salient issues raised during the presentation of papers and ensuing discussions.

The Mountain Perspective and Beekeeping

Mountains have several special characteristics that differentiate them from other regions. The important ones among them are inaccessibility, fragility, marginality, diversity, niche (comparative advantage) and people's adaptation experiences. The significance of these mountain characteristics, in relation to the development of apiculture in the Hindu Kush-Himalayan region, was one of the main topics of discussion. It was noted that, in comparison to all other land-based activities, apiculture faces less constraints because of features such as inaccessibility, fragility, and marginality.

Furthermore, other mountain characteristics such as diversity, niche, and people's adaptation experiences are more conducive to apiculture. This Expert Meeting also observed that constraints such as

severe climate, high altitude, non-availability of honeybee genetic resources, and honey plant resources do not limit beekeeping development programmes in the region. Certain constraints such as poverty, remoteness, transport, travel problems, and neglect of native bee genetic resources, to some extent hamper development and promotion of beekeeping. Problems such as deforestation, soil erosion, and degradation of watersheds are other factors responsible for the loss of the natural habitats of honeybees and decline in bee floral resources.

Honeybee Resources

The Hindu Kush-Himalayan region is the richest in the world from point of view of bee resources. There are at present four different species of honeybee in this region. Among them, *Apis cerana*, *Apis dorsata/laboriosa*, and *Apis florea* are native, whereas the European honeybee, *Apis mellifera*, has been introduced in some countries of the region. There was a lot of discussion on whether *Apis mellifera* should be introduced in a country such as Nepal where traditional beekeeping with *Apis cerana* is widespread. There was general agreement that introduction of the exotic, *Apis mellifera*, in northern India, the North West Frontier Province of Pakistan, and Thailand is now the basis of flourishing apicultural industries. This exotic bee species produces three times more honey than the native, *Apis cerana*, and is more suited to modern bee management technology. However, many importations of the exotic, *Apis mellifera*, have proved disastrous because of its allopatric nature, the introduction of new diseases, and parasitic mites.

There was general apprehension that the importation of *Apis mellifera* would lead to the extinction of the native, *Apis cerana*. This process of extinction is almost complete in Japan, and has already commenced in China where the number of *Apis cerana* bee hives has declined from 100,000 to 30,000 only. In certain mountain areas of the North West Frontier Province of Pakistan, *Apis cerana* populations are likely to decline to a level that is no longer viable. Such extinction would not only have a serious negative impact on the income level of farmers, living at or below subsistence level, but would also cause serious impairment or partial loss of essential ecological services such as, cross-pollination and propagation of several cultivated and wild plant species. Furthermore, apiculture with the exotic, *Apis mellifera*, requires high cost technology which the farmers living at, or below, subsistence levels in mountain areas cannot afford.

The native hive bee, *Apis cerana*, has many valuable characteristics of biological and economic importance which have not been scientifically explored. This native bee species is being replaced by the

exotic, *Apis mellifera*, because of its frequent swarming and absconding habits and also because of its lower honey yield. However, these negative traits in the native bee species can be improved through selective breeding and by adopting suitable management practices. There exists a great genetic diversity in this native bee species in the Himalaya. Two sub-species and five different geographic populations have already been identified in the Indian Himalaya. Genetic diversity in this native bee species should however be explored for the entire Hindu Kush-Himalayan region. Such information will provide excellent opportunities for the genetic improvement of this species by selective breeding.

Beekeeping for Sustainable Mountain Crop Productivity and Honeybee Forage

The sustainable development of mountain agriculture in the 21st century will necessitate a reorientation of the present crop production technologies. Instead of making substantial use of chemical fertilizers, biocides, irrigation facilities, and heavy machinery for yield enhancement, a shift towards biologically-based agriculture, which includes increased photosynthetic efficiency, biological nitrogen fixation, genetic engineering, efficient nutrient uptake, and biological cross-pollination is necessary. At the Expert Meeting, one such technology became an interesting topic for discussion—enhancement of the productivity levels of different mountain crops through cross-pollination by honeybees.

From the different papers presented, it became clear that cross-pollination of entomophilous crops by honeybees is one of the most effective and cheapest methods of increasing yield and improving the quality of seed and fruit produced. The vital role that honeybees play in enhancing the productivity levels of mountain crops such as temperate fruits, vegetables, oils, fodder, and spice seeds has often been underestimated in the Hindu Kush-Himalayan countries. As a matter of fact, bee pollination researches carried out in western countries reveal that the main significance of honeybees and apiculture is in cross-pollination, whereas hive products such as honey and beeswax are of secondary value.

In the Hindu Kush-Himalayan region, Himachal Pradesh in northern India has taken a lead by adopting a planned bee pollination programme as one of the essential inputs for improving the quality and yield of temperate fruit crops, particularly apples. However, in other temperate areas, it has not been adopted as an integral part of mountain crop production technology, despite the fact that all these hilly areas have rich apicultural traditions. The main reasons for this are ignorance and lack of technical know-how on the part of agricultural extension agencies and farmers.

Nectar and pollen from flowering plants are the raw materials of beekeeping. It is important to know about the honey plants in a particular area for the production of surplus honey, to increase the carrying capacity of a particular area in terms of the number of bee hives it can sustain, and to meet slack season needs during the winter. Most of the papers presented during this Expert Meeting revealed that the Himalayan region has very rich and diverse bee flora, such as temperate zone fruits, vegetable crops, agricultural crops, grasses, bushes, shrubs, forests, and avenue trees. There were also detailed discussions on the continuous decline in bee floral resources in the Hindu Kush-Himalayan region due to the degradation of forests and grassland ecosystems as well as changing agricultural patterns.

In order to improve the situation, it was recommended that honey plants should also be included wherever new planting programmes are initiated. Some efforts, made in the past in this direction, have yielded satisfactory results. For example, roadside plantations in Pakistan, social forestry programmes in northwest India, and community forestry plantations in Nepal included several multipurpose plant species which included bee forage plants also. As a result of this, apiculture has flourished in these areas. For commercial apiculture, it may not be possible to have enough bee flora available in one particular locality, so beekeepers are migrating their colonies from one place to another in order to exploit the floral resources fully throughout the year and harvest additional honey crops. The most successful examples of such migratory beekeeping practices are in the North West Frontier Province of Pakistan, Himachal Pradesh, and the Kashmir region (northern India).

There are still a large number of indigenous plant species in the Hindu Kush-Himalayan region, and the potential from an apicultural point of view has not been fully tapped. So, instead of encouraging the introduction of exotic plant species for bee forage, which involves risks of one kind or another, emphasis should be laid on the preparation of detailed floral calendars, based on local flora, for each potential beekeeping area.

Mountain Women and Beekeeping

In the overall socioeconomic perspective of the Hindu Kush-Himalayan region, women are the most neglected and underprivileged group. One of the important tasks for future policy planners must be the integration of the underprivileged sections of mountain women into the economic life of the whole rural population. This integration is possible through full utilization of underutilized resources. One such resource,

is apiculture. It offers great potential for raising the socioeconomic status of rural mountain women.

Projects to encourage women apiculturists are essential, because the work is not heavy and women can easily perform all the hive management operations. Apiculture provides flexibility in terms of time, gainful employment close to home, nutritional benefits for children, and financial independence for housewives. It broadens the food base of rural communities and is an excellent sweetening source, particularly in the hills where sugar cane is not grown. The Asiatic hive bee, *Apis cerana*, is gentle in temperament and much easier to handle than the European honeybee, *Apis mellifera*, and is ideal for the woman entrepreneur.

Status and Economics of Beekeeping

Apiculture is an old traditional household activity for mountain farmers. All over the Hindu Kush-Himalayan region, it has been linked with the cultural heritage of the people as a sustenance oriented activity. From the point of view of mountain characteristics, apiculture offers several advantages, varied possibilities, and great opportunities to a developing economy. It is different from other developmental activities because it has only positive ecological consequences. Apiculture can be taken up both at the household and commercial levels to generate additional income and employment.

Beekeeping with the native hive bee, *Apis cerana* in the Hindu Kush-Himalaya has not yet developed along the modern scientific lines which are followed in the cold climatic zones of advanced countries. In the temperate parts of China and India, efforts have been made to improve the traditional methods of beekeeping with *Apis cerana* and in certain such areas, this native bee species matches the European honey bee, *Apis mellifera* in honey production and pollination activities. However, in other countries of the Hindu Kush-Himalaya, the situation is far from satisfactory, despite the fact that climatic conditions, and multiplicity of flora available throughout the year, in the temperate and sub-tropical parts of this region, offer great potential for beekeeping development. The major constraints are lack of basic infrastructure, skilled manpower, training, extension facilities, or basic and applied research programmes. All attempts to introduce *Apis mellifera*, into this temperate region have met with little success. The largest and most valuable species of honey bee, *Apis laboriosa*, is on the verge of extinction in the Hindu Kush-Himalayan region because of traditional honey-hunting methods.

Economic analyses, carried out in Hindu Kush-Himalayan countries, revealed that, as a small cottage industry, beekeeping with *Apis*

cerana, required only low cost technology and even the poorest person could engage in this with very little support. On a commercial scale, apiculture with the exotic *Apis mellifera*, does require higher investments, but there is a wide margin of profit, besides full exploitation of the temporal and spatial diversity of mountain floral resources that would otherwise go waste.

There are no standard methods available for economic studies on apiculture. Economic studies reported in the Expert Meeting were mainly by bee specialists and not by economists. Thus, they were based on data from pilot projects and personal experiences. The level of profits at the farm level may not be that high, as indicated in these studies. Also, in these studies, the indirect benefits of honeybees as pollinators of cultivated and wild plants were not quantified. Thus there is a need for systematic studies of the economics and profitability of apiculture for different target groups in the mountain areas of the Hindu Kush-Himalayan region. Such studies will help in determining the potential apicultural area and the potential value of apicultural development for the mountain people.

Beekeeping Training and Research

The ecological resources of the Hindu Kush-Himalayan region offer great potential for the development of beekeeping. Due to the ideal climatic conditions and the diversity of bee and floral resources, this region can be converted into a land of honey, provided there is adequate original planning on the part of policy-makers as well as continuing commitment to the programmes.

The lack of basic knowledge of *Apis cerana* biology is a major constraint in developing appropriate apiary management technology with this native bee species. Very little is currently available in literature covering this subject compared to volumes of material specific to *Apis mellifera*. As a result several national and international development projects for the promotion of beekeeping with this bee species in the developing countries of Asia, which attempted the application of European honeybee, *Apis mellifera*, apiary management technology on *Apis cerana*, ended in failure. *Apis cerana* shows striking differences to *Apis mellifera* in certain biological traits such as colony cycle, foraging, temperature regulation, colony defence, aggressiveness, absconding and swarming. Some of these act as negative behavioural traits from a practical beekeeping point of view. For example, frequent swarming and absconding by *Apis cerana* especially during honeyflow seasons, lead to decline in colony strength and adversely affect honey production and pollination efficiency. There are no such problems in beekeeping with *Apis mellifera* and it is easier to get surplus honey from

this bee species. However, these negative traits in *Apis cerana* are amenable through research efforts. This scientifically neglected bee species has the potential to match *Apis mellifera* in economic usefulness. Many studies, especially in India, have demonstrated the ability of *Apis cerana* to pollinate a wide range of agricultural crops. Further studies on the biology and behaviour of this bee species will lead to better exploration of its honey production and pollination efficiency.

At the Expert Meeting, it also became obvious that different international funding agencies have focussed their attention on tropical and sub-tropical apiculture and have ignored the potentials in temperate hill regions, such as the Hindu Kush-Himalaya, for the development of this important enterprise. It was noted that in the hilly regions of India (Kashmir and Himachal Pradesh) and China, modern methods of apiculture have been adopted and basic infrastructural and technical know-how also exist. However, in other countries of the Hindu Kush-Himalaya, apicultural development programmes are still facing teething problems. Several countries in this region do not have the extension and training facilities, or basic and applied research programmes for the advancement of apiculture. At present, scattered efforts being made for the promotion of the industry, with the Asiatic species of honeybee, by different national and international agencies, have not yielded the desired results.

It was unanimously agreed that a coordinated effort is required to correct the situation. For this, an International Centre for Apicultural Research and Training should be established in the region. The primary objective of this Centre should be to generate and deliver improved apicultural management technology through research and training, primarily on the Asiatic species of honeybee. It was also agreed that Nepal would be an ideal host country for such a Centre. Keeping in mind the fact that ICIMOD covers all of the *Apis cerana* countries, it would provide a suitable platform from which to take initiatives for the establishment of the International Centre for Apicultural Research and Training.

Conclusions and Recommendations

1) Since apiculture has positive ecological consequences, and offers specific advantages for the development of sustainable agriculture, off-farm income and food-generating activities for mountain communities living at, or below, subsistence level, there is a need to convince the Governments of the Hindu Kush-Himalayan region, as well as international organizations, of its importance.

2) Introduction of the European honeybee, *Apis mellifera*, in certain parts of the Hindu Kush-Himalayan region, may lead to the extinction of the native hive bee, *Apis cerana*, which offers great potential for the development of apiculture in this region.

Keeping this in mind, the Expert Meeting recognizes the need to establish an International Research and Training Centre, with substantial international funding, in Nepal. The major objectives of this Centre should be:

i) to generate and deliver improved beekeeping management technology, through research and training, primarily on the Asiatic species of honeybee,

ii) to create a cadre of apicultural experts by providing training in both the practical and scientific aspects of apiculture,

iii) to encourage the transfer and sharing of technology and information, and

iv) to assist countries of the Hindu Kush-Himalayan region, especially Nepal, Bhutan, and Bangladesh to establish national programmes for apiculture.

In this respect, participants of this Expert Meeting appreciate and welcome the interest of HMG/Nepal in hosting this Centre in Nepal.

To ensure prompt and effective action for establishing such an International Apicultural Research and Training Centre in Nepal, a regional project on the Himalayan sub-species of honeybee, *Apis cerana*, and its genetic improvement, along with a scientific "train the trainer" component, should be initiated by ICIMOD in collaboration with HMG/Nepal.

Since the United Nations' Food and Agriculture Organisation (FAO) and the United States' Department of Agriculture (USDA) have expressed interest in the promotion of beekeeping, through Asiatic honeybee species, they should be approached as the appropriate funding agencies.

3) The value of honeybees as pollinators of agricultural crops is greater than their value as honey and beeswax producers. A large number of mountain crops are either dependent upon, or benefited by, bee pollination. Apiculture, therefore, should be made an integral part of agricultural and horticultural crop management technology.

4) Indiscriminate use of biocides in the developing countries of the Hindu Kush-Himalayan region is severely affecting the useful cross-pollination activities of honeybees. In order to minimize bee losses from the harmful effect of pesticides, each Government in the region should formulate and enact legislation to regulate the use of biocides.

5) Rich and diverse bee flora is constantly declining throughout the Hindu Kush-Himalayan region. This is happening due to large-scale deforestation and changing agricultural practices. This warrants greater attention on the part of the concerned national and international agencies involved in environmental management programmes.

Knowledge about the bee flora of the Hindu Kush-Himalayan region is not yet comprehensive. An international agency such as ICIMOD should undertake such studies in order to fill the lacunae.

6) In certain parts of the Hindu Kush-Himalayan region, there is harmful exploitation of native wild bees through honey hunting. As a result of this practice, the population of wild bees is declining at an alarming rate, with serious ecological consequences. In such areas, efforts should be made to introduce modern hive beekeeping as a substitute.

7) In order to initiate action to develop beekeeping as an income-generating activity for different target groups in the mountain areas of the Hindu Kush-Himalayan region, and to project the importance of this enterprise, there is a need for systematic study of the economics of the industry. There is also a need to assess the marketing potentials of different hive products in the Hindu Kush-Himalayan region. The Expert Meeting welcomed the suggestion of the Chinese participants that an international workshop on, "Hive Products: Production Technology and Marketing Potentials", be organized in Beijing and that an international aid agency, such as IDRC, be approached for funding.

8) At present, there is no practical training manual on beekeeping with the native hive bee, *Apis cerana*. Since the technology of western bee management is not appropriate for this region, because of different ecological and socioeconomic conditions, ICIMOD should be requested to take necessary steps for preparing such a manual.

9) Participants of this Expert Meeting appreciate and thank ICIMOD, particularly the Director, Dr. Colin Rosser, and the Professional and Administrative staff members of ICIMOD for their part in making this Expert Meeting successful.

10) Participants of this Expert Meeting appreciate and thank the Ministry of Agriculture, HMG/Nepal, and the FAO of the United Nations for the support given to the Expert Meeting.

PART I

Beekeeping and Mountain Ecosystems



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Introduction

Opportunities

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technological levels. In many of the regions, honey hunting has given
way to traditional beekeeping with fixed-comb hives, and in some of
them traditional beekeeping has been wholly or partly replaced by
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movable-frame hives.

Table 1.1 lists 24 examples of mountain beekeeping of which I
have personal experience. It shows the altitude and latitude, the bees
used, and the type of hive. Four examples of honey hunting recorded
in prehistoric rock paintings are added, to show the great antiquity of
honey collection from bees in mountain regions.

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Beekeeping in Mountain Life-support Systems

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Introduction

Opportunities for beekeeping occur in mountainous regions of all continents, and at latitudes ranging from 0° at the equator to latitudes at least as high as 50°N and 30°S. I have seen productive honey production at the equator up in the Andes at 2800 m, and at 47°N in the European Alps up to 1500 m. Mountain beekeeping is feasible with native or introduced honeybees, and in areas covered by widely different types of vegetation. These include tropical and deciduous forests, coniferous forests where honeydew is produced, steppeland, high pastures, and cultivated land where suitable arable crops or fruits are grown. Beekeeping is currently carried out in mountain regions at all technological levels. In many of the regions, honey hunting has given way to traditional beekeeping with fixed-comb hives, and in some of them traditional beekeeping has been wholly or partly replaced by the use of top-bar hives with movable combs or, more commonly, of movable-frame hives.

Table 1.1 lists 24 examples of mountain beekeeping of which I have personal experience. It shows the altitude and latitude, the bees used, and the type of hive. Four examples of honey hunting recorded in prehistoric rock paintings are added, to show the great antiquity of honey collection from bees in mountain regions.

TABLE 1.1
Examples of mountain beekeeping and prehistoric honey hunting
at different altitudes and latitudes

Place	Alt. (m)	Lat.	Honeybee	Type of hive
1. Andes, nr Quito, Ecuador	2800	0°N	temp Am	movable-frame
2. Andes, nr Bogotá, Colombia	2600	5°N	temp Am	movable-frame
3. Western Highlands, Ethiopia	2400	9°N	trop Am(n)	traditional
4. Rocky Mts, Wyoming, USA	2140	42°N	temp Am	movable-frame
5. Rocky Mts, Colorado, USA	2040	39°N	temp Am	movable-frame
6. Drakensberg Mts, S. Africa	2000	27°S	trop Am(n)	honey hunting*
7. Swat, NWFP, Pakistan	2000	35°N	trop Ac(n)	traditional
8. Uludag, Turkey	to 1860	40°N	temp Am(n)	movable-frame
9. Ruwenzori Mts, Uganda	1750	1°S	trop Am(n)	trad, top-bar
10. Kashmir, India	1700	34°N	temp Ac(n)	trad, mf
11. Morelos Province, Mexico	1700	28°N	temp Am	movable-frame
12. White Highlands, Kenya	1630	0°	trop Am(n)	top-bar
13. Matopo Hills, Zimbabwe	1600	20°S	trop Am(n)	hh*, mf
14. Concession, Zimbabwe	1500	23°S	trop Am(n)	hh*, mf
15. Andes, nr Medellín, Colombia	1500	6°N	temp Am	movable-frame
			trop Am	movable-frame
16. Caucasus Mts, USSR	c.1500	43°N	temp Am(n)	movable-frame
17. Alps: Switzerland, Austria etc.	c.1500	47°N	temp Am(n)	movable-frame
18. Western Ghats, India	1300	18°N	trop Ac(n)	movable-frame
19. Kathmandu, Nepal	1280	28°N	trop Ac(n)	traditional, top-bar, mf
20. Cascade Range, Oregon, USA	1200	44°N	temp Am	movable-frame
21. Anatolian plateau, Turkey	1100	38°N	temp Am(n)	trad, mf
22. Central India	?1000	22°N	Ad	honey hunting*
23. Swat, NWFP, Pakistan	1000	35°N	trop Ac(n)	movable-frame
24. Khyber Pass, NWFP, Pakistan	1000	34°N	trop Ac(n)	movable-frame
			temp Am	movable-frame

*Evidence from prehistoric rock paintings

Am = *Apis mellifera*; Ac = *A. cerana*; Ad = *A. dorsata*; n = native;
temp = temperate-zone; trop = tropical

I have seen effective traditional beekeeping with simple and inexpensive home-made hives: at 2400 m in the western highlands of Ethiopia at 9°N (Table 1.1.) (3), at 1750 m in the Ruwenzori mountains of Uganda on the equator (9), and at lower levels—on the Anatolian plateau in Turkey at 38°N (21) and in Europe at 47°N (17). All the above beekeepers had native *Apis mellifera*, tropical bees in Africa, and temperate-zone bees in Turkey and Europe. In Uganda and Kenya, both on the equator, top-bar hives are used which are well suited to tropical African bees. Some top-bar hives are also used outside Africa, but modern movable-frame hives are much more usual as the successor to traditional fixed-comb hives. In the Americas, where

the bees kept are introduced *Apis mellifera*, there are modern hives in a number of high regions: in the Andes (1, 2, 15), in the high interior of Mexico (11), and in the Rocky and associated mountains (4, 5, 20) of North America. In Asia, I have seen *Apis cerana* kept in movable-frame hives at fairly high altitudes in India—Kashmir (10) and the Western Ghats (18), in Nepal (19), and in Pakistan: Swat (23) and Khyber Pass (24), NWFP. Modern hives are also used in many other parts of the Hindu Kush-Himalayan region.

In the mountains of northeast Italy, royal jelly as well as honey is produced from both nectar and honeydew (Barbattini 1988).

Climatic and Plant Requirements for Beekeeping

Climate has important effects on the plants from which bees feed, and thus indirectly affects colonies and their honey yields. Direct effects of climate on bees are considered in the next Section.

Table 1.2 shows broadly how the earth's vegetation changes at different latitudes, and different altitudes (heights above sea level). If we start on the equator at sea level, and move north or south to higher latitudes, the vegetation changes roughly in accordance with columns 1 and 2 of the Table. If, instead of moving north or south, we travel to the higher altitudes entered in column 3, the vegetation changes in a rather similar way, as shown in column 4.

TABLE 1.2
Variation of vegetation with latitude at sea level,
and with altitude at the equator

Latitude at sea level	Vegetation	Approx. altitude at equator		Vegetation
0°		0 ft	0 m	
10°	wet jungles	2,000 ft	600 m	tropical forests
20°	savannas	4,000 ft	1,200 m	tropical forests
30°	deserts	5,500 ft	1,650 m	subtropical forests
45°	steppes, evergreen woods	7,000 ft	2,100 m	subtropical forests
55°	deciduous forests	10,000 ft	3,000 m	temperate deciduous forests
65°	pine forests	13,000 ft	3,900 m	temperate pine forests
75°	tundras	16,000 ft	4,800 m	mosses and lichens
90°	perpetual snow	—		perpetual snow

(Data from Good, 1974)

Flowering plants that can support honeybee colonies, and provide surplus honey for the beekeeper, are found at sea level from the equator to a latitude of about 55°. At the equator they grow at altitudes up to about 3000 m. At intermediate latitudes the height limit for flowering plants is correspondingly lower. The final vegetation belt providing

bee forage consists of pine forests, which may extend to a latitude of 65° at sea level, or at the equator to a height of nearly 4000 m. At one season in the year, some of these forests provide a honeydew flow that can be exploited by migratory beekeeping. Honeydew is produced by aphids on certain trees, and the bees collect it as an alternative to nectar. At about 42°S in New Zealand, certain mountain slopes are covered with beech trees (*Nothofagus solandri* v. *cliffortioides*) on which much honeydew is produced, and thousands of tonnes of honey are harvested annually from it. On Uludag, a mountain in Turkey (entry 8 in Table 1.1), large amounts of honeydew are produced on the fir *Abies bornmülleriana* and several species of pine (*Pinus*).

Bees and flowering plants evolved together: bees obtain their food from flowers, and also pollinate them. So temperatures that are high enough for native plants to flower are likely to be high enough for native bees to forage on them. Experience at high latitudes in western Canada shows that beekeeping can be carried out even if the flowering period (when bees can forage) lasts for less than four months in the year, with eight months at temperatures too low for bees to fly. Colonies of bees can survive over the long winter months because temperatures are so low that they are quiescent in their hives, consuming a minimal amount of food. At lower latitudes winter temperatures are higher, so the bees are more active and their food consumption is greater, thus reducing the beekeeper's harvest.

There is one important effect at high latitudes which is absent near the equator. The days are very long around midsummer—giving 18 hours of daylight in southern Sweden, and 19 hours in Leningrad, USSR, and Finland. Not only do the long days give bees a greatly extended foraging period each day, but flowers are stimulated by the high insolation during midsummer days, and secrete much more nectar. Near the equator, daylight does not last much more than 12 hours at any time of year.

TOXIC HONEYS

Honeys from a few plant species are poisonous to man, because of a toxic component of the nectar. Some of those listed by Crane (1989a) grow at high or fairly high altitudes, and include the following members of Ericaceae:

Species	Toxic agent
<i>Arbutus unedo</i> , strawberry tree	arbutin (a glucoside)
<i>Kalmia latifolia</i> , mountain laurel	acetylandromedol (grayanotoxin I, andromedotoxin, rhodotoxin, asebotoxin)

some *Rhododendron* spp. including:

<i>R. ponticum</i>	andromedotoxin/acetyl-andromedol
<i>R. anthopogon</i>	

Many *Rhododendron* honeys are not toxic; Kafle (1984) includes *R. campanulatum*, *R. ferrugineum*, *R. hirsutum* and *R. thomsonii* among these, and he reports that in Nepal the only toxic one is *R. anthopogon* which grows above 4200 m, so honeys harvested below this altitude should be safe. However, Kerkvliet (1981) studied components of toxic honey from unknown *Rhododendron* species purchased at 1500 m, 40 km east of Lukla in Nepal, and he found grayanotoxin analogues known in some other species, but not grayanotoxin I, II or III.

The Suitability of Different Honeybees for Mountain Beekeeping

As far as my experience goes, many types of honeybees (*Apis* species), except *florea*, live and produce surplus honey in mountain regions (see Table 1.3). The species that nest in cavities (*Apis mellifera* and *Apis cerana*) have both proved suitable for beekeeping in mountainous regions where both the climate and the bee forage are appropriate. In any one area, native honeybees evolved to survive under the conditions prevalent in that area, and altitude is not a direct determining factor, as latitude is. However, a beekeeper needs more than colony survival, which would itself give him good honey harvest. He needs his colonies to store honey surplus to their own requirements, although this characteristic is of no benefit to the bees themselves. Certain mountain races and ecotypes are noted for their ability to survive and to store surplus honey. In Europe, *A. mellifera carnica* (Carniolan) bees from the eastern Alps, are very frugal in their use of food, but start brood rearing early in the spring; they do well also in lowland areas farther north than in their native mountains. In tropical Africa, *A. mellifera monticola* does well at high altitudes on Mount Kenya, and is reputed to be more gentle than lowland bees, but Dietz and Krell (1986) did not find that this was so, at any rate between 1600 and 2500 m.

Apis cerana bees in the temperate Kashmir valley in India are extremely good performers; they are large, and can be kept in Langstroth hives. They behave like temperate-zone bees; colonies have not developed the habit of absconding at the start of a nectar dearth, as tropical *Apis cerana* colonies have. Verma (1989) reports beekeeping in India, with *Apis cerana* at 2077 m in Kashmir, and at 3017 m with the rather similar *Apis cerana* in Himachal Pradesh. I do not know of substantial trials with Kashmir bees at lower altitudes.

Table 1.1 shows that both tropical and temperate-zone *Apis mellifera*, whether native (in the Old World) or introduced (in the New

TABLE 1.3
Honeybees used for honey production in mountain regions,
with examples from Table 1.1

Honeybees	Altitudes of colonies
<i>In hives</i>	
native tropical <i>Apis mellifera</i> 3, (6), 9, 12, (13), (14),	up to 2500 m
tropical (Africanized) <i>A. mellifera</i> 1, 2, 15	up to 3000 m
European (temperate-zone) <i>A. mellifera</i> native: 8, 16, 17, 21 introduced: 1, 2, 4, 5, 11, 15, 18, 20, 24	up to 3000 m
native tropical <i>A. cerana</i> 7, 18, 19, 23, 24	up to 2500 m
native temperate-zone <i>A. cerana</i> 10	up to 2000 m
<i>Wild colonies</i>	
native <i>A. dorsata</i> (22)	up to 1200 m
native <i>A. dorsata/laboriosa</i>	up to 3500 m
native <i>A. florea</i>	up to 500 m

Numbers in parentheses refer to prehistoric honey hunting

World), are successfully used at high altitudes. The same is true of both tropical and temperate-zone native *Apis cerana*. *Apis cerana* has been introduced into only one or two new areas, but I am not able to report on its performance in new territory.

The conclusion must be that the honeybees themselves do not limit beekeeping at high altitudes, provided the climate and the seasons are suitable, and there are sufficient plants, providing flowers for the bees to forage on, for a long enough period. The situation is in fact the same as in lowland areas.

EFFECTS OF LATITUDE ON PLANTS AND HONEYBEES

It is a general rule that many plants can succeed if moved from a lower to higher latitude, but not if moved to a lower latitude, i.e. nearer the equator. The reason is that one or more stages of the annual growth cycle of these plants occurs at a season of the year when there is a certain change in photoperiod (daylength). The stage of plant development may be triggered by the direction of the change (for instance at midwinter, when daylength ceases to decrease and starts to increase), or by the rate of change, which is higher at higher latitudes, as one goes from the equator to the poles. Secondly, the most rapid rate of increase occurs at the spring equinox, and at this time, many

plants grow very rapidly. A plant from a high latitude taken to the equator lacks the stimulus of a rapidly increasing daylength, and may therefore not complete its growth cycle.

Experiments with temperate-zone *Apis mellifera* in controlled-environment chambers (Kefuss 1978) showed that brood can be reared under both long-day and short-day conditions, so there is no critical daylength to be exceeded before brood rearing can start. Brood rearing was stimulated by increasing daylength (as after midwinter) and it was suppressed by decreasing daylength (as at the end of summer). Kefuss also suggested that the rate of change might have an influence: that a rapidly increasing daylength might be a strong stimulus to egg-laying and brood-rearing in honeybees. If so, it could partly explain why colonies of Italian bees taken to higher latitudes continue to rear much brood in spring and summer—a feature welcomed by beekeepers where there are prolific honey flows, but disastrous where spring or summer flows are poor and interspersed with dearth periods. Such latitude effects would be independent of altitude or climate. A different view is taken by Omholt (1987) from theoretical calculations: that brood is reared in the winter cluster to reduce the water content of individual bees when this reaches a specific level.

EFFECTS OF HIGH ALTITUDES ON HONEYBEES

Wilson (1965) carried out experiments on temperate-zone European bees, in the Rocky Mountains at about 40°N in Colorado, U.S.A. During four successive summers, colonies normally kept at 1585 m were placed at altitudes between 2896 and 4267 m for the months of June to August. Virtually no changes were found in the rates of the queens' egg laying, brood development, or mortality of brood or adult bees. Pollen and nectar foraging were also unaffected; bees were seen foraging 4 km from their hives at 1609 m, and 1.6 km from them at 4023 m. Swarming occurred, although night temperatures in summer were often below freezing point at high altitudes; but at the end of the summer, workers did not evict drones from the hives until there was an appropriate reduction in daylength, as at low altitudes.

Colonies were altogether remarkably little affected by the higher altitudes. In a disease study, colonies inoculated with *Melissococcus pluton*, all developed symptoms of European foul brood, as expected. But the high altitude did not in itself increase the occurrence of the disease. Wilson expected to find signs of stress in the bees, due, for instance, to the very cold summer nights, to low oxygen concentration in the air, or to other factors, but he found virtually none.

Working at 1538 m in the Western Himalaya, Dhaliwal and Sharma (1974) found that in mountain areas the foraging range of *Apis cerana* was reduced, not because of the altitude itself, but in

relation to the gradient of the land. The first three entries below are their results, and the other entries are quoted by them.

0.25 to 0.30 m	W. Himalaya, along steep slopes
about 0.65 m	W. Himalaya, along gentle slopes
1.4 m	W. Himalaya, maximum for all foragers
0.9 m	Bihar, Central India
1.04 m	maximum in Bihar
0.7 to 0.8 m	maximum in Sri Lanka

In Europe, the flight of *Apis mellifera* drones on and over mountain ridges in the Alps was studied by Ruttner (1976).

The Use of Different Hive Bees

INTRODUCTION OF NEW TROPICAL HONEYBEES

In both the Americas and Asia, an important and sometimes over-riding factor has been the importation of exotic honeybees. In the Americas, tropical African *Apis mellifera* was introduced in the fifties (Crane 1989a), and this has led to the disappearance, from many tropical and subtropical regions, of temperate-zone *Apis mellifera* that originated in Europe, which itself had been introduced before 1900.

The 'Africanized' bees that resulted from hybridization between the two races of *Apis mellifera* have proved unsatisfactory for bee-keeping: they are difficult to manage in modern hives, and very readily alerted to sting. However, since they are less able to survive at high altitudes than in lowlands, their effect on beekeeping has been less in mountain areas. **It is most important that tropical African bees are never allowed to reach Asia.**

INTRODUCTION OF NEW TEMPERATE-ZONE HONEYBEES

The introduction of European (temperate-zone) *Apis mellifera* has quite different effects. In certain temperate and subtropical countries in the Americas, Australasia and Asia, this bee is now the basis of a flourishing beekeeping industry. European *Apis mellifera* is much more productive than most native *Apis cerana*, and more suited to modern bee management using movable-frame hives. The better strains are nearly as gentle as most *Apis cerana*. In the tropics, European *Apis mellifera* generally does best in hill or mountain areas, especially where nectar-yielding crops are grown.

But many importations of exotic *Apis mellifera* have been disastrous because new diseases or parasitic mites have been introduced with the bees, and have then infected or infested the native honeybees: *Apis cerana* in tropical Asia, or *Apis mellifera* in North Africa

and Turkey. All but a few per cent of the native honeybee colonies may then be wiped out, and the existing long-established craft of beekeeping destroyed.

A visit to some mountain areas of the North West Frontier Province of Pakistan in May 1989 led me to the unhappy conclusion that *Apis cerana* populations are likely to decline to a level that is no longer viable. In certain areas, traditional *Apis cerana* beekeeping may be replaced by a more productive type of beekeeping with European *Apis mellifera*, but this requires a higher capital investment and higher technological operation if it is to be effective. If the rural population is rich and educated enough, to satisfy these requirements, much good can arise. If not, the opportunity for a modest improvement in the standard of living of the poorest families will be lost.

Requirements and Motivation of People in Mountain Regions to Keep Bees

When we consider, instead of the bees, the people in mountain regions who might be—or who might become—beekeepers, we find different and even more significant forces **at work**.

HUMAN COMMUNICATIONS AND POPULATION DENSITY

All over the world, mountainous regions are commonly characterized by broken terrain, with steep and rocky slopes that cannot easily be cultivated, supporting only a low density of human population. Transport and travel are slow and arduous. So are communications among the scattered inhabitants, and also between them and people at centres from which help and advice might come—in our case, on beekeeping activity. In some mountain regions, the rural people are also extremely poor, and have very few possessions.

POVERTY

The 24 mountain locations where I have experience of hive beekeeping (Table 1.1) are distributed in different continents as follows:

Americas: 1, 2, 4, 5, 11, 15, 20

Africa: 3, 9, 12, 14

Europe/Mediterranean: 8, 16, 17, 21

Asia: 7, 10, 18, 19, 23, 24.

Beekeepers in the seven locations in the Americas, and in the four in Europe or the Mediterranean region, had sufficient or ample incomes; they could buy or make movable-frame hives and honey-extracting equipment. If necessary, they could afford to fence their apiaries. Many

owned a car or truck; one (20) used a small plane to monitor his apiaries. In some mountain beekeeping locations in Africa, comparatively rich beekeepers were using modern hives. But in Ethiopia (3), Uganda (9) and Kenya (12), for instance, some beekeepers were extremely poor. At most of the seven locations in Asia, I have seen modern beekeeping by some people who get a sufficient income from it. I have also visited beekeepers who were financially very poor indeed, and to them, a simple form of beekeeping with *Apis cerana* could give welcome additional food although it would be unlikely to provide sufficient total income for the family.

In 1973 in Ethiopia, the people were financially extremely poor but they had a very long and rich tradition of beekeeping. Bees were an integral part of their lives, and the beekeepers made hives of local materials to a very high standard of craftsmanship. The same is true to a certain extent in Kashmir in India. Shah (1984) suggests that bees have been kept in hives there since the 1400s, and I believe that the date may well be much earlier.

Special Problems in Tropical Asia

In tropical Asia there is another factor which is common to both mountain and lowland areas: more than one species of honeybees is present and can be exploited. Large honey harvests can be obtained from wild nests of the giant or rock bee *Apis dorsata/laboriosa* which is found up to 3500 m, and in lowland areas small harvests from the gentle dwarf bee *Apis florea*. Intermediate amounts can be harvested from wild nests, and especially from hives, of *Apis cerana*. In regions where *Apis dorsata* was absent, and *Apis cerana* was the most prolific source of honey, traditional hive beekeeping with *Apis cerana* started many centuries ago. But where *Apis dorsata* was present, its much larger honey yields suppressed interest in *Apis cerana*, and the more convenient method of exploitation—by keeping these bees in hives—did not start until quite recently (Crane 1989b). In most mountain regions of tropical Asia except at the head of the Indus valley, *Apis dorsata* is present, and its nests are still a source of much honey. These regions lack any long tradition of beekeeping with *Apis cerana*. Moreover in Bhutan and other Buddhist areas, there is resistance to beekeeping on the grounds that it might involve killing bees.

As I see it, there are special difficulties in promoting and developing beekeeping in many parts of the Hindu Kush-Himalayan region. But these lie less in the high altitude itself, or in the native bees or bee forage, than in diseases and parasitic mites introduced with exotic honeybees, and to deficiencies in human life. These deficiencies may include poverty, inaccessibility due to the broken terrain, lack of

education, and in some regions lack of tradition of beekeeping. In our attempts to alleviate poverty by using beekeeping as a life-support system, we should concentrate much attention on aligning our proposals according to the background of the people we are trying to help. In areas where the educational level is higher, and transport is easier, beekeepers can learn to work at a higher technological level, and may obtain a good income from beekeeping. But in poorer areas, we must promote types of beekeeping, and of hives, that conform to the general way of life of the people. There must not be a western intrusion at an entirely different technological level.

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Mountain Perspective and Beekeeping

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Introduction

The dominant scenario characterizing most of the mountain areas clearly indicate the following trends:

- 1) Widening gap between efforts and achievements in the field of mountain development
- 2) Emerging indicators of unsustainability of resource base, production streams and resource use/management practices as manifested by persistent negative changes.

The primary reason for the above scenario can be associated with disregard of mountain perspective (to be elaborated), by the development activities in mountain areas. Hence, the search for solution to the above problem should be concentrated on activities/options: (a) which fit well with the mountain specificities, and (b) which have potential to redress or salvage the side effects of processes and factors contributing to the unsustainability scenario in mountains. Beekeeping seems to possess some attributes which can satisfy the above two requirements. In the following discussion, first I elaborate on mountain perspective and then try to look at beekeeping with mountain perspective.

Mountain Perspective¹

In simple terms mountain perspective means, explicit consideration of mountain specificities (characteristics) and their implication, while conceiving and implementing activities in mountain areas. Disregard of these specificities tend to make most of the development interventions in mountains relevant, ineffective, often counterproductive, and give rise to a scenario reflecting a widening gap between development effort and achievement.

Mountains have several characteristics which differentiate them from most other regions. However, important amongst them are: inaccessibility, fragility, marginality, diversity, niche (or comparative advantage) and people's adaptation mechanisms in mountain areas (Table 2.1 and Annexure 2.1). These specificities are not only inter-related due to their common causes as well as shared consequences, but they have intra-mountain variations. Moreover, they have physical (climatic), biological and socio-economic dimensions. The complexity of these specificities and their interrelationships have important operational consequences.

Operational Implications/Consequences

Firstly, these specificities give rise to certain objective circumstances in the form of constraints or potentialities. Some of them include distance, poor mobility and high transport cost (due to inaccessibility and fragility); seasonability, narrow production base, limited but diverse production options, strict limits to resource use intensity (due to fragility, marginality, diversity, niche etc.), diverse potentialities of specific activities with their spatial and temporal dependencies (due to diversity and a number of physical constraints).

Secondly, the complex of specificities or the objective circumstances give rise to dependent patterns of activities, as reflected through transformation processes of mountain areas in the past. These dependent activities fall under three categories.

1) First, the pattern of activities, including resource use systems which are in keeping with the mountain specificities. They include, diversified and interlinked production activities (e.g. crop, horticulture, livestock), with spatial and temporal linkages, traditional methods of resource management including social sanctions to regulate use of resources.

¹ For detailed discussion on Mountain Perspective and its implications for integrated mountain development see Jodha (1990).

TABLE 2.1

Match between mountain specificities and attributes of beekeeping

Attributes of beekeeping	Mountain Specificities					
	Inaccessi- bility	Diversity	Fragility	Margina- lity	Niche	Adaptation mechanisms
<i>Product:</i>						
Low weight	*					
High value	*					
Non-perishable	*					
<i>Operation:</i>						
Low investment				*	*	*
Flexible scale				*		*
Non-competing resource user			*	*		*
<i>User of:</i> Slack resource;						
diversity, niche		*			*	
local skill/ resource						*
<i>Contributor to:</i>						
Diversity, integration, environmental health; addn. income/employment, agr. productivity cottage industry	Can partially salvage the side effects of extractive "dependent patterns", help pollination of wild/diverse flora leading to ecological diversity.					

2) The second category of dependent patterns includes the same set of activities as mentioned above but have higher intensity of resource use, and some additional activities which are insensitive to mountain specifications. Owing to forces of change like increased pressure on land, market links and public interventions, the emerging pattern of activities in mountain areas (e.g. extension of cropping to sub-marginal lands, deforestation etc.), violate the imperatives of mountain specificities and generate unsustainability scenario, because they have strong extractive orientation generated by higher local and external demands.

3) The third category of activities, which could be described better by calling them "independent patterns" rather than dependent patterns, cover most of the development interventions, which are conceived and implemented with little concern for mountain perspective. In a way they complement the dependent patterns mentioned under (2) above.

Attributes of Beekeeping

Role and importance of beekeeping in mountains can be discussed with reference to: (1) mountain specificities, and (2) 'extractive' dependent patterns of activities and resource use systems, mentioned above. However, to facilitate this we have to briefly discuss some attributes of beekeeping as an activity by mountain people.

Beekeeping is not a new activity for mountain farmers. Using traditional methods of management, beekeeping has been a sustenance-oriented small-scale cottage industry in many mountain areas. Modern management-based beekeeping offers much higher income potential for these areas. Without going into technical details like type of bee, their behaviour and productivity, as discussed by others (Verma 1990), the following attributes of beekeeping could be noted and related to mountain perspective (Table 2.1):

Products of Honeybee

The products of honeybee such as honey, pollen and wax are characterized by low-weight, high-value, nonperishability, high storability and easy transportation. These attributes match very well with first order requirements of any product which could adapt well to 'inaccessibility' characteristics of mountains.

Beekeeping as a Side Activity: Cost and Scale Factors

In this regard beekeeping has several positive features. Unless picked up on a commercial scale, beekeeping is a low-investment activity with plenty of flexibility to match any scale of operation. This makes it suitable to low-resource farmers (reflecting economic marginality). Furthermore, since beekeeping does not compete for other resources especially land area and labour, it fits well into small farmers' resource situation. It helps in the prevention of further increase in pressure on land, which otherwise leads to higher resource-use intensity, and resource degradation. Moreover, honeybees contribute to income generation at a time when income from other sources might not be available. Thus beekeeping helps in generating (non-covariates) flows of incomes.

User of Slack Resource

Honeybee is a user of a slack resource (a resource otherwise not used) associated with diverse flora of mountains, some of which are best for the honeybee (Verma 1990). In both macro- and micro-context this is an additional income-generating activity, without much involvement

of additional input. However, once picked up on commercial scale with mobile hives, etc., investment may be quite high. But that adds to beekeeping's potential to make much higher use of temporal and spatial diversity of mountain resources. This offers an ideal option to match imperatives of mountain specificities like diversity, niche etc.

Indirect Contribution

Besides generating direct income and employment and helping in self-provisioning of nutrients in farm families, beekeeping performs an important function in pollination activity (Verma 1990). The service of honeybees can be utilized more in the macro-level context, but even in the case of orchards, etc., it can be associated at the individual farm level. Through this service, honeybees help in yield, quality and stability of several agricultural products. This is an integrative function of beekeeping, where it effectively contributes to sustainability and diversity of agriculture and botanical resources in general. Thereby, it adds to environmental health, in some measure by pollination of wild plant species. These gains may be higher in mountain areas because of the diversity of flora. In fact, beekeeping is one of the important activities that strengthens nature's regenerative systems despite pressure of market and resource-extractive technologies adopted in mountain agriculture. A detailed enquiry into "service functions" and "direct income-generation functions" of the honeybee can reveal the potential of beekeeping in relieving the stresses caused by "extractive, dependent patterns" of activities in mountain areas. More quantification of the issues raised above can be made to sharpen the role of beekeeping in the mountain context (see Table 2.1).

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ANNEXURE 2.1

A Note on Mountain Specificities

Mountain Specificities: The important conditions characterizing mountain areas which, for operational purposes, separate mountain habitats from other areas are termed here as 'mountain specificities'. The important six mountain specificities (some of which might be shared by other areas such as deserts in the plains), are as follows:

Inaccessibility. Due to slope, altitude, overall terrain conditions, and periodical seasonal hazards (e.g. landslides, snow storms etc.) inaccessibility is a well known feature of mountain areas. Its concrete manifestations are isolation, distance, poor communication, and limited mobility. Besides the dominant physical dimension, it has socio-cultural and economic dimensions, which are reflected by socioeconomic differentiation and inequity of access to resources, information, and opportunities. Inaccessibility, greatly help reinforce other conditions such as marginality and diversity as mentioned below.

Fragility. Mountain areas, due to altitude and steep slopes, in association with geologic, edaphic, and biotic factors, which limit the former's capacity to withstand even a small degree of disturbance, are known for their fragility. Their vulnerability to irreversible damages due to overuse or rapid changes, extends to physical land surface, vegetative resources, and even delicate economic life support systems of mountain communities. Consequently, when mountain resources and environment start deteriorating due to any disturbance, it happens at a fast rate. In most cases the damage is irreversible or reversible only over a long period. This factor is largely responsible for the vicious circle of 'poverty—resource degradation—poverty', in fragile ecological zones of mountain regions.

Marginality. 'Marginal' (in any context) is one which counts the least with reference to 'mainstream' situation. This may apply to physical and biological resources or conditions as well as to people and their sustenance systems. The basic factors which contribute to such status of any area or a community, are remoteness and physical isolation, fragile and low-productivity resources, and several man-made handicaps, which prevent one's participation in the 'mainstream' patterns of activities. The above basic factors, also lead to secondary patterns of relationship between 'mainstream' and 'marginal entities'. They are reflected through neglect and exploitation of the latter by the former. The mountain regions being marginal areas as against prime areas in most cases, share the above attributes of marginal entities and suffer consequences of such status in different ways.

Diversity or Heterogeneity. In their natural state, some degree of heterogeneity is a characteristic of all types of habitats. Soil type changes every 20 miles as they say. However, in mountain areas, one finds immense variations among and within eco-zones, even at short distances. This extreme degree of heterogeneity in mountains, is a function of interactions of different factors such as elevation, altitude, geologic and edaphic conditions, steepness and orientation of slopes, wind and precipitation, mountain mass, and relief of terrain. The biological adaptations (e.g. naturally suited plant types) and socio-economic responses (e.g. cultural patterns, structure of economic activities etc.), to the above diversities, also acquire a measure of heterogeneity of their own. The 'diversity or heterogeneity' phenomenon, applies to all mountain characteristics discussed here.

'Niche' or Comparative Advantage. Owing to their specific environmental and resource related features, mountains provide a 'niche' for specific activities or products. At the operational level, mountains may have comparative advantage over the plains in these activities. Examples may include: specific valley serving as habitat for special medicinal and bee plants, mountains acting as source of unique products (e.g. some fruits, flowers,

minerals, etc.), and mountains serving as well known sources of hydro-power production. Thus, 'niche' has both physical and biological dimensions. Though not comparable to biophysical niches, it is not difficult to identify some specific socio-cultural characteristics of mountain communities (e.g. their social organization, attitudes, etc.), which may impart some added advantage to them in activities such as management of collective goods and community resources. In practice, however, niche or comparative advantage may remain dormant unless circumstances are created to harness it. On the other hand, if certain developments lead to elimination of 'exclusiveness' characterizing a situation or resource base, the comparative advantage may cease to exist. Production of special hill crops (e.g. flowers, hive products, mushrooms, medicinal plants, etc.) in the plains by creating artificial environments or by help of research, is one such example, where the comparative advantage of mountain is lost. However, mountains, owing to their heterogeneity, have several, often narrow, but specific niches, which are harnessed by local communities, through their diversified activities. The modern development programmes often lead to their elimination or over-exploitation.

Human Adaptation—Mechanisms. Mountains, through their heterogeneity and diversity even at the very micro-level, offer a complex of constraints and opportunities. Mountain communities through trial and error over the generations, have evolved their own adaptation mechanisms. Accordingly, the mountain characteristics are either modified (e.g. through terracing and irrigation) to suit their needs or activities are designed to adjust to the requirements of mountain conditions (e.g. by zone specific combination of activities, crops, etc.). Adaptation mechanisms or experiences are reflected through formal and informal arrangements for management of resources, diversified and interlinked activities, to harness micro-niches of specific eco-zones, and effective use of upland-lowland links. However, with the changed circumstances such as increased population pressure, increased role of market forces, and side effects of public policies and programmes, a number of adaptation mechanisms are losing their feasibility and efficacy. (Note: Extracted from Jodha [1990]. Refer to the same for references and illustrations).

PART II

Honeybee Resources

...tal role in sustainable mountain development as it increases economy without changing environmental balance. As a cottage industry it is a source of income of the rural people. Beekeeping is one of the important components of Integrated Rural Development Programmes. The Hindu Kush-Himalayan region has a thriving beekeeping industry. Great strides in modernising beekeeping with the exotic and native honeybee species are being made. From the beekeeping point of view, temperate (high hills and interior valleys), sub-temperate (mid-hills) and sub-tropical (low-lying hills) zones are ideally suited.

Species Diversity

Out of the four species of the genus *Apis* found in the Hindu Kush-Himalaya, *Apis cerana* F., *Apis dorsata* F., and *Apis florea* F.

3

Species and Genetic Diversity in Himalayan Honeybee

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Introduction

Honeybees are social insects with which man has established a harmonious coexistence and can be considered as an example of gene-culture coevolution. These insects are of great economic importance because they not only produce honey and beeswax but also act as primary pollinating agents of many agricultural and horticultural crops. It is due to bee pollination that crop yield increases, quality of seed and fruit improves, and heterosis can be exploited. Beekeeping can play a vital role in sustainable mountain development as it increases economy without changing environmental balance. As a cottage industry it is a source of income of the rural people. Beekeeping is one of the important components of Integrated Rural Development Programmes. The Hindu Kush-Himalayan region has a thriving beekeeping industry. Great strides in modernizing beekeeping with the exotic and native honeybee species are being made. From the beekeeping point of view, temperate (high hills and interior valleys), sub-temperate (mid-hills) and sub-tropical (low-lying hills) zones are ideally suited.

Species Diversity

Out of the four species of the genus *Apis* found in the Hindu Kush-Himalaya, *Apis cerana* F., *Apis dorsata* F. and *Apis florea* F.

are sympatric and exotic species *Apis mellifera* L., the European bee is allopatric in distribution. Sakagami *et al.* (1980) reported *Apis laboriosa* from the Himalaya as another new distinct honeybee species even larger than *Apis dorsata*. However, these findings of the Japanese researchers need further confirmation. A brief account of the biological and economic characteristics of these species of honeybee in relation to beekeeping is given here.

APIS DORSATA F. (ROCK BEE)

This species of honeybee is found all over the Himalaya up to the height of even 2000 metres above mean sea level. This species is migratory in nature. The colonies arrive in the temperate mountain region in the spring season, (March–April) and descends to the plains in June, before the monsoon. During migration of the colonies, swarms are known to make a short halt *en route*. They build a single-comb nest fixed to a branch in an open cave under a roof or rock. The size of a single open air comb of *Apis dorsata*, depending on the season and stage of development of a colony, measures 1.5 to 2.0 m from side to side and 0.6 to 1.2 m from top to bottom. In the upper portion of the comb is stored honey and pollen, and this is generally 10 to 25 cm thick. Below this storage area is the brood nest. A single colony has 60,000 to 100,000 worker bees. Sometime 50 to 100 colonies aggregate on a single tree. According to an estimate made in 1950, 75 per cent of all harvested honey and 81 per cent beeswax is harvested from the colonies of this species in India. However, with the large-scale introduction of *Apis mellifera* and with the expansion of modern beekeeping with *Apis cerana*, the percentage has changed considerably and it is difficult to make an exact estimate. According to different authors, honey yield per colony may vary from 5 to 50 kg. However, the average honey yield per colony is about 5 to 10 kg. This species of honeybee is also an important pollinator of different agricultural and horticultural crops.

APIS FLOREA F. (LITTLE BEE)

Like *Apis dorsata*, this small bee also builds a single comb which is often suspended from branches of bushes, hedges, trees, caves of building, house chimney, empty caves, piles of dried sticks, etc. The comb measures about 35 cm in length and 18 cm in height and about 2 cm in thickness. Honey is stored in the upper part of the comb which is about 5 to 7 cm thick. The species usually inhabits the plains and hilly areas and is generally found up to the height of 1500 m above mean sea level. This species can exist with the other three species of honeybee including exotic *Apis mellifera*. These bees migrate frequently

and colony seldom remains at one place for more than five months at a stretch. The bees choose a shady nesting place during the hot summer and in autumn they make short migration to an unshaded place. The annual honey yield from a colony varies from 1 to 3 kg. It is believed that the honey produced by *Apis florea* has special medicinal value and mystical properties. *Apis florea* honey has a higher dextrin content and less tendency to granulate as compared to the honey from other *Apis* species. These bees are valuable pollinators of many agricultural crops including sarson, toria, sunflower and alfalfa.

Seelay (1985) has given very interesting biological and foraging statistics regarding *Apis florea* and *Apis dorsata*. According to him, *Apis dorsata* worker bees are five times heavier, the colony size is 30 times more massive, and the foraging area 100 times larger than that of *Apis florea*. The maximum flight range of *Apis dorsata* is 10 km and it is 10 times more than *Apis florea* (1 km). During flight, the *Apis dorsata* worker bee consumes three times more energy as compared to *Apis florea* but the former species can carry a given mass of pollen/nectar across a given distance with 30 per cent less energy.

APIS MELLIFERA L. (EUROPEAN HIVE BEE)

The European honeybee, *Apis mellifera*, is the most important of all the species as a honey and beeswax producer. This species of honeybee is superior to others due to the maintenance of a prolific queen, less swarming tendency, gentle temperament, good honey gathering qualities, and guard against enemies except wasps and mites. Several attempts have been made, since the beginning of this century, to introduce this exotic species of honeybee into some countries of this region. However, the Italian strain of this species (*Apis mellifera ligustica*) was successfully introduced and established in northern India for the first time at the beekeeping research station at Nagrota Bagwan (Himachal Pradesh) during the early sixties by a group of scientists from Punjab Agricultural University, Ludhiana headed by Dr. A.S. Atwal. Subsequently the experiment was extended to the plain areas of Himachal Pradesh and Punjab. Through extensive research and experiments for the past 20 years, it has been possible to acclimatize these bees. However, large-scale import and multiplication of exotic *Apis mellifera* for higher honey production into several parts of Asia (including this region) is still a controversial subject among leading bee scientists. Doubts are being expressed that this species may not adapt well in its new environment due to different climatic conditions, flora, mating competition with *Apis cerana* and hazards of predators and disease. Koeniger (1976) made the following observations regarding

the introduction of *Apis mellifera* into Asia during the International Conference on Apiculture in Tropical Climates:

In the past, many attempts have been made to import *Apis mellifera* to Asia, but most of these experiments were failures. The northern *mellifera* bees are not adapted to the various enemies of honeybees. In Pakistan for example, the hornet (*Vespa orientalis*) destroys the colonies, in Sri Lanka it was observed that all *mellifera* bees were caught by bee eaters (*Merops*). In other parts of Asia, it has been reported that *Apis cerana* robbed *mellifera* colonies. At other places, where the *mellifera* colonies were protected against predators, it was observed that all virgin queens failed to mate during their mating flights and we can guess that the *mellifera* drones were prevented from copulating with the queens by the competition from drones of the other honeybee species. Nevertheless, at some places in northern India, *Apis mellifera* seems to survive. In consequence of this situation, some might consider it useful to import a tropical race of *Apis mellifera* but I want to stress that this would be a very hazardous and risky project. In the light of the sequence of events in South America, it seems possible that a tropical *Apis mellifera* could irreversibly damage the fauna of Asia, and indeed the consequence of such a step cannot be calculated.

However, so far, this exotic species is doing well in the plains and the sub-mountainous region of northern India, and parts of Pakistan except at heights beyond 1500 m above mean sea level, where the native *Apis cerana* is well adapted. Thus both species seem to be complementary to each other as far as beekeeping in the plains and hilly regions of this subcontinent is concerned.

APIS CERANA F. (ASIAN HIVE BEE)

The closest relative of *Apis mellifera* L. is *Apis cerana*. This species is native to southern and eastern Asia. Generally speaking, it is a bee with a gentle temperament, industrious, with cleanliness qualities, and can be handled easily. However, this species has not become very popular with the beekeepers because of its frequent swarming, absconding and robbing habits; production of a large number of laying worker bees and the helplessness against the predators. Honey yield obtained from *Apis cerana* is about three times less than that of *Apis mellifera*. In spite of these limitations, the species is similar to *Apis mellifera* as far as nesting and dancing behaviour and in build-

ing of parallel combs are concerned. This native species of honeybee has many valuable characters of economic importance which have not been explored so far.

Genetic Diversity of *Apis cerana*

Before discussing the different geographic races and ecotypes of *Apis cerana*, it is important to make a distinction between these two concepts based on the earlier studies on *Apis mellifera*. As a result of a continuous process of natural selection through centuries, different geographic races of a particular species of honeybee have evolved. Such geographic or natural races are different from other domestic animals because the latter were evolved through planned breeding by man. In the case of honeybees, such geographic races have been evolved under the influence of natural abiotic and biotic factors existing in the environment. Such geographic races of *Apis mellifera* existing in tropical Africa, north Africa and near east and west Mediterranean region have been identified through computer-based biometric analyses (Ruttner 1985, 1986). These results reveal that even each geographic race of honeybee species has further locally adapted populations called ecotypes which differ from each other in several biological and economic characters. Such ecotypes adapted to specific environment have also evolved through the process of natural selection. The biological and economic differences existing in different geographic races and ecotypes of honeybees provide an excellent opportunity for their genetic improvement by selection and breeding. These differences have been extensively exploited by man in *Apis mellifera* with remarkable success.

For example, by the crossbreeding of *Apis mellifera* races, it is possible to increase honey production by 200 per cent (Fresnaye and Lavie 1976) and to develop low and high preference lines for the better pollination of agricultural crops (Nye and Mackensen 1970). However, very little is known about *Apis cerana* except the arbitrary hilly and plain varieties of this species (Kapil 1956; Narayanan *et al.* 1960, 1961a and b, Kshirsagar 1976). These earlier biometric investigations were based on a few morphological characters and geographical samples and also lacked proper statistical analysis of data. However, in the recent past, attempts have been made to identify different races of *Apis cerana* by using computer-assisted standard statistical methods. These results are reviewed as follows:

Ruttner (1985, 1986, 1987) has distinguished four different races of *Apis cerana*: *Apis cerana cerana*, *Apis cerana himalaya*, *Apis cerana indica* and *Apis cerana japonica*. His study was based on 34 morphological characters studied in 68 samples of *Apis cerana* collected from

different parts of Asia (Fig. 3.1). Statistical methods included principal component analysis, discriminant analysis or cluster analysis. Research group in Himachal Pradesh University, Shimla, has also carried out biometric studies on *Apis cerana* worker bees found in northeast, northwest and south India representing different physiographic conditions. From each locality, 60 field bees (workers) were collected in the summer from four to five wild colonies located in forests. In all, 55 morphological characters related to the tongue, antenna, forewing, hindwing, hindleg, tergites and sternites were studied. These characters were selected on the basis of previous work of Alpatov (1929) and Ruttner *et al.* (1978). Statistical analysis were carried out by using computer-based univariate and multivariate discriminant analyses in collaboration with Professor Howell V. Daly at the University of California, U.S.A. The results of these analysis as well as those of Ruttner (1985, 1986, 1987) are given as follows:

a) *Apis cerana cerana*

This sub-species/race is distributed over north China, northwest India, northern Pakistan and Afghanistan. In northwest India, Mattu and Verma 1983, 1984a and b, Verma and Mattu, 1982; Verma *et al.*, 1984 made detailed biometric studies on worker bees of *Apis cerana* from 12 localities of Himachal Pradesh (Himachal region) and eight localities of Jammu and Kashmir (Kashmir region) representing different altitudes.

Univariate analysis of data computed for 55 morphological characters of *Apis cerana cerana* showed significant differences in 28 characters in the Himachal region and 18 characters in the Kashmir region. In bees of Himachal, 40 characters showed a significant positive correlation with altitude, whereas, in Kashmir, 22 characters were positively correlated with altitude. Worker bees from the mountainous zone were significantly bigger in size and darker in colour than those of the sub-mountainous zone. Bees of the Kashmir region were significantly larger in 39 morphometric characters as compared to the Himachal region. This sub-species is also larger in body size as compared to bees of northeast and south India.

Verma, *et al.* (1987) also made discriminant analysis of *Apis cerana cerana* found in Kashmir and Himachal regions by computing their centroids based on the mean values. In this analysis, 97.04 per cent of the bees were correctly classified according to geographic regions. These results also supported our earlier univariate analysis results (Mattu and Verma 1983, 1984a and b) that bees from the Kashmir and Himachal regions of northwest India can be clustered biometrically into two separate sub-groups. Thus *Apis cerana cerana* in north-

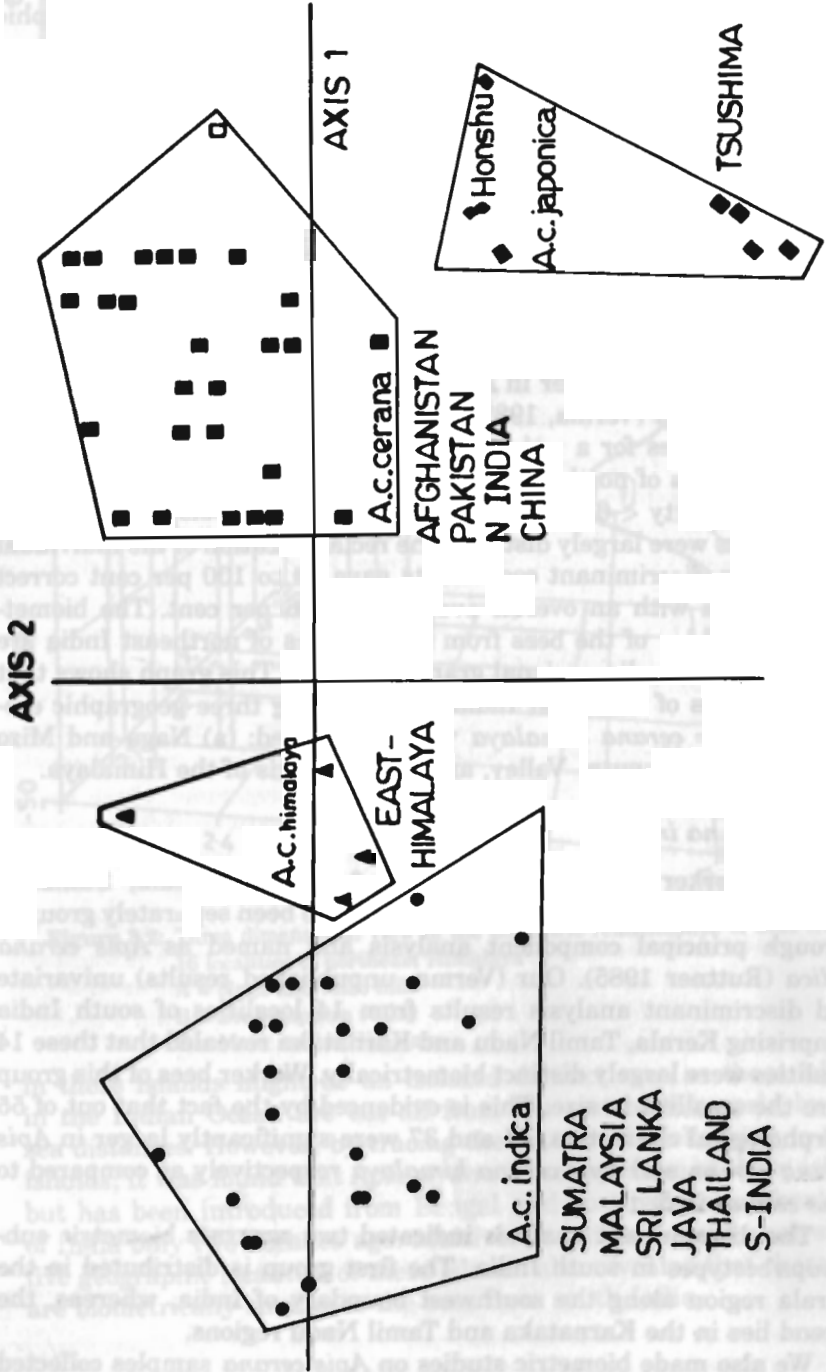


Figure 3.1: Principal component analysis (34 characters) with 68 *A. cerana* samples of 20 worker bees each (after Ruttner 1986)

west India may further comprise two separate ecotypes or geographic populations.

b) Apis cerana himalaya

Ruttner (1985) reported that bees from the eastern Himalaya form a separate cluster from the bees of the western Himalaya. These bees are possibly a separate race which he named as *Apis cerana himalaya* (Ruttner, personal communication). Biometric results on *Apis cerana* from northeast India (comprising Nagaland, Manipur, Mizoram, Assam, Meghalaya, Arunachal Pradesh and Sikkim) support these observations of Ruttner (1985) because out of 55 morphological characters, more than 45 were larger in *Apis cerana cerana* as compared to *Apis cerana himalaya* (Verma, 1987).

The F values for a univariate analysis for each of 55 characters for 16 localities of northeast India were all highly significant (significance probability < 0.0000). The discriminant analysis indicated that 16 localities were largely distinct. The reclassification of the individual bees by the discriminant coefficients gave 80 to 100 per cent correct classification with an overall average of 91.6 per cent. The biometric relationships of the bees from 16 localities of northeast India are shown in a three-dimensional graph (Fig. 3.2). This graph shows that from the bees of northeast India, the following three geographic ecotypes of *Apis cerana himalaya* were recognized: (a) Naga and Mizo Hills, (b) Brahmaputra Valley, and (c) Main axis of the Himalaya.

c) Apis cerana indica

The worker bees of *Apis cerana* from south India, Sumatra, Malaysia, Sri Lanka, Java and Thailand have been separately grouped through principal component analysis and named as *Apis cerana indica* (Ruttner 1985). Our (Verma, unpublished results) univariate and discriminant analysis results from 14 localities of south India comprising Kerala, Tamil Nadu and Karnataka revealed that these 14 localities were largely distinct biometrically. Worker bees of this group were the smallest in size. This is evidenced by the fact that out of 55 morphological characters, 44 and 37 were significantly larger in *Apis cerana cerana* and *Apis cerana himalaya* respectively as compared to *Apis cerana indica*.

The discriminant analysis indicated two separate biometric subgroups/ecotypes in south India. The first group is distributed in the Kerala region along the southwest boundary of India, whereas, the second lies in the Karnataka and Tamil Nadu regions.

We also made biometric studies on *Apis cerana* samples collected from five localities of the Andaman Islands with the idea that bees

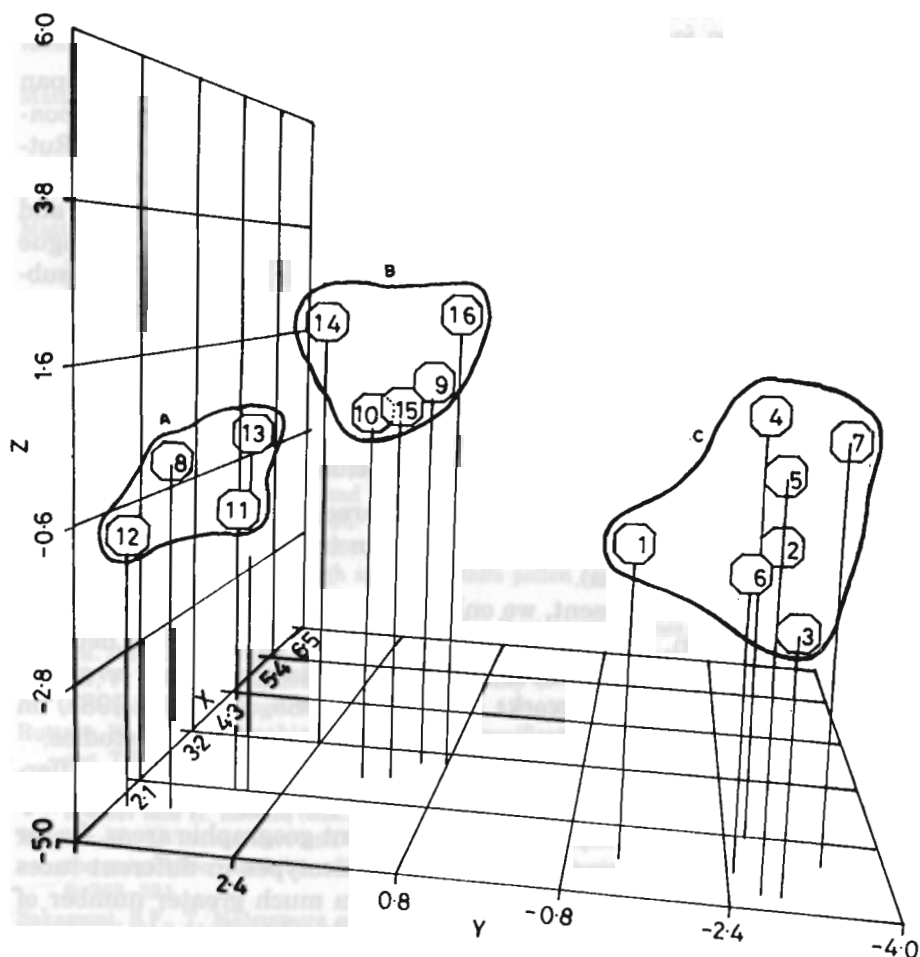


Figure 3.2: Three dimensional view of the biometric relationships of bees from 16 localities of northeast Himalaya
 A = Naga and Mizo hills
 B = Brahmaputra valley
 C = Main axis of Himalaya

in these islands might be an isolated distinct race as these islands in the Indian Ocean are cut off from the rest of the world by long sea distances. However, by tracing the history of beekeeping in these islands, it was found that *Apis cerana* is not a native of these islands but has been introduced from Bengal and possibly from other parts of India only two decades ago. Multivariate discriminant analysis for five geographic localities of these islands also revealed that these bees are biometrically similar to the bees from south India.

d) *Apis cerana japonica*

This sub-species is well adapted to the temperate climate of Japan except Hokkaido island in the north. However, *Apis cerana japonica* is gradually being replaced by *Apis mellifera* (Okada, 1986). Ruttner (1985) reported that this sub-species can further be divided into two separate ecotypes or sub-groups i.e. Honshu (Tokyo region) and Tsushima bees. These two ecotypes differ from each other in tongue length, forewing length, hair length and colour patterns. This sub-species also has higher cubital index and slender abdomen as compared to other races of *Apis cerana*.

Conclusions

From the above results, the following conclusions can be drawn:

1) Morphometric comparison of the three *Apis cerana* races found in India revealed significant differences in (northwest India > north-east India > south India).

2) Although at present, we only know four races of *Apis cerana* in the Asian region, there may be more addition to this list if detailed investigations are made in other regions of Asia where *Apis cerana* is found. Above-mentioned works of Ruttner (1985, 1986 and 1987) on the biometry of *Apis cerana* provide excellent base for such studies.

3) Each race of *Apis cerana* can be further divided into different ecotypes or geographic populations. These ecotypes are biologically meaningful because they occupy the adjacent geographic areas. So far we have identified seven such sub-groups/ecotypes in different races of *Apis cerana* in India but there may be a much greater number of ecotypes representing the different geographical regions.

4) Present results also suggest that any taxonomic decision or construction of evolutionary relationship among the races of *Apis cerana* should be based on the total distribution of the species in the geographic region wherever, it is found. For such investigation, a regional project aided by some international agency is proposed.

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4

Impact of Human Activities on the Himalayan Honeybee, *Apis laboriosa*

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Although it has been exploited by humans for perhaps thousands of years, the Himalayan honeybee, *Apis laboriosa*, has only very recently come under scientific scrutiny. Our limited knowledge of this bee is mainly due to the fact that *laboriosa* is found only in remote valleys of the mountainous regions of Bhutan, China, India, and Nepal, where it nests beneath rock overhangs on vertical cliff faces (Sakagami *et al.* 1980). The more that is learned, the more it becomes apparent that human activities are having an increasingly deleterious effect on populations of this bee. Anecdotal evidence suggests that within the last 50 years the number of colonies of *laboriosa* has greatly declined throughout much of Nepal (see Valli and Summers 1988) and possibly in other countries as well.

Given the worldwide importance of honeybees as pollinators, and the probability that *laboriosa* is of similar importance, a decline in numbers of colonies may, in turn, have an adverse impact on the quality of human life in those areas where it is found. Therefore, it is of some interest to understand how human activities interact with the ecology of *laboriosa* and to examine the implications of those interactions. Because most of what is known about *laboriosa* stems from studies conducted in Nepal (Underwood 1986, 1990a, 1990b), much of

the following discussion will be directly applicable there, but, because of cultural or geographic differences, may have slightly less relevance in other parts of its range.

Habitat and Seasonal Cycle

In order to understand the impact of human activities on *laboriosa*, it is important to know the habitat and seasonal cycle of colonies of this bee. *Apis laboriosa* nests on cliffs at altitudes ranging from 1200 to 3500 metres or more, but an individual colony does not remain in one place the year round (Underwood 1990a). From about early February until late November or early December, colonies are found at heights of at least 10 metres above the ground and are typically aggregated, with as many as 76 colonies or more at a single cliff site. The high altitude sites, above about 2500 metres, are occupied only during the short summer season, from May or June until late September or early October. The best available information indicates that reproduction, the multiplication of colonies via swarming, takes place only during spring and is concentrated during the months of April and May. Thus colonies probably do not reproduce at the high altitude sites occupied during summer. Certain cliff sites are favoured and are returned to year after year. At lower altitudes (1200–2000 metres), if colonies are undisturbed, they may remain on a given cliff from early spring until late fall and a few may even stay through the winter if conditions are unusually favourable. Most colonies exhibit a very different wintering strategy, however.

In late November or early December, colonies abandon their combs at the cliff sites and move to protected locations beneath rocks or fallen logs or at the base of overhanging trees (Underwood 1990b). Winter clustering sites differ from cliff sites in two important ways: they are always near the ground, often less than a metre high, and they are small and dispersed, meaning that only one colony occupies a single wintering site. If undisturbed, a winter swarm will remain clustered, without building a comb, for as long as six to eight weeks. At this time of the year, temperatures may drop below freezing and bees in the cluster must rely on the food stored in their honey stomachs or what little forage they can find on those days when it is warm enough to fly. For a full month from about mid-December until mid-January there is little or no forage available even if the weather is favourable for flight. In late January or early February, the swarms move back to the cliffs and immediately begin to build a comb, thus starting the yearly cycle again.

Impact of Environmental Degradation

In Nepal, the lower range of altitudes at which the Himalayan honeybee is found is precisely that at which some of the greatest alterations to the environment due to human activities have occurred. Until about 30 or 40 years ago, the population density of humans at altitudes below 1000 metres was quite low due to the threat of malaria. Also, because of the shortening growing season with increasing altitude, there were few permanent settlements higher than 2500 metres. With the vast majority of the population concentrated in the middle hills, much of the forest in this area disappeared as land was cleared for agriculture. What forest remained was under increasing pressure from the cutting of firewood, lopping of trees for fodder, and the direct grazing of buffalo, cattle, goats, and sheep on the forest floor. Such is still the case today, for although efforts at reforestation have begun, they have not yet turned the tide and although many people have relocated to lower altitudes and to the Terai, the middle hills are, from an ecological point of view, still dangerously overpopulated.

The destruction of forest habitat has undoubtedly had a great deal to do with the reported decline in numbers of *laboriosa* colonies. In fact, it can be argued that habitat destruction has probably had a greater impact on *laboriosa* than has the direct destruction of colonies during the honey harvest. When forests containing many different types of flowering trees and other plants are replaced by agricultural land, it usually means a reduction in the amount of forage available to bees. Many of the staple crops grown in the hills are of little or no value to honeybees. Such crops include rice, wheat, barley, potatoes, radishes, and various green vegetables. Although corn may provide some pollen, it produces no nectar and is of questionable value to bees. Furthermore, increasing amounts of insecticides are being used and bees collecting pollen from corn have been killed because of sprays used to control harmful insects (personal observations).

One of the few widely grown crops that is of value to honeybees is mustard or rape, *Brassica campestris*, grown for oil seed. Since this crop is grown on only a limited amount of land in the hills and is in flower for a relatively brief part of the year (late winter or early spring depending on the altitude), it cannot make up for the myriad variety of honey plants that might have been available if the land had not been cleared for agriculture. Because of the loss of forage plants due to the conversion of forests to fields, colonies in spring would not be able to build their populations as rapidly and this might force them to forego swarming or cause them to cast small swarms that would have a reduced probability of survival. In either case, the result would be an eventual decline in colony numbers.

Another aspect of the problem of habitat destruction became evident during a recent study of the behaviour of winter swarm clusters of *laboriosa* (Underwood 1990b). As has been mentioned, the sites occupied by colonies in winter are very different from the cliff sites where colonies nest during the rest of the year. The cliff sites seem to be chosen to thwart predators such as bears or martens that would be interested primarily in the brood and honey. Colonies on cliffs are very visible, but the bees are active and able to mount effective counterattacks that probably ward off even flying predators such as large hornets and birds. Also, the practice of nesting on the same cliff with other colonies probably gives a measure of additional security.

Given the advantages of nesting high above the ground in close proximity to other colonies, why do bees seek winter quarters that are near the ground and separated from the clustering sites of other swarms? Since colonies in winter have no stored honey or brood to protect, there is little danger from predators interested in these commodities. This might explain why winter clusters are seemingly unconcerned with being near the ground, but is not in itself an explanation of why bees leave the cliffs.

One of the key factors leading to the effort to conceal winter clusters in low, dispersed locations seems to be bird predation. Although apparently not a serious problem at other times of the year, predation by birds can have devastating effects in winter. Because of the cold temperatures, the bees are unable to defend themselves effectively. Ashy drongos (*Dicrurus leucophaeus*), little bronzed drongos (*D. aeneus*), and chestnut-bellied rock thrushes (*Monticola rufiventris*) have all been observed preying on winter clusters of *laboriosa* (Underwood 1990b). If colonies remained on the cliffs in winter, they would be completely exposed and visible to birds from a long distance. Winter swarms are probably dispersed because an aggregation of such colonies would be more difficult to conceal and a colony unable to defend itself could expect to derive no benefit from other nearby swarms that would be in a similar predicament. Repeated attacks by birds cause swarms to abscond; presumably they seek another, better hidden, clustering site.

The practice of grazing livestock in the forest may affect the survival of winter clusters in two ways. First, a swarm unlucky enough to choose a site near a major forest trail may be intentionally molested by those whose charge it is to look after the animals. Such a swarm may be stoned in an effort to cause it to abscond or it might be destroyed outright by burning. It is feared that cattle or buffaloes might be stung and, in trying to escape, could blunder off a precipice or otherwise injure themselves. A second consequence of the grazing of livestock is that the animals destroy, by eating or trampling, low vegetation that

helps to conceal winter swarms. If a swarm is made more visible, its chances of being detected by birds are increased. Absconding because of attacks by humans or other predators is an energetically expensive undertaking for winter swarms. It is possible that several such moves might so deplete a swarm's food reserves that it would be unable to survive the winter even if it did not succumb directly to the attacks themselves.

Impact of Human Predation

One of the major threats to *laboriosa* colonies nesting on cliffs is predation by humans. Because colonies reuse the same cliff sites every year, these locations are well known to people and there is in many parts of *laboriosa*'s range a long history of honey-hunting (Valli and Summers 1988). A typical honey harvest starts with the smoking of the bees to drive them out from their combs and make them less aggressive. Often a smokey fire is built at the base of a cliff and the smoke rises to the colonies above. Then a rope ladder is tied to a tree and lowered from the top of the cliff so that the honey hunter who descends it will be within reach of some of the colonies. Each colony of bees builds a single comb and usually this entire comb is destroyed; the brood portion (the lower part of the comb) is taken first and then the upper, honey portion is harvested.

Between the time the cliff is smoked and the time when the comb is cut, the bees usually are able to imbibe enough of the stored honey to allow them to survive for at least several days. This is enough time for the colony to move to a new cliff (once their comb has been destroyed bees rarely remain at the same site) and begin the task of building a new nest. In some instances, the topography of the cliff is such that the honey hunter cannot reach all of the colonies nesting there and not all are harvested. If the whole cliff has been smoked and all of the bees disturbed, however, even those colonies that did not have their comb destroyed will abscond (personal observations).

The destruction brought by the honey harvest is one of the most obvious consequences of human interaction with the Himalayan honeybee and it is tempting to lay much of the blame for the decline in colony numbers on this practice. In fact, there are probably few colonies directly destroyed during the harvest. These would involve colonies whose queens were accidentally killed or perhaps colonies that had recently swarmed and had not yet had a new queen emerge. Such colonies would be unable to rear new queens since their brood would have been destroyed and they would be doomed.

At the lower altitudes, the timing of the honey harvest often coincides with the time of reproductive swarming by *laboriosa*. If a colony

is harvested before it has swarmed, it is unlikely that it will be able to muster the resources for another attempt at reproduction until the next year. Even if a colony were successful in reproducing before the harvest, its population would be depleted by the act of swarming and the destruction of brood comb by the honey hunters. If that colony then absconded to a cliff at a higher altitude, it might again fall prey to another honey harvest and be further weakened to the point where it might not survive. Thus, the effect would be one of no net reproduction. A lowering of the reproductive rate would have the effect of reducing colony numbers since those colonies that died (for whatever reason) would not be replaced as quickly.

If there were no environmental degradation (*i.e.*, no loss of forage for bees) and the decline in *laboriosa* populations could be attributed to the practice of honey hunting alone, one would expect that the production of honey per colony among those that remained would rise since fewer bees would be competing for the same resources. This has apparently not been the case as the amount of honey harvested per colony is also said to have declined (Valli and Summers 1988). The recent discovery of the brood disease European Foulbrood in colonies of *A. laboriosa* in western Nepal may be an indication that environmental deterioration has reached a critical stage. European Foulbrood occurs in colonies of the Western honey bee, *Apis mellifera*, but is considered a "stress disease". That is, it only manifests itself in colonies that have been weakened by some kind of stress, such as poor foraging conditions. It is also possible that the foulbrood was recently introduced in Nepal through the importation of colonies of *A. mellifera* (such an importation is rumoured to have occurred, but there is no way to confirm it). In either case, this disease, which may be severe enough to kill some colonies, can be blamed, directly or indirectly, on the actions of humans.

Conclusions

There can be little doubt that human activities have had an adverse impact on many aspects of the environment in the Himalaya. The decline in population of the Himalayan honeybee is just one example of that impact, but, as is so often the case in questions of ecology, this decline may have ramifications that affect the quality of human life as well. The importance of *Apis laboriosa* as a pollinator has never been studied, but it is safe to say that a decline in colony numbers cannot but have negative consequences for agriculture, especially at high altitudes in the Himalaya.

It has been stated that many of the traditional agricultural crops are of little value to honeybees and the bees, in turn, are not needed to

pollinate those crops. This situation is changing, however, especially in those areas where efforts have been made to promote the growing of fruits as a cash crop. Throughout the Himalayan region, temperate fruits, especially apples, grow best at altitudes of about 2000 to 3000 metres. Apples require insect pollination and, worldwide, honeybees are the pollinators of choice. There is reason to believe that, at least for some varieties, *Apis laboriosa* may be a superior pollinator to either of the two species of honeybees (*A. mellifera* and *A. cerana*) commonly kept in hives. Of these two, only *cerana* is native to the Himalaya and it is rarely found at altitudes as high as 3000 metres.

At the present time, there is no reason to believe that *Apis laboriosa* is in any danger of extinction because of the negative consequences of human activities. However, nothing has yet been done to stem the decline of colony numbers and the activities discussed above are unlikely to stop in the near future. Although the grazing of livestock in forested areas is a destructive process, preventing such grazing, even if of long-term benefit, would pose a great hardship to people in the near term and would be an unpopular policy difficult to enforce. Reforestation efforts are essential in order to repair ecological damage already done, but these are unlikely to be of much benefit to honeybees. When tree plantings are made, they typically involve blocks of one or a few species chosen for their fast growth and utility for fuel or fodder and with little regard for other useful qualities.

Perhaps one of the first steps in the salvation of *laboriosa* will occur as a result of the very decline in the number of colonies and of production per colony already noted. As the value of the honey harvest declines, the practice of honey hunting will become less attractive and there is some hope that with reduced hunting pressure, *laboriosa* populations will rebound. Recently, a direct effort toward conservation has been made in Bhutan, where harvests of cliff bee nests have been banned. Although apparently initiated because of religious considerations rather than any concern for a decline in the bee population, the ban may provide indirect agricultural benefits.

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5

Honeybee Resources in North West Frontier Province of Pakistan

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Honeybees are kept mainly for honey production in Pakistan for the last two hundred years whereas in the United States of America, honeybee pollination contributes US\$18 billion annually to agriculture in addition to the direct income from honey production and pollination service charges to the beekeeper. Now the awareness of the multiple benefits of bees pollination is being created through the government TV/radio and seminars/workshops and training courses throughout the country to convince the farmers, particularly the progressive fruit and oil seed growers, to increase their crop productivity through the renting of honeybee colonies on subsidy for pollination purposes.

North West Frontier Province of Pakistan is very suitable for beekeeping on account of its different ecological zones of tremendously rich flora on 8.33 million hectares, out of which two million hectares, i.e. about one-fourth is cultivated. There are about 20,000 honeybee colonies. This province has a potential of producing 35 tons of honey per annum. Whereas at present only about two tons of honey is produced in a year as shown in Table 5.1. Major sources of honey are loquat, sunflower, sarson (winter crops); citrus, sheesham, eucalyptus, willows, stone and pome fruits (spring crops); bekar, acacia, shaftal, berseem and lucerne, corn and sorghums (summer crops); ber, sunflower and shein (autumn crops) both in the mountain areas as well as the plains. Apiary migration (migratory beekeeping) is vigorously followed in accordance of the floral charts.

There are four species of honeybee in North West Frontier Province of Pakistan. These are widely spread in the province.

- 1) *Apis dorsata*
- 2) *Apis florea*
- 3) *Apis cerana*
- 4) *Apis mellifera*

The first two species of honeybee cannot be domesticated and build their nests in the open air on tall trees and shrubs respectively. Whereas the rest of the species i.e., *Apis cerana* and *Apis mellifera*, are domesticated and kept in modern movable-frame hives for honey production as well as for pollination. *Apis cerana* is a native species and is being kept in the northern hill and mountain areas of Pakistan such as Dir, Chitral, Swat and Kashmir in earthen pitchers, hollowed logs fixed in the walls of the room of the house for the last 200 years. It was found in natural nests in crevices and cracks of the hills and mountains and dead hollowed trunks of the old trees much before the dawn of civilization in the above-mentioned hilly tracts.

Eighty-five per cent of the local bee colonies were destroyed during 1981–82 due to the acarine disease caused by *Acarapis woodi* which was possibly introduced by the Afghan refugee beekeepers who brought bee colonies along with their other belongings from their homeland, Afghanistan, in 1980.

1) *Apis dorsata*

This species is locally called Domna or giant honeybees. They build nests in the open air on strong branches of mostly tall trees, in shady places during summer and in sunny places or at least facing toward the sun in winter. Even on a single large tree many nests are found. This species passes summer and autumn in the forest reserves in Changa Manga, Punjab and Haripur on Ber (*Zizyphus* spp.), early bloom of sarson and loquat blossom in the Punjab and Haripur respectively and then in late winter migrate to the North West Frontier Province to continue foraging on mustard, citruses, stone and pome fruits, bekar, *Acacia*, berseem up to mid-June. They have a very long flight and migrate long distances throughout the country and help tremendously in crop pollination.

Their nests are always tapering at one end to form a honey chamber. The other end consists of the brood. The size of the nest is variable, depending on the location, flora and blossom duration. Usually its length ranges from three to seven feet and the width varies from two to three feet. Obviously the nest is divided into two chambers/apartments in a 3:1 ratio for brood and honey respectively. The tapered end contains honey which is white in colour and the brown chamber consists

of eggs, larvae and pupae. At the base line, i.e., attachment line, the honey chamber base is about 10 cm wider as compared to the brood chamber base of 4 cm.

This species is a high honey producer and good pollinator, but hard to handle on account of its aggressive temperament. There is a need for immediate research for improvement of honey collection technology and to demarcate separate suitable location for them in order to avoid food competition with other species of honeybees.

Honey hunters collect a lot of honey from this species at a nominal rate of leasing forest reserve from the forest department. A large number of *Apis dorsata* nests are usually seen on trees from February to June in North West Frontier Province.

2) *Apis florea*

Apis florea is also commonly called small/little bee because its size is the smallest among the other species of honeybees. This species also builds its nests in shrubs, trailers (grapes), bushes around bungalows, gardens, lawns in the open air in a protected places. This species forms a single comb on a twig or branch of the host plants. The comb size is very variable; producing about 1 to 2 kg of honey at one time.

Several experiments were conducted for its domestication in hive type shelters or confinements but none of them was found feasible and economical. We developed a method which involved collecting stray wild nests along with the twigs which are then tied to a branch of a fruit tree in a row, in the months of December/January facing the sun. In the winter months, these nests are sheltered with gunny bag and plastic sheets placed on top. In the months of April, May and June the shelter is removed and only thick shade is ensured to avoid the heat of the direct sun. This method ensures clean and easy harvest of honey: one from mustard/citrus and another from fruits, *Acacia* and berseem, in March and May respectively. This honey is very costly particularly if sold as comb honey.

3) *Apis cerana*

This is a native species of the region and is found abundantly in the northern areas of North West Frontier Province. It is kept in earthen pitchers/logs by mountain communities and also in modern movable-frame hives, in the plains. This species is smaller in size than the European bees. *Apis cerana* is very prone to swarming and wax moth. It requires frequent cleaning and prevention from the attack of wax moth. It has some posture good traits, such as the ability to escape predators (hornets), and good clustering to avoid cold temperature in

winter. These bees fly swiftly and in a zigzag manner. They are well suited to the mountain areas. They forage extensively and intensively. Geographic ecotypes have evolved through natural selection over a long period of time exhibiting a variable vast genetic pattern or traits. This species works for longer durations, starting from early dawn and carrying to late evening. This species does not produce propolis. In the Himalaya, there are certain "bee dens" and some specific valleys in the mountains which are known for the honey hunting during the honey flow season, such as Champtali valley around the 'Shangla hills and Darora in Bunir hills'. These "bee dens" are locally called as "Mucho Qamar" or "Mucho Qamaroona" in Pushto. Such bee dens are also found in Barawal and Termangal districts of Dir and Kohistan. In late spring or early summer, the mountain people go to these dens for honey hunting and for the collection of wild bee swarms of *Apis cerana*. These dens are full of *Apis cerana* where they build their nests usually in cracks/crevices or in trunks of dead and hollowed old trees. The mountain local people fix their own pitchers, or mostly logs, in these bee dens for harvesting honey from their own logs in September or October. This is one source of income for the mountain community, to sell honey and beeswax in the local markets. The mountain men do not use bee swarm collection baskets but they still use old trousers (*shilwars*) fitted with a string for closing it after collection of the swarm.

4) *Apis mellifera*

The European bees were imported from Italy, West Germany, Russia, the United Kingdom (U.K.) and Australia during the past 20 years into Pakistan. Due to the lack of bee specialists at the quarantine posts and the non-existence of bee disease laboratories in the country, many bee diseases were inadvertently introduced into the country. This situation was much worsened when the Afghan refugees brought honey bee colonies along with their belongings, into Pakistan during 1980–81. The Afghan refugee beekeepers kept migrating/shifting their apiaries from one place to another throughout Pakistan without any specific search for seasonal bee flora. This resulted in the outbreak of an epidemic causing heavy destruction, of about 85 per cent colonies of *Apis cerana* and 55 per cent colonies of *Apis mellifera*, in 1982.

Apis mellifera is good for migratory beekeeping and produces more honey and other hive products such as propolis and royal jelly. A migratory beekeeper is able to harvest five times more honey in accordance to the honey extraction calendar as given in Table 5.1, with an average yield of 23 kg honey per colony.

TABLE 5.1
Honey extraction calendar

No. of times of honey harvest	Period of honey extraction	Nectar source	Average honey yield per colony
First	4th week of January to end of February	Loquat (<i>Eriobotrya</i> sp.), Mustard (<i>Brassica</i> spp.)	10–15 kg
2nd	4th week of April	Bhaikar/Baza (<i>Adhatoda vasica</i>) <i>Citrus</i> spp. <i>Eucalyptus</i> sp. Stone and pome fruits	15–20 kg
3rd	3rd week of May	Phulai (<i>Acacia modesta</i>). Guava (<i>Psidium guajava</i>) <i>Eucalyptus</i> sp. Bottle brush (<i>Callistemon</i> sp.) Shisham (<i>Dalbergia sisoo</i>). Keekar (<i>Acacia</i> sp.)	20–25 kg
4th	3rd week of June	Shaftal (<i>Trifolium resupinatum</i>) Berseem (<i>Trifolium alexandrianum</i>) Alfalfa (<i>Medicago sativa</i>)	25–40 kg
5th	2nd week of September to the end of October	a) Ber (<i>Zizyphus zuzuba</i>) Cotton (<i>Gossypium</i> spp.) Dates (<i>Phoenix</i> sp.) Bananas & summer vegetables b) Shain (<i>Plectranthus rugosus</i>)	a) in plains 15–20 kg b) in hilly areas 30–42 kg
		Range:	19–42 kg
		Mean:	23 kg per colony per season

Thus a commercial migratory beekeeper can obtain about 23 kg round the year per strong colony in the North West Frontier Province of Pakistan including the Himalayan region.

Honey Extraction Practices

There are mainly two methods of honey extraction in NWFP. One is the indigenous/crude method and the other is the centrifugal machine method.

(1) Honey Extraction by Squeeze

A crude method of honey extraction is where the honeybees are kept in an earthen pitcher or hollowed log, mostly in mountain areas of this province. The pitchers or hollowed logs are imitations of the

natural nests found in the cracks and crevices of the mountains, hill dens and hollowed walls/trunks of old dead trees. The honey hunters of the hill communities felt the need to keep the bees in their natural environments. Therefore, keeping the natural nests as models, the old/primitive honey farmer prepared the logs and pitchers or pipe of not less than 30 cm diameter, from mud. A narrow hole is made in the anterior end of the pitcher or log and a lid of about 15 cm diameter is made at the posterior end. These logs/pitchers do not have frames or separate honey super/chamber. These are fixed in walls of rooms with the anterior end (entrance for the bees) facing the sun, and the posterior end inside the room, for easy removal of honey comb. At the end of the honey flow season the bees are smoked out from the posterior end after removing the lid and then the beekeeper either removes the entire comb or two parallel combs on either side. The combs are crushed and squeezed in a tin or iron mesh to obtain honey. This is not a good method of honey extraction because the brood gets destroyed and in most cases, the bees abscond. The honey also, is not of good quality as it carries a lot of pollen grain and brood contents.

About 15 years ago, the squeezed comb-wax was not utilized for any purpose and was thrown away. But, thanks to our extensive training courses, now it is sold to the wax dealer in Mangwara, District in Swat valley. The wax dealer melts it in large pans to remove the impurities and converts it into wax blocks, each of 21×30 cm. These are then marketed for foundation sheets, candles and cosmetics at the rate about Rs 60 to 80 per kg.

The local beekeepers sell the honey in tins to the honey dealers at Mangwara city, each tin of honey weighs about 25 kg. The honey is then bottled after filtration, in 1 kg or half kg bottles, for retail sale at the rate about Rs 50 to 60 per kg.

2) Honey Extraction by Machine

In the plains both the species, *Apis cerana* and *Apis mellifera*, are kept in modern bee hives. After honey flow season the well capped honey frames are taken out of the supers. These are uncapped either by knife or fork. These uncapped frames are then put into a honey extractor, which works on the centrifugal driven principle. There are two types of honey extractors; one machine is manual and the other is power-driven. The former is usually kept by small/hobbyist beekeepers and the latter by commercial beekeepers. Honey extracted by this method is fine and clear, and it is stored in tins or barrels for wholesale or is bottled from the outlet of the extractor for direct home/family consumption and retail sale in Jomma Bazar and the Flea markets.

3) *Honey Hunting*

This is also a crude/rough method of obtaining honey from the wild bee colonies of *Apis dorsata* in the forest. This honey is thus called forest honey. This honey is generally “robbed” by honey hunters. They use a rope and a long telescopic pipe fitted with a sharp blade a sickle type of knife, for either removing the entire comb or for cutting only the honey portion. Honey is squeezed out using a fine thin cloth or mesh. Forest reserve such as Changa Manga are given on lease to the honey hunters by the forest department. They produce an approximate yield 4 tons of honey annually.

PART III

Mountain Crop Pollination and Honeybee Forage

6

Beekeeping and Pollination Ecology of Mountain Crops

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At present, several countries of the Hindu Kush-Himalaya are making desperate efforts to achieve self-sufficiency in food production, by physical expansion of the area under cultivation and better management of resources. These include use of better quality seeds and animals, bringing more wasteland under cultivation, the use of fertilizers, pesticides, and bringing in more irrigation. However, in the past decade or so, food production has come to a point of stagnation for some cultivated crops. Emphasis in the future, therefore, should be on the full utilization of under-utilized resources. One resource which concerns us here is an increase in the yield of various cultivated crops through cross-pollination by honeybees. The vital role which honeybees play in the pollination of large numbers of agricultural and horticultural crops is often under-estimated. As a matter of fact, the main significance of honeybees and beekeeping is pollination, whereas, hive products, such as honey and beeswax, are of secondary value. This is evidenced by the fact that income from agriculture by the use of honeybees for crop pollination is many times greater than their value as honey and beeswax producers. Many cultivated crops do not yield seeds or fruits without cross pollination of their flowers by honeybees and other wild insects. Cross-pollination of entomophilous crops by honeybees is one of the most effective and cheap methods of increasing their yield. Other agronomic practices such as the use of manure, fertilizers, pesticides

and irrigation are cost-effective, but these may not yield the desired results without the use of honeybees to enhance the productivity levels of different cultivated crops through pollination. It is not only the self-sterile varieties or cultivars which require cross-pollination, but also the self-fertile forms which also produce more and better quality seeds and fruits if pollinated by honeybees and other insects.

Despite the great economic and biological significance of honeybees as pollinators of agricultural crops, it has not yet been made an integral part of agricultural and horticultural management technology, particularly in the developing countries of the Hindu Kush-Himalaya.

In recent years, a number of techniques have been developed to increase the productivity of certain agricultural crops through cross-pollination by honeybees. These include the use of pollen dispensers, pollen bombs, scent training of bees, development of high and low preference strains of honeybees through selective breeding for pollination of specific crops, domestication and utilization of non-*Apis* pollinators and safeguarding bees against pesticides. All these techniques are at present being used only in developed countries; however, there is now growing awareness in the developing countries of the fact that agricultural crops give better yield and higher financial returns if honeybees are used for optimal pollination. For example, Verma (1984) made the following observation in a report submitted to FAO Expert Consultation on Beekeeping: "In view of the importance of bees in increasing the yield of cross-pollinated crops, different species of honeybees and solitary bees are being utilized in North India. Himachal Pradesh, Uttar Pradesh and Kashmir are the principal temperate fruit-growing regions of the country. In Himachal Pradesh, more than 75,000 hectares of land are under temperate fruit cultivation and they require more than 2,00,000 colonies of honeybees against the present number of 10,000. The population of non-*Apis* pollinators is declining at an alarming rate owing to growing deforestation, the clearance of wasteland for cultivation and increased use of pesticides. This makes domesticated hive bees essential for pollination. In addition to pollinating temperate fruits, both species (*Apis cerana* and *Apis mellifera*) are also being utilized for the pollination of vegetables, oil seed crops and clovers. Himachal Pradesh has taken the lead in renting *Apis cerana* colonies to orchardists for the pollination of apple crops. This programme has helped to create awareness among the orchard owners about the importance of honeybees for pollination."

Advantages of Bee Pollination

Honeybees are the most efficient pollinators of several cultivated and wild plants because of their following characteristics.

- their bodies are specially adapted to pick up pollen grains
- they show flower fidelity and constancy
- have long working hours
- micro-manipulate flowers
- maintain high populations when and where needed
- adaptable to different climates and niches.

As a result of cross-pollination by bees, somatic, reproductive and adaptive heterosis or hybrid effects occur in plant progeny, either in a single way or in different combinations. Such hybrid effects bring the following qualitative and quantitative changes in the economic and biological characters of plants:

- stimulate germination of pollen on stigmas of flowers and improve selectivity in fertilization
- increase viability of seeds, embryos and plants
- more nutritious and aromatic fruits are formed
- increase vegetative mass and stimulates faster growth of plants
- increase number and size of seeds and yield of crops
- enhance resistance to diseases and other adverse environmental conditions
- increase nectar production
- increase oil content in oil-seed crops
- increase fruit set and reduces fruit drop. Deodikar and Suryanarayana (1977) have reported the following increase (in percentage) in seed or fruit yield in various crops due to bee pollination.

A. Oil Seeds (Seed Yield)

Linseed	=	2-49
Mustard	=	13-222
Niger	=	17
Safflower	=	4-114
Sunflower	=	21-3,400

B. Fodder and Grain Legumes (Seed Yield)

Alfalfa	=	23-19,733
Beans	=	3-1,000
Bird's Foot trefoil	=	900
Clovers	=	40-3,315
Sainfoin	=	2,815
Vetches	=	39-20,000

C. Vegetables (Seed Yield)

Asparagus	=	12,405
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Cabbage	=	100-300
Carrot	=	9-135
Onion	=	354-9,878
Radish	=	22-100
Turnip	=	100-125

D. Orchard Crop (Fruit Yield)

Apple	=	180-6,950
Blackcurrant	=	81-2,200
Blueberry	=	11-9,800
Cherry	=	56-1,000
Citrus	=	7-233
Cranberry	=	19-2,153
Cucumber and squash	=	21-6,700
Gooseberry	=	29-300
Grape	=	23-54
Guava	=	12
Litchi	=	4,538-10,246
Peach	=	7-3,788
Pear	=	244-6,014
Persimmon	=	21
Plum	=	536-1,655
Raspberry	=	291-463
Strawberry	=	17-92
Buckwheat	=	63

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 honeybee, 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. 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 Hindu Kush-Himalayan countries, 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:

- 1) Density of plant stand
- 2) Total number of flowers in inflorescence of one plant
- 3) Number of flowers over an area of one hectare of land
- 4) Duration of flowering
- 5) Strength of bee colonies

In general, two colonies of *Apis mellifera* per hectare of crop in blossom are recommended 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.

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 Hindu Kush-Himalayan countries, 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 Hindu Kush-Himalaya, 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 a 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.

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.

Apple Pollination in Hindu Kush-Himalaya

Apple is the most important of the temperate fruits cultivated in the Hindu Kush-Himalayan countries. Of the total land in this region under fruit cultivation, more than two-third is under apple cultivation. The areas under this crop in different parts of the Hindu Kush-Himalaya are as follows:

	Area (000 hectares)	Production (000 MT)
Arunachal Pradesh	4.8	3.3
Himachal Pradesh	52.3	359.3
Kashmir	65.1	723.8
Uttar Pradesh	52.0	170.0
North West Frontier Province (Pakistan)	19	212.0
Bhutan	3.6	4.6
Nepal	5.0	50.0

These figures show that in 1986–87, more than 200 thousand hectares of land of Hindu Kush-Himalaya was under apple cultivation. Every year approximately 10 per cent of the total area already under apple cultivation is being added and according to this estimate, about 250 thousand hectares of land should be under this crop in the entire region of the Hindu Kush-Himalaya.

With such a drastic increase in the area coming under apple cultivation, some management problems inevitably have arisen. The major problem has been found to be in pollination. The Delicious and other commercial varieties of apple are self-incompatible and require cross-pollination by honeybees. The population of non-*Apis* pollinators is declining at an alarming rate due to growing deforestation, vast clearance of wasteland and increased use of pesticides. The most effective way of assuring adequate pollination is through the introduction of honeybees into the orchard at the time of blossoming, a practice well developed for apples in Canada, western and eastern Europe, Japan and so on.

Most of the orchards of the Hindu Kush-Himalayan region are small (about one ha or less) and owned by local farmers. Thus each orchard requires about three hives of bees (although this figure is only an educated guess). Nevertheless, a conservative estimate of the number of bee hives needed exclusively for pollination of the apple crop in the entire region of the Hindu Kush-Himalaya is more than one million. In the temperate mountainous region of the Hindu Kush-Himalaya, the bee species which is available for beekeeping is not the European hon-

eybee, *Apis mellifera*, but the native Asiatic honeybee, *Apis cerana*. At present there are only a few thousand colonies of *Apis cerana* kept in modern hives by farmers and orchardists. A major problem, therefore, is that the present large-scale expansion of the horticultural industry in the region has not been accompanied by corresponding increase in pollination resources and technology through availability of appropriately managed bee hives. It is not surprising that it has been noticed that many orchards do not bear sufficient fruit because the population of bees is too small. Moreover, with the increased use of pesticides for the control of apple pests, the population of pollinators as represented by various species of naturally occurring solitary ground-nesting bees is decreasing at an alarming rate. This makes the domesticated hive bee essential for pollination and beekeeping an essential part of fruit production.

A large horticultural undertaking such as that of the Hindu Kush-Himalayan region cannot flourish in the long run, without the large-scale development of scientific beekeeping. Nevertheless, there are problems to be addressed and overcome. The wealth contributed by beekeeping as a cottage industry would run into several millions of dollars spent on hive rental, pollination and honey production.

Distribution, Abundance and Diversity of Insect Pollinators in the Apple Orchards of Shimla Hills

According to Verma and Chauhan (1985), insects visiting apple blossom comprised 44 species belonging to 14 families and five orders. Of these, 16 species belonged to Hymenoptera, 11 to Diptera, nine to Lepidoptera, seven to Coleoptera and one to Hemiptera (Table 6.1).

Data on the relative abundance of different insect pollinators in the Shimla hills indicated that *A. cerana* constituted 24.01 to 43.03 per cent of the total pollinator population.

Besides honeybees and bumble bees, *Halictus dasygaster* was predominant in one experimental orchard at Thanadhar (Shimla Distt. of H.P.). Besides hymenopterous insects, dipterans were other visitors to crops in the Shimla hills. These were *Eristalis tenax*, *E. angustimarginalis*, *Eristalis* sp., Mucids (*Musca* sp. and *Orthelia* sp.) Syrphids (*Epilobium* sp., *Scava* sp., *Metasyrphus* sp., and *Macrosyrphus* sp.).

The above results reveal that the relative abundance of all the insects varied from place to place. Differences in the environmental conditions, location and altitude of orchards could be possible reasons for such variation (Verma and Chauhan, 1985).

TABLE 6.1
Insect species visiting apple flowers with their taxonomic status in northwest Himalaya

(A) HYMENOPTERA	(B) DIPTERA	(C) LEPIDOPTERA	(D) COLEOPTERA	(E) HEMIPTERA
(a) APIDAE	(f) MUSCIDAE	(h) NOCTUIDAE	(l) COCCINELLIDAE	(o) PENTATOMIDAE
(1) <i>Apis cerana</i>	(17) <i>Musca</i> sp.	(28) <i>Plusia onchaicae</i>	(37) <i>Coccinella septempunctata</i>	(44) <i>Apodiphus</i> sp.
(2) <i>Apis mellifera</i>	(18) <i>Orthelia</i> sp.	(29) <i>Heliothis armigera</i>		
(3) <i>Bombus tunicatus</i>		(30) <i>Agrotis flammatra</i>		
(4) <i>Bombus</i> sp.		(31) <i>Agrotis ipsilon</i>	(m) CHRYSOMELIDAE	
(5) <i>Bombus</i> sp.	(g) SYRPHIDAE		(38) <i>Altica</i> sp.	
	(19) <i>Melanostoma univittatum</i>	(i) NYMPHALIDAE	(39) <i>Alticinae</i> sp.	
(b) ANTHOPHORIDAE	(20) <i>Eristalis tenax</i>	(33) <i>Neptis</i> sp.	(40) <i>Nonartha variabilis</i>	
(6) <i>Anthophora</i> sp.	(21) <i>Eristalis angustimarginalis</i>	(32) <i>Vanessa cashmirensis</i>	(41) <i>Minastra cymura</i>	
	(22) <i>Eristalis arvorum</i>			
(c) HALICTIDAE	(23) <i>Eristalis</i> sp.			
(7) <i>Nomodo</i> sp.	(24) <i>Epilobium bolteatus</i>	(j) PIERIDAE	(n) SCARABAEIDAE	
(8) <i>Halictus dasygaster</i>	(25) <i>Scaeva pyrastris</i>	(34) <i>Pieris canidia</i>	(42) <i>Protaetia neglecta</i>	
(9) <i>Halictus</i> sp.	(26) <i>Metasyrphus corollae</i>	(35) <i>Delias balladona</i>	(43) <i>Brahmina crinicolis</i>	
(10) <i>Halictus</i> sp.	(27) <i>Macrosyrphus</i> sp.	(k) LYCANIDAE		
(11) <i>Xyloropa</i> sp.		(36) <i>Heodes</i> sp.		
(d) VESPIDAE				
(12) <i>Polistes maculipennis</i>				
(13) <i>Vespa magnifica</i>				
(14) <i>Vespa auraria</i>				
(15) <i>Vespa flaviceps</i>				
(e) ICHNEUMONIDAE				
(16) <i>Natalia tatra</i>				

A, B, C, D, E = order

a, b, c, d, etc. = family

Source: Verma and Chauhan, 1985.

Role of Honeybees in Yield and Quality of Apple in Shimla Hills

Most of the commercial varieties of apple give good yields only after cross-pollination. Cross-pollination is done mostly by insects, the role of wind in cross-pollination of apple bloom being negligible because of the heavy and sticky nature of apple pollen. Honeybees are the most efficient pollinators among insects because they can be managed in sufficient number and show flower constancy (Free, 1970). Although, self-compatible varieties of apple do not need as many insect visits as self-incompatible varieties to give an adequate fruit set, yet some visits are essential. A lot of work has been done regarding the role of honeybees in the pollination of apple bloom in many developed countries (McGregor, 1976), but very little has been done in the temperate region of the Hindu Kush-Himalaya. Dulta and Verma (1987) studied the role of honeybees on fruit set, fruit drop and fruit quality of apple in Shimla Hills of Himachal Pradesh.

The following experiments were conducted in three different apple orchards of 0.8 hectare each, located in Kotkhai and Jubbal area of Himachal Pradesh (India) at heights of 1350, 1875 and 2400 metres above mean sea level, to study the effect of honeybee pollination on fruit set, fruit drop and quality of apple.

- No insect pollinator
- Open-pollinated flowers (natural insect pollinators)
- Honeybee pollinated flowers

The results are summarized as follows:

Effect of insect pollinators on fruit set

In self-compatible varieties such as Golden Delicious, the percentages of fruit set in controlled, open and honeybee-pollinated flowers were 24.57, 30.73 and 34.53 respectively, not significantly different. Similarly, in another self-compatible variety, Red Gold, the percentages of fruit set in controlled, open and honeybee pollinated flowers were recorded as 15.76, 18.34 and 22.45, respectively, did not differ significantly either. These small differences in fruit set for Golden Delicious and Red Gold under different conditions could be due to the self-compatibility of these varieties. In self-incompatible varieties like Royal Delicious and Red Delicious, there was no fruit set in the absence of insect pollinators, but the fruit set was significantly higher in honeybee-pollinated flowers of Royal Delicious (23.33 per cent) and Red Delicious (19.69 per cent) than in open-pollinated flowers of Royal Delicious (13.21 per cent) and Red Delicious (11.42). No fruit set in the absence of any insect pollinator in self-incompatible varieties clearly

TABLE 6.2
Percentage of fruit set and fruit drop in three different experimental conditions

Varieties	Honeybee-pollinated flowers (H)	Open-pollinated flowers (O)	No insect pollinated control (C)
A. Golden Delicious	34.53 (25.22)	30.73 (27.62)	24.57 (38.45)
B. Red Gold	22.45 (25.02)	18.34 (28.38)	15.76 (38.07)
C. Royal Delicious	23.33 (25.50)	13.21 (28.69)	0.00 (0.00)
D. Red Delicious	19.69 (25.73)	11.42 (28.86)	0.00 (0.00)

*Data in parentheses pertain to fruit drop.

For fruit set in C and D varieties: $H > O > C$ ($P > 0.01$)

For fruit drop in A and B varieties: $C > O > H$ ($P < 0.01$)

$P < 0.01$ = Highly significant.

Source: Dulta and Verma, 1987.

indicated that there was no pollen transfer from pollinizer to the varieties to be pollinated, without an insect pollinator (Table 6.2).

The higher fruit set in honeybee-pollinated flowers than in open-pollinated flowers suggested that the degree of cross-pollination by honeybees was certainly higher than that of other natural insect pollinators (Table 6.2).

Effect of Insect Pollinators on Fruit Drop

The fruit drop in self-compatible varieties of apple was significantly higher from flowers under controlled conditions, as compared to fruits from open-and honeybee-pollinated flowers. For example, in Golden Delicious and Red Gold, the fruit drop was maximum 38.45 and 38.07 per cent respectively under control, and minimum (25.22 and 25.02 respectively) in honeybee-pollinated flowers. In open-pollinated flowers of Golden Delicious and Red Gold, the fruit drop was 27.62 and 28.38 per cent respectively with no significant difference. In self-incompatible varieties like Royal Delicious, the fruit drops in open-pollinated and honeybee-pollinated flowers were 28.69 and 25.50 per cent respectively, without any significant difference. The same trend was observed in the other self-incompatible variety (Red Delicious), where the fruit drop in open and honeybee pollinated flowers was 28.86 and 25.73 per cent respectively with no significant difference. The high percentage of fruit drop in controlled experiments was due to poor pollination whereby the number of ovules fertilized was less (Table 6.2).

Effect on Fruit Quality

In Golden Delicious, there was an increase in the weight, length, breadth, volume and number of seeds per fruit by 22, 9, 7, 17 and 9 per cent respectively, in the fruits which developed from flowers; exclusively pollinated by honeybees as compared to open-pollinated flowers; whereas, in Red Gold, the weight, length, breadth, volume and number of seeds per fruit increased to 18, 9, 9, 9 and 32 per cent respectively and fruits of these two self-compatible varieties followed the pattern: fruits from honeybee-pollinated flowers > fruits from open pollinated flowers > fruits from controlled experiment ($P > 0.01$).

In the Royal Delicious variety of apple, the increase in weight, length, breadth, volume and number of seeds per fruit was 33, 15, 10, 51 and 49 per cent respectively, in fruits which developed from flowers exclusively pollinated by honeybees as compared to open-pollinated flowers. Similarly, in Red Delicious, the increase in weight, length, breadth, volume and number of seeds per fruit which developed from flowers exclusively pollinated by honeybees was 19, 9, 10, 16 and 30 per cent respectively as compared to those fruits which developed from open-pollinated flowers. In these self-incompatible varieties, the fruit quality was significantly better ($P < 0.01$) of fruits from honeybee-pollinated flowers, as compared to fruits from open-pollinated flowers. The improvement in the quality of fruits due to cross-pollination by honeybees (also other natural insect pollinators) might be a result of heterosis. The increase in weight, size (length and breadth) and volume of the fruits which developed from honeybee-pollinated flowers might be due to a greater number of seeds per fruits (mean number of seeds, 8.92, 9.22, 7.31 and 6.78 in Golden Delicious, Red Gold, Royal Delicious, and Red Delicious respectively, Table 6.3). The better pollinating efficiency of the honeybees helps in the fertilization of the maximum number of ovules and thereby more seeds are formed. In this way, the maximum amount of auxin, a growth hormone, is produced which results in better sized fruit (Table 6.3).

Comparative Foraging Behaviour of *Apis cerana* and *Apis mellifera* on Apple Bloom

Verma and Dulta (1986) studied the comparative foraging behaviour of *Apis mellifera* and *Apis cerana* on apple bloom and the results of these investigations are reviewed as follows:

Worker bees of *Apis cerana* started their foraging activities earlier in the morning (mean time 0603 hours) than *Apis mellifera* (mean time 0627 hours). In the evening *Apis mellifera* ceased its foraging activity earlier (mean time 1855 hours) than *Apis cerana* (mean time

TABLE 6.3
Effect of insect pollinators on the quality of apple fruit in different cultivars grown in northwest Himalaya

Variety	Honeybee-pollinated flowers (H)				No. of		Open-pollinated flowers (I)				No. of		No insect pollinator (Control, J)				No. of	
	Weight* (WH)	Length** (LH)	Breadth** (BH)	Volume (VH)	Seeds (SH)		Weight (WI)	Length (LI)	Breadth (BI)	Volume (VI)	Seeds (SI)		Weight (WJ)	Length (LJ)	Breadth (BJ)	Volume (VJ)	Seeds (SJ)	
A. Golden																		
Delicious	208.88	7.34	7.74	193.33	8.92	188.00	6.76	7.26	165.77	8.11	104.44	5.58	6.12	82.86	6.00			
B. Red Gold	152.67	5.97	7.00	138.00	9.11	135.33	5.81	6.85	133.00	7.77	82.00	4.94	5.75	63.67	7.00			
C. Royal																		
Delicious	266.55	7.88	8.13	268.39	6.78	201.16	6.87	7.41	177.00	6.20					No fruit set			
D. Red																		
Delicious	217.67	7.21	7.69	184.44	6.78	183.80	6.61	7.00	159.80	5.33					No fruit set			

Statistical significance:

$A^{WH} > A^{WI} > A^{WJ}$ ($P < 0.01$); $A^{LH} > A^{LI} > A^{LJ}$ ($P < 0.01$); $A^{BH} > A^{BI} > A^{BJ}$ ($P < 0.01$); $A^{VH} > A^{VI} > A^{VJ}$ ($P < 0.01$); $A^{SH} > A^{SI} > A^{SJ}$ ($P < 0.01$);
 $B^{WH} > B^{WI} > B^{WJ}$ ($P < 0.01$); $B^{LH} > B^{LI} > B^{LJ}$ ($P < 0.01$); $B^{BH} > B^{BI} > B^{BJ}$ ($P < 0.01$); $B^{VH} > B^{VI} > B^{VJ}$ ($P < 0.01$); $B^{SH} > B^{SI} > B^{SJ}$ ($P < 0.01$);
 $C^{WH} > C^{WI}$ ($P < 0.01$); $C^{LH} > C^{LI}$ ($P < 0.01$); $C^{BH} > C^{BI}$ ($P < 0.01$); $C^{VH} > C^{VI}$ ($P < 0.01$); $C^{SH} > C^{SI}$ ($P < 0.01$);
 $D^{WH} > D^{WI}$ ($P < 0.01$); $D^{LH} > D^{LI}$ ($P < 0.01$); $D^{BH} > D^{BI}$ ($P < 0.01$); $D^{VH} > D^{VI} > D^{VJ}$ ($P < 0.01$); $D^{SH} > D^{SI}$ ($P < 0.01$). —Highly significant.

* Weight in gm

** Length and breadth in cm

Source: Dulta and Verma (1987a).

1913 hours). Thus, the average duration of foraging activity in *Apis cerana* was 13.10 hours and for *Apis mellifera*, it was 12.28 hours (Table 6.4). The mean duration of a foraging trip by *Apis cerana* and *Apis mellifera* was 11.85 and 17.92 minutes respectively. Thus the duration of a foraging trip was significantly longer for *Apis mellifera* ($P < 0.01$) than for *Apis cerana* (Table 6.4).

TABLE 6.4
Foraging data for *Apis cerana* and *Apis mellifera* honeybees
on apple flowers at 1350 m in the northwest Himalaya in April–May

Parameter	<i>A. cerana</i>	<i>A. mellifera</i>
Initiation (time of day) of foraging	06.03 \pm 0.01	06.27 \pm 0.02
Cessation (time of day) of foraging	19.13 \pm 0.01	18.55 \pm 0.01
Duration (h) of foraging activity	13.10 \pm 0.002	12.28 \pm 0.003
Duration (min) of foraging trip	11.85 \pm 0.36	17.92 \pm 0.36
Peak foraging hours (time of day)	09.00 – 11.30	11.00 – 13.20
Weight (mg) of pollen load:		
09.00	9.06 \pm 0.02	9.24 \pm 0.04
12.00	9.26 \pm 0.02	12.22 \pm 0.04
15.00	8.64 \pm 0.06	11.12 \pm 0.03
No. of stigmas touched/flower	3.09 \pm 0.39	3.33 \pm 0.32
Time(s) on flower (sec)	5.90 \pm 0.22	6.63 \pm 0.23

Each mean (\pm SE) is for eight observations, for times of initiation, cessation and duration of daily foraging activity, duration of a foraging trip and weights of pollen loads, differences between species are significant ($P < 0.01$); for number of stigmas touched per flower and time spent on flower ($P > 0.01$).

Source: Verma and Dulta, 1986.

Observations made at three different times of the day (0.900, 1200 and 1500 hours) during apple flowering in order to study the nature of food (nectar, pollen or both) collected by worker bees of *Apis cerana* and *Apis mellifera*, revealed that in both the species, nectar collectors were significantly more ($P < 0.01$) than pollen collectors (Table 6.5).

In *Apis cerana*, no pollen plus nectar collectors were observed, whereas, in *Apis mellifera*, the percentage of such worker bees varied from 6 to 11 during different hours (Table 6.5). However, in *Apis mellifera* the number of nectar collectors was significantly higher than pollen collectors (41 and 20 per cent respectively). For *Apis mellifera*, the number of nectar collectors was significantly higher at 0900 and 1500 hours (73 and 70 per cent respectively) than pollen collectors (48

TABLE 6.5

Percentage of *Apis cerana* and *Apis mellifera* honeybees collecting pollen, nectar, or both from apple at different hours of the day in April–May at 1350 m in the northwest Himalaya

Forage	09.00		12.00		15.00	
	<i>cerana</i>	<i>mellifera</i>	<i>cerana</i>	<i>mellifera</i>	<i>cerana</i>	<i>mellifera</i>
P	46.0	18.0	41.0	40.0	20.0	22.0
N	51.0	73.0	55.0	44.0	76.0	70.0
PN	0	6.0	0	11.0	—	7.0
P:N	1:1.11	1:4.05	1:1.34	1:1.10	1:3.80	1:3.18

Percentage are based on eight observations.

P = pollen collectors; N = nectar collectors; PN = pollen and nectar collectors

At 12.00; NC > PC ($P < 0.05$) for *A. cerana*, at 15.00, NC > PC ($P < 0.01$) for *A. cerana*.

At 09.00 and 15.00 NC > PC ($P < 0.01$) for *A. mellifera*; at 09.00 PC *A. cerana* > PC *A. mellifera* ($P < 0.01$) and NC *A. mellifera* > NC *A. cerana* ($P < 0.01$); at 12.00 NC *A. cerana* > NC *A. mellifera*; at 12.00 PC + NC *A. mellifera* > PC + NC *A. mellifera* at 09.00 or 15.00 ($P < 0.05$). Depending on the hour, 1–5% of bees might collect water.

Source: Verma and Dulta, 1986.

and 22 per cent respectively). At 1200 hours, no significant difference was observed in the proportion of pollen and nectar collectors.

At 0900 hours, the number of pollen collectors of *Apis cerana* was significantly higher ($P > 0.01$) than *Apis mellifera* whereas, at 1200 and 1500 hours, there was no significant difference ($P < 0.01$) in the number of pollen collectors of *Apis cerana* and *Apis mellifera* (Table 6.5). Nectar gatherers of *Apis mellifera* were significantly more ($P < 0.01$) than that of *Apis cerana* at 0900 hours, whereas at 1200 hours, the trend was significantly more ($P < 0.01$) than that of *Apis mellifera*. At 1500 hours, there was no significant difference ($P < 0.01$) in the number of nectar collectors of both the species (Table 6.5). Pollen plus nectar collectors of *Apis mellifera* were maximum at 1200 hours (Table 6.5).

Observations made on hourly fluctuations in the number of bees leaving the hive per five minutes showed that peak activity of *Apis cerana* was between 0900 and 1100 hours (mean 132 bees per five minutes) when the temperature ranged from 13.5 to 21.0 degrees C, and that of *Apis mellifera* was between 1100 and 1300 hours (mean 118 bees per five minutes) when the temperature ranged from 21–25 °C during the months of March and April in the Shimla Hills (Table 6.4, Fig. 6.1).

Pollen loads carried by *Apis mellifera* 0900, 1200 and 1500 hours of the day were 9.24 mg, 12.22 mg and 11.12 mg respectively, whereas these values for *Apis cerana* were 9.06 mg, 9.26 and 8.64 mg at 0900, 1200 and 1500 hours respectively. A worker bee of *Apis mellifera* carried significantly heavier ($P < 0.01$) pollen loads than *Apis cerana*

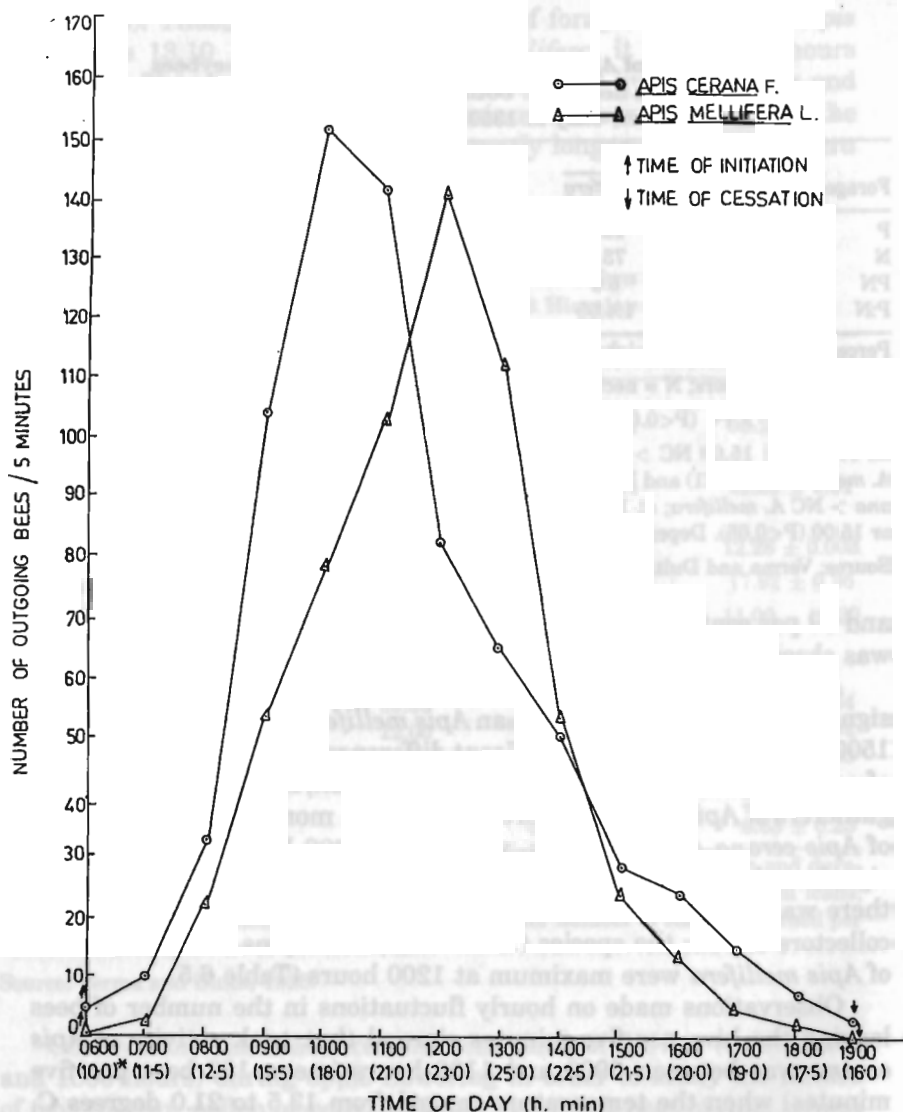


Figure 6.1: Peak hours of foraging activity (number of outgoing bees/5 min) of *A. c. indica* and *A. mellifera* honeybees on apple flowers in northwest Himalaya. Temperatures are indicated in parentheses (°C).

Source: Verma and Dulta, 1986.

throughout the day (Table 6.4).

While foraging apple blossom, *Apis cerana* contacted on an average 3.09 stigmas (2.65 to 3.60) per visit to flowers, whereas *Apis mellifera* touched 3.33 stigmas (3.20 to 3.45) per visit at 1350 metres a.s.l.

Apis cerana spent an average of 5.90 seconds per flower, whereas

Apis mellifera spent 6.63 seconds on a single visit to an apple flower at a height of 1350 metres a.s.l. (Table 6.4).

Foraging studies also showed that at 0900, 1200 and 1500 hours, *Apis mellifera* visited significantly ($P>0.01$) more apple trees in the same rather than in different rows. However, for *Apis cerana*, the number was significantly ($P<0.01$) more in the same than in different rows at 1500 hours only. No significant difference ($P<0.05$) was observed between *Apis cerana* and *Apis mellifera* with regard to their visits to the same or different rows of apple trees. There was no significant difference between *Apis cerana* and *Apis mellifera* in the number of flowers visited per apple tree except at 0900 hours. However, *Apis mellifera* visited significantly more apple trees at 0900, 1200 ($P<0.01$) and 1500 hours ($P<0.05$) than the *Apis cerana*.

The ratio of top and side worker bees on apple bloom at particular time of the day did not differ significantly in *Apis mellifera* and *Apis cerana*. However, the percentage of side and top worker bees varied according to the time of day in both species. For example, at 0900 hours top workers out-numbered side workers in both species but at 1500 hours, the reverse was true. At 1200 hours, the percentage of side worker bees was greater than top workers for *Apis cerana*. The time spent by top and side workers of both species on each flower did not differ significantly. However, at 1200 and 1500 hours, the time spent per flower by side workers of *Apis cerana* was significantly greater than for top workers (Verma, unpublished results).

Effects of altitude on the foraging behaviour of *Apis cerana* and *Apis mellifera*

Studies on the foraging behaviour of *Apis cerana* and *Apis mellifera* at three different altitudes, 1350, 1875 and 2400 metres a.s.l., showed that worker bees of the former species started their foraging activities earlier in the morning and ceased later in the evening at all three altitudes. Initiation of foraging activity by both the species was delayed with increasing altitude. For example, times of initiation by *Apis cerana* were 0603, 0606 and 0618 hours at 1350, 1875 and 2400 metres a.s.l.; whereas, for *Apis mellifera* the times of initiation at 1350, 1875 and 2400 metres a.s.l. were 0627, 0641 and 0648 hours, respectively. On the other hand, foraging by both species ceased earlier with increased altitudes. *Apis cerana* ceased its foraging activity at 1913, 1902 and 1825 hours at 1350, 1875 and 2400 metres a.s.l. and *Apis mellifera* ceased activity at 1855, 1838 and 1804 hours at 1350, 1875 and 2400 metres a.s.l. Thus, the duration of foraging activity per day of *Apis cerana* and *Apis mellifera* bees on apple bloom decreased with increase in altitude (mean duration, 13:10, 12:56 and 11:76 hours for

Apis cerana and 12:28, 11:57 and 11:16 hours for *Apis mellifera* at 1350, 1875 and 2400 metres a.s.l. (Verma and Dulta, 1986).

The duration of each foraging trip for both the species of honeybees increased with increase in altitude of orchard location and it was found to be maximum (mean time, 17.83 minutes and 22.67 minutes in *Apis cerana* and *Apis mellifera*, respectively) at 2400 metres a.s.l., followed by at 1875 metres a.s.l. (mean time, 17.58 minutes and 22.25 minutes in *Apis cerana* and *Apis mellifera* respectively) and at 1350 metres a.s.l. (11.85 minutes and 17.92 minutes in *Apis cerana* and *Apis mellifera* respectively).

Altitude had no significant effect ($P > 0.01$) on other parameters such as bee preference for pollen or nectar or both during a visit, peak hours of foraging activity, pollen load, number of stigmas touched per visit and time spent per flower (Table 6.6).

TABLE 6.6

Effect of altitude on foraging of *Apis cerana* and *Apis mellifera* honeybees on apple flowers in orchard at different altitudes in the northwest Himalaya in April–May

Para- meter	Annu orchard		Penghumas orchard		Amin orchard	
	<i>cerana</i>	<i>mellifera</i>	<i>cerana</i>	<i>mellifera</i>	<i>cerana</i>	<i>mellifera</i>
IF	06.03 ± 0.01	06.27 ± 0.02	06.06 ± 0.01	06.41 ± 0.01	6.18 ± 0.01	06.48 ± 0.01
CF	19.13 ± 0.01	18.55 ± 0.01	19.02 ± 0.01	18.36 ± 0.01	18.25 ± 0.01	18.04 ± 0.01
DF	13.10 ± 0.002	12.28 ± 0.003	12.56 ± 0.003	11.57 ± 0.004	12.07 ± 0.004	11.16 ± 0.008
DT	11.85 ± 0.36	17.92 ± 0.36	17.85 ± 0.25	22.25 ± 0.39	17.83 ± 0.41	22.67 ± 0.32

Annu orchard is at 1350 m, Penghumas at 1375 m and Amin at 2400 m above sea level.

Means (± SE) are for eight observations. Times of initiation and cessation, and duration of daily foraging activity in an orchard were not affected significantly by altitude.

Duration of a foraging trip by either species at 2400 m or 1875 m > duration 1350 m ($P < 0.01$).

IF = initiation (time) of daily foraging activity;

CF = cessation (time) of daily foraging activity;

DF = duration (h) of daily foraging activity;

DT = duration (min) of an individual trip.

Source: Verma and Dulta, 1986.

The above data on comparative foraging behaviour of *Apis mellifera* and *Apis cerana* suggest that both species of honeybees are complementary to each other for sufficient and efficient pollination of horticultural and agricultural crops. Instead of providing two colonies of the same species per hectare of crop in bloom, one strong colony each of *A. mellifera* and *Apis cerana* should be kept to ensure efficient pollination. During low temperatures, *Apis cerana* should be preferred to

Apis mellifera. Additional research on comparative foraging behaviour of *Apis cerana* and *Apis mellifera* on other agricultural and horticultural crops in the Hindu Kush-Himalayan region should be carried out to augment the present data.

Renting of Bee Hives for Pollination in Himachal Pradesh

The state horticulture department and a few private beekeepers rent *Apis cerana* and *Apis mellifera* colonies to fruit growers at the time of apple bloom for pollination. Generally, at the onset of winter (November–December), colonies of both *Apis cerana* and *Apis mellifera* are brought from the temperate hilly region to sub-tropical plain areas where brood rearing usually starts in the first or second week of February. By the middle of March, the colony strength reaches its maximum and this is also the time when flowering begins in apple orchards. These colonies are transported in trucks directly to the apple growing belt of the state and distributed to fruit-growers at the rate of Rs 25 per colony for one flowering season. However, private beekeepers charge higher rental fees than state government owned apiaries. At present, such colonies are distributed to about 1000 fruit-growers, each one gets about two to five colonies, irrespective of the size of their orchard. Although the number of colonies distributed for pollination is perhaps too small, keeping in view the large areas of land under fruit cultivation in Himachal Pradesh, it has, nevertheless, created awareness among apple-growers of the important role that honeybees play in apple pollination. As a result of this practice, fruit-growers now maintain their own colonies of bees for the purpose of pollination and honey production.

Bee Management Practices in Relation to Apple Pollination

1. It is now well-documented that bee pollination improves the size, shape, colour, storage capacity and taste of apples. Inadequate pollination in an apple orchard may be due to the following reasons:
 - lack of pollinizer varieties suitable for cross-pollination
 - non-overlapping of blooming period of main cultivar and the pollinizer variety
 - inadequate pollinator force in the orchard
 - unfavourable weather conditions
 - production of non-functional pollen or ovules
 - irregularities in the development of embryo sacs

2. Some of the above problems of orchard management can be overcome by adopting the following pollination practices:
 - When planning a new apple orchard, the planting pattern should be such that every third tree in every third row is a pollinizer.
 - The flowering period of a pollinizer variety should overlap with the flowering period of the main cultivar to be cross-pollinated.
 - The pollinizer variety, besides helping in cross-pollination of the main cultivar, should also have commercial value.
3. Changes recommended for good pollination in an established orchard are:
 - Replace the whole tree
 - Top work or grafting of pollinizer cultivar
 - Provide cut flowering branches of the pollinizer cultivar to the main cultivar
 - Use of pollen dispenser
 - Keeping in view the shorter flight range of *Apis cerana*, the bee hives should be spread throughout the orchard, or possibly around the perimeter, rather than in groups
4. Two bee hives of *Apis mellifera* per hectare of apple orchard provide adequate pollinator force. However, due to the smaller colony size of *Apis cerana*, three colonies per hectare are recommended.
5. If the weather is good, honeybees should not be kept in the apple orchard for more than two days because of the adverse effect of pesticides.
6. To obtain good economic yield of apple, 5 per cent of flowers or approximately 55,000 flowers per 0.4 hectare of orchard must be set and mature.
7. Around the orchard, such trees should be planted which act as good wind breaks.
8. The strength of bee colonies to be used for pollination can be increased by adopting the following management practices:
 - 1) feeding of sugar syrup,
 - 2) introduction of a prolific queen, and
 - 3) increasing the amount of brood by adding combs of an unsealed brood.
9. Remove combs containing stored pollen to create a pollen dearth in the colony.

10. Place colonies in the orchard at the time when 5–10 per cent of the crop is in bloom.
11. Shift colonies from one site to another, or even interchange them, as this will broaden the search areas of bees, which is helpful in pollination.
12. Mowing of orchards in bloom will keep away the bees from flowering weeds.

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Past Focus and Future Needs

Apiculture is identified as a promising non-land-based farming activity in the context of sustainable development of mountain agriculture. It is a food-, nutrition- and income-generating activity which offers comparative advantages of using an unharnessed ecological niche, nectar and pollen of flowers from various plants. These plant parts cannot be harnessed for human use without honeybees acting as the mediating agents. It highlights a unique ecological phenomenon—wherein components of plants which are ostensibly of no consequence and use to man, but they benefit human beings, when used as an ecological niche by honeybees. At the centre stage of discussion on apiculture remain honeybees and hive products. Finally, the primary sources, are generally relegated to secondary focus largely because of their abundance and the extractive nature of human activities. It is often taken for granted that development of apiculture in the context of mountain agriculture will use the immense flora available. How much abundant would honey flora be in the coming decades, if the present trends of agricultural transformation continue? The primary role of honeybees, as producers of hive products, may also see a change whereby using the insect as an agent to save biodiversity and maintain crop produc-

Honey Plant Sources in Mountain Areas: Some Perspectives

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tion may become a primary factor. Therefore, in the coming decades apiculturists may have to direct more attention to various dimensions of honey plant sources.

Past focus of research in honey plant sources gave top priority to identify and rank honey plant species according to the quality and quantity of nectar or pollen from them. The Directory of World Honey Sources (Crane et al., 1984) is a standing example of such efforts. A review of research efforts made in the Hindu Kush-Himalayan region, on honey plant sources (Verma, 1990) highlighted a similar approach being followed. Focus is on identifying and evaluating local species both for honey and pollen, besides their flowering period and geographic location. The latter point is important from the mountain context.

Researchers, designing future focus of research in honey sources will have to keep in mind rapid transformation of mountain agriculture and its impact on honey sources. It will affect beekeeping both in purpose and management style.

It is in view of this thinking, that this paper highlights issues and approaches related to honey plant sources needs for apiculture. The objective is not of only harnessing honey plants but also making apiculture activity sustainable. The paper examines apiculture and the need for honey plants from different angles. Beekeeping for different purposes will have different supportive needs from plants for sustaining it. How well the plantation needs for honey sources can be integrated with conservation of biological diversity and local development programmes, is also discussed.

Apiculture Objectives and Honey Source Needs

Today, apiculture development is promoted with anyone of the following primary objectives:

(A) Promotion of small-scale/household beekeeping by the mountain farmers as one of their off-farm activities. The goal is to supplement the nutritional needs of the families and earn some cash income from beehive products.

(B) Use of honeybees for pollination of cash crops to enhance yields.

(C) Apiculture on a commercial scale, as an industry for hive products which are in great demand, both locally and in foreign markets.

This means that although beehive products are obtained in each case and plants are also pollinated, the primary objectives of promoting the activity differ. Accordingly, the requirements of honey plant sources and approaches to fulfil these requirements will also differ.

Beekeeping as a Small-scale Activity of the Mountain Farmer

Honey plant sources at this scale were never a problem in the past, because of diversity of flora. Different agro-ecological zones may have taxonomically different plant species but from the viewpoint of the ecological niche of honeybees, many of them are similar.

Beekeeping in rural areas also benefits much from the diversity of components of farming systems. For example, if the flowering period of crops is over, the weeds and wild plants on the hedges, on wastelands and in nearby forests, would have some plant species flowering at any period of time in the year. The quality of the honey sources may differ but many of these sources act as means of survival strategies of honeybees in lean periods.

In many mountain areas, honey sources may not be a problem but a situation is increasingly arising in which traditionally existing plant diversity has given way to monocultures. Components of farming systems, e.g., nearby wastelands and forests no longer exist.

Technically, increasing inaccessibility of honey sources is a significant point, few would care to understand. All the honey sources of an area cannot be visited by the honeybees. It is against the common man's belief. Honeybees as a rule visit those sources which are within 0.3 to 0.5 km radius from the apiary (Verma 1990). At a distance of more than 0.5 km, the visits by honey bees diminish significantly (Verma 1990). Bee behaviour research has shown that generally the duration of foraging trips of honeybees varies from 15 to 25 minutes (Verma 1990). This is taking into account time to reach the honey source, collection period and return journey. These reports are of significance to judge availability of honey sources for every individual beehive.

It clearly emerges that to maintain or increase yields under small scale beekeeping a general assessment of both availability and accessibility of honey sources is desirable. A need for supplementing the honey sources specially during the lean periods might also be felt. As floral needs for small scale beekeeping are small, therefore an approach to select different species for garden plantation or as hedges around the fields is one way. Multipurpose trees or shrubs which serve as good honey sources might be selected for such plantations. The plantation approach is later discussed in detail under separate heading.

Apiculture for Crop Pollination as a Primary Aim and the Honey Plant Sources

Cross-pollination of crops by honeybees is one of the most effective and cheapest methods of increasing crop yields. The practical use

of honeybees for this purpose started in 1895 in USA when honeybees were recommended as pollinators to avoid pear crop failures in Virginia (Waite 1895). Later honeybees were utilized for apple pollination (Benton 1896). Research efforts during the past few decades, included several other crops within the scope of pollination method using honey bees, namely, cauliflower (Adlaka and Dhaliwal, 1979) Cardamom (Chandran et al., 1983) Safflower (Deshmukh et al., 1985), Sunflower (Manzoor and Muhammad 1980) and Citrus fruits (Manzoor et al., 1978).

Likewise there is a body of literature available to suggest that honeybees can also be used for the pollination of several other crops (McGregor, 1976; Kozin 1976; Kevan 1984; Crane and Walker, 1984).

What are the trends on future role of honeybees in pollination? What kinds of honey plant needs may be felt under such conditions? An overview of trends shows that populations of most non-*Apis* pollinating insects are declining because of the vast clearance of wastelands for cultivation. The extensive agriculture and monocultures are reducing their hibernating and nesting places. Indiscriminate pesticidal/insecticidal sprays are killing them continuously. In such a state of affairs, we may have to depend almost entirely upon domesticated honeybees for pollination of crops in the near future. To sustain bees and encourage apiculture, varieties of bee flora are required which provide subsistence to the bees during some parts of the year and surplus during the other. The agricultural and horticultural crops that are pollinated, serve as useful and plentiful forage but the availability is restricted to short durations only.

It is not just the survival but also the strength of the colonies that matters for an effective pollination. Verma (1990) while explaining principles of bee pollination emphasized that larger and stronger colonies are better pollinators than smaller and weaker ones. Strength of a colony depends upon availability of nectar and pollen plants as food sources, management practices as well as the breed. He further stated that in the Hindu Kush-Himalayan region, the colony strengths are poor because of low temperatures and dearth of bee flora. In the early spring season when honey bee colonies are required for the cross-pollination of fruit crops like apple, these colonies do not build enough strength for effective pollination. To overcome this constraint several apiary owners in Himachal Pradesh in India migrate their colonies to lower altitudes where there is no dearth of flora. This helps build enough strength of bees for effective pollination.

Further, many of the bee-pollinated crops are not attractive enough to lure required numbers for effective pollination. Realizing this, several measures have been suggested for attracting bees to a particular crop in bloom by planting high nectar-yielding plant species or crops

among the poor nectar-secreting crops. Verma (1990) cited an example of such a combination, where sweet clover, a poor nectar-secreting crop requiring bees for pollination, can be sown in a mixed cropping pattern with buckwheat, a mountain crop which is a high nectar-yielding honey source.

Thus, when pollination of crops is the main purpose behind beekeeping, the focus of honey sources aims at sustaining the bee colonies over the rest of the period. It is more important in this case than under small-scale household beekeeping, that sufficient bee flora is managed around the apiaries for most of the period of the year, particularly for the slack winter period. This has a significant bearing on the strength of the colony, that is so important for effective pollination.

Two types of honey source requirements are visualized under crop pollination objective:

- a. Plants to sustain healthy bee colonies during the period other than the blooms of the crops.
- b. In some cases excellent quality honey plant sources would also be needed for attracting the honey bees to pollinate the crops.

The number of honeybee colonies needed by individual households for the purpose of pollination would not be very large because of smaller size of landholdings in mountain areas. On an average, these landholdings are smaller than one hectare (Bhatti et al. 1990; Shrestha and Katwal 1990; Mulk 1990; Yanhua et al. 1990). Verma (1990) puts an educated guess of three beehives for less than one hectare of the crops needed for pollination. Therefore the demand can be met in two possible ways:

First, in the case of each household keeping an average of less than five colonies will mean that all villagers will have a collective interest in raising honey sources. Therefore, such honey plant sources could be raised on common property lands so as to meet the needs of everybody. These plant species need to be selected carefully for each locality and agroecological zone bearing in mind the following:

- (i) Number of species having flowering periods spaced over lean periods.
- (ii) Species that are quality honey sources.
- (iii) Species which meet farming needs of the community, such as fodder plants. Growing economically important plants such as fruit trees on common land has not been a practical proposition. Moreover, fodder and fuelwood are important needs of the community and they are conventionally drawn from commons land. More novel ideas could be, raising live fences of such honey source shrubs e.g. *Prinsepia* and *Plectranthus*. *Prinsepia*,

a thorny bush, is used as a fencing material under traditional practice of the farmers in the horticulture zone of Himachal Pradesh and in several other areas of Hindu Kush-Himalaya.

However, the selection of plant species in mountain areas is highly location specific. Therefore it would be naive to prescribe general combinations. The best way is to work out a list of honey sources on agroecological zone or agroecosystem basis from which selections can be made.

Secondly, large number of bee colonies raised on commercial scale can be rented to farmers for pollination. The apiculture under such conditions could also be oriented to beehive products. It could be managed privately by individuals or farm cooperatives, and by government institutions depending on the systems.

The advantage of such a practice is that owners would have means and purpose to move colonies to places near the honey sources and farmers would also be benefited. This is further discussed under commercial apiculture.

Apiculture on Commercial Scale and Approaches to Meet Demand of Honey Plant Sources

Under commercial scale apiculture, a large number of bee colonies are owned by an individual concern for the sole purpose of producing honey and other beehive products for sale. There is enough evidence to show that it is being promoted in almost all countries of the Hindu Kush-Himalayan region (Verma, 1990). China leads other countries of the region in commercial beekeeping. It produces over 200,000 tons of honey, 800 tons of royal jelly, and 1000 tons of bee pollen every year. China is also the largest exporter of honey in the world, contributing to 16 percent of the world exports (ITC-UNCTAD-GATT, 1986).

Likewise, in mountain areas of other countries of the Hindu Kush-Himalaya e.g. Pakistan, India, Nepal and Bhutan, tremendous potential exists. In some cases such as in northern mountain areas of Pakistan, beekeeping is already a large-scale venture for many. In Himachal Pradesh, a tiny hill state of India, the government maintains a large number of colonies, along with some cooperatives and individual farmers, loaning them to apple growers for pollination.

Therefore, for maintaining such large colonies several honey plants would be needed throughout the year. Plantation for this purpose is neither suggested nor practically possible. But mountain areas provide comparative advantage in this regard. Assuming that mobility is possible, bee hives can be moved up and down the agroecological zones of mountain areas to take advantage of the natural vegetation. Spending winters in the foothills, where winter crops and other plants are

abundant, will help. Colonies can be moved into mid-hills and valleys with warming up of the weather. By April, temperate fruit zone provides a most suitable niche where the honey bees would be needed for pollination of fruit crops. Plenty of flora is available during this period in this zone. Summers open up scopes for availability of flora in high mountain areas which continue until the end of rainy season.

Autumn is a lean period but by that time some of the rosaceous plants start flowering in the foothills. Colonies can then be moved straight down into these areas.

The system is in practice in China, and northern areas of Pakistan. Afghan refugees in NWFP, Pakistan can be seen moving with their colonies up and down alongside the highways, staying for a few weeks at one place. Large number of colonies can be seen in deep forests, near the wastelands, and on sides of crop fields. The practice of moving colonies in space and time is advantageous in more than one ways. It helps in harnessing honey sources in their natural state avoiding need for concentrated plantations. Also, this way honey bees provide benefits of pollination to several plant species, both cultivated and wild. At places, farmers may be willing to cooperate with commercial concerns to allow placement of colonies in their fields without costs because of mutual benefit. This alternative land use practice for agriculture through movement of colonies is possible only on commercial scale. Another constraint to the practice could be inaccessibility. It is convenient in areas connected with roads. Transporting beehives to remote areas would however be a difficult task.

Honey Sources Plantation Approaches

Plantations solely from apiculture viewpoint are rarely done. The motive is always linked to other development programmes. Hypothetically speaking even if they were to be done with the sole purpose of beekeeping, good and bad choices remain. Outline of the appropriate approach is given in Table 7.1.

As is well known, land is a scarcity in mountain areas and it would be naive to think of using large areas for plantations to meet the needs of a secondary activity like apiculture. Therefore, unconventional land-use practices are much favoured for the purpose. Plantations on common lands, roadside plantation and community forestry are some of the examples.

Roadside plantations established with the purpose of bee forage, particularly for forage scarcity periods, enhance the scope of beekeeping (Table 7.2). It increases possibilities for the farmers to get additional economic returns from honey and also increases crop yields by way of pollination services by bees. Recent experiences of using road-

TABLE 7.1

Honey plant resources systematic plantation approach

STEP 1

Honey plant resources and existing populations of honeybees of an area e.g. Kathmandu Valley

STEP 2

- Melissopalynological studies to prepare inventory of honey sources of the area

STEP 3

- Carrying capacity of available flora
- in bloom (maximum)
 - in lean season (minimum)

STEP 4

Honey production levels in different seasons to mark lean season/period of an area

STEP 5

To ensure sustainable yields, of honey or to maintain healthy bee colonies for pollination. Provide suggestions for plantations. Keeping in view the local farming systems and biodiversity needs

side plantation for large-scale apiculture, as a form of off-farm activity are available in China and Pakistan. Therefore apart from crops, other kinds of plantations are also needed which flower during rest of the periods in a calendar year. Several trees and other plant species that blossom during different months, so that nectar and pollen are almost continuously available to honeybees is an ideal combination. The plantation done on roadside and other common property lands would involve different climatic regions. This would give an advantage of diversity in terms of species and their blossom calendars (Table 7.2). To ensure variations in efficient utilization of this flora throughout the year, the bee colonies may need constant movement nearer to such areas.

Tables 7.2 and 7.3 list species which have their importance as honey plants for plantation on common property land, government land and private land in different agro-ecological zones, besides other uses.

TABLE 7.2

A sample survey of multipurpose honey source tree species of different climatic regimes of the Hindu Kush-Himalaya to facilitate selection of appropriate plantations on common property lands and roadsides

Species (1)	Uses (2)	Remarks (3)
A. TEMPERATE REGION COMPRISING MOSTLY OF HIGH MOUNTAIN AREAS:		
1 <i>Alnus nepalensis</i>	Timber, fuel, nitrogen fixing	Large tree suitable for growing on river banks, ravines, and newly formed soils. Useful for soil conservation in landslide areas. More common in the Eastern Himalaya. Grown by direct sowing or by entire transplanting. Good for slope stabilization.
2 <i>Alnus nitida</i>	Timber, fuel, nitrogen fixing	Similar to above. More common in the Western Himalaya on riversides and ravines. Good for slope stabilization.
3 <i>Buxus almoides</i>	Plywood, furniture, and tool handles	A medium-sized tree. Suitable for broken marginal lands. Can be grown by entire transplanting and also by direct sowing. Can be used for slope stabilization.
4 <i>Corylus colurma</i>	Timber for shuttle making, fuel, fodder	Medium-sized tree. Wood used. Grown by entire transplanting.
5 <i>Eucalyptus saligna</i>	Fruits, timber, fuel	Medium-sized trees. Edible fruit is much relished. Can be grown by entire transplanting as well as by direct sowing. Can be planted on gentle slopy roadsides.
6 <i>Juglans regia</i> (akhrot)	Timber, furniture, and carving, gun-stock, fruits	Large tree. Grown by entire transplanting and also by direct sowing.
7 <i>Morus serrata</i> (kimu)	Fodder, sports goods, furniture, toys	Large tree. Suitable for growing on marginal slopy lands and on roadsides passing through farmlands. Can be grown by branch cuttings and direct sowing.

Contd.

Table 7.2: Contd.

Species (1)	Uses (2)	Remarks (3)
8 <i>Prunus cerasoides</i> (padam)	Timber, fuel, fodder, wood used in religious ceremonies	Medium tree. Suitable for marginal lands and around villages. Grown by entire transplanting, also by branch cuttings. Good for beekeeping.
9 <i>Prunus persica</i> (aru)	Fruits, timber, fuel	Small tree. Suitable for near habitation, gentle stable slopes, and plain valley areas. Grown by entire transplanting.
10 <i>Pyrus malus</i> (sew)	Fruits	Small trees. Suitable for growing near habitations, farming areas in valleys and marginal lands. Grown by entire transplanting.
11 <i>Quercus incana</i> (ban)	Timber for agricultural implements, medicinal, trussar silk rearing	Large tree of the eastern Himalaya. Suitable for marginal lands. Grown by direct sowing. Good for slope stabilization in high mountain areas.
12 <i>Robinia pseudoacacia</i>	Fuel, fodder, soil conservation	Medium tree. Suitable for marginal lands and for stabilizing ravinous land. Grown by entire transplanting. Commonly planted on roadsides in lower hills. Can be planted on slopes of any degree.

B. SUB-TROPICAL REGION COMPRISING THE FOOT HILLS OF THE WESTERN HIMALAYA AND CENTRAL HIMALAYAN MOUNTAINS

1 <i>Albizia lebbek</i> (sirisi)	Timber, fuel, fodder, medicinal	Large trees. Suitable for open roadside lands and along narrow pathways. Grown by entire transplanting, direct sowing, and cuttings.
2 <i>Bauhinia purpurea</i> (khairwal, guiral)	Gum, fuel, fodder	Medium tree. Suitable for roads passing through farm. Grown by entire transplanting and direct sowing.
3 <i>Bauhinia variegata</i> (kachnar)	Gum, fuel, fodder	Medium tree. Suitable for road passing through farm. Grown by entire transplanting and direct sowing.

4 <i>Dalbergia sissoo</i> (shisham)	Timber, furniture, plywood, fuel, fodder	Large or medium tree. Suitable for growing in lower to mid hill plantations, on village roads. Grown by entire transplanting, root and shoot. Suitable on slopy sites.
5 <i>Dendrocalamus strictus</i> (bans)	Paper pulp, construction, tent, poles, basket-making	Large bamboo. Suitable for growing on open marginal land, roadsides and near homesteads. Grown by entire transplanting and from rhizomes.
6 <i>Embllica officinalis</i> (sonia)	Fruits, tannin, timber, fuel, fodder	Medium tree. Suitable for roadsides near homesteads and farms. Grown by entire transplanting or direct sowing. Himachal Pradesh is already using it for roadside plantations for socioeconomic value.
7 <i>Eucalyptus camaidulensis</i>	Timber, fuel, charcoal, gum, medicinal	Large tree. Suitable for both dry and swampy areas. Grown by entire transplanting.
8 <i>Grevillea robusta</i>	Ornamental, timber, cabinet making, toys, fuel, panelling, shade tree in tea gardens	Large tree. Suitable for shade or as avenue. Grown by direct sowing.
9 <i>Grewia optiva</i> (bhimal)	Timber, cot frames, fibre, fodder	Medium tree. Suitable for farming need areas. Good as fodder, fibre and fuel. Grown by entire transplanting.
10 <i>Morus alba</i> (tut)	Fruits edible, timber, sportsgoods, fodder, leaves for silk-worm feeding.	Medium tree. Suitable for marginal lands. Grown by entire transplanting, direct sowing, or branch cuttings.
11 <i>Populus deltoides</i>	Matchwood, pulpwood, light timber, fuel	Small tree near habitation, farm land roadsides. Grown by branch cuttings.

Table 7.2: Contd.

Species (1)	Uses (2)	Remarks (3)
12 <i>Prunus armeniaca</i> (zardalu)	Fruits, timber, fuel	Small tree near habitation, farm- land, roadsides. Grown by branch cuttings.
13 <i>Prunus persica</i> (aru)	See (A) (9)	In valleys and on stable land near habitation, roadsides.
14 <i>Pyrus communis</i> (nashpati)	Fruits, fuel	Small tree. Suitable for homesteads and field edges. Grown by grafting.

C. SUB-TROPICAL CLIMATE OF CENTRAL AND EASTERN HIMALAYA

1 <i>Albizia lebbeck</i>	See (B) (1)	
2 <i>Bauhinia purpurea</i> (khairwa, guiral)	Timber, fuel, fodder	Large tree. Suitable for growing on village commons, marginal lands, and road- sides. Grown by entire trans- planting and direct sowing. Good for areas requiring fuel and fodder.
3 <i>Grevillea robusta</i>	Essential oil, fuel, charcoal, timber	Medium tree. Suitable for slopy and plain roadsides. Grown by entire transplanting.
4 <i>Grewia elastica</i> (dhaman)	Ornamental, timber, toy making, fuel, fodder	Medium tree. Suitable for slopy and plain roadsides. Grown by entire transplanting.
5 <i>Morus serrata</i> (kimu)	See (A) (7)	

D. TROPICAL REGION

(i) HIGH RAINFALL AREAS OF NEPAL AND NORTHEASTERN PARTS OF INDIA

1 <i>Dalbergia</i> <i>latifolia</i> (shisham, biti, jitengi, iti) <i>The</i> rosewood	Timber, furniture, cabinet	Large tree. Suitable for growing on village, state and national highways. Grown by entire transplanting.
2 <i>Lagerstroemia</i> <i>speciosa</i> (jarul)	Timber, constructional purpose, furniture agricultural implements, telegraph poles, fodder, medicinal	Large tree. Suitable along path- ways. Grown by entire transplanting.

3 <i>Melocanna baccifera</i> (Bans)	House construction, mats, baskets, paper pulp	Medium bamboo. Suitable for growing in 3rd row onwards. Grown by entire transplanting.
4 <i>Mangifera indica</i> (am), Mango tree	Edible fruits, fatty oil, plywood, shoe heels, furniture fuel	Large tree. Suitable for growing on roadsides of all kinds of roads. More preferable for village roads. Good only for valleys and stable areas. Grown by entire transplanting (grafted).
5 <i>Parkia roxburghii</i> (supota)	Fruits, fuel, ornamental, medicinal	Medium tree of eastern parts. Suitable for roadsides. Grown by entire transplanting.

(ii) MEDIUM RAINFALL AREAS OF LOW TO MID HILLS

1 <i>Acacia auriculiformis</i> (Akashmuni)	Timber, fuel, ornamental	Medium trees. Suitable for slopy lands. Grown by entire transplanting and direct sowing.
2 <i>Acacia nilotica</i> (babul, kikar)	Timber, fuel, fodder, tannin, gum	Medium tree. Suitable for sites for slopy lands, marginal lands and village commons. Grown by direct sowing.
3 <i>Aegle marmelos</i> (bel, vilva)	Fuel, gum, bark, and fruit, medicinal	Small tree. Suitable for roadsides near rural habitations and houses. Grown by entire transplanting.

E. TRANS HIMALAYAN, HIGH MOUNTAIN COLD ARID ZONE

1 <i>Salix</i> spp.		A popular tree of the trans Himalaya.
2 <i>Populus</i> spp.	See (B) (11)	Also commonly grown by mountain communities for fuel and fodder.
3 <i>Prunus armeniaca</i> (Khurmani)	See (B) (12)	A popular oil seed and fruit tree wild as well as domesticated.
4 <i>Alnus</i> spp.	Nitrogen fixing See (A) (1 & 2)	Wild forms for roadside plantations.
5 <i>Betula utilis</i> (Bhoj Patra)		

Contd.

Table 7.2: Contd.

Species (1)	Uses (2)	Remarks (3)
6 <i>Hippophae</i> spp.	Fruits, fuel, timber, nitrogen fixation, soil fertilization.	Shrub and tree both suitable for dry sandy or rocky locations, riversides, moist areas. Good for roadside passing through farm lands.
7 <i>Prunus persica</i>	Fruits, fuel	Wild forms of roadside plantations.

Source: Compiled from multipurpose sources.

Honey Source Plantations and Conservation of Genetic Resources

As is well known, the threat of extinction of several species and their populations is increasing. Economically important plant resources are over exploited leading to their decline. Similarly, habitats of several rare species are being destroyed leading to their extinction. This makes it desirable that development programmes based on plant resources, care for enhancing populations of those species which are dwindling.

Such threatened plant species which otherwise are a good honey source, can be promoted for both small scale plantations (say a few trees/shrubs around the houses) or large scale plantations on common property lands and roadsides. The concept is an ideal example of combining development with conservation. For deciding priorities regarding the conservation of species through plantations, selection criteria developed by (IUCN, 1980) will be most useful. It outlines that priorities should be given to these categories:

- i. Species that are endangered throughout their range.
- ii. Species that are the sole representatives of their family or genus. The formulation is illustrated in Table 7.4. Further, priority should be given to those plant species, that are most threatened and most needed.

Such conservation efforts, however, call for multidisciplinary efforts to prepare an inventory of appropriate species for different areas. In addition to its honey source qualities and multipurpose use value, the status of existence of species would be another added criterion of selection for plantation, under this approach. Given the national awareness, and international concerns over the issue of loss of genetic resources and biological diversity, implementing this new approach to

TABLE 7.3

A sample survey of honey source shrubs of multipurpose value found in the Hindu Kush-Himalayan region, for selective plantations as fencing, wasteland and common property lands

Plant Species	Common Name	Honey Potentialities	Flowering Period	Distribution	Type (Nature)	Other Economic Uses
<i>Adhatoda zeylanica</i> Nees	Basuti	N ² P ²	APR-NOV	S. Tropical, S. Temperate, Temperate	Shrub (W)	Medicinal & Soil reclamation
<i>Strobilanthes wallichii</i> Nees	Bankas	N ² P ²	AUG-OCT	S. Temperate, Temperate	Shrub (W)	
<i>Agave americana</i> L.	Century plant	N ³ P ³	SEP-NOV	S. Tropical	Shrub (W)	Ornamental & Fibre
<i>Carissa caranda</i> L.	Karandas	N ² P ²	APR-MAY	S. Tropical, S. Temperate, Temperate	Shrub (W/C)	Preservation
<i>Phoenix</i> spp.	Wild date palm	N ² P ³	MAY-JUL	S. Tropical, S. Temperate	Shrub (W)	Fruit
<i>Asclepias curassavica</i> L.	Milkweed	N ² P ²	APR-JUN	S. Tropical, S. Temperate		Medicinal & Fibre
<i>Berberis lycium</i> L.	Barberry	N ² P ¹	MAY-JUN	S. Tropical, S. Temperate	Shrub (W)	Medicinal Root and Fruit

Contd.

Table 7.3: Contd.

Plant Species	Common Name	Honey Potentialities	Flowering Period	Distribution	Type (Nature)	Other Economic Uses
<i>Corylus colurna</i> Dence.	Hazelnut	P ²	MAR-MAY	S. Tropical, S. Temperate	Shrub (W/C)	Seeds Edible & Fuel
<i>Opuntia</i> spp.	Prickly pear	N ² P ²	APR-MAY	S. Tropical, S. Temperate, Temperate	Shrub (W)	Medicinal
<i>Lonicera sempervirens</i> L.	Honey suckle	N ³ P ³	MAY-AUG	S. Tropical, S. Temperate,	Shrub (W/C)	Ornamental
<i>Viburnum</i> spp.	Vikurum	N ³ P ³	MAY-JUN	S. Tropical, S. Temperate	Shrub (C)	
<i>Euphorbia royleana</i> Bros.	Euphorbia	N ³ P ³	APR-MAY	Temperate	Shrub (W)	Medicinal
<i>Ricinus communis</i> L.	Castor oil-plant	P ³	MAY-AUG	S. Tropical, S. Temperate	Shrub (W/C)	Lubricant, Oilseed, Purgative & Medicinal
<i>Plectranthus rugosus</i>	Shain	N ¹ P ²	AUG-NOV	S. Temperate, Temperate	Shrub (W)	
<i>Plectranthus coetsa</i> Benth.	Shain	N ¹ P ²	SEP-OCT	S. Temperate, Temperate	Under Shrub (W)	
<i>Plectranthus gradianus</i>	Shain	N ¹ P ²	AUG-OCT	S. Temperate, Temperate	Under Shrub (W)	
<i>Thymus</i> spp.	Thyme	N ² P ³	MAY-OCT	S. Temperate, Temperate	Shrub (W)	Medicinal & Aromatic

<i>Lagerstroemia indica</i> L.	Pride of India	N ² P ²	JUL-SEP	S. Tropical, S. Temperate, Temperate	Shrub (W)	Purgative, Timber & Ornamental
<i>Musa sapientum</i> L.	Banana	N ³ P ³	MAR-DEC	S. Tropical, S. Temperate	Shrub (C)	Fruit & Medicinal
<i>Indigofera</i> spp.	Indigofera	N ² P ²	JUN-AUG	S. Tropical, S. Temperate, Temperate	Shrub (W)	Fodder
<i>Lespedeza</i> spp.	Lespedeza	N ²	JUN-JUL	S. Tropical, S. Temperate, Temperate	Shrub (W)	
<i>Punica granatum</i> L.	Pomegranate	N ² P ¹	APR-MAY	S. Tropical, S. Temperate	Shrub/Tree (C)	Fruit, Soil reclamation & Fodder
<i>Clematis</i> spp.	Clematis	N ² P ²	MAR-MAY	S. Tropical, S. Temperate, Temperate	Shrub (W)	Ornamental
<i>Potentilla</i> spp.	Silver weed	N ² P ³	JUN-AUG	S. Tropical, S. Temperate, Temperate	Herb/ Shrub (W/C)	Medicinal
<i>Prinsepia utilis</i> Royle	Bekhal	N ¹ P ²	SEP-NOV	S. Tropical, S. Temperate, Temperate	Shrub (W)	Fatty Oil & Hydrogenation

Contd.

Table 7.3: Contd.

Plant Species	Common Name	Honey Potentialities	Flowering Period	Distribution	Type (Nature)	Other Economic Uses
<i>Rosa macrophylla</i> L.	Rose	N ³ P ²	MAR-MAY	S. Tropical, S. Temperate	Shrub (C)	Fruit, Hedge & Ornamental
<i>Rubus</i> spp.	Berries	N ² P ²	APR-JUN	S. Tropical, S. Temperate	Shrub Climber (W/C)	Hedges & Fruit
<i>Solanum melongena</i>	Brinjal	N ³ P ³	JUN-AUG	S. Tropical, S. Temperate	Shrub (C)	Fruits & Ornamental
<i>Daphne oleoides</i> Scherb.	Daphne	N ³ P ³	JUL-SEP	S. Temperate	Shrub (C)	Ornamental & Purgative
<i>Vitex negundo</i>	Bannah Voilet	N ² P ²	MAY-JUN	S. Tropical, S. Temperate	Shrub (W)	Ornamental Hedge & Medicinal
<i>Vitis vinifera</i> L.	Grapes	N ³ P ³	MAY-JUN	S. Tropical, S. Temperate	Shrub (W)	Fruit & Fermented Fruit Juice

N¹ = Major honey sources P¹ = Major pollen source
 N² = Medium honey sources P² = Medium pollen source
 N³ = Minor honey sources P³ = Minor pollen source
 W = Wild S. Tropical = Sub-tropical
 C = Cultivated S. Temperate = Sub-temperate
 Source: Verma, 1990.

TABLE 7.4

Criteria for determining conservation priority of threatened species (Adopted from: IUCN, World Conservation Strategy, 1980), to be added as a point for honey source selection for plantations.

Size of Loss	Imminence of loss		
	Rare	Vulnerable	Endangered
Family	○ 4 ○	// // // // // // // // // // // // 2 // // // // // // // // // // // //	// // // // // // // // // // // // 1 // // // // // // // // // // // //
Genus 7	○ 5 ○	// // // // // // // // // // // // 3 // // // // // // // // // // // //
Species 9 8	○ 6 ○
Note: Nos. 1–9 indicate = suggested order of priority 1, 2, 3 (// // //) = highest priority 4, 5, 6 (○ ○ ○ ○ ○) = intermediate priority 7, 8, 9, (.....) = lower priority			

help conserve the biological resources, diversity becomes all the more important.

Acknowledgements

I am thankful to Dr. L.R. Verma for permitting me to reproduce a short list of honey plant resources from his book, in addition to his persistent efforts to force me to think on Honey Source perspectives.

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PART IV

Mountain Women as Beekeepers

invisible contribution to agriculture and food production. They are the dominant labour force and are engaged in agricultural activities from preparation of the soil to post harvest operations. In some areas, males have their valuable indirect support in raising food and cash crops and other village-based commodities.

A much greater commitment to rural women's development and improvement of their economic conditions would be through income-generating programmes. New changes intended to benefit women should not add to their burden because they are already busy as mothers, producers and family cooks. Thus, the income-generating activities should be structured in a way that the women not only become significant co-owners of family income, but also take care of their children and help their families in different agricultural operations.

8

Beekeeping—An Income-generating Cottage Industry for Rural Women in Pakistan

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Introduction

Pakistan occupies an area of about 0.8 million square kilometres. Its population comprises 100 million individuals and rural women and youth constitute over 50 per cent of the total of about 72 per cent of the rural population (Anon, 1987). In Pakistan, like in most Asian countries, small-scale agriculture makes up the bulk of total production and employment and rural women make a crucial, but silent and invisible contribution to agriculture and food production. They are the dominant labour force and are engaged in agricultural activities from preparation of the soil to post harvest operations. In some areas, males have their valuable indirect support in raising food and cash crops and other village-based commodities.

A much greater commitment to rural women's development and improvement of their economic conditions would be through income-generating programmes. New changes intended to benefit women should not add to their burden because they are already busy as mothers, producers and family cooks. Thus, the income-generating activities should be structured in a way that the women not only become significant co-earners of family income but also take care of their children and help their families in different agricultural operations.

Beekeeping has tremendous scope for expansion in the country (Ahmad and Muzaffar 1984). Transfer of appropriate technologies at their level will have a positive effect on both production and family income. An increased percentage of women in work force would be involved in this suitable scientific profession so as to bring them in to the mainstream of development as is the case in many developed countries. It would also suit women in the improvement of their health and nutritional standards with quick economic results.

Beekeeping and Rural Women

Like other industries, beekeeping depends upon capital, woman-man-power and raw material for its establishment and successful maintenance. There is no dearth of woman power for undertaking beekeeping as a rural industry. Several females, males and children can take up beekeeping as part time or full time occupation in the rural areas. Landless labourers, small farmers, women in landless families and persons engaged in other occupations can also keep honeybees and earn an additional livelihood in villages. Regarding the raw material, there is a huge and unutilized natural floral wealth that is waiting to be tapped, but is, at present, left back to nature. In highly industrialized countries, beekeeping technology tends to be capital intensive so as to reduce the inputs of woman-man-hours as in large factories. In Pakistan, beekeeping has to be labour-intensive to maximize creative self employment so that it is a way of life to be in tune with the natural environment and have lesser involvement of mechanical automation. Anyhow, among the village industries, beekeeping, if started on a small scale, is perhaps the only industry which demands the least capital investment. In fact, for beekeeping as a part time occupation, the only essential requirement to make a start is a few bee hives and a few other implements. A beekeeper with an initial investment of Rs 5000 (US\$ 278) and five honeybee colonies can earn Rs 2700 (US\$ 150) per annum. Thus the women can easily undertake beekeeping as a profitable cottage industry.

Besides honey production, honeybees are most important pollinating insects. A large number of crops and fruit and forest trees require or at least benefit from bee pollination. Honeybee colonies are rented out for pollination of crops and fruit plants in various countries. The farmers of California State pay about US\$ 30 million annually to beekeepers as rent of honeybee colonies supplied to them for the pollination of their crops in comparison to beekeepers' income of about US\$ 10 million from honey production. Thus, honeybees are an important component of the agricultural production system. The women of

rural areas can earn additional income from honey and can simultaneously help farmers in better yield of their crops.

Beekeeping products include honey, beeswax, royal jelly, pollen, propolis and bee venom. Honey is one of the most nutritive foods containing various kinds of sugars, proteins, free amino acids, minerals, trace elements, enzymes and vitamins with a fairly high caloric value (303 calories per 100 g). It has been used as a component of many commercially manufactured pharmaceutical products. At least 200 tons of honey is used in various types of cough mixtures in the world annually. Beeswax is used in cosmetic industry, beekeeping industry, pharmaceuticals, dentistry, foundries in manufacturing process, component of waterproofing materials and polishes for floors, furniture, appliances, leather, etc. Royal jelly is the most precious product of the hive. It is used for the treatment of human diseases, human dietary supplements, cosmetics and rearing queen bees. Pollen is used as a chief source of protein, fat and mineral for bees. It is also used as health food for stabilizing faulty metabolism. Propolis is the most precious product of beekeeping. It is used as health food, component of ointments for treating burns, external ulcers and eczema in human beings, in alcohol tincture for the treatment of hearing defects and in anaesthetics used in dental practice. Honeybee venom is produced in several countries and is used for the treatment of rheumatoid arthritis and several other diseases. It is also used for desensitizing hypersensitive individuals.

From the floral point of view, beekeeping has tremendous scope for expansion in the country. Some 900 plant species are known to constitute honeybee flora in Pakistan. Most of these are minor sources of nectar and pollen. Some plants produce nectar in large quantities, but these are not abundantly available and are therefore not important for beekeeping. Honey production is dependent on a few plant species which yield nectar abundantly and are sufficiently common to bees. Among these, alfalfa (*Medicago sativa*), berseem (*Trifolium* spp.), citrus (*Citrus* spp.), cotton (*Gossypium* spp.), mesquite (*Prosopis* spp.), phulai (*Acacia modesta*) and shain (*Plectranthus* spp.) are most important and provide a major part of commercial honey in the country.

The good location for beekeeping is one where there are at least three plant species which yield surplus honey in considerable quantities and bloom at different periods. Besides, there should be a great variety of minor plants yielding both pollen and nectar to support bees between main honey flows. Such locations are common almost throughout the country except in desert areas and fairly large quantities of honey can be produced from these areas.

Besides honey production, honeybees are very important pollinating insects. Several crops, and fruit and forest trees require, or at

least benefit from bee pollination. Among these, almond, apple, apricot, avocado, some varieties of citrus, peach, pear, persimmon, plum (fruit plants), alfalfa, clover (forage), sarson, safflower, some varieties of sunflower (oil seeds), carrots, cole crops, egg plants, onion, pumpkin, squash, radish, and turnip (vegetables) require honeybees to supplement pollination and to increase their yield.

Honeybee colonies have been rented for the pollination of crops and fruit plants in various countries. The rent of a honeybee colony in California, USA varies from \$10 to 30 depending upon the flowering period and nectar and pollen potential of the crops and fruit trees. The farmers in Japan rent about 114,500 honeybee colonies annually for the pollination of strawberry, melon, watermelon and vegetable crops and fruit trees at the rate of 8000–15000 yen per colony. Honeybees are, therefore, vital to agriculture production system. It is important that our rural women and men start beekeeping both for honey production and crop pollination.

Popularization of Beekeeping through Low Cost Langstroth Hives

The oriental bee *A. cerana* is kept mostly in wall-, log-, and pitcher hives in most of the beekeeping areas particularly some parts of Peshawar, Hazara and Swat Divisions and Murree hills. The beekeepers, except a few progressive ones, of these areas are using traditional honeybee management practices. The modern Langstroth hives are very expensive. Therefore, beekeepers cannot afford to purchase them. Thus an abrupt change to Langstroth hive is not easily acceptable by beekeepers. Studies were, therefore, conducted to develop some low cost Langstroth type hives and comb foundation sheets to persuade beekeepers of remote areas to use of modern hive and other equipment for increasing honey yield per colony.

Low cost hives were manufactured using indigenous material. The performance of *A. cerana* was tested in hives made up of: (1) clay and chopped wheat straw (CCWS); (2) glauconite, newspapers and fine wheat flour (GNPWF); (3) glauconite, newspapers, fine wheat flour and dry agave leaves (GNPWFAL); (4) cement, sand and newspapers (CSNP); (5) clay and rice husk (CRH); and (6) clay and rice husk ash (CRHA). These low cost hives proved almost equally well for the performance of bees. However, temperature maintained by honeybees was about 1–1.5°C lower in glauconite and clay hives in May–June (summer) and 1–2°C higher in December–January (winter) as compared to Langstroth hives. Transportation of all these hives was more difficult than that of Langstroth hives. The cement and sand hives were the heaviest.

These hives were recommended for stationary beekeeping. These are being popularized, both among the women and men beekeepers because of their low cost (US\$ 1 to 2) as against the Langstroth hives (US\$ 28) which are expensive owing to the high cost of wood.

Women who are restrained by some physical disability and are not able to participate in routine farm operations can get training in beekeeping at rural centres. These community development activities would directly benefit women and enhance their socio-economic conditions and family health. It has truly been advocated that shared power is a double power. Rapid development of the rural women and their full participation as equal partners in the economics and social mainstreams of national life is at present, one of the greatest challenge being faced by the country. Their participatory development approach would ensure fulfilment of needs and interconnected roles so that they can use their time and energy optimally for multiple tasks. There is no denying the fact that if rural women start beekeeping they can supplement their income by producing honey. The income-generating beekeeping programmes would provide them unique opportunities to enhance their productivity by increase in the yield of several crops through honeybee pollination with additional benefit from sale of bees, honey and other hive products.

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9

Mountain Women and Beekeeping in Nepal

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Introduction

When we speak of mountain women, we refer to those who live in rural communities with agriculture as their means of livelihood. Economically, a large proportion of them fall under the poverty line. But most of them are apparently self-sufficient because their needs are limited to fulfilling their basic needs. This situation is changing because farm productivity is declining, population pressure is increasing and market economy is on its way to development. Women in Nepal are the most neglected and under-privileged group in rural communities: one of the important tasks for future policy planners would perhaps be to integrate women skill into the social and economic development of the mountain population. Integration implies the utilization of women resources in some income-generating activities, e.g. beekeeping.

Mountain ecology is most suited for mixed farming and forestry activities. Horticulture development has been regarded as a most lucrative option for economic upliftment. Women play a key role in the socio-economic system of a rural community. Women can generate additional economic benefits from their off-farm activities and cottage industries if proper opportunities and facilities are provided to them. In certain parts of Nepal such as Rapti zone, Karnali zone and Seti zone, beekeeping has become an additional source of income for the family.

What are the Main Activities of Mountain Women?

Mountain women are very poor. They have to work from early in the morning to late in the night. Their main activities are:

1. cleaning the houses and carrying out all the household chores
2. cooking food
3. collecting fuelwood and fodder
4. grazing animals
5. preparing manures for their farms
6. fetching drinking water
7. working in the farms
8. taking care of their clothes
9. post-harvesting activities
10. weaving and knitting their clothes.

They have to devote all their time to their families and yet have no money at their own disposal. Therefore, beekeeping is an important income-generating activity for mountain women. Training should be given to them to bring about an awareness on modern techniques of beekeeping.

Advantages of Beekeeping for Mountain Women

There are many advantages for mountain women if they are involved in beekeeping. The following main advantages result from this profession:

- 1) Beekeeping is very compatible to mountain women as it is a less time-consuming profession and does not interfere with the day-to-day work.
- 2) Beekeeping is a profession which generates direct income. It has been proved that each family can earn Rs. 3400* per year per hive.
- 3) Since mountain women are directly involved in agricultural activities—beekeeping also improves agricultural and horticultural productivity through the process of cross-pollination. It should be noted however, that for this process, the environment should be free from pollution (especially from insecticides).

Beekeeping Constraints

In Nepal, native *Apis cerana* has been domesticated for honey production. This species is very susceptible to Thai sacbrood virus disease.

* 35 Nepalese rupees = 1 US\$

This disease has killed more than 65 per cent bee colonies in several parts of Kathmandu valley in recent years. This disease was possibly brought into Nepal from China via India and Thailand. It is possible that the spread of this disease might also be due to the import of exotic *Apis mellifera* into Nepal. It is well known that the European bee (*Apis mellifera*) is commonly susceptible to virus diseases and this must be controlled at once by the concerned authorities. Otherwise consequences would be disastrous for the entire beekeeping industry in Nepal. Beekeeping with *Apis cerana* still faces some constraints like absconding, frequent swarming, predators, wax moths, robbing habits, production of large number of laying workers and other bee diseases. Sometimes beekeeping may fail due to lack of technical know-how. However, these problems can be solved by better management techniques. To overcome these problems, training in beekeeping must be given to both women and men. Recently, special emphasis is being put on training rural women so as to raise their status by demonstrating appropriate techniques and new skills in beekeeping.

Beekeeping can be conveniently integrated into the daily activities of mountain women for the following reasons:

- 1) Low investment
- 2) Cash income
- 3) Part-time job
- 4) Easy to learn and practise
- 5) Easy to market

The majority of mountain women in Nepal are illiterate. But, fortunately beekeeping requires no specialized education. They can learn beekeeping from some orientation programmes and can do it effectively, thereby generate substantial income. Beekeeping does not require any huge investments. Most mountain women from all over the country use traditional methods of beekeeping, producing about 2 to 5 kg of honey per year per colony. As per traditional method, they have to destroy their bee colonies at the time of honey extraction. But by using modern techniques mountain women can produce on an average 15 kg of honey per year from each colony without destroying the colonies. This can give them an additional income of about Rs 3,000 per year from each colony. Honey is in great demand and costs about Rs 200 per kg. Every mountain woman should start beekeeping from atleast two colonies to derive their benefit. If 10 colonies can be maintained, one can earn as much as Rs 30,000 per year and which would raise the standard of living considerably.

In addition to its being a potential source of income, the bee industry could also help in boosting agricultural production significantly by increasing the yield of crops, vegetables, fruits and seeds through

cross-pollination. Mountain farmers have no idea about the importance of bee pollination. It is well known that keeping honeybee colonies during the flowering of oil crops, wild flowers, vegetables, fruits and other agricultural crops, help in increasing the yield by 30 to 40 per cent which is the indirect benefit obtained from beekeeping. The list of the important honey plants is given in Table 9.1.

Beehive Types Found in Nepal

There are different types of beehives found in Nepal:

Traditional types

1. Log hive
2. Wall hive
3. Cavity hive
4. Old trunk hive
5. Wooden box hive

Improved types

1. Newton 'A' village type hive
2. Newton 'B' type hive
3. Indian hive
4. Godawari hive
5. African top bar hive

From all the above-mentioned beehives, Newton 'A' village type of bee hive is the best for honey production. Traditionally, mountain women use log and wall hives which are not profitable for them. Honey production also depends on the size of the bee hives, so appropriate bee hives should be used for generating more income.

Recommendations and Conclusions

1) Beekeeping may be integrated into any farming system in the mountains. Beekeeping promotes agricultural and horticultural productivity. Modern methods of beekeeping can be extended to most mountain communities. It would not be a new element in their system. Economic investment remains low, but yield is very high.

2) An initial training of two weeks and subsequent monthly supervision would be adequate for the development of beekeeping in mountain areas. Agricultural extension officers or technicians should be trained in beekeeping to promote this activity among the farmers.

3) There must be some Government support to run this industry on a larger scale. Bee hives should be given to the mountain women at subsidized rates by the government or aid donors. Bank loans should be made easily available through Agricultural Development Bank in Nepal.

4) There should be uniformity of bee hives throughout the country to run the extension programme on beekeeping.

5) A regional centre for beekeeping research and training both for the trainers and extension workers should be established in Kath-

mandu valley. Such a centre should promote research on local honeybees and local bee flora and their contribution to honey production.

Species	True hemp	Cannabaceae	P	m
<i>Cannabis sativa</i>	Cannabis	Cannabaceae	P	m
<i>Capsicum annuum</i>	Capsicum	Solanaceae	P	m
<i>Capsicum frutescens</i>	Red cluster pepper	Solanaceae	P	m
<i>Capsicum microcarpum</i>	Bird pepper	Solanaceae	P	m
<i>Carica papaya</i>	Papaya	Caricaceae	N	M
<i>Carthamus tinctorius</i>	Bastard saffron	Compositae	P	m
<i>Cassia fistula</i>	Cassia pods	Leguminosae	N	M
<i>Cassia floribunda</i>	—	Leguminosae	N	M
<i>Cassia mimosoides</i>	—	Leguminosae	N	M
<i>Castanopsis indica</i>	Nepal chestnut	Fagaceae	P	M
<i>Castanopsis tribuloides</i>	—	Fagaceae	P	M
<i>Cedrela toona</i>	Tooni	Meliaceae	N	m
<i>Chickrassia tabularis</i>	—	Meliaceae	N	M
<i>Chenopodium album</i>	Lamb's Quarter	Chenopodiaceae	P	m
<i>Chenopodium ambrosioides</i>	—	Chenopodiaceae	P	m
<i>Chrysanthamum cinerariaefolium</i>	Insect flower	Compositae	n	m
<i>Cicer arietinum</i>	Chick pea	Leguminosae	P/N	m
<i>Cinnamomum tanala</i>	Cinnamon leaf	Lauraceae	N	m
<i>Cinnamomum zeylanicum</i>	Cinnamon bark	Lauraceae	N	m
<i>Citrullus colocynthis</i>	Bitter apple	Cucurbitaceae	P	M
<i>Citrus aurantifolia</i>	Lime	Rutaceae	N	M
<i>Citrus grandis</i>	Melon fruit	Rutaceae	N	M
<i>Citrus junos</i>	Rough lemon	Rutaceae	N	M
<i>Citrus limetoides</i>	Sweet lime	Rutaceae	N	M
<i>Citrus media</i>	Citron	Rutaceae	N	M
<i>Citrus sinensis</i>	Sweet orange	Rutaceae	N	M
<i>Colebrookea oppositifolia</i>	—	Labiatae	P	M
<i>Coriandrum sativum</i>	Coriander	Umbelliferae	N	M

Contd.

<i>Rhododendron arboreum</i>	Rhododendron	Ericaceae	N	m	
<i>Rhus javanica</i>	Chinese sumac	Anacardiaceae	P	M	
<i>Rhus succedanea</i>	Wax tree	Anacardiaceae	P	M	
<i>Rhus wallichii</i>	—	Anacardiaceae	P	M	
<i>Rosa moschata</i>	Mush rose	Rosaceae	P	M	
<i>Rosa alba</i>	Rose	Rosaceae	P	M	
<i>Rosa brunonii</i>	Rose	Rosaceae	P	M	
<i>Rosa sp.</i>	Rose	Rosaceae	P	M	
<i>Rubus ellipticus</i>	Golden evergreen raspberry	Rosaceae	N	M	
<i>Salix babylonica</i>	Napoleon willow	Salicaceae	P	M	
<i>Sambucus hookeri</i>	—	Caprifoliaceae	P	m	
<i>Sapindus mukorossi</i>	Soap nut	Sapindaceae	N	m	
<i>Saurauia nepalensis</i>	—	Saurauiaceae	P/N	m	
<i>Schima wallichii</i>	—	Theaceae	P	m	
<i>Sesamum indicum</i>	Sesame	Pedaliaceae	P	M	
<i>Senecio densiflorus</i>	—	Compositae	P	m	
<i>Shorea robusta</i>	Sal tree	Dipterocarpaceae	P	m	
<i>Solanum indicum</i>	—	Solanaceae	P	M	
<i>Solanum nigrum</i>	Black night shade	Solanaceae	P	M	
<i>Solanum melongena</i>	Brinjal	Solanaceae	N	m	
<i>Spondias axillaris</i>	Nepalese hog plum	Anacardiaceae	N	M	
<i>Symplocos paniculata</i>	—	Symplocaceae	P	m	
<i>Taraxacum officinale</i>	Pissabed	Compositae	P	M	
<i>Terminalia bellerica</i>	Belleric myrobolan	Combretaceae	N	m	
<i>Trachyspermum amnina</i>	Ajowain	Umbelliferae	N	M	
<i>Trichosanthes anguina</i>	Snake gourd	Cucurbitaceae	P	m	
<i>Trifolium repens</i>	White clover	Leguminosae	N	M	
<i>Trigonella sp.</i>	Fenugreek	Leguminosae	N/P	m	

Contd.

Table 9.1. Contd.

Plant Species	English Name	Family	Sources	Status	Flowering Months											
					J	F	M	A	M	J	J	A	S	O	N	D
<i>Vicia faba</i>	Broad bean	Leguminosae	P/N	M												
<i>Vigna catjang</i>	Cow pea	Leguminosae	P	m												
<i>Vitex negundo</i>	—	Verbenaceae	P	m												
<i>Vitis vinifera</i>	Wine grape	Vitaceae	P	M												
<i>Yucca smalliana</i>	Adam's needle	Agavaceae	P	M												
<i>Zanthoxylum armatum</i>	Nepal pepper	Rutaceae	P	m												
<i>Zea mays</i>	Maize	Gramineae	P	M												
<i>Zinnia</i> sp.	—	Compositae	P	M												
<i>Zizyphus incurva</i>	Bead plum	Rhamnaceae	N	M												

M = Major, m = Minor, N = Nectar, P = Pollen.

PART V

Status and Economics of Beekeeping

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Introduction

China is a vast country spread over 9.6 million sq. km. It boasts of mountains, rolling hills, great plateaus, huge basins and vast plains. It spans the north temperate, subtropical and tropical zones with favourable natural conditions. China is rich in honey resources and has great beekeeping potential.

Beekeeping and the use of bee products have a long history in China. Thanks to the attention and support from the government, apicultural production in China has developed rapidly since the Liberation in 1949. The total number of honeybee colonies has increased from 500,000 in 1949 to more than 7,000,000 at present. The output of honey has gone up from less than 10,000 tons to 200,000 tons. The output of royal jelly has reached over 800 tons. All these are at the front rank in the world. In recent years, bee pollen have been developed and widely used and the annual output has reached 1,000 tons. About 25-30 per cent of bee product raw materials and processed products are exported and the rest are sold in the domestic market. Now, beekeeping has become an important profession for farmers in many areas of the country, for their individual prosperity, and an important development support to the rural economy. Bee products are also be-

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The Advancement of Apicultural Science and Technology in China

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Introduction

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coming the nourishing tonic products which are well received by the Chinese people.

With the development of beekeeping (apiculture) science and technology, China has registered noticeable development and achievement while there was no apicultural research before 1949. The Institute of Apicultural Research of the Chinese Academy of Agricultural Sciences was established in Beijing in 1958. It has now become the major centre of bee research in China with strong research capacity and relatively complete science subjects. The Institute makes short-term and long-term scientific development plans in apiculture, undertakes and coordinates important apicultural research projects and exchanges information throughout the country. It now has a staff of over 130, of whom about 70 are engaged in research work directly and more than 30 are professors and associate professors. The Institute is divided into six departments: Bee Genetics and Breeding, Modernization of Beekeeping Technology, Prevention and Control of Bee Diseases, Bee Products, Development of Apicultural Techniques, Natural Resources of Apiculture. In the meantime, about ten regional apicultural institutes in provinces with well-developed apiculture have been established to carry out local apicultural projects. Besides, an apicultural department has been established in Fujian Agricultural College to train specialized persons in apiculture.

Exotic *Apis mellifera*

The European honeybee *Apis mellifera* is the most important species in Chinese apiculture. This species comprises two-third of the total bee colonies throughout the country and produces 90 per cent of the honey, and nearly all the royal jelly. In China, apiaries are generally small and most are family apiaries of three to eighty colonies. An average beekeeper has thirty colonies. The primary beekeeping method in China is still the long-distance migratory method although in some places, it has been changed to keeping to a fixed position, combined with short-distance migratory beekeeping. The management of bee colonies is very meticulous. In European honeybees, the honey output of each colony is 30 kg per year and the highest can be as much as 150–200 kg. The royal jelly output of each colony is 0.25 kg in the north and 0.50 kg in the south per year. The highest is 2.5 kg. We have conducted research on a series of beekeeping techniques, which are adaptable to apiculture in China. Our research objectives are of good quality and high output with strong colonies. These include the techniques of rapid reproduction in early spring, two queen colony management with multiple stories, package bee, the design and production of transport truck for colonies, plastic extractor, spring graft-

ing needle, plastic pollen trap, plastic queen-cell bar, and venom collection through electric shocks. These techniques are being accepted and applied by beekeepers throughout China. Our mechanization level is still very low when compared with the developed countries, and needs continuous improvement.

The main bee species used in China is the yellow Italian bee (*Apis mellifera ligustica*). There are a few black bees in the northeast and in Xinjiang. In recent years, Carniolan and Caucasian bees were introduced into China. The major bee breeding methods in China are: cross-breeding, producing good strains by group breeding or closed population breeding, inbreeding by artificial insemination of the queen, outbreeding some lines within the same race or with other races. Several superior hybrid bee strains and cross-combinations, and the high-level royal jelly producing bee strains with selection generation after generation have been bred. In addition, the Chinese bee breeding workers studied the "genetic engineering breeding technique", and put forward the mosaic inbreeding system to maintain the inbreeding lines of bees. There are only a few commercial queenrearing apiaries which are insufficient to meet the needs of beekeepers in China. It is, therefore, necessary to make further efforts to perfect the system of reproduction of good stocks in the country and to strengthen the research work on breeding and selection of superior bees and its relevant techniques.

Apis cerana

Apis cerana is a valuable natural resource of beekeeping in China. These bees are industrious foragers and mite resistant. They are adaptable to the local climate and nectar plants and survive well throughout the year in the subtropical mountains, where western bees do not do well due to the heat of summer and limited nectar. *Apis cerana* bees can collect the good late autumn nectar from plants such as *Eurya* while the western bees stop collecting when it gets cold in autumn. The *Apis cerana* population which survives in the different ecological environments has a little difference in economic and biometrical characteristics. We have accordingly divided the native bee into five different geographic types. It is therefore worthwhile to exploit and use them. We have also done research on a series of techniques such as using movable-frame hives, instead of keeping them in the traditional round wooden buckets, with considerable success and the per colony honey output of *Apis cerana* has doubled.

From 1976 to 1983, a coordination team, formed by the Beekeeping Institute of the Chinese Academy of Agriculture, Guangdong Insect Research Institute, and Yunnan Beekeeping Institute, conducted

investigations on *Apis cerana* and its subspecies which are found in China, and the results are as follows:

Distribution: This species occurs in the broad-leaved or needle-leaved forests in China among southern subtropical zones, and southern temperate zones, with the rough distribution lines as follows:

In the north: From Xiaoxinganling mountainous areas in Heilongjiang Province southward to the areas like Yanshan mountain nearby Zhangjiakou City; from the Yellow River westward to the areas like Yanchi, Hailan of Ningxia Autonomous Region, ended in Jiewushan mountain of Gansu Province.

In the west: From Wugiaoling mountain in Gansu Province, across over Qilianshan mountain, to Xining City; from the northern slope of Armaqing mountain southward to the up-reaches of the Dado River, reaching the middle-and-low reaches of the rivers of Yagongjiang, Jinshajiang, Nujiang and Yaluzangbujiang.

In the east: Southeastern coast areas and Taiwan Province.

In the south: Hainan island and southern Yunnan Province.

There is no *Apis cerana* found in Xinjiang and northern inner Mongolia.

Subspecies: It has been established that there are five subspecies of *Apis cerana* existing in China. They are:

1) *Apis cerana cerana*

Popularly named the Chinese bee or *Apis cerana cerana*, is the name of the subspecies, consisting of five geographic types distinguished according to the above-mentioned investigation.

a) **Guangdong-Guangxi Type:** referring to the bee species inhabiting along the coast areas of Guangdong, Zhejiang, Fujian and Guangxi, with the main features being worker, small body; yellowish abdomen, with tergites II, III and IV predominantly covered with yellow spots; strong swarming ability; generally maintaining a colony weight about 1.5–2 kg; low productivity.

b) **Hunan Type:** referring to the bee species native to places like Jiangxi, Anhui, Guizhou, Hubei, Hunan, southwestern Jiangsu, and northern Guangdong with the main features being the body of worker bee is bigger than that of Guangdong-Guangxi type; abdomen is black alternating with yellow, becoming darker in early winter; colony weight is above 2 kg in general, with high productivity.

c) **Yunnan Plateau Type:** referring to the bee species inhabiting in Yunnan Plateau, mountainous areas of Guizhou, and southwestern Sichuan, with the main features being workers are comparatively big; black abdomen and tongue is up to 5.30 mm; longer than the

above-mentioned two types; suitable for the ecological conditions of the plateau; colony weight is 2–2.5 kg, with high productivity.

d) *North China Type*: referring to the bee species inhabiting in Shanxi, Hebei, Shaanxi, Shandong, and eastern Gansu, with the main features being workers are comparatively big; abdomen being yellowish in summer and darker in autumn; short tongue, strong tolerance to cold; strong resistance to robbing; maintaining a colony weight about 2–2.5 kg.

e) *Changbaishan Type*: referring to the bee species inhabiting in the mountainous areas of Jilin and Xiaoxinganling of Heilongjiang, with the main features being worker is big; abdomen being predominantly black; tolerant to cold; maintaining a colony weight bigger than North China Types.

The geographical conditions of the above-mentioned five types are so diverse that each type has developed with different habits, colour and size, but the differences do not go beyond the range within the subspecies.

2) *Apis cerana skorikovi* Maa

Worker: body length 11–12 mm, tongue 5.11 ± 0.05 mm, forewing 8.63 ± 0.12 mm long and 3.07 ± 0.07 mm wide, grey and yellow or grey and black body, abdominal tergite III is 4.38 mm wide with clear yellow spots on it, narrow and long abdominal tergite V, thin and slender abdomen, maintaining a colony weight about 2 kg, and low productivity.

This species is mainly distributed over the river valleys of the Yaluzangbu, Chayu, Xiluo, Shubanli and Kaman, found at an average height between 2,000 and 4,000 m above sea level, of which Muotuo, Chayu and Cuona counties are the most concentrated inhabiting areas. In comparison with *Apis cerana indica* Fabricus, this species has longer wings and tongue, bigger and darker body and wider abdomen.

Based on the specimens collected from southern Tibet, this species was identified as *Apis indica skorikovi* by Ma Junchao, an entomologist in Taiwan, in 1944, but renamed as *Apis cerana skorikovi* through the recent international standardization of denomination. According to our investigations and considering the ecological conditions of Tibet, it is thought that this is indeed an independent subspecies, quite different from *Apis cerana cerana* Fabricus and *Apis cerana indica* Fabricus, though Ma Junchao later doubted the existence of the subspecies.

3) *Apis cerana abaensis* subsp. Nov, Yang, etc.

This is a newly-found subspecies, pertaining to an ecological type of high mountain valleys, mainly distributed in Arba district of northwestern Sichuan, and Southeastern Qinghai, worker: body length

12.5–13.5 mm, tongue 5.45 ± 0.08 mm, forewing 9.04 ± 0.13 long and 3.15 ± 0.05 mm wide, tergites III and IV 4.21 ± 0.10 mm long, tiny yellow spots on abdominal tergites III and IV, black part occupying more than two-third, maintaining a colony weight of about 2.5 kg or more, capable of producing a large quantity of honey.

4) *Apis cerana hainanensis*

This is also a newly-found subspecies. Worker: body length 10.5–11.5 mm, tongue 4.6 ± 0.13 mm, forewing 7.79 ± 0.80 mm long and 2.95 ± 0.06 mm wide, tergites III + IV 3.84 ± 0.07 mm, cubital index 4.53 ± 0.96 , abdominal tergites III + IV yellowish in summer, yellow scutellum, maintaining a colony weight of not more than 2 kg, with strong swarming ability.

5) *Apis cerana indica* Fabricus

This is a subspecies originally found in India which later spread to China, distributed over the mountain valleys at $24^{\circ}30'N$ in Yunnan Province and concentrated in the autonomous districts of Xishuangbanna and Dehong. The major differences of the subspecies in comparison to *Apis cerana skorikovi* are that is abdominal tergite III is not more than 4.00 mm wide, and the worker has a yellowish body; in general, maintaining a colony weight of below 1.5 kg, low productivity.

All types of the specimens have been deposited in the Beekeeping Institute of the Chinese Academy of Agriculture.

Honey Bee Parasitic Mites in China

Two honey bee parasitic mites (*Varroa jacobsonii* and *Tropilaelaps clareae*) have posed the most serious problems for Chinese beekeeping during the last thirty years.

Since 1956, when the *Varroa* mite was found in China, Chinese apicultural researchers and beekeepers have made continuous efforts to find suitable measures to control these mites. As a result, some effective and safe acaricides have been developed and widely applied by beekeepers. The biology of both mites has also been investigated under ecological conditions of China.

1. OCCURRENCE AND DISTRIBUTION OF BEE PARASITIC MITES IN CHINA

Varroa jacobsonii was first discovered in 1904 on *Apis cerana* in Java. Fifty years later, when migratory beekeeping with *Apis mellifera* became popular in China, this exotic bee species came in frequent contact with *Apis cerana*, the original host of *Varroa* mite. As a result,

Varroa got transferred from *Apis cerana* to *Apis mellifera*. The exotic *Apis mellifera* was more susceptible host for the *Varroa* parasite and led to the rapid reproduction of this mite species. In 1956–57, an infestation of *Varroa* broke out in colonies of *Apis mellifera* in Jiangsu and Zhejiang, two coastal provinces in east China. In 1958, *Varroa* spread to the regions along the Yangtze river. In that year, an estimated 60 per cent of all the colonies of *Apis mellifera* were lost due to the attack of the mite in several honey producing regions of China. By 1964, *Varroa* had spread to every beekeeping area throughout the country.

Another mite infesting bees in China is *Tropilaelaps clareae* which Delfinado and Baker discovered in Philippines in 1961. But a year earlier, infestation by *Tropilaelaps* had already been reported in colonies of *Apis mellifera* in Guangdong, a southern province of China. Later, *Tropilaelaps* like *Varroa* also spread rapidly from south to north. In the late fifties and early sixties, both *Varroa* and *Tropilaelaps* posed a serious threat to the Chinese beekeeping industry.

Biology of bee parasitic mites

In 1963, the male adult mite of *Varroa* was recorded for the first time by Zhang Jiaqi. A year later, an attempt was made to rear the *Varroa* mite under controlled conditions. Mites raised on bee pupae in small glass tubes kept in an incubator laid an average of 3.5 eggs per female. Some new protonymphs and deutonymphs were successfully reared. The development time from egg to adult was reported as eight to nine days for the female. Later, the *Tropilaelaps* was reared successfully too.

Further investigations on the biology of *Tropilaelaps* revealed that in general, a female mite lays one to six eggs, most of which can develop into adult mites during the period of cell sealing since the development period from egg to adult is only five days. In addition, the young mite gets into the new brood cell for egg laying just within four hours after coming out of the sealed cell in which it has developed. So the reproduction and damage caused by *Tropilaelaps* are greater than *Varroa*. It has also been found that *Tropilaelaps* cannot survive on adult workers or combs for more than three days. This is the weak link in its life cycle which can be exploited for its control. *Tropilaelaps* cannot survive the winter in north China because the broodless period of colonies is long.

Control of parasitic mites

Since 1957, chemical control has been practised in China. It remains the major method of control even today. With increasing knowledge of the biology of mites, such a control method has been developed

from the mere use of acaricides. The kinds of chemicals being used have also improved and include those which can kill the mites parasitizing on the adult bee body, as well as the acaricide which can kill the mites parasitizing on the brood inside the cells.

The development of mite controlling methods in China can be divided into three stages.

The first stage: (1957–1963): During the initial outbreak of the bee mite infestation, Rotenone, Trichlorphon, Nicotine etc. were used by beekeepers to control the mites. Although the method was effective to some extent and it initially controlled the rampant growth of the bee mites; it was not safe for the bees and also contaminated bee products.

The second stage: (1963–1970s): As a result of more knowledge about the biology of bee mites as well as the development of new acaricides such as Phenothiazine and “Mie manlin” fumigant, a new method was developed. Taking advantage of the mites’ life cycle of reproducing in sealed cells, this method includes separate treatments to the sealed brood combs in which the mites hide and reproduce, and to the combs with adult bees. Sealed brood combs with bees were transferred from the original colony into an another empty hive, and the original colony was then immediately treated with acaricide. When all the pupae had emerged, from the sealed brood combs, a queen was introduced into the separated colony or returned to the original colony. This method cuts off a link in reproductive cycle of the mites and made it possible to expose the mites to the acaricide. Although this method is complicated and takes a long time, yet it is quite effective.

Early spring and autumn are the two crucial periods in the year for mite control. Spring is the time to reduce the basic population of mites for reproduction and autumn is the time to rear the over wintering bees, avoiding the chemical contamination of hive products during the honey production season.

The third stage: Since 1980, highly effective and safe acaricide sprays and fumigants such as Amitraz (Tactic) and Chlorobenzilate (folbex) have been developed and widely used to kill the mites on bee bodies. The Chinese Institute of Apicultural Research has also developed the “Qiangli” cell fumigant which can penetrate the wax cap and kill the *Varroa* and *Tropilaelaps* in sealed cells. Tests showed that the combined use of two acaricides, can kill more than 95 per cent of the mites on bees’ bodies and inside sealed brood cells respectively, during the crucial period of autumn. This method is simple to follow, shortens the time of operation, assures the rearing of the overwintering bees, thus facilitating a good harvest of spring honey in the next year.

Due to the successful control of both mites, the Chinese beekeeping industry has developed rapidly. In 1957, honeybee colonies in China totalled 1,000,000 and the annual output of major bee products was 10,000 tons of honey, without any royal jelly. By 1988, the total number of colonies had increased to more than 7,000,000 and the annual output of bee products had increased to 200,000 tons of honey, 800 tons of royal jelly. These figures are in the front rank of the world.

The prospect of research on bee mites in future

With the possibility of hive products being contaminated by chemicals and the mites developing drug-resistance, there is a need to find new long-term solution to control mites besides the above-mentioned chemical methods.

1) It is necessary to search and screen new acaricides of plant origin or use other biological products which are effective against bee mites, safe for bees, and leave no harmful residues in hive products.

2) To select and breed mite-resistant lines of honeybee. During the past thirty years, mite-infestation occurred practically in all the colonies of *Apis mellifera* in China. But beekeepers have observed that various degrees of infestation existed in the colonies of same apiary. This indicates the existence of a resistance mechanism against mites in certain colonies. If it does exist and the source of the resistance is identified and collected, new mite-resistant sub-species of bees might be bred. This would be the best solution to mite control.

The Chinese bee (*Apis cerana*) has evolved resistance to both mites during the long evolutionary course. Individual and group cleaning behaviour of the Chinese bee is an important aspect of the resistance mechanism. Transfer of such resistance from *Apis cerana* to *Apis mellifera* may be possible through genetic engineering in the future.

(3) Research on biological-control methods: Search for natural enemies such as bacterial, fungal and viral pathogens of *Varroa* and *Tropilaelaps*, and subsequently testing them as biological control agents for the mites should be attempted.

4) Study an integrated control system against bee mites. There is a need for an overall control strategy, coordination of various control measures, control methods through further research.

Hive Products in China

China is the only country in the Hindu Kush-Himalayan region which has developed technology for the production of royal jelly. The total royal jelly production in this country is 800 MT per year. Before 1957, royal jelly in China was produced from queenless colonies on a small scale. Commercial production of royal jelly from queenright colonies

started in 1959. A relatively strong colony of *Apis mellifera* in southern China at present produces 0.5–1 kg of royal jelly (maximum = 2 kg), whereas in northern China 0.3–0.5 kg of royal jelly per colony is produced. This difference in the yield of royal jelly per colony is due to the longer bee activity period (six months). Thus royal jelly production in China is now one of the important components of the beekeeping industry and the wholesale price of royal jelly was about US\$ 100/kg in 1985.

Production technology: Royal jelly production technology in China is as follows: A queenright colony is separated into the brood chamber and production (super) chamber by means of queen excluder. The brood chamber contains the queen, sealed brood and some empty combs, whereas the production chamber is provided with one to two frames of unsealed larval brood, sealed brood and the combs with honey and pollen stores. For royal jelly production, a large number of nurse bees are needed, and this is achieved by transferring the sealed brood combs to the brood chamber. One royal jelly producing frame with 80 to 100 cups is placed in the production chamber at a time. After 60 to 72 hours of grafting, about 300 mg royal jelly is produced in each queen cell cup. These queen cell cups are regrafted for the production of more royal jelly. Chinese bee scientists have developed special plastic grafting needles and plastic queen cell cups for the production of royal jelly. Beekeepers in rural areas often use sterile brushes to collect royal jelly in clean bottles and then store it in a refrigerator. However, in big commercial bee farms, royal jelly is collected from the cups by electrical suction.

In China, experiments are also being conducted to collect royal jelly from *Apis cerana* colonies. However, the amount of royal jelly produced by this native bee species is much lower than *Apis mellifera*. This difference may be due to the smaller size and activity of the hypopharyngeal glands of individual worker bees, smaller colony size, as well as a concentration of more nurse bees in the brood chamber than in the production chamber in *Apis cerana* as compared to *Apis mellifera*. Since royal jelly gets spoiled with time, it cannot be stored for an indefinite period. In order to overcome this problem, markets for royal jelly are being developed near the production unit so that it can readily be sold in its fresh form. Further, royal jelly is now mixed with medicine, tonics, beverages, and cosmetic products without any chance of changes in its chemical composition. "Beijing Royal Jelly" extract has now become famous all over the world as a tonic.

Pollen, Venom and Propolis

Production of pollen, as an apicultural product, started in 1983. Since then, a relatively good plastic trap for collecting pollens and

techniques for keeping it fresh have been successfully developed. The pollen output is now approximately 1000 tons. It is mainly used in health food, tonics and medical products. For example, Huanhuangbao is one of the tonics made of pollens. Research on this aspect is being conducted further.

Venom was used in China as early as in 1958 for curing arthritis and neuritis and is produced in a small scale. It is now used for acupoint injections for curing arthritis with good effects, in a few hospitals.

Chinese bee scientists have successfully developed electric venom-collector which is easily operated for collecting pure venom and without injury to worker bees. This venom-collector can also be used to collect venom from *Apis cerana cerana*.

Propolis is produced mainly by *Apis mellifera* and scrubbed directly from covering clothes and frame beams. Propolis is mainly exported, with a small quantity used in medicine. The technology for propolis production in China is still at the development stage.

***Eurya* sp.: An Important Honey Source in China**

Eurya is a nectariferous plant of the winter and spring seasons, found in the hilly areas of south China which makes it important from the point of view of apiculture.

People in the hilly areas of south China have been using *Eurya* for rearing Chinese bees since ancient times. Modern beekeepers of China have yet to harness its full potential. A few researchers working on this plant have proved that this species is very important from the point of view of apiculture.

I. Morphological features. *Eurya* belongs to Theaceae. The plants are evergreen shrubs or small trees with a height of about 1–5 m. It is a unilobed plant and the leaves are alternate and coriaceous. Some young shoots have wings (e.g. winged *Eurya*) and others do not (e.g. muricate *Eurya*). Some young shoots and leaves have hairs (down-branched *Eurya*) and some do not (e.g. shortstyle *Eurya*). The flowers of *Eurya* are small and most of them are white, others are pink. The flowers are unisexual. Some times one can see the synoecious plants with hermaphrodite flowers.

II. Distribution area and ecological environment. There are more than 130 species of *Eurya* in the world which are distributed over southeast Asia. China has about 80 species of *Eurya* and they are scattered over the vast tropical and subtropical hilly areas. These areas are at the range of 18–32° north latitude and 100–123° east longitude, i.e. the middle reach of the Changjiang river and various provinces south of the river. Most of the *Eurya* are found growing

among the woods of various trees and shrub forests in river valleys, hill land, and mountain slopes with an elevation of less than 2000 m. In the hilly areas of Hunan, Hubei and Jiangxi provinces, plants of *Eurya* can be seen everywhere. Its local name is wild sweet-scented osmanthus or mountain sweet-scented osmanthus. Therefore, this area is called the land of wild sweet-scented osmanthus. *Eurya* is a good nectariferous plant base for the development of apiculture.

III. Flowering and nectar pattern. Usually, the flowering season of *Eurya* is relatively short, only about ten days. The alabastrums appear in as early as summer and the duration is long. They blossom completely as soon as they enter the flowering season. For instance, the flowering of muricate *Eurya* begins in late October and ends in early November. The flowering seasons of *Eurya* that grow in the same area are different because of various microenvironments, such as in the southern slopes and the northern exposure, the mountain slopes, the valleys, and the barren lands. The flowering seasons of *Eurya*, therefore, can last for 10 to 15 days. The winter-flowering *Eurya* has a special flowering character, i.e., in places where the temperature is lower, *Eurya* blossoms earlier than those plants it does where the temperature is higher. Thus the flowering season of the same *Eurya* species gets delayed gradually from the north to the south. The spring-flowering *Eurya* are just opposite to the winter-flowering *Eurya*. Herein, the flowering season of the same species of *Eurya* is delayed gradually from the south to the north. As a result of this phenological phenomenon for many species of *Eurya* growing in the same area, the flowering seasons criss-cross so that the general flowering season is prolonged one. That is why it is said that the flowering season of *Eurya* is from October to the March of next year. The people in Jiangxi and Hunan provinces call the winter-flowering *Eurya*, the winter osmanthus, and the spring-flowering *Eurya*, the spring osmanthus. Muricate *Eurya* flowers from late October to early November, Loquiana *Eurya* flowers in the middle of November, and winged *Eurya* flowers from late November to mid-December. These differences in the flowering periods of *Eurya* are very good for apiculture.

The plants of *Eurya* have unisexual flowers. Usually, the male flowers come into bloom one to two days earlier than the female flowers. The flowering season of each *Eurya* is regular and is also influenced by the environment. If the weather is dry just before the flowering season, the bloom will be a few days earlier than usual, and if there is more rainfall, the bloom will be few days later. If the weather is wet, the bloom is delayed until the weather is dry again. However, the unopened alabastra will never come into bloom if the cloudy and wet days last too long. *Eurya* is a cryophilic nectariferous plant. The blossom and secretion of nectar of *Eurya* is not susceptible to the vari-

ations in temperature. The plant can secrete large amounts of nectar during the fine days when the air temperature is high. However, if the weather is cloudy or even if it is raining lightly, the plant can still secrete large amounts of nectar provided the air temperature is not too low, i.e., higher than 15°C. The nectar of *Eurya* cannot be washed away from the flowers because the corolla is facing the ground, therefore, honeybees (especially the Chinese honeybees) can forage actively during the light rain period. During the nectar flow, the flowers of *Eurya* secrete nectar all day and the honeybees are busy from morning to evening. There are no problems in setting high yields of honey because most of the days in the blooming period are fine and the wind is not strong.

IV. The main species of *Eurya* for beekeeping. The main species of *Eurya* which have important value for beekeeping are

- 1) Muricate *Eurya* (*E. muricata* Dunn)
- 2) Shortstyle *Eurya* (*E. brevistyla* Kobuski)
- 3) Groff *Eurya* (*E. groffii* Merr.)
- 4) Slenderbranch *Eurya* (*E. loguiana* Dunn)
- 5) Winged *Eurya* (*E. alata* Kobuski)
- 6) Chinese *Eurya* (*E. chinensis* R. Br)
- 7) Down branched *Eurya* (*E. hebeclados* L.K. Ling)
- 8) Shining *Eurya* (*E. nitida* Korthals)
- 9) Largehairy fruit *Eurya* (*E. megatrichocarpa* H. T. Chang)

V. The values of *Eurya* for beekeeping: *Eurya* secretes a great amount of nectar and there is no conspicuous variation in the secretion of nectar from year to year. The flowers of *Eurya* have sufficient pollen and they are very favourable for the reproduction of a bee colony whether in winter or in early spring. Usually, 10–20 kg honey can be produced by one hive of bees; sometimes more than 40 kg honey can be produced by the high-yielding bees. *Eurya* honey is very good high-grade honey and it may be rated as the best in China. The concentration of this honey is heavy and it is nearly colourless and transparent, or light amber. It does not granulate readily. It has the scent of wild osmanthus. The chemical compositions of *Eurya* honey are as follows through analysis.

- 1) moisture 24.33 per cent
- 2) levulose 36.03 per cent
- 3) glucose 34.4 per cent
- 4) sucrose 0.50 per cent
- 5) pH 3.96
- 6) amylum 8.8 per cent

7) vitamin B₁ 0.0319 mg/100g, vitamin B₂, 0.011 mg/100g

8) protein 0.09 per cent

9) amino acids (mg/100g):

aspartate	15	threonine	3
serine	3	glutamic acid	9
proline	9	glycine	9
alanine	4	valine	5
methionine	2	isoleucine	4
leucine	6	tyrosine	1
phenylalanine	3	lysine	5
histidine	2	arginine	2

10) minerals (ppm)

Al	0.1792	Ba	0.3827	Ca	0.0521
Cu	0.3036	Bi	0.1515	Mg	0.4547
Mn	1.2237				

The pollen of *Eurya* is greyish and occur in great abundance. During the winter, the Chinese honeybees not only collect large amounts of nectar, but the population of the colony also expands rapidly. The same applies to the Italian bees in early winter when the weather is relatively warmer.

In order to produce more honey, in the course of investigation on nectar plants of *Eurya*, besides the investigations on quantity, distribution, and secretion of nectar etc., the investigation on the species of *Eurya* should be done as well, because, as already explained, the flowering seasons are different for various species of *Eurya*. Migratory beekeeping can then be correctly timed. Generally, there are many types of *Eurya* in an area and are grown both on distant and close mountains. So **appropriate migratory beekeeping** in an area, based on the flowering and nectareous condition of *Eurya*, can optimally utilize the local resources and produce good honey.

There are also many species of spring *Eurya*, but their economic value is not as good as that of winter *Eurya*, because the colonies are weak that they cannot collect good nectar in spring. However, they are very good for the expansion of colonies in early spring.

VI. Protection of nectar plants of *Eurya*: The nectar plants of *Eurya* are scattered over the vast area of south China. They have important economic significance in production of honey, although they are not very useful in other aspects. Just as other economic forests, they are a valuable resource in China. Of course, only through the special method, i.e. beekeeping, these valuable resources can be utilized and become an endless wealth. Many colonies of Chinese bee are raised in south China and tremendous quantities of high-quality

honey can be produced every year, both for export and for the domestic market. Unfortunately, sufficient importance was not attached to this valuable resource by the people and the plants have been seriously destroyed in last ten years. Moreover, they have also been used as firewood by some people in many places. Therefore, the need to protect *Eurya* plants should be emphasized, making everybody aware of its economic value. Mixed cultivation of various species of *Eurya* can be done in areas where the conditions permit and these areas can be considered as bases of *Eurya* nectar plants, generating a high and stable yield of nectar.

11

Strategies for Apicultural Development in Nepal

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Apiculture development in Nepal is being hindered on several fronts. First, there are the problems caused by the native hive bee, *Apis cerana*. Compared to the European honeybee, *Apis mellifera*, it can be as difficult to get surplus honey production from the local *Apis cerana* as it is to get egg production from wild birds instead of domesticated chickens. However, variations in the biological and economic characteristics exist in *Apis cerana*, from larger, more populous colonies in the higher, cooler areas of Nepal, to the smaller, more swarm-inclined colonies in the hot terai. This indicates potential for genetic improvement. The key to success would be to identify the beneficial sub-species and races of *Apis cerana*, and increase their genetic improvement by selective breeding. Before such a breeding programme is launched, it is essential to develop techniques for successful queen rearing and mating, and possibly techniques for artificial queen rearing for this native bee species.

The undesirable traits, such as frequent absconding and swarming, in *Apis cerana* possibly emerged during the process of evolution. It could also be the result of harmful exploitation by human predation. Traditional honey hunting methods either killed most of the bees or left no honey stored behind in the nest for consumption by the bees during periods of scarcity. As a result of this and other forces, colonies which survived and propagated in nature, developed the trait of migrating/absconding to safer and better honey-flow pastures. Excessive

disturbance was also not tolerated by the bees.

Modern management practices with moveable-frame hives, which emphasize the collection of moderate honey harvests, in a timely manner and without harming the bees, may eventually reverse the trend which natural selection has encouraged. However, the hive bees of today in Nepal are extremely sensitive to disturbance and manipulation, and it will be many generations of selection for domesticable traits before honey production can be increased appreciably.

Another problem facing the apiculture industry in Nepal is that different agencies and institutions are competing with each other rather than helping each other even though their goals may be similar. For this reason a central research centre and clearing-house for dissemination of information about *Apis cerana* needs to be established, in which all available research results could be collected and to which all other agencies could turn for advice. Such a centre should publish a comprehensive manual on the management of *Apis cerana*. Very little is currently available in print, covering this subject in depth, compared to the volumes of material specific to *Apis mellifera*.

Modern Technology

In addition, various development and extension agencies in Nepal should revise their opinion about the wisdom of using the distribution of modern hives to farmers as an index for success in an apicultural development programme. It is rather the skill and knowledge of the beekeepers that are more important, and whether that skill and knowledge are applied in a timely manner. To assume that the hive itself will produce surplus honey without additional efforts is a wrong notion, and extension workers should remove it from the minds of beekeepers.

Following the traditional pattern of one or two hives belonging to each farmer or family is another mistake with modern technology for several reasons:

- 1) Not every beekeeper is going to show the patience and aptitude to shift from traditional techniques and adapt to the efficient use of modern frame hives. Thus a broad, scattered distribution of modern hives is more than just a waste of money, it is counterproductive as it results in several testimonials of failure, rather than a few good examples of success. If low-cost frame or top-bar hives can be made from mud and stone or mud and bamboo, for instance, the beekeepers with the correct aptitude can be identified at a greatly reduced initial investment. Such beekeepers can then be encouraged to expand their operation into modern hives where they can conduct a profitable small business.

2) For the efficient use of expensive, modern honey extracting and processing equipment, a larger number of hives is necessary in each operation. Better still, several large beekeepers should be encouraged to cooperatively pool their honey harvests, and to harvest smaller amounts of honey from each hive, but at more frequent intervals. This should help reduce the problem of absconding as mentioned earlier, discourage the tendency to revert to the old methods of comb squeezing when only a few frames of honey are available.

3) For the effective selection and propagation of better stock, beekeepers need to have larger apiaries from which to choose good producers, and in which to manage the time-consuming and colony-consuming job of queen rearing and mating.

Another advantage of modern technology hives is not being fully utilized in Nepal because of current limited transportation systems. Migrating hives to take advantage of various honey flows by putting the hives on trucks for movement to better pastures, cannot be done on a large scale. Any cost-benefit analysis of the use of modern hives should take this into account.

Some Problems and Proposed Solutions

In some of the villages in the mid-hills which I surveyed, the occupancy rate of all hives was extremely low, less than 50 per cent. The occupancy rate of modern hives in the same villages was even worse: zero per cent. The answer to why none of the modern hives was occupied may be because of the characteristic of *Apis cerana* to rely heavily on visual stimulation in the selection of a hive for occupancy. Comb transfers are being made into these modern hives, but when absconding occurs from all types of hives, swarms of returning bees invariably choose a log or wall hive over the unfamiliar modern wooden hive. Odour may also play a part in their selection of a replacement hive. Thus I encourage beekeepers to set out empty log hives to attract swarms, which can then be transferred into modern equipment.

Marketing of good quality honey in Nepal is another problem. The standards of hygiene expected by the type of consumer who would be willing to pay a good price for honey, and the standards of hygiene of most of the village farmers who produce and process honey for sale, are extremely different. Traditional comb squeezing technologies in the village result in a dirty product. Since in the past, most honey was meant for home use, marketing never became an issue, until recently. Even with modern extractors, however, rust, dirt, flies, grease used in lubricating moving parts of the extractor, bee brood or other bee body parts, pollen, wax, and one of the worst contaminants of all, water, are being left in or even added to the product that is being bottled for sale.

Beekeepers anxious for a harvest, may extract unripe honey as well. The result is a thin, fermented, unsanitary product with frequently a metallic taste. Containers of metal should be discouraged, as all but stainless steel will react with the acidity in honey. Honey processing techniques need to stress cleanliness, as well as the importance of keeping the honey as dry as possible.

Business ethics should be taught to all those involved in the processing and marketing of honey, so that connection can be realized between delivering a reliable quality product and continued consumer confidence. Short-term profits with no thought for the future will hamper the honey industry.

Women in Nepal have shown a strong interest in beekeeping, but very few women actually participate in the activity and many are shy about attending co-education training programmes. Beekeeping is an activity well-suited to women, and there is no evident social restriction or other reasons why women should not be encouraged to take training and become active beekeepers.

Training Strategies

In all trainings, for both men and women, emphasis should be laid on profitability and cost effectiveness. Procedures which make a significant economic difference should be clearly taught, such as the importance of timely bee population build-up or control in anticipation of and response to floral honey flows. A floral calendar should be developed for each village location.

Participants should be taught about the economic costs and risks of using pesticides on their fields, as well as using antibiotics and other medications on their bees. Sometimes these products can save money if a farmer is threatened with disaster, but frequently there is a perceived need for modern miracle cures when better management or simple hygiene improvements might be a wiser and more economical choice.

In the same way, the feeding of sugar syrup should be taught as a tool for management only, not as a regular, necessary input. If beekeepers rely heavily on expensive inputs, especially imported products, they are at the mercy of suppliers and thus at a much higher risk of failure in an already high risk activity.

Training in modern and intermediate technology of beekeeping should also emphasize the importance of moveable frames and combs. This means that all causes of immoveability must be eliminated, such as: frames fitting too tightly in the box; foundationless frames being given to the bees; comb transfers where the combs are not centred under the top bars because the beekeeper is hesitant to cut into the

comb for the insertion and proper centring of the frame wire. These are the most common mistakes and causes of failure with beekeepers who have completed trainings and tried to proceed on their own. If the combs are not straight and removeable, all advantages of modern hives are lost, and the beekeeper is left with a very expensive "log". If frames are too difficult to remove, the bees become agitated in the attempt, the beekeeper is stung frequently, and is consequently discouraged from continuing regular care and inspection of the hive. This is a downward spiral.

Beekeepers in all countries and cultures learn best by hands-on participation. This is especially true in Nepal. A classroom orientation, however, is usually the rule here, and field trips can sometimes be disappointing if the owner of the bees giving the demonstration is hesitant to have the bees handled and disturbed by strangers. Therefore, it is important that training should be at an active beekeeping site with a demonstration apiary of bees under the control of the trainer, several weeks before the training so that good examples of problems and processes can be set up in advance for hands-on work during the training sessions.

Conclusions

If serious consideration of these suggestions is not made and acted upon soon, the development of apiculture in Nepal will be too much slow. In that case it will require the importation of *Apis mellifera* into Nepal. The diseases which might be carried into the country are, for the most part, already here, and will be spread inevitably from neighbouring countries in any event since wild bees know no international boundaries.

Finally, it is disappointing that the emphasis on apiculture by agencies, funding such development work, is so low. Here is an activity and industry which directly and indirectly benefits agriculture and food production, does not contribute to deforestation, does not require terracing of fields or tilling of soil which might contribute to erosion, and which is taking advantage of an existing floral resource which would otherwise be wasted. The price of honey relative to other commodities in this economy is quite high, and the potential for making a significant contribution to the income and well-being of the farmers in this struggling mountainous country is very great. But the risks are also high if programme are not conducted wisely.

Therefore, if *Apis cerana* is to be maintained as the choice bee in Nepal, I recommend a strategy of genetic selection and improvement; establishment of a bee research centre and publication of a manual for the management of *Apis cerana*; encouragement of fewer beekeepers

who will establish larger, more profitable private enterprises; marketing schemes which emphasize high quality honey processing and sensible business ethics; and training programme which include women and which emphasize cost-effectiveness, timeliness of operations, the importance of moveable frames and hands-on training in a demonstration apiary setting.

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Salient Features of Beekeeping in Nepal

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General

Nepal is situated on the southern flank of the central Himalayan range between $80^{\circ}30'$ to $88^{\circ}12'$ eastern longitudes and $26^{\circ}20'$ to $30^{\circ}27'$ northern latitudes of the earth. It covers an area of 147181 sq km bound by India along the eastern, southern and western frontiers, and to the north by China.

Physically, Nepal may be divided into four broader zones:

- a) the southern Terai and inner Terai zone varying from 75 to 500 m asl with hot and humid subtropical climates;
- b) the mid-hills zone ranging from 500 to 4000 m asl having warm to cold temperate climates;
- c) the greater Himalaya above 4000 m asl with perennial snow covered mountains; and
- d) the Tibetan marginal land across the greater Himalaya with alpine type of climate.

Except for the greater Himalayan zone, the environments of other zones have favoured the existence of one or the other species of honeybees up to 3000 m altitude above sea level.

The rural people of Nepal have exploited bees for honey since time immemorial. Beekeeping has been an extra household activity for the rural farmers and is traditionally linked with crop farming and animal

husbandry. However, despite its long term adoption, it is still practised in the age old primitive fixed comb hives with which scientific management can not be integrated. The production is limited to 5 to 6 kg of honey per colony per year, as a national average. The pollination aspects of beekeeping is still little known to both the beekeepers and orchard-keepers. But ecologically, Nepal represents for greater potential for beekeeping activities. At places, the situation is so favourable that rural farmers are extracting as much as 20 to 25 kg of honey per colony per year even from the fixed comb hives. There is good scope for improvement and the government has laid greater emphasis for developing beekeeping as a worthwhile income-generating activity for the rural, small and marginal farmers comprising over 70 per cent of the country's farming population.

The Honeybees

The three popular Asian honeybees are commonly found in Nepal. These are, the little bee *Apis florea*, the rock bee *A. dorsata*, and the common Asian hive bee *A. cerana*. Besides, there is a fourth honey bee species *A. laboriosa* which is well established in the mountainous regions of Nepal.

Apis florea

The little bee is found in the tropical and subtropical habitat of the southern Terai, inner Terai, foothills and warmer river valleys up to altitudes of 1000 m asl. It has low range of production of 0.5 to 1 kg per colony per year. Its honey is liked intensively by the people and harvested by hunting methods. It is a very good pollinator in the warmer belts.

Apis dorsata

The rock bee also occupies the warmer habitats of the Terai, inner Terai, foothills and low-lying warmer river valleys. At times, the rock bee has been observed up to an altitude of 1350 m asl in Nepal. It is an erratic yielder and has been a regular professional pursuit of people living in the nearby forest areas. In the times when the Terai and inner Terai were densely forested, *A. dorsata* honey was a greater source of forest revenue. Even today, forest dwellers hunt for its honey and sell it in the nearby rural markets. A professional hunter manages to collect up to 30 kg of honey per colony per year.

Apis laboriosa

Recently, Sakagami, et al. (1980) described the giant rock bee found in the higher altitudes in Nepal as a separate species of the rock bee, quite different from the common rock bee of the lower belts. It inhabits the higher mountainous areas. This species has been observed to forage up to an altitude of 4000 m asl. The authors have reported the new bee as the little known largest honeybee of the world, *A. laboriosa*. It is similar to *A. dorsata* in its nesting habit, nest architecture and temperament but differs markedly in body size, body colour and nesting habitat. It is bigger in size and darker in colour than *A. dorsata*. Unlike the rock bee of the lower belts, this bee has existed exclusively in the colder and higher belts, of the country ascending to as high as 4000 m asl.

Apis cerana

The hive bee is the common and the only one well established in different agro-climatic belts of Nepal. Almost all the ecological belts inhabited by man up to elevations of 2300 m asl are known to have been occupied by *A. cerana* colonies. It is commonly found in the warmer belts of the Terai, inner Terai, foothills and low-lying river valleys going up to the chilly inner Himalayan valleys and the Tibetan marginal land across the greater Himalaya. This bee is kept and managed traditionally around human settlements and honey is drawn by squeezing the combs.

A. cerana is seen in Nepal in two distinct races or ecotypes. One is lighter in colour, smaller in size, less populous but mild in temperament. The other is darker in colour, bigger in size, more populous and relatively less mild in temperament. The former is common in the lower warmer belts whereas the latter is more prevalent in the higher mountainous belts of the country.

At times people have tried to introduce few colonies of the European hive bee, *Apis mellifera*, within Kathmandu valley, but with no success so far. The introduced colonies have not been able to compete with the local indigenous species and natural enemies such as *Varroa jacobsonii*.

Besides the above five species of *Apis*, there exists a stingless bee of the genus *Melipona*. This has occupied the same habitat as that of *A. florea* and *A. dorsata* in the lower warmer belt of the country. Farmers in the mid-hill river valleys of western Nepal have managed to keep the stingless bees in hollow logs. The logs occupied by the *Melipona* colonies are hung around living houses like the log hives of *Apis cerana*. The honey of the stingless bees is thinner in consistency

and acidic in taste. The yield level ranges from 2 to 3 kg per colony per year.

The Hives

Traditionally, the bees are kept either in *khope* hives or in *mud* hives. The *khope* hives are recesses in walls of houses. The recesses are planked and plastered with cowdung and mud paste from inside the house, while they opens to the outside with small round holes serving as bee entrance. Sensible farmers of the hills and mountains leave rectangular recesses while constructing their house with a belief that bee swarms will fly in sometime. The *mud* hives are made out of hollow logs. The open ends of the logs are planked and the entrance holes are made at suitable points. These *mud* hives are always hung around the outside walls of the living house. Both these traditional hives are left to self-occupation by swarms of bees or sometimes stray swarms are caught and put into them.

At places, it is commonly observed, that bees enter and make nest structures in containers such as abandoned almirahs, chests, boxes, mud pitchers and wicker baskets. All these containers along with *khope* and *mud* hives do not have uniformity in dimensions resulting in variations in inhabiting colony size and their production level.

During recent years, moveable comb hives are introduced from different sectors. These are intermediate top-bar hives and frame hives. Among top-bar hives there are two types. One is the trapezoidal top-bar hive which is a reduced or smaller version of the popular Kenya top-bar hive containing 20 top bars. It was introduced and distributed by the UNICEF financing scheme under the nutrition programme. The second is the top-bar log hive. This was tested recently with considerable success. While making the top-bar log hive the usual hollow logs are split open with a two-third lower part as a receptacle and a one-third upper part as the lid of the hive. The number of top bars varies depending on the length of the logs available. Frame hives currently used in Nepal are of different models and dimensions developed by different agencies. These models are Khopasi resembling Newton B of India, Birgunj, Godavari (Saubole, 1979), Gokarna and Lumle models. The Lumle model is similar to the Khopasi model but with horizontal extension for side supering. Out of these different moveable comb hives the Birgunj, Khopasi, and Lumle models and the trapezoidal top-bar type of hives are more in use. The Godavari and Gokarna models have limited use within the Kathmandu valley. The effectiveness of the trapezoidal top-bar hive at the present size has been questioned from different sectors (Speth et al., 1986).

The Bee Forage

Nepal is characterized by variations in altitude, topography, aspects of mountain slopes and weather elements within short distances both horizontally as well as vertically. These situations have developed smaller ecological pockets in which the plant communities are of diverse nature. Except in the plains of southern Terai and inner Terai, the plant communities in the hills and mountains change markedly within the foraging distances of the honeybees. Moreover, during recent years the composition of natural vegetation at all the agroclimatic belts has been extensively modified by man due to cutting trees for firewood, by lopping fodder to feed livestock and cleaning out forests for intensive farming. The land left uncultivated around the rural settlements is also heavily grazed and no surface vegetation has reached the flowering stage. However, during the last couple of years more awareness has developed towards the conservation of natural vegetation and the rural people have started planting trees around settlements, therefore, in the near future the situation will improve.

The vegetations have been closely observed in various places, from the point of view of beekeeping. Various cultivated as well as wild floral elements are known to provide a mixed type of bee forage (Kafle, 1979, 1984; Sharma and Kafle, 1981). The following are some of the forage elements contributing for beekeeping in the different agroclimatic belts: Among cultivated crop communities, *Nephelium litchi*, *Psidium guajava*, *Citrus* spp., *Mangifera indica*, *Moringa oleifera*, *Carica papaya*, various cucurbits, *Brassica* spp., *Raphanus sativus*, *Punica granatum*, *Guizotia abyssinica*, *Fagopyrum esculentum*, *Zea mays*, *Malus* sp., *Pyrus* sp., *Prunus* spp., *Abelmoschus esculentus*, etc., are some of common elements. Among ornamentals *Althea rosea*, *Malva rotundifolia*, *Ageratum conyzoides*, *Aster thomsonii*, *Centaurea cyanus*, *Cosmos sulphureus*, *Solidago longifolia*, *Lagerstroemia indica*, *Delonix regia*, *Tagetes patula*, etc., are eagerly visited by bees.

The *Bauhinia* spp., *Buddleia asiatica*, *Schefflera venulosa*, *Ilex excelsa*, *Prunus cerasoides*, *Brasseopsis* sp., *Madhuca latifolia*, *Leucaena leucocephala* are some of the fodder trees providing nectar and pollen to the bees. Similarly, *Trifolium repens*, and *Cynodon dactylon* are among the pastures on which honeybees are observed to forage.

Among wild communities, *Aesandra butyracea*, *Azadirachta indica*, *Albizia* spp., *Sapindus mukorossi*, *Syzygium cumini*, *Terminalia tomentosa*, *T. belerica*, *T. chebula*, *Salmalia malabarica*, *Shorea robusta*, *Fraxinus floribunda*, *Plectranthus rugosus*, *Colquehonia coccinea*, *Leucoscepterum cannum*, *Acer oblongum*, *Zizyphus incurva*, *Pyrus pashia*, *Eupatorium adenophorum*, *Innula cappa*, *Gentiana amoena*, etc. are important bee plants. Similarly *Rubus ellipticus*, *Berberis aris-*

tata, *B. asiatica*, *Mahonia nepalensis*, *Salix babylonica*, *Rosa cericia*, *Ricinus communis*, *Vitex negundo*, *Castanopsis indica*, *Colebrookia oppositifolia*, *Pogostemon* sp., are some other wild vegetations visited by bees.

Some of the plant species like *Rhododendron cinnabarinum*, *Atropa belladonna*, *Argimone mexicana*, *Papaver* sp., *Pieris formosa*, *Lyonis ovalifolia*, *Prinsepia utilis* are suspected to secrete intoxicating nectar and degrade the quality of honey. Out of these *Pieris formosa* and *Atropa belladonna* honey are recorded to be highly poisonous.

Bee Management

With traditional fixed comb hives there is almost no management being practised. The hives are opened to draw out honey combs during the traditionally habituated season and then closed again until the next harvest. Fresh colonies are started with stray swarms.

While hiving the swarms people generally clip the queen. During extraction the fixed combs are cut down along with the brood. The brood and honey parts are separated. The honey combs are pressed to squeeze out the honey. The brood combs are either given to the children or thrown away. Generally, extraction is done three times a year, once in March–April, the second in May–June, and the third in November. In the Terai and inner Terai, a winter harvest is also taken in late January.

With the introduction of movable comb hives some management has been practised. In such hives some beekeepers have started colony splitting for propagation. Sensible beekeepers have also taken to artificial feeding during dearth periods of dry summer and prolonged rains. People realized the significance of bee migration, in recent years. With the management point of view, beekeeping in Nepal should be divided into two categories with variations in both. One category will be applicable to the Terai and inner Terai and the next to the hills and mountains. In the Terai areas, bees suffer due to the severe dry and scarcity period during April to July, when the colonies need to be fed lavishly or be moved to more suitable areas. In the hills, the weather is not that extreme and honeybees remain in the hives throughout the year except for absconding due to disturbances.

Honey Types

Except for mustard and some selective cash crops such as cotton, jute, sugar cane and tobacco in the Terai and inner Terai, there does not exist any extensive monoculture of any crops in Nepal. Also, among wild vegetations the populations of bee forage elements are sparse and

mixed well within the foraging distance of the bees. Under such situations of sparse bee forage elements, it is not possible to find pure unifloral honey. Therefore classification of honey on the basis of plant sources is not possible. However, Nepalese honey may be classified on the basis of bee species, seasonal and geographical variations. Therefore, the honey of Nepal will be available in the following types:

- dorsata*, *floreana*, *cerana* and *laboriosa* honey;
- spring, summer, autumn and winter honey;
- Terai, hill and mountain honey.

A careful skilled beekeeper will be able to produce unifloral mustard honey in the Terai and the inner Terai region of the country during winter time. Otherwise, all types of honey produced in Nepal are of multifloral characteristics. Also, since in traditional practice all honey is squeezed honey and contains plant pollen.

Diseases of the Honeybees

Nepal did not know of any serious bee disease until 1980, when the serious outbreak of the sacbrood disease caused by the Thai sacbrood virus, occurred first along the eastern border areas. The disease spread so fast that within four years it covered the entire length of the country. By 1983, the disease was at its peak along the western border areas. It was so devastating, that almost 90 per cent of bee colonies were lost. By 1984, the disease started to subside and the bees started to regain normal condition again from the eastern border. At present the country is almost free from the disease.

Sporadic symptoms of irridiscent virus infestations are noticed at places. The Asian mite *Varroa jacobsonii* is long associated with *Apis cerana indica* but causes no serious problem as it has done in *Apis mellifera* everywhere in the world. Occasional visitors also have reported *Tropilealaps clareae* and *Neocypholealaps indica* to occur in Nepal.

Natural Enemies of Honeybees

Many harmful insects and higher animals are known to inflict severe losses to beekeeping in Nepal. Most troublesome among insects are the wasps, *Vespa mandarina magnifica*, *V. affinis* and *V. auraria* and the wax moths, *Galleria mellonella* and *Achroea grisella*. Sometimes *Bradymerus* sp. is also noticed to damage combs, specially uncovered ones. The death head moth, *Achrontia* sp. is known to cause desertion of the colony specially in the traditional hives. Several instances of colony losses are recorded due to a phorid fly, *Megaselia* sp. Various ants like *Camponotus* sp., *Dorylus* sp., and *Oecophyllus* sp. have become troublesome to bee colonies mainly in the traditional hives.

Pseudo-scorpion, *Chelifer* sp. is commonly seen clinging to the legs of the workers but their role in bee colonies is not clearly known. There are many higher animals like pine martens *Charonia flavigula* etc. causing big problem in the rural areas. Birds like *Merops orientalis* and *Dicrurus ater* are serious pests of honeybees.

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Apiculture in Bhutan: Problems and Prospects

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Introduction

Bhutan is situated in the lap of the Himalayan ranges. It lies between $26^{\circ}45'-28^{\circ}10'$ north latitude and $88^{\circ}45'-92^{\circ}10'$ east longitude. Altitudes range from 300 m to 7000 m above sea level. Four major rivers viz. Torsa (Am Mochhu), Raidak (Wang chhu) Sankosh (Mo chhu), and Goomari (Dangme chhu) constitute Bhutan's principal drainage system. The terrain and climate varies as one moves from south to north. The terrain can be divided into the following categories:

- **The Southern foothills:** This region has a subtropical mountain climate with an annual rainfall of 150 inches a year. Natural deciduous vegetation is most abundant in this region. Land is used for agriculture and horticulture. The climate is well suited to the growth of particularly citrus fruit, bananas and pineapple.
- **The Inner Himalaya:** This includes the central region of Bhutan and consists of higher mountains forming watersheds between rivers and narrow valleys. The climate of the valley is moderate at lower elevations but at higher elevations it becomes extremely cold. The annual rainfall is moderate and the region possesses an abundance of forest wealth. It has several fertile valleys such as Thimphu, Paro, and Punakha. Rice, wheat,

maize, and other crops are cultivated extensively in the rich alluvial soil which is also suitable for horticulture.

- **The Great Himalaya:** The lofty ranges of the northern region are snow covered and barren.

In Bhutan, the lower valleys and high hill areas with a moderate climate are the most suitable for agriculture, horticulture, and apiculture. Bhutan is the richest country in the world from the bee resource point of view. There are at present five different species of honeybee in Bhutan. Among them *Apis cerana*, *Apis laboriosa*, *Apis dorsata*, and *Apis florea* are native, whereas a European honeybee, *Apis mellifera*, was introduced in recent years by Mr. Fritz Maurer, in order to increase honey production in the Bumthang and Phuntsholing areas. It is only the native, *Apis cerana*, and the exotic, *Apis mellifera*, that can be domesticated, and the other three species occur in a wild state. The native, *Apis cerana*, is generally kept in primitive traditional hives by farmers in southern Bhutan.

A successful apiculture industry needs rich bee resources and large areas under pollen and nectar-yielding plants, so that the bees can produce surplus honey and other valuable hive products. Bhutan is the only country in the Hindu Kush-Himalayan region that has more than 70 per cent of the total land area covered by virgin forest and other natural vegetation. Several natural plant species are of great value from the beekeeping point of view.

Despite the rich and diversified bee and floral resources, apiculture in Bhutan is still a primitive household activity. It is mainly practised by the rural communities in the southern parts of Bhutan. In northern Bhutan, harvesting honey is considered sinful. Such religious beliefs have a sound scientific base and have helped to conserve the different species of honeybee in Bhutan. Some of these species are on the verge of extinction in other parts of the Hindu Kush-Himalaya due to harmful exploitation.

With the introduction of modern bee management technology and the use of **movable-frame hives**, such religious beliefs are changing gradually. It is now possible to harvest honey without causing any harm to the bees and leave enough of it in the combs as food for the brood and adult bees. Modern apiculture ensures the protection of bees from all kinds of natural catastrophe.

Modern Apiculture in Bhutan and Reasons for Its Failure in the Past

In the past, attempts were made to introduce modern apiculture methods in Bhutan with the native *Apis cerana* in movable-frame hives. An apicultural development officer was appointed and apiculture equip-

ment was procured from the Khadi and Village Industries Commission, Government of India. Efforts were made to start apiaries in Samchi, Geylegphug, and Paro, as well as other parts of Bhutan, but all of them ended in failure. The result was that the agricultural department abolished the post of apiculture development officer and the apicultural project was closed down. This raises an important issue regarding the causes of these failures. Unfortunately, no official records of the past apicultural projects are now available. After a great deal of discussion with the officials of the agricultural department, the following conclusions were drawn.

In the past, special difficulties were experienced in promoting and developing apiculture in different parts of Bhutan. Such difficulties did not lie in the lack of bee resources, bee flora, severe cold temperate climate, or high altitude effects. The major reasons for failure were certain drawbacks in the human environment and these can be summed up as follows:

- Inaccessibility due to broken terrain and inadequate transport facilities
- Lack of education and skilled manpower
- Lack of apicultural traditions in northern Bhutan
- Poor knowledge about bee and flora resources
- Lack of measures to overcome calamities such as bee diseases, predators, and pests
- Lack of communication with the scientific world.

However, in recent years the socio-economic conditions of the people of Bhutan have changed for the better, and there are now greater chances of developing a successful apicultural programme in Bhutan.

Present Status of Apiculture in Bhutan

a) Number and Yield of Colonies

- | | |
|--|---|
| i) Number of beekeepers who gather honey by hunting and traditional methods | : About 60 per cent of the farmers in southern Bhutan |
| ii) Number of colonies maintained by Government and non-Government Organizations | : 45 colonies of <i>Apis mellifera</i> in Bumthang. |
| | 50 colonies of <i>Apis cerana</i> in southern Bhutan |

* Such a low number of *Apis cerana* colonies may be due to the incidence of Thai sacbrood virus disease.

- iii) Number of colonies owned by private beekeepers : 50 colonies of *Apis cerana*
- iv) Name of the districts where apiculture is not practised :

Thimphu	Mongor
Ila	Tshigang
Chuk	
Paro	
Wangdipholtran	
Gasa	
Tongsa	
Lhunsi	
- v) Reasons for the non-existence of apiculture in the above districts : All these districts are rich in bee flora. However, because there has been no previous tradition in this field, beekeeping is not practised.
- vi) Periods of honey flora : April–May—northern Bhutan
October–November—southern Bhutan
- vii) Honey yield : 3 kg/colony from *A. cerana*
30 kg/colony from *A. mellifera*
- viii) Beeswax : It is the property of the forestry department and special permission is required from this.

b) Colony Management

- i) Types of hives : Traditional log hives and movable-frame hives.
- ii) Position of hives : Movable-frame hives are kept on the ground. Traditional log hives are either suspended under the roof or kept on the ground.
- iii) Construction of the hive : Modern rectangular shape movable-frame hives are made of blue pine wood in

Bumthang. The traditional log hives of southern Bhutan are made of oak wood.

- iv) Skill of beekeepers : The number of beekeepers following modern methods of apiculture is negligible.
- v) Beekeepers' knowledge : Limited
- vi) Expectation of beekeepers from technical aid programme : Loans or subsidies for the purchase of apicultural equipment and supplies.

c) Apicultural equipment

- i) Sources of equipment : Local dealers in Bumthang.
- ii) Woodwork skills in villages : Skilled and efficient craftsmen for woodwork and metal work are available.
- iii) Equipment to be imported : All major equipment is available in Bumthang.

d) Bee Resources

- i) Species of honeybee : Five species of the genus *Apis* i.e. *A. cerana*, *A. florea*, *A. dorsata*, and *A. laboriosa* are native to this region, whereas *A. mellifera* was introduced in Bumthang in 1986 and in Phuntsholing in 1987.
- ii) Size of bees : The domestic *Apis cerana* is smaller in size than the *Apis mellifera*. Further, the *Apis cerana* of northern Bhutan is bigger than those found in southern Bhutan.
- iii) Aggressiveness : *Apis cerana* is comparable to *Apis mellifera*.

- iv) Cleanliness : *Apis cerana* is better than *Apis mellifera*.
- v) Peak brood activity : March to July.
- vi) Swarming season : February to March in southern Bhutan.
July–August in northern Bhutan.
- vii) Rate of absconding : *Apis mellifera* do not abscond; the rate is 50 to 100 per cent in *Apis cerana*.

e) Hazards for colonies

- i) Theft of colonies : None.
- ii) Predators : Bears and wasps are serious predators.
- iii) Diseases : *Apis cerana* no information available;
for *Apis mellifera*,
i) Acarine mite.
ii) *Tropilaelaps* mite.
iii) European foul brood.

f) Honey marker situation

- i) Consumers of honey : Local people and tourists.
- ii) Price of honey : Nu 50/kg*
- iii) Trading System : Non-existent.
- iv) Availability of honey : Scarce.
- v) Consumer demand versus local supply : Demand is much greater than supply.
- vi) Imported Honey : Honey of Indian origin available.
- vii) Honey containers : Used glass bottles only.

* 16.50 Nu = One US Dollar

g) Training Facilities

- | | |
|---------------------------------|--|
| i) Apiculture instructors | : Nil. |
| ii) Courses | : One Bhutanese national is presently receiving apicultural training in Canada. |
| iii) Demonstration apiaries | : One of <i>A. mellifera</i> in Bumthang. |
| iv) Apiculture training courses | : Efforts are being made to start a "train the beginner course" by Mr. Fritz Maurer in Bumthang and by Mr. Gordon Temple in Pema Gytschel. |

Linkages of Apiculture to Agriculture, Horticulture, and Animal Husbandry in Bhutan

The developing countries of the Hindu Kush-Himalayan region have either achieved, or are trying to achieve, self-sufficiency in food production by physical expansion of resources in terms of more and better seeds, fertilizers, and pesticides, or more cultivated land. This situation has reached saturation point and the productivity levels of certain crops are now increasing beyond those achieved around the middle of the twentieth century. The major emphasis in the future should, therefore, be on the full utilization of those resources that are under-exploited. One such resource is increase in the yield of different cultivated crops through honeybee pollination. Apiculture thus forms an integral component of different farming systems such as agriculture, horticulture, and animal husbandry. It has estimated that the value of honeybees as pollinators of different agricultural, horticultural, and fodder crops is 10 to 20 times more than their value as honey producers. Evidence of this lies in the fact that half of the world's diet of fats and oils comes from oilseed crops, and these are directly dependent upon honeybees for cross-pollination. Apiculture can play a significant role in increasing the yields realized from animal husbandry. Fodder is derived, either directly or indirectly, from crops such as clover, alfalfa, and trefoil and these are all species that are pollinated by the honeybees. Many honeybee-pollinated legume plants enrich the soil through their use of atmospheric nitrogen. Several commercial varieties of fruits, vegetables, and nuts are self-incompatible and require cross-pollination. Honeybees are most efficient in this respect.

The following table lists major cultivated plants that are dependent upon, or beneficiaries of, honeybee pollination in Bhutan:

— Cereals	:	Buckwheat.
— Oil crops	:	Mustard.
— Fruits	:	Apple, peach, pear, plum, apricot, sweetcherry, and chestnut (in temperate Bhutan).
— Spices	:	Cardamom.
— Vegetables	:	Cabbage, cauliflower, radish, carrot, turnip etc.
— Pulses	:	Soybean, kidney bean, cowpea etc.
— Timber trees and other natural vegetation.		

Honeybees and the Pollination Ecology of Horticultural Crops in Bhutan

Apples, oranges, and cardamom are the major horticultural crops grown in Bhutan. Of the total of 18,000 hectares of land under fruit cultivation, about 2000, 8000, and 6000 hectares are under apple, citrus, and cardamom cultivation respectively. With such a large annual increase in the area under fruit and cardamom cultivation, some management problems will inevitably arise and among these cross-pollination may become a serious one.

In general, apples are self-incompatible and require cross-pollination by bees. This applies to the most tasty and valuable varieties of apple (such as Royal and Red Delicious) grown in this country. It is now well-documented that no fruit set occurs at all in the commercial varieties (such as Red Delicious and Royal Delicious) in the absence of insect pollinators. Wind does not play any role in the cross-pollination of apple bloom due to the heavy, sticky nature of apple pollen. Other insect pollinators are not found in sufficient number at the time of apple bloom because of the low temperatures. The most effective way of assuring adequate pollination is by introducing honeybee colonies into the orchard at the time of blossoming, a practice adopted and developed in Canada, Western Europe, Eastern Europe, Japan, and northern India (Himachal Pradesh and Kashmir valley.)

Research on apple pollination conducted in northern India (Himachal Pradesh and Kashmir valley), as well as in other parts of the world, clearly indicate that cross-pollination by honeybees increases fruit set and reduces fruit drop by 20 to 30 per cent. Similarly, the size and yield of the apples subjected to honeybee pollination increases by

30 to 40 per cent. There is also remarkable improvement in the quality of the apples in terms of shape, aroma, and flavour.

Orange, lemon, and lime are the main citrus fruits cultivated in Bhutan and these are an excellent source of pollen and nectar for honeybees. Citrus-flavoured honey is considered to be of good quality. During the last few decades, honeybee pollination has been found to be beneficial in the production of fruit crops. Many citrus cultivars are self-incompatible and the pollination requirements of different kinds of citrus plants are quite diverse. In some species, there is almost complete self-sterility and pollen transfer from another compatible type is essential for fruit production. In others, it is beneficial for the plant if pollen is transferred from flower to flower within the cultivar or within the species. A general recommendation of one to two bee hives/ha has been made for citrus crops.

Cardamom, one of the world's costliest seed spices, is also a cross-fertilized crop and depends exclusively upon honeybees for pollination. The yield and seed quality data for honeybee pollination in India is as follows:

The total harvest is 35 to 45 per cent more in bee pollinated than in control plots. Recovery percentage of dry capsules is also significantly higher in plants cross-pollinated by bees. Bee pollination gave 66 per cent fruit set (control 11 per cent) and increased the number of seed pods per panicle from 2.1 to 27.4.

The number of bee visits is found to be directly proportional to the capsule set percentage. The capsule set in all cultivars is meagre when flowers are not visited by bees. Bee pollination not only increases the yield but also improves the quality of capsules. In the case of cardamoms this is important in view of the current competition in the international market.

These examples indicate that, in Bhutan, efficient pollination to the required degree will assist in realizing the maximum yield from important fruit crops. Most orchards in Bhutan are small (about one hectare or less) and are owned by local farmers. Each orchard requires about three to five hives of bees (an educated guess), and a conservative estimate of the number of hives needed to pollinate horticultural crops at present, is about 50,000.

Currently, there are about 50 colonies of *Apis cerana* and 45 colonies of *Apis mellifera*, and these are kept in modern hives by a few farmers. One of the major problems is that the proposed large-scale expansion of the horticultural industry does not envisage a corresponding increase in the number of appropriately managed hives. It is not surprising that many orchards do not bear sufficient fruit because the population of pollinators available for pollination work is too small. Moreover, the increase in the use of pesticides in horticulture

has resulted in an alarming decrease in the population of beneficial insects. This means that domesticated hive bees (*Apis cerana* and *Apis mellifera*) are essential for pollination and apiculture is an essential part of fruit pollination.

A large horticultural undertaking, as envisaged by the Royal Government of Bhutan, will not be successful without the development of scientific apiculture. The problems that exist, can be addressed and overcome, and much progress can be made through the action plan outlined in this proposal. Moreover, the wealth contributed by apiculture, as a cottage industry, could run into several millions of Nu, when calculated on the basis of cash realized from honey production and the benefits of pollination. There is no doubt that the rational development of apiculture could make a magnificent contribution. In addition, as a cottage industry, it can be used to improve the economic circumstances of small marginal farmers, or of landless labourers living at, or below, subsistence level.

Action Plan/Strategies for Apicultural Development in Bhutan

For the development of apiculture on sound scientific lines, the following action plans or strategies are suggested. Before starting a pilot project, some basic information, as outlined below, is required on different practical aspects of apiculture in order to make it attractive as an income-generating activity to the rural communities of this country.

Survey of Bee Resources and Zonation of Apicultural Areas

The European honeybee, *Apis mellifera ligustica* (Italian race), was introduced into the Bumthang and Phuntsholing areas of Bhutan by Mr. Fritz Maurer in 1986. The very first consignment of imported bees was affected with *Acarine* diseases, parasitic *Tropilaelaps clareae* mite, and European foul brood. The first two diseases occur also in the native, *Apis cerana* but European foul brood (a bacterial epidemic) was not known of on this continent. Nevertheless, these *Apis mellifera* colonies are surviving and in Bumthang their number is 32. According to Mr. Maurer, the average honey yield per colony is 30 kg/annum. However, diseases of the exotic, *Apis mellifera*, can easily spread to the native bee species and vice-versa. This may become a serious problem and, therefore, requires immediate attention. With this in mind, it would be wise to make a survey of the native bee species as follows:

- Identify the principal habitats of the native, *Apis cerana*, and ascertain whether beekeeping is practised or is possible. In such areas, apiculture with *Apis mellifera* should not be encouraged.

- There are certain races/ecotypes of *Apis cerana* which are less prone to absconding, swarming, and robbing, and among such races the average honey yield per colony is 15 kg/annum, making apiculture a commercially attractive proposition. Such races/ecotypes of the native, *Apis cerana*, occur in Nepal and parts of northwest India (Himachal Pradesh and the Kashmir valley). Such races/ecotypes may occur in Bhutan also and surveys should be conducted to identify these for the purpose of commercial honey production.
- Besides the exposure to diseases, as mentioned above, keeping the native, *Apis cerana*, and the exotic, *Apis mellifera*, together creates serious problems of interspecific robbing, unsuccessful mating flights (due to mating competition), and competition for flora etc. Keeping this in mind, the specific ecological zones for *Apis cerana* and *Apis mellifera* should be identified.
- In addition to the domestic, *Apis cerana*, and *Apis mellifera*, the largest known social honeybee, *Apis laboriosa*, is found in Bhutan. This species cannot be domesticated. In winter it migrates to the sub-tropical region of southern Bhutan and returns to the temperate northern region in summer. In the southern foothills, professional honey hunters use very crude methods to harvest honey and beeswax from this species and eventually this may lead to its extinction. In order to save this species, modern apiculture with movable-frame hives should be promoted in the southern areas of the country.

Survey of Honey Plant Resources and Preparation of Floral Calendars

One of the strongest arguments in favour of developing apiculture in Bhutan is the abundance of rich and diverse bee flora, in comparison to other areas of the Hindu Kush-Himalaya. At present, this country has the maximum per capita forest area (2.37 ha) and also the second largest total area under forests in the world. With such richness and diversity Bhutan could become a veritable land of honey. The current policies of the Royal Government of Bhutan for the preservation of forests and mountain areas ensure that tremendous potential for the development of apiculture exists.

The existing information on Bhutanese flora indicates the presence of hundreds of pollen and nectar-yielding species. These include both natural forest and cultivated trees, bushes, shrubs, temperate fruits, vegetables and agricultural crops. There is a need for more information so that floral calendars can be prepared in order to develop the

apicultural industry along scientific lines. The following information should be compiled:

- Taxonomic status of honey plants.
- Honey potentials of major, medium, and minor sources of pollen and/or nectar.
- Flowering periods.
- Temperate, sub-temperate, or sub-tropical distribution
- Wild or cultivated.
- Alternative economic uses of honey plants.
- Area covered by each species in the various apicultural regions.

Management of Bee Colonies for Pollination of Horticultural Crops

The Royal Government of Bhutan plans to increase the cultivation of apples and other temperate fruits. Such an expansion of the horticultural industry would require a corresponding increase in pollination resources and technology. This can be achieved through appropriately managed bee hives. Horticulturists in the Hindu Kush-Himalayan region are fully aware of horticultural management practices such as use of fertilizers, pesticides, irrigation, pruning, etc. to achieve maximum fruit yield. However, bee pollination has not yet been included as an integral part of orchard management technology, except in Himachal Pradesh. A recent FAO report states "In view of the importance of honeybees for increasing the yield of cross-pollinated crops, different species of honeybees are being utilized for this purpose in northern India. Himachal Pradesh has taken the lead in renting *A. cerana* and *A. mellifera* colonies to the orchardists for the pollination of apple crops. This programme has helped to create awareness amongst the orchard owners of the importance of honeybee for pollination."

The time is ripe for Bhutan to follow the example of Himachal Pradesh and start a pilot project on bee pollination in the existing horticultural research stations. One would venture to suggest that the project to be run in Yushipang for apples, in Santalakha for cardamoms, and in Geylephug for citrus fruits along the following lines:

- The number of hives needed per hectare of orchard.
- The best placing and management of hives for maximum pollination.
- The effect of pesticides on bees in the pollination season.
- The diversity and abundance of pollinators other than the domestic species of honeybee.

- The problems of alternative foods for hived bees in the non-blooming period e.g. other nectar plants, supplementary feeding, or migratory apiculture (see also next section).

Migratory Apiculture

In a temperate country like Bhutan, most areas may not be able to provide bee flora throughout the year. Under these circumstances, beekeepers have two choices, i.e. either to feed the colonies with sugar syrup or move them to other areas where bee flora are available. Beekeepers in other parts of the Hindu Kush-Himalaya prefer the latter, because they can harvest more than two crops of honey in a year. In addition, full strength colonies are necessary for the optimum pollination of temperate fruit crops such as apples, and this is only possible if these colonies are moved to the sub-tropical regions at the onset of winter. In these regions sufficient bee flora are available and colonies can build up their strength during February and March. At the onset of the spring season, these colonies are then moved to the temperate regions. The transportation costs involved in the practice of migratory apiculture is duly compensated in terms of pollination services and surplus honey yields. In Himachal Pradesh (northern India) experiments on migratory beekeeping have been very successful for apple pollination. Initially, this programme should be undertaken by the Royal Government of Bhutan. Later, when fruit farmers and beekeepers realize its usefulness, they will adopt it into practice, as has been shown in other areas of the Hindu Kush-Himalayan region such as Himachal Pradesh in northern India and the North West Frontier Province in Pakistan. The distances involved in migratory practice in Bhutan will not exceed 200 km and the technical skills required are readily available. However, successful migratory apiculture needs a proper migratory schedule and information concerning seasonal bee flora.

Establishment of Extension/Demonstration Apiaries

At present Mr. Fritz Maurer is establishing an extension/demonstration apiary in Bumthang which contains about 35 *Apis mellifera* colonies. Mr. Maurer (an experienced bee-keeper) also runs training programmes for beginners and some of these trainees have been given bee colonies. Mr. Maurer states that, apart from a good income from the sale of honey, the yield of certain horticultural and agricultural crops has also improved because of honeybee cross-pollination.

Based on these promising results, it is recommended that the Government should open another extension/demonstration apiary, at Yushipang, on an experimental basis. Local sources indicate that there

are no native, *Apis cerana*, bees in the Thimphu area, so this apiary should be started with European honeybees. Besides meeting the honey demands of Thimphu city, which is now becoming an attractive tourist destination, this apiary will also act as a model for pollination technology for fruit farmers, as outlined earlier in this paper. This apiary should be migratory in nature, as detailed in this report. The migratory route to be followed could be Thimphu/Yushipang/Santalakha/Phuntsholing. At the same time, the possibility of starting a pilot project on apiculture with the native, *Apis cerana*, species at Samchi or Geylegphug should be explored.

These extension/demonstration apiaries should work on the following lines:

- Multiplication of honeybee colonies by raising pedigree queens of good quality.
- To develop or modify appropriate bee management practices to suit the local conditions.
- To monitor different pests, predators, and diseases of honeybees and to suggest measures for their prevention and control.

Apicultural Training Programmes

One of the major reasons for the failure of programmes in the past has been the lack of local trained, or skilled manpower. Training involves both the beginner and the trainer. At present, Mr. Fritz Maurer in Bumthang and Mr. Gordon Temple in Pema Gatshel are trying to start "Train the beginner" programmes. Soon they will be joined by a Bhutanese national who has received training in Canada. Although for a small country, such as Bhutan, two or three instructors may be enough initially, they will not be able to provide follow-up and technical advice. Supervision is needed constantly for a period of about a year until a new beekeeper can operate independently. Keeping in mind the difficult terrain, and the problem of inaccessibility, more trained extension workers will be needed for the successful implementation of the programme. This cadre of trained extension workers can be created either by the services of an outside expert or by sending more personnel abroad for training.

Assessment of the Honey Market

In several SAARC and ASEAN countries, the introduction of the European honeybee, *Apis mellifera*, has revolutionized the apiculture industry by producing surplus quantities of honey for which there is no well-developed market. Himachal Pradesh and the Punjab in northern

India, the North West Frontier Province in Pakistan, and the Chiang Mai area in Thailand are examples of this. In the coming years, this may also happen in Bhutan, once the industry is well established. Assessment of the marketing situation is, therefore, of primary importance and of a necessary survey on the following lines needs to be undertaken:

- Consumers of honey.
- Trading system to be followed.
- Availability of honey in the towns.
- Consumer demand versus local supply.
- Honey import and export situation.
- Honey processing, grading, and packing facilities.

The Bhutan Fruit Processing Industry at Samchi is the ideal agency for processing and marketing honey, because it is already providing the same service for fruit products in Bhutan.

Economics and Profitability of Apiculture in Bhutan

Before apiculture is introduced on a mass scale in Bhutan, it is important to assess whether, as a cottage industry, it is commercially viable or not. Economic analyses have already been carried out in northern India, Nepal, and the North West Frontier Province of Pakistan, and reveal that it is an attractive and profitable activity both with native, *Apis cerana*, as well as exotic *Apis mellifera*, species. Such an analysis should be carried out in Bhutan on the following lines:

- Cost and return per colony.
- Cash-flow projections of honey production, starting with two colonies in the first year and increasing to 10 colonies in the fifth year, at the rate of two colonies per year.
- Sensitivity analysis by reducing the returns by 50 per cent and maintaining the cost at the same level.

Manual for Practical Apiculture

For the beginner, a manual in practical apiculture is necessary, as this will provide the necessary information about different management practices. Because of the problems of inaccessibility, it may not be easy for a beginner to seek the advice of extension workers or instructors immediately, particularly if there are natural calamities such as diseases in the bee colonies. Under such circumstances, a practical manual should prove of great help. There are several such manuals published in the economically advanced countries. However, western

bee management technology is not so easily applicable to our local conditions, because of different ecological and socio-economic conditions. Such a manual should be published in English as well as in local languages and should include the following:

- Introductory bee biology.
- Bee flora.
- Bee management practices such as hive management, supplementary feeding, swarm control, migratory apiculture, requeening of colonies, queen rearing, and bee diseases.
- Extraction, processing, storage, and marketing of honey.

Apicultural Section in the Agricultural Department

At present, apiculture does not figure anywhere in the official agriculture, forestry, or integrated rural development programmes being run by the Royal Government of Bhutan. Keeping in mind the vast scope and potential of apiculture, as already outlined, it is recommended that a small unit or section on apiculture be created in the Agricultural Department and that an apicultural research and development officer be appointed. The main responsibilities of this section should be as follows:

- To act as the core agency for promoting, fostering, and establishing an apicultural industry in Bhutan.
- To initiate pilot projects in apiculture as outlined in this report.
- To provide apicultural and honey extracting equipment at subsidized rates.
- To prepare and distribute extension literature for the popularization of apiculture amongst rural communities.

Role of ICIMOD in the Apicultural Development Programme

Apiculture fits into the policies and programmes of ICIMOD, in relation to sustainable mountain development. Therefore, it is recommended that it should help the Royal Government of Bhutan in the apicultural development programme as outlined.

Acknowledgements

I wish to express my sincere thanks to Dasho Khandu Wangchuck, Director General of Agriculture, the Royal Government of Bhutan, for inviting me to prepare this report. I derived much benefit from various discussions with Mr. Fritz Maurer, an experienced beekeeper

from Bumthang. I am indebted to a number of officials in the Agricultural Department of the Royal Government of Bhutan, particularly Mr. J.D. Awasthi, Mr. D.B. Rai, Mr. R. Dorji and Mr. B.S. Padda.

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Scope and Strategies for Apicultural Development in Himachal Pradesh

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Introduction

Apiculture is a scientific method of observation and rearing bees for the production of important hive products such as honey, beeswax, royal jelly, bee venom and propolis, and for the pollination of crop plants (Fries, 1981). Beekeeping can play an important role in the development of hilly areas as it increases earnings without changing the environmental balance. As a cottage industry, it is an important income-generating activity for the rural people of the hills.

Beekeeping in Himachal Pradesh has a long historical background. Although this state is not a comparatively large producer of honey, yet it has been noted countrywide for the quality of the honey produced. Honey collected by crude and modern methods is used as food and medicine. In Himachal Pradesh, both traditional and modern methods of beekeeping are in vogue. Modern beekeeping in India has its origin in Himachal Pradesh (Verma, 1988a, b).

Modern beekeeping in Himachal Pradesh was started by Sir Louis Dore (1908), who for the first time kept Indian hive bee, *Apis cerana* F. (modern hives in the Kullu valley (Verma, 1988a). Since then this species has been domesticated for commercial honey production and pollination services. As a result of this, today we have a progressive

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beekeeping industry and great efforts are being made in modernizing it.

Himachal Pradesh is mainly a hilly state lying in the lap of the northwest Himalaya between $30^{\circ}-22'$ to $33^{\circ}-12'N$ latitude and $75^{\circ}-45'$ to $79^{\circ}-04'E$ longitude with altitudes ranging from 350 to 6500 metres above msl. Five major rivers, Yamuna, Sutlej, Beas, Ravi and Chenab, drain water from this state. Average rainfall in the state stands at 1051 mm although it varies from a minimum of 515 mm at Lahul and Spiti to a maximum of 4400 mm at Dharamshala. The temperature in the state varies according to elevation. From the end of February, mercury rises gradually till June, which is generally the hottest month in the region. With the onset of the monsoon there is a gradual fall in temperature. When the monsoon ends by middle of September, temperature falls gradually at first and fairly rapidly after November (Anonymous, 1989).

Himachal Pradesh can be divided into four major agriculture zones; sub-tropical comprising valleys and low-lying hills with an altitude ranging from 350 to 1000 metres; sub-temperate comprising mid-hills and altitudes varies from 1000 to 1500 metres; temperate high hill zone comprising high hills and interior valleys with altitude ranging from 1500 to 3000 metres and cold and dry zone lying between 3000 and 3700 metres above msl. Beekeeping is widespread with several potential honey-producing areas in first three zones and also some in a few warm pockets in cold and dry-zone.

The Present Status of Apiculture in Himachal Pradesh

Beekeeping is a part of the cultural heritage of the Himachali people. Except in a few desolate and uninhabited areas, there is no place where beekeeping or honey hunting is not practised. The art of traditional beekeeping in Himachal Pradesh is very old. For centuries, the rural people in the state have collected honey from the nests of three native species of honeybees. Use of honey as a favourite dish and as medicine is well known among the hilly people since ages. Traditionally, *Apis cerana* is reared in native hives. Indigenous beekeeping with this native species is practised either in fixed wall hives or movable simple hives (Verma, 1988a, b). Beekeepers make their own traditional hives from materials locally available, such as tree trunks, bark, grass, and stems of climbing plants.

At present, modern beekeeping in Himachal Pradesh is practised with native *Apis cerana* F. and exotic *Apis mellifera* L. (Atwal, 1987; Mattu and Verma, 1979; 1980). Both these species differ in several behavioural characteristics and keeping in view these differences, the modern hives presently in use are wooden movable-frame hives (com-

monly called ISI villager's hives) adapted to the size of *A. cerana* of Himachal Pradesh. European bees are kept in standard Longstroth ten frame hives (Atwal, 1987; Verma, 1984).

Beekeeping Potentials of Himachal Pradesh

Himachal Pradesh offers very rich potentiality for the development of beekeeping because of vast areas under horticulture, agriculture and forests. It is estimated that more than 78 per cent area in the state has very good potential for the development of this industry and only less than 10 per cent of it has been exploited.

The beekeeping potential of Himachal Pradesh can be assessed in the light of the following important facts:

BEE GENETIC RESOURCES

Himachal Pradesh is very rich from the bee resources point of view. There are at present four species of the genus *Apis* found here. Of these, *Apis cerana* F., *Apis dorsata* F., *Apis florea* F., are native of India and *Apis mellifera* L. has been recently introduced for experimental use (Atwal and Goyal, 1973). Large scale importation and multiplication of exotic, *Apis mellifera* for higher honey production into Himachal Pradesh has become a controversial subject among bee scientists. Doubts are being expressed that this species may not adapt well to the higher altitudes due to different climatic conditions, flora, mating competition with *Apis cerana* and hazards of predators and diseases (Mattu and Verma, 1980; Verma, 1988b). It is a well-recognized fact that native bees are best adapted to the specific climate and environment. However, this exotic species has so far done well in the plains and sub-mountainous regions of Himachal Pradesh, except at a height beyond 1500 metres from sea level where *A. cerana* is well adapted. Thus both species seem to be complementary to each other as far as beekeeping in the plains and the mid-hills of Himachal Pradesh is concerned.

Although the exotic bee species *A. mellifera* produces three to four times more honey than the native *A. cerana* (Atwal and Sharma, 1970) and is more suited to modern bee management technology, its importation may prove disastrous in the long run because of its allopatric nature, the introduction of parasitic mites and new diseases. Moreover, beekeeping with *Apis mellifera* requires high cost technology which the poor beekeeper in this hilly state cannot afford. On the other hand, *Apis cerana* has many valuable biological and economically important characteristics which have not been scientifically explored (Rana, 1987; Verma *et al.*, 1988a, b).

Our research group at the Himachal Pradesh University, Shimla made an attempt to study the genetic diversity of *A. cerana* in the Himalaya. Two sub-species and five different geographic populations in the northwest and northeast Himalaya have already been identified (Mattu, 1982; Verma and Mattu, 1982; Verma *et al.*, 1984; Singh, 1989). In Himachal Pradesh only one geographic population/ecotype of native bee species has been recognized (Mattu and Verma, 1980; 1983; 1984a, b).

BEE MANAGEMENT

Himachal Pradesh presents a variety of ecological conditions ranging from the sub-tropical to temperate. Combined with this ecological diversity, there is biological diversity in the form of four species of *Apis* and ecotypic variations within each species (Mattu, 1982; Mattu and Verma, 1984a, b). The problem of bee management has, therefore, to be dealt with on a purely zonal basis.

The annual cycle in Himachal Pradesh passes through well-marked five seasons spring, summer, rainy, autumn and winter. In the temperate zone, winters are severe and summers are pleasant, whereas, in the plains, summers are severe and winters are pleasant except for few spells of severe cold (Anonymous, 1989). In the lower hills of Himachal Pradesh although summers (April to June) are hot, clovers, cucurbits, some vegetables and wild bushes and trees like *Eugenia*, *Tamarindus* and *Azadirachta* provide good forage in several localities (Sharma *et al.* 1986; Sharma, 1989). In the later half of summer, bee flora decrease, water requirements of the colony shoot up, brood rearing depletes to a greater extent and enemies like ants and waxmoth become active. Supply of enough fresh water, food in the shape of very light syrup, shade and windbreak are the important requirements of the colonies. In the rainy season, activities of waxmoth and ants increase and some colonies even desert, but some good floral sources like *Sorghum*, *Zea* and legumes are available and can be utilized for the judicious management of colonies. In autumn, the early mustard crop provides good honey flow in many localities. Then the period up to spring through winter is good except a few spells, and various honey flows in different localities are available. In spring (Feb–March) there are some good honey flows like those of *Nephelium*, *Azadirachta*, *Eugenia*, and *Dalbergia* and clovers in various localities.

In the higher hills, the colonies develop well in spring and natural swarming occurs in early March to April in various localities. May–June is the period of major honey flow (Mattu, 1982; Mattu and Verma, 1985). During the rainy season, although some good sources of pollen and nectar like herbs, bushes and certain crops are present, the bees seldom accomplish good work because the weather does not allow

them to work well and the rains wash off nectar and pollen. Wasps, and to some extent waxmoths, are the worst enemies during this season. Autumn is again a season of honey flow from *Plectranthus* sp., *Prunus* sp. *Eucalyptus* etc. (Sharma, 1989). During winter the colony activity declines, flora become scanty and winter packing is required according to the altitude of place.

The flowering season in the hills and the adjacent agricultural plains alternate in different zones of Himachal Pradesh. Thus, when there is an acute shortage of bee forage in the hills during severe winter, the adjacent foothills and plains provide abundant nectar and pollen from agricultural crops. Similarly, when the bees face acute dearth in the plains, there is a minor or major build up and flow periods in the hills. Intermigration of colonies between hills and plains, therefore, help to augment colony number and strength. Incidentally, such migrations provide bee pollination services to farmers and orchardists.

In Himachal Pradesh, frequent swarming and absconding are very severe problems in beekeeping with *A. cerana*, but there is no such problem with *A. mellifera* (Verma, 1988a; Dulta *et al.*, 1988). Frequent swarming and absconding may be beneficial for the survival and propagation of species but sometimes it poses a serious threat to beekeeping especially when it occurs during the honey flow seasons. The rate of absconding of *Apis cerana* may vary from 30 to 100 per cent and this species resembles Africanized bees in its absconding behaviour. *A. cerana* colonies are robbed by *A. mellifera* causing the former to abscond. Robbing of diseased and weak colonies of *A. cerana* by strong colonies of *A. mellifera* leads to the spread of the acarine disease in the latter (Verma, 1984). Classical hanging ball experiments (Stort, 1974) also support the view that *A. mellifera* is more aggressive than *A. cerana*, keeping in view the overall dominance of the former over the latter (Mattu, 1982; Rana, 1989).

For successful beekeeping operations it is just not enough to have efficient colony management. It is also essential to have easily available modern equipment. In Himachal Pradesh, *A. cerana* is reared in villager's local hives, whereas, *A. mellifera* is kept in Langstroth hives with ten frames. Modern beekeeping equipment such as smoker, uncapping knife, queen excluder, bee veil, swarm nets, feeder, queen cage, gloves, comb-foundation are supplied by Government as well as by private local dealers. Skilled and efficient craftsmen for wood and metal work are also available locally (Verma 1984).

BEE FORAGE

Himachal Pradesh is mainly a hilly state with a great variety of pollen and nectar-yielding plants which can be classified as tem-

perate fruits, vegetables, agricultural crops, bushes, shrubs, forests and avenue trees. Our research group conducted detailed studies on bee flora of Himachal Pradesh and prepared a floral calendar for the state (Mattu *et al.*, 1988, 1990; Sharma, 1989). These studies have revealed that bee forage is mainly derived from wild arboreal and cultivated plant species like *Taraxacum*, *Impatiens*, *Berberis*, *Scrophularia*, *Salvia*, *Aesculus*, *Plantago*, *Rosa*, *Polygonum*, *Origanum*, *Rubus*, *Prinsepia*, *Adhatoda* and *Plectranthus*. Several of these weeds, bushes and shrubs are sources of surplus honey in Himachal Pradesh. A number of fruit trees such as *Pyrus* spp., *Prunus* spp., *Citrus* spp., *Syzygium* sp., *Nephelium* sp., etc. are also useful during the build-up period of the bee colonies. Annual crops like *Trifolium* sp., *Zea* sp., *Brassica* sp., *Medicago* sp., *Melilotus* sp. and *Fagopyrum* sp., are also important floral resources of the region. Vegetables and ornamental plants such as *Artemisia* sp., *Carduus* sp., *Brassica* sp., and *Rosa* sp., are useful to bees particularly during the dearth periods. Besides these, other species such as *Toona*, *Acacia*, *Albizzia*, *Dalbergia*, *Sapindus*, *Tilia*, *Bauhinia*, *Robinia*, *Salix*, *Cassia*, *Terminalia* and *Acer*, are also eagerly visited by bees. These flowers blossom for short duration and are erratic yielders.

Crop Pollination

Honeybees play a very important role in the pollination of agricultural and horticultural crops, increasing their yield and improving the quality of crop (Dulta, 1986; Rana, 1989). It has been estimated that for every rupee worth of honey produced by bees, there is an increase in crop production worth over twenty rupees. In insect-pollinated crops any amount of irrigation, fertilizers and other inputs have no meaning unless adequate population of pollinators is also not provided (Verma, 1984; 1988a, b).

Himachal Pradesh is a principal fruit-growing state in India. Nearly 1,49,234 hectares of land is presently under orchards producing about 4,34,499 tons of temperate fruits (Based on the report of Horticulture Department, 1989). Apple is the most important of the temperate fruits cultivated in the state and apple orchards cover about 75 per cent of the total area under temperate fruit cultivation. The other temperate fruits cultivated in the state are cherry, peach, plum, and apricot. Every year more and more area is coming under cultivation of fruit crops. With such a dramatic increase in the area coming under cultivation of the fruits every year and when most delicious and money-fetching varieties of apple such as Royal and Red delicious are self-incompatible, maximum yield is only possible through efficient and sufficient pollination by honeybees.

Similarly, maximum yield of certain vegetables, pulses, oils and forage crops is only possible through insect pollination, especially honeybees (Verma, 1984; 1988a, b). Further, population of non-*Apis* pollinators is decreasing at an alarming rate due to growing deforestation, vast clearance of wastelands for cultivation and increased use of pesticides.

The present large-scale expansion in the horticulture industry in the State has not been accompanied by a corresponding increase in modern bee hives and it has already been noticed that many orchards do not bear adequate fruits due to the inadequate populations of honeybees available for pollination. Therefore, a big horticultural undertaking, as is present in Himachal Pradesh, will not be able to flourish in the long run without the large-scale development of scientific bee-keeping.

In Himachal Pradesh, the State Horticulture Department and few private beekeepers rent out honeybee colonies to fruit growers at the time of apple bloom for the purpose of pollination. Thus, Himachal Pradesh has taken a lead in the renting out of colonies of *A. cerana* and *A. mellifera* to the orchardists. Although the number of colonies distributed for pollination is perhaps too small, keeping in view the large areas of land under fruit cultivation in Himachal Pradesh, this programme has helped in creating awareness among orchard owners about the importance of honeybees for pollination (Verma, 1984; 1988a).

Hive Products

Among the important hive products of Himachal Pradesh, honey is at present the only cash crop which is harvested from the bee hive. Honey extraction and its processing is done by both the traditional and modern methods. Depending on the type of beekeeper, climate and bee forage, honey harvest per colony per year of *A. cerana* varies between 3 and 5 kg, whereas, *A. mellifera* produces three to four times more honey as compared to *A. cerana* (Atwal, 1987; Verma, 1988a). Himachal Pradesh at present produces about 70,680 kg of honey annually (1988-89). India is the second major honey-producing Asian country contributing 18 thousand metric tons. Total annual world honey production varies from 815 to 893 thousand metric tons (Based on FAO 1986).

Another important byproduct of the beekeeping industry is beeswax. In Himachal Pradesh, large quantities of beeswax is collected from the wild colonies of *A. dorsata*, *A. cerana* and *A. florea* and only a small quantity of wax is produced by the domesticated *A. cerana* and *A. mellifera* (Verma, 1984; 1988a). There are other hive products like royal jelly, pollen, propolis and bee venom which can be used for

many purposes and a lot of foreign exchange can be earned through their export. However, such products are yet to appear in the Indian market because of a lack of technical know-how.

Enemies and Diseases

The most important enemies of honeybees in Himachal Pradesh include parasitic mites, waxmoths, predatory wasps, beetles, ants and birds. Among the mites, the ectoparasitic mite, *Tropilaelaps clareae* has been found to attack the larvae, pupae and adult bees of exotic *A. mellifera*, whereas, *Acarapis woodi* is also a serious pest of the native bee, *A. cerana*. On an average Acarine disease takes a toll of 10–20 per cent colonies every year. So far *Varroa jacobsonii* has not created any serious problem to the beekeeping industry in Himachal Pradesh. These mites can be controlled either through chemotherapy or by adopting better management techniques (Verma, 1984; 1988a, b). Besides parasitic mites, the most dreaded and universal enemies of honeybees are the waxmoth, *Galleria mellonella* and *Archoria grisella*. In the low hills of Himachal Pradesh these waxmoths often cause the colonies to desert. These pests can easily be controlled in *A. cerana* colonies by fumigating the empty beehives and combs.

Various species of predatory wasps are also known to cause serious damage to bee colonies. Among these, prominent species are *Vespa magnifica*, *V. auraria*, *V. cincta* and *V. bassalis*. In Himachal Pradesh about 20 to 25 per cent of colonies especially of *Apis mellifera*, annually desert their nests due to the predatory activities of wasps (Verma, 1984; Sharma and Raj, 1988). Because of shimmering and evasive behaviour, *A. cerana* can resist the attack of wasps better than *A. mellifera*. At present no satisfactory remedial measures are available to control these wasps.

Among the important diseases, Nosema, Acarine, Virus cluster and Sacbrood are very prominent in Himachal Pradesh. Thai Sacbrood disease caused the major havoc to the beekeeping industry of *A. cerana* in recent years killing more than 95 per cent of the colonies in the state (Rana, 1987; Verma, 1988a,b). This disease not only affected the pollination services rendered by honeybees but also caused great economic loss to the apiculture industry with regard to the production of honey and beeswax. At present most of the *A. cerana* colonies of Himachal Pradesh are showing signs of resistance to sacbrood disease.

Problems and Strategies for Apicultural Development

An assessment of the potential and present status of apiculture in Himachal Pradesh indicates that there is indeed an enormous scope

for the development of beekeeping in the state and it can be converted into a land of honey through modern scientific beekeeping. For this, the following problems need immediate attention:

1. DEVELOPMENT OF PRODUCTIVE BEE STRAINS

Practically, no work on the genetic improvement of *A. cerana* has been done. Therefore, superior and tested bee stocks of this species are almost non-existent. On the other hand, the progeny of high-yielding *A. mellifera* hybrids (established in the sixties at Nagrota) is very limited and not available to most interested beekeepers. It is, therefore, suggested that rapid multiplication programme for the exotic species should be taken up and at the same time better strains of *A. cerana* should be developed through a selection and breeding programme, because *A. mellifera* may not prove successful in high altitude belts. At present there are 43 State Government apiaries located in different parts of Himachal Pradesh. These apiaries can act as model bee farms for the improvement of the local bee races by selective breeding, large-scale multiplication of colonies, and production of pedigree queens.

Our research group has already identified five different geographical populations of *A. cerana* in the Indian Himalaya. They show difference in biological, morphometric and economic characters. This variability provides an excellent opportunity for the genetic improvement of *A. cerana* through selection and breeding.

2. DEPLETING HONEY PLANT RESOURCES

The success of apicultural development programmes depends not only on using better bee strains but also on the abundance and richness of honey plant resources around an apiary. Our research group has made detailed studies on the bee flora of Himachal Pradesh and we have got adequate information on bee plants of this state. Yet, there is a need for compiling floral maps and calendars, region wise, to study the duration and availability of pollen and nectar from the plants, eco-physiology of major honey resources, and the contamination of honey by poisonous plants. Another problem faced by the beekeeping industry is depleting floral sources perpetuated by the cutting down of useful honey plants and utilization of cleared land for agriculture. There is thus an urgent need to conserve and further augment the melliferous sources of the state. This can be done by selecting the bee plants for forests, pastures, gardens and roadside avenues and planting them through an afforestation programme.

3. BEE MANAGEMENT

The productiveness of bee colonies can be boosted not only by better strains and better forage but also by developing improved management practices duly related to local ecological, phenological and floristic patterns. While the routine management of bee colonies has been adequately developed, the specialized practices of managing colonies for migratory beekeeping, crop pollination, queen production, package bees etc., under our conditions, are least available. Besides, no particular emphasis has been laid on serious problems such as absconding, swarming and wintering of bee colonies.

4. CROP POLLINATION AND INDISCRIMINATE USE OF PESTICIDES

Orchardists and farmers in Himachal Pradesh are not yet fully aware of the important role which honeybees and other natural insect pollinators play in increasing the yield of temperate fruit crops. Fruit growers, therefore, need to be educated about the benefits derived from beekeeping by pollination. In Himachal Pradesh at the time of apple blossoming, a large variety of fungicides and pesticides are used to control insect pests. Indiscriminate use of such biocides results in killing large populations of honeybees and other insect pollinators. Therefore, there is a need to check the harmful effect of pesticides through legislation or improved pest control programmes.

5. DISEASES AND ENEMIES

Well over 100 species of pathogens, parasites and predators are known to infest or predate on honeybees in India. Although their collective negative impact on Indian beekeeping has not been fully evaluated, yet, sufficient information is available to suggest that most of the damage to *A. cerana* colonies in Himachal Pradesh was done by the Sacbrood virus and acarine diseases. Damage to *A. mellifera* colonies is caused by various species of predatory wasps and mites.

As already stated, Sacbrood virus disease killed more than 90 per cent of colonies of *A. cerana* in Himachal Pradesh recently. However most of these colonies have recovered from this disease and are working normally. But there is a need for strict quarantine measures for preventing the entry of other dangerous diseases such as European foulbrood, American foulbrood, Chalk brood etc., in Himachal Pradesh. These diseases have not been reported so far from any region of Himachal Pradesh.

Beside diseases, various species of predatory wasps are known to cause serious damage to the colonies of bees especially *A. mellifera*. Most of the colonies of exotic bee species desert due to the predatory activities of wasps. The deserted colonies invariably perish due to

starvation as the wasps attack often synchronizes with dearth periods when little natural flora is available. Several recommendations have been made by different investigators for the control of wasps, yet the problem is still serious in Himachal Pradesh. Therefore, research on wasp biology and behaviour may result in the development of safer and economically feasible methods of wasp control.

6. APICULTURAL RESEARCH AND TRAINING

Himachal Pradesh offers very rich potential for the development of beekeeping due to the ideal climatic conditions and multiplicity of bee flora available throughout the year. But research and extension efforts are not commensurate with the gigantic task of exploiting the vast nectar sources through the use of honeybees, which otherwise go waste. These efforts are greatly hampered due to financial problems as well as low availability of personnels trained in beekeeping research and extension work.

Acknowledgements

I express my gratitude to Prof. L.R. Verma of ICIMOD, Nepal, who inspired and introduced me to the fascinating field of apiculture.

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Beekeeping in the North West Frontier Province of Pakistan

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North West Frontier Province (NWFP) is located in the northwest of Pakistan between 30° to 37° North and 68° to 70° East. It is surrounded on the west by Afghanistan, on the north by the USSR, on the east by the Punjab and India and in the south by Baluchistan.

The NWFP mostly comprises mountainous areas on the north and west and submountainous areas east-west wise, in the middle. The plains are mostly in Peshawar, Mardan, Bannu and D.I. Khan. In Peshawar and Mardan, the plains are mostly irrigated, and in Bannu and D.I. Khan, partly so. In addition, terrace farming is practised all over the mountainous and submountainous areas of the province, wherever spring water is available. In general, the province is arid or semi-arid in nature. The amount of rainfall varies from up to 12 inches in the southern districts, to up to 20 inches in the northern districts. It has temperate climate: winter is very cold with snow in the mountains and frost in the plains; summer is mild in the mountains but very hot in the plains. Varied, yet ideal ecological conditions exist for beekeeping in the province.

Species of Bees Found in the NWFP

Four species of honey bees are distributed in the province.

1) *APIS FLOREA*

This species builds single-comb nests, rested on branches of shrubs and small trees. These bees are predominantly found in the plains and submountainous areas of the province. These bees have a habit of swarming and absconding. Although the honey obtained from these bees is extremely good with very pleasant flavour, the yield is very low. Sometimes two or three colonies can be seen in the same shrub or tree. Although very gentle in nature, all attempts to domesticate these bees have failed. The bees are found only in wild form and the number of their colonies varies greatly, with no statistics available. These bees take an active part in the cross-pollination of vegetables and ornamental plants.

2) *APIS DORSATA*

This is the largest of all the species of honeybees found in the province. These bees are very aggressive and have the habit of forming a single large comb on branches of tall trees and protected places, such as in tall buildings. They are mostly found in the plains where the winter temperature hardly reaches freezing point. The comb size sometimes may be as big as 2 metres long and one metre wide. These bees cannot be domesticated and are found only in wild form. Sometimes, numerous colonies can be seen on different branches of old big trees. Plenty of honey is obtained from *A. dorsata* but only certain professional people know how to harvest honey from it. These bees take an active part in the cross-pollination of a large number of crop plants, forest and fruit trees and vegetable and ornamental plants.

3) *APIS CERANA*

This is most typical and common species of the honeybee found in the plains as well as in the submountainous and mountainous areas of the province. It is found in its wild as well as domesticated form. It has the habit of forming parallel combs. Its temper is relatively mild. People have been breeding the species from time immemorial in all kinds of old wooden boxes, hollow trees, hollow walls, pitures and in cupboards, etc., specially in the mountains. Most of the honey output comes from this species. About 30 years ago, as people's interest in commercial beekeeping grew, they started with this species. But due to the lack of knowledge about the management techniques the efforts often failed. At present there are approximately 8000 bee colonies in hives, in addition to those found wild in the nature.

4) *APIS MELLIFERA*

This species is larger than *Apis cerana*. Since 1927, several efforts were made on the importation and establishment of this species, but it was only in 1977 that these bees could be successfully established and multiplied. These bees are very mild in temper, and have the habit of forming parallel combs. These also do not swarm or abscond as much as the local bees. The honey yield is very high. Because of so many positive traits, people in the province are replacing the local bees with the European bees for maintaining them in hives for commercial beekeeping. At present there are over 5000 colonies of the European bee in the province.

A comparative account of the two species *A. cerana* and *A. mellifera* is as follows:

Character	Local bee (<i>A. cerana</i>)	Imported bee (<i>A. mellifera</i>)
1. Temper	bad to mild	mild to good
2. Honey yield (stationary)	3-5 kg per colony	8-12 kg per colony
3. Honey yield (migratory)	10-12 kg per colony	above 35 kg per colony
4. Pollination of crops	good	very good
5. Reaction to wax moth	very susceptible	relatively resistant
6. Reaction to acarine disease	very susceptible	relatively resistant
7. Reaction to <i>Varroa</i> mite	slightly resistant	very susceptible
8. Reaction to hornets	slightly resistant	very susceptible
9. Foulbrood diseases	slightly resistant	very susceptible

Honey Bee Flora of the NWFP

A. MAJOR SOURCES OF NECTAR AND POLLEN

These include those plants or trees from which the honeybees collect surplus honey or use the pollen for brood rearing during honey-flow seasons. Each source is given here with a brief description.

1) Shisham (*Dalbergia sissoo* Roxb.)

Shisham is a deciduous tree grown in the plains all over the province, especially in Peshawar, Haripur, Kohat, and Bannu. The trees bloom in March and April and produce small greenish-yellow flowers which secrete nectar for the bees for about three weeks. The honey from shisham is amber to dark-amber in colour and of strong flavour.

2) Phulai (*Acacia modesta* Wall.)

Phulai is a medium-sized gregarious deciduous tree of eroded low hilly areas of Khairabad, Nowshera and Chirat. The tree blooms in April. The flowers are creamy white in colour and produce ample quantity of nectar. Its honey is white or very lightly tinged, with a very good flavour.

3) Bhaikar (*Adhatoda vasica* Nees.)

This is a shrub found in Haripur, Rustam and Mardan. It blooms in April along with phulai and produces creamy white flowers which are a good source of nectar for the bees.

4) Apple (*Malus sylvestris* Mill.)

This is a deciduous fruit tree of higher elevations e.g. Swat, Dir and Parachinar. It blooms in February and March and is an important source of nectar and pollen. Its honey is of amber colour.

5) Citrus trees (All species)

These are evergreen trees and include lemon, sour orange, sweet orange, grape fruit, kinnoo and mandarin, which are abundantly grown in Peshawar, Mardan, Haripur and Dargai. The citrus trees bloom in March and provide nectar as well as pollen for bees. Their pollen is specially very useful for early brood rearing after swarming. The honey from citrus is of light amber colour.

6) Guava (*Psidium guajava* Linn.)

Guava is a popular fruit tree of Kohat, Haripur and Dargai and is also sparsely distributed throughout the province. It blooms from middle of May to middle of June and is a good source of nectar and pollen.

7) Ber (i) *Zizyphus jujuba* Mill & Lamk.

(ii) *Zizyphus hysudrica* Hole.

These trees grow wild in the plains and hills up to 1000 metres elevation and are abundantly found in Khairabad, Peshawar, Kohat and Bannu. Ber produces flowers in August which provide plenty of nectar and pollen for bees. Its honey is of a dark colour.

8) Loquat (*Eriobotrya japonica* Thumb. Lindley)

Loquat is a common fruit tree of Peshawar, Kohat, Haripur and Dargai and is also lightly distributed throughout the province. Loquat

blooms from the first week of November and continues to provide nectar and pollen for bees up to the last week of January, a time when the other bee flora are not available. Its honey is white and becomes granulated.

9) Dates (*Phoenix* spp.)

Dates grow in D.I. Khan and Bannu districts. The date trees bloom in August and is a major source of nectar and pollen. Its honey is of dark amber in colour and strongly flavoured.

10) Clovers: Shaftal (*Trifolium resupinatum* L.) and Berseem (*Trifolium alexandrianum* L.)

Berseem and shaftal are grown on a large scale for fodder in the irrigated plains of Haripur, Mardan, Peshawar, and Bannu. These bloom in the first week of May and continue to provide nectar and pollen till the end of June. They are the best source of nectar and pollen. The bulk of honey in the irrigated plains comes from this source.

11) Sarson (*Brassica campestris* L.)

Sarson is grown chiefly as an oil-seed crop in the irrigated and rainfed plains of Peshawar, Haripur, Mardan, Dargai, Kohat and D.I. Khan. The early sown crop blooms in February and the late varieties in March. The honey flow, from sarson lasts for about a month. Sarson is a very good source of nectar and pollen. Its honey is yellow in colour and becomes granulated in a few days after extraction.

12) Maize (*Zea mays* L.)

Maize is grown in both the plains and mountains, all over the province. It is a very useful source of pollen during July and August when the other bee flora are not available. This crop supplies larger quantities of pollen than other plants.

13) Shain (*Plectranthus rugosus*)

This is a wild shrub of medium elevations. The shrub produces small white flowers which provide nectar and pollen to bees from the mid-September to mid-October, a time when other sources of nectar are not available in the plains. Bulk of honey in the mountains comes from this plant.

14) Sunflower (*Helianthus annuus*)

This is a newly introduced oil-seed crop and is becoming more and

more popular among the farmers. There are two crops: the spring crop from March to middle of June, and the summer crop from July to September. This flower provides great quantities of pollen and a little nectar, to honeybees. It is grown in almost all the irrigated plains of the province.

B. MINOR SOURCES OF NECTAR AND POLLEN

A detailed study of the minor sources of nectar and pollen in the province revealed that there is a larger number of plants from which honeybees do not generate surplus honey, yet the plant provide enough nectar and pollen that the bees can survive on them during dearth periods. These minor sources have been given in Table 15.1 showing their common name, scientific name, family, distribution and whether providing nectar or pollen along with the blooming period.

Honey Flows and Migratory Beekeeping with *A. cerana/mellifera*

Extensive survey of the honeybee flora of NWFP revealed that there are five different honey flow seasons at the places given in the following Table.

Season	Crops	Localities
1. February–March	Mustard, Citrus fruits	Peshawar, Mardan
2. April	Stone fruits, Phulai	Khairabad, Nowshera, Peshawar, Mardan.
3. May, June	Clovers	All irrigated plains of Peshawar, Mardan, Bannu and D.I. Khan.
4. Sept–Oct	Shain	Swat, Dir.
5. Nov–Jan	Loquat	Haripur, Peshawar.

Normally there are two kinds of beekeepers, the amateur and the commercial. The amateur beekeepers normally maintain up to eight colonies while the commercial beekeepers have from as few as 50 to as many as 200 colonies. Migration of bee colonies to a particular locality during the honey flow season is a must for the commercial production of honey. Therefore, commercial beekeepers follow the migration very strictly. In the case of *Apis cerana*, the honey yield is up to 10–12 kg from the migration of bee colonies to different places in different times against the 3–5 kg per colony in stationary beekeeping. In the case of *A. mellifera*, the honey yield from the migration of bee colonies to appropriate localities at the right time is over 35 kg against 8–12 kg per colony as generated in one locality. It has been observed that instead of transportation of bees to different localities for the five differ-

ent honey flows, most commercial beekeepers make use of the major honey flow from clovers in May-June in the plains, where after extraction of honey, they migrate their colonies to the mountain areas of Swat and Dir for honey from Shain in September-October. Then they transport the bees back to the plains before the onset of winter for the honey flow from loquat in November-January, and from sarson, citrus, stone fruits, phulai and clovers. By doing so, the bees escape the extremely high temperature of the plains. Waxmoth attack is also avoided, since the waxmoths flourish with the rise of relative humidity after the monsoon rains. The beekeepers harvest an extra crop of honey from Shain in the mountains. This is the minimum of transportation which the commercial beekeepers undertake is essential for profitable honey production. Such transportation is one of the compulsory management practices for commercial honey production in the NWFP.

Similarly, for higher yields of honey, another important management practice is to maintain good honeybee germplasm at species level and then within the species, careful selection of the queen and her bee swarms for desirable characters is essential. These desirable characters are collection of more honey, laying more fertilized eggs, less swarming and absconding habit, more tolerance to higher temperatures of the plains in summer and more resistance to the attack of waxmoth, mites and diseases. In the following table, a comparison has been made of the indigenous and exotic germplasms that have been introduced and successfully established and multiplied during the past few years.

<i>Germplasm</i>	<i>Yield</i>	<i>Indigenous</i>	<i>Exotic</i>
1. Poultry	egg layers	50 eggs per year	250 eggs per year
2. Poultry	broiler weight	1 kg per 7 month	1 kg per 6 weeks
3. Cows	milk	1200 litres/ lactation	6000 litres/ lactation
4. Cows	meat	200 kg/2 years	200 kg/6 months
5. Wheat	grain	1000 kg/ha	3000 kg/ha
6. Cotton	fibre	200 kg/ha	600 kg/ha
7. Honey bees (stationary)	honey	3-5 kg/hive	8-12 kg/hive
8. Honey bees (migratory)	honey	10-12 kg/hive	Over 35 kg/hive

It is obvious that whenever a high-yielding germplasm is available to a farmer, he always goes for it. This is one of the reason that the exotic bee is becoming more and more popular among beekeepers of NWFP. Presently over 50 per cent beekeepers have replaced the local

TABLE 15.1
Honey plant resources of North West Frontier Province of Pakistan

S. No.	Local or English name	Scientific name	Family	Distribution	Yield Nectar or pollen	Blooming
(a) Forest trees						
1.	Neem	<i>Azadirachta indica</i> (Linn.) A. Juss	Meliaceae	Hazara, Haripur	Nectar	April-May
2.	Amaltas	<i>Cassia fistula</i> Linn.	Leguminosae	Throughout the province	Nectar	May-June
3.	Keekar	<i>Acacia arabica</i> (Lam.) Willd	-do-	Throughout the unirrigated tracts	Nectar	April-May
4.	Imli	<i>Tamarindus indica</i> Linn.	-do-	Hazara	Nectar	April and October
5.	Sharin, Siris	<i>Albizia lebbek</i> (Linn.) Benth	-do-	Hazara	Nectar	April
6.	Lassoora	<i>Cordia myxa</i> Linn.	Boraginaceae	Throughout the plains	Nectar	April
7.	Polygonum	<i>Polygonum glabrum</i> Willd.	Polygonaceae	Hazara	Nectar	Aug-Sept.
8.	Toon	<i>Cedrela toona</i> Toxb. ex. Rottl. and Willd.	Meliaceae	Hazara, Kohat	Nectar and pollen	April-June
9.	Kachnar	<i>Bauhinia variegata</i> Linn.	Leguminosae	Throughout the province	-do-	Feb-March
10.	Dela, Karir	<i>Capparis decidua</i> (Forsk.) Edgew.	Capparidaceae	Throughout the dry places of the province	Pollen	March-April
11.	Rakha, Frasb	<i>Tamarix aphylla</i> (L.) Karst.	Tamaricaceae	Throughout the province	Nectar	May-Sept
12.	Dhaman	<i>Grewia elastica</i> Royle	Tiliaceae	Hazara	Nectar	April-June
13.	Eucalyptus	<i>Eucalyptus</i> spp.	Myrtaceae	Throughout the province	Nectar and pollen	Different species at different times

14.	Bottle brush	<i>Collistemon viminalis</i> (Solander) Cheel	-do-	Nectar	April-May
15.	Sing	<i>Eucynus hamiltonianus</i> Wall.	Hazara	Nectar	April-May
16.	Unab	<i>Zizyphus sativa</i> Gaertn.	Throughout the province	Nectar	June-July
17.	Kansheli	<i>Acer pictum</i> Thunb.	Hazara	Nectar	April-May
18.	Duswila	<i>Rhus chinensis</i> Miller	Dir, Swat and Hazara	Nectar	
19.	Locust tree	<i>Robinia pseudoacacia</i> Linn.	-do-	Nectar and pollen	April-May
20.	Safed Siris	<i>Albizia procera</i> (Roxb.)	Hazara	Nectar	April-May
21.	Bakain	<i>Melia azedarach</i> Linn.	Throughout the province	Nectar and pollen	March-April
22.	(b) Fruit trees				
	Apricot	<i>Prunus armeniaca</i> Linn.	District Peshawar	Nectar and pollen	Feb-March
23.	Plum	<i>Prunus bokhariensis</i> Royle ex. C.K. Schin.	-do-	-do-	-do-
24.	Peach	<i>Prunus persica</i> (Linn.) Batsch.	-do-	-do-	-do-
25.	Pears (Nashpati) (Nakhi)	<i>Pyrus communis</i> Linn. <i>Pyrus lindleri</i> Rehder.	-do-	-do-	-do-
26.	Batong	<i>Pyrus pashia</i> Ham. ex D. Don	-do-	-do-	-do-
27.	Wild berry	<i>Prunus cerasoides</i>	-do-	-do-	-do-
28.	Almond	<i>Prunus amygdalus</i> Bail	Throughout the hilly tracts	-do-	-do-
29.	Jaman	<i>Syzgium cumini</i> (L.) Skeels	Hazara, Kohat, Bannu	Nectar	May
30.	Pomegranate	<i>Punica granatum</i> Linn.	Throughout the province	Nectar and pollen	Mid April-Mid May
31.	(c) Field crops and vegetables.				
	Cotton	<i>Gossypium</i> spp.	Plains of the province	Nectar	July-Sept

Contd.

Table 15.1. Contd.

1	2	3	4	5	6	7
32.	Sorghum	<i>Andropogon sorghum</i> (Linn.) Brot	Gramineae	Dry region of the province	Pollen	July-Aug
33.	Gram	<i>Cicer arietinum</i> Linn.	Leguminosae	-do-	Nectar	July
34.	Turnip	<i>Brassica rapa</i> Linn.	Cruciferae	Throughout the province	Nectar and pollen	Feb-March
35.	Radish	<i>Raphanus sativus</i> Linn.	-do-	-do-	-do-	Jan-March
36.	Cauliflower	<i>Brassica oleracea</i> Linn. Var. <i>Botrytis</i> L.	-do-	-do-	-do-	-do-
37.	Coriander	<i>Coriandrum sativum</i> Linn.	Umbelliferae	-do-	-do-	Feb-March
38.	Carrot	<i>Daucus carota</i> Linn.	-do-	-do-	-do-	April
39.	Brinjal	<i>Solanum melongena</i> Linn.	Solanaceae	-do-	Pollen	May-June
40.	Tomato	<i>Lycopersicon esculentum</i> Mill.	-do-	-do-	-do-	Jan-April
41.	Long Melon	<i>Cucumis melo</i> Var. <i>utilissima</i>	Cucurbitaceae	-do-	-do-	April-May
42.	Bottle Gourd	<i>Lagenaria siceraria</i> (Molina.) Standley.	-do-	-do-	-do-	May-June
43.	Lady's finger	<i>Abelmoschus esculentus</i> (L.) Moench	Malvaceae	-do-	-do-	-do-
44.	Bitter Gourd	<i>Momordica charantia</i> Linn.	Cucurbitaceae	-do-	-do-	-do-
45.	Cucumber	<i>Cucumis sativus</i> Linn.	-do-	-do-	-do-	-do-
46.	Fennel	<i>Foeniculum vulgare</i> Mill.	Umbelliferae	-do-	Nectar and pollen	March-April
47.	Onion	<i>Allium cepa</i> Linn.	Liliaceae	-do-	-do-	-do-
48.	(d) Weeds and shrubs					
48.	Oxalis spp.	<i>Oxalis pes-caprae</i> Linn.	Oxalidaceae	-do-	Pollen	September
49.	Mako	<i>Solanum nigrum</i> Linn.	Solanaceae	Peshawar, Mardan Kohat and Bannu	Nectar and pollen	February
50.	Euphorbia	<i>Euphorbia heterophylla</i> Linn.	Euphorbiaceae	Throughout the province	Pollen	April
51.	Salvia spp.	<i>Salvia plebeja</i> R. Br.	Labiatae	-do-	Nectar and pollen	September

52.	Ruellia	<i>Ruellia prostrata</i> Lamk.	Acanthaceae	Dir, Swat	Pollen	-do-	-do-
53.	Piazia	<i>Aphodelus tenuifolius</i> Cav.	Liliaceae	Peshawar, Haripur Mardan and Kohat	-do-	-do-	March-April
54.	Lagerstroemia	<i>Lagerstroemia indica</i> Linn.	Lythraceae	Dir, Swat	-do-	-do-	September
55.	Crepe myrtle	<i>Ranunculus</i> spp.	Ranunculaceae	Swat and Agencies	Nectar and pollen	-do-	September
56.	Berberis	<i>Berberis lycium</i> Royle	Berberidaceae	Hazara, Swat, Dir	Nectar	-do-	April-May
57.	Geranium	<i>Geranium nepalense</i> Sweet	Geraniaceae	Dir, Swat etc.	Pollen	-do-	September
58.	Impatiens	<i>Impatiens edgeworthii</i> Hk. f.	Balsaminaceae	Dir, Swat	Nectar	-do-	-do-
59.	Cynoglossum	<i>Cynoglossum wallichii</i> G. Don.	Boraginaceae	Dir, Swat	Pollen	-do-	-do-
60.	Nepeta	<i>Nepeta spicata</i> Bth.	Labiatae	Dir, Swat	-do-	-do-	-do-
61.	Polygonum	<i>Polygonum amplexicaule</i> D. Don.	Polygonaceae	-do-	-do-	-do-	Aug-Sept
62.	Calamintha	<i>Calamintha umbrosa</i> (M. Bieb) Fisch. & Mey.	Labiatae	-do-	-do-	-do-	Sept-Oct.
63.	Aster	<i>Aster nova-angliae</i> Linn.	Compositae	-do-	-do-	-do-	-do-
64.	Begonia	<i>Begonia picta</i> Sm.	Begoniaceae	-do-	-do-	-do-	September
65.	Cenchrus	<i>Cenchrus ciliaris</i> Linn.	Gramineae	Dir, Swat	-do-	-do-	-do-
66.	Cichorium	<i>Cichorium intybus</i> Linn.	Compositae	Throughout the province	-do-	-do-	-
67.	Origanum	<i>Origanum vulgare</i> Linn.	Labiatae	Dir, Swat	Nectar and pollen	-do-	Sept-Oct
68.	(e) Ornamental flowers	<i>Rosa</i> spp.	Rosaceae	Throughout the province	Pollen	-do-	March-June
69.	Sun flower	<i>Helianthus annuus</i> Linn.	Compositae	-do-	-do-	-do-	July-Sept.
70.	Corn flower	<i>Centauria cyanus</i> Linn.	Compositae	-do-	-do-	-do-	March-April
71.	Paipatia	<i>Euphorbia pulcherrima</i> Willd. ex Kl.	Euphorbiaceae	-do-	-do-	-do-	Nov-June
72.	Portulaca	<i>Portulaca grandiflora</i> Hk.	Portulacaceae	-do-	-do-	-do-	April-June
73.	Golden rod	<i>Solidago canadensis</i> Linn.	Compositae	-do-	-do-	-do-	Sept-Oct
74.	Duranta	<i>Duranta repens</i> Linn.	Verbenaceae	-do-	-do-	-do-	April-June
75.	Cosmos	<i>Cosmos bipinnatus</i> Can.	Compositae	-do-	-do-	-do-	Sept-Oct

Contd.

Table 15.1. Contd.

1	2	3	4	5	6	7
76.	<i>Jatropha</i> spp.	<i>Jatropha hastata</i> Jacq.	Euphorbiaceae	Throughout the province	Pollen	Sept-Oct
77.	Rangoon creeper	<i>Quisqualis indica</i> Linn.	Combretaceae	-do-	Nectar	April-May
78.	Honey suckle	<i>Lonicera sempervirens</i> Linn.	Caprifoliaceae	-do-	Nectar and pollen	April
79.	Railway creeper	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	-do-	Pollen	-do-
80.	Golden wave	<i>Corchoris drummondi</i> Torr and Griseb.	Compositae	-do-	-do-	Feb-March
81.	Gaillardia	<i>Gaillardia</i> spp.	-do-	-do-	Nectar and pollen	July-Aug
82.	Nasturtium	<i>Tropaeolum</i> sp.	Tropaeolaceae	-do-	-do-	April-May
83.	Marigold	<i>Calendula officinalis</i> Linn.	Compositae	-do-	-do-	March-April
84.	Commelina spp.	<i>Commelina benghalensis</i> Linn.	Commelinaceae	Dir, Swat etc.	Pollen	Feb-March
85.	Rubus spp.	<i>Rubus</i> spp.	Rosaceae	Hazara, Dir, Swat	-do-	September
86.	Dicliptera sp.	<i>Dicliptera roxburghiana</i> Nees.	Acanthaceae	Dir, Swat	Nectar and pollen	-do-
87.	Rumex spp.	<i>Rumex dentatus</i> Linn.	Polygonaceae	Dir, Swat	-do-	Sept-Oct
88.	Podina	<i>Mentha longifolia</i> (Linn.) Huds.	Labiatae	Dir, Swat	Pollen	Winter
89.	Harmal	<i>Peganum harmala</i> Linn.	Zygophyllaceae	Throughout the province	-do-	Sept-Oct
90.	Ak	<i>Calotropis gigantea</i> R.Br.	Asclepiadaceae	-do-	-do-	-
91.	Wild berries	<i>Rubus biflorus</i> Ham. ex. sm.	Rosaceae	-do-	-do-	April
92.	Dandelion	<i>Taraxacum officinale</i> Wigg.	Compositae	Hazara, Peshawar	Nectar and pollen	Spring
93.	Berberis spp.	<i>Berberis kunziaurensis</i> Royle.	Berberidaceae	Mardan	-do-	June
94.	Berberis spp.	<i>B. joeschkeana</i> C.K. Schn.	-do-	Hazara	-do-	May-June
95.	Zanthoxylum spp.	<i>Zanthoxylum alatum</i> Roxb.	Rutaceae	Dir, Swat	-do-	March-April
96.	Sensulat	<i>Indigofera cassioides</i> Rottler ex. De	Leguminosae	Hazara, Swat	-do-	July-Aug

97.	<i>Lespedeza</i> sp.	<i>Lespedeza elegans</i> Camb.	-do-	-do-	Pollen	April-May
98.	<i>Sorbaria</i> sp.	<i>Sorbaria tomentosa</i> (Lindl. Rehder.)	Rosaceae	-do-	Nectar and pollen	-do-
99.	Wild currant	<i>Ribes orientale</i> Poir.	Saxifragaceae	-do-	Pollen	April-May
100.	Dahlia	<i>Dahlia variabilis</i> (Willd.) Desf.	Compositae	Throughout the province	-do-	April-May
101.	Michaelmes daisy	<i>Aster novi-belgii</i> Linn.	-do-	-do-	Nectar and Pollen	Sept-Nov
102.	Gul-i-Khaira	<i>Althaea rosea</i> (Linn.) Can.	Malvaceae	-do-	-do-	March-April
103.	Puppy	<i>Papaver rhoeas</i> Linn.	Papaveraceae	-do-	Pollen	March-April
104.	Ageratum	<i>Ageratum conyzoides</i> Linn.	Compositae	-do-	-do-	-
105.	Gul-i-daudi	<i>Chrysanthemum</i> spp.	-do-	-do-	-do-	Feb-March
106.	Salvia	<i>Salvia splendens</i> Ker.-Gawl.	Labiataeae	-do-	Nectar and pollen	-do-
107.	Pelargonium	<i>Pelargonium zonale</i> Linn.	Geraniaceae	-do-	-do-	September
108.	Ishq paicha	<i>Ipomoea caribica</i> (Linn.) Sweet.	Convolvulaceae	-do-	Pollen	-do-
109.	Antigonon	<i>Antigonon leptopus</i> Hook.	Polygonaceae	-do-	-do-	-

These minor sources provided plenty of nectar and pollen for the maintenance of the colonies at times when the major sources were not available.

bees with the exotic bees for commercial honey production. It is hoped that in the next few years the European bees will fully replace the native bees for commercial honey production. In this province honey is now no more a rare commodity as it was in the past. It has become increasingly available in the markets. The usual market price of good quality honey is Rs 60 per kg. Similarly, beekeeping is becoming increasingly popular in the NWFP as an industry and hobby due to the fact that:

1) There is greater realization of:

- (a) beekeeping as a profession for earning one's own living,
- (b) honey as a food for use in breakfast,
- (c) honey as medicine for curing several diseases,
- (d) Natural wax as a useful product for use in all sorts of polishes including car, shoes and furniture polishes, and in cosmetics, etc., and
- (e) honey bees are important agents of cross-pollination of some crops like clovers, sunflower, sarson, and loquat.

2) Training courses being offered at:

- (a) National Agricultural Research Centre, Islamabad,
- (b) Deptt. of Agricultural Research, ARI Tarnab, Peshawar, and
- (c) Deptt. of Entomology, NWFP Agricultural University, Peshawar.

3) Bee supplies are now becoming available e.g. hive boxes, comb foundation wax sheet, comb foundation press, the literature, both technical and extension and beekeeping programmes in the local language both on radio and T.V.

4) More than three million Afghan refugees have fled in to the NWFP. They brought with them hundreds of *Apis mellifera* colonies of Russian origin which have been multiplied into thousands over the past eight-nine years and have been a major means of the introduction and success of the exotic bees in the NWFP.

5) United Nations High Commission for Refugees provided funds for income-generating projects like horticulture, and apiculture for the Afghan refugees. Under apiculture, hundreds of *A. mellifera* colonies from Australia were imported and propagated among the refugees. They multiplied the bee colonies in large number in the province. So we have now *A. mellifera* bees from Russia, Australia and Europe in the province.

6) There has been a big five-year PL-480 project on honeybee management which was extended for another five years and now the Pakistan Agricultural Research Council has established a full-fledged Honeybee Research Programme at the NARC. Through research it has been possible to successfully introduce and establish the European

bees and generate a lot of knowledge on the management of local and foreign bees. The NARC has played a very important role in the promotion of the cause of beekeeping in Pakistan and the NWFP.

Problems of Beekeeping in the NWFP

There are several problems which bees and beekeepers face in the province. These are briefly mentioned here:

Wax moth is one of the very serious problems of beekeeping (specially with *Apis cerana* in the plains, where there is no migration of bee hives. Two species of wax moth are involved. The greater wax moth (*Galleria mellonella*) and the lesser wax moth (*Archoria grisella*). The attack starts in July and August immediately after the monsoon rains with a rise in relative humidity. The larvae feed on the wax of empty combs in the frames or the empty part of the comb and make silken tunnels across the cells. The bees are very allergic to this. When a single larva of wax moth is noticed by the bees in a frame, they abandon the frame and start working on the adjacent, unaffected, frame. If the wax moth larvae are extended to the adjoining frame, the bees abandon that also. If the attack of wax moth spreads to all the frames, then the bees abscond.

The best method to suppress the attack of wax moth is to migrate the colonies to the mountains of Swat and Dir immediately after the extraction of honey, in the end of June. The summers are mild in the mountains and plenty of bee flora, specially "Shain", are available. Not only do the bees escape the attack of wax moth but they also collect an extra crop of honey in the mountains.

The bee hives should also be checked constantly during July, August and September for wax moth adults and larvae. Any frame with wax moth larvae, should be exposed to sunlight for half an hour. The larvae walk out of wax sheets and die in the high temperature.

The infested frames may also be kept in a deep freezer for 10 minutes. Exposure to very low temperature also kills the wax moth larvae.

For immediate control, the frames should be exposed to fumes of phosphine gas released from phosphine gas tablets in a small airtight box or chamber.

Also, if the empty frames are not needed in the bee hive, they should be removed, because the attack of wax moth always starts on the empty frame.

In non-migratory beekeeping, over 60 per cent colonies are normally destroyed by wax moth during July and August. The attack is more serious in *Apis cerana*. *Apis mellifera* is relatively less damaged by the wax moth.

Bee Eater Bird (*Merops* spp.): Different kinds of bee eater birds have been noticed to prey on honeybees. They sit and wait on the trees and on electric wires in the vicinity of bee hives and as soon as they see a bee alighting from the hive, the birds catch it right away with the long beak and feed on it. These birds have to be either shot down or frightened away with brightly coloured shining plastic strips, etc.

Acarine disease: This disease is caused by a mite (*Acarapis woodi*) which infests the tracheae of the bees. They are parasites and feed inside the tracheae and when they reproduce abundantly, they cause death. This disease is more serious in the case of *A. cerana* than *A. mellifera*. Some years ago the outbreak of the acarine disease destroyed thousands of *A. cerana* colonies in the NWFP. The higher susceptibility and destruction of *A. cerana* by the acarine mite has forced beekeepers to opt for *A. mellifera*.

The usual control method of acarine disease includes fumigation (smoke) of Folbex strips which should be done four to five times at weekly intervals. The entry hole is blocked for about an hour while smoke of the Folbex strip is released in the hive.

Vorroa mite (*Varroa jacobsonii*). This is another very serious mite parasite of *Apis mellifera*, found in the mountains. The local bees are less affected. The mites enter the brood cells with young bee larvae and feed on different body parts of bee larvae, thus killing them. The adults are also affected. As ectoparasite, the mites feed on abdomen, throat and other soft parts of bee body. They become sluggish with drooping wings and ultimately die.

Insecticidal Spray

Another serious problem faced by beekeepers in the irrigated plains of the NWFP is that often insecticides are sprayed from the air for the protection of crops from insect-pests. The honeybees get exposed directly to insecticides or their residues on crop plants and get killed. This has resulted in the practical destruction of hundreds of honeybee colonies in the past and has posed a serious threat to the beekeeping industry in the province. There are ways and means by which plants can be protected with insecticides and yet bees can be saved. Greater coordination is needed between the governmental agencies doing the aerial spray and the public, especially the beekeepers who can be forewarned about aerial spraying so that they may either transport their colonies out to some safer locality or confine the bees in the colonies at the time of spray. Use of granular and systemic insecticides is another solution for the protection of not only honeybees but other insect pollinators of crop plants and the useful parasites and predators in the ecosystem. Recommendations have been made by the entomologists of

the province to the government to stop aerial spraying because of serious threat to the existing useful insects including honeybees and also because the conditions in the province are not at all suitable for aerial spraying of insecticides. As a result the government has reduced the aerial spraying of insecticides.

Hornets

A number of hornets and wasps (*Vespa* spp.) have often been seen robbing honey from the hives. The European bee is more bothered by hornets than the local bees. The bee hives can be saved from hornets by locating and destroying the latter's colonies and by putting out poison baits for the hornets.

Ants

Ants are universal in distribution. Different species of ants enter hives to feed upon honey. The bees mind the presence of ants very much. Infestation by ants can be controlled by the destruction of ant hills and colonies in the vicinity of bee hives by spraying and/or flooding with 0.5 per cent solution of Malathion or BHC.

The old yet simple method of placing bowls full of water at the base of the legs of the stand of a bee hive is excellent. This keeps the ants away.

Beekeeping is practised on a small scale almost throughout Pakistan except in the desert areas. Most beekeepers, with the exception of the progressive ones, are still using very old honeybee management methods and are not familiar with modern technology. Therefore, honey yield per colony is low as compared to that in America and Australia. Floral sources are fairly abundant and the climate is quite suitable for beekeeping in most areas in Pakistan. Therefore, there is a great scope for further expansion of beekeeping in the country.

Honeybees are known to play a vital role in the production of crops. Pakistan is one of the countries where honeybees and other insects pollinate flower populations are lowest in the world. As a result, pollination and consequently yields of fruit trees (almond, apple, apricot, etc.) and some varieties of citrus, peach, pear, persimmon, plum, jujube (alfalfa, clover), all seed crops (barley, millets), some varieties of sunflower, vegetable seed crops (cumin, new crops, egg plants, etc.), pumpkin, spinach, radish, turnips are adversely affected. Therefore, the population levels of honeybees and other insect pollinators need to be enhanced to supplement pollination and to increase the yield of these crops.

16

Present Status of Beekeeping in Pakistan

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Introduction

Beekeeping is practised on a small scale almost throughout Pakistan, except in the desert areas. Most beekeepers, with the exception of the progressive ones, are still using very old honeybee management methods and are not familiar with modern technology. Therefore, honey yield per colony is low as compared to that in America and Australia. Floral sources are fairly abundant and the climate is quite suitable for beekeeping in most areas in Pakistan. Therefore, there is a great scope for further expansion of beekeeping in the country.

Honeybees are known to play a vital role in the production of crops. Pakistan is one of the countries where honeybee and other insect pollinator populations are lowest in the world. As a result, pollination, and consequently yields, of fruit trees (almond, apple, apricot, avocado, some varieties of citrus, peach, pear, persimmon, plum), fodder (alfalfa, clovers), oil seed crops (sarson, safflower, some varieties of sunflower), vegetable seed crops (carrots, cole crops, egg-plants, onion, pumpkin, squash, radish, turnip) are adversely affected. Therefore, the population levels of honeybees and other insect pollinators need to be enhanced to supplement pollination and to increase the yield of these crops.

Honeybee Species

There are four species of honeybee in the country: the oriental bee (*Apis cerana* F.), the rock bee (*A. dorsata* F.), the little bee (*A. florea* F.), and the occidental bee (*A. mellifera* L.). Of these, the oriental bee occurs in the northern and western hills and foothills in some parts of NWFP, Punjab and Baluchistan and the rock bee and little bee are found in the foothills, plains and semi-desert areas in all the provinces. The first three species are native to Pakistan. The occidental bee has been established since 1977-78. Now the colonies of this species are reared in almost all the distribution areas of the local three *Apis* species.

Some 14,000 colonies of the occidental bee are, at present, maintained in modern hives by progressive beekeepers. Some 35,000 to 40,000 colonies of the oriental bee are reared in earthen pitchers, log hives, hollow portions of trunks of trees, cavities in the walls of houses and in several other types of hives. Of these, 24 to 35 per cent colonies are usually sub-normal and produce little or no surplus honey. Some 65,000-70,000 colonies of the rock bee occur mostly in the forest areas in the country. These, being wild, move from one place to another depending on the availability of flora. The little bee is also fairly common in some forest plantations. It produces considerably large quantity of honey in Las Bela (Baluchistan), Thatta and Badeen areas (Lower Sind).

Honeybee Flora

More than 800 plant species are known to be visited by bees in Pakistan. Most of these are minor sources of nectar and pollen. Some plants produce nectar in large quantities but these are not sufficiently plentiful and are not important for beekeeping. Honey is produced mainly from a few important honey plants sufficiently common to bees. These include rape and mustard (*Brassica campestris* and *B. juncea*), sunflower (*Helianthus annuus*) and other oil seed crops grown in about 500,000 ha, cotton (*Gossypium* spp.) in 2,262,900 ha, pulses (*Phaseolus* spp., etc.) in 1,335,400 ha, vegetables (*Brassica oleracea*, *B. rapa*, *Cucurbita* spp. etc.) in 144,300 ha, fodder (*Medicago* spp., *Trifolium* spp.) in 1,004,000 ha, maize (*Zea mays*), millets (*Panicum* spp. and *Echinochloa* spp.) and sorghum (*Sorghum* spp.) in 1,617,600 ha, castor (*Ricinus communis*) in 31,500 ha, fruit plants such as apple (*Malus pumila*), almond, apricot, cherries, peach, plum (*Prunus* spp.), citrus (*Citrus* spp.), dates (*Phoenix* spp.), grapes (*Vitis* spp.), guava (*Psidium guajava*), loquat (*Eriobotrya japonica*), pear (*Pyrus* spp.) and pistachio (*Pistacia* spp.), etc. in 368,700 ha. Of these crops, rape, mustard,

pulses and fodders are mainly concentrated in NWFP, Punjab and Sind, cotton in the Punjab and Sind, and temperate fruits in Baluchistan, NWFP and Punjab. Most of these honey sources remain unexploited in the country.

There are different forests spread over an area of 10,487,000 ha in the country. In these forests, several plant species valuable to honeybees abundantly occur depending on the climatic factors such as temperature, rainfall and vegetation etc. These species include some fairly important honey plants such as acacia (*Acacia* spp.), 'siris' (*Albizzia lebeck*), ash (*Fraxinus* spp.), eucalyptus (*Eucalyptus* spp.), 'shain' (*Plectranthus* spp.), mulberry (*Morus alba*), wild olive (*Olea cuspidata*), mesquite (*Prosopis* spp.), 'jaman' (*Syzygium cumini*), tamarix (*Tamarix* spp.), ainul-asl (*Robinia pseudoacacia*), 'shisham' (*Dalbergia sissoo*), 'ber' (*Zizyphus* spp.). In addition, 'shain shobeh' (*Perovskia abrotanoides* and *P. atriplicifolia*), asle-amir (*Vitex negundo* and *V. pseudo-negundo*) also occur in forests. These are important honey plants, but are found in small numbers.

These flora can support 0.5–0.6 million colonies in all the provinces, producing 8,000–10,000 tonnes of honey per annum. It would also help increase the income of farmers and other persons, thereby providing gainful employment to more than 30–40 thousand persons.

Migration of Colonies

Survey in different areas in the country showed that most of the areas do not provide flora to honeybees throughout the year. Therefore, migration of colonies is most essential for honey production and further development of apiculture. Keeping this situation in view, some of the beekeepers migrate their colonies in accordance with the following schedules: maize (*Zea mays*), mesquites (*Prosopis cineraria* and *P. juliflora*), ornamental plants (*Lagerstroemia indica*, *Stenolobium stans*, *Portulaca* spp.) and forest tree (*Acacia modesta*) in Rawalpindi, Hazara Division, Peshawar Valley and Swat in July–August; 'ber' (*Zizyphus* spp.) in Rawalpindi, Khairabad, Peshawar, Malakand during July–September; 'shain' (*Plectranthus rugosus*) in Swat and Hazara in September–October; and 'loquat' (*Eriobotrya japonica*) in the foothills (Rawalpindi, Wah, Haripur, Swabi, Rustum, Bataber and Tarbela) in November–February; sarson and toria (*Brassica campestris*) crops in the plains (Sahiwal, Sargodha, Gujranwala, Gujrat, Lahore, Faisalabad and Jhang) during November–December, in Peshawar Valley and foothills (Jhelum, Rawalpindi, Attock, Haripur, Swabi and Tarbela) during February–March; 'phulai' (*Acacia modesta*) oranges (*Citrus* spp.), 'shisham' (*Dalbergia sissoo*) in the foothill and

plains, and peaches and plums (*Prunus* spp.), pears (*Pyrus* sp.), 'garanda' (*Carissa opaca*) and mesquites in the Peshawar Valley, Rawalpindi and Hazara Divisions during March–April; and clovers (*Trifolium* spp.) in the foothill areas in Rawalpindi, Hazara Division and Peshawar Valley in May–June. Migration of bee colonies in accordance with these schedules increased honey yield three to five times as compared with that of colonies placed in the respective areas, or shifted to their vicinities, throughout the year.

Beekeeping Equipment

A few comb foundation machines for *A. cerana* and *A. mellifera* are available at the government institutes including Pakistan Agricultural Research Council, Islamabad. These have been imported from abroad. Non-availability of Comb Foundation Machine posed a serious problem for getting comb foundation wax sheets. Beekeepers had to travel long distances to get the foundation sheets. But with the development of low cost comb foundation press (price Rs 80 or US\$ 4), the problem of getting the sheets has been completely solved in the country. Most of the other beekeeping equipments are manufactured locally. PARC also prepares hives and other beekeeping articles on a small scale and sells these as samples on a no-loss, no-profit basis.

There are 12 types of bee hives used in various parts of the country: (1) wall, (2) pitcher, (3) log, (4) wall moveable frame, (5) cement moveable frame (cement and sand ratio 1:3), (6) clay and chopped wheat straw (ratio 8:1), (7) Glaucanite ("multani mitti"), newspapers and fine wheat flour and dry agave leaves (ratio 16:4:2:1), (9) cement, sand and newspapers (ratio 2:5:2), (10) clay and rice husk (ratio 15:1), (11) clay and rice husk ash (ratio 25:1), and (12) Langstroth. The first three hives are easy to make, cheap and safe from theft, but their management is difficult and the colony is often destroyed at the time of honey extraction. Hive types 4–11 have been introduced by the Federal Honeybee Research Laboratory for a transitional period to persuade beekeepers to use the modern moveable-frame hives.

1) *The wall hive* is a cavity built in the wall of the house made of natural stone or mud, preferably on the southern side of the house or in the walls facing down the valley. Honey is harvested from the inside of the house after removing the mud from the entrance of the wall hive. This type of hive is commonly used in Swat, Dir and Hazara.

2) *The pitcher hive* is a further development of the wall hive. It is a cavity formed by a clay pitcher inserted horizontally in the wall. A clay lid frequently serves as a covering for the opening inside the house.

3) The *log hive* is made from a section of hollowed out tree trunk with two openings on either sides sealed with a mixture of mud and cowdung. The bee entrance is kept at one end of the wooden cylinder. It is used in some localities in the forest areas in the northern hills. This type of hive is disappearing because of the large amount of wood required for its preparation.

4) *Wall moveable frame hive* consists of a cavity containing moveable frames in the wall of the house. Sometimes, it includes pitchers with moveable frames placed in the wall. This hive is used in Swat and Hazara.

5-11) These hives are manufactured by mixing various constituents with sufficient quantity of water and prepared to form fudge. It is difficult to mix newspapers with other constituents. These are torn into pieces, heated in water (100°C) and mixed well. These materials are used to construct brood chambers, shallow supers and top covering having dimensions of the Langstroth hive. These hives are used by some beekeepers in permanent beekeeping areas in the hills. Prices of these vary from Rs 18 to Rs 30 (US\$ 1-1.5) per hive.

12) *Langstroth or modern moveable-frame hive* is used by progressive beekeepers and other persons such as teachers, professional soldiers, small-scale businessmen or public servants. Price of one complete hive varies from Rs 500 to Rs 1200 depending on the location.

Pests and Predators

1) WAX MOTHS

These pests destroy 8-23 per cent of *A. cerana* colonies traditionally maintained in the wall hives in the northern hills in NWFP. These pests have also been recorded to infest 12-48 per cent colonies of *A. dorsata* in the plains of Punjab, Sind and NWFP. The incidence of these pests has been recorded in up to 10 per cent *A. mellifera* colonies in Punjab and NWFP. Anyhow, the wax moths cause very little damage to the colonies of later honeybee species.

2) HORNETS

Among these *Vespa basalis*, *V. orientalis*, *V. tropica haematodes* and *V. velutina pruthii* are common and destroy adults and brood of bees and honey reserves particularly in crucial floral dearth period during July-October. The occidental bee *A. mellifera* is more susceptible to hornet attack than the oriental bee *A. cerana*.

TABLE 16.1
Investment and income from beekeeping with *Apis mellifera* in Pakistan

Item	Low cost hives/ Stationary colonies	Langstroth hives			
		Part-time beekeeper		Full-time beekeeper	
	5	5	80	250	500
Amount in rupees					
Number of European bee colonies	5				
Capital expenditure					
Package bees @ Rs 600 per 1½ kg	3,000	3,000	48,000	150,000	300,000
Hives (wooden) each @Rs 500 & low cost @ Rs 30	150	2,500	40,000	125,000	250,000
Transport (one Suzuki pick-up)	—	—	—	62,000	62,000
Comb foundation machine	—	—	—	12,000	12,000
Honey extractor	—	—	6,000	7,000	8,000
Nucleus wooden hives each @ Rs 100 and low cost each @ Rs 10	50	500	4,000	10,000	20,000
Pollen traps each @ Rs 200	—	—	2,000	4,000	8,000
Comb foundation sheets @ Rs 50/kg	500	500	8,000	25,000	50,000
Misc. tools	200	200	500	1,000	2,000
Total	3,900	6,700	108,500	396,000	712,000
<i>Cost of Production</i>					
Pollen and nectar					
Migration of colonies	—	—	5,000	15,000	30,000
Supplemental feeding 15 kg per colony @ Rs 9 per kg	675	675	10,800	33,750	67,500
Depreciation (10%) on equipment	40	320	5,250	22,100	36,200
Interest (15%) on capital expenses	585	1,005	16,275	59,400	106,800
Rent of store	—	—	2,400	4,800	7,200
Rent of apiary site in the form of honey	—	—	600	1,500	3,000

Bee Attendant Rs 800 per month	—	—	9,600	28,800	57,600
Misc. expenses	—	100	1,600	5,000	10,000
Total	1,300	2,100	51,525	170,350	318,300
Gross income					
Honey 12 kg in low cost & 18 kg per wooden hive @ Rs 50 per kg	3,000	4,500	72,000	225,000	450,000
Royal jelly 5 kg per 100 colonies @ Rs 1500 per kg	—	—	6,000	18,750	37,500
Wax 1/4 kg per hive @ Rs 30 per kg	37	37	600	1,875	3,750
Pollen 1/2 kg per colony @ Rs 50 per kg	—	—	2,000	6,250	12,500
Package bees 15 kg per 100 colonies @ Rs 400 per 1 1/2 kg	400	400	3,200	10,000	20,000
Total	3,437	4,937	83,800	261,875	523,750
Net income					
Income will be only from honey production in the first year, honey and package bees in the second year and honey, royal jelly, wax, pollen and package bees during third year and onwards.					
First year	1,700	2,400	20,457	54,600	131,700
Second year	2,100	2,800	23,675	64,650	151,700
Third year	2,137	2,837	32,275	91,525	205,450

3) MITES

The outbreak of acarine mite *Acarapis woodi* brought about heavy mortality of *A. cerana* colonies. Some 9,000 colonies of this bee with the progressive beekeepers succumbed to this disease during 1982-83. The disease also attacked some colonies of *A. dorsata*, but remained restricted to few areas. Its incidence on *A. mellifera* was very low as compared with that on *A. cerana*.

Varroa jacobsonii is also fairly common in Swat and Hazara. Its incidence is mostly very low in *A. cerana* colonies. It attacked some colonies of *A. mellifera*, but now it is a minor pest of this honeybee.

Tropilaelaps clareae has been recorded from all the apiaries in Pakistan. Its incidence is very low and it does not cause considerable damage to the colonies.

Diseases

Infection caused by the fungi *Aspergillus flavus* Link. and *A. niger* Van Tieghem, *Apis iridescent* virus and sacbrood disease have been recorded from some areas in the country. The virus has been detected during July-August when there was high humidity and dearth of flora. Anyhow these pathogens rarely cause any considerable loss to the colonies.

Economics

The investment and income is worked out for a stationary beekeeper for maintaining five colonies in suitable area, a part-time beekeeper having 5 and 80 colonies and for full-time beekeepers having 250 and 500 colonies (Table 16.1). Five colonies in low cost hives can be maintained at certain localities without shifting to other locations or by shifting in Langstroth hives, at short distances, while 80, 250 and 500 colonies need to be migrated to different locations depending upon the availability of honeybee flora.

Honey production depends on management technology of the colonies. The occidental bee requires very high management standard. Therefore, it is imperative that the beekeeper should be keenly interested and highly trained in management practices.

Honey Production

Honey is produced by the oriental bee *Apis cerana* in the northwestern hills; by the occidental bee in the hills; foothills and central and southern plains; by the rock bee in the forest areas in the plains and foothills, and by the little bee mainly in the southern plains and semi-

desert areas. The details of approximate honey production by these species are given in Table 16.2.

TABLE 16.2
Honey production by various species

Honeybee species	Quantity (tons)
Oriental bee <i>Apis cerana</i>	225
Occidental bee <i>A. mellifera</i>	240
Rock bee <i>A. dorsata</i>	170
Little bee <i>A. florea</i>	5
Total	640

The wholesale honey price of the producers varies from Rs 40 to Rs 50 per kg depending on the kind of honey and honey harvest. The wholesale intermediary price varies from Rs 60 to 80 per kg. Finally honey in small casks and bottles is sold at the rate of Rs 80-140 per kg in the markets in cities.

In addition to honey, the beekeepers are also producing wax, royal jelly, pollen and propolis on small scale for local use.

Honey Import and Export

Honey is exported and imported on a very small scale. But it is not properly processed and packed by beekeepers in the country. A considerably large proportion of honey ferments and goes waste. Small honey processing and packing plants are required to be set up in beekeeping areas for increasing honey export.

Consequently, a process of desertification and erosion of land has started leading to environmental problems. The performance in terms of productivity of crops is not satisfactory. Realizing this, the attention of governments has shifted from agriculture to cash crops, such as horticulture. This activity is also land-based and has increased pressure on both cultivated and uncultivated lands. Although the growth of this sector is fast but the economy is limited to a few pockets only. This has led to problems relating to disease, reducing fertility, packing material, marketing etc.

The development of livestock sector in this region is lacking a clear long-term sustainable development policies. The pressure on land is increasing leading to degradation and erosion. The other programmes in the name of rural development are creating infrastructures, such as roads, dams, etc., or target oriented development programmes. Almost all are land-based activities and increasing pressure on land.

All these efforts in the development of HH-II region seem to be

Economics of Beekeeping in Hindu Kush-Himalayan (HK-H) Region

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The development efforts scenario in HK-H region can be described as follows: All governments are emphasizing extensive and intensive cultivation to increase agricultural production to meet the food requirement of the fast-growing population. Per capita availability of land is declining and consequently agriculture is being extended to sub-marginal and marginal lands. Consequently, a process of degradation and erosion of land has started leading to environmental problems. The performance in terms of productivity of crops is not satisfactory. Realising this, the attention of governments has shifted from agriculture to cash crops, such as horticulture. This activity is also land-based and has increased pressure on both cultivated and uncultivated lands. Although the growth of this sector is fast but the success is limited in a few pockets only. This too has led to problems relating to disease, reducing diversity, packing material, marketing etc.

The development of livestock sector in this region is lacking a clear long-term sustainable development policies. The pressure on land is increasing leading to degradation and erosion. The other programmes in the name of rural development are creating infrastructure, such as, roads, dams, etc., or target oriented development programmes. Almost all are land-based activities and increasing pressure on land.

All these efforts in the development of HK-H region seem to in-

crease the gap between the efforts and performance i.e. leading to unsustainability of agriculture in mountain areas.

Beekeeping

Here we come up with an activity which is not land-based; does not compete with other developmental efforts; is low capital and time demanding; and yet, has the potential to supplement the income of the rural households. This can be a useful activity/occupation for the landless and poor households, who are the target group of all the governments in their poverty-elevation programmes. There are many direct and indirect benefits of beekeeping and some of them are as follows:

- 1) provide food and income to the landless and marginal farmers
- 2) generate employment if operated commercially
- 3) easier to plan, less investment and elementary skill required
- 4) hive products can be exported to earn foreign exchange
- 5) help in diversifying the economy
- 6) overcome many environmental problems
- 7) increase agricultural and horticultural output
- 8) play a key role in sustainability of mountain agriculture
- 9) important role in human nutrition and health
- 10) conservation of large number of wild plant species

Beekeeping provides opportunity for small, medium and large-scale beekeeping. Person may adopt it as a spare time, part-time or full-time occupation and ensure nutritive food and cash for the family. Bee-management skills are simple to acquire and need a bare minimum infrastructure to start. Apiaries can be established with local material to which the rural population is familiar. The products are non-perishable, have a long-keeping quality and do not require special storage facilities.

Linkage with Agriculture, Horticulture and Animal Husbandry

In the period between 1965 and 1975 the agriculture sector in the region had a major breakthrough in terms of new seeds called HYV's of wheat and maize. Later, the production was further increased through intensive use of inputs such as, fertilizer, irrigation and pesticides. During the early eighties the yield of all the major crops started stagnating and also, increase in input use was not economic and effective. Therefore, this situation called for new sources/methods to increase yield of food and other crops. Beekeeping came to be recognized as a

new hope to increase yields through honeybee pollination. The following crops and plants can be benefited by honeybee pollination:

- 1) Cereals (buckwheat, millets)
- 2) Pulses (soybean, kidney bean, chenopod)
- 3) Oilseed crops (mustard, rape)
- 4) Fruits and Nuts (apple, almond, cherry)
- 5) Forage crops (Alfalfa, clovers)
- 6) Timber trees
- 7) Other natural vegetations
- 8) Medicinal plants
- 9) Wild plant species

Beekeeping, therefore, forms an integral part of different farming systems. Interestingly, beekeeping does not compete with other elements/components of the system. It rather supplements and complements the system. Bees survive on the plant products such as pollen and nectar, which are otherwise wasted. It has been estimated that the value/importance of bees as pollinators of different agricultural, horticultural and fodder crops is 10 to 20 times more than as honey producers.

Role of Hive Products in Human Nutrition and Health

Honeybee products presently used are honey, royal jelly, pollen, propolis, beeswax and bee venom. These materials have been widely used as nutritive foods and for medicinal and pharmacological purposes since ancient times. Extensive research on the chemical and biological properties of honey has shown that it contains most elements found in food and pharmaceutical products. Besides sugar, honey is rich in minerals, proteins and amino acids, vitamins, enzymes and about 181 other minor constituents. It is generally eaten as table honey and is also used in packing, confectionery, preserves, spreads, syrups, meat packing or in cosmetics, etc. Many tribal people in the Himalayan region are almost entirely dependent on honey for sweetness because cane sugar cannot be grown in the hilly regions. Even otherwise, honey is considered superior to other sugars because of its flavour, texture and keeping qualities.

Pollen collected by honeybees is very rich in minerals, proteins, carbohydrates, lipids and is considered a highly concentrated energy source. Pollen products are now being marketed as human food supplements with various nutritional and health benefits. Pollen and pollen protein extracts can serve as bio-stimulants in feeding domestic ani-

mals. For example, pollen feeding increases egg production in poultry by 17 per cent.

Another miracle food produced by honeybees is royal jelly. The nutritional effects of royal jelly may be attributed to the combined action of various components such as sugar, protein, vitamin B, sterols, etc. It is used either as fresh or raw, mixed with honey or freeze dried. Royal jelly improves health and longevity. Several Asian countries have already taken a lead and are among the world's largest producers of royal jelly. For example, Taiwan produces about 150 tons and China about 800 tons of royal jelly.

The above natural products of the hive, besides their nutritive role, also have been used for centuries all over the world in therapy as medical agents. These materials along with bee venom (Acupuncture), beeswax and propolis can cure more than 50 human diseases varying from simple body burns or cuts to complex diseases such as cancer.

Economics of Beekeeping

Presently, the importance of above hive products is undermined because their direct economic gains and indirect benefits are not projected properly. As is the general criticism against economists that they have never taken ecology seriously, similarly, beekeeping has also been bypassed. This may be because the activity was not commercially organized and existed at the household level in rural areas, or because it is very difficult to estimate indirect benefits. There is a need for systematic study of the economics of beekeeping for this region to project the immense importance of this enterprise.

In the absence of any systematic economic study it is difficult to draw any firm policy conclusions but there are a few studies, mainly by bee scientists than economists of the HK-H region, which we have tried to put together. These results provide us few broad guidelines to initiate action to develop beekeeping as an enterprise for different target groups in the mountain areas of HK-H region.

Table 17.1 from Bangladesh shows that beekeeping can be started with very low investment, so that, even the poorest person can go for it with very little support. On the other hand Table 17.2 from Pakistan reveals that this enterprise can be taken up both at the household and commercial levels to generate large profits and greater employment. In Himachal Pradesh in India, this enterprise has a dual purpose i.e. generate income and increase horticultural output. Native *A. cerana* is being replaced by the European bee, *Apis mellifera*. Tables 17.3 and 17.4 relate with the former and Tables 17.5 and 17.6 give accounts of the latter.

TABLE 17.1
Economics of beekeeping with *Apis cerana* in Bangladesh*

Items	Amount (Taka) per colony (Taka 33 = US\$ 1) 1987
I Expenditure	
Bee box	20
Bees	20
Equipment	0
Extractor/filter cloth	20
Sugar	50
Total cost (T)	110
II Income	
Honey	400
Beeswax	80
Total income (T)	480
III Net Return per colony (II-I) = 480 - 110 =	370 T

*Table drawn from Borje Svensson, "Beekeeping Technology in Bangladesh—A Description of Past and Present Situation with Suggested Modifications", pp. 31-32.

If one starts with one hive of native bees and all equipment, the returns will be Rs 369 per year. If the returns are calculated over total investment, there is a loss. Table 17.4 gives a projection of cash flow over ten years. The authors have also tried to give an optimal number of colonies per household i.e. 10 to be raised in five years by adding two colonies each year. The net income generated per year with 10 colonies will be around Rs 4,023. The assumption under suggestion of 10 colonies per household is that with this number this activity will be a sideline or part-time enterprise and will be no extra strain on the household.

The economics improves with the introduction of European bees, the net profit doubles and reaches Rs 10,735 per year. This is mainly because of the higher yield of these bees.

Presently, the Himachal government is providing incentives in the form of 50 per cent subsidy on capital cost to introduce *Apis mellifera*, and that is a debatable issue.

Tables 17.7 and 17.8 show the economics of beekeeping in Nepal. Table 17.7 gives account of net returns per colony with *Apis cerana*. The returns per colony per year are Rs 1,795. This high profit is mainly because of the high price of honey in Nepal and not because of higher yield. Table 17.8 details about ten years cash flow for the beekeeping enterprise with a size of 10 colonies. After the fifth year the profit crosses over Rs 20,000 per year for 10 hives. If managed at a commercial level the profits may be quite high.

TABLE 17.2
Economics of beekeeping with *Apis mellifera* in Pakistan, 1988*

Items	Amount (Pak. Rs.)
I Capital Expenditure	
Package bees @ Rs 600 per 1/2 kg	60
Hives (wooden) @ Rs 500 each	50
Honey extractor	—
Nucleus hives each @ Rs 100	100
Comb foundation sheets @ Rs 50/kg.	10
Misc. tools	20
Total Fixed cost	240
II Variable Cost	
Supplement feeding (15 kg per colony @ Rs 9 per kg)	135
Misc. Expenses	20
Total variable cost	155
III Total Cost (I + II)	395
IV Gross Income	
Honey (18 kg per colony @ Rs 50 per kg)	900
Wax (1/4 kg per hive @ Rs 30 per kg)	7.4
Total income	907.4
V Net Return	
Return over variable cost (IV—II) =	Rs 752.4
Return over Total cost (IV—III) =	Rs 512.4

*Table drawn from article by Ahmad, R.(1988) "Beekeeping in Pakistan", *Progressive Farming*, 8(2): 32–37.

All these tables show clearly that beekeeping is a profitable enterprise and has good scope in the mountain areas where forage for the bees is available. Some other findings are as follows:

1) The initial investment in this enterprise is very low as compared to any other productive activity.

2) The returns are low with only one or two colonies but has flexibility to increase up to size of 10 without much investment.

3) Beekeeping can be taken up as a poverty-elevation programme requiring little support/subsidy in the initial years.

TABLE 17.3

Cost and returns of beekeeping enterprise with Indian hive bee
Apis cerana in Himachal Pradesh (India), 1989

			(per hive)
Item	Price (Rs.)	Life years	Cost/year (Rs.)
I. COSTS			
A. Fixed Costs:			
Bees	25.00	10	2.50
Bees veil	25.00	3	0.75
Hive tool	15.00	10	0.15
Smoker	30.00	5	0.60
Honey extractor	300.00	5	6.00
Uncapping tray and knife	250.00	5	5.00
Village hive	150.00	10	15.00
Hive stand	25.00	10	2.50
Sub-total	820.00	—	32.00
B. Variable costs:			
Comb foundation sheet	40.00	1	40.00
Hessian cloth	8.00	1	8.00
Sugar (5 kg @ Rs. 8/- per kg)	40.00	1	40.00
Acaricide and other drugs	2.00	1	2.00
Sub-total	90.00	—	90.00
Total costs (A + B)	910.00	—	122.50
II RETURNS			
Honey (8 kg @ Rs. 60/- per kg)			480.00
Beeswax (0.15 kg @ Rs. 75/- per kg)			11.25
		Total returns	491.25
III NET RETURNS (II-I)			368.75

Source: Verma, L.R. (1989), "Apiculture as a component of Hill Farming Systems: Case of Himachal Pradesh", Report from Department of Bio-Sciences, H.P. University, Shimla, India.

TABLE 17.4
Cash flow projection of beekeeping enterprise with Indian
honeybee *A. cerana* in Himachal Pradesh (India), 1987

Item	Years									
	1	2	3	4	5	6	7	8	9	10
A. Cash outflows										
i) Bees*	50	50	50	—	—	—	—	—	—	—
ii) Villagers hive**	300	300	300	300	300	—	—	—	—	—
iii) Hive stand	50	50	50	50	50	—	—	—	—	—
iv) Bee veil	25	—	—	25	—	—	25	—	—	25
v) Hive tool	15	—	—	—	—	—	—	—	—	—
vi) Smoker	30	—	—	—	—	30	—	—	—	—
vii) Honey extractor	300	—	—	—	—	300	—	—	—	—
viii) Uncapping tray and knife	250	—	—	—	—	250	—	—	—	—
ix) Comb foundation sheet	80	160	240	320	400	400	400	400	400	400
x) Sugar (10 kg @ Rs. 8/- per kg)	80	160	240	320	400	400	400	400	400	400
xi) Hessian Cloth	16	32	48	64	80	80	80	80	80	80
xii) Acaricide	2	4	6	8	10	10	10	10	10	10
Total	1198	756	934	1087	1240	1470	915	890	890	915
B. Cash inflows										
i) Honey (8 kg per hive @ Rs. 60/- per kg)	960	1920	2880	3840	4800	4800	4800	4800	4800	4800
ii) Bees wax (0.30 kg @ Rs. 75/- per kg)	22	45	68	90	113	113	113	113	113	113
Total	982	1965	2948	3930	4913	4913	4913	4913	4913	4913
C. Net cash flow (—) (B—A)	216	1209	2014	2843	3673	3443	3998	4023	4023	3998

*Two beehives to be added up to three year and then can generate at their own.

**10 hives per household is an ideal size and these to be raised over five years by increasing two hives each year.

Note: All costs and returns are calculated at constant price and constant honey yield per colony.

TABLE 17.5

**Cost and returns of honey production in beekeeping with
European honeybee *Apis mellifera* in Himachal Pradesh, 1989**

(per hive)

Items	Cost (Rs)	Life (Years)	Cost/Year/Colony (Rs)
I. COSTS			
A. Fixed costs:			
Bees	200.00	10	20.00
Bee veil	25.00	3	0.75
Hive tool	15.00	10	0.15
Smoker	30.00	5	0.60
Honey extractor	750.00	5	15.00
Uncapping tray/knife	250.00	5	5.00
Village hive	327.00	10	32.70
Hive stand	25.00	10	2.50
Subtotal	1622.00	—	76.70
B. Variable costs:			
Comb foundation sheet	150.00	1	150.00
Hessian cloth	8.00	1	8.00
Sugar (10 kg Rs 8/- per kg)	80.00	1	80.00
Acaricide and other drugs	2.00	1	2.00
Subtotal	240.00	—	240.00
Total cost (A + B)	1862.00	—	316.70
II. RETURNS			
Honey (20 kg per hive @ Rs 60/- per kg)	1200.00		1200.00
Beeswax (0.5 kg @ Rs 100/- per kg)	37.50		37.50
Total Returns	1237.50		1237.50
III. NET RETURNS (II-I) =	- 624.50		920.30

TABLE 17.6
Ten years cash flow projections of honey production from European
honeybees *Apis mellifera* in Himachal Pradesh, 1989

Items	Years									
	1	2	3	4	5	6	7	8	9	10
A. Cash outflows:										
i) Bees	400	400	400	—	—	—	—	—	—	—
ii) Langstroth hive	654	654	654	654	654	—	—	—	—	—
iii) Hive stand	50	50	50	50	50	—	—	—	—	—
iv) Bee veil	25	—	—	25	—	—	25	—	—	25
v) Hive tool	15	—	—	—	—	—	—	—	—	—
vi) Smoker	30	—	—	—	—	30	—	—	—	—
vii) Honey extractor	750	—	—	—	—	750	—	—	—	—
viii) Uncapping tray/ knife	250	—	—	—	—	250	—	—	—	—
ix) Comb foundation sheet	150	300	450	600	750	750	750	750	750	750
x) Sugar (20 kg Rs. 8/- per kg for two colonies)	160	320	480	640	800	800	800	800	800	800
xi) Hessian cloth	16	32	48	64	80	80	80	80	80	80
xii) Acaricide	2	4	6	8	10	10	10	10	10	10
Total	2502	1760	2088	2041	2344	2670	1665	1640	1640	1665

B. Cash inflows:

i) Honey (8 kg/colony

@ Rs 60 per kg)

ii) Bee wax (0.5 kg)

(1 kg per two

colonies; Rs 75/-

per kg)

	2400	4800	7200	9600	12000	12000	12000	12000	12000	12000
Total	2475	4950	7425	9900	12375	12375	12375	12375	12375	12375

C. Net Cash Flow (B-A)

	-27	3190	5337	7859	10031	9705	10710	10735	10735	10710
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Note: The cash inflows and outflows are calculated at constant price and constant honey yield per colony.

TABLE 17.7
Economics of beekeeping in Nepal, 1988

Asian hive bee <i>Apis cerana</i>			
Items	Price (Rs.)	Life (years)	Cost/year/colony (Rs.)
I. COSTS			
A. Fixed costs:			
Bees	500.00	10	50.00
Bee hive	75.00	3	25.00
Hive tool	50.00	10	5.00
Smoker	50.00	5	10.00
Honey extractor	1000.00	5	200.00
Uncapping tray/knife	200.00	5	40.00
Village hive	1000.00	10	100.00
Subtotal	2875.00	—	430.00
B. Variable costs:			
Comb foundation sheet	150.00	1	150.00
Hessian cloth	10.00	1	10.00
Sugar	60.00	1	60.00
Acaricide and other drugs	5.00	1	5.00
Subtotal	225.00	—	225.00
Total Cost (A + B)	3100.00	—	655.00
II. RETURNS			
Per Year (Rs.)			
Honey (8 kg @ Rs 300/kg)			2400.00
Beeswax (0.5 kg @ Rs 100/kg)			50
Gross Income =			2450.00
III. NET RETURNS (II-I)			
(Gross income - Total cost)			1795.00

Source: Himal Bee Concern, Kirtipur, Kathmandu.

TABLE 17.8
Ten years cash flow projections for beekeeping enterprise with Asian hive bee *Apis cerana* in Nepal, 1989

Items	1	2	3	4	5	6	7	8	9	10
A. Cash outflows:										
i) Bees	1000	1000	—	—	—	—	—	—	—	—
ii) Village hive	2000	2000	2000	2000	2000	—	—	—	—	—
iii) Bee veil	75	—	—	75	—	—	75	—	—	75
iv) Hive tool	50	—	—	—	—	—	—	—	—	—
v) Smoker	50	—	—	—	—	50	—	—	—	—
vi) Honey extractor	1000	—	—	—	—	1000	—	—	—	—
vii) Uncapping tray/ knife	200	—	—	—	—	200	—	—	—	—
viii) Comb foundation sheet	300	600	900	1200	1500	1500	1500	1500	1500	1500
ix) Sugar	120	240	360	480	600	600	600	600	600	600
x) Hessian cloth	20	40	60	80	100	100	100	100	100	100
xi) Acaricide	10	20	30	40	50	50	50	50	50	50
Total	4825	3900	3350	3875	4250	3500	2325	2250	2250	2325
B. Cash inflows										
i) Honey (8 kg/colony @ Rs 300 per kg)	4800	9600	14400	19200	24000	24000	24000	24000	24000	24000
ii) Beeswax (0.5 kg)	50	100	150	200	250	250	250	250	250	250
Total	4850	9700	14550	19400	24250	24250	24250	24250	24250	24250
C. Net cash flow (B-A)	25	5800	11200	15525	20000	20750	21925	22000	22000	21925

18

Apis cerana Beekeeping in Japan

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Apis cerana japonica Rad., a subspecies of *A. cerana* lives in Honshu and the southern islands of Japan. The northernmost known location is Higashidori village on the Shimokita peninsula in Aomori Prefecture (41°N, 141°E) (Okada, 1985). Historically, the first record of keeping these bees in AD 627 appeared in a document, but only a few comments can be found in Japanese literature until the end of the 18th century when several publications described the nature of these bees and the beekeeping techniques (Watanabe, 1981).

One beekeeper recorded his experiences for about 40 years until 1904. According to his records, he harvested 17.3 tons of honey from 3,619 colonies from 1882 to 1902 for an average of 4.8 kg of honey per colony. His standard hives (40 × 30 × 24 cm high) were hand-made. After the introduction of European honeybees, *Apis mellifera*, into Japan in 1880, commercial beekeeping developed rapidly. The recent situation of Japanese beekeeping has been described previously by Sakai and Matsuka (1982); about 300,000 colonies produce about 6000 tons of honey each year. Pollination of strawberries in greenhouses as well as other crops in fields is very common and requires a further 100,000 colonies (Matsuka and Sakai, 1989). By contrast, traditional beekeeping with *A. c. japonica* has decreased. This is because of the inferior management and honey harvest resulting from primitive keeping methods, poor honey production compared to *A. mellifera*, frequent

absconding, and tendency to being robbed easily when coexisting with *A. mellifera*.

Currently, the Tsushima islands, which are the closest islands to Korea, are unique because only *A. cerana* colonies are kept there. About 4000 colonies are kept by about 1000 people (Yoshida, personal communication). The total number of *A. c. japonica* colonies in Japan is estimated to be 50,000 to 100,000 including natural colonies. In a few other regions besides Tsushima, people try to keep Japanese honeybees isolated from *A. mellifera* to maintain a more natural environment.

Since *A. c. japonica* beekeeping is on a small scale, the management techniques are primitive and vary individually. Standing-log hives are popular, although box type hives are also common. In spring, bait hives are set at places where people know swarms can be trapped. These colonies are moved to a suitable place where they are kept throughout the honey-flow season or until autumn. Usually honey is harvested once a year. Movable frames are seldom used so the honey harvest depends on crushing whole combs or cutting out parts of them. The product generates only a bonus income although the price of *A. c. japonica* honey is more than five times that of honey from *A. mellifera*. Local people prefer its different taste and flavour. Some believe in its medicinal value. *A. c. japonica* beekeeping could be reconsidered from the economic and health-oriented value of the honey product.

Yoshida *et al.* (1989) reported a method of keeping *A. c. japonica* in a movable-frame hive developed from a Langstroth hive. Modifications were: (1) an empty box was placed at the bottom below the brood chamber, (2) comb foundation with a smaller cell size was used, (3) the frame top bars were thinned to create narrower bee space. With this new type of frame, the same extractor as used for *A. mellifera* can be used to harvest honey. Further improvements will be made in the future.

Biological Aspects of *A. cerana* Related to Beekeeping

A. c. japonica is an independent subspecies of *A. cerana*, as indicated by Ruttner (1988). The biology of the Japanese honeybee has already been outlined by several researchers (see Sasaki *et al.* 1989). A former director of our institute, Dr. Okada investigated colonies at various locations in Japan and observed his own colonies to compile data concerning their biology, keeping and harvesting methods, honey plants, and enemies.

A. c. japonica seems to be adapted for a northern climate. Wintering cluster works fairly well and enables them to survive the severe winters of northern Honshu where the minimal temperature falls be-

low -20°C . The increased colony size may be related to cold hardiness and it may be advantageous for beekeeping because more honey can be harvested from a colony. The colony size is, however, smaller than that of *A. mellifera* colonies. Research in Asia has shown some differences between their *A. cerana* and *A. c. japonica*. These differences should be investigated in basic and applied fields by future cooperative research.

On the other hand, the common characters of *A. cerana* subspecies are separate from those of *A. mellifera*. Beekeeping in Asian countries should make the best use of these characteristics. In particular, it is now possible to utilize the best genetic characteristics of each species to produce a new hybrid.

In this connection, a remarkable feature is *A. cerana*'s strategies against enemies such as *Varroa* mite (Peng et al., 1987), and Vespids (Ono et al., 1988). *A. cerana* is more resistant and defensive against these enemies than *A. mellifera*. This fact may be vital to beekeeping in Asia. There are also some differences among the honey plants they visit. This is a problem worthy of study. Asian plants and crops may need their co-evolved Asian pollinators.

We are now investigating the qualitative chemical differences of beeswax. Wax from *A. cerana* contains much higher levels of free fatty acids than wax from *A. mellifera*. Specific and suitable uses could be developed for the former.

Another feature of Asian beekeeping depends on the difficult co-existence of *A. cerana* and *A. mellifera*. Severe robbing has been experienced between these species in Japan because they occupy similar niches in the ecosystem. Their territoriality or competition should be considered when *A. mellifera* is to be introduced into an Asian region.

Dedication and Acknowledgement

This small article is dedicated to Dr. Ichiji Okada. Emeritus Professor of Tamagawa University and the first director of our institute, for his 80th anniversary. The author is grateful to Dr. L.R. Verma for his offering the opportunity of this contribution.

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19

Beekeeping Problems in Developing Countries of South East Asia

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Introduction

The first description of honeybees in South East Asia (S.E. Asia) appeared about 1000 years ago, describing a comb of bees and a description of using honey was found at Angkor Wat in Cambodia (Giteau 1976). Some ancient medicinal recipes were inscribed in stone during the reign of King Jayavarman VII (1181–1215) in the Surin province, telling of the use of medicinal plants mixed with honey as well as the use of beeswax for candles and cosmetics (Kaewklai 1985). There are two illustrations of native honeybees in the Natural Museum of Thailand, showing presumably a giant honeybee, *Apis dorsata* and a dwarf honeybee, *A. florea* (Wongsiri and Tangkanasing 1986a). The raising of the honeybee, *A. cerana*, began over a hundred years ago in Thailand when the villagers started to keep bees in coconut plantations on Samui Island (Areekul 1979).

Modern beekeeping in S.E. Asia started in the early forties. European honeybees, *Apis mellifera* in movable-frame hives were introduced at Chulalongkorn University (Thailand) for research, and also reported the result of *A. cerana* beekeeping (Wanitwattana 1940). After the Second World War, a report on *A. cerana* beekeeping was prepared by Saman Watanakit in 1953 at Kasetsart University, and it was also reported in Vietnam at the same time (Mulder 1988). Sub-

sequent introductions of modern beekeeping of *A. cerana* to Samui Island (Thailand) were made, however, beekeeping did not succeed as an industry until the early seventies. Table 19.1 shows the number of beekeepers and of their colonies of *A. mellifera* and *A. cerana* in 1986 in Thailand. There was a boom in beekeeping after 1980, due to the low honey production from the native bees. The number of colonies of *Apis cerana* in S.E. Asia showed less increase as compared to *A. mellifera* colonies which reached the number of 100,000 in 1988 (Tables 19.1 and 19.2).

TABLE 19.1

**Number of *Apis mellifera* and *A. cerana* colonies in Thailand
(Thai Department of Agriculture 1986)**

Area	<i>Apis mellifera</i>		<i>Apis cerana</i>	
	No. of Beekeepers	Colonies	No. of Beekeepers	Colonies
North	612	28,800 2,000*	50	310
North East	182	2,500	62	620
Central	81	1,600	51	90
East	54	1,490	40	201
West	41	630	311	810
South	31	1,300	312	5,920
Total	1,001	38,320	826	7,951

*Non-members of the Northern Beekeepers Association.

TABLE 19.2

**Number of *A. cerana* and *A. mellifera* colonies in some countries
of South East Asia (Advance Course in Beekeeping with *Apis cerana*
in Tropical and Subtropical Asia, 1988)**

Area	No. of Beekeepers	<i>Apis cerana</i>	<i>Apis mellifera</i>
		Colonies	Colonies
Thailand	826	10,951	50,000
Malaysia	483	5,000	*
Indonesia	600	30,000	20,000
Philippines	66	500	2,000
Vietnam	3,000	11,000	29,000
Sri Lanka	*	12,000	*
Total	*	69,451	101,000

*No reports.

Present Beekeeping

At present, four species of honeybees are present in S.E. Asia: the giant honey bee, *A. dorsata*; the dwarf honey bee, *A. florea*; the Eastern honey bee, *A. cerana* and the European honey bee *A. mellifera*, which includes Italian bees, *A. m. ligustica*, and Carniolans *A. m. carnica*. The biology of *A. cerana* has been studied by Atwal and Goyal (1969), Ruttner et al. (1972), Ruttner et al. (1973), Woyke (1976), Areekul (1979), Seeley et al. (1982), Wongsiri and Tangkanasing (1986b) and Wongsiri (1987).

Apis cerana F. covers a very large area of different climatic conditions across 60 west-east and 56 north-south in Asia. A preliminary morphometric statistical analysis revealed three major subspecies groups: (1) *A. c. cerana* in the entire north of the area, from Afghanistan to Peking, (2) *A. c. indica* in south India, Sri Lanka, Burma, Thailand, Vietnam, Laos, Cambodia, Malaysia, Indonesia and the Philippines, (3) *A. c. japonica* in Japan (Ruttner 1988).

Based on discussion with beekeepers and a review of the statistical records of the Advanced Course (1988) in beekeeping with *Apis cerana* we estimate that there are now more than 60,000 colonies of *A. cerana* maintained in hives (Table 19.2). There are also many wild *A. cerana* colonies throughout the countries.

Beekeeping with *A. cerana* in S.E. Asia has not advanced to the same level as presently found in China and in India (Wongsiri et al. 1986). In most cases the colonies are wild colonies transferred to modern hives. These bees can produce 5–10 kg of honey per year (Wongsiri and Tangkanasing 1986a). They are very prone to swarming and absconding, their egg-laying rate is lower than *A. mellifera*, and no method of queen rearing is practised except in research (Wongsiri et al. 1986). The method for rearing queens of *A. mellifera* (Laidlaw 1979) was applied to *A. cerana* queen rearing at the Chulalongkorn University Bee Biology Research Station in Samut Songkram province, where up to 90 per cent of the grafted larvae were accepted (Wongsiri 1988).

There are more than one hundred species of cultivated and wild plants in Thailand which are sources of nectar and pollen for honeybees (Areekul 1979; Pyraman and Wongsiri 1986). In S.E. Asia, the most important ones that have been reported at present are: coconut, *Cocos nucifera* Linn.; longan, *Euphoria longana* Lamk.; litchi, *Litchi chinensis* Sons.; rambutan, *Nephelium lappaceum* Linn.; durian, *Durio zibethinus* Linn.; rubber tree, *Hevea brasiliensis* Muell. Arg.; maize, *Zea mays*; snake root grass, *Eupatorium odoratum* (Linn.); kapok, *Ceiba pentandra* Gaertn. and mimosa plants, *Mimosa* spp. Maize only provides pollen but the authors observed honeybees vigorously collecting its pollen during a dearth of other sources. Because of the large va-

riety of plant species and blooming times, sources of nectar and pollen exist throughout the year in some areas. At other locations there are dearth periods. For example, from July to October there is a shortage of food sources for honey bees in the central part of Thailand, but in the southern part along the Gulf there are large areas of plantations with coconut trees that bloom all year round. This is suitable for migratory beekeeping of *A. cerana* (Table 19.3).

Problems

HONEY PRODUCTION BY *APIS CERANA*

Honey production of *A. cerana* had been limited for a long time by outdated management methods in S.E. Asia and South China (Wongsiri et al. 1986). The colony numbers and yields did not increase until new methods were adopted. In Chonghua county, Guangdong, China there were a total of 2,000 colonies of *A. cerana*, an annual yield of approximate 10,000 kg honey or an average of less than 5 kg honey from each colony. After adopting modern methods, the colony number and honey yields increased year by year. By 1963, honeybee populations expanded to 6,000 colonies with an annual yield of 300,000 kg honey (a nearly 50 kg honey average per colony).

THE PEST OF *APIS CERANA*

A. cerana does not seem to have enemies which cause problems comparable to those found with *A. mellifera*. However Wongsiri et al. (1987) have found that the wax moth (*Galleria mellonella*) is a problem in managed colonies of *A. cerana*. Mites do not appear to be a problem with *A. cerana* with several reporters saying they have never seen mites or symptoms of their damage. Other beekeepers and scientists said that the common practice of removing all combs for honey extraction controls the mites. The fact was considered to be the result of the mechanism of mite resistance particularly the cleaning behaviour of *A. cerana* workers (Peng et al. 1987; Wongsiri et al. 1987).

BIOLOGY OF *APIS CERANA*

On the other hand, most beekeepers report significant problems with swarming and especially absconding. A beekeeper with the most colonies of *A. cerana* in Thailand (about 50) told that more than half of his colonies always abscond after he removes all combs for honey extraction. However the recent successful report is able to regulate 90 per cent of them by the scientific method, preventing absconding (Wongsiri 1987).

TABLE 19.3

Seasonal beekeeping cycle with *Apis cerana*, on the cultivated coastal plain of Samut Songkram and Samui Island, Thailand

Month	Samut Songkram (Central)	Samui Island (South)
January	Blooming time of snake root, <i>Eupatorium odoratum</i> and coconut, <i>Cocos nucifera</i> .	Most colonies are now in the jungle.
February	Continue blooming time of coconut, (Some hives can move to Chantaburi for honeyflow in rubber plantation).	<p>Beekeepers put out trap hives to attract the swarms moving from the jungle (interior, uncultivated) to the plain.</p> <p>Time of coconut and sensitive plant, <i>Mimosa pudica</i>.</p> <p>Colonies, now in hives in apiaries, expand their populations.</p> <p>Enough honey has been stored to enable the beekeepers to harvest honey.</p> <p>Honey storage continues, and colonies rear queens, preparatory to (reproductive) swarming, and swarms issue.</p> <p>If colonies could be divided now (to increase numbers) they would be much less likely to swarm/abscond.--</p> <p>Honey storage and harvest continues. October -December is the rainy season in the southern Thailand.</p>
March	Blooming time of nipa, <i>Nypa fruticans</i> (Continual honeyflow in Chantaburi).	
April	Best time for honey harvesting. Lowest moisture and hottest month in Thailand	
May	Honey storage continues. May-July is a natural mating and swarming.	
	May-October is the rainy season.	
June to September	Queen rearing time and dividing colonies, management before next honeyflow. Replace new queens and feeding syrup to the colonies.	
October	Abscending, if food is not enough, coconut flower blooming is almost all year round.	Honey flow ceases, but pollen may be available, colonies abscond to the honey flow in the jungle.

Contd.

Table 19.3. Contd.

Month	Samut Songkram (Central)	Samui Island (South)
November	Abscending continues, as in October.	As in October.
December	Weed flowers are starting to bloom but still feeding syrup if shortage of food.	Most colonies are now in the jungle.

• By the observation of Dr. Eva Crane and the authors during our study of *Apis cerana* at Samui Island.

• What is called "abscending" may be partly or largely a seasonal migration from a resource poor area on the plain to a resource-rich area in the jungle (Wongsiri and Tangkanasing 1986).

The authors observed much variation within Thai *A. cerana* for stinging behaviour. Some colonies were very gentle; one colony did not sting anyone in a group of observers standing around it, even when a comb was dislodged and fell to the bottom of the hive. Other colonies at the slightest disturbance would disgorge many bees ready to sting. Choice of gentle bees should be kept in mind in any selection programme (Sylvester and Wongsiri 1986).

The knowledge of *A. cerana* biology is limited compared to *A. mellifera*, but a successful method of advanced beekeeping of this species can be worked out only when the details are better known.

The Effects of Import of *Apis mellifera* L. to S.E. Asia

European foulbrood is caused by *Streptococcus pluton* (Bailey 1981). It has long been recognized in Europe and North America and has been diagnosed more recently in Thailand. In 1988, we found this disease caused absconding of 18 *A. cerana* colonies from 30 colonies in BBRU, Chulalongkorn University. It was believed to be contaminated by *A. mellifera* colonies which were located in the same area. This disease was also found to be more serious in *A. cerana* in Vietnam (Mulder, 1988).

The Effects of *A. mellifera* to *A. cerana*

The comparative aggressiveness of *A. mellifera* and *A. cerana* were studied. It was found that, in general, a stronger colony was more aggressive than a weaker colony. It was not depended on species. Under favourable natural conditions, *A. mellifera* will increase rapidly even in the presence of *A. cerana*. Ten colonies of *A. mellifera* in Chantaburi were robbed by the stronger colonies of *A. cerana* every day until we managed and combined together to be a few stronger colonies. Only weak colonies of *A. mellifera* were robbed by *A. cerana* and vice versa. The strong colonies of both species can stand side by side in the same area without robbing. But *A. mellifera* had been very difficult to maintain in the natural condition without any special care-taking by beekeepers in Thailand where *A. cerana* and *A. dorsata* are. However, in Japan it was shown that robbing by *A. mellifera*, seriously damaged colonies of *A. c. japonica* and dominated this native species (Okada 1985). The mating flight times of both species were found to be overlapping and this might be the result of reduction in mating of *A. cerana*.

Research Needs

The most pressing research and transfer technology need for *A. cerana* is to find, through research or from other countries, an efficient and reliable method of queen rearing. Research on other problems cannot be effectively conducted until the reproduction of the bees can be controlled by researchers.

The next major need is to find ways of controlling absconding and swarming, either through management or selection. It is very difficult to conduct research or keep bees profitably when a high percentage of the colonies abscond and swarm.

The final major need is to develop efficient methods of managing *A. cerana*, probably while simultaneously selecting and breeding improved stock. The best management methods and stock will depend greatly upon what role *A. cerana* comes to play in beekeeping in S.E. Asia. This role will probably be very limited if the problems of queen rearing, absconding and swarming are not solved.

The solution of these problems will depend on our scientific advancement and improvements in management techniques. In the future, we think the Eastern honeybee, *A. cerana*, should be reared in modern hives instead of the old method. The adoption of scientific queen rearing and artificial insemination techniques are necessary. Since 1957, some work has been done in this area in China and useful experiences are accumulating. The Chinese researchers and bee scientists at Chulalongkorn University have developed a technique to meet the problems of transferring *A. cerana* into modern hives, the increase in colony reproduction, the selection for high honey yield, the control of bee diseases, the commercial queen rearing, the colony splits, and others (Wongsiri et al., 1986).

Conclusion

Beekeeping in S.E. Asia, especially in Thailand with *A. mellifera*, has increased greatly in the last few years and is now an established industry. Recognition of parasitic mites as a problem and development of methods for their partial control has contributed greatly to its expansion. Significant problems still remain in adapting *A. cerana* beekeeping to S.E. Asia. However, these problems are amenable to research and training efforts. Since, the reproductive biology of *A. cerana* has been under investigation by the Bee Biology Research Unit, Chulalongkorn University and a modern beekeeping research and development has been done in University of Pertanian, Malaysia. *A. cerana* will become the favoured species for small-scale beekeeping in

S.E. Asia where a low capital investment is important, especially if the problems of queen rearing and absconding can be solved.

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PART VI

Beekeeping Training and Research

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Beekeeping Research and Training in Hindu Kush-Himalayan Region: Future Perspectives

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Introduction

Generally speaking, it may be said that beekeeping with native hive bee "*Apis cerana* F." in many countries of HK-H region is still an old traditional household activity. It is mostly the small and marginal farmers in this region who keep only a few colonies of *A. cerana* in different types of traditional hives, and even today honey is generally harvested by squeezing the whole comb and is sold in pre-used utensils of different types without any quality control standards. This raises an important question as to why beekeeping with *A. cerana* has not developed on modern lines to the extent as it has on commercial scale with the European honeybee, *Apis mellifera* L. despite the fact that beekeeping with this native bee species has been closely linked with the cultural heritage of the rural people of this region.

In Nepal, beekeeping has been a traditional household activity since the time immemorial. There are areas where even with the traditional methods, beekeeping has flourished well. Beekeeping has also been associated with some communities like Chepang in central Nepal. Beekeeping is also carried on elsewhere in Nepal, specially in the mid-hills. However, beekeeping methods still rely on the use of hollow logs

and wall receptacles with fixed combs, thus, the traditional way of beekeeping in Nepal is still a primitive and imperfect one with great potential for improvement. This is also true in case of other countries of the region.

Recently, improved methods of beekeeping have drawn much attention in Nepal. Efforts are being made to develop beekeeping in some districts mainly in the midhills and some in the Terai. The beekeeping training and extension support project of HMG, Nepal and SNV, Nepal, now in its second year, at the cost of Rs. 18 m. is being implemented for six years on doing training, extension and construction activities. Similarly, other institutions like, G.T.Z., U.S.A.I.D., J.O.C.V. and social service organizations are also engaged in aspects of beekeeping development in Nepal.

Favourable Aspects of Beekeeping with Himalayan Hive Bee, *A. cerana*

Himalayan bees have many valuable characteristics of biological and economic importance which have not yet been scientifically explored. Some of them are mentioned here.

1. Bees are gentle to handle, industrious and better adapted to the ecological conditions of south and south-east Asia.

2. Himalayan bees are also less susceptible to *Nosema* disease, do not have serious problems with *Varroa* mite, and are less prone to the attack of predatory wasps.

3. The European honeybee, *A. mellifera* requires chemical treatment of colonies to control diseases, parasites and predators: no such use of chemicals is required in beekeeping with *A. cerana*.

4. A variety of geographic races/populations of *A. cerana* in the entire Himalayan region provide excellent opportunities for the genetic improvement of this native bee species through selective breeding.

5. It may also be safely concluded that Himalayan bees are more suitable to cross-pollinate entomophilous crops grown in small holdings of this region due to its shorter flight range and longer foraging hours than exotic one and also with other natural flora and fauna, they have coexisted together during the entire evolutionary processes.

6. In addition, through the genetic engineering techniques, it may be possible in the future to introduce genes that code for desirable characteristics of *A. cerana* into the populations of *A. mellifera*.

7. *A. cerana* can also co-exist with other native species of honeybees without any adverse ecological consequences.

Some Problems in Beekeeping with *A. cerana*

It is observed that *Apis cerana* has not become very popular with beekeepers because of its several inherent behavioural characteristics. They include frequent swarming and absconding, proneness to robbing, production of large number of laying workers, and lower honey yields per colony, etc. These negative traits of *A. cerana* vary from apiary to apiary and country to country depending on the expertise, experience and knowledge of the beekeeper managing the apiary.

Sacbrood virus disease has been another problem in recent years with *A. cerana* in several countries of the Hindu Kush-Himalayan region including Thailand, Pakistan, Nepal, China, Burma and India. It is revealed that this disease generally has a five-year cycle. After this period, few colonies escape or become resistant to the attack of this disease. In a period of five years, after the incidence of this disease, the normal population of *A. cerana* colonies has been restored in Nepal.

One of the other major constraint in *A. cerana* beekeeping is the lack of information on them. At present, knowledge from *A. mellifera* is often being used on *A. cerana* with little or no success. Hence, it is now well-established that Asian bees need more attention in terms of resources for the generation of technological information on them.

Beekeeping with *A. cerana* versus *A. mellifera* in Hindu Kush-Himalayan Regions

One of the reasons that beekeeping with *A. cerana* has not made much progress is due to the fact that several national and international agencies are focussing their attention on the introduction and acclimatization of *A. mellifera* at the cost of *A. cerana* in Asia. Such attempts date back to the beginning of this century and it is only after 1960 that some success in beekeeping with exotic *A. mellifera* has been achieved particularly in the plains of the Punjab (India) and NWFP in Pakistan where this exotic species of honeybee is now well-acclimatized and produces more honey than *A. cerana*. However, from other parts of Asia, the introduction of *A. mellifera* has become controversial subject. It is being argued that introduction of this exotic species may prove a risky project in the long run because of different climatic conditions, flora, mating competition with native *A. cerana*, hazards of diseases, parasites and predators etc. There is no doubt that native bees are best adapted to the specific climate and environment and the future of beekeeping in this region of Asia possibly lies in *A. cerana*.

In the Hindu Kush-Himalayan region there are still many countries where *A. mellifera* has not yet been introduced and attempts are being made to improve beekeeping with *A. cerana* through techni-

cal and financial assistance from different national and international agencies. However, such efforts have not yielded satisfactory results. One of the obvious reasons for the failure of these projects has been the transfer and application of the western bee management technology and expertise to improve beekeeping with *A. cerana* in this region. This native bee species certainly requires different beekeeping management practices and equipment because of its different body size, nest building techniques, colony cycle, temperature regulation, foraging, colony defence and other behavioural characteristics. Some attempts have been made in India and China to improve the traditional methods of beekeeping with *A. cerana* and in certain parts of these countries *A. cerana* matches *A. mellifera* in honey production. This justifies the use and potential of Asian bees.

Need for an International Beekeeping Centre in Asia

1) In the developed countries, beekeeping is a well-established industry while in the developing countries of this region, it is still a small traditional household activity and its full potentials are yet to be realized.

2) Because of the ideal climatic conditions, multiplicity of bee flora throughout the year, and close link of beekeeping with the cultural heritage of rural communities, this region offers untapped potential for beekeeping development.

3) The productivity level of several agricultural and horticultural crops and the quality of seeds and fruits are improved by cross-pollination. This aspect is still little known and scientifically neglected in developing countries of the Hindu Kush-Himalayan region.

4) The introduction of European honeybee, *Apis mellifera*, into several parts of Asia may prove a risky project in the long run as this may lead to the extinction of the Asiatic honeybee, *Apis cerana*, as has already happened in Japan and thus irreversibly damage the fauna of the Hindu Kush-Himalayan region. On the other hand, the native Asiatic honeybee, *Apis cerana* has many valuable characters of economic and biological importance which still remain scientifically unexplored.

5) *Apis mellifera* also requires chemical treatment of colonies to control several diseases, parasites and predators; no such use of chemicals is required in beekeeping with the Asiatic *Apis cerana*.

6) An increasing interest even among the western bee scientists and beekeepers in Asiatic *Apis cerana* is found now because of the recent problem of *Varroa* mite (a bee parasite) on European *Apis mellifera* and also the danger of the spread of Africanized bees to the northern hemisphere.

7) Any scientifically sound information obtained about Asiatic *A. cerana* could potentially be of great importance to beekeeping even in developed countries. New technologies in molecular biology will present opportunities to introduce genes that code for desirable characteristics of *A. cerana* into the population of *A. mellifera*.

8) Frequent absconding and swarming habits, robbing behaviour, production of large numbers of laying workers and lower honey yields are some of the problems and the constraints with Asian bees. It is possible to overcome these through applied research in the area of selective breeding and bee management practices.

9) *Apis dorsata* and *Apis florea* are the basis for most of the commercial forest honey sold in several countries of Hindu Kush-Himalayan Region and these are also important pollinators of several cultivated crops. Hence, there is a great need to improve beekeeping with these wild species of honeybees on scientific lines.

10) Many countries of south and southeast Asia do not possess the basic infrastructure, skilled manpower, extension and training facilities or applied research programmes for the advancement of apiculture.

11) The *mellifera* technology of the west is not transferable and applicable for the development of beekeeping in this region because of the different ecological and socio-economic conditions existing here.

Resolutions at International Fora in Favour of Regional Centre for Beekeeping in Asia

The following international conferences/workshops have already passed resolutions in favour of establishing a regional centre for beekeeping in Asia.

1) Advanced course and workshops on beekeeping with *Apis cerana* in tropical and sub-tropical Asia organized by the International Development Research Centre (IDRC) Canada held in Kuala Lumpur, Malaysia in February, 1988.

2) F.A.O. of the United Nations workshop on parasitic bee mites and their control held in Pulawy, Poland in September, 1987.

3) International conference on Beekeeping (Apiculture) organized by International Federation of Beekeeper's Association (APIMONDIA) held in Warsaw, Poland in August 1987.

4) Second International conference on Apiculture in Tropical climates organized by International Bee Research Association, in New Delhi in 1980.

Resolutions of the Fourth International Conference on Apiculture in Cairo, 1988

RESOLUTION ON ASIAN BEES

In order to generate and deliver improved beekeeping technology with Asiatic species of honeybees, there is a strong need for a Regional Research and Training Centre in south and southeast Asia. It is recommended that an International Centre for Beekeeping Research and Training should be established in Kathmandu, Nepal.

An Ideal Place for Beekeeping with Asian Bees: Nepal

Nepal is very rich in ecological resources and is one of the ideal places for the proposed regional centre for beekeeping in the Hindu Kush-Himalayan region:

- Nepal is one of the few countries in this region, Asia, which has not yet introduced beekeeping with European honeybee *Apis mellifera* L.
- The varied physiographic conditions and abundance of bee flora makes beekeeping operations possible throughout the year.
- Bilateral beekeeping and extension support project already in operation between the Nepal Government and Government of the Netherlands provides the basic infrastructure for the development of a regional centre in beekeeping.
- Network of national and international agencies like Royal Botanical Garden, Gokarna Safari Park, Tribhuvan University and ICIMOD offer an environment ideal for the proposed centre.
- There is a strong continuing commitment on the part of the Government of Nepal to beekeeping development programme which falls directly under His Majesty the King of Nepal's directive programme.
- Beekeeping in Nepal is an old traditional occupation closely linked with the cultural heritage of rural people.

One important point in favour of establishing the proposed regional centre for beekeeping in Nepal, is the existence of ICIMOD there. The primary objective of the ICIMOD is to "promote economically and environmentally sound development in the eight developing countries of the Hindu Kush-Himalaya and to improve the well-being of the local population." These countries are Afghanistan, Bangladesh, Burma, China, India, Nepal and Pakistan.

Mandate and Objectives of the Proposed Regional Centre

1. The overall objective will be to generate and deliver improved beekeeping management technology through research and training primarily on Asiatic species of honeybees.
2. To assist different Government agencies, beekeeping communities and commercial enterprises to create a cadre of beekeeping experts by training them in both practical and scientific aspects of beekeeping.
3. To provide information and advisory services and also to act as co-ordinating centre for international co-operation in beekeeping.
4. To assist different developing countries of this region.

Organization

The proposed centre will have three major programmes in beekeeping.

- i) Research
- ii) Training
- iii) International co-operation

Research may be carried out in the following basic and applied areas primarily on Asiatic species of honeybees.

- a) Bee biology
- b) Bee pathology
- c) Bee botany and pollination
- d) Beekeeping technology and equipment
- e) Beekeeping economics and marketing hive products
- f) Apitherapy, etc.

Training courses both in practical and scientific aspects of beekeeping will be offered for the benefit of beekeepers, beekeeping instructors, beekeeping extension personnel from the department of agriculture, forestry and rural development representing different beekeeping communities or associations, commercial enterprises and government departments from the entire region of the Hindu Kush-Himalaya.

An international cooperation programme will deal with technology sharing and technology transfer for the advancement of beekeeping in this region. It will organize regional training programmes, workshops, seminars, conferences and monitoring tours. It will also act as information dissemination centre by publishing extension literature for the popularization and promotion of beekeeping. It will also render beekeeping advisory services to individual participating countries and on regional basis also.

All the above programmes will be carried out by keeping continuing contacts with national and international agencies.

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