BEE FLORA
of
THE HINDU KUSH-HIMALAYAS

INVENTORY AND MANAGEMENT

Uma Partap

Bee Flora of the Hindu Kush-Himalayas
Inventory and Management

Uma Partap

International Centre for Integrated Mountain Development
Kathmandu, Nepal

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Cover Plates
(From Top Right)

Prunus domestica
Callistemon citrinus
Melilotus alba
Bauhinia variegata
Malus domestica
Amaranthus cruentus

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Acknowledgements

The thought of writing a book on Himalayan Bee Flora came to mind while I was carrying out a field survey on bee flora. While capturing honeybees with a camera, sucking nectar, I had a chance to understand the varying degrees of affinity bees maintain with plants. The flowers that look beautiful to us are not always attractive to honeybees. Similarly, some wild shrubs which look unattractive are favourites of bees. I felt sharing this knowledge would be useful to beekeepers.

I felt compelled to write even more so after experiencing under nutrition and malnutrition of honeybees leading to lower honey yields and colony deaths in several mountain villages where project activities were undertaken . So it became clear that the message of the book should be — farmers and extension workers need to assess the bee flora in their area and make contingency plans to supplement them, should it be necessary — even before they begin beekeeping. This is a necessary, but little understood, aspect of beekeeping.

The framework of the publication was prepared and discussed with colleagues in ICIMOD and outside. It also set the scene for fresh surveys, lab work, photography, and writing. The initiative received ready support from other project colleagues and the ICIMOD management, farmers, beekeeping entrepreneurs, and experts in the HKH countries. I would like to name the few ICIMOD staff who provided me with the essential support: Mr. Egbert Pelinck, Director General; Dr. Mahesh Banskota, Deputy Director General; Dr. Tej Partap, the Head of Mountain Farming Systems' Division; Mr. K.K. Shrestha, Coordinator of the Beekeeping Project; Mr. A.N. Shukla, Beekeeping Extensionist; Mr. S.R.Joshi, Beekeeping Field Supervisor; Mrs. Sofy Jomi, Computer Assistant, Beekeeping Project; Mrs. Greta Rana, Senior Editor; Mrs. Anita Pandey, Assistant Editor; Mr. A.K. Thaku, Cartographer, DITS, Mr. Sushil Man Joshi, Desktop Publisher, DITS; and Mr. Govind Joshi, Cartographer, MENRIS. I would also like to express my gratitude to Prof. L.R. Verma, Vice Chancellor of the Dr. Y.S.P. University of Horticulture and Forestry, Solan, Himachal Pradesh, India, and Former Beekeeping Project Coordinator at ICIMOD for introducing me to this fascinating field.

The final presentation of the book is largely due to the critical reviews and comments made by the following five experts on the first draft: Dr. Eva Crane, Honorary Life President of the International Bee Research Association (IBRA), U.K.; Dr. Nicola Bradbear, President of Bees for Development, U.K.; Dr. Rafiq Ahmad, Ex. Director of the Honeybee Research Institute, Pakistan Agricultural Research Council (PARC); Dr. Cleofas R. Cervancia, Coordinator of the Bee Programme, University of the Philippines; and Mr. Gopal P. Kafle, an experienced bee expert in Nepal.

It was possible for me to think of and plan the publication only because of the financial support provided by the ICIMOD Beekeeping Project granted by the Federal Chancellory of Austria through Austroproject. I greatly appreciate the opportunity provided by the Austrian Government to share my experiences in this fascinating work.

This work also took the time I otherwise would have spent with my two daughters, Bhoomika and Uttara. They supported me with their patience and became expert field workers by locating honeybees on the flowers for me to photograph. Last of all, I am indebted to my husband for his encouragement; for training me in photography, of which I knew nothing before; and for his constant advice.

Foreword

Beekeeping is one of the many strategies that mountain farmers in the Hindu Kush-Himalayas employ to harness the biological resources of their environment. Of direct benefit is the honey, as a nutritional food item or as one of the few cash income sources. With its high-value, low-volume – low perishability, honey and other beekeeping products are excellent examples of mountain products that should be promoted. Bees play an equally important role in rural mountain development as pollinators of agricultural and horticultural crops. It is, therefore, imperative that bees find adequate bee forage round the year for their survival and optimum utilisation.

Unfortunately, while in the past few decades considerable progress has been made in promoting beekeeping as a cottage industry and occasionally as a substantive agro-enterprise, this has not been matched with a concurrent increase in the availability of bee forage. Presently, beekeeping extension systems in many parts of the Hindu Kush-Himalayas are constrained by the lack of information about assessing and managing the bee flora of different agroecological zones and farming systems of the region. As a result, promotion of beekeeping has not always lived up to the expectations raised.

In this context, and within the overall framework of ICIMOD's programme on 'Promotion of Conservation and Development of *Apis Cerana*', a special effort has been made to gather information about bee flora of different agro-ecological zones of the HKH region, including the multiple management options farmers may have in their use.

The present book is the result of the painstaking work carried out by Dr. Uma Partap, Research Officer, in the project. With its numerous photographs showing habitats and pollen grain forms of most of the plants complementing a detailed text, this book is the first comprehensive compilation of the bee flora of the HKH. I am particularly grateful to Dr. Uma Partap for her hard work in bringing all this information together. The final text has greatly benefited from a review by an eminent panel of beekeeping specialists, mentioned on the next page, to whom I would add my appreciation also.

Finally, I do hope that this book will prove to be of practical utility to scientists, extension workers, and beekeeping entrepreneurs in promoting increased benefits from beekeeping to the rural population of the Hindu Kush-Himalayas.

Egbert Pelinck
Director General

June 1997

Abstract

More than 1,000 plant species, including various agricultural, horticultural, and forage crops; ornamental plants; avenue trees; wild plants; and forest trees are visited by honeybees in different agroecozones of the Hindu Kush-Himalayan region. So far, much of the information about bee plants of the region is related to the amount of nectar and pollen they provide, and it has not been made available from the point of view of practical use by farmers, beekeepers, beekeeping entrepreneurs, and firms *per se*. Bridging this gap, this publication aims to increase awareness about the significance of honey plant resources for beekeeping management; make available a practical guide on honey plant resources; and provide beekeepers of the HKH region with tools for identifying bee flora.

This book is divided into two sections. The first section consists of four chapters. Chapter One provides an introduction to beekeeping and the different species of honeybees found in the region, hive products, and the role of honeybees in crop pollination. The second chapter focusses on bee forage and the status of Himalayan bee flora. Chapter Three deals with the identification and characterisation of bee flora. Chapter Four focusses on bee forage management methods. A list of multipurpose plants has been provided for different agroecosystems of the Hindu Kush-Himalayan region. The second section is the major contribution of this book. It describes 237 promising plant species, including those which provide surplus honey and others which help to build up colony strength and support bee colonies during dearth periods. Plant species of great value to beekeeping as well as for other economic uses are recommended as probable choices for targeted multipurpose plantation work. Morphological features of plants as well as their habitats and utilisation by honeybees are supported with more than 120 coloured plates. In addition to this, a general inventory of bee flora of the HKH region, containing 366 plant species, their ecological habitats, blossoming periods, and nectar and pollen potentials, is also provided. A glossary of 50 important scientific terms has also been added. This is a valuable reference book for bee scientists, beekeepers, farmers, extension workers, and entrepreneurs practising beekeeping in the mountain areas of the HKH and other regions.

Contents

Readers please take note of the following adjustments in sizes of pollen grains in the black and white plates in Section Two

Plate No	Page	Adjusted Size (%)
9b	77	118
13b	82	74
13c	83	76
17b	86	120
17c	86	120
17d	86	120
18b	87	82
18c	87	82
27b	97	88
38b	111	95
41c	117	95
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ANNEXES

Section One

Introduction to Bee Flora of the HKH

ONE
Introduction

The Hindu Kush-Himalayan region extends from Afghanistan in the west to Myanmar in the east, covering hill and mountain areas of eight countries; viz., Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. It is not only the world's highest mountain region but also the most populous; the total population of this region is about 120 million. The Himalayan region could be divided into the Outer Himalayas or Siwalik Hills lying in the south, followed in the north by the Lesser Himalayas, Main or Central or Great Himalayas, and Trans-Himalayas in the northern part of this mountain chain. The altitude of the Siwaliks is relatively low, up to 1,000masl, and the climate varies from tropical to subtropical. The annual rainfall in this zone ranges from 1,500-1,800mm. The Lesser Himalayas consist of parallel ranges in the west and scattered mountains in the central region. The altitude ranges from 1,000-1,500masl, and the climate varies from subtropical to sub-temperate. The climate of the Great Himalayas is temperate and the altitude varies from 1,500-3,500masl. The Trans-Himalayan zone consists of the valleys of the rivers rising behind the Great Himalayas. The altitude of this region varies from 3,500-4,500masl and the climate varies from temperate to semi-arctic.

Agriculture is the main occupation of more than 80 per cent of the people, as many as 95 per cent of the farmers have small land holdings of up to 0.5-2.0 ha each (Bhatti et al. 1992; Mulk 1992; Shrestha and Katwal 1992; Yanhua et al. 1992). Due to the small land holdings and other inherent problems of mountain areas, such as undulating physiography, cold and harsh climatic conditions, and limited sunlight, farming alone is not sufficient to make an adequate living. Thus, there has always been a need to explore alternative income-generating opportunities which help to alleviate the pressure on land, on the one hand, and improve the economic conditions of the people on the other.

Beekeeping is one such off-farm based, food and income-generating activity for small farmers in the mountain areas. Beekeeping as a profession means rearing honeybees for the production of honey and other bee products and for crop pollination. Honeybees use the unharnessed ecological niche — nectar and pollen from various plants — that cannot be harnessed for human use without the mediation of honeybees. Beekeeping is a flexible occupation and it creates off-farm employment opportunities for many sectors, including women and the landless. An equally important role of beekeeping is the increase in productivity of agricultural, horticultural, and forage crops. This recognition of honeybees' role in the conservation of natural ecosystems and biodiversity is rather recent but is gaining ground.

Honeybee Species in the Hindu Kush-Himalayan Region

In the context of honeybee species' diversity, the Hindu Kush-Himalayan Region is one of the richest in the world. At least five different species of honeybee are found in this region. Among these, *Apis cerana, Apis dorsata, Apis florea,* and *Apis laboriosa* are native, whereas the European honey bee, *Apis mellifera*, has been introduced. Among the native honeybee species, *Apis dorsata, Apis florea,* and *Apis laboriosa* cannot be kept in hives; these species build their nests in the open air on tall trees, on shrubs, and on vertical cliffs respectively. The other two species, *Apis cerana* and *Apis mellifera,* can be kept in hives, and they play a key role in honey production and crop pollination (Figure 1.1).

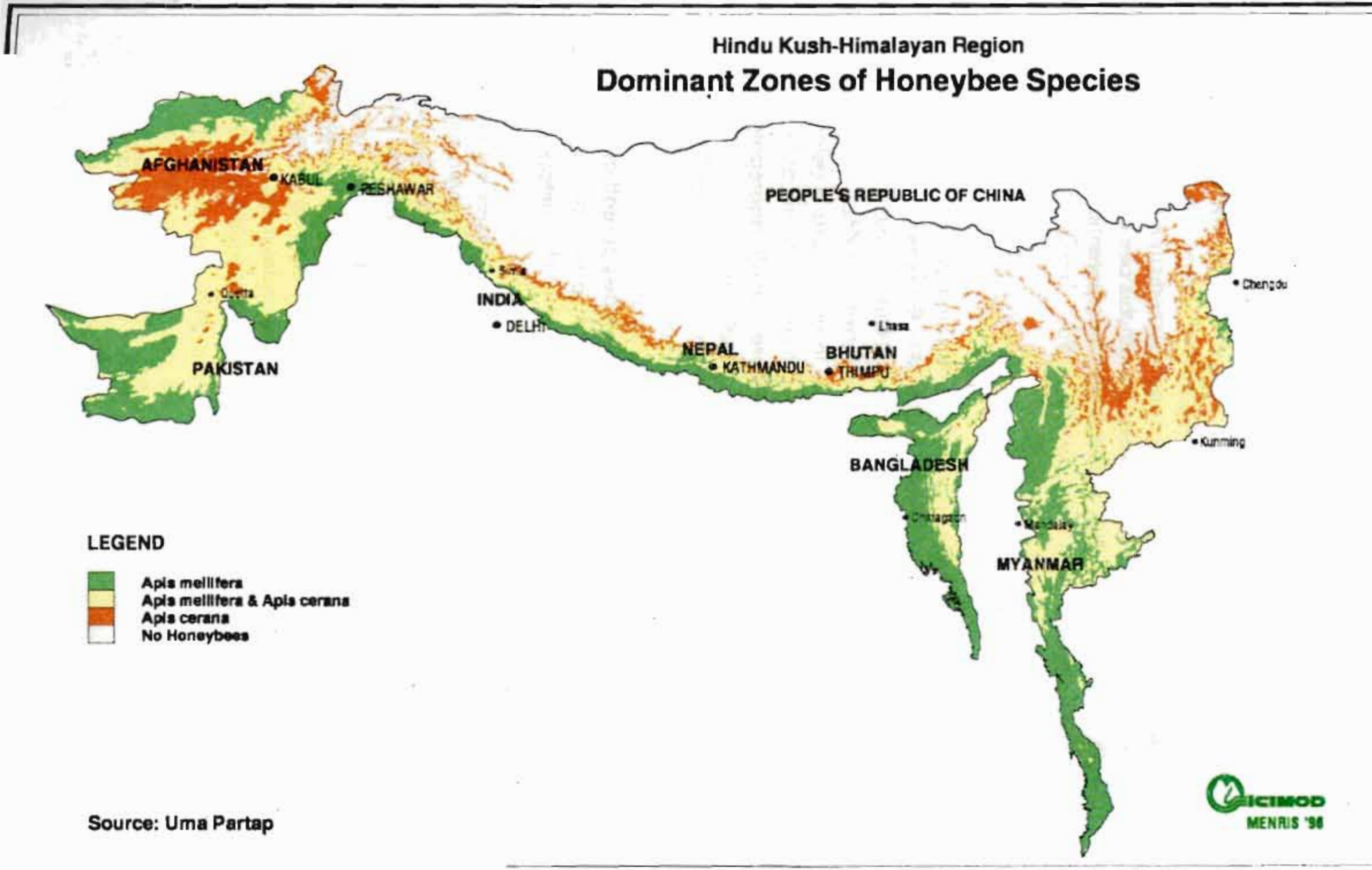
Apis dorsata

Apis dorsata is known as the giant honeybee or rock bee. This species is distributed throughout the Himalayas up to an altitude of even 2,000masl. It builds single comb nests in the open air, mostly on branches of tall trees; in shaded places during summer; and in sunny places during winter. One may find several nests of *Apis dorsata* on a single large tree. This species is generally migratory in nature. *Apis dorsata* produces abundant honey and is an important pollinator of different agricultural and horticultural crops. It, however, is difficult to handle because of its defensive behaviour. Honey-hunting communities collect a lot of honey and beeswax from this species. In a few places, beekeeping with this bee species is carried out in open nest sites.

Apis florea

Apis florea is the smallest amongst the honeybee species and is, therefore, called the little bee. Similar to *Apis dorsata*, this species also builds single

Figure 1.1


Hindu Kush-Himalayan Region
Dominant Zones of Honeybee Species
AFGHANISTAN
KABUL
PESHAWAR
PAKISTAN
INDIA
DELHI
NEPAL
KATHMANDU
BHUTAN
THIMPU
Lhasa
PEOPLE'S REPUBLIC OF CHINA
Chengdu
Kunming
BANGLADESH
MYANMAR
LEGEND
Apis mellifera
Apis mellifera & Apis cerana
Apis cerana
No Honeybees
Source: Uma Partap
ICIMOD
MENRIS '98

comb nests which are often suspended from the branches of bushes, hedges, trees, caves of buildings, chimneys, and so on. This species is distributed in the plains and hill areas and found at up to 1,500masl. This species is also migratory in nature and a colony seldom remains in one place for more than five months. The annual honey yield from this bee species varies from one to three kg/colony. Farmers believe that the honey produced by *Apis florea* has a special medicinal value. Farmers in a few places also carry out beekeeping with this bee in open nest sites as with *Apis dorsata* *Apis florea* is another potential pollinator of agricultural crops.

Apis laboriosa

This species has only been recently reported and studied. It is found at altitudes ranging from 1,200 to 3,500masl in the remote, mountainous valleys of Bhutan, China, India, and Nepal where it nests beneath the rock overhangs of vertical cliff faces (Underwood 1992; Sakagami *et al.* 1980). This species is also migratory in nature and a colony does not remain in one place all year round. 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.

Apis cerana

Apis cerana is one of the native bees and is widely spread all over the Hindu Kush-Himalayan Region at altitudes of up to 3,600m. It has a gentle temperament, is industrious, has qualities of cleanliness, and can be handled easily. Unlike *Apis dorsata* and *Apis florea*, this bee builds parallel combs inside a cavity. Beekeeping with this species is a common tradition among several mountain communities. Farmers keep it in traditional fixed comb hives made from logs, walls, and earthen pitcher frames and in modern, movable frame hives.The honey yield of *Apis cerana* varies between 10-20kg per colony per year, which is much less than that of the European bee, *Apis mellifera*. However, it is an excellent crop pollinator. This species is not popular among commercial beekeepers because of its low honey yield and undesirable behavioural traits such as frequent swarming, absconding, and robbing habits.

Apis mellifera

The European honeybee, *Apis mellifera*, has been imported in recent years to the countries of the Himalayan region for commercial honey production. This species produces more honey and beeswax than the native bee, *Apis cerana*. This bee also builds parallel combs. The species has become popular with commercial beekeepers because it maintains prolific queens, has less swarming and absconding tendencies, and has good honey-gathering qualities. However, beekeeping with this species requires expensive technology and a substantial amount of chemical treatment to control epidemics, because it is highly susceptible to diseases and parasites. The species has been introduced to almost all the countries of the Hindu Kush-Himalayan Region and is doing well in the plains and sub-mountainous regions of China, India, Nepal, and Pakistan below altitudes of 1,500masl. Above this altitude, only *Apis cerana* is well adapted.

Melipona spp

Melipona spp are stingless honeybees. These are distributed throughout the warmer areas of the region, below 1,000masl. Two species are known to occur in the *Terai* areas of Nepal (personal communication with Beekeeping Development Project (BDP) officials). Like true honeybees, *Melipona* also has a well-developed social system. This species makes its nest within cavities and can also be kept in hives. In the Hindu Kush-Himalayan region, only a few farmers in the Dang, Rolpa, and Surkhet districts of Nepal are keeping *Melipona*. This species stores honey in special honey pots kept separately from the brood cells. It is an important and efficient pollinator of crops, but its uses and management as a crop pollinator are largely unexplored (Crane 1990).

Bee Products

The main purpose of beekeeping in countries of the Hindu Kush-Himalayan Region has been the production of honey and other bee products which are used as food and medicine and sold for cash income. **Honey** is the most important of all the bee products in all countries of the region. It is a nutritive food which is mostly composed of the sugars, fructose and glucose, with very small amounts of amino acids, enzymes, and minerals. The FAO Commission (*Codex Alimentarius*) defines honey as the *"unfermented, sweet substance produced by honeybees from the nectar (secreted by floral and extrafloral nectaries) and honeydew (secretions of or on living parts of plants) which the bees collect, transform, and combine with specific substances and then store in honeycombs."* While codifying the standards, the commission stressed that *"honey shall not have any objectionable flavour, aroma or taint absorbed from foreign matter during its processing and storage, and* *shall not contain natural plant toxins in an amount which may constitute a hazard to health."*

In the Hindu Kush-Himalayan Region, honey is harvested both from the wild colonies of *Apis cerana, Apis dorsata,* and *Apis laboriosa* and from the domesticated *Apis cerana* and *Apis mellifera*. China is the biggest producer and exporter of honey among the countries of this region.

Beeswax is another important bee product, and it is widely used for making candles, medicines, and in the cosmetics' industry, especially for skin creams, lipsticks, and various lotions. In countries of the Hindu Kush-Himalayan Region, most of the beeswax is obtained from wild colonies of *Apis dorsata*. As for honey, China is the largest producer of beeswax.

Other bee products include **pollen, royal jelly, and bee venom**. All these products are used for medicinal purposes. So far, China is the only country in the Hindu Kush-Himalayan Region which has developed a technology for the commercial production of these bee products. Such products are mainly exported and they bring in large amounts of foreign exchange.

Pollen, harvested from bee colonies, is used as a protein supplement in human dietary systems. It is also used to feed honeybees during the dearth periods when pollen is not available from flowering plants. Date palm pollen has been used for treating human sterility caused by the presence of gonadotropic hormones. Pollen is also used to facilitate the proper functioning of the human prostrate gland.

Royal jelly is the most expensive of all the hive products (over US$ 100 per kg). It is a milky white substance produced by the hypopharyngeal glands of young worker bees exclusively to feed the queen (throughout her larval and adult life) and the young (up to three days old) worker and drone larvae. Royal jelly is rich in Vitamins B and C and has antibiotic and antitumor properties. It is used in medicines, tonics, beverages, and cosmetics.

Bee venom is a very minor product. It is stored in the poison sac of the sting apparatus. It is acidic in nature and has a complex chemical composition. Bee venom is used to treat rheumatoid arthritis and for desensitising patients who are allergic to bee stings. In recent years, bee acupuncture therapy has been used for the treatment of various diseases.

In India and China, bee venom is collected with the help of an electric venom collector without causing any injury to the bees.

Yet another hive product which is collected by *Apis florea, Apis mellifera,* and *Melipona* spp is **propolis**. This is the resinous substance collected by the foragers of these bee species to seal cracks in the hive and reduce the number of entrances. *Apis dorsata* bees have also been observed to use propolis to strengthen the attachment of their comb to its support, but this does not seem to be very common. Propolis is gathered from the sticky and gummy exudations of some plants such as alders, poplars, and some conifers. Propolis has many antibacterial and antifungal properties and is used for medicinal purposes, e.g., skin ointments. One of the commercial products presently being tried out in China is propolis soap.

Honeybees and Pollination of Mountain Crops

Another very important role of beekeeping is increasing the quality and yield of fruits and seeds of various crops through the pollination services of honeybees. There are good examples in both developed and developing countries where the pollination services of honeybees are used to increase the productivity of various agricultural and horticultural crops (Partap and Partap 1997). Many commercial varieties of crops, for example, apples, almonds, citrus, pears, and various vegetable crops, are self-sterile and require cross-pollination to produce fruits and seeds.

The availability of natural insect pollinators is decreasing rapidly due to the continuous use of pesticides and decline of habitats necessary for nesting and hibernation. This has increased the need for managing hive bees, such as *Apis cerana* and *Apis mellifera,* for the pollination of different crops (Figure 1.2).

Information on the role of honeybees in pollination, which leads to increases in the quality and yield of crops, has been widely documented (McGregor 1976; Crane 1991; Free 1993; Partap and Verma 1994; Verma and Partap 1993 and 1994). Studies have shown that bee pollination increases fruit production in apples, lemons, litchis, peaches, pears, persimmons, and plums by 24, 15, 2, 2, 14, 1.2 and 6 times, respectively (Crane 1991). Improved seed production has also been found in the case of greater cardamon, mustard, sesame, sunflower, and onion by 10, 1.4-1.6, 1.3, 1.5 and 1.7 times, respectively (Table 1.1). Such high increases in the yields of various crops are expected in

Figure 1.2 Colonies of Honeybee (Apis cerana) for pollination of Indian mustard in the Kathmandu Valley, Nepal (L.R. Verma)

crops which are self-sterile and, therefore, produce seeds and fruits only if cross-pollinated.

Table 1.1 **Examples of Increase in Crop Production due to Honeybee (Apis Cerana) Pollination**

Increase in Fruit Production			Increase in Seed Production		
Apples	x	24	Greater Cardamon	x	10
Lemons	x	15	Mustard	x	1.4-1.6
Litchis	x	2	Sesame	x	1.3
Peaches	x	2	Sunflower	x	1.5
Pears	x	14	Berseem	x	2.7
Persimmons	x	1.2	Onion	x	1.7
Plums	x	6			

Source: Crane 1991

Bee pollination studies carried out in Kathmandu Valley (Table 1.2) proved that there is a significant increase in the fruit setting, seed setting, and seed weight (i.e., seed yield and quality) of vegetable crops such as cabbages, cauliflowers, Indian mustard, lettuce, and radishes (Partap and Verma 1994; Verma and Partap 1993 and 1994).

Among the countries of the Hindu Kush-Himalayan region, India has promoted beekeeping as an essential component for the pollination of fruit crops as well as for vegetable seed production. Considering the importance of bee pollination, government institutions and farmer

Table 1.2 ***Impact of Apis Cerana Pollination on Vegetable Seed Production in Hilly Areas***

Crop	Increase in Pod Setting (%)	Increase in Seed Setting (%)	Increase in Seed Weight (%)
Cabbages	28	35	40
Cauliflowers	24	34	37
Radishes	23	24	34
Indian Mustard	11	14	17
Lettuce	12	21	9

Source: Verma and Partap 1993

entrepreneurs in Himachal Pradesh, a hill province in the Indian Himalayas, rent bee colonies to orchardists for the pollination of temperate fruit crops. This is increasing the awareness of fruit farmers about the application of honeybees for pollination. The State Horticultural Department of Himachal Pradesh gives bee colonies on rent at a rate of Indian rupees (IRs) 50 (US$ 1.5) per colony per season. Some private beekeepers also rent out honeybee colonies for pollination, but at higher rates.

In other countries of the Hindu Kush-Himalayan region, the practice is yet to be adopted as an integral part of mountain crop production technology. The awareness of policy-makers, researchers, and extension workers about promoting bees and beekeeping as an important component in increasing the crop productivity of mountain agriculture is necessary.

Need to Study Bee Flora

In beekeeping, we use honeybees as micro-manipulators of flowers to produce honey and other hive products. Honeybees visit a variety of plants for pollen and nectar (McGregor 1976). However all the plant species are not available in one locality, and a given plant species may also show variations in usefulness for bees when it is in different localities (Latif *et al.* 1958; Singh 1989; Kiew and Muid 1991). The nectar and pollen potentials of a plant are affected by the longitude, latitude, altitude, and soil and climatic conditions. A plant which produces nectar and pollen prolifically in one area may not yield the same amount of nectar and pollen in another area. Moreover, a plant that produces abundant nectar and pollen may not be of much importance to honeybees and beekeeping in an area, if it is not fairly abundant in that particular area. For example, the Indian butter tree is an extremely prolific secretor of nectar and is a source of pure *chiuri* honey in western Nepal, where it occurs in abundance, but only a few trees of this species are found in other areas of Nepal and therefore it is not important for beekeeping in those areas.

In addition to the abundance of honey plants and their nectar and pollen potentials in an area, the foraging range of honeybees is also important in determining the utility of honey plants for them. Foraging range refers to the distance over which a bee can forage for the collection of pollen and nectar. Only those plants which are present within the foraging range of honeybees are important for beekeeping. To make use of other plants, such as forest and avenue trees, which are outside the foraging range, the honeybee colonies have to be carried (migrated) to these areas. Migratory beekeeping will be discussed in detail in Chapter 4.

Hive bees prefer to forage closer to their hives (normally within a 300-800 metre radius of the apiary), and this preference is further emphasised by the tendency of successful foragers to recruit more bees when foraging nearer rather than when foraging from distant sources. Thus, the honey plants present within this range have the greatest value for beekeeping. However, if necessary, the bees can forage a considerable distance from their hives. The maximum foraging range of the Himalayan honeybee, *Apis cerana*, is within a radius of up to two kilometres from the apiary (Verma 1990). In extreme circumstances, the European honeybee, *Apis mellifera*, foraged on a crop up to a distance of 11.3km away from the apiary (Eckert 1933; Free 1993).

The success of beekeeping essentially depends on the abundance of bee flora in an area. A good crop of honey from bee colonies can be harvested only if bees have an abundance of honey plants to forage. Therefore, the following knowledge about bee flora is very important.

1) The beekeeping potential of an area must be known. This is an essential step in promoting beekeeping in any area.
2) The carrying capacity of an area in terms of the number of bee colonies it can sustain.
3) Slack season needs of good bee-food during winter should be managed.
4) Proper bee management by honeybee entrepreneurs and farmers is essential.

Two

An Overview of Himalayan Bee Flora

The Hindu Kush-Himalayan (HKH) region is one of the world's richest eco-systems in terms of plant diversity. This richness is due to the great variations in climate and habitat that are found there. Although the exact number is not known, it is estimated that over 9,000 species of flowering plants could be distributed throughout different ecological regions (Collett 1971; Polunin and Stainton 1987). The bees, however, do not visit all the plants, they have particular floral preferences; they visit some plants frequently, and others they do not visit at all. Moreover, different plants produce different amounts of nectar and pollen. The plants that the bees visit to collect their food (nectar and pollen) are called bee plants or bee flora. Based on a thorough knowledge of plants that provide nectar, pollen, or both, and their relative importance, management strategies can be implemented to maintain the strength of the colonies and to maximise honey yields. This chapter reviews the available information about bee flora in the Hindu Kush-Himalayan region. It also provides information on the food of the honeybee, i.e., nectar and pollen, and the factors influencing its availability.

Existing Information on Himalayan Bee Flora

Beekeeping research in the Hindu Kush-Himalayan region is mainly focussed on honeybees and bee products. Research on plants, the primary sources of honeybee forage and bee products, has generally been neglected. There is scattered information on the honey plant resources in different countries of the region, and the focus of this research is to identify and rank the honey plants according to the quality and the quantity of nectar and pollen available from them. Isolated reports on the bee flora in different agro-ecological zones of the Hindu Kush-Himalayan region indicate that it is host to diverse bee flora; including various agricultural, horticultural, and forage crops, ornamental plants, avenue trees, wild plants, and forest trees. The sources of this information on bee plants in the HKH are field surveys and melissopalynology (i.e., identification of the pollen grains in honey). Bee scientists at various universities and research institutions in different countries of the region have, so far, identified over 1,000 bee plants. The information documented on the honey plant resources in different countries of the region is reviewed in the following sections.

Afghanistan

There is very little information about the honey plant resources of Afghanistan, though beekeeping is a traditional household activity in this country. However, the distribution of many plants described in this book extends to several hilly areas of Afghanistan. The available information shows that *Acacia* spp, *Alhagi pseudoahagi, Cassia* spp, *Robinia pseudoacacia, Gossypium* spp., *Callistemon* spp, *Eryobotryn japonica, Prunus* spp, and *Citrus* spp are important honey sources in Afghanistan (Crane 1973)

Bangladesh

Among the variety of honey plant resources found in the hill areas of Bangladesh, about 36 plants, including *Acacia* spp, *Albizia* spp, *Brassica* spp, *Citrus* spp, *Litchi chinensis, Shorea robusta, Toona* spp, and *Zizyphus* spp constitute the major nectar sources (Alam and Zannat 1980; Dewan 1980; 1984). The recent establishment of large-scale rubber plantations by the Chittagong Hill Tracts' Development Board (CHTDB) in three hill districts, i.e., Bandarban, Khagrachari, and Rangamati, will increase nectar availability and promote commercialisation of beekeeping in these hill areas.

Bhutan

There is little information recorded on the bee flora of Bhutan. However, Bhutan is the only country in the HKH where more than 70 per cent of the total land area is covered by forests and other natural vegetation. These forests have a variety of plant species that are of great value to beekeeping. Other bee flora include temperate fruits, vegetables, and agricultural crops.

China

There are more than one thousand plant species providing nectar and pollen in the Chinese Himalayas (Focke 1968; Deh-Feng and Wen-

Cheng 1981; Yue-Zhen 1984). Among these, *Astragalus* spp, *Brassica campestris*, *Citrus* spp, *Eucalyptus* spp, *Fagopyrum* spp, *Frangula* spp, *Gossypium* spp, *Lamium* spp, *Medicago* spp, *Melilotus* spp, *Litchi chinensis*, *Robinia* spp, *Tilia* spp, *Trifolium* spp, and *Vicia sativa* are major bee plants. According to Shikui and Zaiji (1989) and Zhen-Ming *et al.* (1992), different species of *Eurya* provide important bee forage in the hill areas of southern China. These reports confirm the existence of about 80 species of *Eurya*, among which the following nine species are very important for beekeeping: *Eurya muricata*, *E. brevistyla*, *E. groffii*, *E. loguiana*, *E. alata*, *E. chinensis*, *E. hebeclados*, *E. nitida*, and *E. megatrichocarpa*. Xu (1993), in his book on nectar and pollen plants of China, described almost 543 nectar and pollen plants belonging to 109 families. Among these, 44 plants are major nectar sources and 24 are major sources of pollen. Many of these species are distributed throughout the Himalayan region of China.

India

Bee flora of the Indian Himalayas have been studied extensively. Saraf (1972) reported 110 plant species, including *Aesculus* spp, *Brassica* spp, *Fagopyrum* spp, *Impatiens* spp, *Plectranthus* spp, *Polygonum* spp, *Prunus* spp, and *Pyrus* spp, as important bee plants from the Kashmir Valley. Singh and Singh (1971) and Atwal and Goyal (1974) identified *Plectranthus rugous* as an important honey plant in the Kashmir and the Kullu valleys. Sharma and Raj (1985) surveyed the bee flora of the Shivalik Hills of Himachal Pradesh and their possible impact on the beekeeping industry. They have reported *Adhatoda vasica*, *Bauhinia variegata*, *Brassica campestris*, *Dalbergia sissoo*, *Ehretia* spp, *Eucalyptus* spp, *Litchi chinensis*, *Mangifera indica*, *Rosa moschata*, *Rubus* spp, *Sapindus detergens*, and *Syzygium cumini* as important bee plants of the Shivaliks. Sharma (1989) made an extensive melissopalynological and botanical survey of the honey plants of Himachal Pradesh. Her list of important honey and pollen plants includes *Brassica napus*, *Dalbergia sissoo*, *Ehretia acuminata*, *Eruca sativa*, *Eucalyptus* spp, *Fagopyrum sagittatum*, *Impatiens glandulifera*, *Malus domestica*, *Medicago sativa*, *Melilotus* spp, *Litchi chinensis*, *Plantago* spp, *Plectranthus* spp, *Prinsepia utilis*, *Prunus* spp, *Pyrus* spp, *Robinia pseudoacacia*, *Sapindus* spp, *Syzygium cumini*, *Tilia* spp, *Toona ciliata*, and *Trifolium spp.*

Analyses of the results of many surveys of bee flora in the Indian Himalayas reveal that *Allium cepa*, *Berberis* spp, *Eucalyptus* spp, *Madhuca* spp, *Litchi chinensis*, *Olea glandulifera*, *Plectranthus* spp, *Polygonum* spp, *Prunus* spp, *Pyrus* spp, *Rosa moschata, Rubus niveus, Rumex* spp, *Shorea robusta,* and *Trifolium* spp are the main honey plants in that area (Singh 1983; Singh et al. 1983; Verma 1983).

By identifying pollen in honey samples from the northeastern Indian Himalayas, Singh (1989) recorded 16 plant species as important sources of pollen and nectar. Among these, *Adhatoda* spp, *Ageratum* spp, *Helianthus* spp, *Brassica* spp, *Bauhinia* spp, *Polygonum* spp, *Clematis* spp, *Mussaenda* spp, *Wendlandia* spp, and *Solanum* spp are major sources and *Acer* spp, *Ceasalpinia* spp, *Ocimum* spp, *Litsea* spp, *Parkea* spp, and *Senecio* spp are minor sources of nectar and pollen.

Myanmar

Zmarlicki (1984) evaluated the bee flora of Myanmar. His evaluation has an added value because of the details given of the honey plant calendars of important nectar- and pollen-yielding plants. He grouped all the honey plants recorded into three groups, viz., agricultural crops, horticultural crops, and wild plants and forest trees. Agricultural crops included *Helianthus annuus, Sesamum indicum, Guizotia abyssinica, Brassica* spp, *Capsicum annum*, various cucurbitaceous plants, and *Gossypium* spp as major sources of honey. Among the horticultural plants, *Citrus* spp, *Cocos nucifera, Litchi chinensis, Prunus insitia, Zizyphus jujuba*, and *Persea gratissima* are identified as major sources of honey. The wild plants and forest trees which are major sources of nectar and pollen for bees are *Eucalyptus* spp, *Eupatorium odoratum, Leucas aspera, Leucas zeylanica, Prunus cerasoides, Salmalia malabarica*, and *Tithonia tagitifolia*.

Nepal

The bee flora of Nepal have been extensively surveyed by Kafle (1984; 1992), Maskey (1989; 1992), and Partap and Verma (1996). These surveys have found that mixed types of bee forage occur in different ecological zones of the country. Among cultivated crops, *Litchi chinensis, 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* spp, *Pyrus* spp, *Prunus* spp, and *Abelmoschus esculentus* are important sources of both pollen and nectar. Among ornamental plants, *Althea rosea, Malva rotundifolia, Ageratum conyzoides, Aster thomsonii, Centauria cyanus, Cosmos sulphureus, Solidago longifolia, Lagerstroemia indica*, and *Delonix regia* are frequently visited in preference to other plants by bees for both pollen and nectar. Wild plants include *Aesandra butyracea, Azadirachta indica, Albizia* spp, *Sapindus mukorossi, Syzygium cumini, Terminalia belerica, T. chebula, T. tomentosa, Salmalia malabarica, Shorea robusta, Fraxinus floribunda, Plectranthus rugosus, Colquihonia coccinia, Leucosceptrum canum, Aster oblongum, Zizyphus incurva, Pyrus pashia, Eupatorium adenophorum, Innula cappa,* and *Gentiana amoena* as important bee plants. Similarly, *Rubus ellipticus, Berberis aristata, B. asiatica, Mahonia nepaulensis, Salix babylonica, Rosa sericea, Ricinus communis, Vitex negundo, Castanopsis indica, Colebrookia oppositifolia,* and *Pogostemon* spp are some of the other wild plants visited by bees.

Bauhinia spp, *Buddleia asiatica, Scheflera venulosa, Ilex excelsa, Prunus cerasoides, Madhuca latifolia*, and *Leucaena leucocephala* are fodder trees that provide nectar and pollen to bees. Similarly, *Trifolium repens* and *Cynodon dactylon* are pastures species among which honeybees are observed to forage.

Kafle's general survey of the bee flora of Kathmandu Valley produced a list of 156 plants (Kafle 1984). Among these, 44 plant species, namely, *Aesandra butyracea, Brassica* spp, *Callistemon* spp, *Castanopsis indica, Citrus* spp, *Elsholtzia fruticosa, Eucalyptus* spp, *Fagopyrum esculentum, Fraxinus floribunda, Gravillia robusta, Guizotia abyssinica, Innula cappa, Psidium guajava, Prunus cerasoides, Punica granatum*, and *Solidago longifolia*, are the major bee forages. A general survey carried out by Partap and Verma (1996) confirmed Kafle's findings and recorded the occurrence of 113 plants constituting the bee flora of the Kathmandu Valley. Similarly, melissopalynological studies of *Apis cerana* honey from Jumla recorded the occurrence of about 103 plant species constituting the bee forage sources of that region. Most important among these are *Aesculus carnea, Ageratum conyzoides, Barleria cristata, Berberis spp, Brassica spp, Castanopsis indica, Clematis spp, Elaeagnus conforta, Elsholtzia spp, Fagopyrum esculentum, Fragaria indica, Gentiana capitata, Goldfussia capitata, Guizotia abyssinica, Helianthus annuus, Impatiens spp, Indigofera spp, Innula cappa, Leucosceptrum canum, Leycestria formosa, Mahonia nepaulensis, Malus domestica, Mentha sylvestris, Nepeta nervosa, Origanum vulgare, Osbeckia nepaulensis, Persicaria posumbo, Plectranthus mollis, Plectranthus rugosus, Polypogon hydropiper, Primula spp, Prinsepia utilis, Prunus cerasoides, Pyrus communis, Pyrus pashia, Pyracantha crenulata, Rhododendron arboreum, Rosa macrophylla, Rosa sericea, Rubus diffusus, Rubus* *ellipticus, Senecio scandens, Swertia ciliata,* and *Swertia dilatata* (ICIMOD 1996).

Owing to the abundance of bee flora, three main flows of pollen and nectar occur in the Kathmandu Valley (Kafle 1984; Maskey 1989). The first, spring flow (February to March), is supported by *Callistemon lanceolatus, Eucalyptus* spp, *Fraxinus floribunda, Grevillea robusta, Trifolium repens, Bauhinia* spp, *Berberis* spp, *Leucosceptrum canum, Pyracantha crenulata,* and *Pyrus pashia*. This flow helps the bees to increase their brood rearing, resulting in numerous swarms. It also has a good impact on honey yield in subsequent seasons. The second flow comes in the period from April to May. With this flow, and the resultant impact of the preceding spring forage, beekeepers in the area have sizeable honey harvests. This flow is followed by a period of dry and dearth conditions and additionally another situation unfavourable to bees, the main rainy season. The period from September until the end of November is the third main flow season of the year. The main forage plants in this period are *Prunus cerasoides, Fagopyrum esculentum, Aesandra butyracea, Brassica campestris, Helianthus annuus, Innula cappa, Solidago longifolia,* and *Vernonia talaumifolia*. A slight variation in honey flow season is observed by Maskey (1989; 1992). She has reported that the first honey flow is contributed by the *Trifolium repens* (April-May), the second by *Brassica campestris* (November-February-March), and the third by the presence of two or more nectar and pollen sources designated as mixed' seasons (September-October).

Pakistan

There are some 900 plant species known to constitute the bee flora of Pakistan (Ahmad 1992; Muzaffar 1992; Shahid 1992). Most of these are minor sources of pollen and nectar; some plants produce large quantities of pollen and nectar but are not abundant in the area. According to Muzaffar (1992), honey production is dependent upon a few plant species that yield nectar and pollen abundantly and which are sufficiently common. Among these, *Medicago sativa, Trifolium* spp, *Citrus* spp, *Gossypium* spp, *Prosopis* spp, *Acacia modesta,* and *Plectranthus* spp are major sources of commercial honey. Ahmad (1984) reported 30 plant species, including *Acacia modesta, Albizia lebbek, Antigonon leptopus, Calliandra calothyrsus, Cedrela toona, Epilobium angustifolium, Eriobotrya japonica, Eucalyptus albens, E. camaldulensis, E. citriodora, E. grandis, E. melliodora, Gleditisia triacanthes, Grevillea robusta, Haematoxylon campechianum, Lamium album, Melilotus alba,* *Medicago arboreum, Medicago falcata, Plectranthus rugosus, Prosopis juliflora, Prunus* spp, *Pyrus spp, Robinia pseudoacacia, Rosemarinus officinalis, Sapindus mucorossi, Terminalia chebula, Trifolium* spp, *Vitex negundo,* and *Zizyphus spina-christi,* as promising honey plants and recommended them for afforestation on erodible lands, in degraded landscapes, and on agricultural farms. In addition to the above-mentioned plant species, he also reported *Brassica campestris* and *Gossypium* spp as important bee plants in Pakistan.

Shahid and Qayyum (1977) listed 122 bee plants found in the North West Frontier Province (NWFP). Of these, 13 plant species, including *Acacia modesta, Adhatoda vasica, Brassica* spp, *Citrus* spp, *Dalbergia sissoo, Eriobotrya japonica, Eucalyptus* spp, *Malus sylvestris, Medicago sativa, Phoenix* spp, *Plectranthus rugous, Psidium guajava, Trifolium alexandrinum, Zea mays,* and *Zizyphus jujuba,* were recorded as major sources for the production of surplus honey, with five major honey flows per year at different localities in the province. They also recommended the migration of bee colonies at appropriate times to different places to facilitate maximum honey yields. Makhdoomi and Chohan (1980) also surveyed the bee flora of the NWFP and West Punjab and identified *Plectranthus rugosus, Eriobotrya japonica, Eucalyptus* spp, *Adhatoda vasica, Acacia modesta, Cedrela toona, Trifolium alexandrinum,* and *Medicago sativa* as major nectar sources. Manzoor and Mohammed (1980) identified *Helianthus annuus* as an important honey plant in Pakistan.

The foregoing review of literature reveals that bee scientists in the countries of the Hindu Kush-Himalayas have made great efforts to identify and rank the bee flora according to the quality and quantity of nectar and pollen produced. However, this information needs to be compiled in order to provide comprehensive data on bee flora of the Hindu Kush-Himalayas. The Directory of World Honey Sources (Crane et al. 1984) is one example of such an undertaking. These authors compiled the work carried out by many bee scientists and described 453 plant species which are important sources of honey in 144 countries, including all the countries in the Himalayan region except Bhutan. The Directory, however, covers only those plants in the HKH which are major sources of honey; it does not describe other important plant species that provide enough nectar and pollen for the survival of bee colonies during dearth periods and which are, thus, very important for beekeeping. Verma (1990) reviewed the work carried out on the bee flora of the HKH region and devoted a chapter to honey plant resources in his book on 'Beekeeping in Integrated Mountain Development'. He listed the important nectar and pollen plants of the region. Yet, detailed data about each one of the potential honey plants in the HKH are lacking.

Information on important bee flora in the HKH *per se* has not yet been compiled, especially in a form that would be of practical use to bee entrepreneurs and firms. Many beekeepers, extension workers, and NGOs need specific information which answers questions such as:

1) which are the important bee plants in a particular agro-ecological zone?
2) how can bee plants be identified?
3) what plants should be grown to increase the beekeeping potential of a given area?
4) during plantation, what should be the considerations in the bee-keeping context? and
5) how can one find the plant source of an unknown honey?

Categorisation of Bee Flora

In order to survive, prosper, and be productive, honeybee colonies need an adequate supply of both pollen and nectar. As stated earlier in this chapter, the plants from which bees collect pollen and nectar are called 'bee plants'. The flora of an area are characteristic of its agroclimatic conditions. For example, the flora of the plains will be different from those of the mountains. Moreover, differences in longitude, latitude, and altitude cause variations in the behaviour of the bees and plant species; climatic conditions also affect the distribution and habit of plant species. The nectar and pollen potentials of a plant species vary, depending upon the longitude, latitude, and altitude. A plant can be a major source of nectar and pollen in one area and only a minor source in another. Among these variations, altitude is the most important factor in the context of creating differences in climate and, thus, in flora. Based on the agroclimatic zones, the bee flora of the Himalayan region are categorised into three groups: **sub-tropical, sub-temperate, and temperate.**

The most widely-accepted criterion used for the categorisation of bee flora is the **type of bee food**. Plants that supply nectar abundantly but little or no pollen are considered to be **nectar or honey plants**. These nectar or honey plants are best suited for honey production. Important nectar sources of different agroclimatic zones of the Himalayan region include *Achras japota, Aesandra butyracea, Calliandra* spp, *Citrus* spp, *Gossypium* spp, *Grevillea robusta, Leucas aspera, L. zeylanica,* *Leucosceptrum canum, Medicago sativa, Melilotus alba,* and *Trifolium repens*. Plants supplying pollen but little or no nectar are called **pollen plants**. Examples are *Bidens* spp, *Cynodon dactylon, Leucaena leucocephala, Mimosa pudica, Vitis vinifera,* and *Zea mays*. Pollen plants are important in beekeeping, especially at the time of colony build-up, when bees need large amounts of protein for brood rearing. Many plants, however, provide both nectar and pollen in good amounts. These plants are called the **nectar and pollen plants**. Such plants include *Acacia arabica, Brassica* spp, *Citrus* spp, *Carthamus tinctorius, Eucalyptus* spp, *Guizotia abyssinica, Helianthus annuus, Litchi chinensis, Prunus insitia, Prunus persica,* and *Raphanus sativus*.

Nectar and pollen plants are further classified on the basis of their **nectar and pollen potentials**. Nectar and pollen potentials can be defined as the quantity of nectar or pollen produced by a crop grown on one hectare area of land (Crane *et al*. 1984). Plants that produce surplus nectar and pollen and are abundantly available in an area are **major sources** of pollen and nectar. These plants supply important annual honey flows. Plants that supply sustained annual flows of nectar and pollen used in the maintenance and development of bee colonies are **medium sources**. These plants provide a main flow under favourable ecological conditions. The third group includes plants from which honeybees do not generate surplus honey, yet the plant provides enough nectar and pollen for the bees to survive on during dearth periods. These plants are called **minor sources** of pollen and nectar and are also important for beekeeping.

Cirnu *et al*. (1976) developed another criterion for classifying bee plants based on their economic contribution to beekeeping. These authors categorised all recorded honey plants into five groups. The first group includes plants with a **very high economic contribution to beekeeping**. They are characterised by high honey potential, cover important areas in a particular country, and supply important honey flows, for example, *Helianthus annuus, Sesamum indicum, Tethonia tagetifolia,* and *Zizyphus jujuba*. The second group includes plants with a **high economic contribution to beekeeping**. These are characterised by high honey potential, cover rather large areas, and supply periodic or annual honey flows, for example, *Brassica* spp, *Citrus* spp, *Aesandra butyracea,* and *Guizotia abyssinica*. The third group includes plants with a **medium economic contribution to beekeeping**. These plants supply sustained annual maintenance flows of nectar and pollen and, in favourable ecological conditions, may even provide the main flow. The fourth group includes plants with a **low economic contribution to beekeeping**. These plants supply nectar and pollen frequently, helping to maintain bee colonies without ensuring the main flows. Lastly, the fifth group includes plants **without any economic contribution to beekeeping**. These plants supply pollen and nectar only from time to time and for short periods, covering either small areas or producing small amounts of nectar and pollen.

Other criteria for the categorisation of bee flora and those generally used for the classification of plants are: i) plant form (**trees**, **shrubs,** or **herbs**) and ii) plant habitat (**cultivated** or **wild**). The categorisation of bee flora is summarised in Table 2.1.

Table 2.1 ***Categorisation of Himalayan bee flora***

Agroclimatic zones	**Plant forms**	**Habitat**
Subtropical bee flora	Trees	Cultivated plants • *Agricultural crops*
Subtemperate bee flora	Shrubs	• *Horticultural crops* • *Forage crops*
Temperate bee flora	Herbs and annuals	• *Ornamental plants*
		Wild plants and forest trees
Bee food	**Nectar and pollen potential**	**Economic contribution**
Nectar or honey sources	Major nectar or pollen sources	Very high
Pollen sources		High
	Medium nectar or pollen sources	
Nectar and pollen sources		Medium
	Minor nectar or pollen sources	Low
		None

Source: Compiled by the Author

In Chapter Five, honey plants are categorised into five major groups: Agricultural Crops, Horticultural Crops, Forage Crops, Ornamental Plants, and Wild Plants and Forest Trees, in order to make this book more useful for beekeepers, beekeeping extension workers, farmers, and other private entrepreneurs.

Honeybee Forage: Nectar and Pollen

Nectar and pollen are the basic raw materials of the beekeeping industry. Nectar provides energy to the bees for flight, foraging, and performing other hive activities. Bees convert the excess nectar into honey and store it in the combs. Pollen is the sole source of the proteins, lipids, minerals, and vitamins needed to feed the brood and immature adult bees. The production of nectar and pollen is affected by numerous factors, and these are described in detail in the following text.

Nectar

Nectar is a water-based solution of sugars and minor amounts of numerous constituents which include proteins, amino acids, organic acids, lipids, antioxidants, dextrin, minerals, volatile oils, and enzymes (Baker and Baker 1983). The concentration of sugar in nectar at the time of collection varies from four or five per cent to more than 60 per cent. The amino acid content of nectar (0.002-4.8mg per 100mg total solids) is too low to contribute significantly to honeybee nutrition. The organic acids and volatile compounds contribute significantly to the flavour of honey.

Nectar is secreted by glands called **nectaries**. **Floral nectaries** are found in parts of the flower such as the receptacle, base and apex of the ovary, below the stamens, on the petals and sepals; or **nectaries** are **extrafloral** when found on the vegetative aerial parts, e.g., between and below the bracts, on the petiole, on the undersurface of leaves; on the leaf midrib and between the midrib, and on the main veins. Both floral and extrafloral nectaries may occur on the same plant, e.g., cotton and broad bean (Butler et al. 1972; Davis et al. 1988). More than one form of extrafloral nectary may be present; for example, cotton has extrafloral nectaries in several locations and the trumpet creeper has four extrafloral nectary systems in addition to the floral system (Elias and Gelband 1975).

Nectaries may consist of a simple group of cells with little to distinguish them from the adjacent tissue or they may be conspicuous structures, as seen in the *Poinsettia*. Often highly-developed nectaries are more richly pigmented than their adjacent tissues. Brighter green, orange-gold, yellow-gold, yellow white, or white nectaries occur in different species of *Lamium*.

Nectar is basically phloem sap which has undergone certain alterations during the secretory process. Depending upon the plant species, xylem sap may be present. The overall process includes the unloading of sap from the phloem sieve tubes, passage of the sap (sometimes called pre-nectar) from cell to cell through the subglandular tissue and secretory cells, and, finally, the expulsion of the finished nectar to the outside.

Factors Influencing Nectar Production

Factors influencing nectar production are classified into two categories:

i) internal factors, and
ii) external (environmental) factors.

These have been discussed below.

Internal Factors. Internal factors affecting nectar production include genetic and physiological factors and pollination and fertilization. These are reviewed by Shuel (1992).

Genetic and Physiological Factors

The potential for nectar yield is determined by heredity; the extent to which the potential is realised depends upon the environmental conditions of weather and soil. In the context of the physiology of secretion, the yield depends upon two basic factors: the secretory capacity of the nectary and the quantity of sugar delivered to it. Different varieties of various crops, for example red clover, alfalfa, white clover, cucumber, and rape seed differ substantially in the amounts of nectar secreted. This hereditary variation in nectar yield is linked to anatomical features such as the volume of nectariferous tissue, nectary size, diameter of the receptacle, and the number of nectary stomata.

Where male and female flowers are present on the same plant, their nectar yields may differ. For example, the female cucumber flower secretes more nectar than the male flower (Collison 1973). The male flowers of the banana yield several times more nectar than the female flowers, and the male flowers of the willow produce more nectar than the female flowers (Fahn 1949).

Secretory rates may differ with the age of the flower. For example, cucumber flowers produce most of their nectar on the day of anthesis, a majority of flowers produce little or none on the second day (Collison 1973), and the dandelion flower secretes on two successive mornings, with a larger yield on the second day (Szabo 1984). Amongst species which flower during the day, variations have been observed in the time of the day at which bee visits occur, which, in turn, may serve as an indicator of the rate of nectar production (Meeuse 1961).

Pollination and Fertilization

Nectar secretion is also affected by pollination and fertilization. It begins about the time the flower opens, pollen ripens, and the stigma becomes receptive. As a result of this timing, pollination is successful and leads to fertilization. Fertilization, in turn, seems to activate a feedback mechanism in the flower which switches off the secretion of nectar. The flowers of lavender, alfalfa, cucumber, and cotton quickly wilt and cease to produce nectar shortly after the bee's visit.

External (Environmental) Factors. The external factors that affect nectar production in plants are light, temperature, atmospheric humidity, and soil.

Sunlight

Sunlight is of primary importance for nectar production. During flowering, it supports a high level of photosynthesis and produces more sugars. Duration of sunshine is the weather factor which is most influential in determining nectar yield in many plants, e.g., alfalfa, sainfoin, and white clover. In red clover and alsike, a close association occurs between solar energy reaching the plants in the 24-hour period immediately preceding nectar secretion and the nectar yield (Shuel 1952; 1957); and there is also a close association between hours of sunshine and the nectar yields of sainfoin and white clover (Kropakova and Haslbachova 1970). In a greenhouse, where temperature and soil conditions were favourable to secretion, daily nectar yields of red clover varied by as much as 300 per cent with fluctuations in incident solar radiation (Shuel 1952).

Temperature

Nectar production involves many individual processes within the plant, each of which is probably affected by temperature. Nectar production hus a direct correlation to air temperature. Alternation of high day and low night temperatures promotes good nectar flows. Minimum threshold temperatures for secretion have been reported for various plants.

Basswood flowers begin to secrete nectar at 18°C, bird cherry at 8°C, cherry laurel at 18°C-20°C, cucumber at 17°C-21°C, and several cultivars of soybean at 21°C (Beutler 1953; Collison 1973; Erickson 1975). There is little information on the optimum temperature range and the upper temperature limit for nectar secretion in different species. In soybean plants, nectar secretion increases progressively with an increase in daytime temperatures from 20° to 32°C. Prolonged high temperatures in the absence of adequate soil moisture adversely affect nectar production, owing to moisture stress in the plant. Under such conditions, photosynthesis and sugar transport are reduced and may cease completely (Crafts and Crisp 1971). When soil moisture is plentiful, continuous hot weather has the effect of accelerating flower development, so the nectar flow may be of shorter duration but of greater intensity.

The temperatures to which plants are exposed before flowering determine the number of flowers produced and, therefore, the nectar yield per plant. When honey crops are obtained from trees and shrubs, temperature effects, like those of sunshine, are extremely complex and difficult to predict. Nectar flows in *Eucalyptus,* for example, are influenced by the weather conditions occurring for several years preceding the honey harvest. Cool temperatures at the time of flowering favour the nectar flow (Porter 1978).

Atmospheric Humidity

Although there is no evidence that atmospheric humidity affects nectar secretion directly, it may have an indirect effect, similar to that of temperature, through its influence on the rate of water loss from the plant by transpiration. Nectar sugar yield in some plants, e.g., cotton, decreases with decreasing relative humidity, probably owing to water stress (Butler et al. 1972). The most important effect of humidity on nectar production is manifested as an inverse correlation with the concentration of solids. This effect is chiefly physical, and can be explained as follows: as nectar is secreted, it begins to exchange water molecules with the surrounding atmosphere, tending to approach an equilibrium with it, but not attaining it (Corbet et al. 1979). Unless atmospheric humidity is very high, the result will be a net loss of water molecules from the nectar and an increase in sugar concentration. The rate of increase in sugar concentration depends on humidity, air movement, temperature, and the degree to which the nectar is protected by the flower parts.

Soil Conditions

The physical condition of the soil with respect to water content, temperature, and aeration is very important in establishing the base for a honey crop. Sandy soils support good nectar yields, except in dry years when heavier soils can be superior (Johnson 1946). Several honey production records indicate that the best crops occur in slightly wetter seasons. Dry soils reduce both nectar and flower production. Water deficiency also promotes a decrease in nectar sucrose and an increase in glucose and fructose.

Soil temperature affects the number of flowers produced by the plant, as well as the amount of nectar produced by individual flowers. Less nectar is produced at a soil temperature of 16°C than at 20°C, and the yield is also reduced in soil with a water content either above or below the optimum (Shuel 1992).

Soil fertility determines both flower production and nectar secretion. Experimental evidence shows that fertilizer input, particularly of potassium and phosphorus, increases the number of flowers and nectar production in a number of crops. The best nectar yields are produced by a reasonable balance between these two elements. Leguminous plants yield good amounts of nectar when grown in calcareous soils, suggesting that calcium, magnesium, or high soil pH favour nectar secretion in leguminous crops. Application of boron to boron-deficient soils makes flowers more attractive to honeybees because of increased concentration of sugar in nectar (Holmes 1960).

Nectar and Honey Potentials

Nectar potential is the amount of nectar produced during a season by a crop in one hectare of land. A plant species is considered to be a major source of nectar if it secretes large quantities of nectar and contributes to surplus honey, or a minor source if it provides just enough nectar for the survival of bee colonies without generating surplus honey. Since honey is produced mainly from nectar, **honey potential** is the estimated weight (kg) of honey that can be obtained in the course of a season from one hectare of land covered with the plant, assuming optimal conditions (Crane 1975). Like nectar, honey potential varies from species to species and also according to climatic and soil conditions. Factors such as air temperature, humidity, and soil moisture, which affect nectar production, also affect the honey potentials of any particular plant species/

crop. As an example, the honey potentials of some common bee plants of the Hindu Kush-Himalayas are given in Table 2.2.

Pollen

Pollen is a key element in pollinator-flower relationships. As discussed earlier (page 23), it is essential for honeybee nutrition and provides pro-

Table 2.2 **Honey Potential of Common Bee Plants in the Hindu Kush-Himalayan Region**

Plant species	Honey Potential (kg/ha)	Remarks/Factors
Brassica campestris	50-100	Needs good irrigation
Eucalyptus spp	1000-1500	Varies with age and size of the tree
Litchi chinensis	500-1000	Healthy plants
Dalbergia sissoo	200-300	Requires good rains during winter
Syzygium cumini	200-300	Large, healthy trees
Azadirachta indica	100-200	Large, healthy trees
Cedrela toona	300-500	Uniform plantations and age of trees
Sapindus mukorossi	300-500	Uniform plantations and age of trees
Berberis spp	100-300	Thick bushes
Terminalia chebula	100-300	Healthy trees and uniform plantations
Prunus armeniaca	100-300	Uniform plantations and healthy trees
Malus domestica	15-20	Requires plentiful rains during winter
Trifolium alexandrinum	300-500	Requires good irrigation
Gossypium spp	100-300	Healthy crop, good irrigation
Robinia pseudoacacia	500-1000	Requires plenty of soil moisture
Acacia catechu	100-300	Requires plentiful rains before flowering and light rain during flowering
Trifolium repens	200-500	Requires good irrigation and soil moisture
Plectranthus spp	500-1000	Requires plentiful rain during rainy season and good soil moisture
Prunus cerasoides	100-300	Requires good soil moisture
Brassica napus	300-500	Requires good irrigation
Helianthus annuus	100-200	Requires good irrigation

Source: Joshi 1992

teins, lipids, minerals, and vitamins that the honeybees feed the and immature adult bees (Gary 1992).

Biologically, nectar and pollen are in different categories; nectar is a product of secretory activities, but pollen grain is an integral part of the plant, a spore, also called a microspore or male gametophyte. In flowering plants, pollen is produced in four pollen sacs in the anthers. Each pollen sac contains numerous pollen mother cells which undergo meiotic cell division to produce haploid pollen grains (microspores). These pollen grains are released by the dehiscence, e.g., opening of the anthers.

The time of the day at which pollen is released is a species' characteristic. Some plants, such as sunflower and rape seed, release pollen early in the morning, whereas others, e.g., broadbeans do so in the late afternoon. Depending upon the time of pollen release, angiosperms are divided into six categories (Percival 1955). In the flowers of some plants, pollen is released continuously throughout the day. The amount of pollen released in flowers of the same species varies widely depending upon the age of the plant. In some plants, e.g., black currants and maize, pollen release takes place almost simultaneously in the stamens of all flowers, whereas in other plants it extends over a period of hours, and a few plants, e.g., raspberries release pollen over a period of several days.

Pollen from different plant species differs greatly in nutritive value and attractiveness to bees. Pollen is classified **as highly nutritious, nutritious, fair, and poor,** depending upon the evaluation of pollen sources on the basis of their efficiency in supporting development of hypopharyngeal glands and fat bodies. Pollen from fruit trees, willows, maize, and clover is among the best, dandelion pollen ranks second, and the pollen of pine and other conifers is the poorest. In tests based on the brood produced per unit of diet consumed, differences were found even among closely-related plant species (Loper and Berdel 1980). From the results of various feeding tests, it appears that the amino acid balance is a major determinant in the nutritional efficiency of pollen. Mixed pollen usually seems to be preferred by bees to a single source.

Factors Influencing Pollen Collection by Honeybees

Pollen collection by honeybees appears to be influenced by a number of factors, both internal and external to the colony (Shuel 1992). The colony's need for protein is important. The presence of unsealed brood stimulates pollen foraging (Free 1967; Barker 1971), and the foraging is intense during population build-up in spring (Free 1967; Barker 1971). The absence of unsealed brood inhibits pollen foraging.

Among the external factors influencing pollen collection, the temperature is most important. In England, a positive correlation exists between daily maximum air temperatures and the number of pollen loads collected by honeybees (Synge 1947). This is mainly because a high temperature accelerates dehiscence of the anthers, whereas a low temperature delays dehiscence by retarding the pollen ripening process. The minimum temperature for dehiscence varies with the species and may be quite low for those which flower in spring, e.g., the anthers of apple have been observed to dehisce at 5°C (Percival 1955).

Three

Aids to Identification of Bee Flora

Honeybees visit a number of plant species to collect food, i.e, nectar and pollen. So far, over 1,000 plant species are known to constitute the bee flora of the Hindu Kush-Himalayan region. In order to fulfill the objectives of beekeeping, proper planning, use, and skilled management of existing bee floral resources are essential. The identification and categorisation of bee flora are, therefore, necessary for proper bee management.

Identification of Bee Flora

The bee flora of an area can be identified through surveying, in the field, plants visited by honeybees, either by direct observation or through published reports. They can also be identified by carrying out pollen analysis of honey (melissopalynology). These methods are described in detail in the following text.

Direct Observation

The bee flora of an area can be identified by observing honeybees foraging on flowering plants. The nature of the plant, whether it is a source of nectar or pollen, can be determined by observing the bee's activity on the flower. If a bee thrusts its proboscis into the interior of the flower basin, the plant is taken to be a source of nectar. The availability of pollen, on the other hand, can be determined by observing bees collecting pollen and carrying it in loads on their hind legs. The status of the material, whether major or minor, is determined by the intensity of bee visits, and the occurrence of the plant species is determined by the density of the plant (number of plants/m^2 for herbacious plants and number of plants/ha for trees and shrubs). Such field surveys have been carried out by Dewan (1980; 1984), Kafle (1984), Shahid and Qayyum (1977), and Makhdoomi and Chohan

(1980) in order to identify the bee flora of Bangladesh, Nepal, and Pakistan respectively.

Published Reports

While making field surveys, it is not always possible to find honeybees foraging, and, hence, it is not always possible to determine whether a particular plant is a bee plant or not. In such cases, the plant is collected (the whole plant for herbs and a flowering branch for shrubs and trees), pressed, identified, and then compared to the published reports of its use by bees.

Melissopalynology

Another method of identifying bee flora in an area is by identifying the pollen in the honey and the bee pollen load sample of the particular area. Honeybees, while foraging on the flowers of different entomophilous plants to collect nectar, also collect some pollen along with it. This pollen is retained in the ripened honey. Thus, the honey which the bees subsequently store in honeycombs always contains a certain amount of pollen. The microscopic examination of pollen grains in honey is known as melissopalynology or pollen analysis. Identifying the pollen in honey helps to identify the honey sources and analysing the bee pollen load reveals the pollen sources of an area. Studies to identify bee plants through melissopalynology have been carried out by many researchers in the Hindu Kush-Himalayan region (Focke 1968; Deh-Feng and Wen-Cheng 1981; Yue-Zhen 1984; Saraf 1972; Atwal and Goyal 1974; Singh 1983; Singh 1989; and ICIMOD 1996).

The Need for Identifying Pollen

Studies on pollen analysis of honey are helpful in both the qualitative and quantitative analyses of honey (Louveaux et al. 1978). Quantitative analysis is useful for confirming the botanical origin of unifloral or multifloral honeys. The types of pollen in honey indicate the flowers from which the bees gathered the nectar. For example, honey samples are considered to be rich, poor, or extremely poor in pollen if the number of pollen grains per 10g sample of honey is above 100,000, 20,000-100,000, or below 20,000 respectively.

Analysing the pollen in honey also helps to identify the geographical origin of the honey, because local bee flora have characteristic plant associations that are reflected in the pollen grains present in local honeys

(Pfister 1895; Maurizio 1975; Nair 1985). Honey pollen analysis also helps to identify the season in which the honey was extracted and the plant sources of toxic honeys. In addition, it indicates the rélative preferences of honeybees for individual plants that flower simultaneously.

How to Identify Pollen

In order to analyse the pollen in honey, an adequate knowledge of pollen morphology is essential. Pollen is a granular mass of male reproductive cells produced in the anthers of a flower. When seen with the naked eye, these appear as minute dust-like particles. However, each particle has its own special structure which indicates its origin. A brief account of pollen grain structure and the diagnostic features used in identifying pollen are given in the next section.

Structure of the Pollen Grain

A pollen grain is a living cell surrounded by two protective coats, the intine and the exine. The cell contains cytoplasm and a nucleus. On the surface are apertures or germinal pores or furrows. The detailed structure of a pollen grain is shown in Figure 3.1.

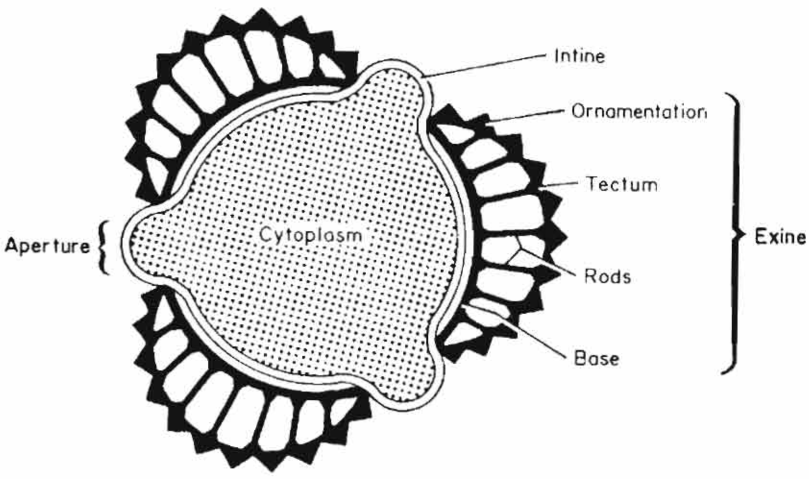


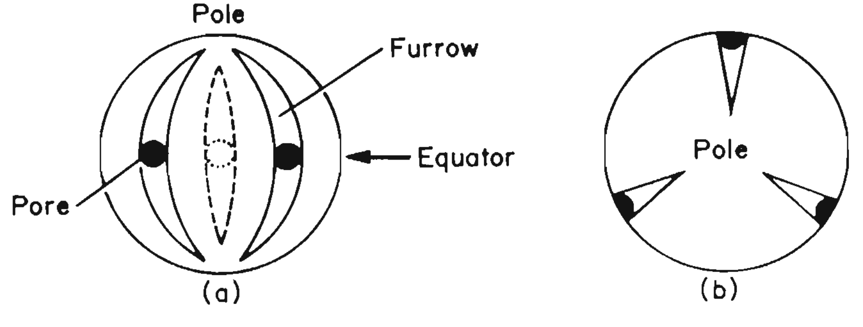
Figure 3.1 Diagram showing the structure of a pollen grain in optical section (Source: Sawyer 1981)

The inner layer or **intine** is thin, delicate, and very elastic. It is a semi-permeable membrane and does not stain. When the grain is seen in section, the intine can be recognised as a thin, clear line surrounding the cell contents. The outer layer or **exine** is thicker, more brittle, and often variously sculptured or provided with various modifications such as spines, outgrowths, or reticulation. The exine is made of an extremely durable material called **sporopollenin**.The exine is composed of four layers, as listed below.

i) ***Base***: This is a clear, uniform layer, the outer part of which can be stained to reveal a dark line in the optical section of the grain.
ii) ***Rods*** or ***Columns***: These are arranged radially from the base.
iii) ***Tectum***: This layer forms a roof over the rods. It may be an incomplete layer, leaving some of the rods free-standing.
iv) ***Ornamentation***: This is provided by a layer of spines, outgrowths, reticulation, and other processes on the tectum.

Usually, all the layers are not present. Those which are present show many modifications that are very useful in identifying a particular pollen grain.

Apertures are present on the surface of pollen grains. These are formed by the thinning or the absence of some of the layers of the exine. They are called **furrows** or **colpi**, if they are elongated and tapering towards the ends, or **pores** when they are round or oval (Figure 3.2). Pores and furrows often occur together, but at different levels of the exine. Apertures allow the grain to dry or to absorb water and thus to change into an



(a) equatorial view (b) polar view

Figure 3.2 Diagrams illustrating the pollen grain apertures (Source: Sawyer 1981) expanded state. They also provide an easy outlet for the pollen tube when the grain germinates. Therefore, they are also called germ pores or germinal furrows.

Pollen Grain Features

Each pollen grain has its own peculiar structural features which helps us recognise its origin. The features that can be used in its identification are as follows.

Size: The size (diameter) of the pollen grain is expressed in microns or micrometres (µm), where 1µm=1/1000mm. The maximum diameter of a pollen grain includes the spines or other ornamentation. Sawyer (1981) used five size classes: i) very small (<20 µm); ii) small (20-30 µm); iii) medium (30-50 µm); iv) large (50-100 µm); and v) very large (>100 µm). However, not all pollen grains are round. Many are either elliptical or triangular, even elongated. Vorwohl (1990) suggested that instead of defining size by the diameter, it should be defined by the length and breadth. He suggested nine classes of length and breadth (Table 3.1).

Shape: Shape is the outline; the optical section seen under the microscope. A pollen grain can be round, oval, elongated, triangular, semi-circular or boat-shaped, and irregular or multi-sided (Figure. 3.3). The shape plays a very minor role in the identification of pollen grains, because it varies depending upon the position in which the grain lies and upon the viewing aspect. Thus, one kind of pollen grain may show several different shapes on the microscope slide. However, Sawyer (1981) considered shape an important feature in pollen identification.

Apertures: As described earlier, pollen grains have apertures on the surfaces. The shape (type) and the numbers of apertures are important characteristics of a pollen grain and can be used in identification. Furrows containing pores are counted as one aperture. In compound pollen grains, the numbers refer to each single grain sub-unit. Nine classes of **aperture number** (as given in Table 3.1) can be used in pollen identification. Regarding **aperture type**, Vorwohl (1990) used the following five classes in pollen identification (Table 3.1).

i) **Pore**: Equatorial, a more or less isodiametric (round) aperture, e.g., all the plants in the family *Poaceae* and many plants in the families *Cucurbitaceae* and *Chenopodiaceae*.

Table 3.1 ***Diagnostic Pollen Grain Features Used for Identification***

1. Length and breadth	1	<10 µm
	2	10-15 µm
	3	15-20 µm
	4	20-25 µm
	5	25-30 µm
	6	30-35 µm
	7	35-40 µm
	8	40-50 µm
	9	>50 µm
2. Aperture number	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	>7
	9	absent or not clear
3. Aperture type	1	Pore
	2	Colpa
	3	Colporate
	4	Syncolpate
	5	Heterocolpate
4. Exine Sculpture	1	Psilate, Faveolate, Fossulate
	2	Scabrate, Verrucate, Gennuate
	3	Echinate
	4	Clavate, Bacculate
	5	Rugulate, Striate
	6	Reticulate
	7	Fenestrate
5. Aggregation	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	>7

Source: Vorwohl (1990).

ii) ***Colpa (Furrow)***: Equatorial, longitudinal aperture, usually tapering towards the ends, e.g., *Allium* spp and *Lamium* spp.

iii) ***Colporate***: Pores with colpa, e.g., *Symphytum* spp. Most probably there are not many monocolporate forms.

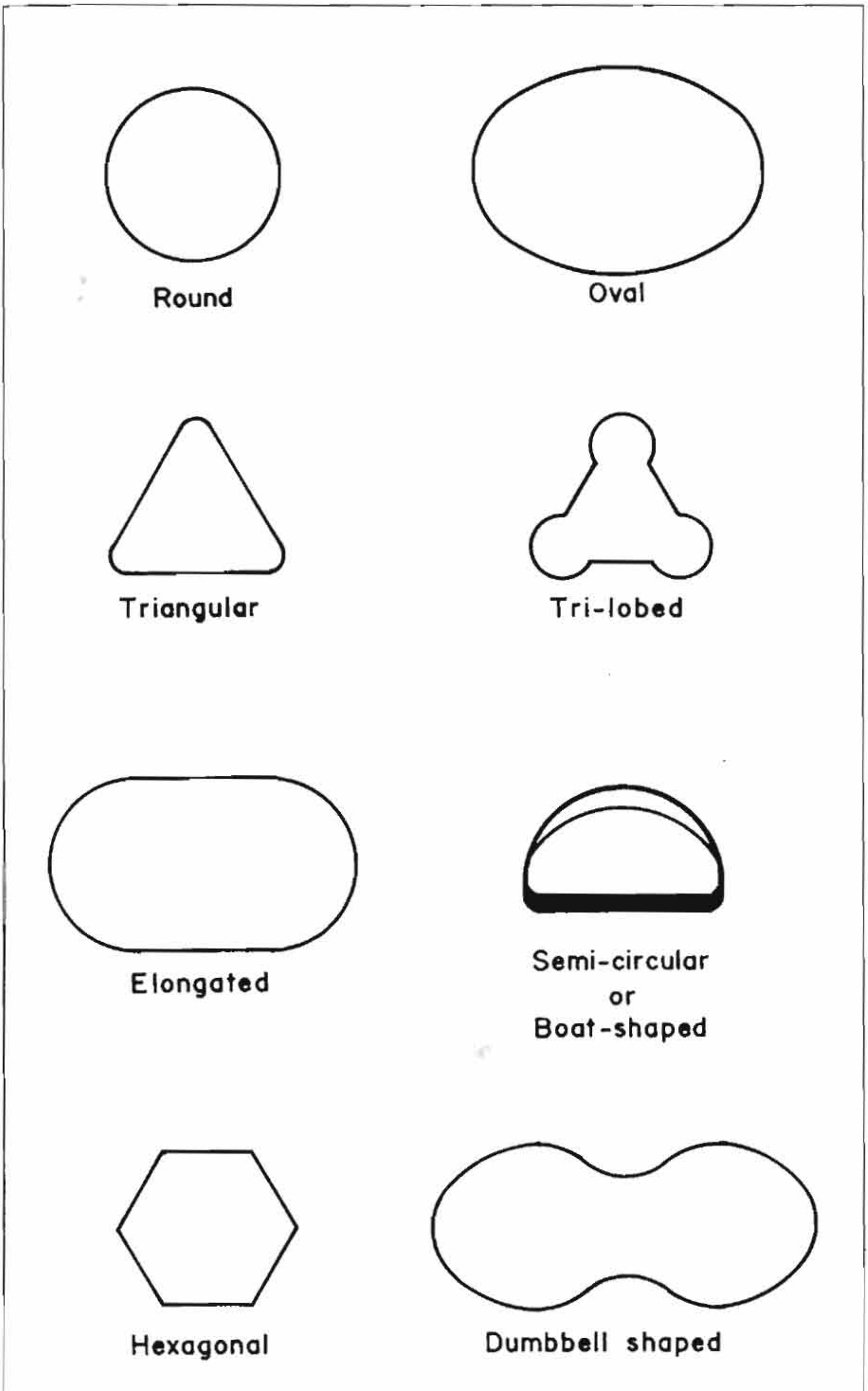


Figure 3.3 Diagrams illustrating different shapes of pollen grains
(Source: Sawyer 1981)

iv) ***Syncolpate***: Apertures are formed as colpi or colporate where the ends of the colpi meet at the polefield, e.g., in some species of *Eucalyptus;* or colpi are like a band and meet with one another, e.g., *Mahonia* spp, *Berberis* spp, *Passiflora* spp, and *Crocus* spp.

v) ***Heterocolpate***: Both pores and colpi occur separately on the same pollen grain, e.g., *Lythrum* spp and *Phacelia* spp.

Sawyer (1981) recognised only four classes of aperture types to be important in pollen identification. These are: i) pores only; ii) furrows only; iii) united pores and furrows; and iv) irregularly occurring furrows.

Exine Sculpture (Exine Ornamentation) and Surface: The exine, the outermost coat of the pollen grain, is either smooth or variously ornamented with different outgrowths or projections, such as granules, various kinds of spines, and reticulum or window-like structures. The ornamentation of the exine has a major effect on the surface of pollen grain as viewed under the microscope.

The surface view of the pollen grain, as seen under the microscope, is regarded as the pollen surface. Since exine ornamentation is the outermost layer of the pollen, the surface view of this layer is considered to be the surface of the pollen grain. The surface of pollen grains, as seen under the microscope, can sometimes change with a change in focus. For example, the pollen grain of *Luffa cylindrica* may appear granular under one focus and reticulate under another.

Diagrams of different exine ornamentations and surface patterns are shown in Figures 3.4 and 3.5 respectively. According to Sawyer (1981), exine ornamentation and surface are two different features, both of which are important in identifying pollen. He identified nine classes of exine ornamentation (thin, medium with no rods, medium with spaced rods, medium or thick with coarse external rods, a layer of closed thin rods having long thin spines, large broad-based spines, small or very small spines or warts, and other projections) and five classes of surface (such as smooth or indefinite, granular, striated, net or pitted, and having isolated dots due to spines or other projections). However, Vorwohl (1990) considered exine ornamentation only as the most important feature in pollen identification and reported seven classes of exine sculpture (Table 3.1). These are described below.

i) ***Psilate, Faveolate and Fossulate***: When exines are smooth, they are known as psilate, e.g., *Betula* spp and *Pyrus* spp. Exine sculpture

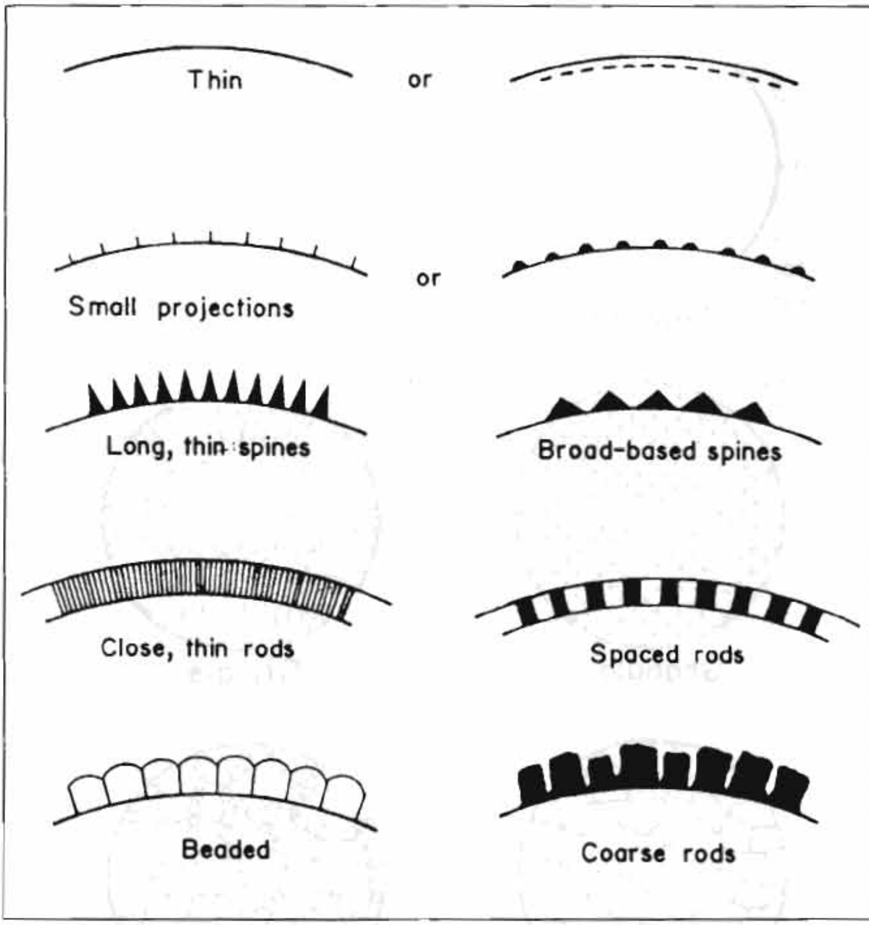


Figure 3.4 Diagrams illustrating different exine sculptures of pollen grains (Source: Sawyer 1981)

with little pits is reported as faveolate and is known as fossulate with relatively larger pits. In viewing the surface, the pollen grains with psilate, faveolate, and fossulate exine sculpture appear smooth or sometimes indefinite.

ii) ***Scabrate, Verrucate and Gennuate***: Exines with little warts and diameters of not more than one µm are scabrate, e.g., some species of *Quercus*. In verrucates, the diameter of the warts is more than one µm, e.g., members of the *Ranunculaceae* family, some *Asteraceae*, and *Nigella* spp. Gennuate is an exine sculpture with round warts which are narrower at the base, for example, *Ilex* spp. In optical sections, this kind of exine appears to have small projections. Pollen grains with this kind of exine sculpture appear granular in viewing the surface.

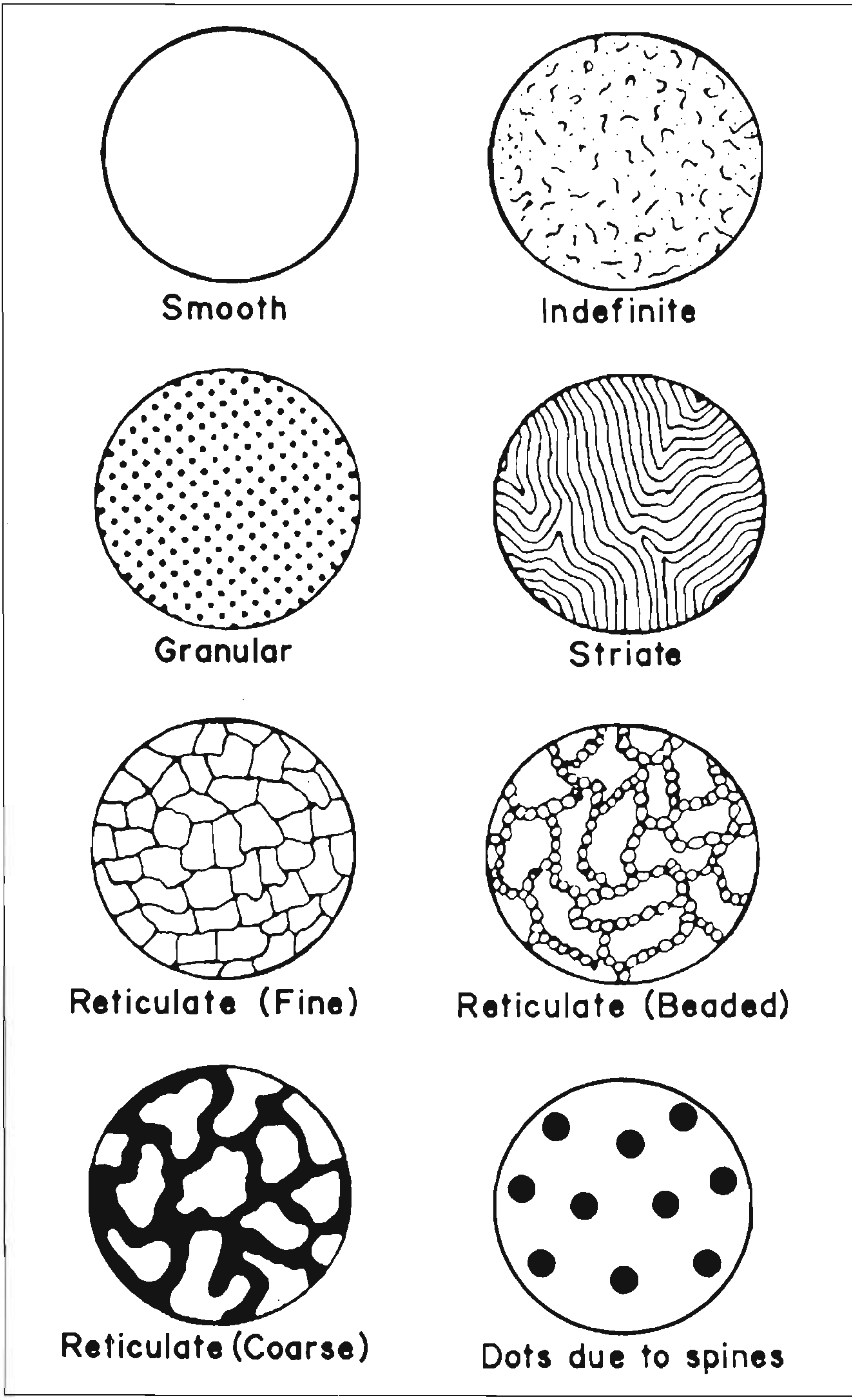


Figure 3.5 Diagrams illustrating different surfaces of pollen grains
(Source: Sawyer 1981)

iii) ***Echinate***: Exines provided with different kinds of spines, e.g., *Malvaceae, Cucurbitaceae, Campanulaceae,* and many *Asteraceae* are echinate. Pollen grains with echinate exine sculpture appear to have dots on the surface.

iv) ***Clavate and Bacculate***: Exines with rods which have thicker ends are clavate and those with stick-like rods are bacculate. Pollen grains with clavate or bacculate exine sculptures are very rare. On examining the surface, the pollen grains with this kind of exine sculpture appear granular (they have larger grains than scabrates, verrucates, and gennuates).

v) ***Rugulate and Striate***: Exine sculptures with striations, e.g., species of *Acer, Prunus, Datura,* and *Fragaria,* belong to these categories. In optical section, the exines appear to have close, thin rods. On examining the surface, the pollen grains also appear striated.

vi) ***Reticulate***: This term is used when the exine sculpture is reticulate or net-like. This category is divided into fine reticulate, or beaded, or coarse reticulate. Examples are *Lilium* spp, *Hedera helix,* and *Ligustrum* spp. In optical sections, reticulate exines appear to have either thin or coarse rods, or they appear to be beaded. Pollen grains with reticulate exine sculpture appear reticulate on the surface also.

vii) ***Fenestrate***: Exines in which there are window-like holes between the ribs of the exine belong to this category. Important examples include *Taraxacum officinale* and members of *Amaranthaceae*. On the surface, the pollen grains appear to have window-like holes.

Other Features: Pollen grains of some plant species have other diagnostic features. For example, the pollen grains of many plant species in the families *Ericaceae* and *Leguminosae* (sub-family, *Mimosoidae*) are polyads, i.e., compound. In *Ericaceae*, four grains are aggregated to form a tetrad, e.g., *Rhododendron* spp, whereas in the *Leguminosae,* eight, twelve, or sixteen pollen grains are aggregated to form a polyad, e.g., *Acacia* spp, *Albizia* spp, *Calliandra* spp, and *Mimosa* spp (Figure 3.6). Aggregation of pollen grains is one of the important features in identifying pollen grains.

Still other features important for identifying pollen include the presence of air sacs in the pollen grains of plant species belonging to the family *Pinaceae*, e.g., *Pinus* spp; thickened or projecting edges to apertures, e.g., *Polygonum* spp; a cap or streak on the apertures, e.g., *Chenopodium* spp and *Cucurbita* spp; granules or projections scattered on the apertures, e.g., *Convolvulus* spp; intine swollen below the apertures, e.g., *Hippophae*; intines thick or very thick, e.g., *Viola*; and cell contents granular, e.g., *Rumex* spp (Figure 3.6).

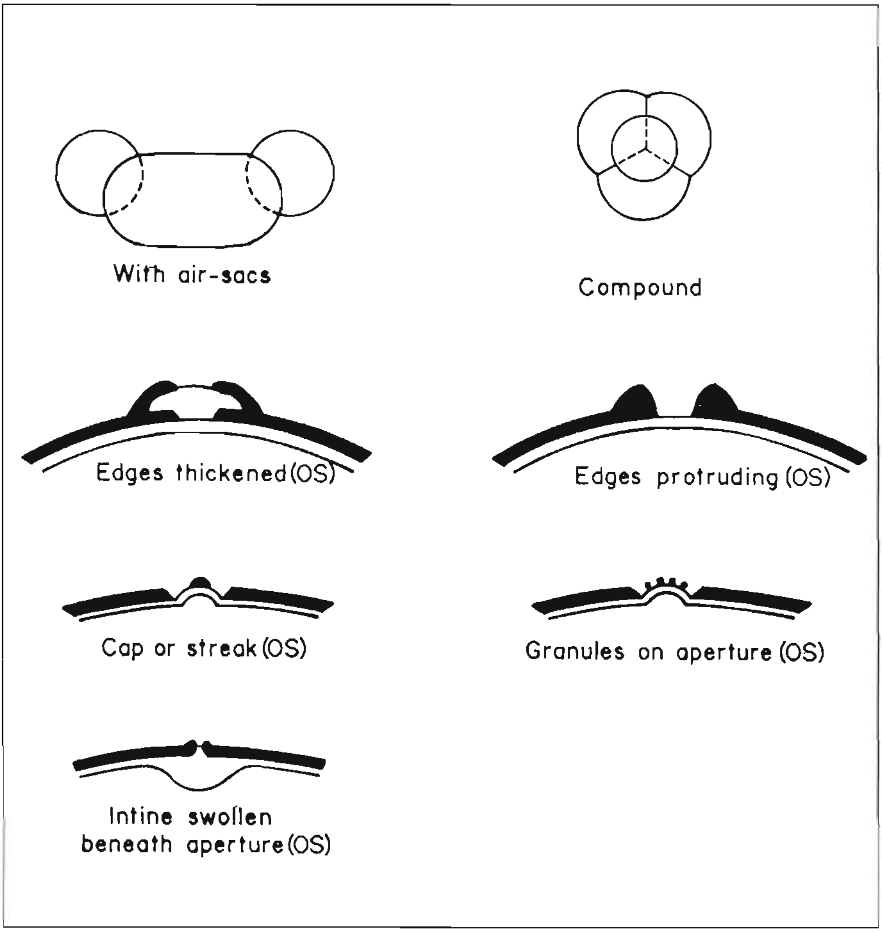


Figure 3.6 Diagrams illustrating other diagnostic features of pollen grains
(Source: Sawyer 1981)

Colour: The colours of dry bulk pollen from the anthers or pollen loads of bees vary considerably and may sometimes provide a valuable clue to the identification of pollen (Sawyer 1981).

How to Examine Pollen Grains in Honey and Bee Pollen Load Samples

From whatever source the pollen is obtained, it must be mounted in a standard manner so that a uniform description and comparison can be made. The simplest and most informative presentation can be obtained from expanded and lightly-stained pollen grains. Pollen can be prepared either by the acetolysis method or without this method. The **acetolysis method** was introduced by Erdtman in 1934 as a way of preparing pollen grains from organic deposits. It relies on the fact that the exine of most pollen grains is highly resistant to both strong acids and bases; so treating a sample thus would dissolve the extraneous materials while not affecting the pollen grain. This technique can be used with herbarium specimens, or with fresh samples in order to prepare reference collections. This method leaves the exine very clean, which makes the pollen grains well-suited for studying sculpturing by light microscopy or scanning electron microscopy.

Erdtman (1969), however, reported that the pollen grains of some taxa are often destroyed or badly damaged by acetolysis, e.g., the genus *Populus* (Salicaceae) and the families *Lauraceae, Ceratophylaceae, Juncaceae, Thruniaceae, Rapateaceae, Cannaceae, Musaceae, Zinziberaceae,* and *Zannichelliaceae*. Therefore, pollen from the plants of these families should be prepared **without acetolysis** (i.e., it should not be treated with the acetolysis mixture).

Whether prepared by acetolysis or without acetolysis, pollen is mounted in glycerine jelly. Erdtman (1960; 1969) developed this technique for use with samples prepared by acetolysis, but it also works well with untreated samples. Methods of preparing pollen, and glycerine jelly and mounting the pollen are described in the following text.

Preparing Reference Slides of Pollen

1. <u>Acetolysis Method</u>

Anthers from known flowers are mashed with a glass rod in a centrifuge tube containing glacial acetic acid, the excess acid is then decanted. Five to10ml of the acetolysis mixture is poured on to the mashed anthers and heated in a water bath at 70°C, stirred thoroughly with a glass rod (one separate glass rod is used for each tube throughout, to prevent mixing the pollen between samples). Acetolysis mixture is prepared by adding one part of concentrated sulphuric acid, drop by drop, to nine parts of acetic anhydride. A fresh mixture is prepared every time it is needed.

The contents are allowed to cool and then centrifuged at 2,500rpm for five minutes. The supernatant liquid and the large pieces of tissue are decanted. The pollen left in the centrifuge tube is washed in glacial acetic acid and centrifuged, and the supernatant liquid is decanted. Distilled water is then added to the pollen, which is thoroughly shaken before it is recentrifuged. After centrifugation, the supernatant liquid is decanted. A few drops of a mixture of equal parts of glycerine and distilled water are added to the pollen and then allowed to stand for 10 minutes before the excess liquid is decanted. This sediment is transferred to the microscope slide and placed on a warm plate at 40°C so that the excess water evaporates. It is then mounted in glycerine jelly.

2. Glycerine Jelly Method

Pollen from the known plant is shaken on to a microscope slide, or the anthers are placed on a slide, and a drop of ether is added to disperse the pollen. Any visible particles that are larger than the pollen grains should be removed. Drops of ether are then carefully run over the pollen from a pipette. This will dissolve any oil in the pollen and carry it to one side where it can be wiped off or where the solution can be absorbed by the tissue. Then two drops, one of warmed, stained jelly and another of unstained jelly, are placed on the pollen by means of a glass rod. A cover slip is carefully positioned on top, one edge lowered first to avoid trapping air bubbles. The slide is left on a warm plate (40°C) for about ten minutes. The jelly should be just sufficient to fill the space under the cover slip.

Glycerine jelly is prepared by dissolving seven grammes of gelatine in 42ml of cold distilled water. 50ml of glycerine is added, warmed gently, and stirred until it is dissolved; 0.5 grammes of phenol is then added to prevent the growth of mould. To prepare the stained glycerine jelly, 0.1 grammes of basic fuchsin is dissolved in 10ml of alcohol (methylated spirit). This stain is then added drop-by-drop to the glycerine jelly until a clear pink colour is produced.

A few hours later, when the jelly has finally set, any surplus should be cleaned off with cold water. The cover slip is then sealed along the edges with clear nail varnish or paraffin wax. Thus treated, the slides will last for many years.

Extraction of Pollen from Honey

Pollen is extracted from honey by mixing 10 grammes of honey with 20ml of hot, distilled water. After a thorough mixing, the solution is placed in two centrifuge tubes and centrifuged at 2,500rpm for 10 minutes. The supernatant liquid is decanted, and both tubes are filled with water and recentrifuged for five minutes. The liquid is again decanted, and the sediment is transferred to a microscope slide using a

Pasteur pipette, spread over a suitable area, and dried. De-greasing is not necessary. The rest of the procedure, i.e., staining, covering, and sealing is the same as that described for reference slides.

In the absence of a centrifuge, the **sedimentation method** can be employed. Ten grammes of honey are diluted with at least 100ml of water. This mixture is allowed to stand overnight; the pollen will settle to the bottom.

In order to use the **acetolysis method**, five to10ml of acetolysis mixture is added to the sediment obtained after centrifugation. This is then placed in a water bath at 70°C for 10 minutes and centrifuged after incubation for five minutes. The supernatant liquid is decanted, and the centrifuge tube is filled with distilled water and a drop of strong detergent (teepol) added. It is again centrifuged for five minutes, and a drop of glycerine and water mixture (1:1) is added to the sediment. The rest of the procedure is the same as that described for preparing reference pollen by acetolysis.

Pollen Loads Carried by Bees

The pollen load is placed on a flat plate. A few drops of water are added and mixed gently, using a glass rod, to form a thin slurry. The slurry is transferred to a microscope slide to form a smear. The smear is dried on a warm plate and treated exactly as the pollen obtained from the flower.

<u>How to Identify, Count and Record Pollen Grains</u>

The pollen grains recovered from the honey and bee pollen load samples are examined microscopically and identified with the help of reference pollen slides made from identified plants; and/or by recording the data on pollen grain features (listed in Table 3.1) and comparing this data with those from the reference slides.

The latest technique in honey pollen identification is a computer-assisted reference pollen data bank which greatly facilitates the procedure. The data on pollen grain features of reference pollen slides as described in Table 3.1 are entered into the computer. Similar data of unidentified pollen grains are also entered into the computer. The computer then displays the name of the plant to which that particular pollen grain belongs. Thus, the plant source of that particular pollen grain is identified.

The number of pollen grains is counted by using a hemocytometer (Louveaux et al. 1978; Seethalakshmi 1980; Suryanarayana et al. 1981). The honey sample is considered to be rich, poor, or extremely poor in pollen if the number of pollen grains per 10 grammes of honey is above 100,000, 20,000-100,000, or below 20,000 respectively (Maurizio 1975).

Similarly, a honey sample having 45 per cent or more pollen grains of a single pollen type is considered to be **unifloral honey** and one having several types of pollen grains in considerable percentages is called **multifloral honey** (Iwama and Melhem 1979; Chaturvedi 1983). Based on the frequencies of pollen grains in the honey, four frequency classes are identified (Louveaux et al. 1978). These are i) **predominant pollen** (when it is more than 45% of the total pollen count); ii) **secondary pollen** (16-45%); iii) **important minor pollen** (3-15%); and iv) **minor pollen** (less than 3%).

To close the gap in research on Himalayan bee flora, the author carried out monthly surveys of blossoming trees, shrubs, and annuals and collected flowering plants to create, **a computer-assisted reference pollen data bank** of more than 1,000 plant species. The important species are given in the Annex to this chapter.

Four

Bee Forage Management

Bee forage management can be important for increasing the beekeeping potential of an area. Without proper bee forage management, it is difficult to maintain an apiary of strong and healthy bee colonies. Poor management of bee forage, especially during dearth periods (the dearth period in the low hill areas is generally during the summer and, in the high hill/mountain areas, during winter), results in weak colonies which are susceptible to various diseases and infections. Such colonies generally abscond and the beekeepers have to suffer the loss of their bees. This has an adverse affect on both honey production and crop pollination. Thus, it is necessary to ensure year-round availability of bee forage.

This chapter deals with the tools for bee forage management. Bee forage management is carried out in two steps: the first step is to assess the bee forage potential of an area and the second is to improve upon it. These are described in detail in the following text.

Assessing the Bee Forage Potential

Before starting beekeeping in any area, it is helpful to know the availability of bee forage or the bee forage potential. This helps in assessing as well as improving the beekeeping carrying capacity of a particular area. The beekeeping carrying capacity of an area is the number of bee colonies it can support. It depends upon the density, distribution, nectar and pollen potentiality, and blossoming of the bee plants existing in an area. In order to assess the bee forage potential, bee forage calendars of the nectar and pollen yielding plants of an area are prepared. A **floral calendar or bee forage calendar** for beekeeping is a time-table that indicates the approximate date and the duration of the blossoming period of the existing honey or pollen plants in an area. In addition to the time and duration of blossoms of honey plants, it also involves the mapping of density, distribution, and honey potential of the regional bee flora. Such floral calendars should be prepared for each ecological region where beekeeping is practised.

Value of Bee Forage Calendars

The bee forage calendar is one of the most useful tools of the apicultural extension worker. It enables her/him to inform beekeepers what to expect and when in terms of bee forage availability so that they can manage their colonies in the most rational manner. Beekeeping in an area cannot develop without an understanding of the calendar; and for migratory beekeeping, floral calendars for different foraging zones along the migration route are required. Thus, the bee forage calendars are very valuable for the development of beekeeping in the temperate Hindu Kush-Himalayan region where mixed types of bee flora exist. These are of great help in selecting the most suitable places for the bees to be moved during winter when the temperature in the Hindu Kush-Himalayan region is very low.

Preparation of a Bee Forage Calendar

Assembling a floral calendar for any specific area is simple though time-consuming. It requires complete observation of the seasonal changes in the vegetational patterns or agro-ecosystems of an area, the foraging behaviour of the bees, and the manner in which the honeybee colonies interact with their floral environment. The accuracy of a bee forage calendar, and hence its practical value, depends solely on the careful recording of the beginning and end of the flowering seasons of the plants, how these vary from year to year, and how they affect the bees. Preparing a bee forage calendar normally requires the following steps (Akratanakul 1986).

1. Make a general survey of the area and list the flowering plants paying special attention to the plants with a high floral density per unit area per tree.
2. Place strong honeybee colonies in the area, inspect the hives regularly, and observe changes in the amount of stores within the hive by weighing them **(but remember that newly-collected nectar contains more water)**.
3. When monitoring the hives' food stores, survey the area in the vicinity of the apiary and within the flight range of the bees to record the species of plants that the bees visit.

4. Record whether each plant is visited for nectar or pollen or both.
5. Study the frequency with which the bees visit each flower species in relation to changes in the level of colonies' food stores. If there is a continuous increase in food stores in direct response to the availability of the plants visited, the plants are good forage sources. If the food stores remain stable, the plants can meet the daily food requirements of the colonies but cannot be classified as major sources of food **(but remember that food is used up more rapidly when more brood is present)**.
6. Carefully record the changes in the blossoming of all the plants visited. When the colonies begin to lose weight, the flowering season should be considered finished for all practical purposes.

Once all data on forage species have been assembled for the whole year and repeatedly verified, they should be judged as they relate to the actual performance of the honeybee colonies. The calendar can then be drawn in the form of circular or linear charts, showing the weekly or monthly availability of plants and their flowering sequence. As an example, the floral calendar of Kathmandu Valley prepared by the author is presented in Table 4.1.

Improving the Bee Forage Potential

After the assessment of bee forage potential, the next step is to improve upon its potential. This, in turn, helps to improve upon the beekeeping potential or the beekeeping carrying capacity of an area. This can be achieved either through beekeeping-oriented plantations or by moving the bee colonies to other areas where bee forage is available (migratory beekeeping). The first option involves the management of bee forage, whereas the second option involves the management of bees.

Beekeeping-oriented Plantations

Bee forage potential and, therefore, beekeeping carrying capacity can be increased by establishing beekeeping-oriented plantations. Managing honey plant resources is necessary for the following reasons.

Improving the Beekeeping Potential of an Area

Subsistence farmers generally keep only a few bee colonies. Since the floral needs for small-scale beekeeping are few, the existing honey plants in an area can support these colonies. However, to promote beekeeping as an income-generating activity or for crop pollination, more bee colonies

Table 4.1: **Bee Forage Calendar for the Kathmandu Valley**

(Only important bee plants are included)

Plant species	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Abelmoschus esculentus						○	●	●	●	○		
Ageratum conyzoides			⊙	⊙	○	○	○	○	●	⊙	⊙	
Albizia spp				●	⊙	○						
Allium cepa				●								
Amaranthus spp							⊙	●	⊙			
Bauhinia purpurea									●	○		
Bauhinia variegata			○	●								
Berberis asiatica			○	●								
Borago officinalis		⊙	⊙	●	●	⊙		⊙	⊙	⊙	⊙	⊙
Brassica campestris	●										●	●
Brassica juncea		●	⊙									
Brassica oleracea botrytis		●	●									
Buddleia asiatica		⊙	●									
Calendula officinalis		⊙	●	⊙								
Callistemon citrinus			⊙	●	⊙					●	●	
Campsis grandiflora					⊙	⊙	●					
Capsicum annum						⊙	●	⊙	○			

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Centauria cyanus		●	●	●								
Choerospondias axillaris				●	⊙							
Cirsium spp				●	⊙	⊙						
Citrus grandis		⊙	●									
Citrus sinensis			●	⊙								
Coriandrum sativum			●	⊙								
Cucumis sativus						●	●					
Cucurbita spp					⊙	●	●	⊙	⊙			
Diospyros kaki			●	●								
Eupatorium glandulosum				●								
Eucaplyptus spp				⊙	⊙	●						
Fagopyrum esculentum									●	⊙		
Grevillea robusta				●	⊙							
Helianthus annuus							●	⊙	⊙			
Lagerstroemia indica						⊙	●					
Leucosceptrum canum		●	●									
Mahonia nepaulensis	●											⊙
Prunus cerasoides											●	
Prunus domestica		●	⊙									

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prunus persica		●	⊙									
Pyrus communis		●	⊙									
Pyrus pashia		⊙	●									
Psidium guajava					⊙	●						
Raphanus sativus		⊙	●									
Rhus spp									●	⊙		
Rubus ellipticus			⊙	●								
Sechium edule					⊙	⊙	●	●	⊙	⊙		
Schima wallichii					⊙	●						
Trifolium repens		●	●	●	⊙	⊙	○					
Vicia faba		●	⊙									
Zea mays						●	●	⊙	⊙			

○ Only a few plants are in bloom;
⊙ 50 per cent of the plants are in bloom;
● All the plants are in bloom

Source: Author's observations

are needed. Therefore, to support a large number of bee colonies, large amounts of bee forage are needed. In this case, the plants that provide surplus nectar and pollen, as well as those which support bee colonies during a dearth period, should be planted.

Improving Quality of Honey

The need to manage bee flora also arises when a beekeeper wants to produce high quality honey for marketing purposes. Some unifloral honeys sold by plant names fetch a premium price, e.g., citrus honey from northeastern India, clover honey from the USA, eucalyptus honey from Australia, and chiuri (Indian butter tree) from Nepal. These are some examples of good quality unifloral honey. In this case, managing multipurpose plant species which provide forage sources for making honey of excellent quality is essential. The established plantations of the Indian butter tree, a multipurpose plant species found in the Jajarkot district of the midwestern region of Nepal, are an example of such management.

Managing Crop Pollination and Bee Forage

When bee colonies are kept for the sole purpose of crop pollination, sufficient bee forage is required around the apiaries throughout the year, particularly for the slack winter period when the crops are not flowering, so that colony strength can be sufficiently built up by the time pollination services are required. This can be achieved by:i) planting such bee plants on wastelands and hedges which provide other benefits; ii) cultivation of crops with optimal agronomic conditions; iii) proper cropping patterns and rotation of useful crops; and iv) planned and judicial application of pesticides.

Meeting Needs in Slack Periods

An ideal location for beekeeping is one in which there are at least three plant species that yield surplus honey in considerable quantities and bloom during different months. In addition, there should be a great variety of minor plants yielding both nectar and pollen to support bee colonies between main flows. Such locations are not common in the Hindu Kush-Himalayan region; in many areas honey plants are available for a certain period of the year and then there is a dearth period for about two months during summer in the low hills and during winter in the high hill areas. Thus, there is a need to manage honey plants in order to support bee colonies during this dearth period by providing enough nectar and pollen for their sustenance; this means growing cultivated crops, ornamental plants, weeds, or small shrubs.

There are other options to support bee colonies during the slack months, for instance, feeding the bees with sugar or migrating them to other areas (to the high hill areas during summer and the low hill areas during winter) where flowering plants are available. However, for a small-scale beekeeper from the mountains, both these options are impractical. Farmers may find feeding sugar syrup to bees an expensive option. Also, migration of bee colonies is profitable only for commercial beekeepers and not practical for small-scale beekeepers. Moreover, the migration of bee colonies is possible only in areas accessible by road.

The Bee Forage Plantation Approach

Several plant species have been named after the beekeepers who championed them. **Chapman honey plant** (*Echinops sphaerocephalus*), **Simpson honey plant** (*Scrophularia marilandica*), and **Pellett clover** (*Trifolium ambiguum*) are a few examples from the early 1900s. While these attempts at planting for bees met with varying degrees of success, none are being pursued today by large segments of the beekeeping community. So far, large-scale planting, solely from an apicultural viewpoint, is not considered profitable in terms of net economic returns (Akratanakul 1986; Partap 1992; Verma 1992). Moreover, land is a scarcity in mountain areas, therefore using large areas for the plantation for bees is not possible. Thus, unconventional land-use practices are much favoured for this purpose and the motive is always linked to other development programmes. Plantations on common property lands and roadsides and community forestry are examples. Past efforts in this direction have yielded satisfactory results. For example, roadside plantations in China and Pakistan, social forestry programmes in northwestern India, and community forestry plantations in Nepal included several multipurpose plant species which were also good bee forage plantations. As a result, apiculture has flourished in these areas. A list of such multipurpose plant species which are important honey plants for plantations on common property land, government land, and private land in different agro-ecological zones, besides other uses, is given in the Annex to Chapter 4.

However, according to Ayers and Harman (1992) under the following three situations, a beekeeper can profitably plant bee forage only for beekeeping. The first is when a beekeeper owns land and wishes to plant something on it but does not intend to manage the land for conventional agricultural production. The second is when land adjacent to an apiary is not owned by the beekeeper but the owner is willing to have it planted for bee forage. The third situation occurs when bees from a particular apiary are routinely poisoned by agricultural pesticides but the beekeeper for some reason is compelled to maintain the apiary in that particular location. Under such conditions, if the land on which the apiary is located belongs to the beekeeper, he can plant it with bee forage. Here bee forage planting could help divert bees from pesticide-laden agricultural areas during risk periods. This helps to reduce the loss of bees and to provide quality bee forage at the same time.

Desirable Properties of Bee Forage Plantations

Bee forage plantations, whether carried out with the sole purpose of beekeeping or linked to other development purposes, should have the following characteristics (Ayers and Harman 1992).

High Quality Honey

The first important property of bee forage plants is that they should produce honey of good quality. For this reason, beekeepers need to consider producing speciality honey. Many common plants are the best source of quality honey in different agroclimatic zones. For example, *Citrus* spp and clovers for low hill areas; Indian butter tree and *Eurya* spp for the middle hills; and apple and *Plectranthus* spp for the high hills.

High Productivity

Bee forage plantations should also be highly productive. Highly productive bee plants are characterised by relatively long blossoming periods, generally in terms of several weeks or months; a high density of nectar-secreting flowers per plant or unit area; good nectar quality with high sugar concentration; and accessibility of the nectaries to the bees. Examples include *Calliandra calothyrsus* and *Callistemon* spp in the low and middle hills and *Plectranthus* spp for the high hill areas.

In an area where the existing forage supplies adequate nectar and pollen throughout most of the season, except for one or more periods when the nectar and/or pollen flows dwindle, plant species that bloom when nectar and/or pollen flows are very low should be considered for planting.

Whereas, in areas where, during most of the period, little nectar or pollen is produced, plantations should be more productive for as much of the season as possible. The most obvious solution is to plant long-blooming and highly-productive plant species.

A second and more interesting solution could be to plant the land in a multi-layered design, as for example, a herbaceous layer with a partial tree layer. In this system, even though the different layers might not be made up of long-blooming species, the unit of land they occupy could remain productive over prolonged periods if the species are chosen correctly. Therefore, careful attention should be given to the blossoming dates of the various components of the plantations. If plants, such as shrubs and vines, that occupy ecological niches different from those of herbaceous plants and trees, are added to multi-layered systems they can become very productive.

It is essential when planning a bee forage system to ensure that the different components of the system are productive in the environment in which they will be planted.

Low Maintenance

The third important property for a bee forage plantation is that it should require minimum maintenance. The first rule for producing a low maintenance system is that the plants should be adapted to the niche in which they are to be planted. While non-agricultural plants can often be grown in inappropriate habitats, the extra maintenance needed to keep them there almost outweighs the benefits.

Perennial plant species with very long life cycles should be preferred for planting so as to avoid frequent replantations. The species should be aggressive enough to quickly occupy the initial interplanting spacing. Finally, the plant species that will compete well with weeds should be chosen. Trees and shrubs possess many of the low maintenance characteristics desired in a bee forage system, since, once established, they often remain in the system for many years. However, they have two main drawbacks. The time interval between establishment and first bloom can be quite long, often many years. In addition, in temperate zones they remain in bloom each year only for short periods of time.

Should Not Become a Weed

Another desirable characteristic of a good forage system is that the species chosen should not become invasive or obnoxious weeds for the neighbouring plant species. Careful consideration should, therefore, be given to native plant species or, at least, to the species that are already established in the area.

Meet the Farming Needs of the Community

The final desirable property of bee forage planting is that instead of acting only as a quality bee forage, it should also meet the needs of the community, i.e., it should be multipurpose. Therefore, plant species that are used as fuel, fodder, and fencing, or that have some other commercial value, should be considered for planting as bee forage.

The selection of plant species in mountain areas is highly location-specific. Therefore, it is not easy to prescribe a general combination. The best way is to work out a list of honey sources from an agro-ecological zone or on an agro-ecosystemic basis and then make further choices considering other uses of plant species and farmers' needs.

***Bee Management Using Bee Forage from Other Areas* (Migratory Beekeeping)**

Another way to overcome the beekeeping carrying capacity limits of an area is to use the bee flora of other areas through migratory beekeeping. **Migratory beekeeping** is actually management of bees to use forage in other areas by the migration of bee colonies. This provides the bees with better forage and the beekeeper with surplus honey. (In commercial-scale beekeeping, a large number of honeybee colonies are owned by an individual beekeeper for production of honey and other hive products.) This practice is also becoming popular in the countries of the Hindu Kush-Himalayan region.

China leads the other countries of the region in commercial beekeeping. It produces over 200,000 tons of honey; 800 tons of royal jelly, and 1,000 tons of bee pollen every year. China is also the largest exporter of honey in the world, contributing to 16 per cent of world exports (ITC-UNCTAD-GATT 1986).

Likewise, in the mountain areas of other countries of the Hindu Kush-Himalayan region, i.e., Pakistan, India, Nepal, and Bhutan, there is tremendous potential for migratory beekeeping. In some areas, such as the North West Frontier Province of Pakistan, beekeeping is already a large-scale venture. In Himachal Pradesh, a province in the Indian Himalayas, the government, some cooperatives, and individual farmers maintain large numbers of colonies, loaning them to apple growers for use in pollination.

Maintaining such a large number of colonies would need good beekeeping areas with several honey plants blossoming during different months of the year to provide surplus honey to support bee colonies during dearth periods. However, such areas are not always available or easy to find, especially during winter months, in mountain areas where bee flora are not available for most of the year. Many other areas also do not provide enough bee flora throughout the year. Under these circumstances, the beekeepers have three choices, i.e., either feed the colonies with sugar syrup or move them to other areas where bee flora are available or harvest less honey. It depends upon the economics involved. Commercial beekeepers prefer the second choice and move their colonies to other places in order to provide the bees with a good, productive foraging environment. This system of migrating bee colonies to a particular locality to provide the bees with a better source of forage is helpful for commercial honey production.

Mountain areas, how-ever, provide a comparative advantage in this respect. The beehives can be moved up and down the agro-ecological zones to take advantage of the natural vegetation. Spending winter in the foothills, where winter crops and other plants bloom will help. And colonies can be moved into the middle hills and valleys when the weather gets warmer. By April, the temperate fruit zone provides a most suitable niche, and honeybees could also be needed for the pollination of fruit crops. Plenty of flora are available in this zone during this period. Summer provides scope, with bee flora available in high mountain areas, and this continues until the end of the rainy season. Autumn is the lean period but by that time some of the rosaceous plants start flowering in the foothills. Colonies are then moved down into these areas.

The system of migratory beekeeping is in practice in parts of China, e.g., Yunnan, Himalayas, Himachal Pradesh and Jammu and Kashmir, the Myomyo area of Myanmar, the North West Frontier Province of Pakistan, and, to some extent, in the middle hills of Nepal. Afghan refugees in the North West Frontier Province of Pakistan and beekeepers from high mountain areas in Himachal Pradesh can be seen moving their colonies up and down along the highways, staying for a few weeks in one place and then moving on. Large numbers of bee colonies can be seen in deep forests, near the wastelands, and along the sides of crop fields (Figure 4.1).

Figure 4.1 Migratory beekeeping in the North West Frontier Province of Pakistan (Photo: L.R. Verma)

The practice of migratory beekeeping is advantageous in more ways than one. It helps to harness the honey sources in their natural state, avoiding the need for concentrated bee forage plantations. It also increases the honey yield to three times that of stationary beekeeping. In addition, honeybees provide the benefits of pollination to several plant species, both wild and cultivated. In Himachal Pradesh, for example, migratory beekeeping has been successfully used in apple pollination. The transportation costs involved in the practice of migratory beekeeping is duly compensated through benefits from pollination services and surplus honey yields.

Guidelines for Migratory Beekeeping

i Potential sites for the migration of bee colonies should be validated. In selecting sites, one should not set up hives in the vicinity of local beekeepers' apiaries.

ii Sites should be easily accessible by vehicle and close to the honey crop. It is best to have sites at the edge of woodlands, even when using flowering crops.

iii Entrances of the hives should be properly blocked with perforated netting so that bees do not get out but still have plenty of air. Hives with supers should be secured with the belt or copper staples hammered in obliquely. Any cracks in the hives should be sealed with a strong, wide sticky tape.

iv Only strong colonies with sufficient food supplies for at least a week should be moved. If the food supplies are not sufficient, the colonies should be fed for three to four days before setting off.

v It is vital to ensure that the colonies have sufficient ventilation for the journey, otherwise the strongest and the best colonies might suffocate. If the bees are being moved a long distance, place some moss (or cloth) soaked in water near them to keep them cool.

vi Use a suitable vehicle for transporting bee colonies. Load and unload bees as gently and steadily as possible.

vii Colonies should be transported during the night and reach the selected places early in the morning. The journey should be as smooth as possible. Avoid making any stops. If it is necessary to stop, keep the engine running to keep the bees quiet. If long breaks are needed, particularly in hot weather, the bees must be unloaded and allowed to fly. The journey should then be continued in the evening.

viii When you reach your destination, do not open the hive entrances until all the colonies are on their stands. In fact, it is better to wait even longer, but be careful that the colonies do not overheat.

Section Two

Important Bee Plants

Most of the secondary information about bee flora of the Hindu Kush-Himalayan region is either contained in large volumes on general flora of the Himalayas, written from the taxonomic and the plant diversity points of view, or there are a few location-specific bee flora studies. Some of these key sources of information are listed in Chapter Two. However, beekeeping entrepreneurs from the countries of the Hindu Kush-Himalayan region may find it cumbersome to extract useful information, because what interests beekeeping farmers is promising bee flora which include about 100-200 agricultural crops, fruits crops, fodder crops, and multipurpose trees that can be planted on farm and on non-farmlands. Most of the general inventory of bee plants has limited value only, e.g., when migratory beekeeping is possible (Annex I). This Section has, therefore, been designed to provide useful information on the most promising honey plants in the Hindu Kush-Himalayan region.

Plant Sources of Nectar and Pollen

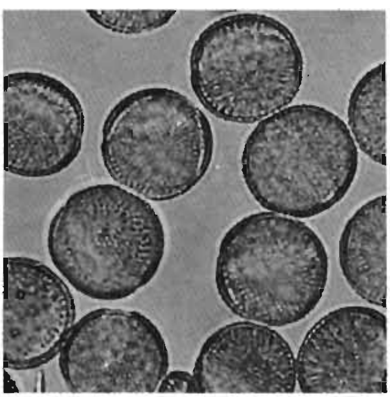
More than 200 promising bee plants of the Hindu Kush-Himalayan region which are most commonly visited by *Apis cerana* and *Apis mellifera* have been described. These include the plants that are sources of surplus honey or which are important for the development of bee colonies or support honeybee colonies during dearth periods. In addition to the honeybees, many of these plants are also visited by other natural insects, including different species of wild bees, butterflies, moths, beetles, and bee-eating wasps and hornets. Amongst these, wasps and hornets mainly visit those plants secreting plenty of nectar, e.g., *Eucalyptus, Calliandra, Callistemon,* and bananas. While visiting these plants for nectar, bee-eating wasps and hornets also capture and kill the honeybees foraging on them, thereby destroying the bee colonies. The presence of large numbers of hornets and wasps indicates that their nests are close by, and these should destroyed.

Bee plants are arranged into the following five groups.

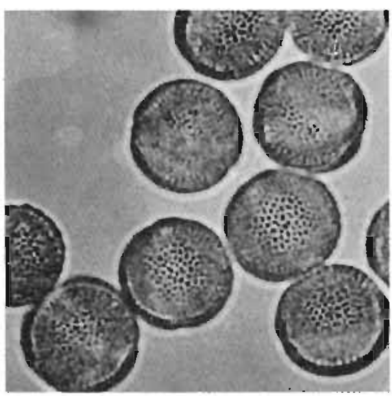
i) Agricultural Crops
ii) Horticultural Crops
iii) Forage Legumes
iv) Ornamental Plants
v) Wild Plants and Forest Trees

Plants in each group are arranged according to their importance in honey production. A description of each plant includes four types of information: its ecological distribution limits, important morphological features and blossoming period; information on honey quality; and the structure of pollen grains. The information on pollen grain shape and size is of great practical significance in identifying bee forage through honey analysis. The importance of each species as a bee plant, i.e., whether it is a source of nectar or pollen or both, and whether it is a major or minor bee plant, is also given. The colour plates show the plant habit, flower structure, and its use by honeybees; and the black and white plates show the different pollen grain structures. Photomicrographs of the pollen grains were taken with the help of an Olympus SC type 12 (OM system) at X400 magnification.

1a. *Brassica campestris*; Ref. **plant no. 1**



1b. *Brassica campestris*: OS; Ref. **plant no. 1**



1c. *Brassica campestris*: SV; Ref. **plant no. 1**

This chapter, in fact, is the most important part of this book. The practical information contained in it will be extremely useful for beekeepers, extension workers, and private entrepreneurs interested in beekeeping.

Agricultural Crops

Various agricultural crops, including foodgrains such as maize, rice, and buckwheat; vegetable crops such as various *cucurbitaceous* plants, beans, lady's fingers (okra), turnip, radishes, cauliflower, cabbages, carrots, coriander, and onions; and oilseeds such as mustard, niger, sesame, and cotton, constitute important sources of nectar and pollen for bees. Among these, mustard, niger, cotton, sunflower, and sesame are major sources of nectar and contribute to the main honey flow in different parts of the Hindu Kush-Himalayan region; whereas others constitute medium and minor sources and help in the development and sustenance of bee colonies. A brief account of some of the important agricultural plants is given below.

1. **Yellow mustard** (***Brassica campestris* L.**) is a winter season oilseed and vegetable crop commonly cultivated from subtropical to temperate agroclimates in all countries of the Hindu Kush-Himalayan region (Afghanistan, Pakistan, India, Nepal, Bhutan, China, Bangladesh, and Myanmar). It has a long blossoming period lasting for about six months, i.e., from December to May, because its flowering is delayed with increasing altitude. It blossoms during December-January in subtropical areas; during February-March in sub-temperate zones; and during April-May in temperate areas. The flowers are 1.5cm in diameter and yellow in colour (**Plate 1a**). The crop produces large quantities of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. It is a major source of nectar and pollen in China, Bangladesh, Nepal, India, and Pakistan. The sugar concentration of the nectar varies between 45-71 per cent, depending upon soil moisture and climatic conditions. Honey yield from this crop is 15-20kg/colony/season in the Chinese Himalayas (Bangyu et al. 1996). Yellow mustard honey is yellow in colour and becomes granulated in a few days after extraction. It contains 18.1 per cent water, 26.43 per cent glucose, 37.26 per cent fructose, 0.45 per cent sucrose, 11.11 per cent maltose, 1.68 per cent higher sugars, and 0.324 per cent ash (White et al. 1962). It has a pH of 4.38 (acidic). Mustard pollen is yellow in colour. Pollen grains are small (24.3 ± 0.7 µm in diameter), round, and tri-colporate with a reticulate exine sculpture (**Plates 1b,c**).

Yellow mustard is a vital honey source and an indicator crop for migratory beekeeping in the Hindu Kush-Himalayas. In winter, it flowers in December-January in the foothills, then it blossoms, moving upwards to higher altitudes until June in the high mountain areas. Beekeepers travel upwards with the blossoming of this crop.

2 **Brown mustard or toria (*Brassica campestris* var. *Dichotoma* Prain)** is another oilseed and vegetable crop cultivated in subtropical to sub-temperate climates in the Hindu Kush-Himalayan region. It blossoms during October-December and produces flowers in axillary and terminal racemes. Flowers are 1.5cm in diameter and yellow in colour. This crop is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. It continues to provide nectar and pollen for over a month. The sugar concentration of the nectar is 31.5-64 per cent (Sharma 1958). Information on the yield and the physico-chemical characteristics of its honey is not available. The structure of its pollen grain is similar to that of *Brassica campestris*.

3. **Sarson (*Brassica campestris* var *Sarson* Prain)** is a typical mountain crop of the Hindu Kush-Himalayan region. The crop is cultivated during the winter season for its seeds which yield edible oils and leaves that are used as vegetables. Similar to yellow mustard, its flowering period is very long, from September-March, depending upon the altitude. Flowers are 1.5cm across, yellow, and produced in the axillary and terminal racemes. It is a major source of nectar in India, Pakistan, and Nepal and is visited by *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar is 32-69 per cent (Sharma 1958). Honey yield with *Apis cerana* is 5-6kg/colony/season (Sharma 1948). There is no information on the physico-chemical characteristics of its honey. The structure of its pollen grains is similar to that of *Brassica campestris* L. The crop is sprayed with pesticides which can also kill bees. Therefore, farmers/beekeepers should not allow their bees to visit this crop for a period of two days after the application of pesticides.

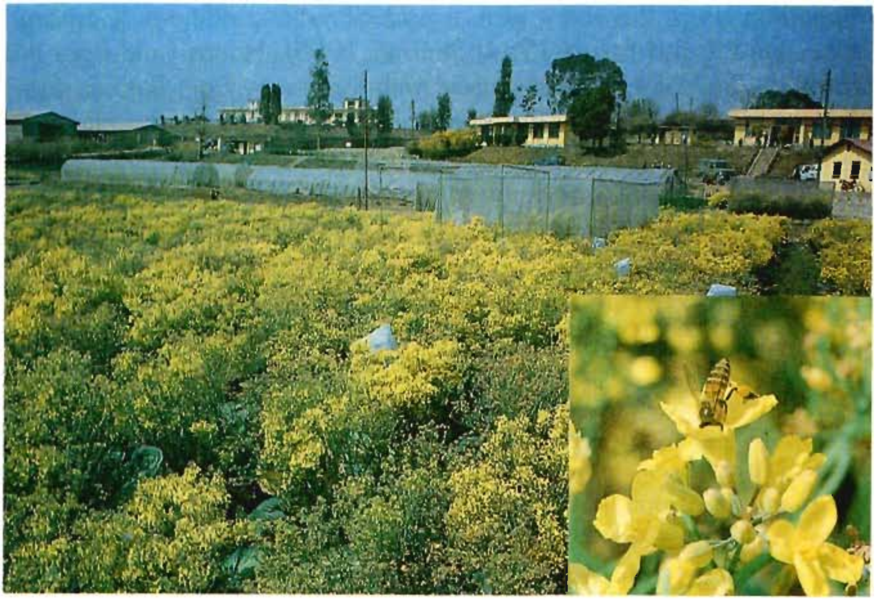
4. **Indian mustard or broad-leaved mustard (*Brassica juncea* (L.) Cosson)** is the taller mustard crop which is cultivated throughout the subtropical Himalayas; mainly for its leaves which are used as vegetables and also for its seeds which yield oil. This crop blossoms during February-March and produces 1.5cm, bright yellow flowers in axillary and terminal racemes. It is a major source of nectar and pollen in China, India, Pakistan, and Nepal. It is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration of its nectar varies between 28-65 per cent,

depending upon the soil moisture and climatic conditions (Camargo 1972; Santos and Ferraz 1954; Sharma 1958). Honey yield from this crop is 5-7kg/colony/season mixed with the honey from *B. campestris* var. *sarson* (Sharma 1948). Information on the physico-chemical characteristics of Indian mustard honey is not available. The pollen grains are small in size (24.6$\pm$2.3 μm long and 22.7$\pm$3.6 μm broad), oval, and tri-colporate, with a reticulate exine sculpture. The colour of its pollen is yellow.

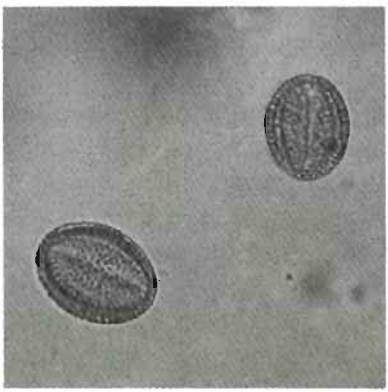
5. Rape (*Brassica napus* L.) is another oilseed and leaf vegetable cultivated as a cold weather crop in the low hills and as a spring crop in the high mountain areas. Weedy forms are common on open grounds and ditches. It blossoms during December-January in the low hills and during March-April in the high mountain areas. The flowers are yellow and measure about 1.5cm in diameter. The crop is a major source of nectar in China (Tseng 1954) and is visited by both *Apis cerana* and *Apis mellifera*. Information on the yield and physico-chemical characteristics of rape honey is not available. Its pollen grains are medium in size (33.4$\pm$3.7 μm long and 30.8$\pm$4.3 μm broad), oval in shape, and tri-colporate with a reticulate exine sculpture.

6. Black mustard (*Brassica nigra* (L.) Koch) is grown to a lesser degree. This crop is found in the subtropical and temperate Himalayan zones. Weedy forms are also found on open ground and in ditches. The crop blossoms during November to May and produces bright yellow flowers. The crop is a major source of nectar in India and Pakistan. It is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration of the nectar is 48.6 per cent (Espina Perez and Ordetx Ros 1983). The honey yield with *Apis mellifera* is over 27kg/colony in Uttar Pradesh, India (Rawat 1980). Available information on the physico-chemical characteristics of black mustard honey shows that it has a high water content and is likely to ferment (Lovell 1977). Black mustard honey is light in colour and has strong aroma when it is fresh (Howes 1979). This crop is also a good source of pollen. The structure of the pollen grain is similar to that of *Brassica napus*.

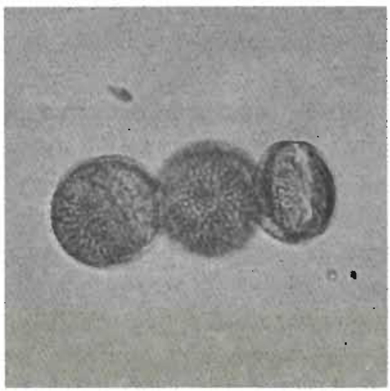
7. Cauliflower (*Brassica oleracea botrytis* L.) is a known vegetable crop in several pocket areas of the subtropical and temperate zones of the Himalayas. Farmers in the temperate areas grow it as an off-season vegetable crop. During recent years, farmers in some areas have shifted to producing vegetable seeds of this crop. It blossoms during February-March and contributes to the major spring flow, which helps in brood



2a. *Brassica oleracea botrytis*; Ref. **plant no. 7**



2b. *Brassica oleracea botrytis*: OS (EV); Ref. **plant no. 7**



2c. *Brassica oleracea botrytis*: SV (PV); Ref. **plant no. 7**

rearing and in the development of bee colonies. Its flowers are visited by *Apis cerana* and *Apis mellifera* for pollen and nectar (**Plate 2a**). This is of medium importance for beekeeping under the climatic conditions of the hill and mountain areas. Honeybees do not produce surplus honey from this crop, therefore information on cauliflower honey is not available. The structure of its pollen grain is similar to that of *Brassica campestris*. Its pollen is also yellow in colour (**Plates 2b,c**).

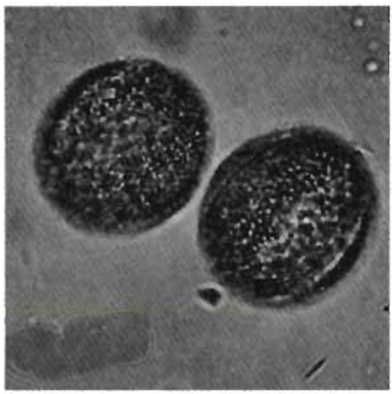
8. Cabbage (*Brassica oleracea capitata* L.) is another important vegetable crop of the Himalayan region. Producing cabbage seed as a high-value cash crop is becoming popular in the hill and mountain areas of the Hindu Kush-Himalayan region. Thus, the crop becomes an important source of nectar and pollen when it is allowed to blossom. It blossoms during February-March and contributes to the major spring flow, which is important for the development of bee colonies and honey production. *Apis cerana* and *Apis mellifera* visit this crop and collect both pollen and nectar from its flowers. This crop is of medium importance for beekeeping under the climatic conditions of hill and mountain areas. Like cauliflower, cabbage does not yield surplus honey. Therefore, the information on the physico-chemical chacteristics of cabbage honey is not available. The structure of its pollen grain is similar to that of *Brassica campestris*. Its pollen is also yellow in colour.

9. **Turnip (*Brassica rapa* L.)** is a favourite crop cultivated over a wide agro-ecological range, i.e., from the low hills to the high mountain areas. At higher altitudes, where radishes do not grow, the turnip is valuable as a vegetable for both its leaves and roots. Turnips blossom during February-March. The flowers are yellow in colour and measure 1.5cm in diameter. It is a major source of nectar and pollen when grown for seed production and is visited by both *Apis cerana* and *Apis mellifera*. Information on physico-chemical characteristics of turnip honey is not available. The structure of the pollen grain is similar to that of *Brassica napus*.

10. **Buckwheat (*Fagopyrum esculentum* Moench.)** is a well-known food crop of the high mountain areas of northern Pakistan, India, Nepal, and Tibet. It is also widely cultivated on marginal farmlands even down in the low hill agro-ecozone. This crop prefers a moist climate, blossoms during August-September, and produces small, white flowers in axillary and terminal racemes (**Plate 3a**). This crop is a major source of nectar in China, India, and Nepal (Kafle 1979; Bangyu et al. 1996) and is visited by both *Apis cerana* and *Apis mellifera*. Nectar flow is copious, mainly in the morning, and the bees become angry in the afternoon when it ceases (Lovell 1977). Nectar secretion from the plant is 0.2-0.4 mg/flower/day (cf Lovell 1977 for statistics from the USA). In China, honey yield with *Apis cerana* is 10-15kg/colony/season (Bangyu et al. 1996). In Nepal, the honey potential of buckwheat is 70-80kg/ha (Kafle 1979). Moisture, lime, phosphorus, and nitrogen in the soil improve sugar concentration (Hansson 1980). Buckwheat honey contains 20.5 per cent water, 33.4 per cent glucose, 33.4 per cent fructose, 5.7 per cent maltose, and 0.12 per cent ash content. Its pH is 3.6 (acidic). Buckwheat pollen is yellow in colour. The pollen grains are medium in size (46.1 ± 2.7 µm long and 42.7 ± 3.1 µm broad), oval, and tri-colporate with a reticulate exine sculpture (**Plates 3b,c**).

3a. *Fagopyrum esculentum*; Ref. **plant no. 10**

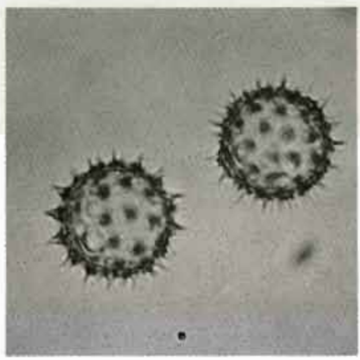
3b. *Fagopyrum esculentum*: OS (EV); Ref. **plant no. 10**



3c. *Fagopyrum esculentum*: SV (EV); Ref. **plant no. 10**

11. Niger (*Guizotia abyssinica* Cass.) is an oilseed crop cultivated throughout the temperate and sub-temperate Himalayas. The crop blossoms during August-September and produces yellow flowers in 2.0-3.0 cm flowering heads. The crop is a major source of pollen and nectar and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 4a**). In Myanmar, the honey yield with *Apis mellifera* is 30kg/colony/season from this crop (Zmarlicki 1984). The sugar concentration of the nectar is 29 per cent. The available information on niger honey shows that it is extra light amber in colour, has a peculiar bitter taste, and does not crystallise for long periods (Zmarlicki 1984). Its pollen grains are small

4a. Guizotia abyssinica; Ref. ***plant no. 11***



4b Guizotia abyssinica: OS; Ref. ***plant no. 11***

(26.3 ± 1.03 µm in diameter), round, and tri-colporate with an echinate exine sculpture (**Plate 4b**).

12. Sunflower (*Helianthus annuus* L.) is cultivated in parts of the Hindu Kush-Himalayan region for its highly-priced seed oil which is used for cooking, salads, paints, and as an industrial lubricant. It is also planted as an ornamental plant throughout the temperate and subtropical Himalayas. The crop blossoms during July to September. The inflorescence of the sunflower consists of two kinds of flower: (i) the disc florets which are bisexual and tubular and (ii) the ray florets which may be pistillate or neuter. It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 5a**). Nectar secretion, however, varies with the microclimate. The sugar concentration in nectar is 38

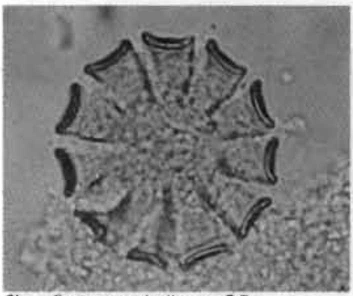
5a. *Helianthus annuus*; Ref. **plant no. 12**

5b. *Helianthus annuus*: OS, SV; Ref. **plant no. 12**

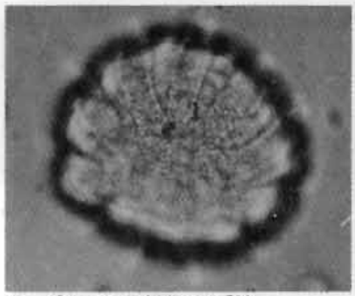
per cent. In China, honey yield with *Apis cerana* is 10-15kg/colony/season (Bangyu et al. 1996). The available information on sunflower honey shows that it is yellow in colour and has a pleasant flavour. Sunflower pollen is yellow in colour. The structure of the pollen grain is similar to that of *Guizotia abyssinica*, except that those of the sunflower are bigger in size (31.5±2.04 μm long and 30.8±2.3 μm broad) and almost round in shape (**Plate 5b**).

13. Sesame (*Sesamum indicum* L.) is cultivated throughout the temperate and subtropical Himalayas for good quality seed oil which is used for cooking, salads, paints, and as an industrial lubricant. At present, it is the most widely grown honey plant in Myanmar where the honey flow from sesame is available four times a year; three times from irrigated and once from rainfall crops (Zmarlicki 1984). The honey flow in June and July is considered the most important. Sesame is a good source of nectar and pollen, and bee colonies develop well and gather surplus honey (**Plate 6a**). The crop is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in the nectar varies between 25-51 per cent, depending upon the time of day, climate, and soil conditions.

6a. Sesamum indicum; Ref. **plant no. 13**



6b. Sesamum indicum: OS; Ref. **plant no. 13**

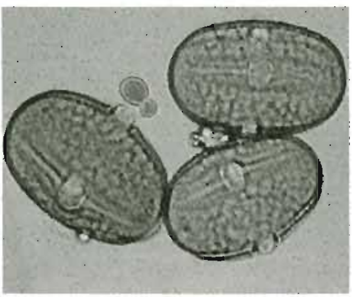


6c. Sesamum indicum: SV; Ref. **plant no. 13**

In the Chinese Himalayas, a colony of *Apis cerana* can produce 10-15kg of honey from its flow (Bangyu et al. 1996). The available information on sesame honey shows that it is generally dark in colour and has a tendency to remain liquid for a long period of time (Zmarlicki 1984). Sesame pollen is white in colour. The pollen grain is very large (63.2 ± 1.1 µm in diameter), round, and has many (9-12) furrows with a reticulate exine sculpture (**Plates 6b,c**).

14. The broad bean (*Vicia faba* L.) is cultivated in the subtropical and sub-temperate Himalayan zones. It blossoms during February-March and produces dull white flowers which are visited by honeybees for nectar and pollen. The flowers produce large amounts of pollen but little nectar. Since it blossoms during the spring season, its flow helps to encourage brood rearing and the development of bee colonies. In the Himalayan region, this crop is a major source of pollen and a minor source of nectar and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 7a**).

7a. *Vicia faba*; Ref. **plant no. 14**

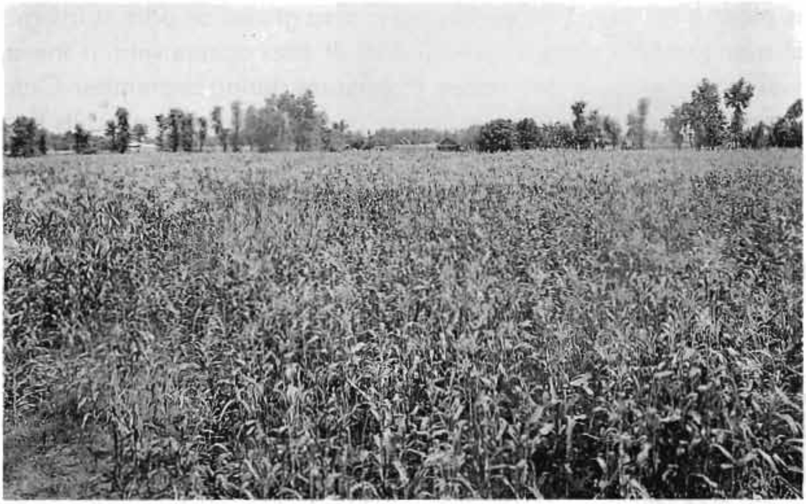


7b. *Vicia faba*: OS; Ref. **plant no. 14**

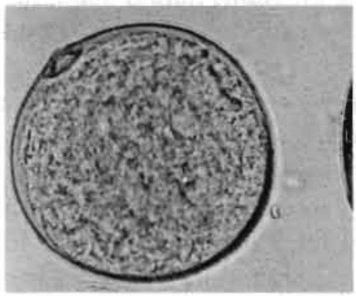
7c. *Vicia faba*: SV; Ref. **plant no. 14**

Since it is a minor source of nectar, the bees do not collect surplus honey. Therefore, information on the physico-chemical characteristics of the broad bean honey is not available. Broad bean pollen is white to grey in colour. The pollen grains are medium in size (43.2 ± 0.6 µm long and 27.8 ± 0.7 µm broad), elongated, and tri-colporate with a reticulate exine sculpture (**Plates 7b,c**).

15. Maize (*Zea mays* L.) is a major food crop cultivated throughout the Hindu Kush-Himalayan region. It blossoms during July-August; the flowers are unisexual, arranged in separate inflorescences; male spikelets are in the panicle at the top of the main shoot and female spikes are axillary (**Plate 8a**). *Apis cerana* and *Apis mellifera* visit its flowers for pollen. It is a major pollen source throughout the region. A male spike of maize consists of 2,000-4,000 small flowers; each flower has three anthers and each anther releases about 2,500 pollen grains. Therefore,



8a. Zea mays; Ref. ***plant no. 15***



8b. Zea mays: *OS;*
Ref. ***plant no. 15***

each spike of maize produces about 15-30 million pollen grains (Bangyu et al. 1996). During one blossoming season, a colony of *Apis cerana* can collect about 1.0-1.5kg of pollen (Bangyu et al. 1996). Maize pollen is of very good quality and helps honeybee colonies to increase broods and raise colony strength. Its pollen is creamy white in colour. The pollen grains are large (89.03 ± 4.2 µm long and 81.3 ± 3.4 µm broad), oval, and have two pores with a granular exine sculpture (**Plate 8b**).

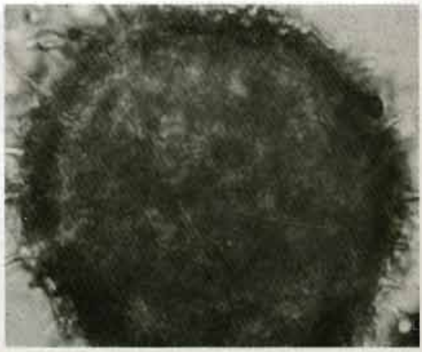
Maize is also a source of honeydew, however the insect is not specified. With *Apis mellifera*, honey yield from honeydew is reported to be 45kg/colony/year (cf Espina Perez and Ordetx Ros 1983 for statistics from the USA). The available information shows that maize honey is yellow, with a peculiar flavour like corn silk. Its granulation is very coarse.

16. Perilla (*Perilla frutescens* (L.) Brit. or Syn. *P. ocimoides* L.) is a minor oilseed crop grown in mountain areas of the Hindu Kush-Himalayas from Kashmir in India to Bhutan, Myanmar, southern China, and Nepal.

This plant is an insect repellent and is also grown as part of integrated pest management programmes (IPMs). It also occurs wild in the open as well as in shaded moist places. It blossoms during September-October and produces white flowers in axillary and terminal racemes. Its flowers are visited by *Apis cerana* and *Apis mellifera* mainly for nectar. It is an important nectar source which contributes to the main autumn flow. Information on the yield and physico-chemical characteristics of perilla honey is not available. Its pollen grains are medium in size (32.$\pm$2.04 μm long and 30.3$\pm$2.3 μm broad) and slightly oval in shape, with six furrows and a reticulate exine sculpture.

17. Egyptian cotton (*Gossypium barbadense* L.) is an important oilseed and fibre crop cultivated throughout the tropical, subtropical, and temperate Himalayas, especially in China, India, Nepal, and Pakistan. The crop is both annual or perennial (if the ground does not freeze). The crop blossoms during September-October and produces yellow flowers with maroon petal spots **(Plate 9a)**. Nectar is present in the flower as well as on the inner circum bractal and outer sub-bractal areas, on leaves, petioles, and flower pedicels. It is a major source of nectar and honeybees prefer extra floral nectar. It is visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion is affected by cultivar, climate, soil fertility, and moisture. Nectar yield ranges between 1.4kg/ha/day-3.4kg/ha/day (cf Butler et al. 1972 for statistics from the USA). The sugar concentration in the nectar is medium (the mean is 21.5 per cent, the maximum up to 65 per cent at 0800 h; and the minimum 12.3-15.9 per cent) (Butler et al. 1972; McGregor 1976). Sugar concentration is

9a. Gossypium barbadense; Ref. ***plant no. 17***



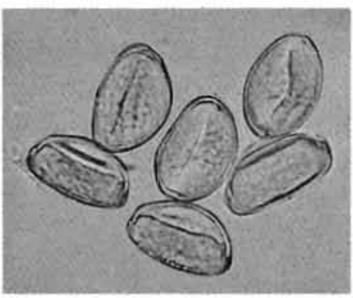
9b. Gossipium barbadense: OS; Ref. **plant no. 17**

40 per cent in the leaf nectar, 17.6 per cent in the sub-bracteal nectar, and 45.3 per cent in nectaries between the bracts and sepals (Butler et al. 1972). The honey potential of the crop is moderate (cf Arizona, USA, 50kg/ha). In the Chinese Himalayas, an *Apis cerana* colony produces about 20-25kg of honey from this crop (Bangyu et al. 1996). The plant also produces honeydew (McGregor 1976). Information on the physico-chemical characteristics of Egyptian cotton honey is not available. It yields 45,000 pollen grains/flower (cf statistics for the USA in McGregor 1976). Honeybees collect its pollen only when there is no more attractive pollen available. Its pollen grains are large (113.1 ± 6.3 µm in diameter), round, and have three pores with an echinate exine sculpture with long thin spines (**Plate 9b**).

The crop is prone to pests and is therefore sprayed with pesticides which can also kill bees foraging on this crop. Therefore, farmers/beekeepers should not allow their bees to visit this crop for up to two days after the application of pesticides.

18. Upland cotton (*Gossypium hirsutum* L.) is like Egyptian cotton. Upland cotton is also cultivated as an oilseed and fibre crop throughout the temperate and subtropical Himalayas. This crop is also both annual or perennial (if the ground does not freeze) and can be grown in a wide range of soils. The crop needs irrigation in low rainfall areas. It blossoms during September-October and is a major source of nectar for both *Apis cerana* and *Apis mellifera*. Floral as well as extra floral nectaries are present as in *G. barbadense*. Nectar secretion is 18.13mg/flower/day. Details available on the physico-chemical characteristics of upland cotton honey show that it has 15-16 per cent water, 33.4 per cent glucose, 39.7 per cent fructose, 1.3 per cent sucrose, 1.8 per cent maltose, and 0.38 per cent ash content. Its pH is 5.9 (slightly acidic). The crop is sprayed to prevent attacks from pests, but this can also kill the bees foraging on this crop.

10a. Allium cepa; Ref. ***plant no. 19***



10b Allium cepa: OS; Ref. ***plant no. 19***

19. Onion (*Allium cepa* L.) is an important cash crop of the Hindu Kush-Himalayan region and is cultivated in subtropical, sub-temperate, and temperate areas. It is also grown in kitchen gardens for its leaves and stem tubers which are used as vegetables and in salads. Onion seeds, commonly known as *kalongi*, are used as a condiment and as a preservative in pickles. It blossoms during April-May and produces ash grey or dull white flowers in a simple oval umbel at the top of the stalk (**Plate 10a**). The onion is a medium source of nectar and a minor source of pollen when grown for seed production in Uttar Pradesh, India, and in the Kathmandu Valley, Nepal (Kafle 1984). Its flowers are visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar varies between 67-75 per cent, depending upon the climatic and soil conditions. Its nectar has a typical smell of sulphur which reduces the comparative attractiveness to honeybees among the competing plants. Thus, nectar gathering bees are often attracted away from onions to visit other flowering plants in the vicinity. Honeybees do not collect surplus honey from onion bloom. Therefore, information on the physico-chemical characteristics of its honey is not available. Pollen grains are small

(29.8±3.1 μm long and 23.3±7.3 μm broad), characteristically boat-shaped, with two furrows and a smooth exine (**Plate 10b**).

20. Coriander (*Coriandrum sativum* L.) is a cash crop of subsistence hill farming systems. It is widely cultivated in kitchen gardens in subtropical, sub-temperate, and temperate zones of the HKH region for its green leaves, which are used to flavour vegetables and curries, and for its seeds which are used as spice. The crop blossoms from March to April and produces small, whitish pink flowers in umbels. It is a medium

11a. Coriandrum sativum; *Ref.* ***plant no. 20***

11b Coriandrum sativum: OS, SV; Ref. ***plant no. 20***

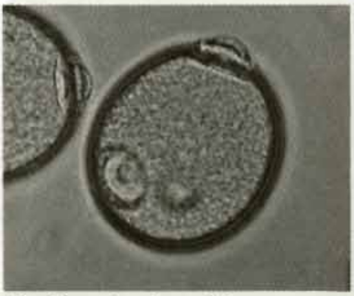
source of pollen and nectar for *Apis cerana* and *Apis mellifera* (**Plate 11a**). When grown over large areas, honeybees collect surplus honey from coriander. The data available on its honey show that it is dark in colour and has 16.8 per cent water, 72.3-73.7 per cent total sugars, 35.2 per cent glucose, 48.1 per cent fructose, 2.2 per cent sucrose, 14.1 per cent maltose, and 0.1-0.25 per cent ash. Its pollen grains are small (29.5±0.6 μm long and 12.9±0.7 μm broad), elongated (dumb-bell shaped), and tri-colporate with a thick but smooth exine (**Plate 11b**).

21. Safflower (*Carthamus tinctorius* L.) is becoming a popular oilseed crop in the subtropical Himalayas. Its leaves are used for vegetables and in salads and the flowers contain two colouring materials; safflower yellow and safflower red. The crop blossoms during February-March and produces orange-red flowers in flowering heads on the apex of the branches and the main stem. The flowering heads are surrounded by numerous spinous bracts. The plant produces large amounts of nectar and pollen and is a major source in both India and Pakistan. Its flowers are visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration of the nectar is 45 per cent, however it varies with the climatic and soil conditions. Information on the yield and physico-chemical characteristics of safflower honey and on its pollen is not available.

12a. Cucumis sativus; Ref. ***plant no. 22***

22. Cucumber (*Cucumis sativus* L.) is cultivated throughout the subtropical and temperate Himalayan zones both in kitchen gardens and as a cash crop. The plant blossoms during the period from June to September and produces yellow, monoecious flowers in the leaf axils. The male flowers are clustered and the female ones are solitary (**Plate 12a**). The crop is a good source of both nectar and pollen for the sustenance of bee colonies during the late summer when there is a dearth of bee flora. It is visited by both *Apis cerana* and *Apis mellifera*. When planted over large areas, a colony of *Apis cerana* can produce five kilogrammes of honey from this crop (Bangyu et al. 1996). In Myanmar, the sugar concentration in its nectar is 27 per cent, however it varies with the climatic and soil conditions. Details on the yield and physico-chemical characteristics of cucumber honey are not available. Its pollen

12b. Cucumis sativus: OS; Ref. ***plant no. 22***

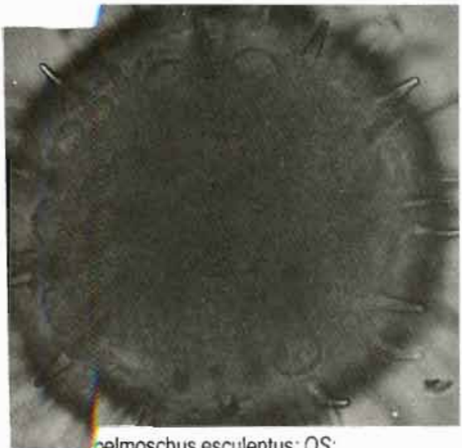


12c. Cucumis sativus: SV; Ref. ***plant no. 22***

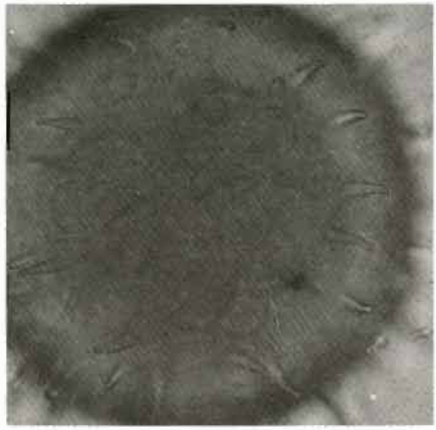
is creamy yellow in colour. The pollen grains are large (65.2 ± 1.9 µm in diameter), round, have three pores, a cap or streak present on the pores, and a smooth exine (**Plates 12b,c**).

13a. Abelmoschus esculentus; Ref. ***plant no. 23***

23. Lady finger or okra (*Abelmoschus esculentus* L.) is a common kitchen garden vegetable crop grown throughout the Himalayan region. It is also becoming an important cash crop under increased vegetable cultivation. The crop blossoms during the period from June to September and produces large, yellow solitary flowers in the leaf axils (**Plate 13a**). The flowers have maroon spots at the base of the petals. Its flowers are visited by honeybees for the nectar secreted in pits at the base of each petal. The large corolla attracts honeybees and other insects which also facilitate the pollination of this crop. The crop is a good source of both nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera* (Kafle 1984). Since it blossoms during late summer when there is a dearth of bee flora, its flow is important for the sustenance of bee colonies.



13b. Abelmoschus esculentus: OS; Ref. **plant no. 23**



13c. Abelmoschus esculentus: SV; Ref. **plant no. 23**

However, honeybees do not collect surplus honey from this crop. Therefore, information on the physico-chemical characteristics of okra honey is not available. Its pollen grains are very large in size (155.1 $\pm$ 5.2 µm long and 148.0 $\pm$ 10.9 µm broad), round in shape, and multiporate (having 8 pores) and the exine is echinate with long, pointed spines (**Plates 13b,c**).

24. Rocket salad (*Eruca sativa* L.) is cultivated throughout the subtropical Himalayan areas as cattle fodder and for seed oil which has medicinal properties. The crop blossoms in the period from February to March and produces light yellow flowers in axillary and terminal racemes.

14a. Eruca sativa; Ref. **plant no. 24**

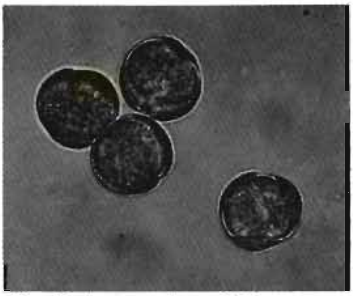
14b. Eruca sativa: OS; Ref. ***plant no. 24***

14c. Eruca sativa: SV; Ref. ***plant no. 24***

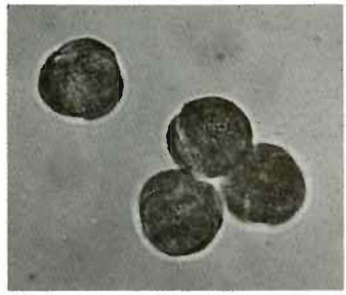
It is a major source of nectar in China and India (**Plate 14a**). It is visited by both *Apis cerana* and *Apis mellifera*. However, information on the yield and physico-chemical characteristics of its honey is not available. Its pollen is yellow in colour and the structure of its pollen grain is similar to that of *Brassica napus* except that it is very small in size (17.5 ± 0.5 µm long and 16.8 ± 0.8 µm broad), almost round or slightly oval in shape, and tri-colporate with a reticulate exine sculpture (**Plates 14b,c**).

15a. Raphanus sativus; Ref. ***plant no. 25***

25. Radish (*Raphanus sativus* L.) is an important cash crop of the subtropical and sub-temperate Himalayas cultivated for its roots which are used as a vegetable. In recent years, radish seed production has become popular as a high-value cash crop activity in several pocket areas of the Hindu Kush-Himalayan region. It blossoms during February-March and produces pinkish white flowers in axillary or terminal racemes. It is a major source of both pollen and nectar for over one month (**Plate



15b. Raphanus sativus: OS; Ref. **plant no. 25**

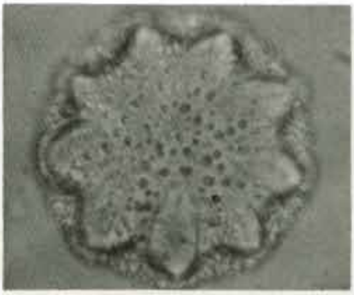


15c. Raphanus sativus: SV; Ref. **plant no. 25**

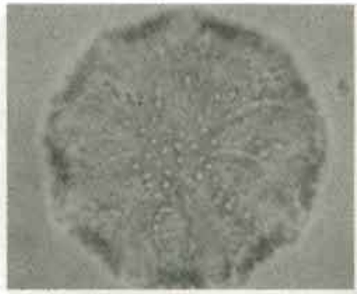
15a). It is visited by both *Apis cerana* and *Apis mellifera*. In the Chinese Himalayas, a colony of *Apis cerana* can produce about 10kg of honey from this crop (Bangyu et al. 1996). The sugar concentration in its nectar is 37 per cent, however this varies with climatic and soil conditions. Information on the physico-chemical characteristics of radish honey is not available. Its pollen grains are small (20.2$\pm$1.1 μm in diameter), round, and tri-colporate with a reticulate exine sculpture (**Plates 15b,c**).

16a. Sechium edule; Ref. **plant no. 26**

26. Chayote (*Sechium edule* (Jacq.) Pers.) is a native of America. It is cultivated as a vegetable in subtropical and temperate areas of the Hindu Kush-Himalayan region, e.g., China, India, Myanmar, Nepal, and Pakistan. It produces large and fleshy one-seeded fruits. It blossoms in the period from July to November and produces light yellow flowers. *Apis cerana* visits its flowers for nectar and pollen. It is of medium importance for beekeeping (**Plate 16a**). Bees do not collect surplus honey from this plant, therefore information on the physico-chemical



16b. Sechium edule: OS; Ref. **plant no. 26**

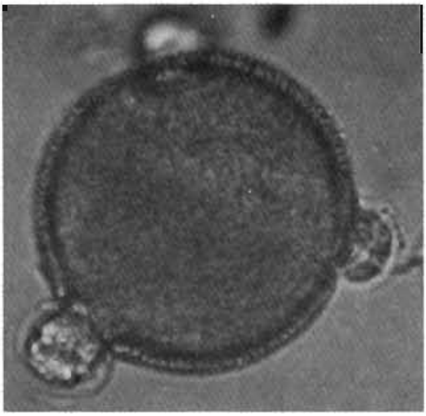


16c. Sechium edule: SV; Ref. **plant no. 26**

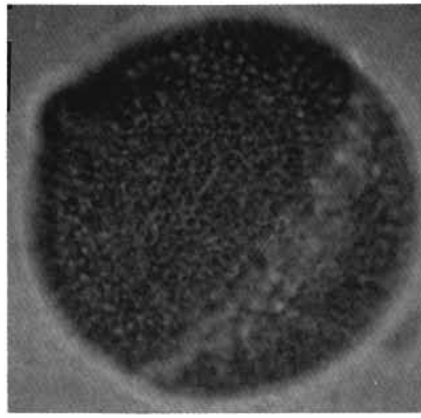
characteristics of its honey is not available. The pollen grains are large (74.9 ± 1.1 µm long, 70.4 ± 3.8 µm broad), oval in shape, have eight pores, and a granular exine sculpture (**Plates 16b,c**).

17a. Luffa cylindrica; Ref. **plant no. 27**

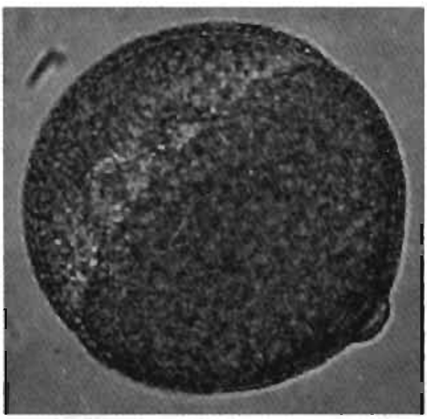
27. Sponge gourd (*Luffa cylindrica* L.) is a fruit vegetable most commonly cultivated in kitchen gardens and as a cash crop throughout the subtropical and temperate Himalayan zones. It blossoms in the period from July to September and produces large, yellow, unisexual flowers in leaf axils (**Plate 17a**). It provides both nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar is 40 per cent, and this varies with climatic and soil conditions. Since it blossoms during late summer or in the early rainy season, it is very important for the development of bee colonies. Information on the yield and physico-chemical characteristics of sponge gourd honey is not available. Its pollen is yellow in colour. The pollen grains are large



17b. *Luffa cylindrica: OS (PV);*
Ref. ***plant no. 27***



17c. *Luffa cylindrica: SV (EV);*
Ref. ***plant no. 27***

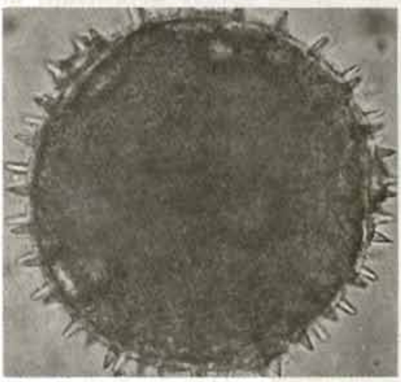


17d. *Luffa cylindrica: OS (EV);*
Ref. ***plant no. 27***

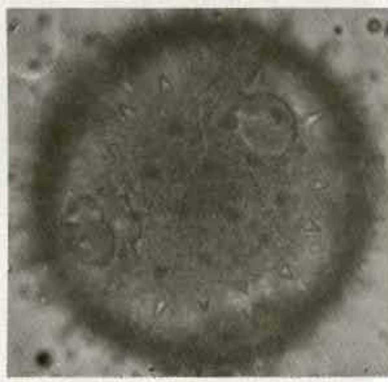
(83.1$\pm$2.8 μm in diameter), round, and tri-colporate with a reticulate exine sculpture (**Plates 17b,c,d**).

28. Great pumpkin or Spanish gourd (*Cucurbita maxima* L.) is widely cultivated in the subtropical and sub-temperate zones of the Hindu Kush-Himalayas. The plants are large climbers with weak stems. It blossoms in the period from February to April and produces solitary large, yellow monoecious flowers which bear nectaries on the inner surface, the base of the stamens, or on the cup-shaped disc (in the case of female flowers). The coloured flowers and the nectaries are responsible for attracting insects, especially honeybees, which collect both pollen and nectar and also bring about pollination. It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. Since it blossoms during the main flow season, it contributes to the surplus honey collection of bee colonies. However, information on the yield and physico-chemical characteristics of its honey is not available. Pollen grains are large in

18a. Cucurbita pepo; Ref. ***plant no. 29***



18b. Cucurbita pepo: OS; Ref. ***plant no. 29***



18c. Cucurbita pepo: SV; Ref. ***plant no. 29***

size (164.4$\pm$4 µm in diameter); round; have eight pores, with a cap present on each of these; and an echinate exine sculpture.

29. Vegetable marrow (*Cucurbita pepo* L.) is an important cash crop cultivated in the subtropical zones of the Hindu Kush-Himalayas. It blossoms during April-May and is of major importance for beekeeping (**Plate 18a**). Honeybees (*Apis cerana* and *Apis mellifera*) collect both nectar and pollen and store surplus honey. The sugar concentration in its nectar varies between 30-40 per cent depending upon the climatic and soil conditions. The honey potential is 30kg/ha (cf the USSR statistics in Fedosov 1955); it also varies depending upon the environmental conditions. There is no information on the yield and physico-chemical characteristics of its honey. Its pollen is golden yellow in colour. The pollen grains are large in size (125.5±7.6 µm in diameter), round, have eight pores with a cap or streak present on the pores, and an echinate exine sculpture (**Plates 18b,c**).

30. The melon pumpkin (*Cucurbita moschata* L.) is similar to the great pumpkin. It is also cultivated in the subtropical and sub-temperate zones of the Hindu Kush-Himalayas. Morphologically, the plant resembles *Cucurbita maxima*. It blossoms in the period from April to September and is a good source of both pollen and nectar for the development of bee colonies. It is visited by both *Apis cerana* and *Apis mellifera*. If planted over a larger area, a colony of *Apis cerana* can produce about 10kg of honey from its flow (Bangyu et al. 1996). The available information shows that its honey is light yellow in colour and granulates into fine grains. The structure of its pollen grain is similar to that of *Cucurbita maxima*.

31. Chick pea or Bengal gram or gram (*Cicer arietinum* L.) is cultivated in the subtropical Himalayas. The wild relatives of gram are known to occur throughout the high mountain areas. Its roots fix atmospheric nitrogen and improve soil fertility. It blossoms during February-March and produces pink flowers in long racemes. It is a major source of nectar and a minor source of pollen and is visited by both *Apis cerana* and *Apis mellifera*. The honey yield with *Apis cerana* is moderate, about 2.0-2.5kg/colony/season. Information on the physico-chemical characteristics of chick pea honey is not available. Pollen grains are medium in size (38.2±0.9 µm long and 25.8±1.2 µm broad), elongated, and tri-colporate with a granular or a reticulate exine sculpture.

32. Water melon (*Citrullus vulgaris* L.) is a cash crop of the subtropical Himalayas cultivated for its fruit. In Myanmar, the plants are mainly grown on alluvial river banks (Zmarlicki 1984). The crop blossoms during April-May and produces large, solitary and yellow flowers in the leaf axils. It is a good source of both nectar and pollen for the development of bee colonies. It is visited by both *Apis cerana* and *Apis mellifera*. Information on the honey and pollen of water melon is not available.

33. Chilli (*Capsicum annum* L.) is a very common plant in kitchen gardens and is also cultivated as a cash crop by subsistence hill farmers in the subtropical to temperate zones of all countries of the HKH. Fresh chilli fruits are used as vegetables and the ripe ones as a condiment. The plants blossom in the period from July to September and are a minor source of pollen and nectar. Though it does not yield surplus honey and the sugar concentration of the nectar is also low (13 per cent), it is important for the survival of bee colonies because it blossoms at a time when there is a dearth of bee flora. It is visited by both *Apis cerana* and *Apis mellifera*. Migratory apiaries in Myanmar fully utilise the sweet pepper honey flow (Zmarlicki 1984). Information on the yield and physico-chemical characteristics of chilli honey is not available. Chilli pollen is off-white in colour. The pollen grains are small (27.5 ± 1.8 µm long and 26.4 ± 1.2 µm broad), spherical, and smooth with three protruding pores.

19. *Momordica charantia*; *Ref.* ***plant no. 34***

34. Bitter gourd (*Momordica charantia*) is a common kitchen garden fruit vegetable grown throughout the Hindu Kush-Himalayan region. It is also being grown as a cash crop under increased vegetable cultivation. It blossoms in the period from June to September, produces bright yellow flowers, and is visited by both *Apis cerana* and *Apis mellifera* for nectar and pollen **(Plate 19)**. It is a minor source. Its flow helps in the development of bee colonies. The bees do not collect surplus honey from bitter gourd, therefore there is no information on its honey.

In addition to the above-mentioned crops, other agricultural crops, such as *Benincasa hispida* (petha), *Lagenaria seceraria* (bottle gourd), *Phaseolus* spp (beans), and *Pisum sativum* (peas), are grown as vegetables in different countries of the HKH region. These crops provide good amounts of both nectar and pollen to support bee colonies.

Horticultural Crops

Agroclimatic conditions in the Hindu Kush-Himalayan region are suitable for the cultivation of different fruit crops. Various kinds of temperate and subtropical fruits are grown in different zones of the region. Temperate crops, e.g., fruits, such as almonds, apples, cherries, peaches, pears, and plums, are planted in the high mountain areas. These crops blossom during early spring (March-April) and produce large quantities of nectar and pollen. However, it is very difficult to obtain pure honey from these crops; the main reason for this is the low colony strength during this period in the colder regions. Therefore, the amounts of nectar and pollen harvested are just sufficient for brood rearing and developing colony strength. Honeybees do not store surplus honey for the beekeeper unless proper care is taken in advance to ensure a strong foraging force during the honey flow season. Thus, if a beekeeper can make strong colonies, a good crop of honey can be harvested and effective pollination of these crops is ensured; and this will also increase the yield and quality of the fruits. Subtropical fruit crops, for example, various species of *Citrus*, litchis, mangoes, and guavas, are planted in the foothills and in the middle hill regions. These crops blossom during March-April and constitute the main spring flow. Since the weather in the low and middle hill regions is warmer during these months and the colonies are strong, good crops of pure honey can be harvested from these crops. Important nectar and pollen yielding fruit crops of the Himalayan region are discussed below.

20. *Malus domestica*; Ref. **plant no. 35**

35. Apples (*Malus domestica* Borkh.) are planted widely in the temperate Himalayan zone for their fruits. It is an important cash crop of Himachal Pradesh, Kashmir, Uttar Pradesh (northern India), Bhutan, northern Pakistan, China, and central and western Nepal. It blossoms during March-April and produces white flowers which are two to three centimetres across. It is an important source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera* **(Plate 20)**. The apple plant secretes 3.3-7.1mg of nectar/flower/day (cf statistics for the U.K. in Free 1993). Nectar secretion varies with the time of day, climate, and soil conditions. Sugar concentration in its nectar also varies between 30-65 per cent depending upon climatic and soil conditions. Its honey potential is moderate (20-30kg/ha) and the honey yield from apples with *Apis mellifera* is 36kg/colony/season. Information is only available on the physical characteristics of apple honey; viz., it is amber in colour and has an aroma of apples.

Apples also produce honeydew which is collected by honeybees. The insect producing honeydew is *Aphis pomi* De Geer, of the family *Aphidae*. Honeydew flow lasts for three to four weeks. Other insects producing honeydew from apples include *Psylla mali* Schmidberger, *Psyllidae*, and *Macrosiphum rosae* (L.), *Aphidae*.

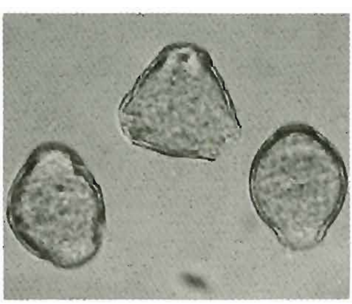
The apple is a major source of pollen too. The colour of the pollen load is pale yellow. The pollen grains of the apple are medium in size (32.8 ± 4.3 µm long and 30.5 ± 2.2 µm broad, round, and tri-colporate with a smooth exine.

36. The almond (*Prunus amygdalus* Batsch.) is planted widely for its seeds in the temperate and subtropical Himalayas from 1,200-2,000masl. Its seed kernels are edible and also yield oil which is used in perfumes. The plant blossoms during March-April and produces pink flowers which are visited by both *Apis cerana* and *Apis mellifera*. It is a major source of both pollen and nectar. Information on the physico-chemical characteristics of almond honey and the pollen grain features is not available.

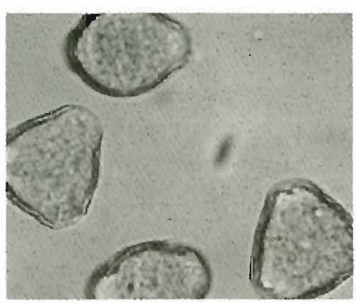
37. Apricots (*Prunus armeniaca* L.) are an important source of income in the high mountain cold and dry areas of the Hindu Kush-Himalayan region, e.g., the Northern Areas of Pakistan, high mountain districts of Nepal, northwestern Indian Himalayas, parts of Tibet, and the Hengduan mountains of China. They are both cultivated and wild. Apricot seeds yield an edible oil which has also become an important source of cash income. The apricot blossoms during February-March and produces

21. *Prunus avium*; Ref. **plant no. 38**

22a. *Prunus domestica*; Ref. **plant no. 39**



22b. *Prunus domestica*: OS; Ref. **plant no. 39**



22c. *Prunus domestica*: SV; Ref. **plant no. 39** white flowers. Honeybees (*Apis cerana* and *Apis mellifera*) visit its flowers for both nectar and pollen. It is of major importance for beekeeping. Information on the physico-chemical characteristics of apricot honey and the pollen grain features is not available.

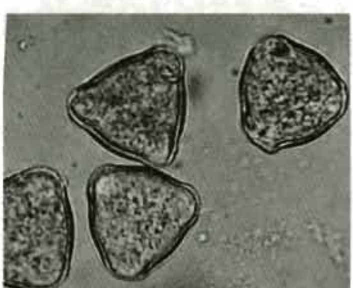
38. The cherry (*Prunus avium* L.) is a small fruit tree planted in the temperate Himalayan zone, e.g., the Northern Areas of Pakistan, northwestern Indian Himalayas, and China. It blossoms in February for about two weeks and produces whitish pink flowers which are eagerly visited by *Apis cerana* and *Apis mellifera* (**Plate 21**). It is a major source of nectar and pollen. The pollen grains are brown in colour, medium in size, round, and tri-colporate with a striated exine sculpture. Information on the physico-chemical characteristics of cherry honey is not available.

39. Plum (*Prunus domestica* L.) - Just below the apple belt of the Himalayas, the agro-climate is suitable for plum fruit farming. Neatly kept, small plum trees are grown in maintained plantations. The plum tree blossoms during February-March for about one to two weeks. The flowers are white in colour and appear before the leaves in clusters of two to three. These are eagerly visited by honeybees (*Apis cerana* and *Apis mellifera*) for nectar and pollen (**Plate 22a**). The plum is a major source of pollen and a medium source of nectar. Information on the physico-chemical characteristics of plum honey is not available. Plum pollen is brown in colour; the pollen grains are medium in size (30.3 ± 0.7 μm in diameter), round to triangular in shape, and tri-colporate with a striated exine sculpture (**Plates 22b,c**).

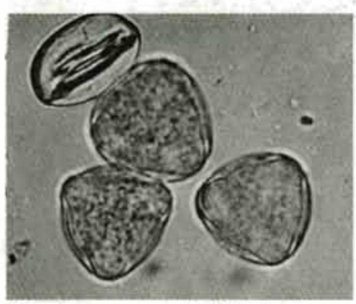
23. *Prunus persica*; Ref. **plant no. 40**

40. Peach (*Prunus persica* L.) - Climatically, peach plantations are found mixed with plum plantations below the apple belt. Farmer's choice and the microclimate are the determining factors between plum and peach crops. Peach blossoms during February-March for about two to three weeks and produces pink flowers. The flowers are two to three centimetres across, appearing before the leaves, and born in clusters of two to three. *Apis cerana* and *Apis mellifera* visit its flowers for nectar and pollen (**Plate 23**). It is a major source of nectar and pollen. However, information on the physico-chemical characteristics of peach honey is not available. The pollen grains of *Prunus persica* are similar to those of *Prunus domestica*, the only difference being that its pollen grain is bigger in size (49.4 ± 0.7 µm in diameter).

24a. *Pyrus communis*; Ref. **plant no. 41**



24b. *Pyrus communis*: OS; Ref. **plant no. 41**



24c. *Pyrus communis*: SV; Ref. **plant no. 41**

41. Pear (*Pyrus communis* L.) - Most farmlands in mountain areas have pear trees along their borders; a few trees per family for personal consumption is a norm. However, in some pockets, modern varieties such as 'Bartlett' are even replacing apples and large orchards are planted by farmers. Pears blossom during February-March for about two weeks and produce white flowers. *Apis cerana* and *Apis mellifera* visit its flowers for nectar and pollen (**Plate 24a**). It is a major source of pollen and a medium source of nectar. Honeybees do not produce surplus honey from the pear flow. Pollen grains show great variation in size but are generally medium-sized (32.9 ± 7.4 µm long and 23.3 ± 3.0 µm broad), oval/triangular in shape, and tri-colporate with a fine-striated exine sculpture (**Plates 24b,c**).

25a. *Citrus aurantifolia*: OS; Ref. **plant no. 42**

25b. *Citrus aurantifolia*: SV; Ref. **plant no. 42**

42. Lime, lemon (*Citrus aurantifolia* [Christm.] Swingle) is native to Asia and planted for its fruit in the subtropical Himalayan zone. It is one of the least frost tolerant *Citrus* spp. It blossoms during March-April and produces fragrant white flowers. It is a major source of pollen and nectar and is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar varies between 34-50 per cent, depending upon the soil and climatic conditions. Information on the physico-chemical characteristics of lemon honey is not available. Lemon pollen is creamy white in colour. The pollen grains are small (23.6 ± 2.6 µm long and 20.6 ± 1.7 µm broad), oval in shape, and tetra-colporate, with a reticulate exine sculpture (**Plates 25a, b**).

43. Pumelo or shaddock (*Citrus grandis* (L.) Osbeck) is native to Asia and is planted throughout the subtropical and temperate Himalayan zones. It blossoms during March-April and produces 2-3cm white flowers. It is an excellent nectar source visited by both *Apis cerana* and *Apis mellifera* (**Plate 26**). The sugar concentration in the nectar is 50 per cent (Zmarlicki 1984); and this varies depending upon climatic and soil conditions. Though this plant is a major source of nectar in mostly planted areas and the bees do collect surplus honey from its flow, information on the physico-chemical characteristics of shaddock honey is not available. The pumelo is a good pollen source also. The pollen

26. Citrus grandis; Ref. **plant no. 43**

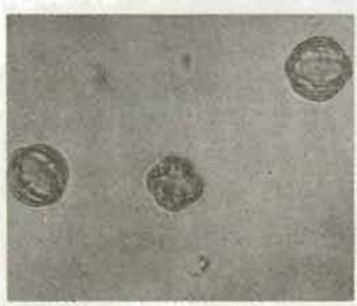
grains are medium in size (32.5±1.04 μm in diameter), round, and tetra-colporate with a reticulate exine sculpture.

44. The sweet lemon (*Citrus limetta* Risso) is native to tropical Asia and is planted widely throughout the subtropical Himalayan zone. It blossoms during March-April and is a major source of nectar. It is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration of the nectar varies between 16-40 per cent, depending upon climatic and soil conditions. It also provides pollen to bees, but data on the pollen grain features of this plant are not available. Similar to shaddock, the bees do collect surplus honey from its flow. Apart from the information that sweet lemon honey has a very pleasant flavour, no other physico-chemical information is available.

45. Citron (*Citrus medica* L.) is planted throughout the subtropical and temperate Himalayan zones and is native to Asia, especially the eastern Himalayas. It prefers a warm temperate climate and is frost tender. The plant blossoms during March-April and is a major source of nectar (PARC 1977). It is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in nectar is medium 35-50 per cent (Sharma 1958). It is a source of pollen too, but data on the pollen grain features are not available. Though the bees collect surplus honey from its flow, information on the physico-chemical characteristics of its honey is not available. The only information shows that the honey from this plant has a very pleasant flavour.

46. Grapefruit (*Citrus paradisi* Macfac) is planted throughout the tropical to the temperate Himalayan zones. The tree prefers a warm climate and is not frost tolerant. It blossoms during March-April and produces white and fragrant flowers which provide both pollen and nectar. It is an excellent source visited by both *Apis cerana* and *Apis mellifera*, mainly for nectar. The sugar concentration of the nectar varies between 21-50 per cent, depending upon climatic and soil conditions. The sugar concentration in the nectar from the honeysac of the bees has also been determined, and it is found to be 61.5 per cent in dry areas and 18.6 per cent in humid areas (Moffett et al. 1974; Gilliam et al. 1980). However, there is no information on the physico-chemical characteristics of its honey. Its pollen grains are small (27.9 ± 2.6 µm long and 18.7 ± 0.2 µm broad), oval, and tetra-colporate with a reticulate exine sculpture.

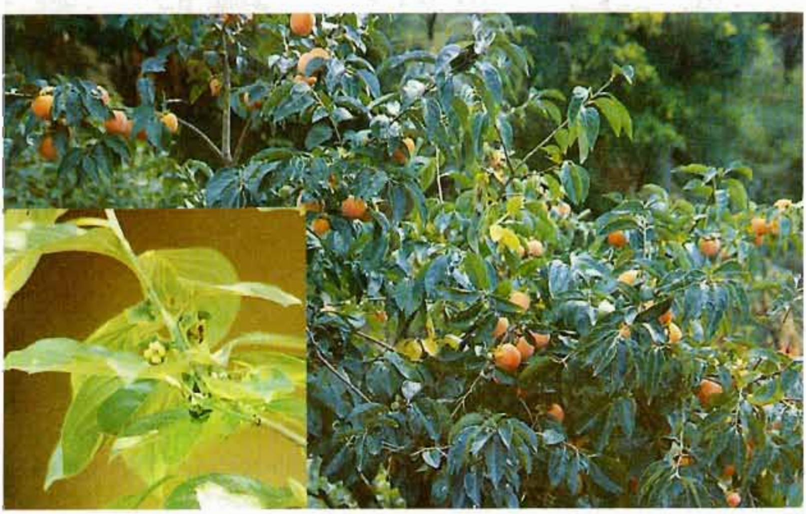
27a. Citrus reticulata; Ref. ***plant no. 47***



27b. Citrus reticulata: OS; Ref. ***plant no. 47***

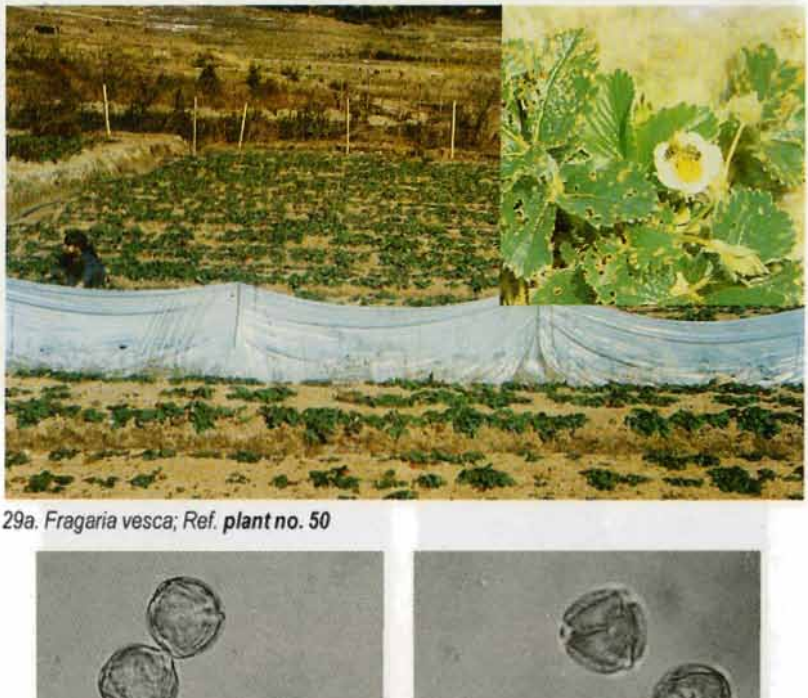
47. The mandarin orange (*Citrus reticulata* Blanco) is native to tropical Asia and is planted widely throughout the subtropical Himalayas. It grows well in warm and humid climates where the average annual temperature is above 15°C, the winter temperature is above 5°C, the frost season is less than 115 days, and the average annual rainfall is over 1,000mm. It blossoms during March-April and is a major source of nectar visited by both *Apis cerana* and *Apis mellifera* (**Plate 27a**). A colony of *Apis cerana* can produce 10kg of honey from this crop. The sugar concentration of the nectar is 16-40 per cent. It also provides pollen to bees. The only information available on the physical characteristics of its honey shows that its honey has a pleasant flavour. Information on other physical and chemical characteristics of mandarin orange honey is not available. The structure of its pollen grains is similar to that of *Citrus aurantifolia*, except that it is slightly bigger (24.6 ± 2.7 µm long and 23.1 ± 2.6 µm broad) **(Plate 27b)**.

48. Sweet orange (*Citrus sinensis* L.) is a native of China and is planted extensively in the subtropical to temperate Himalayan zones in areas with a medium-range climate. The plant is not frost-tolerant and prefers light loam soil. It blossoms during March-April and produces white, fragrant flowers. It is a major source of pollen and nectar and is visited by both *Apis cerana* and *Apis mellifera*. The nectar flow is available for three or more weeks and the bees collect surplus honey from it, but, like other species of *Citrus*, information on the physico-chemical characteristics of sweet orange honey is also not available. The structure of its pollen grains is similar to that of *Citrus aurantifolia* but different in size. Its pollen grains are slightly bigger in size (25.8 ± 2.4 µm long and 24.8 ± 1.2 µm broad), oval, and tetra-colporate with a reticulate exine sculpture.



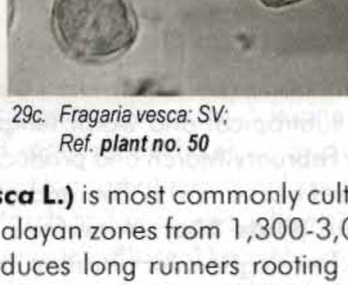
28. Diospyros kaki; Ref. ***plant no. 49***

49. The Persimmon (*Diospyros kaki* L. f.) is planted in the subtropical to temperate Himalayas from 1,200-2,200m. It blossoms during March-April for about two weeks and produces yellow-coloured unisexual flowers. *Apis cerana* and *Apis mellifera* visit its flowers for nectar and pollen (**Plate 28**). It is of medium importance for beekeeping. The bees do not collect surplus honey from the persimmon flow. Thus there is no information on the physico-chemical characteristics of its honey. Its pollen grains are large, round/triangular in shape, and tri-colporate with a smooth exine.



29a. Fragaria vesca; Ref. ***plant no. 50***

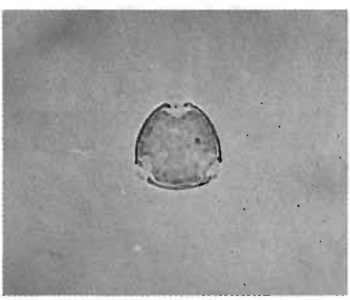
29b. Fragaria vesca: OS; Ref. ***plant no. 50***



29c. Fragaria vesca: SV; Ref. ***plant no. 50***

50. The strawberry (*Fragaria vesca* L.) is most commonly cultivated in the subtropical and temperate Himalayan zones from 1,300-3,000m. The root stock is perennial and produces long runners rooting at the joints. It blossoms from February to May and produces 2.0-2.5cm white flowers which are eagerly visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 29a**). It is of minor importance for beekeeping, providing nectar and pollen for a long period of four months. Its flow helps to build up colony strength. The bees do not collect surplus honey from its flow. Thus, there is no information on the physico-chemical characteristics of strawberry honey. Strawberry pollen is yellow in colour. The pollen grains are medium in size (36.0 ± 3.6 µm long and 33.3 ± 4.4 µm broad), oval or triangular in shape, and tri-colporate with a striated exine sculpture (**Plates 29b,c**).

30a. *Litchi chinensis; Ref.* ***plant no. 51***

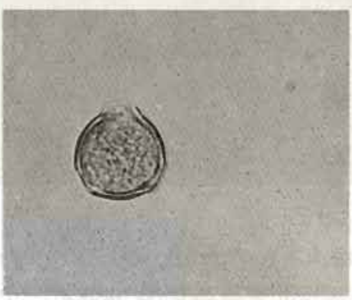


30b. *Litchi chinensis: OS (PV); Ref.* ***plant no. 51***

30c. *Litchi chinensis: SV (EV); Ref.* ***plant no. 51***

51. The litchi (*Litchi chinensis* Gaertn) is a small-sized fruit tree, planted in the subtropical and warm temperate Himalayan zones. It blossoms during February-March and produces greenish white flowers. It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 30a**). Honeybees also collect juice from the damaged fruits. The sugar concentration in the nectar is high – 62 per cent (Zmarlicki 1984). In Myanmar, the honey yield with *Apis mellifera* is reported to be about 20kg/colony/season (Zmarlicki 1984). Litchi honey is amber coloured and possesses a characteristic rosy and delicious flavour. The only information available on the chemical characteristics is that its honey contains 18.5 per cent water and does not ferment if kept airtight (Kohli 1959). It granulates slowly. Its pollen is yellow in colour. The pollen grains are small (20.8±1.3 µm in diameter), round to triangular, and tri-colporate with a smooth exine (**Plates 30b,c**).

31a. Mangifera indica; Ref. ***plant no. 52***



31b. Mangifera indica: OS (PV); Ref. ***plant no. 52***

31c. Mangifera indica: SV (EV); Ref. ***plant no. 52***

52. Mango (*Mangifera indica* L.) is a large, spreading evergreen fruit tree with large, green, leathery foliage. It occurs both in the wild as well as in a cultivated state in subtropical areas. The mango is one of the best-known fruits in India with several varieties, each known by a special name. All parts of the mango plant contain great medicinal properties. This tree blossoms during February-March and produces yellowish green and reddish flowers at the terminal panicles (**Plate 31a**). About 25 per cent of the flowers are bisexual, while the remaining are staminate with sticky pollen grains, therefore they need insect pollination. *Apis cerana* and *Apis mellifera* gather both nectar and pollen. However, the yield is erratic varying with the climatic conditions each year (Singh 1962). Nectar production is reduced by cold and drought. Honeybees also collect juice from damaged fruits and are reported to forage on leaves, either for honeydew or extrafloral nectar (Crane et al. 1984). Information is available only on the physical characteristics of its honey, which is reddish amber in colour and has a distinctive flavour, probably because honeybees also collect fruit juice which affects its flavour.

Honeydew is also produced from mangoes in India and Nepal. However, the insect is not specified. Mango pollen is yellow in colour. The pollen grains are medium in size (22.6 ± 1.8 µm in diameter), round or triangular in shape, and tri-colporate with a granulate exine sculpture (**Plates 31b,c**).

32. Musa sapientum; Ref. ***plant no. 53***

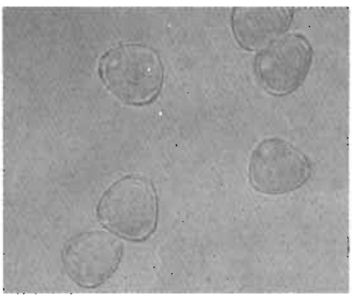
53. The banana (*Musa sapientum* L.) is a giant herb having a tree-like stem. It is planted widely in subtropical and sub-temperate areas up to 1,500m. It blossoms practically throughout the year and produces a massive inflorescence which consists of the combs of female flowers with the male flowers forming the heart at the pendant tip (**Plate 32**). Cultivated bananas are sterile and the male flowers produce very little pollen (Kiew and Muid 1991). One bract unfurls each night to expose the six mm long, white male flowers which produce copious nectar. Banana flowers are visited by both *Apis cerana* and *Apis mellifera*. Banana nectar contains 24 per cent of sugar. Since it blossoms almost throughout the year, it is, therefore, very important for beekeeping. Information is available only on the physical characteristics; viz., banana honey is dark in colour and has a stringent, tamarind-like flavour (Espina Perez and Ordetx Ros 1983). Banana pollen is off-white in colour, the pollen grains are 145.2 ± 5.3 µm in diameter and slightly oval in shape.

33. *Eriobotrya japonica*; Ref. **plant no. 54**

54. The loquat (*Eriobotrya japonica* Thunb. Lindley) is a medium-sized fruit tree growing in subtropical areas. It grows well in deep and fertile soil, rich in organic materials, and in a warm and humid climate with an average annual temperature of between 12-15^{0}C and rainfall of 1,000mm. It blossoms twice a year, i.e., February through March and September through October and produces white flowers which provide good quantities of nectar and pollen (**Plate 33**). Both *Apis cerana* and *Apis mellifera* visit its flowers and collect nectar and pollen. In the usually planted areas of the Chinese Himalayas, a colony of *Apis cerana* produces five kilogrammes of honey from this crop. The sugar concentration in the nectar is high (30.5-65.0 per cent). In Pakistan, honey yield is 3.6kg/colony/season (PARC 1977). Information is available on the physical characteristics indicating that loquat honey is white in colour and becomes granulated (Shahid and Qayyum 1977). Its pollen grains are medium in size (35.9 ± 0.1 µm in diameter), round, and tri-colporate with a granular exine sculpture.

55. Guava (*Psidium guajava* L.) is an important fruit of the subtropical areas of the Hindu Kush-Himalayas. It is planted in both kitchen gardens and on a large scale in orchards in the low hill to the middle hill Himalayan areas. It blossoms during May-June and produces white flowers in the leaf axils. The flowers are visited by both *Apis cerana* and *Apis mellifera* (**Plate 34a**). Nectar secretion is abundant throughout the day. Sugar concentration in the nectar is medium — about 28 per cent. Honeybees also collect juice from the damaged fruits. It is a major source of nectar and its honey yield is important in the North West Frontier Province (NWFP)

34a. Psidium guajava; Ref. ***plant no. 55***

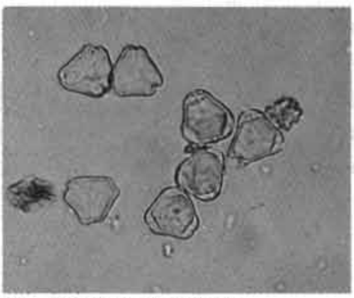


34b. Psidium guajava: OS, Ref. ***plant no. 55***

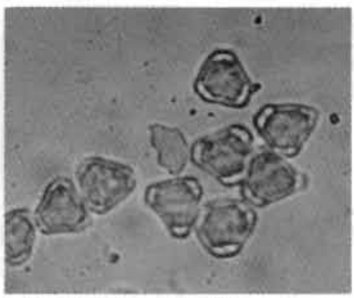
of Pakistan (PARC 1977; Shahid and Oayyum 1977). However, there is no information on the physico-chemical characteristics of guava honey. It is a major source of pollen too. Guava pollen is white in colour. The pollen grains are very small (18.1 ± 1.9 µm long and 16.4 ± 1.6 µm broad), oval/triangular in shape, and have three furrows and a smooth exine (**Plate 34b**).

56. Jambos or black berry (*Syzygium cumini* (L.) Skeels) is a large evergreen, avenue and wasteland fruit and timber tree occurring throughout the foothill areas of the Himalayas. It blossoms during late spring and early summer (April-May) for about two to three weeks and produces pale or dull white flowers in panicles, usually below the leaves (**Plate 35a**). It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion is erratic depending upon the weather conditions. Sugar concentration in the nectar is very high, up to 72 per cent. Its honey is light reddish brown in colour and possesses a characteristic pungent flavour. On storage, fermentation is

35a. Syzygium cumini; Ref. ***plant no. 56***



35b. Syzygium cumini: OS; Ref. ***plant no. 56***

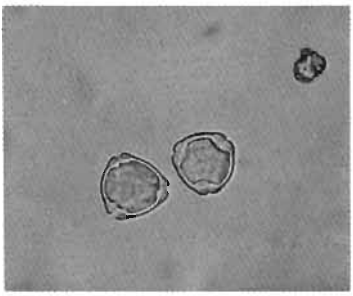


35c. Syzygium cumini: SV; Ref. ***plant no. 56***

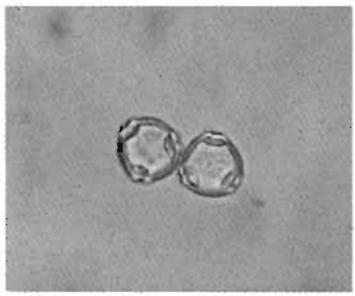
likely after a few months. Granulation is very slow. It contains 18.4 per cent water, 32.3 per cent glucose, 43.3 per cent fructose and 0.18 per cent ash. Its pollen grains are very small (17.5 ± 0.9 µm long and 15.8 ± 0.7 µm broad), almost round, with three pores, and a smooth exine (**Plates 35b,c**).

57. Rose apple (*Syzygium jambos* (L.) Alston; Syn. *Eugenia jambos* L.) is a small-sized cultivated fruit tree, up to 10m tall. It occurs in the subtropical Himalayan zone up to 1,500m. It blossoms almost throughout the year, i.e., between February to June and September to November. It produces large white flowers with a fluff of stamens about two to three cm long and sweet scented (**Plate 36a**). It is eagerly visited by *Apis cerana* and *Apis mellifera* and is a major bee plant providing both nectar and pollen. It yields a good amount of honey. The available information on the physico-chemical characteristics of rose apple honey shows that it has 18.5 per cent water, 36.1 per cent glucose, and 39.7

36a. *Syzygium jambos*; Ref. **plant no. 57**



36b. *Syzygium jambos*: OS; Ref. **plant no. 57**



36c. *Syzygium jambos*: SV; Ref. **plant no. 57**

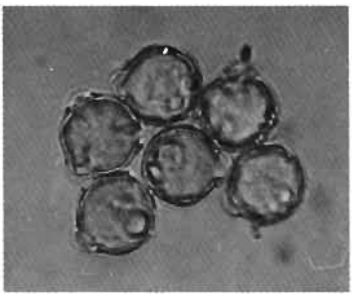
per cent fructose. It is of amber colour and has a mild flavour. The pollen is off-white in colour, each grain is small in size (19.9±1.7 µm in diameter), round/triangular, with three pores and a smooth exine sculpture (**Plates 36b,c**). As it blossoms for most of the year, it is highly recommended for planting near apiaries to increase honey production as well as for the sustenance of bee colonies.

58. Chinese jujube (*Zizyphus jujuba* Mill.) is an evergreen fruit tree, three -12 metres tall, with both spiny and spineless varieties occurring in India. The Chinese jujube is planted in the sub-Himalayan areas and in the hills, but it flourishes best in the low hill areas below 600m. Its leaves are used as fodder and for rearing silkworms. The plant also yields fuelwood and timber and is grown as a living fence. The bark yields tannin. It is a host plant for lac insects. The plant tolerates severe heat and frost and is highly drought resistant. It blossoms during July to October (Zmarlicki 1984). The flowers are small and greenish yellow and are eagerly visited by *Apis cerana* and *Apis mellifera*. The Chinese jujube is a major source of nectar in China, India, Myanmar, and Pakistan (PARC 1977; Zmarlicki 1984). A colony of *Apis cerana* can produce 10-15kg of honey from its flow. The sugar concentration of the nectar is over 50 per cent. Honey from this plant contains 23 per cent of water, 31.5 per cent glucose, 35.3 per cent fructose, 0.5 per cent sucrose, and 0.63 per cent ash. The pH of the honey is 5.9 and is slightly acidic. The colour of the honey is yellowish brown (Lin et al. 1977). Its relative density is 1.38 (Lin et al.1977), granulation is slow, and the flavour is extra sweet.

59. The Indian jujube (*Zizyphus mauritiana* Lam.) is similar to the Chinese jujube. The Indian jujube is also an evergreen fruit tree, three-12m tall, which is grown as fencing around the fields. It is planted in the sub-Himalayan hill areas below 1,000m. Its leaves are used as fodder and for silkworm rearing. The plant yields timber and the bark yields tannin. The Indian jujube is also used as a host for lac insects. It blossoms during September-October and produces small greenish flowers which are visited by *Apis cerana* and *Apis mellifera*. It is a major source of nectar in China, India, and Pakistan (PARC 1977; Xu 1993). The sugar concentration in the nectar is over 50 per cent (Zmarlicki 1984). The Indian jujube honey has 23 per cent water, 31.5 per cent glucose, 35.3 per cent fructose, 0.1 per cent sucrose, and 0.6 per cent ash. It is yellowish brown in colour and possesses an extra sweet flavour. Its granulation is slow.

60. Chestnut (*Castanea mollissima* Blume.) - This is a deciduous tree which grows up to 20m. It has a grey-brown bark and a semicircular crown. It is planted widely in large areas in southern Tibet and in the Hengduan mountain range. It grows well in damp and deep-sanded soils which are rich in organic materials with a pH value ranging between 4.0-7.5. It blossoms during April-May and produces unisexual flowers. The male flowers are many and in thin, erect inflorescences with two to three female flowers at the base of the inflorescence. Its flowers produce good amounts of nectar and pollen and are visited by *Apis cerana* and *Apis mellifera*. Information is only available on the physical characteristics of chestnut honey which shows that it is dark in colour and slightly bitter in taste. It has little commercial value but helps to sustain bee colonies during the slack summer period (Bangyu et al. 1996). Since it blossoms during the slack summer months and is rich in nectar and pollen, it is very important for beekeeping in the Chinese Himalayas (Bangyu et al. 1996). Information on the pollen grain features is also lacking.

37a. Punica granatum; Ref. ***plant no. 61***



37b. Punica granatum: ~~OS;~~
Ref. ***plant no. 61***

61. Pomegranate (*Punica granatum* L.) is a small fruit tree commonly found wild and also planted in the subtropical Himalayan region of China, India, Nepal, and Pakistan. There are pocket areas in the HKH region where its pure wild forests exist in hot, dry valley areas. People collect its fruits, dry their seeds, and sell them to earn cash income. It blossoms during late spring to early summer (May-June) and produces bright red flowers on the tips of axillary shoots (**Plate 37a**). Honeybees (*Apis cerana* and *Apis mellifera*) visit its flowers for pollen. It is a bee plant of medium importance. Honeybees do not produce honey from this plant. Thus, there is no information on the characteristics of pomegranate honey. Its pollen is yellow in colour. The pollen grains are small (22.6 ± 1.04 μm long and 21.6 ± 1.9 μm broad), spherical in shape, and tri-colporate with a smooth exine (**Plate 37b**).

62. Papaya (*Carica payaya* L.) is an evergreen, dioecious fruit tree planted in subtropical regions of the Himalayas. Papain is extracted from the fruits and is used for brewing. Papaya leaves are used for tenderising meat. It blossoms during May and produces small yellow flowers. Honeybees visit its flowers for nectar and pollen. It is reported to be a major source of nectar (Crane 1973; Rowley 1976) and pollen, but the nectar in male flowers is inaccessible to bees. The sugar concentration in the nectar varies between 24-34 per cent, depending upon the climatic and soil conditions (Rowley 1976; Crane et al. 1984). There is no information available on the pollen grain features or the characteristics of papaya honey.

63. The walnut (*Juglans regia* L.) occurs both wild as well as in cultivated plantations. It is grown for its fruits and good quality wood in temperate Himalayan areas. Walnut wood is used for making furniture, carving, cabinets, musical instruments, and other ornamental work. The bark, leaves, and the outer covering of green fruits yield dyes and tannin. The seed kernel is edible and is rich in Vitamin B and oil. The walnut blossoms during March and produces small, yellowish green unisexual flowers in catkins. Male catkins are slender, pendulous, and five-13cm long, and the females are terminal and have only between one to three flowers. *Apis cerana* visits its flowers for pollen only because the flowers of walnut do not produce nectar. It is a medium source of pollen. Walnut pollen is yellow in colour. The pollen grains are medium in size, round in shape, and have five pores; they have a smooth exine which is swollen beneath the apertures.

Forage Legumes

Various legumes such as alfalfa (*Medicago* spp.), clover (*Trifolium* spp.), and melilots (*Melilotus* spp) are cultivated as forage crops in different countries of the Hindu Kush-Himalayan region such as China, India, and Pakistan. These crops secrete prolific amounts of nectar and pollen and, therefore, constitute major sources of both nectar and pollen for honeybees. Good quantities of pure honey can be harvested from these crops. In addition to providing forage for cattle as well as for honeybees, these plants also fix atmospheric nitrogen and contribute to soil fertility, help in soil conservation, and prevent soil erosion. Some of the important species are described below.

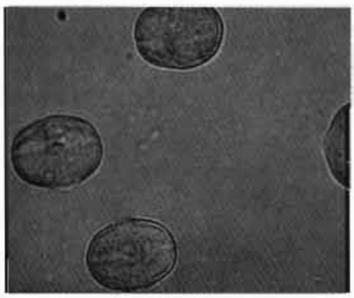
64. Alfalfa (*Medicago sativa* L.) is cultivated in the temperate and subtropical Himalayan areas of China, India, and Pakistan. It has been called the world's greatest forage crop. The roots of this crop fix atmospheric nitrogen and improve soil fertility. It blossoms during August-September; its flowers are white, purple, and greenish yellow, depending upon the subspecies. The crop is a major source of nectar in China, India, and Pakistan (Tseng 1954; PARC 1977) and it is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar varies between 18-48 per cent, depending upon the soil moisture (Nye 1971; Cirnu et al. 1976). The honey yield with *Apis mellifera* is 56kg/colony/season (cf figures for the USA in McGregor 1976). Crops can give the heaviest honey yields when grown for the seeds and left uncut. Alfalfa honey is light in colour and the flavour is mild. It granulates rapidly with hard, fine white grains. It has 14.4-17.6 per cent water, 79.4 per cent total sugars, 32.6 per cent glucose, 36.2 per cent fructose, 5.2-6.8 per cent sucrose, and 0.1 per cent ash. It is slightly acidic with a pH of 5.5 (White et al. 1962; Mohamed et al. 1982). The crop is also a medium source of pollen for honeybees. The pollen value is greater in dry hot regions and varies according to the area and other crops nearby (Free 1993). The colour of the pollen is lemon yellow.

65. Black medick; hop clover; yellow trefoil (*Medicago lupulina* L.) grows wild on wastelands, pastures, and in meadows in the subtropical and temperate Himalayas. The roots of this plant fix atmospheric nitrogen and improve soil fertility. The plant blossoms during April-May and produces yellow flowers which are visited by *Apis cerana* and *Apis mellifera*. In Pakistan, it is a major source of nectar and a medium source of pollen (PARC 1977). The honey potential varies between 24-30kg/ha (cf Cirnu et al. 1976 for statistics on Romania). Information is not available on the physico-chemical characteristics of honey and the pollen grain features of black medick.

66. Sickle medick (*Medicago falcata* L.) is cultivated as a forage crop in the subtropical and temperate Himalayas, especially in the north west Indian Himalayas. Its fresh leaves are used as a pot herb and its dried leaves are sold in small packets as condiments for flavouring purposes. The crop blossoms during the early spring season (February-March); the flowers are yellow in colour and produced on peduncles in clusters of more or less compact racemes. Flowers are eagerly visited by *Apis cerana* and *Apis mellifera*. In India, the crop is reported to be a medium source of nectar and a minor source of pollen (**Plate 38a**). Information is not available on the physico-chemical characteristics of sickle medick honey. Its pollen grains are small (26.3 ± 0.9 µm long and 22.8 ± 0.9 µm broad), oval, and tri-colporate with a smooth exine (**Plate 38b**).

67. Medick (*Medicago laciniata* (L.) Mill.) a forage legume, occurs wild in the subtropical and temperate Himalayan zones of India, Pakistan,

38a. Medicago falcata; Ref. **plant no. 66**



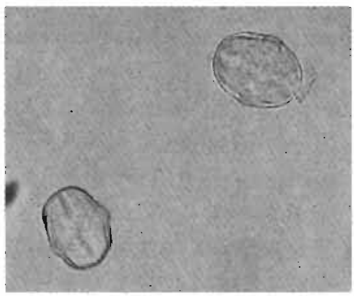
38b. Medicago falcata: OS; Ref. **plant no. 66**

and China. Its roots improve soil fertility by fixing atmospheric nitrogen. It blossoms during March-April and is visited by both *Apis cerana* and *Apis mellifera*. In Pakistan, it is reported to be an important source of nectar (PARC 1977). Information is not available on the amount of nectar secreted by the flower, physico-chemical characteristics of medick honey, and the pollen grain features.

68. Sweet clover or white melilot (*Melilotus alba* Desr.) is cultivated in the subtropical and temperate Himalayan zones of China, India, and Pakistan. It also occurs as a casual or established weed. It increases soil fertility by fixing atmospheric nitrogen, and it also helps control soil erosion. The crop blossoms in the period from March to May; the total blossoming period being seven to eight weeks. *Apis cerana* and *Apis mellifera* visit this crop for both nectar and pollen. It is the major source of nectar and pollen in China, India, and Pakistan (**Plate 39a**). Nectar secretion starts at 18ºC and reaches its maximum between 20-25ºC (Bangyu et al. 1996). Sugar concentration in the nectar is between 23-

39a. Melilotus alba; Ref. ***plant no. 68***

39b. Melilotus alba: OS (PV); Ref. ***plant no. 68***



39c. Melilotus alba: SV (EV); Ref. ***plant no. 68***

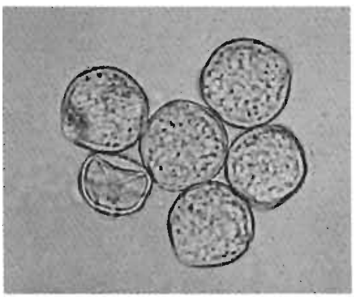
55 per cent, depending upon the soil moisture; being low in wet soil and high in dry soil (Nye 1971). The honey potential has been estimated to be between 26-678kg/ha (cf Demianowicz et al. 1963 for figures from Poland); 211.8kg/ha (cf Petkov 1977 for figures from Bulgaria); and 200-500kg/ha (cf Cirnu et al. 1976 for figures from Romania). In the Chinese Himalayas, the honey yield with *Apis mellifera* is 30-35kg/colony/season and with *Apis cerana* 15-20kg/colony/season (Bangyu et al. 1996). Sweet clover honey is light in colour and has a mild flavour (Pellett 1976; Bangyu et al. 1996). It granulates rapidly within a week after being removed from the hive (Pellett 1976; Howes 1979). It contains 18.8 per cent water, 33.2 per cent glucose, 36.8 per cent fructose, 1 per cent sucrose, and 0.041 per cent ash (Maurizio and Grafl 1982). The honey is acidic with a pH value of 3.65 (White et al. 1962). Sweet clover pollen is yellowish brown in colour. The pollen grains are small (24.6 ± 1.04 μm long and 21.1 ± 0.9 μm broad), oval/triangular almost round, and tri-colporate with a smooth exine (**Plates 39b,c**).

69. Yellow melilot (*Melilotus parviflora*) is a plant similar to *Melilotus alba*, the only difference being that the flowers of *M. parviflora* are yellow in colour. This crop blossoms in the period from March to June and is visited by both *Apis cerana* and *Apis mellifera*, mainly for nectar. It is a major source of nectar and a minor source of pollen. The bees collect a lot of honey from yellow mellilot but information is not available on the physico-chemical characteristics of its honey. The pollen grains are similar to those of *Melilotus alba*. Each pollen grain is 26.8 ± 0.7 µm long and 20.3 ± 1.1 µm broad, oval, and tri-colporate with a smooth exine.

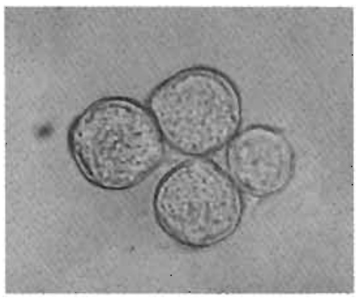
70. Egyptian clover (*Trifolium alexandrinum* L.) is native to Asia and is cultivated widely in the temperate and subtropical Himalayas. The crop is grown on a large-scale for fodder in the hill areas of India and Pakistan. It blossoms during May-June and produces large quantities of nectar and pollen. It is visited by both *Apis cerana* and *Apis mellifera*. It is a major source of nectar and pollen in India and Pakistan. The honey yield from this crop is estimated to be nine-27kg/colony/season and the honey potential of the crop is 65kg/ha (PARC 1977). Egyptian clover honey granulates slowly and is slightly acidic with a pH value of 5.0. It contains 15.6-16.8 per cent water, 31.6-35.8 per cent glucose, 38.2-42.5 per cent fructose, 3.6-4 per cent sucrose, and 0.09 per cent ash.

71. Red clover (*Trifolium pratense* L.) is a perennial crop of the subtropical and temperate Himalayas and grows in meadows and pastures at high altitudes in the subtropics. The crop blossoms in the period from April to September and is visited by both *Apis cerana* and *Apis mellifera*. It is a major source of nectar. Sugar concentration in the nectar varies between 17-60 per cent, depending upon the climatic and soil conditions (Maurizio and Grafl 1982). The honey potential of the crop is moderate, i.e., 28.9 kg/ha (Petkov 1977). In the Chinese Himalayas, the honey yield with *Apis cerana* is 5kg/colony/season (Bangyu et al. 1996). Red clover honey has a reddish or pinkish tinge, a mild flavour, and granulates rapidly (Crane 1975). It has 79.6 per cent of total sugars, a glucose content of 49 per cent, and the fructose content is 50.1 per cent of the total sugars (Vermeulen and Pelerents 1965). The honey is slightly acidic with a pH value of 4.2. Some carbonyl compounds have also been identified in the honey (Hoopen 1963). The plant is a good source of pollen too. The colour of the pollen load is greenish brown. Each pollen grain is medium in size, round or slightly oval in shape, and tri-colporate; it has a reticulate exine sculpture with granules scattered on the apertures.

40a. Trifolium repens; Ref. **plant no. 72**



40b. Trifolium repens: OS; Ref. **plant no. 72**



40c. Trofolium repens: SV; Ref. **plant no. 72**

72. White clover (*Trifolium repens* L.) is an annual or perennial crop growing in the subtropical and temperate Himalayas. It also grows wild as a pasture plant in mountainous areas and is common on lawns and in heavily grazed areas, on roadsides, and on wastelands. It blossoms from spring to early summer (February- June) and is a very good source of nectar and pollen for *Apis cerana* and *Apis mellifera* for over five months a year (**Plate 40a**). The nectar secretion is 0.05-0.40mg/flower/day (cf statistics for Germany in Maurizio and Grafl 1982) and the nectar flow is heaviest in the season following a year of excessive rain (Pellett 1976). The sugar concentration of the nectar varies from 25-50 per cent (Petkov 1977). The honey yield with *Apis mellifera* is 50kg/colony/season (cf figures for the USA in Pellett 1976) and the honey potential of the crop is 32.2 kg/ha. White clover honey is bright in colour (Howes 1979), with a characteristic mild and sweet flavour (Lovell 1977; Roberts 1956; Crane 1975). Granulation is slow, fine, and uniform with smooth and white grains (Crane 1975; Howes 1979). It contains 19.4-21.3 per cent water, 28.1-32.1 per cent glucose, 37.6-39.9 per cent fructose, 0.7-1.4 per cent sucrose, and 0.09-0.6 per cent ash (White et al. 1962). White clover honey is acidic with a pH value of 4.0 (White et al. 1962). The pollen grains are small (23.8 ± 1.04 µm in diameter), round, and tricolporate with a granular exine sculpture. The colour of the pollen is brown (**Plates 40b,c**).

73. Persian clover or strawberry clover (*Trifolium resupinatum* L.) is cultivated in the subtropical and temperate Himalayan region of China, India, and Pakistan. It also grows wild in grassy places and on disturbed grounds. The crop blossoms in the period from April to June and constitutes a major source of nectar and pollen. It is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar varies between 35-50 per cent (Free 1993). The honey potential of the crop varies from 70-100 kg/ha. The only information available on the physical characteristics of Persian clover honey is that it is light in colour. Information is not available on other physical and chemical characteristics of the honey and pollen grain features.

74. Astragalus (*Astragalus sinicus* L.) is a herb, native to China, distributed from the subtropical to the temperate Himalayan zones. It occurs wild as well as cultivated in rice fields as a soil improver, because it controls soil erosion and is used as green manure. Its roots fix atmospheric nitrogen and improve soil fertility. The plant blossoms during April and produces reddish purple flowers which are visited by both *Apis cerana* and *Apis mellifera*. In China, it is a major source of nectar (Deh-Feng and Wen-Cheng 1981). The honey yield is very high, i.e., 30-40kg/colony/season with *Apis mellifera* and 15-20kg/colony/season with *Apis cerana* (Bangyu et al. 1996). Its honey is of very good quality. It is pale brown in colour and contains 22 per cent water, 30.6 per cent glucose, 35.6 per cent fructose, 3.9 per cent sucrose, and 0.03-0.06 per cent ash (Crane et al. 1984).

75. *Vicia cracca* L. is an annual with a weak rambling stem. It is cultivated widely in the river valley of the Hengduan mountain range. It grows well on sandy soils with good drainage. Its roots fix atmospheric nitrogen and improve soil fertility. It blossoms during April-May and produces purplish-red flowers in stalked, erect, axillary clusters. Its flowers secrete large amounts of nectar and are visited by both *Apis cerana* and *Apis mellifera*. The nectar secretion is highest at 20-25°C. The honey yield with *Apis cerana* is 30kg/colony/season (Bangyu et al. 1996).

Information is only available on the physical characteristics of its honey, and this indicates that it is light in colour, thick, and has a sweet flavour. The granulation is fine and it becomes white after granulation. There is no information on the chemical characteristics of its honey and pollen grain features.

Ornamental Plants and Avenue Trees

There are many plant species grown for their ornamental beauty in home gardens, along roadsides and avenues, and in other localities developed for recreation. While most of these plants produce nectar and pollen which is collected by honeybees, the yield from them is very low since a majority of these ornamental plants are too scattered for them to act as a major source of nectar and pollen. Since one or the other of these ornamental plant species keeps flowering, they ensure a continuous supply of both nectar and pollen throughout the year in dry and hot summers and in the cold winter months. Therefore, these are very important for the sustenance of bee colonies during dearth periods. Some of the species, for example, *Ageratum conyzoides, Poinsettia pulcherrima,* and *Salvia splendens* flower most of the year.

Some ornamental plants, for example, *Calliandra callothyrsus* and *Callistemon citrinus,* which are planted as roadside avenue trees, and *Antigonon leptopus,* grown in home gardens, blossom during the main flow season and produce large quantities of nectar and pollen. These plants contribute to honey yields and are thus useful for beekeeping. It is, therefore, desirable for beekeepers to plant these ornamental and avenue plants around their apiaries. Some of these plants facilitate the production of surplus honey, while others help to sustain bee colonies. A brief account of the more useful ornamental and avenue plants is provided below.

76. Coral vine or Mexican creeper (*Antigonon leptopus* Hook and Arn.) is a large, almost evergreen, climbing shrub planted in gardens in the subtropical Himalayan zone. It has beautiful rosy pink flowers and its tubers are used as food. The plant produces flowers for quite a long period almost throughout summer and the rainy months; i.e., from May to October. It is a prolific nectar producer and also a major source of pollen. It is visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion is higher on cloudy humid days (Ordetx Ros 1954). Sugar concentration in the nectar varies between 22-50 per cent, depending upon climatic and soil conditions (Wiese 1980). Its honey is light or almost white in colour (Crane 1975; Pellett 1976). It has a flavour like that of aster honey, and it also has a characteristic aroma (Crane 1975). It contains

16.3-17.2 per cent water, 28.7 per cent glucose, 34.9 per cent fructose, 0.6 per cent sucrose, and 0.62 per cent ash. Its pollen is pale yellow in colour. The pollen grains are large (69.1 ± 1.8 µm long and 57.4 ± 2.1 µm broad), oval, and tri-colporate with a granular exine sculpture. It is recommended for increasing honey plant resources and the beekeeping potential of an area.

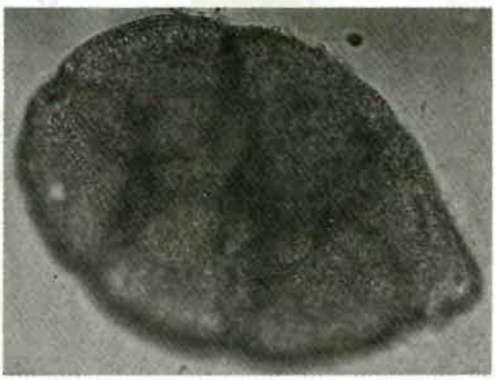
41a. Callistemon citrinus; Ref. ***plant no. 77***

41b. Callistemon citrinus: OS; Ref. ***plant no. 77***

41c. Callistemon citrinus: SV; Ref. ***plant no. 77***

77. Bottle brush (*Callistemon citrinus* (Curt) Skeels) is a small tree planted in gardens as well as along roadsides in the Himalayan region at altitudes of up to 1,500m. The plant blossoms for a long period from March to October and produces 7-15cm long, showy cylindrical clusters of red flowers with very long red stamens (**Plate 41a**). It is a major source, visited by both *Apis cerana* and *Apis mellifera,* for nectar and pollen (PARC 1977; Kafle 1984). Information is not available on the physico-chemical characteristics of bottle brush honey. Its pollen is pale pink in colour. The pollen grains are very small (17.8 ± 1.3 µm in diameter), round/triangular, with three pores (tri-porate) and a smooth exine (**Plates 41b,c**). The plant is recommended for increasing honey production and to provide the bees with a year-round source of nectar and pollen.

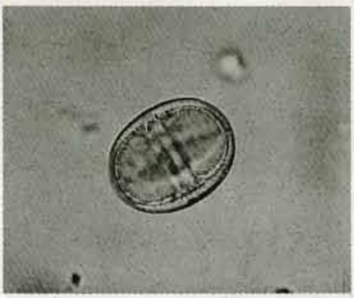
42a. Calliandra calothyrsus; Ref. ***plant no. 78***



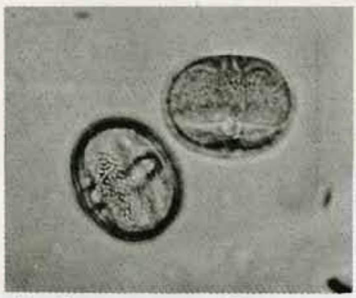
42b. Calliandra calothyrsus: OS; Ref. ***plant no. 78***

78. Red calliandra (*Calliandra calothyrsus* Meissn) is a shrub or small tree planted as an ornamental or hedge plant in the subtropical Himalayan region up to 1,500m. It is a multipurpose plant grown for its beauty and for shade. It forms good ground cover for soil erosion control. Its roots fix atmospheric nitrogen and its leaves are used as green manure and as fodder. The plant blossoms throughout the year. The flowers are red with long stamens (**Plate 42a**). It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. The honey yield with *Apis cerana* from this plant is moderate, one to three kg/colony/month (cf figures for Indonesia and Java in Perum 1980). The flavour of its honey is bitter-sweet. There is no information on other physical and chemical characteristics of calliandra honey. It is a good source of pollen also. Its pollen is creamy white in colour. The pollen grains are aggregated (polyad). Each polyad is large (203.6±6.9 μm long and 105.3±3.5 μm broad), each grain of the polyad is tri-colporate, and it has a smooth exine (**Plate 42b**). Calliandra is recommended for increasing honey production and beekeeping potential in an area. It can be propagated from seeds or large cuttings.

43a. Centaurea cyanus; Ref. ***plant no. 79***



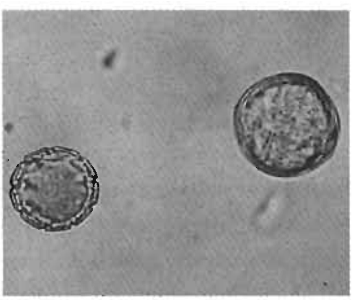
43b. Centaurea cyanus: OS; Ref. ***plant no. 79***



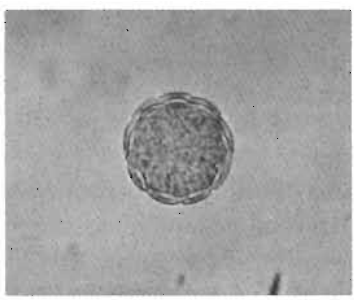
43c. Centaurea cyanus: SV; Ref. ***plant no. 79***

79. The cornflower (*Centauria cyanus* L.) is planted widely in gardens. It has beautiful blue, pink, purple or white flowers and grows in the subtropical and temperate Himalayas. It blossoms in the period from February to April and produces white, bluish-purple, or pink flowers (**Plate 43a**). The plant has both floral as well extrafloral nectaries on the floral buds which produce large quantities of nectar (Dustmann 1969). It is visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion from this plant is 0.43mg/flower/day (cf figures from Germany in Maurizio and Grafl 1982). The sugar concentration in the nectar is 30-40 per cent and the honey potential of this plant is 50-60 kg/ha (cf figures from Romania in Cirnu et al. 1976). Cornflower honey contains 37.4 per cent glucose; 44 per cent fructose; 6.3 per cent sucrose, 7.9 per cent maltose and 4.4 per cent fructomaltose. It is slightly acidic and the pH value is 4.3. It is greyish yellow in colour and has a flavour of almonds (Fedosov 1955). This plant is also a good source of pollen and yields 7.8 mg pollen/floral head (cf figures from Germany in Maurizio and Grafl 1982). The colour of the pollen loads is whitish or grey. The pollen grains are medium-sized (37.9±3.2 µm long and 30.5±2.2 µm broad), oval, and tri-colporate with a smooth exine (**Plates 43b,c**). It is recommended for increasing honey production as well as for improving beekeeping potential.

44a. Borago officinalis; Ref. ***plant no. 80***



44b. Borago officinalis: OS; Ref. ***plant no. 80***

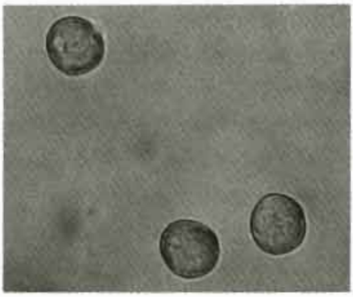


44c. Borago officinalis: SV; Ref. ***plant no. 80***

80. Borage (*Borago officinalis* L.) is a native of Europe where it occurs wild on dry wastelands. Borage is planted as an ornamental plant in the subtropical and temperate parts of India and Nepal. The plant blossoms in the period from February to September; the flowers are bright blue and pendant. These produce large quantities of nectar and pollen and are preferably visited by *Apis cerana* and *Apis mellifera* (**Plate 44a**). The plant secretes 5.0-8.1mg of nectar/flower/day (cf figures for Germany in Maurizio and Grafl 1982). Sugar concentration in the nectar varies between 19-52 per cent. The honey potential of this plant is 200-300 kg/ha (cf figures for Germany in Becker 1967; Maurizio and Grafl 1982). Its honey is whitish in colour with a yellow grey tint (Crane 1975). It contains 31.6 per cent glucose, 54.8 per cent fructose, 3.8 per cent sucrose, 7.5 per cent maltose, and 2.3 per cent fructomaltose. Its pollen grains are small (28.5±1.2 μm long and 27.5±1.3 μm broad), almost round, and penta-colporate with a granular exine sculpture (**Plates 44b,c**). The colour of its pollen is white. Since it blossoms for a long period from spring to autumn, it is highly recommended as a bee plant for increasing honey production as well as for supporting bee colonies during slack summer months.

45a. Echium vulgare; Ref. ***plant no. 81***

81. Blue thistle or blue weed (*Echium vulgare* L.) is an exotic herb introduced from its native home in Europe where it grows as a wild plant/ weed in dry open places, on roadsides, in fields, and in sandy areas. It is planted as an ornamental plant in the subtropical and temperate Himalayan zones below 2,000m. It blossoms for most of the year from January to June and provides both nectar and pollen to bees (**Plate 45a**). It is a major source of nectar visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion varies between 0.5-8.8 mg/flower/day (cf figures for Germany in Maurizio and Grafl 1982). The maximum secretion of nectar occurs at 1500h. Sugar concentration in the nectar

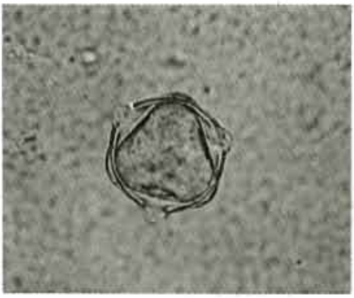


45b. *Echium vulgare*: OS;
Ref. **plant no. 81**

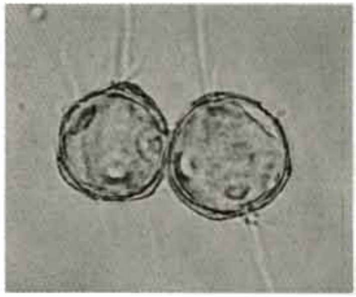
varies between 17-43 per cent. Its honey potential varies from moderate to very high; (cf 128.8kg/ha in Bulgaria [Petkov 1976; 1980], 400kg/ha in Germany [Becker 1967], and 180-400 in Romania [Cirnu et al. 1980]). Its honey is white to light golden in colour and possesses a delicate flavour (Crane 1975). It contains 16.4 per cent water, 31.3 per cent glucose, 37.3 per cent fructose, 1.3 per cent sucrose, 8.4 per cent maltose, 2.5 per cent higher sugars, and 0.045 per cent ash. Its pH value is 3.88. It is recommended for planting near apiaries to increase honey production and also to provide a year-round forage source. Its pollen is dark in colour. The pollen grains are very small (19.8$\pm$0 μm long, 17.4 μm broad), oval, and tri-colporate, with a smooth exine (**Plate 45b**).

46a. *Lagerstroemia indica*; Ref. **plant no. 82**

82. Pride of India (*Lagerstroemia indica* L.) is a small ornamental tree of great beauty planted in gardens in the subtropical and sub-temperate areas up to 1,600m. The plant is adapted to a wide variety of climatic conditions. It blossoms during June-July and produces pink, bluish purple or white flowers according to the variety (**Plate 46a**). It is a medium source of nectar and pollen and is visited by *Apis cerana* and



46b. Lagerstroemia indica: OS; Ref. **plant no. 82**

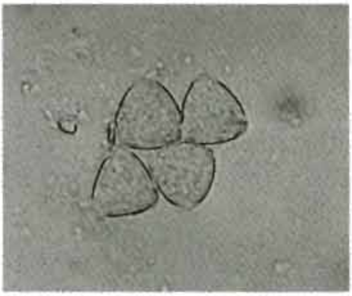


46c. Lagerstroemia indica: SV; Ref. **plant no. 82**

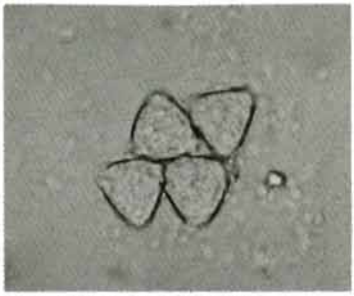
Apis mellifera. It helps to sustain bee colonies during the slack summer months. The bees do not collect surplus honey from its flow. Thus there is no information on the physico-chemical characteristics of its honey. Its pollen is yellow in colour. The pollen grains are medium in size (31.5 ± 0.7 µm long and 29.0 ± 2.6 µm broad), round, and tri-colporate with a granular exine sculpture (**Plates 46b,c**). It is recommended for increasing the honey plant resources of an area.

83. Lagerstroemia (*Lagerstroemia parviflora* Roxb.) is a large tree which occurs widely in the hill areas. It blossoms during April-May and produces pale violet flowers in panicles. It is a major source of nectar and pollen and visited by *Apis cerana* and *Apis mellifera*. Since it blooms during the honey flow season, the bees collect surplus honey, but there is no information on the physico-chemical characteristics of its honey. The structure of its pollen grain is similar to that of *L. indica*. The plant is recommended for planting near apiaries to increase honey production.

47a. Cuphea micrantha; Ref **plant no. 84**



47b. *Cuphea micrantha: OS;*
Ref. **plant no. 84**

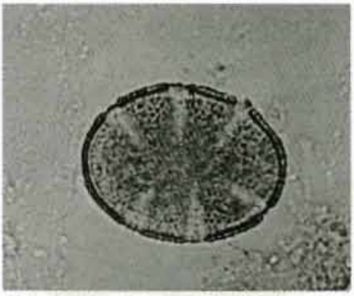


47c. *Cuphea micrantha: SV;*
Ref. **plant no. 84**

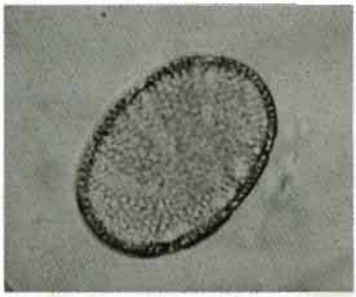
84. Cuphea (*Cuphea micrantha*) is a small shrub which is planted as an ornamental hedge in the gardens in subtropical and warm temperate areas. It blossoms for most of the year, i.e., from February to November, and produces small, 0.5mm, pinkish purple, solitary flowers in the leaf axils (**Plate 47a**). Wherever *Cuphea* is planted, its flowers are the favourites of honeybees (*Apis cerana* and *Apis mellifera*), and they generally ignore other plants in the vicinity. It mainly provides nectar which supports bee colonies for long periods of nine months. However, bees do not collect surplus honey from this plant. Therefore, information is lacking about the physico-chemical characteristics of cuphea honey. Its pollen is yellowish brown in colour; the pollen grains are very small (18.6 ± 1.2 µm in diameter), round/triangular in shape, and tri-colporate with a smooth exine (**Plates 47b,c**).

48a. *Salvia splendens; Ref.* **plant no. 85**

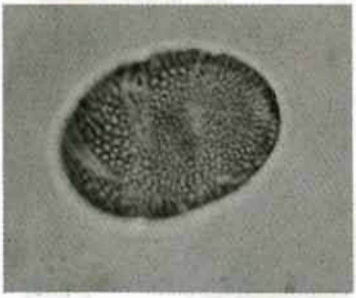
85. Salvia (*Salvia splendens*) is a common flower which is grown in the gardens throughout the subtropical to temperate Himalayan zones.



48b. *Salvia splendens*: OS (PV); Ref. **plant no. 85**



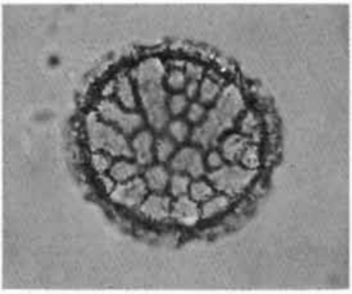
48c. *Salvia splendens*: OS (EV); Ref. **plant no. 85**

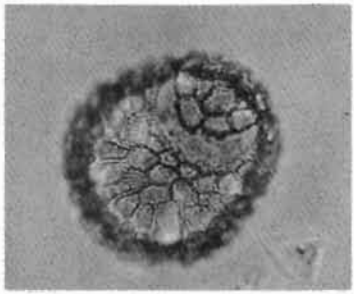


48d. *Salvia splendens*: SV; Ref. **plant no. 85**

It blossoms throughout the year and produces small, beautiful, scarlet red tubular flowers in axillary and terminal racemes. It is a major source of nectar and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 48a**). Information is not available on the physico-chemical characteristics of its honey. The pollen grains are large (55.6 ± 0.6 µm long and 46.1 ± 2.4 µm broad) and oval, with six furrows and a reticulate exine sculpture (**Plates 48b,c,d**). It is recommended for planting near apiaries to provide nectar and a year-round source of forage for honeybees.

49a. *Ocimum basilicum*; Ref. **plant no. 86**


49b. Ocimum basilicum: OS; Ref. **plant no. 86**


49b. Ocimum basilicum: SV; Ref. **plant no. 86**

86. Basil (*Ocimum basilicum* L.) is planted for its ornamental and medicinal value in the subtropical to warm temperate Himalayan zones of China, India, Myanmar, Nepal, and Pakistan at altitudes of up to 600m. It blossoms during August-September and produces whorled, purplish white flowers in thyrsoid racemes which are visited by *Apis cerana*, *Apis mellifera*, and *Apis dorsata*, mainly for the nectar (**Plate 49a**). Information is not available on the physico-chemical characteristics of its honey. The pollen grains are large (60.8 ± 2.2 µm long and 57.5 ± 1.9 µm broad), almost round, with six furrows and a reticulate exine sculpture (**Plates 49b,c).**


50. Elsholtzia sp; Ref. **plant no. 87**

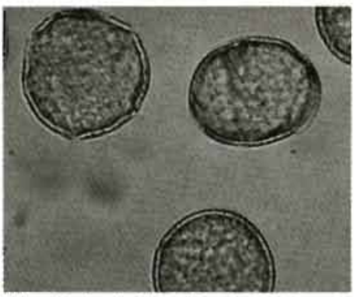
87. Elsholtzia (*Elshotzia sp*) is an aromatic herb, more than one metre tall with a purple stem and leaves. It is planted in gardens in subtropical and temperate regions. It blossoms during September-October and produces small pinkish flowers in slender, panicled spikes **(Plate 50).** It is a medium source of nectar and is visited by *Apis cerana* and *Apis mellifera*. In densely-cultivated areas, the bees collect some honey but information is not available on the physico-chemical characteristics of its honey and its pollen grain features.

51. *Hibiscus rosa-sinensis; Ref.* ***plant no. 88***

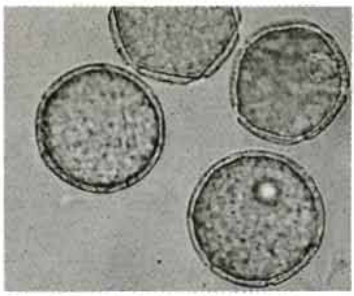
88. Chinese rose (*Hibiscus rosa-sinensis* L.) is a shrub that grows up to two metres tall which is planted widely throughout the tropical, subtropical, and temperate Himalayan zones at altitudes of up to 1,800m. It blossoms from March to May and produces bright red flowers which are visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 51**). In India and Pakistan, it is a medium source of nectar and pollen (PARC 1977). The sugar concentration in the nectar varies between 19-21 per cent. The only information on the physical characteristics indicates that its honey is watery, white in colour, and granulates at once (Crane et al. 1984). Information is not available on other physical and chemical characteristics. The pollen grains of this species are very large (143.0 ± 7.6 µm in diameter) and round, with eight pores and an echinate exine sculpture.

89. Californian poppy (*Eschscholzia californica*) is planted for its bright yellow flowers. It blossoms from March to June and is a good source of pollen for bees. Its flowers are preferably visited by *Apis cerana* and *Apis mellifera,* despite other plants flowering in the same area (**Plate 52a**), and they collect mainly pollen. The flowers produce only a little nectar which the bees generally do not collect, and therefore they do not produce honey from this plant. The colour of the pollen loads is yellow.

52a. Eschscholzia californica; Ref. **plant no. 89**



52b. Eschscholzia califomica: OS; Ref. **plant no. 89**



52c. Eschscholzia californica: SV; Ref. **plant no. 89**

The pollen grains are small (27.8±1.2 µm long and 25.1±1.3 µm broad) and oval, with three pores (tri-porate) and a smooth exine sculpture (**Plates 52b,c**).

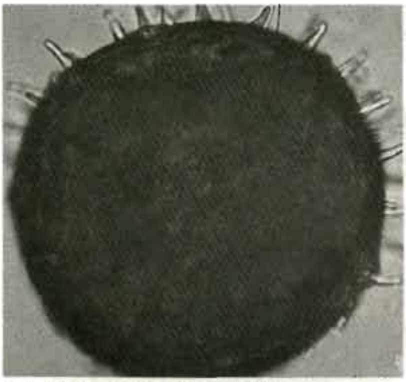
90. Pink balsam (*Impatiens balsamina* L.) is a native of southeast Asia which is planted widely in gardens in India, Nepal, and Pakistan at altitudes of up to 1,800m. It is an erect annual, 15-50cm tall with narrow lanceolate leaves and many solitary pink or white flowers with slender curved spurs. It blossoms during July-August and is a major source of nectar for *Apis cerana* and *Apis mellifera* honeybees in the Chinese Himalayas (**Plate 53a**). Honey yields with *Apis cerana* total 10-15kg/ colony/season in China (Bangyu et al. 1996). However, there is no information on the physico-chemical characteristics of pink balsam honey. The plant also is a major source of pollen in China and helps in brood rearing and increasing colony strength. Its pollen is white to grey in colour. The pollen grains are medium in size (37.1±1.9 µm long and 20.7±1.6

53a. *Impatiens balsamina*; Ref. **plant no. 90**

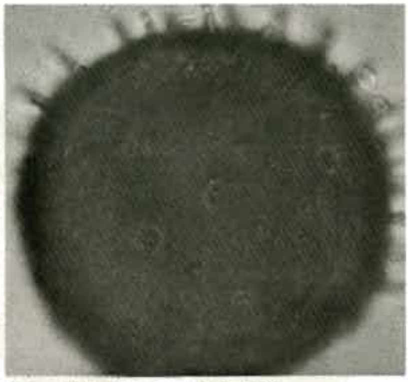
53b. *Impatiens balsamina*: OS; Ref. **plant no. 90**

µm broad) and elongated, with four furrows and a reticulate exine sculpture (**Plate 53b**).

54a. *Malvaviscus arboreus*; Ref. **plant no. 91**



54b. *Malvaviscus arboreus: OS; Ref.* **plant no. 91**



54c. *Malvaviscus arboreus: SV; Ref.* **plant no. 91**

91. Malvaviscus (*Malvaviscus arboreus*) is a small perennial shrub up to two metres tall which is cultivated in gardens or as a hedge plant. It also occurs wild along roadsides in the tropical and subtropical Himalayas at altitudes of up to 1,700m. The plant blossoms practically throughout the year and bears scarlet red flowers which are visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 54a**). It is a medium source of nectar and pollen, and generally surplus honey is not produced from this plant. Therefore, there is no information on the physico-chemical characteristics of malvaviscus honey. The pollen grains are yellowish in colour, very large (161 ± 10 µm in diameter), and round, with eight pores and an echinate exine sculpture with long pointed spines, as in other members of the *Malvaceae* family (**Plates 54b,c**).

92. Balsam (*Impatiens glandulifera* Royle) is a wild annual found in abundance in the mountain meadows in India, Nepal, and Pakistan at altitudes of from 1,800-4,000m. It grows gregariously in bushy places and on grazing lands. It is a hairless plant, about one to two metres tall, with opposite, whorled and lanceolate leaves and flat topped clusters of axillary flowers produced near the tips of the shoot. It blossoms from July to September. The flowers are three to four cm long, reddish pink or white in colour, and spotted and yellow within. It is a medium source of nectar and pollen and is visited by *Apis cerana* and *Apis mellifera*. The bees do not produce surplus honey from this plant and therefore, there is no infomation on physico-chemical characteristics of its honey. The structure of its pollen grain is similar to that of *Impatiens balsamina*.

93. The trumpet vine (*Campsis grandiflora*) is a perennial climber, planted in gardens for its beautiful orange red flowers. It is a minor bee plant that blossoms for a long period, i.e., from May to August when

55a. *Campsis grandiflora*; Ref. **plant no. 93**

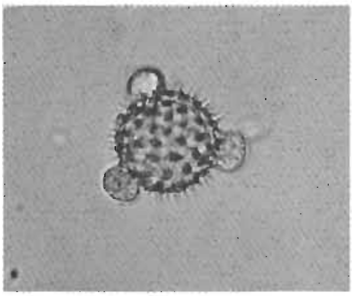
55b. *Campsis grandiflora*: OS; Ref. **plant no. 93**

55c. *Campsis grandiflora*: SV; Ref. **plant no. 93**

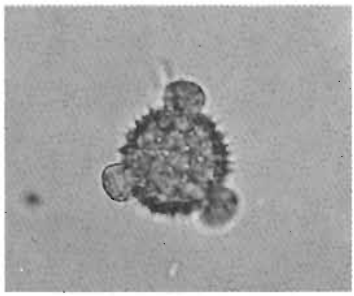
there is a dearth of bee flora, thus helping to sustain bee colonies during this period. *Apis cerana* and *Apis mellifera* visit its flowers, mainly for nectar, and they sometimes collect pollen also (**Plate 55a**). It is an important bee plant since it blossoms during the dry summer months and helps in the sustenance of bee colonies. The bees do not produce surplus honey from its flow. Its pollen is yellow in colour. The pollen grains are medium-sized (33.7 ± 1.4 µm in diameter) and round, with two furrows and a reticulate exine sculpture (**Plates 55b,c**).

94. The marigold (*Calendula officinalis* L.) is a well-known ornamental plant of the subtropical and temperate Himalayan zones. It blossoms from February to April, the flowers are bright yellow to orange and are visited by *Apis cerana* and *Apis mellifera* for pollen and nectar (**Plate 56a**). It is of minor importance as a bee plant. Since it is a minor bee plant, it does produce surplus honey. The pollen colour is yellow, the

56a. Calendula officinalis; Ref. **plant no. 94**



56b. Calendula officinalis: OS; Ref. **plant no. 94**

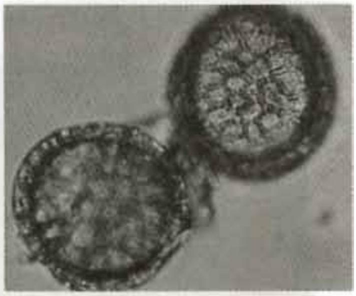


56c. Calendula officinalis: SV; Ref. **plant no. 94**

grains are medium-sized (35.2±2.3 µm long, 31.3±2.2 µm broad), slightly oval in shape, and tri-colporate with an echinate exine sculpture and broad-based spines (**Plates 56b,c**).

95. Gulmohr (*Delonix regia* Raf.) is a fairly large deciduous flowering tree that was introduced to the region from its native home, Madagascar, within the last few hundred years (McCann 1985). It is planted widely as an ornamental and avenue tree in the subtropical Himalayas (**Plate 57a**). It blossoms during May-June and is a medium source of nectar and pollen for honeybees (Thakur 1991). Since it blooms during the slack summer months, it helps to sustain bee colonies. Bees do not produce surplus honey from this plant. It is visited by both *Apis cerana* and *Apis mellifera*. *Delonix* pollen is orange red in colour. The pollen grains are large (63.2±4.1 µm long, 59.7±2.7 µm broad) and oval, with three pores (tri-porate) and a reticulate exine sculpture (**Plate 57b**).

57a. Delonix regia; Ref. **plant no. 95**



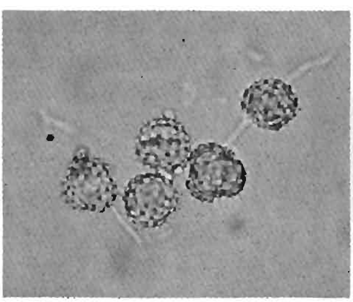
57b. Delonix regia: OS,SV; Ref..**plant no. 95**

58. Jacaranda mimosifolia; Ref. **plant no. 96**

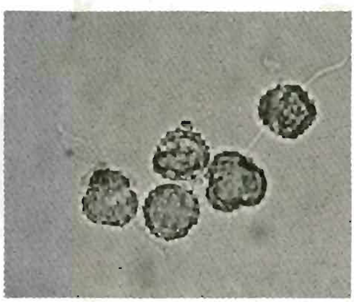
96. The jacaranda (*Jacaranda mimosifolia* D.Don; Syn. *J. ovalifolia* R.Br.) is a native tree of south America, it grows up to 12m in height and has a straggly crown. It is planted widely as an ornamental and avenue tree on roadsides in the outer foothills of the Himalayas at altitudes of up to 1,500m. It blossoms during May-June and bears clusters of large, scentless, lilac blue, drooping, and tubular flowers which open and fall on the same day. It is a minor source of nectar and pollen and helps to sustain bee colonies. Its flowers are visited by both *Apis cerana* and *Apis mellifera* (**Plate 58**). Bees do not produce surplus honey from its flow. Jacaranda pollen grains are off-white in colour, medium in size (48.8 ± 2.2 µm long, 43.2 ± 2.5 µm broad), oval, and tri-colporate with a reticulate exine sculpture.

97. Ageratum (*Ageratum conyzoides* L.) is planted in gardens. It has beautiful mauve/blue flowers, and it also grows abundantly as a wild

59a. Ageratum conyzoides; Ref. ***plant no. 97***



59b. Ageratum conyzoides: OS; Ref. ***plant no. 97***



59c. Ageratum conyzoides: SV; Ref. ***plant no. 97*** plant along water channels, in fields, and in moist shady places throughout the Himalayan region. It blossoms most of the year, generally from February to November, and provides nectar and pollen for a long period (**Plate 59a**). It is a minor source of nectar and pollen and helps to support bee colonies (Thakur 1991). Its flowers are visited by both *Apis cerana* and *Apis mellifera*. Bees do not produce surplus honey from its flow. Its pollen grains are small (18.3 ± 1.4 µm in diameter), round, and tri-colporate with an echinate exine sculpture and small, broad-based spines (**Plates 59b,c**).

98. The hollyhock (*Althea rosea* Cav.) is planted in gardens throughout the subtropical and warm temperate Himalayan areas. The plant has medicinal properties; the flowers are used for rheumatism and the roots for dysentery. It blossoms during spring and summer, i.e., from April to June. The flowers are large and pink and yield nectar and pollen to support bee colonies during the lean summer months. It is visited by both *Apis cerana* and *Apis mellifera*. Bees do not produce surplus honey from its flow. Its pollen grains are large (89.0 ± 4.5 µm in diameter), round, and multiporate (having more than eight pores) with an echinate exine sculpture and long, pointed spines.

60a. Amaranthus cruentus; Ref. ***plant no. 99***

99. The garden amaranth (*Amaranthus cruentus*) is a broad-leaved pinkish green herb, growing to heights of two metres. It is cultivated in gardens throughout the warmer areas of the Himalayas. It blossoms during August-September and produces small purple flowers in terminal spike-like racemes which are visited by *Apis cerana* and *Apis mellifera* for their pollen (**Plate 60a**). It is a minor source of pollen but does produce

60b. *Amaranthus cruentus*: OS; Ref. **plant no. 99**

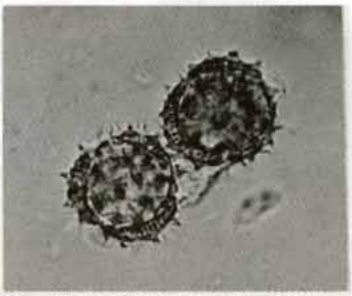
a little nectar. Amaranth pollen is creamy white in colour. The pollen grains are small (27.5 ± 1.8 µm in diameter) and round, with many pores and a granular exine sculpture (**Plate 60b**).

61. *Callistephus chinensis*; Ref. **plant no. 100**

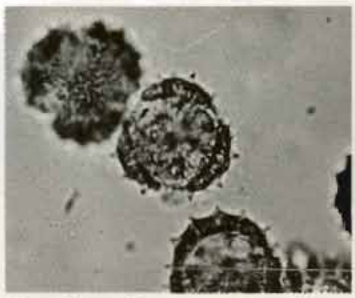
100. The Chinese aster (*Callistephus chinensis* (L.) Nees.) is planted in gardens throughout the sub-temperate to temperate Himalayan areas up to 3,900m. The Chinese aster blossoms during April-May and produces beautiful pink, purple, or maroon flowers like those of *Aster* spp. Its flowers are visited by both *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 61**). It is a minor source of nectar and pollen and helps support bee colonies during the slack summer months. Bees do not produce surplus honey from its flow. Information on the pollen grain features of this plant is not available.

101. The chrysanthemum (*Chrysanthemum segetum*) is planted widely in gardens in the subtropical and temperate Himalayas. Its leaves have insecticidal properties. It blossoms during August-September and

62a. Chrysanthemum segetum; Ref. ***plant no. 101***



62b. Chrysanthemum segetum: OS; Ref. ***plant no. 101***

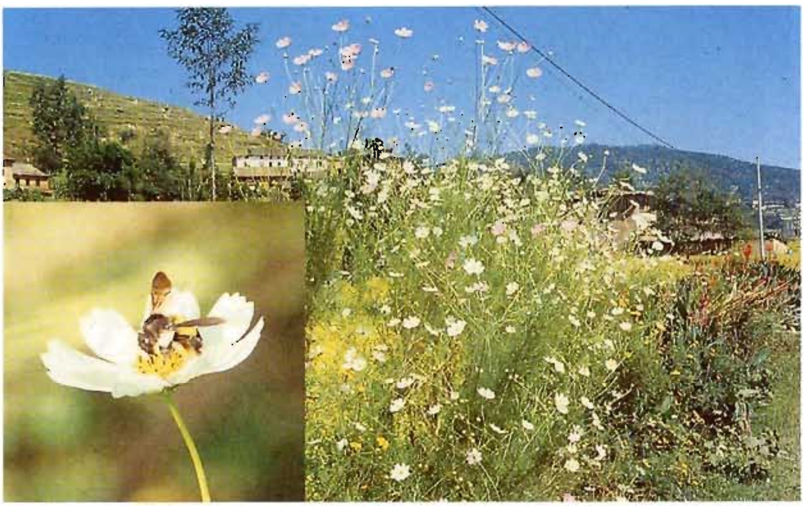


62c. Chrysanthemum segetum: SV; Ref. ***plant no. 101***

produces large white, yellow or maroon-red flowers which are eagerly visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 62a**). It is a minor source of both nectar and pollen. It helps to support bee colonies but does not yield surplus honey. The pollen grains are medium-sized (36.5 ± 3.8 μm in diameter), round, and tri-colporate with an echinate exine sculpture and small broad-based spines (**Plates 62b,c**).

102. Cineraria (*Cineraria hybrida*) is planted widely in gardens because of its attractive flowers. It blossoms during February-March and produces flowers of different colours, e.g., white, pink, red, or purple. Its flowers are frequently visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 63**). It is a minor source of both of these. It also helps to support bee colonies but does not yield surplus honey to bees. Its pollen grains are medium in size, round/triangular, tri-colporate with echinate exine sculpture and small broad-based spines.

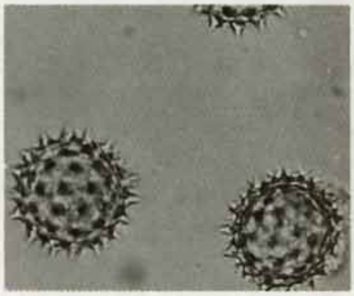
63. *Cineraria hybrida*; Ref. **plant no. 102**



64. *Cosmos sulphureus*; Ref. **plant no. 103**

103. Cosmos (*Cosmos sulphureus* Cav.) is a flowering plant growing to heights of up to two metres or more. It is planted in gardens, because of its beautiful white or mauve pink flowers. It blossoms during October. Its flowers are visited eagerly by both *Apis cerana* and *Apis mellifera* (**Plate 64**). It is good source of pollen and nectar and also contributes to the autumn flow. Bees do not produce unifloral honey from this plant. Therefore, information on the physico-chemical characteristics of cosmos honey is not available. It is of medium importance for beekeeping. Its pollen grains are small (26.1 ± 2.4 µm long and 25.1 ± 0.6 µm broad), round, and tri-colporate with an echinate exine sculpture.

65a. Dahlia pinnata; Ref. **plant no. 104**



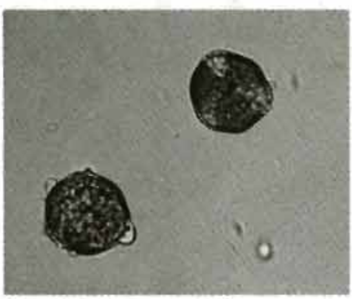
65b. Dahlia pinnata: OS; Ref. **plant no. 104**

66. Dahlia spp; Ref. **plant no. 104**

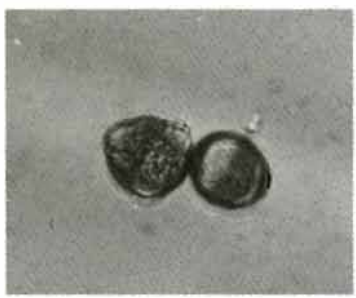
104. Dahlias (*Dahlia* spp) are grown for their beautiful flowers. They blossom for a long period, i.e., from July to January, and produce eight-

10cm yellow, pink or maroon flowers which are eagerly visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plates 65a,66**). *Dahlia* spp constitute the main auxiliary source of nectar and pollen and help support bee colonies for a long period, especially during the slack winter months. Bees do not produce surplus honey from this plant. Dahlia pollen is yellow in colour. The pollen grains are medium in size (37.5 ± 1.4 µm long and 34.7 ± 0.3 µm broad), oval, and tri-colporate with an echinate exine sculpture (**Plate 65b**).

67a. Delphinium roylei; Ref. ***plant no. 105***



67b. Delphinium roylei: OS; Ref. ***plant no. 105***



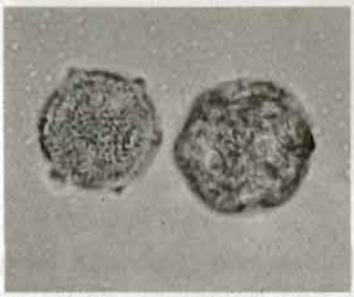
67c. Delphinium roylei: SV; Ref. ***plant no. 105***

105. Larkspur (*Delphinium Roylei* Munz.) is planted in gardens in the low hill and middle hill Himalayan areas. It blossoms from March to May and produces light pink or bluish purple flowers. It is a minor source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 67a**). It helps to support bee colonies but does not yield surplus honey. Its pollen grains are medium in size (29.7 ± 0.4 µm long and

27.8±0.5 μm broad), almost round, and tri-colporate, with a smooth exine sculpture (**Plates 67b,c**).

68a. Dianthus caryophyllus; Ref. ***plant no. 106***

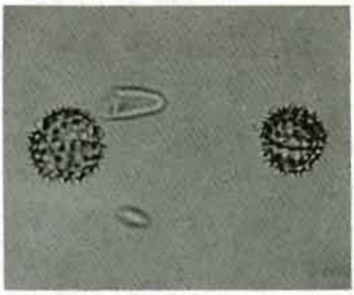
68b. Dianthus caryophyllus: OS; Ref. ***plant no. 106***



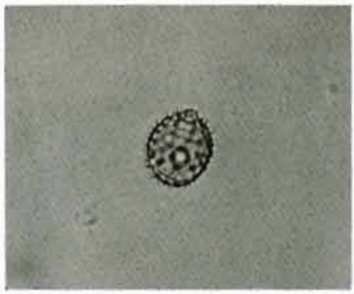
68c. Dianthus caryophyllus: SV; Ref. ***plant no. 106***

106. Carnations (*Dianthus caryophyllus*) are well-known for their mosaic of flower colours. These are planted in the subtropical and temperate Himalayan areas. They blossom from April to June and produce pink, maroon, or purple-coloured fragrant flowers which are frequently visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 68a**). The carnation constitutes a minor source of both nectar and pollen and helps to sustain bee colonies during the hot and dry summer months. It does not yield surplus honey. The pollen grains of the carnation are medium-sized (34.9±0.7 μm long and 32.8±1.9 μm broad), oval/triangular, and tri-colporate with a granular/or a reticulate exine sculpture (**Plates 68b,c**).

69a. Solidago longifolia; Ref. **plant no. 107**



69b. Solidago longifolia: OS; Ref. **plant no. 107**



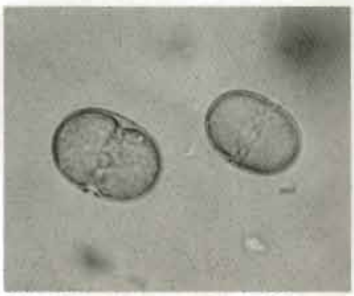
69c. Solidago longofolia: SV; Ref. **plant no. 107**

107. Golden rod (*Solidago longifolia* Schard) is an erect, usually unbranched perennial, about one metre tall. It blossoms during September-October and produces small, golden yellow flowers in 1.5cm-long, cylindrical, short-stalked flowering heads in crowded spike-like terminal clusters. The flowers are visited by both *Apis cerana* and *Apis mellifera* for nectar and pollen. It is the main auxiliary (medium) source of nectar and pollen (**Plate 69a**). Bees do not produce pure honey from this plant, but it contributes to the main autumn flow. Therefore, there is no information on the physico-chemical characteristics of its honey. Its pollen is yellow in colour. The pollen grains are small (21.6 ± 1.1 µm in diameter), round, and tri-colporate with an echinate exine sculpture and small broad-based spines (**Plates 69b,c**).

108. Symphytum (*Symphytum peregrinum* Ledeb.) is cultivated in the subtropical and temperate Himalayas. Its leaves are used as a vegetable and its roots as a medicine. It blossoms from June to September and

70a. Symphytum peregrinum; Ref. **plant no. 108**

70b. Symphytum peregrinum: OS; Ref. **plant no. 108**

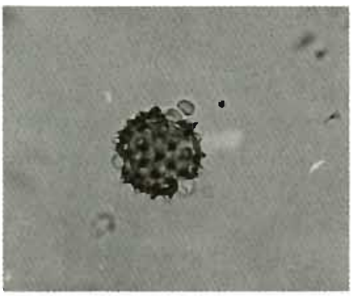


70c. Symphytum peregrinum: SV; Ref. **plant no. 108**

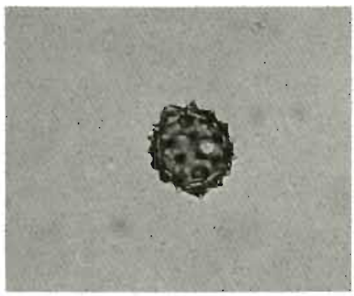
produces pinkish purple flowers which are produced on pendulous racemes at the apex (**Plate 70a**). The flowers are visited by *Apis cerana* and *Apis mellifera* for both pollen and nectar. It is reported to be a main auxiliary (medium) source of both pollen and nectar in China (Xu 1993). The bees do not produce surplus honey from this plant. Its pollen grains are small (27.3 ± 3.2 µm long and 22.8 ± 3.4 µm broad), oval, and penta-colporate with a smooth exine (**Plates 70b,c**).

109. The paper flower (*Helichrysum arenarium*) is famous for its dry flowers and is now being planted in hilly areas of the Hindu Kush-Himalayan region as a cash crop. Its flower heads, especially the ray florets and the bracts, are papery and everlasting. Farmers in the middle hills of Nepal are cultivating this plant on a large scale for export. It blossoms from February to June. Flowers are of various colours and are visited eagerly by both *Apis cerana* and *Apis mellifera* for nectar (**Plate 71a**). It is a minor source of nectar and does not yield surplus honey. Its

71a. Helichrysum arenarium; Ref. ***plant no. 109***



71b. Helichrysum arenarium: OS (PV); Ref. ***plant no. 109***



71c. Helichrysum arenarium: SV (EV); Ref. ***plant no. 109***

pollen is yellow in colour and the pollen grains are small (26.04 ± 1.2 µm in diameter), round, and tri-colporate, with an echinate exine sculpture and broad-based spines (**Plates 71b,c**).

110. The zinnia (*Zinnia elegans*) is planted in gardens for its attractive flowers in the subtropical and temperate Himalayas. These blossom from June to September and produce pink, maroon or purple flowers on the apex of main stems and branches. The flowers are visited by honeybees for pollen and nectar (**Plate 72**). Zinnias constitute a minor source of pollen and nectar and support bee colonies during slack periods. Bees do not produce surplus honey from this plant. The pollen grains of zinnia are small, oval/triangular, and tri-colporate with an echinate exine sculpture.

In addition to the plants described above, others, such as *Antirrhinum majus, Billis perenis, Gladeolus* spp., *Papaver* spp, *Poinsettia*

72. *Zinnia elegans*; Ref. **plant no. 110**

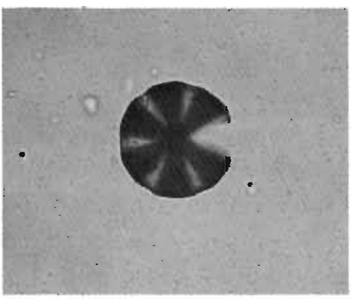
pulcherrima, Primula spp, and many other ornamental plants, provide both nectar and pollen during different months of the year and are visited eagerly by honeybees. All these plants are minor sources of nectar and pollen and help to sustain bee colonies in the absence of other major sources.

Wild Plants and Forest Trees

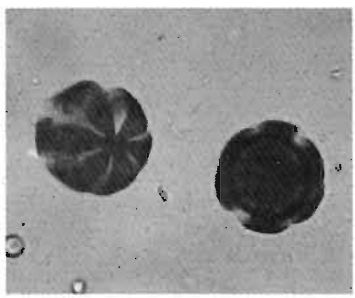
There are many forest trees and wild plant species that are visited by honeybees. Though the forest trees blossom for comparatively shorter durations than many agricultural and horticultural crops and different weeds, still several tree species are major sources of nectar and pollen for honeybees and contribute to the main honey flows. In fact, in the subtropical and warm temperate regions of the Himalayas, many forest tree species form the chief sources of nectar. These are of specific value to wild honeybee species, such as *Apis dorsata* and *Apis laboriosa*, and honey hunters harvest large quantities of honey from these wild bee species by traditional honey-hunting methods.

Hive-kept species of honeybee, such as *Apis cerana* and *Apis mellifera*, can only use the honeyflow from these forest trees during migratory beekeeping. Since these domesticated bees are kept in man-made hives in man-made areas, they generally visit the flowers of different agricultural and horticultural crops, ornamental plants, weeds, and some forest tree species cultivated near villages, for example, *Bauhinia spp, Cedrela toona, Eucalyptus* spp, and *Grewia optiva*. However, during migratory beekeeping these forest trees are of great value to hive-kept of honeybees also. During migration, the bees fully utilise the nectar and pollen from these plants and the beekeepers harvest a good crop of honey. A brief account of some important forest trees and wild plants is given below.

73a. Plectranthus rugosus; Ref. ***plant no. 111***



73b. Plectranthus rugosus: OS; Ref. ***plant no. 111***



73c. Plectranthus rugosus: SV; Ref. ***plant no. 111***

111. Shain (*Plectranthus rugosus* Wallich ex Benth.) or Syn. *Rabdosia rugosa* (Wall. ex Benth.) Hara) is a wild shrub, about one to two metres tall, distributed throughout the temperate Himalayan region on hilly slopes, even with sharp gradients. It is also cultivated as an ornamental plant for landscaping and as ground cover for soil erosion control on hill slopes. It blossoms from the middle of August to the middle of October and produces small white flowers which are most prolific in nectar and pollen production (**Plate 73a**). Its flowers are visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion is highest with good rains before flowering and maximum rainfall during flow, together with cold nights and clear warm days. In India and Pakistan, honey yields from this plant are 50kg/colony/season with *Apis mellifera* (Shah 1979; Singh and Singh 1971). Most of the honey in the mountain areas of the North Western Frontier Province (NWFP) (Pakistan), Kashmir, and Himachal Pradesh (India) comes from this plant (Shahid and Qayyum 1977; Verma 1990). Its honey contains 17.5-19.0 per cent water, 38.4 per cent glucose, 40.0 per cent fructose, 3.3 per cent sucrose, and 0.3 per cent ash. Its colour is greenish (Shah, 1979), the flavour mild, and granulation fine. The pollen grains are medium-sized (31.5 ± 1.7 µm long and 28.8 ± 2.2 µm broad) and oval, with six furrows and a reticulate exine sculpture (**Plates 73b,c**). It is recommended for increasing honey production and beekeeping potential.

74. Plectranthus coesta; Ref. ***plant no. 112***

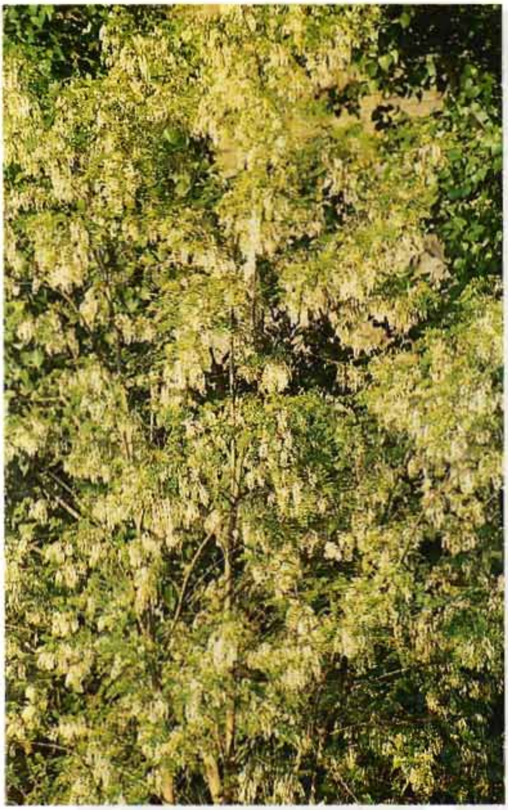
112. Shain (*Plectranthus coesta* Buch.-Ham. ex D. Don.) or Syn. *Rabdosia coesta* (Buch.-Ham. ex D. Don.) - A strong-smelling shrub growing up to two metres in height, distributed in the Himalayas (India, Pakistan, and southwestern China) from 1,000-3,300m. It occurs on hillsides in the temperate Himalayas, in the lower ranges of the Himalayas, and is a very common under-shrub in mixed and oak forests. It blossoms from August to November and produces attractive lavender blue flowers with a down-curving corolla tube which is much longer than the bristly-haired calyx (**Plate 74**). It produces large amounts of nectar and is a major honey plant in northwestern India and the NWFP of Pakistan (Singh 1962; PARC 1977; Shahid and Qayyum 1977; Verma 1990). It is visited by both *Apis cerana* and *Apis mellifera*. The bulk of the honey in the mountain areas of the North West Frontier Province (Pakistan) and

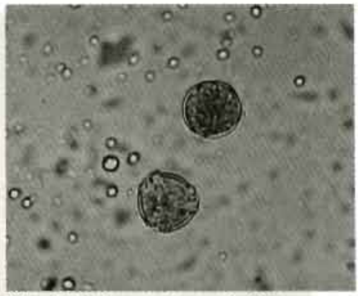
Himachal Pradesh (India) comes from *Plectranthus* spp. For higher nectar production, heavy rains before flowering and occasional rains during flow are essential (Singh 1962). Honey yield from this plant is high, about 7-9kg/colony/season. Information is not available on the physico-chemical characteristics of its honey. Pollen grains are medium-sized and oval, with six furrows and a reticulate exine sculpture. It is recommended for increasing honey production and beekeeping carrying capacity, especially on stony hillsides.

113. *Shain* (*Plectranthus gerardianus* Wall. ex Benth.) is a small shrub about one to two metres tall, occurring in the lower ranges of the Himalayas in India and Pakistan. It blossoms during August-September and produces white flowers spotted with purple which are visited by both *Apis cerana* and *Apis mellifera*. It produces a large amount of nectar and is a major honey source in northwestern India and northeastern Pakistan (PARC 1977). However, information on the physico-chemical characteristics of its honey and the pollen grain features is not available.

114. Shain (*Plectranthus striatus* Wall. ex Benth.) is a shrub or under-shrub, about one to two metres tall, distributed throughout the subtropical Himalayan regions of India and Pakistan. It blossoms from October to December and produces white flowers which are visited by both *Apis cerana* and *Apis mellifera*. It yields large amounts of nectar and is a major honey plant in northwestern India and northeastern Pakistan (PARC 1977). However, information on the physico-chemical characteristics of honey and the pollen grain features of this plant is not available.

115. False acacia or black locust (*Robinia pseudoacacia* L.) is a large tree, native to north America. It is distributed throughout the temperate Himalayan region from 1,600-2,200m. It is also planted as an avenue tree on roadsides and as a hedge plant. The tree provides shade, acts as a windbreak, and is used for afforestation; it also checks soil erosion and improves soil fertility by fixing atmospheric nitrogen. Its leaves are used as fodder for cattle. It blossoms for a very short period during April, and produces fragrant white flowers in pendulous racemes (**Plate 75a**). Though it blossoms only for a short period, this plant is highly prolific in production of nectar. It is a major bee plant in India, China, and Pakistan and is visited by *Apis cerana* and *Apis mellifera*. In the Chinese Himalayas, the plant secretes 12.6-13.0mg of nectar/flower/day (Bangyu et al. 1996). Nectar secretion varies with climatic and soil conditions. Sugar concentration in the nectar varies between 33.0-62.3 per cent. In the Chinese Himalayas, honey yield from nectar flow





75b. Robinia pseudoacacia: OS: Ref. **plant no. 115**

75a. Robinia pseudoacacia; Ref. **plant no. 115**

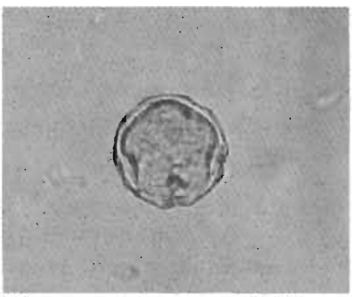
is over 20-50kg/colony/season with *Apis mellifera* and 15-30kg/colony/season with *Apis cerana*.

The plant also produces honeydew. The insect producing honeydew is *Aphis medicaginis* Koch, of the Aphidae family, and *Parthenolecanium corni* (Bouche) of the Coccidae family. Its honey contains 15.2-20.4 per cent water, 29.02 per cent glucose, 41.45 per cent fructose, 1.015 per cent sucrose, and 0.04-0.215 per cent ash. It has a pH value of 3.68. *Robinia* honey is pale yellow in colour and has a sweet flavour. Granulation is slow and may take many years.

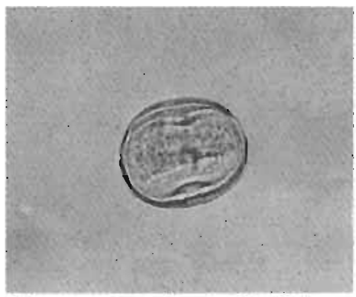
Its pollen grains are very small (18.9$\pm$0.6 µm long and 17.9$\pm$0.7 µm broad), round or slightly oval, and tri-colporate with a granular exine sculpture (**Plate 75b**). It is recommended for increasing honey production and beekeeping potential.

116. The Indian butter tree (*Aesandra butyracea (Roxb.) Baehni* or **Syn. *Bassia butyracea)*** is a tree about 20m tall, with dark grey or

76a. Aesandra butyracea; Ref. ***plant no. 116***



76b. Aesandra butyracea: OS (PV); Ref. ***plant no. 116***



76c. Aesandra butyracea: SV (EV); Ref. ***plant no. 116***

brownish bark; it is distributed throughout the subtropical forests of the Himalayan region from Kumaon to Bhutan and throughout central and western Nepal. The Indian butter tree is a multipurpose plant. Its fruits are eaten and a sugar-like sweet substance, locally called *gur*, is extracted from the flowers. The seeds yield fat which is used as a substitute for butter. The leaves provide fodder for cattle. The plant also yields timber and fuelwood. Realising its importance, the people in western Nepal have started conserving and planting this species near the villages. It blossoms from September to February and produces long stalked, white flowers crowded below the sub-terminal leaves. Flowers are 1.2-2.5cm in diameter and secrete large quantities of nectar (**Plate 76a**). It is a major source of nectar, and beekeepers in western Nepal harvest large quantities of honey from its flow. Information is available only on the physical characteristics of Indian butter tree honey (*chiuri*). This indicates that its honey is light in colour when liquid and becomes creamy white after granulation. It has a pleasant flavour. The granulation of the honey is smooth. Its flowers are visited by both *Apis cerana* and *Apis mellifera*. The plant is a good source of pollen also. Its pollen is creamy white in colour. The pollen grains are medium-sized (36.6$\pm$0.9 µm in diameter), round, and tetra-colporate with a granular exine sculpture (**Plates 76b,c**). The tree is recommended for beekeeping-oriented multipurpose plantations.

77. Eucalyptus camaldulensis; Ref. ***plant no. 117***

117. Eucalyptus or River red gum (*Eucalyptus camaldulensis* Dehnh.) is a large-sized tree, over 40m tall. It is native to Australia and has been introduced into the countries of the Himalayan region, e.g., Afghanistan, China, India, Myanmar, and Pakistan. It is planted in subtropical and sub-temperate zones of the Himalayas at altitudes of up to 1,500m for shade and amenity, fuelwood, charcoal, and termite-resistant timber. The plant has medicinal uses and yields paper pulp, rayon, and tannin from the bark. It blossoms from May to June and is a prolific nectar and pollen producer (**Plate 77**). It is a major source of nectar and pollen and is one of the highest nectar-yielding plants. It is visited by both *Apis cerana* and *Apis mellifera*. Sugar concentration in the nectar varies from 61-81 per cent. The honey yield with *Apis mellifera* is 60kg/colony/season in Australia. It is recommended for increasing honey production and beekeeping potential. Its honey contains 32.7 per cent glucose, 38.2 per cent fructose, 1.8 per cent sucrose, and 0.12 per cent ash. It is clear golden in colour, has a mild flavour, and granulates rapidly. The pollen grains are small (20.1$\pm$1.0 µm long and 18.4$\pm$0.7 µm broad) and oval or triangular, with three pores and a smooth exine.

118. The lemon-scented gum tree (*Eucalyptus citriodora* Hook.) is a large tree, about 25-40m tall. It has been introduced into the countries of the Himalayan region, e.g., Afghanistan, China, India, Myanmar, and Pakistan, from its native home, Australia. It is planted in subtropical and sub-temperate regions of the Himalayas at altitudes of up to 1,500m for shade and amenity, fuelwood, charcoal, and timber. It yields a non-edible oil from its leaves which is used in perfumes. It blossoms during June-July and produces cream-coloured flowers which are visited eagerly by honeybees, mainly for nectar and pollen. It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in its nectar varies from between 38-45 per cent. In the Chinese Himalayas, honey yield with *Apis cerana* is 5-10kg/colony/year (Bangyu et al. 1996). The only information on the characteristics of its honey is that it is light amber and granulates very rapidly. Information on its pollen grain features is not available. This plant is recommended for increasing the beekeeping carrying capacity of an area.

119. The blue green eucalytptus tree (*Eucalyptus grandis* W. Hill ex Maiden) is planted widely in subtropical and sub-temperate Himalayan areas. A large tree, 40-60m tall, it provides shade and amenity, fuelwood, timber, and wood pulp for paper and rayon. Its bark yields tannin. It blossoms from June to August and produces creamy white flowers. It is also a prolific nectar producer but a medium source of pollen. It is visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion is highest in the cool weather and is improved by good rains. The sugar concentration in its nectar varies from between 35-40 per cent. Information on the characteristics of its honey from this species indicates that it has a low water content. It is pale to medium amber in colour and has a strong flavour. Granulation is medium with soft, smooth grains. Information is not available on the pollen grain features of this plant. It is recommended for increasing honey production and beekeeping potential.

120. The yellow box tree (*Eucalyptus melliodora* A. Cunn. ex Schauer) is planted as an ornamental tree in the subtropical and sub-temperate Himalayan zones of Afghanistan, China, India, Myanmar, and Pakistan. It also provides fuelwood and timber. It blossoms from October to December and produces white or, rarely, pink flowers. It is a major source of nectar and is visited by both *Apis cerana* and *Apis mellifera*. The nectar flow is copious and is maintained in dry weather, but heaviest in warm moist weather. The honey yield with *Apis mellifera* is 25-75kg/colony/season. Its honey contains 14 per cent water, 30.4 per cent glucose, 42.9 per cent fructose, 5.1 per cent sucrose, and 0.06 per cent ash. It has a pH value of 4.1. It is pale in colour with a sweet flavour and has slow granulation. Information on its pollen grain features is not available. It is recommended for increasing the beekeeping potential of an area and honey production.

78a. Eucalyptus robusta; Ref. **plant no. 121**

78b. Eucalyptus robusta: OS; Ref. **plant no.121**

78c. Eucalyptus robusta: SV; Ref. **plant no. 121**

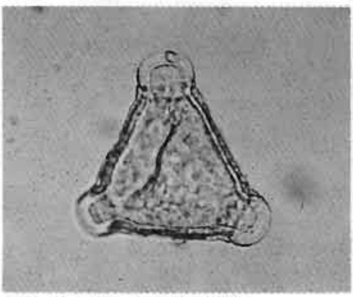
121. The swamp mahogany (*Eucalyptus robusta* Smith) is a large tree, over 27m tall; it is planted in the subtropical and sub-temperate areas of the Himalayas at altitudes of up to 1,500m for fuelwood, timber, and wood pulp. It blossoms during June-July and produces white flowers which produce large quantities of nectar. It is visited eagerly by *Apis cerana* and *Apis mellifera* (**Plate 78a**). The nectar flow is reliable. Its nectar has a 51 per cent sugar content. In the Chinese Himalayas, honey yield with *Apis cerana* is 10-30kg/colony/season (Bangyu et al. 1996). Honey from this species contains 17.0-17.5 per cent water and 0.21 per cent ash and its pH value is 4.2. It is amber in colour. Its pollen is white. The pollen grains are very small (19.6 ± 1.04 µm in diameter), round/or triangular in shape, and tri-colporate with a smooth exine (**Plates 78b,c**).

122. The eucalyptus (*Eucalyptus excerta* Muell.) is a large tree with dark, coarse, and vertically cracked bark. It is distributed throughout the Hengduan mountain range where the climate is warm and humid and the soil fertile, with soil pH values ranging from between 5.0-7.5. It blossoms from May to July and produces lateral or axillary clusters of white flowers. The flowers produce large amounts of nectar and pollen and are visited by *Apis cerana* and *Apis mellifera*. Nectar secretion starts at higher temperatures of from 25°C to 30°C (Bangyu et al. 1996). A colony of *Apis mellifera* produces eight-12kg and a colony of *Apis cerana* five-10kg of honey from its flow. Information is not available on the physico-chemical characteristics of its honey and the pollen grain features. The plant begins blossoming when it is three years' old and becomes a major source of nectar and pollen for honeybees. Therefore, it is recommended for increasing beekeeping potential and honey production.

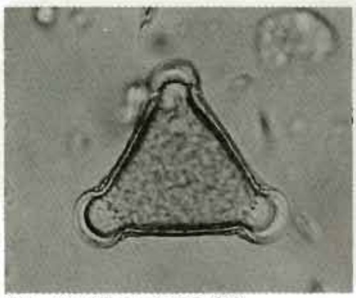
123. The eucalyptus (*Eucalyptus globulus* Labll.) is a large evergreen tree with peeling bark. It is distributed throughout the south of the Hengduan mountain range where the climate is warm and humid and the soil fertile, with soil pH values ranging from between 5.0-7.5. It blossoms during October and produces large quantities of nectar. It is visited by both *Apis cerana* and *Apis mellifera*. Its nectar is thin. Honey yield with *Apis cerana* is 10-20kg/colony/season in the Chinese Himalayas (Bangyu et al. 1996). There is no information on the physico-chemical characteristics of its honey or on the pollen grain features.

124. The silky oak (*Grevillea robusta* A. Cunn. ex. R. Br.) is a large tree with a robust trunk, more than 25m tall. A native of eastern Australia, it occurs in the tropical and subtropical Himalayan regions, ascending up to 1,500m. It is planted as an ornamental and avenue tree. The tree also provides timber, is a windbreak, and provides shade and amenity. Silky oak blossoms during April-May and produces orange to golden brown flowers in racemes which produce large quantities of nectar and pollen. It is a major bee plant visited by both *Apis cerana* and *Apis mellifera* (**Plate 79a**). Each flower secretes abundant nectar for about three days. Its nectar has a 78 per cent sugar content (Wakhle et al. 1981). Its honey is reddish black in colour and possesses a pronounced flavour. It granulates rapidly. Its pollen is yellowish brown in colour. The pollen grains are large (56.8±4.8 μm long and 43.7±4.4 μm broad),

79a. *Grevillea robusta*; Ref. **plant no. 124**



79b. *Grevillea robusta*: OS; Ref. **plant no. 124**

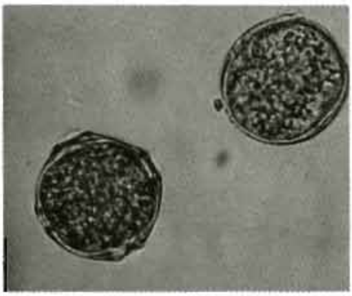


79c. *Grevillea robusta*: SV; Ref. **plant no. 124**

tri-lobed, and tri-colporate with a granular exine sculpture (**Plates 79b,c**). It is recommended for beekeeping-oriented multipurpose plantations and also for increasing honey production.

125. The margosa (*Azedirachta indica* A. Juss.) is a moderately to large-sized tree, over 11m tall, with a fairly dense crown. It is usually evergreen, except in extreme drought. It occurs in a wild state and is also planted as a roadside avenue tree in many parts of the Indian subcontinent and Myanmar in the plains and low hill areas at altitudes of up to 1,000m. It yields fuelwood and timber; the leaves are used as fodder; the seeds yield margosa oil which is used for lamps, as lubricants, and also in soaps, as well as for generating gas (NAS 1980). The whole plant has many medicinal properties; the bark is regarded as a bitter tonic; an astringent; is used for fever, thirst, nausea, vomiting, and skin diseases; the gum exuding from the stem is highly esteemed as a stimulant; the fruits are useful in the treatment of intestinal worms and

80a. Azadiratcha indica; Ref. ***plant no. 125***



80b. Azadiratcha indica: OS; Ref. ***plant no. 125***

as a purgative; and the dried flowers are used as a tonic after fever, under the name of *punchamrita:* a medicine prepared from flowers, fruits, leaves, bark, and roots. Neem leaves and seeds also have insecticidal properties. A fibre is extracted from the bark. The flowers are small, white, sweet-scented, and smell of honey. They appear in April-May (**Plate 80a**). It is a major source of nectar and a minor source of pollen and is visited by both *Apis cerana* and *Apis mellifera*. Its honey contains 22.8 per cent water, 7.4 per cent sucrose, and 0.06 per cent ash. The honey is thin, light green in colour, and has a slightly bitter flavour; it is of medicinal value. The pollen is yellow in colour and the pollen grains are medium in size (36.6 ± 0.8 µm in diameter), round, and tetra-colporate with an indefinite exine sculpture (**Plate 80b**). This plant is recommended for beekeeping-oriented, multipurpose plantations.

126. Sissoo (*Dalbergia sissoo* Roxb.) is a large, deciduous tree which grows up to 21m tall, and is found in the tropical and subtropical Himalayan zones at altitudes of up to 1,300m. It is native to the foothills of the Himalayas. A source of commercial timber, its leaves are used as

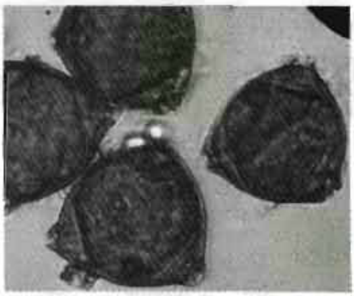
81a. *Dalbergia sissoo*; Ref. **plant no. 126**

81b. *Dalbergia sissoo*: OS; Ref. **plant no. 126**

fodder, it yields fuelwood, and it helps to control soil erosion and fix nitrogen. It is also planted as a windbreak, for shade, and for afforestation. The tree blossoms during the major honeyflow season, i.e., in March-April, and produces small greenish yellow flowers which secrete nectar for about two weeks (**Plate 81a**). The plant is a major source of both pollen and nectar in Pakistan and India. It is visited by both *Apis cerana* and *Apis mellifera*. The honey yield from its flow is four to five kg/colony/season with *Apis cerana* (Singh 1962). Its honey contains 18.75 per cent moisture, 34.6 per cent glucose, 39.1 per cent fructose, 1.04 per cent sucrose, and 0.18 per cent ash. Its honey is amber to dark amber in colour and has a strong flavour. It is recommended for beekeeping-oriented multipurpose plantations and also for increasing honey production. The pollen is yellow in colour and the pollen grains are small (26.9 ± 0.2 µm in diameter), round or triangular, and tri-colporate with a smooth exine sculpture (**Plate 81b**).

127. Ivory wood (*Ehretia accuminata* R. Br. Prodr.) is a tall tree, about 10m high, distributed throughout the eastern Himalayas from 1,300-

2,000m in sunny open places. The tree yields timber; the leaves are used as fodder; and the fruits are edible. It blossoms during March-April and produces minute, fragrant, white, and sessile flowers in terminal, densely-flowered compound panicles. It is a major source of nectar and a medium source of pollen and is visited by *Apis cerana* and *Apis mellifera*. The honey yield from this plant is 4.5kg/colony/season with *Apis cerana* (Singh 1962). The only information available shows that its honey is amber in colour and has a characteristic flavour. The pollen grains of this species are small (21.3 ± 1.2 µm long and 19.5 ± 1.2 µm broad), oval or triangular, and tri-colporate with a reticulate exine sculpture.



82. *Elaeagnus angustifolia: OS; Ref.* ***plant no.128***

128. Oleaster (*Elaeagnus angustifolia* L.) is a deciduous, somewhat spiny shrub or small tree, two to eight metres tall. It occurs in the subtropical and temperate Himalayas (Afghanistan to western China) at altitudes of from 1,500-3,000m. It blossoms from March to June and produces yellowish, fragrant flowers in axillary clusters. *Apis cerana* and *Apis mellifera* visit its flowers for nectar and pollen. It is of major importance for beekeeping. The plant secretes 0.41 mg of nectar/flower/day (cf figures from Bulgaria in Simidchiev 1980). The concentration of sugar in the nectar varies between 34.9-38.1 per cent (Simidchiev 1980). The honey potential is moderate. There is no available information on the physico-chemical characteristics of oleaster honey. The plant yields 0.002 mg of pollen/10 flowers in (cf figures from Bulgaria in Simidchiev 1980). Its pollen grains are large (54.8 ± 3.1 µm long and 44.2 ± 1.9 µm broad), oval or triangular, and tri-colporate with a smooth exine (**Plate 82**).

129. The wild jujube; Ber (*Zizyphus incurva* Roxb.) is a tree growing to heights of from five-15metres tall. It occurs in the sub-temperate and temperate Himalayan zones of Nepal, Bhutan, India, and western China. It blossoms during June-July and produces small greenish flowers in axillary cymes (**Plate 83a**). It is a major source of nectar and is visited by both *Apis cerana* and *Apis mellifera*. Information on the physico-chemical

83a. *Zizyphus incurva*; Ref. **plant no. 129**

83b. *Zizyphus incurva*: OS (PV); Ref. **plant no. 129**

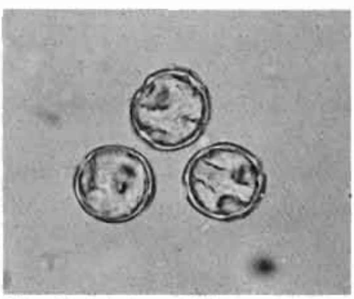
83c. *Zizyphus incurva*: SV (EV); Ref. **plant no. 129**

characteristics of its honey is not available. Its pollen is creamy yellow in colour. The pollen grains are small (24.3 ± 1.9 µm in diameter), round, and tri-colporate with an indefinite exine sculpture (**Plates 83b,c**).

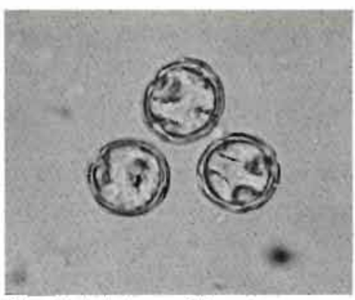
130. The wild jujube (*Zizyphus numularia* [Burm.f.] Wight and Arn.) species is a shrub, less than four metres tall, occurring in the subtropical Himalayas; it is native to Arabia. Its fruits are edible, the leaves are used as fodder (browse for goats and camels) and the stems for fuel. It is also grown as a hedge plant. All parts of the plant, such as young leaves, bark, fruits, and seeds, are medicinal. It blossoms from April to June and produces small greenish flowers. It is a major source of nectar in India and in several parts of Pakistan (PARC 1977) and yields surplus honey. It is an important source of pollen too. It is also visited by both *Apis cerana* and *Apis mellifera*. Information about the physico-chemical characteristics of its honey and the pollen grain features is not available.

131. The wild jujube (*Zizyphus oxyphylla* Edgew) species is a wild shrub about four metres tall. It is a native of Arabia and is distributed throughout the low and middle hill Himalayan areas, especially in northwestern India and Pakistan. Its fruits are edible; the stem is used for fuel and has medicinal properties. The plant blossoms from June to September in Pakistan and is a major source of nectar. This plant yields good amounts of honey in several parts of India and Pakistan (PARC 1977). It is also a pollen source. It is visited by both *Apis cerana* and *Apis mellifera*. Information about the physico-chemical characteristics of its honey and the pollen grain features is not available.

84a. Cedrela toona; Ref. ***plant no. 132***

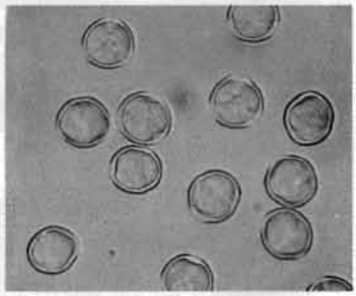


84b. Cedrela toona: OS; Ref. ***plant no. 132***



84c. Cedrala toona: SV; Ref. ***plant no. 132***

132. The cedrela (*Cedrela toona* Roxb.; Syn. *Toona ciliata* Roem.) is a tall deciduous tree occurring all along the Himalayan tract in the plains and the low hills ascending up to 1,300m. The tree is also planted for its good quality timber and leaves which are used for fodder. It blossoms during April for two to three weeks and produces small, creamy white flowers (**Plate 84a**). This species yields both nectar and reddish pollen. It is a major source of nectar and a medium source of pollen and is visited by both *Apis cerana* and *Apis mellifera*. Honeybee colonies benefit from this tree a great deal, gaining 10-15 pounds in weight during its flow (Thakur 1991). Information is available only on the physical characteristics of its honey which shows that it is white to light amber with a pronounced flavour. Cedrela pollen is greyish white in colour. Pollen grains are small (22.6$\pm$1.8 μm in diameter), round, and tetra-colporate with a smooth exine sculpture (**Plates 84b,c**). It is recommended for beekeeping-oriented multipurpose plantations.



85b. Eurya accuminata: OS; Ref. ***plant no. 133***

85a. Eurya accuminata; Ref. ***plant no. 133***

133. The wild osmanthus (*Eurya* spp.) grows as an evergreen shrub or a small tree, up to five metres tall, distributed throughout the temperate and subtropical Himalayan areas of India, China, and Nepal from 1,200-2,400m, occurring on south-facing slopes or in sunny places. The most important species for beekeeping in the Chinese Himalayas include *E. alata, E. brevistyla, E. chinensis, E. groffii, E. hebeclades, E. loquiana, E. megatrichocarpa, E. nitida, and E. rubiginosa* (Zhen-Ming et al. 1992; Bangyu et al. 1996). Since different species occur in the same area, and they have different blossoming periods, the total blossoming period is quite long – from October to March. Its flowers are small, unisexual, and creamy white, produced in almost stalkless clusters arranged along the stems. The flowers produce large amounts of nectar and pollen and are eagerly visited by *Apis cerana* and *Apis mellifera* (**Plate 85a**). An *Apis cerana* colony can produce up to 40kg of honey from its flow. *Eurya* spp are one of the best sources of high quality honey in the Chinese Himalayas. Eurya honey is thick, transparent, and does not granulate. It has a sweet flavour and contains 24.3 per cent moisture, 34.4 per cent glucose, 36.03 per cent fructose, and 0.5 per cent sucrose. It is slightly acidic with a pH value of 3.96. Eurya species also produce plenty of pollen and blossom throughout the winter season. It is very important for brood rearing and colony development. The pollen grains are very small (14.9 ± 0.7 μm in diameter), round, and tri-colporate with a smooth exine sculpture (**Plate 85b**).

134. The behul (*Grewia optiva*) is a small deciduous tree, growing to a height of from five to eight metres. It is distributed throughout the subtropical and sub-temperate Himalayan zones in China, India, Nepal, and Pakistan. It is a multipurpose tree planted for its wood which is used for making tool handles, shafts, agricultural implements, spokes of wheels, furniture, tennis racket frames, and so on. The fibre extracted from the bark is used for making ropes. Its leaves are the only available green fodder for cattle during the winter season. It blossoms during May-June and produces yellow flowers in axillary cymes. It is a major source of nectar and pollen for both *Apis cerana* and *Apis mellifera* in the low hill areas during the slack summer months. There is no information on the yield and physico-chemical characteristics of its honey. It is recommended for beekeeping-oriented multipurpose plantations.

135. Silk cotton tree (*Bombax ceiba* L.or Syn. *Bombax malabarica* or *Salmalia malabarica*) is a large deciduous tree, more than 20m tall, with a very thick trunk. It is distributed throughout subtropical areas at altitudes of up to 1,200m. Its flowers are used as vegetables, the leaves as fodder, and the silky fibre of the seed for stuffing pillows and quilts. The plant also yields timber and fuelwood. It is a traditional nesting site for the wild honeybee species, *Apis dorsata* (**Plate 86**). The plant blossoms during February-March and produces large, bright crimson red flowers (**Plate 87**). The flowers yield a large amount of nectar, but its sugar concentration is very low, only six per cent. It also yields large amounts of pollen and therefore bees are active around it. It is visited by *Apis cerana* and *Apis mellifera*. Information about the physico-chemical characteristics of its honey is not available. Its pollen is creamy white in

86. *Apis dorsata nests on Bombax ceiba*; Ref. **plant no. 135**

87. *Bombax ceiba*; Ref. **plant no. 135**

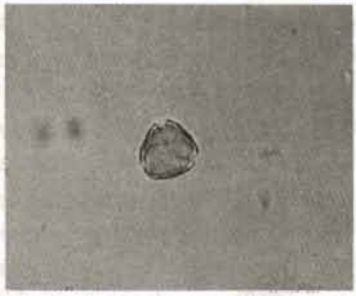
colour. The pollen grains are large, round, and tri-colporate with a reticulate exine sculpture.

136. The palas (*Butea monosperma* (Lam) Kuntze or Syn. *Butea frondosa* Koen. ex Roxb.) is a deciduous timber tree about 10-20m tall; it flowers during winter, i.e., during January-February. It is distributed throughout the subtropical Himalayas at altitudes of up to 1,300m. Its bark, leaves, flowers, and seeds have medicinal properties. The stem yields gum which is also used as a medicine; the leaves also provide food for lac insects. A red dye is obtained from its flowers. The palas tree blossoms during January-February and produces 1.5-2.5cm-long bright red flowers in rigid axillary and terminal clusters. It is extremely prolific in secreting nectar and is a major honey plant in the low hill areas; it is visited by *Apis cerana* and *Apis mellifera*. However, there is no information on the physico-chemical characteristics of its honey and the pollen grain features. It is recommended for beekeeping-oriented multipurpose plantations.

137. The ben tree or horse radish tree (*Moringa oleifera* Lam.or Syn. *Moringa pterigosperma* Gaertn.) is a small- or medium-sized deciduous tree, about 10m tall. It is native to India and is planted throughout the subtropical Himalayan region as a hedge and as an amenity plant. It is a multipurpose plant grown for its leaves, roots, flowers, and pods which are used as vegetables. An oil is extracted from its seeds, and this is used for perfumes and lubricants. The oil cake is used as a fertilizer. Gum is extracted from the stem. Twigs and leaves are lopped for fodder. The juice of the leaf has antibacterial properties. It blossoms for a long period of three months from January to March and produces small, white fragrant flowers in large panicles which are visited by both *Apis cerana* and *Apis mellifera*. The plant secretes large quantities of nectar and pollen and is of major importance for beekeeping. However, there is no information about the physico-chemical characteristics of its honey and the pollen grain features. It is recommended for beekeeping-oriented multipurpose plantations.

138. The soapnut (*Sapindus detergens* Roxb.; Syn. *Sapindus mukorossi*) is a medium-sized, handsome deciduous or semi-deciduous tree. It is fairly common in the open forests of the subtropical Himalayan region. The tree is also planted for shade and other amenities such as its fruit and bark which are used in medicines and as a soap substitute. It blossoms during May-June and yields large quantities of nectar and pollen. It is a major bee plant in Himachal Pradesh (India) and is much sought after by *Apis cerana* (**Plate 88a**). In India, the honey yield from its flow is 6.8-9.1 kg/colony/season with *Apis cerana* (Singh 1962). Its honey is watery white to white in colour and has a mild flavour. It contains 15.4 per cent water, 35.4 per cent glucose, 41.8 per cent fructose, 5.4 per cent sucrose, and 0.3 per cent ash. Its granulation is fine and, after granulation, it becomes milky white. Soapnut pollen is yellow in colour. The pollen grains are small (16.4 ± 1.04 µm long and 14.9 ± 0.9 µm broad), round or triangular, and tetra-colporate with a smooth exine (**Plate 88b**). It is recommended for increasing beekeeping potential.

139. The ash tree (*Fraxinus floribunda* Wall.) is a large deciduous tree with grey bark, distributed throughout the Himalayan region from



88b. Sapindus detergens: OS;
Ref. ***plant no. 138***

88a. Sapindus detergens;
Ref. ***plant no. 138***

northwestern India to southwestern China from 1,200-2,700m. It occurs in forests and is also planted around villages. Its wood is used for oars, poles, and ploughs. It blossoms during April-May and produces numerous, white fragrant flowers in large branched clusters about 25cm across. The flowers produce plenty of nectar and are visited by *Apis cerana* and *Apis mellifera*. It is a major nectar source in Nepal (Kafle 1979), but there is no information about the physico-chemical characteristics of its honey and pollen grain features.

140. The pogostemon (*Pogostemon glaber* Benth.) is a herb or small shrub, about two metres tall, with a dark purple stem. It is distributed throughout the Hindu Kush-Himalayan region from 1,200-2,100m, occurring in shaded places. The pogostemon blossoms for a long period from January to June and produces white or light mauve flowers in dense flowered whorls forming continuous spikes. The flowers produce plenty of nectar and pollen and are visited by both *Apis cerana* and *Apis mellifera*. Honeybees collect both nectar and pollen and produce plenty of honey from the nectar flow. It is a major source of nectar and pollen in Nepal (Kafle 1979), but there is no information about the physico-chemical characteristics of its honey and pollen grain features.

141. *Sophora viciifolia* Hance is a deciduous shrub, growing to heights of up to two metres, has brown branches with sharp prickles and is distributed throughout the Himalayan region from India to southwestern China. It is found on slopes and along roadsides. Its roots fix atmospheric nitrogen and help in soil conservation. It blossoms during March-April and produces white or bluish flowers in terminal clusters. Its flowers begin to secrete nectar when the temperature reaches 20°C. Nectar secretion is highest when the temperature is 25°C and the relative humidity over 70 per cent (Bangyu et al. 1996). It is a major source of nectar in the Chinese Himalayas (Bangyu at al. 1996) where it is visited by both *Apis cerana* and *Apis mellifera*. The honey yield is 20-25kg/colony/season with *Apis mellifera* and 10-15kg/colony/season with *Apis cerana*. The only information on the characteristics of its honey is that it is light in colour while liquid, becomes white after granulation, and is of very good quality (Bangyu et al. 1996). There is no information about the pollen grain features of this plant.

142. *Wendlandia tinctoria* DC var. *intermedia* How is a shrub or small tree with elliptic leaves, distributed throughout the subtropical Himalayas from 1,000-1,600m. It is found in forests. It blossoms from February to April for about 40 days and produces terminal clusters of greenish-white, stalkless flowers. Its flowers produce plenty of nectar and pollen and are visited by both *Apis cerana* and *Apis mellifera*. It is a major source of nectar and pollen in China (Bangyu at al. 1996). Nectar secretion commences at 18°C and reaches its peak at 25°C. Its nectar is thin. A colony of *Apis cerana* can produce 15-20kg honey from its flow. The information available on the characteristics of its honey is that it is light in colour, has a strong flavour, and fine granulation (Bangyu et al. 1996). There is no information about the pollen grain features of this plant.

143. The rubber tree (*Hevea brasiliensis* Muell.-Arg.) is an evergreen tree, planted in the low hill areas for commercial production of rubber. It is found in hot, humid areas with dense rainfall. It blossoms twice a year and produces unisexual flowers; the main blossoming period is from March-April. Nectar secretion is very high during this period. Its second blossoming period is from May to July; however, some trees blossom during August-September. Male flowers blossom earlier than female flowers.

Nectar is secreted not by the floral nectaries but by extrafloral nectaries present at the base of the leaflets. When it is blossoming, the three extrafloral nectaries at the base of the leaflets secrete large amounts of nectar. Nectar secretion is maximum between 0600h and 0900h in the morning and 1700h and 1900h in the evening. It is a major source of extrafloral nectar and a minor source of pollen and is visited by both *Apis cerana* and *Apis mellifera*. In the Chinese Himalayas, honey yield with *Apis mellifera* is 40-50kg/colony/season and, with *Apis cerana,* 30-35kg/colony/season (Bangyu et al. 1996). Rubber honey contains 40.7 per cent glucose, 27.2 per cent fructose, and 4 per cent sucrose. When liquid, it is light in colour and has a sweet flavour. It granulates rapidly with coarse grains and becomes light yellow in colour. Pollen from this plant may be inadequate for brood rearing (Crane et al.1984). There is no information on the pollen grain features of this plant.

144. *Sapium sebiferum* (L.) Roxb. is a deciduous tree with ovate leaves which become red during autumn. It is distributed throughout the Hengduan mountains of China at an altitude of 1,600m. It is found on slopes, along roadsides, and on the margins of fields. Its seeds yield oil. It blossoms from July to August for about 40 days and produces fragrant, unisexual flowers. The male flowers are greenish-yellow and are produced before the female flowers. Many male flowers are produced on terminal racemes; and four to six female flowers are produced at the base of the inflorescence. It is a major source of nectar and is visited by *Apis cerana* and *Apis mellifera*. High temperature and high humidity are beneficial for nectar secretion. An *Apis mellifera* colony can produce 50kg of honey, whereas *Apis cerana* can produce 30-35kg honey from its flow (Bangyu et al. 1996). The available information on the characteristics of its honey is that it is thick, dark in colour, and has a sweet flavour. There is no information on the pollen grain features of this plant.

145. *Sapium discolor* (Champ.) Muell-Arg. is a small deciduous tree with elliptic leaves. It is distributed throughout the Hengduan mountain area below 1,000m and is found in mixed forests, on yellow or red soil containing organic minerals and water. It blossoms during May-June for about 25 days. It produces unisexual flowers on the same inflorescence; male flowers on the upper part of the inflorescence and female flowers at the base. It is a major source of nectar and is visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion is maximum in the morning between 0700h-1100h and in the afternoon between 1500h-1700h. A colony of *Apis mellifera* can produce 40-50kg and a colony of *Apis cerana* can produce 30-40kg of honey from its flow

(Bangyu et al. 1996). The only available information on the characteristics of its honey is that it is light yellow in colour and has an unpleasant taste, but it can be used in confectionery. Information is not available about the pollen grain features of this plant.

146. *Crataeva religiosa* Forst. is a tree that grows to a height of 16 metres and has pale grey or brown branches. It is distributed throughout the Himalayan region of China, India, Nepal, and Myanmar. It grows abundantly in the sub-temperate region from 1,500-1,800m. It blossoms during April-May and produces large white flowers in terminal corymbs. Its flowers are visited by *Apis cerana* and *Apis mellifera* for nectar. In Nepal, it is a major source of nectar and its honey has medicinal properties (Kafle 1979). However, there is no information on the physico-chemical characteristics of its honey and the pollen greain features.

147. The arjun tree (*Terminalia arjuna* (Roxb.) Wight & Arn.) is a large, deciduous timber tree, over 16m tall, found in in the subtropical Himalayan areas of India, Nepal, and Pakistan. Its bark contains tannin and has medicinal properties. It blossoms from April to June and produces yellowish white flowers in erect spikes. The flowers yield plenty of nectar and pollen for *Apis cerana* and *Apis mellifera*. It is a major bee plant in India (KVIC 1959; Singh 1962). However, there is no information on the physico-chemical characteristics of its honey and the pollen grain features.

148. The myrobalan (*Terminalia belerica* (Gaertn.) Roxb.) is a large deciduous tree, over 16m tall, and it is distributed throughout the subtropical low hill Himalayan areas of India, Nepal, and Pakistan. Its fruits are used as medicine and the bark yields dyes and tannin. It blossoms during April-May and produces greenish yellow flowers which have an offensive smell. Its flowers are without petals and are formed in spikes. It is a major bee plant and yields plenty of nectar and pollen (KVIC 1959). Its flowers are visited by both *Apis cerana* and *Apis mellifera*. Information about the physico-chemical characteristics of its honey and pollen grain features is not available.

149. The yellow myrobalan (*Terminalia chebula* Retz.; Syn. *Myrobalan chebula*) is a large, deciduous timber tree, distributed throughout the subtropical Himalayan areas of India, Nepal, and Pakistan. Its fruits yield tannin and dyes and are also used as medicine. It blossoms during April-May and produces fragrant, pale yellow flowers in panicled spikes. It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera* (Chaubal and Deodikar 1965;

KVIC 1959; Khosla 1992). Information about the physico-chemical characteristics of its honey shows that it is light yellow in colour with medium granulation, and it has a characteristic flavour and pungent aroma (Phadke 1962; Chaubal and Deodikar 1965; Narayana 1970). Its honey contains 17.2 per cent water, 35.7 per cent glucose, 40.35 per cent fructose, and 0.16 per cent ash. There is no information on the pollen grain features of this plant.

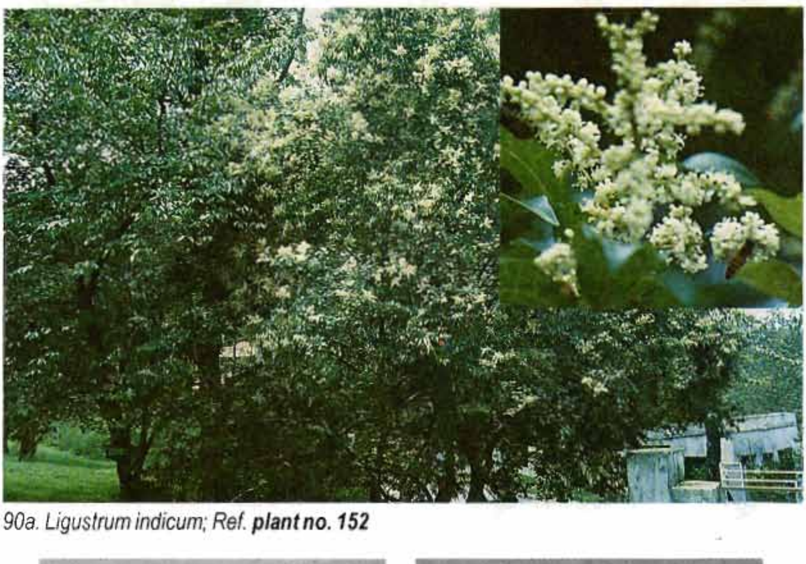
89a. Leucosceptrum canum; Ref. ***plant no. 150***

89b. Leucosceptrum canum: OS; Ref. ***plant no. 150***

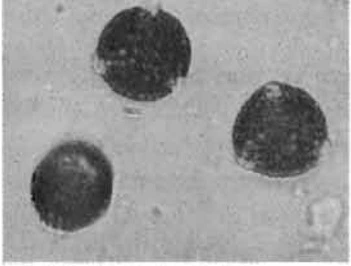
89c. Leucosceptrum canum: SV; Ref. ***plant no. 150***

150. Leucosceptrum (*Leucosceptrum canum* Sm. Exot.) is the only tree from the *Labiatae* f. which occurs in the Himalayas (Kumaon to Bhutan, northeast Himalayas, Myanmar, and western China). It grows on shaded slopes at altitudes of up to 2,300m. This species blossoms during February-March and produces white or pink flowers in five -12cm long, densely-flowered terminal spikes which resemble those of the bottle brush. The difference between the two is that the spikes of this plant stand erect while those of the bottle brush hang down (**Plate 89a**). The flowers produce large quantities of nectar which is collected by *Apis cerana* and *Apis mellifera*. In addition to nectar, the flowers also produce pollen for bees. Information on the physico-chemical characteristics of its honey is not available. Its pollen grains are small (27.5$\pm$1.1 μm long and 25.1$\pm$1.1 μm broad), oval, with six furrows and a reticulate exine sculpture (**Plates 89b,c**).

151. *Madhuca latifolia* (Roxb.) A. Chev. is a deciduous tree distributed throughout the low hill areas at altitudes of up to 1,500m and is found in dry forests. Its flowers are used for vegetables and the seeds yield oil. It blossoms during February-March and produces plenty of nectar and pollen which are collected by *Apis cerana* and *Apis mellifera*. In Nepal and India, it is a major source of nectar and pollen (Dewan 1972; Kafle 1984). Information on the physico-chemical characteristics of its honey and pollen grain features is not available.



90a. Ligustrum indicum; Ref. ***plant no. 152***

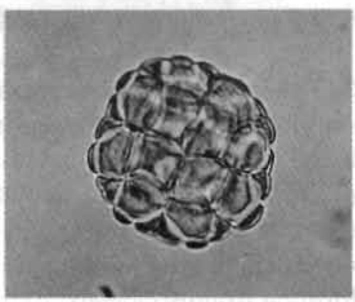


90b. Ligustrum indicum: OS; Ref. ***plant no. 152***

90c. Ligustrum indicum: SV; Ref. ***plant no. 152***

152. Ligustrum (*Ligustrum indicum* (Lour.) Merr.or Syn. *Ligustrum nepalense* Wall.) is a small tree growing up to heights of five metres or a little more. It is distributed throughout the Himalayas from Uttar Pradesh in India to Bhutan, i.e., from 1,200-2,700m. It is commonly found in open and shaded places, damp gulleys, and wet oak forests. It blossoms during June-July and produces large, branched terminal clusters of small white, fragrant flowers. The flowers are about five mm across (**Plate 90a**). It is a good source of nectar and pollen and is visited by *Apis cerana* and *Apis mellifera*. Since it blossoms during summer/early rainy season, which is a relatively lean period, its flow is very important for the sustenance of bee colonies. Bees do not produce surplus honey from this plant. Its pollen is creamy yellow in colour, and the pollen grains are small (26.8 ± 0.7 µm long and 24.6 ± 1.6 µm broad), oval/triangular in shape, and tri-colporate with a reticulate exine sculpture (**Plates 90b,c**).

91a. Acacia arabica; Ref. ***Plant no. 153***

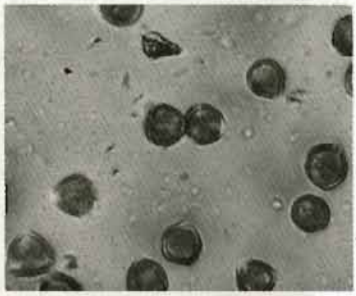


91b. Acacia arabica: OS; Ref. ***plant no. 153***

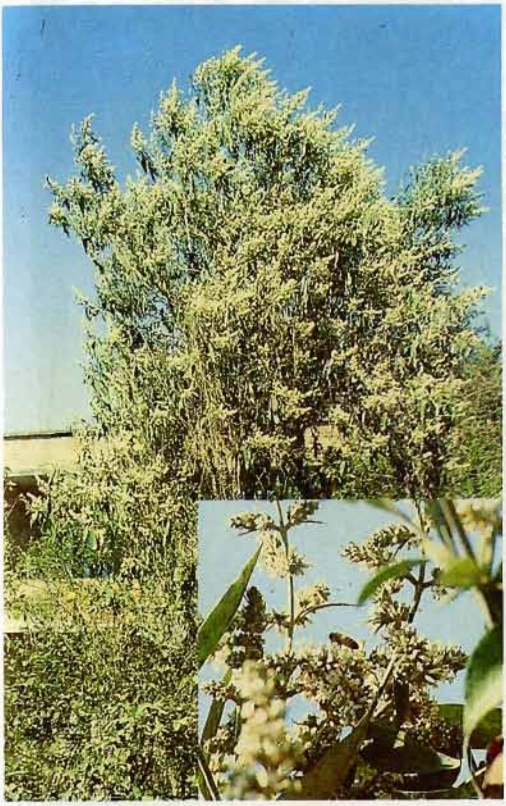
153. The acacia (*Acacia arabica* Willd.) is a wild tree, attaining a height of 20m in the plains but usually stunted in the hills. It is found in the tropical and subtropical Himalayas at heights of up to 1,700m. Its wood is used in the construction of agricultural implements, boats, tent pegs, fuel, and so on. Its stem yields gum arabic, which is used in local medicines; the bark is used for tanning and dyeing; and the roots for preparing native spirits. The green leaves and pods make excellent fodder. It blossoms from May to July and produces yellow, fragrant flowers crowded in long stalked, globose heads 1.5-2.0cm in diameter, forming axillary clusters of from two to five **(Plate 91a)**. Honeybees (*Apis cerana* and *Apis mellifera*) collect both nectar and pollen. Since it blossoms during summer, its flow helps colony development and surplus honey production by strong colonies. Information is available only on the physical characteristics of its honey. Acacia honey is almost water white and has a mild aroma. Acacia pollen is yellow in colour and the pollen grains are aggregated (polyad). Each polyad is made up of five, single pollen grains (monads). Each monad (single grain) is small (21.1 ± 1.5 µm long and 19.9 ± 1.6 µm broad), almost round, with three furrows and a granular exine sculpture **(Plate 91b).**

154. The cutch tree (*Acacia catechu* (L.f.) Willd.) is a moderately-sized tree, more than 10m tall. It is distributed throughout the subtropical Himalayas and occurs in dry, open places. The plant yields timber, fodder, and fuelwood. It is an important source of *cutch, katha,* and *kheersal*. The plant also yields a gum which is one of the best substitutes for gum arabic. It is also a host for lac insects. The species blossoms during April-May and produces yellow flowers in axillary spikes. It is a major source of both nectar and pollen and is visited by *Apis cerana* and *Apis mellifera*. In the Indian Himalayas, the honey potential of *Acacia catechu* is reported to be between 100-300kg/ha (Joshi 1992). Good rains before flowering and light rains during blossoming are reported to increase nectar production and hence honey potential/yield (Joshi 1992). Information on the physico-chemical characteristics of its honey and pollen grain features is not available.

155. The acacia (*Acacia modesta* Wall.) is a small tree occurring in the subtropical Himalayas at heights of up to 1,300m in northwestern India, Pakistan, and Afghanistan. Its wood is used for making agricultural implements, and its fuel and leaves are used as fodder. The plants blossom from May to July. Its flowers are creamy white, forming in stalked, cylindrical drooping spikes, 2.5-5.0cm long, solitary or forming axillary clusters, and they produce good quantities of nectar and pollen which are collected by *Apis cerana* and *Apis mellifera*. Nectar flow can be adversely affected by a sudden rise in temperature. The pollen grains are similar to those of *Acacia arabica*. In Pakistan, this plant is major source of nectar and pollen (Sahid and Qayyum 1977). Its honey is white or very light in colour. Other information on the physico-chemical characteristics of its honey and the pollen grain features is not available.



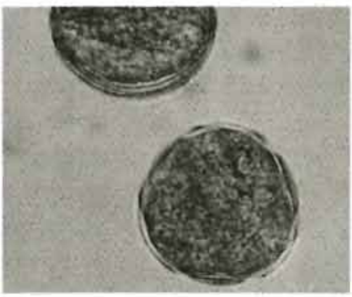
92b. *Buddleia asiatica: OS;*
Ref. **plant no. 156**



92a. *Buddleia asiatica;*
Ref. **plant no. 156**

156. The buddleia (*Buddleia asiatica* Lour.) is a shrub or small tree growing to three metres in height. It is distributed widely in the subtropical and warm temperate Himalayan areas from 1,200-1,800m. It is found in open places. This plant species blossoms during February-March and produces small, white flowers which are eagerly visited by *Apis cerana* and *Apis mellifera* for their nectar (**Plate 92a**). This species contributes to spring forage which helps to facilitate brood rearing and also honey production, if the colonies are strong. It is a medium source of nectar and a minor source of pollen. Bees generally do not produce pure honey from its flow but it is always mixed with other sources. Therefore, information on the physico-chemical characteristics of its honey is not available. Its pollen is creamish yellow. Pollen grains are very small (11.9 ± 0.7 µm in diameter), round, and tri-colporate with a smooth exine (**Plate 92b**).

93a. Caryopteris odorata; Ref. ***plant no. 157***



93b. Caryopteris odorata: OS; Ref. ***plant no. 157***

157. Caryopteris (*Caryopteris odorata* [Buch. - Ham. ex D. Don.]) is an erect and spreading shrub, one to three metres in height. It is found on open slopes and in shaded places in the forest clearings of the subtropical and temperate Himalayas, at altitudes of 2,200m. It blossoms during February-March and produces bluish pink, fragrant flowers in terminal cymes. It is visited by *Apis cerana* and *Apis mellifera* for both nectar and pollen (**Plate 93a**). It is a medium source of nectar and a minor source of pollen. There is no information on the physico-chemical characteristics of its honey. Its pollen is whitish grey in colour and the pollen grains are medium-sized (47.4 ± 3.2 µm long and 44.4 ± 1.04 µm broad), slightly oval, with six furrows and a granular exine sculpture (**Plate 93b**).

158. The barberry (*Berberis aristata* DC.) species is a shrub, usually two metres in height, distributed from Himachal Pradesh to central Nepal at altitudes of from 1,800-3,500m, occurring in shrubberies. The plant has pale yellow branches and often spineless leaves. Extracts from its wood, bark, and roots are used medicinally. The dried berries are commercially known as *ziriskh turash* and are also used medicinally. An oil is extracted from the seeds and a yellow dye from the wood. It blossoms from April to June and produces short-stalked clusters of numerous yellow flowers. The flowers are visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (Kafle 1984). It is a moderate source of nectar and pollen. It contributes to the main spring flow which helps in the development of bee colonies and also results in sizeable honey harvests, if the colonies are strong. Bees do not produce pure honey from this plant, it is mixed with other sources. Therefore, information on the physico-chemical characteristics of its honey is not available. Data on the pollen grain features of this plant are also not available.

94a. Berberis asiatica; Ref. ***plant no. 159***

94b. Berberis asiatica: OS;
Ref. ***plant no. 159***

159. The barberry (*Berberis asiatica* Roxb. ex DC.) species is a many branched shrub, two to four metres in height, distributed from Himachal Pradesh (northwest India) to southwestern China at altitudes of from 1,200-2,500m. It has pale yellow branches and thick rigid, evergreen leaves, usually with two to five spiny teeth. Its fruits are edible. The wood, bark, and plant extract yield *berberine*, a bitter alkaloid used medicinally. The wood also yields a yellow dye used for dyeing leather. It blossoms from March to May and produces pale yellow flowers in somewhat flat-topped clusters. Honeybees (*Apis cerana* and *Apis mellifera*) visit the flowers to collect nectar and pollen (**Plate 94a**). The shrub is a medium source of both nectar and pollen and is important for beekeeping, since it provides bee forage for a long period of time, from spring to summer. Bees do not produce pure honey from its flow. Therefore, information on the physico-chemical characteristics of its honey is not available. The pollen grains of *B. asiatica* are medium in size (42.4$\pm$3.2 µm long and 41.5$\pm$2.9 µm broad), almost round, with two furrows and a granular exine sculpture (**Plate 94b**).

160. The barberry (*Berberis lycium* Royle) species is a shrub, three to four metres in height, distributed from Pakistan to eastern Nepal at altitudes of from 1,500-3,000m. It is found in shrubberies and is also common in cultivated areas of the western Himalayas. The plants are used medicinally. The wood yields yellow dye used for dyeing leather. It blossoms from April to June and produces yellow flowers. It is a medium source of nectar and pollen, visited by both *Apis cerana* and *Apis mellifera*. Its flow helps in the development of bee colonies and in collection of surplus honey by strong colonies. However, bees do not produce pure honey from its flow. Therefore, information on the physico-chemical characteristics of its honey is not available. The structure of its pollen grains is similar to that of *Berberis asiatica*.

161. Mahonia (*Mahonia nepaulensis* DC; Syn. *Berberis nepaulensis* Spreng) is a winter flowering, evergreen shrub or small tree with yellow wood, growing to about three metres height. It is distributed throughout the central Himalayan region from Nepal to Bhutan, ascending from 1,500-2,900m. The berries are edible and also have medicinal uses. It blossoms from December to February and produces small yellow flowers in eight to10cm-long, densely-flowered racemes. The flowers are visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 95a**). It is a medium source of nectar and pollen. Since this plant blossoms during a period when there is a dearth of bee flora, its flow is very important for supporting bee colonies. The bees do not produce surplus honey from its flow. *Mahonia* pollen is yellowish brown in colour. Pollen grains vary greatly in size. Generally, these are medium-sized (47.3$\pm$7.4 µm long and 42.7$\pm$7.9 µm broad), oval, with two pores and a granular exine sculpture (**Plate 95b**).

95a. Mahonia nepaulensis; Ref. **plant no. 161**

95b. Mahonia nepaulensis: OS; Ref. **plant no. 161**

162. *Schefflera impressa* Clarke is a tree of up to 15 metres in height with digitate leaves. It is distributed throughout the Himalayas from India to southwestern China at altitudes of from 2,000 to 3,400m. It is also planted as a fodder tree. It blossoms from August to September and produces maroon flowers in formation with woolly umbels, producing a large inflorescence about 30-38cm across. Its flowers are visited by *Apis cerana* and *Apis mellifera,* mainly for nectar. It is a major source of nectar in Nepal (Kafle 1984). Information on the physico-chemical characteristics of its honey and pollen grain features is not available.

163. *Schefflera octophylla* (Lour.) Harms is an evergreen shrub or small tree, growing up to 15m tall with thick branches and digitate leaves. It is distributed in the warmer areas of the river valley of southern Tibet and south of the Hengduan mountain range. It is found in sunny, warm and humid places growing in acidic soils. It blossoms for a long period (from October to January) and produces cream-coloured flowers. Its blossoming period is divided into three phases: first, it blossoms for from eight-12 days, then, after an intermission of from six-12 days, it blossoms again for from 12-15 days. Again there is an intermission period of from five-12 days, after which it blossoms again for from seven-10 days. The flowers produce plenty of nectar which is collected by *Apis cerana* and *Apis mellifera*. Nectar secretion is maximum at noon when temperatures range between 18-22ºC and when the relative humidity is between 60-80 per cent. An *Apis mellifera* colony can produce 10-25kg of honey from its flow. The only information available on the characteristics of its honey is that it is light in colour and slightly bitter in taste. It granulates rapidly with fine grains (Bangyu et al. 1996). Data on the pollen grain features are not available.

164. *Schefflera venulosa* (Wight & Arn.) is an unarmed, evergreen climbing shrub growing on rocks and trees. It has digitate leaves with dilated stalks clasping the stem at the base. It is distributed throughout the Himalayan region from India to southwestern China at altitudes of from 300-1,800m. It blossoms for a long period from January to May and produces cream-coloured flowers in globular umbels measuring about 1.5cm and cross-arranged in large, branched purple-stemmed clusters. Its flowers produce plenty of nectar which is collected by *Apis cerana* and *Apis mellifera*. It is a major nectar source in Nepal (Kafle 1984). Information on the physico-chemical characteristics of its honey and the pollen grain features is not available.

96a Saurauia nepaulensis: Ref ***plant no. 165***

165. *Saurauia nepaulensis* DC. is a large, deciduous shrub or small tree distinguished by its large elliptic leaves which are conspicuously rusty-haired beneath. It is distributed throughout the Himalayan region from India to southwestern China and from Myanmar at altitudes of from

600-1,200m. It is found in the forests and is also planted as a fodder tree. It blossoms during September-October and produces axillary clusters of pink flowers (**Plate 96**). Its flowers produce good amounts of nectar and pollen which are collected by *Apis cerana* and *Apis mellifera*. In Nepal, it is a major source of nectar and pollen (Kafle 1984). However, information on the physico-chemical characteristics of its honey and pollen grain features is not available.

166. *Elsholtzia rugulosa* Hemsl. is a many-branched, perennial herb with a brown stem marked by irregular furrows. It is distributed throughout the Hengduan mountain areas at altitudes of from 1,600-3,000m, occurring on sunny slopes, in forests, and in river valleys. It blossoms from October to December for about 40-50 days and produces numerous, small light yellow flowers in dense slender terminal spikes. It is visited by *Apis cerana* and *Apis mellifera*. Nectar secretion begins at a very low temperature, i.e., at 8°C with the highest secretion being at 18°C. With a long blossoming period, it is an important nectar plant during the slack winter season. Usually an *Apis cerana* colony produces 20kg of honey from its flow (Bangyu et al. 1996). The only information available on the characteristics of its honey is that it is light in colour when liquid and becomes white after granulation. It has a sweet flavour and the granulation is fine (Bangyu et al. 1996). Data on the pollen grain features are not available.

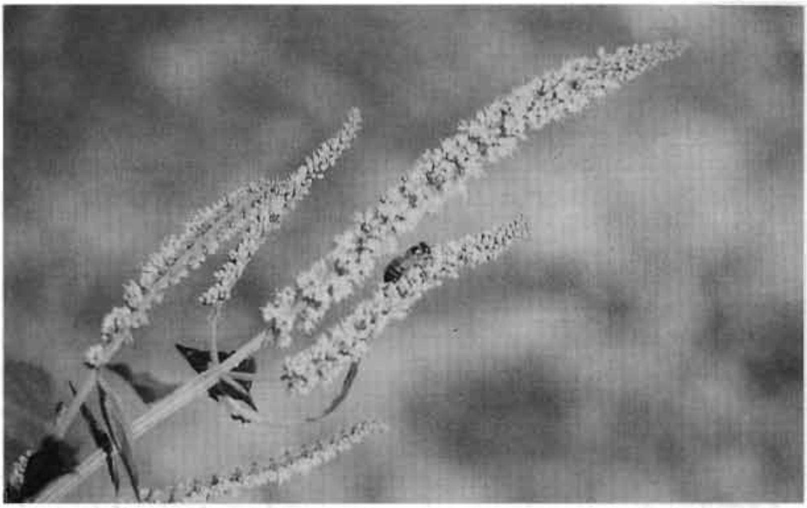
167. *Elsholtzia dense* Benth. is a perennial with a 20-70cm-long, erect purple stem and leaves. It is distributed throughout the subtropical and temperate Himalayan areas at altitudes of from 1,600-2,500m, where it is found in moist forests and on wastelands, and it is also planted in gardens. It blossoms during August-September for about 30 days and produces pinkish purple flowers in axillary or terminal spikes. Its flowers produce large amounts of nectar, and this is collected by *Apis cerana* and *Apis mellifera*. Nectar secretion is greater if there is good rainfall just before blossoming. In China, the honey yield with *Apis cerana* is 20-30kg/colony/season (Bangyu et al. 1996). The only information available on the physical characteristics of its honey is that it is of superior quality, light in colour, and has a sweet flavour (Bangyu et al. 1996). Data on the chemical characteristics of its honey and the pollen grain features are not available.

168 *Elsholtzia ciliata* Hyland is a 50-70cm tall annual with an erect squarish stem and elliptic lanceolate leaves with sharp apexes. It is distributed throughout the Chinese Himalayas where it is found occurring on dry wastelands, along roadsides, on field margins, and along river banks. It blossoms during October-November and produces tiny, light purple flowers in cylindrical terminal spikes about two to six cm long. It is a major source of nectar and is visited by both *Apis cerana* and *Apis mellifera*. An *Apis cerana* colony can produce about 10-12kg of honey, which is yellowish-green in colour and has a sweet flavour, from its flow (Bangyu et al. 1996). There is no information on the chemical characteristics of its honey and the pollen grain features.

169. *Elsholtzia cypriani* (Pavo l.) C.Y. Wuet S. Chow. is an annual with an erect stem, growing up to one metre tall. It is distributed in the river valley of the Hengduan mountain range and grows on slopes, along riversides, around villages, and in sparse forests. It blossoms during September-October and produces numerous small, light purple flowers in terminal spikes. The flowers secrete plenty of nectar and pollen which are collected by *Apis cerana* and *Apis mellifera*. Nectar secretion begins at from 15-18^{0}C. Its flow is very important for colony build-up during autumn and also for honey production. Honey yield with *Apis mellifera* is 10-15kg/colony/season and with *Apis cerana* 10kg/colony/season (Bangyu et al. 1996). Its honey is yellowish green in colour and has a minty flavour. It granulates rapidly (Bangyu et al. 1996). There is no information on the chemical characteristics of its honey and the pollen grain features.

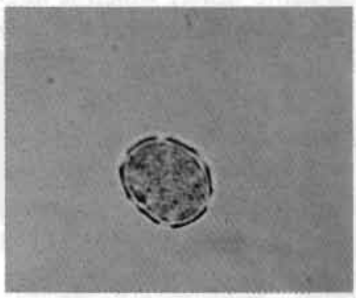
170. *Elsholtzia bodineiri* Vaniot is a perennial with a prostrate stem and opposite lanceolate, linearly-toothed leaves. It is distributed throughout the Hengduan mountain range at altitudes of from 2,000-2,500m, occurring on slopes with sparse trees and grasses. It blossoms during November-December for one month and produces small flowers in spikes arranged in two rows. It produces large amounts of nectar. This is collected by *Apis cerana* and *Apis mellifera*. A colony of *Apis cerana* can produce about 10kg of honey from its flow. Its honey is of good quality. It is light yellow in colour and has a strong flavour. Its granulation is fine. Since it blossoms during the slack winter months, its flow is also important for nurturing honeybee colonies over the winter. Information on the chemical characteristics of honey and the pollen grain features of this plant is not available.

171. *Elsholtzia fruticosa* (D. Don) Render; (Syn. *E. polystachya* Benth.) is a small shrub with elliptic, lanceolate leaves. It is distributed from Pakistan to northwestern China, India, and Nepal at altitudes of from 1,600-3,300m, and it is found in open places and shrubberies. It



97a. Elsholtzia fruticosa; Ref. **plant no. 171**

97b. Elsholtzia fruticosa: OS; Ref. **plant no. 171**



97c. Elsholtzia fruticosa: SV; Ref. **plant no. 171**

blossoms during September-October and produces long narrow spikes of tiny white flowers. The spikes are 10-25 cm long, eight mm broad, and strongly aromatic. The flowers produce good amounts of nectar, and this is collected by *Apis cerana* and *Apis mellifera* (**Plate 97a**). Information on the physico-chemical characteristics of the honey from this plant is not available. Pollen grains are very small (18.8 ± 0.5 µm long and 17.9 ± 1.1 µm broad) and hexagonal, with six furrows and a reticulate exine sculpture (**Plates 97b,c**).

172. Marjoram (*Origanum vulgare* L.) is a perennial herb with ovate leaves. It is distributed from Pakistan to Bhutan, at altitudes of from 1,500-3,600m, and it is found on open slopes. It blossoms during August-September and produces light red, umbrella-shaped flowers in panicles. Its flowers secrete good amounts of nectar and pollen which are collected by *Apis cerana* and *Apis mellifera*. Nectar secretion is greater in the morning than in the afternoon, with maximum secretion occurring at

20°C. In the areas where it is found in abundance, a colony of *Apis cerana* can produce three to five kg of honey from its flow (Bangyu et al. 1996). Marjoram honey is light in colour and has a sweet flavour. It is also a major source of pollen and is, therefore, important for brood rearing (Bangyu et al. 1996). There is no information on the chemical characteristics of the honey and the pollen grain features of this plant.

173. *Cynoglossum amabile* Stapfet Drumm. is a perennial herb with circular, cone-shaped, yellowish-grey main roots. It is distributed throughout the Hengduan mountain range where it is found along roadsides and on grassy slopes. It blossoms during July-August and produces blue or white flowers in dense terminal clusters. Its flowers are visited by both *Apis cerana* and *Apis mellifera*. In the areas where it is found in abundance, it is a major source of nectar and honeybees produce some honey which is thick and yellowish in colour (Bangyu et al. 1996). Information on the chemical characteristics of honey and the pollen grain features of this plant is not available.

174. *Verbena officinalis* L. is a perennial with a squarish stem which is found throughout the Hengduan mountain range. It occurs in grasslands and along roadsides. It blossoms during June-July for about 40 days. Its flowers produce good amounts of nectar, and it is visited by *Apis cerana* and *Apis mellifera*. Nectar secretion commences when the temperature is above 20°C. In areas where it occurs in abundance, it is a major source of nectar and honeybees produce honey which is thick and light yellow in colour (Bangyu et al. 1996). Information on the chemical characteristics of honey and the pollen grain features of this plant is not available.

175. Throughwort (*Eupatorium glandulosum* H.B.K. Banerji) is a tall, gregarious herb, originally from Mexico. It has recently been naturalised in the Himalayas where it grows abundantly on wasteland and in secondary forests. It blossoms during honey flow season (March-April) and produces minute, dull white flowers in small 0.5-1.0cm heads which are eagerly visited by *Apis cerana* and *Apis mellifera* for nectar only. Honeybees prefer its flowers, ignoring other plants in the vicinity. It is a major honey plant in the areas where it grows in abundance (**Plate 98**). However, information on the physico-chemical characteristics of honey of this plant is not available. *Eupatorium* pollen is white in colour, and it pollen grains are very small (18.6 ± 0.9 µm in diameter), round, and tri-colporate with an echinate exine sculpture.

98. *Eupatorium glandulosum*; Ref. **plant no. 175**

99. *Choerospondias axillaris*; Ref. **plant no. 176**

176. Lapsi (*Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill) is a deciduous, dioecious tree, growing to heights of up to 20m or more, distributed throughout the eastern Himalayas, central China, and Nepal. It grows wild and is also planted in warm temperate places for its edible fruits which are either pickled or made into candies. *Lapsi* wood is soft and used for making tea boxes. It blossoms during April-May and produces small flowers in axillary and terminal panicles. The staminate flowers are many, small, 0.3cm in diameter, and the pistillate flowers are solitary, in leaf axils, and about 0.8cm in diameter. The flowers are visited by *Apis cerana* for nectar and pollen (**Plate 99**). It is a minor source of both nectar and pollen and bees do not produce surplus honey from this plant. The pollen grains are medium in size (34.2±1.7 µm in diameter), round, and tri-colporate with a striated exine sculpture.

177. *Eriobotrya dubia* Decne. is a small tree, about four to nine metres tall, distributed throughout the Himalayan region at altitudes of from 1,500-2,500m. It occurs on exposed plots. It blossoms during February-March and produces white flowers in six to eight cm-long, branched pyramidal panicles. *Apis cerana* and *Apis mellifera* visit its flowers for nectar and pollen. It is a major source of pollen and a minor source of nectar in Nepal (Kafle 1984). This plant does not yield surplus honey.

178. The holly tree (*Ilex excelsa* Wall. ex Hook.) is a large tree with ash-coloured bark, growing up to 20m tall. It is distributed throughout the Himalayan region from Pakistan to southwestern China at altitudes of from 1,500-3,000m. It is planted as a fodder tree. It blossoms during April-May and produces small white flowers in pubescent umbels. It is a medium source of nectar and pollen and is visited by *Apis cerana* and *Apis mellifera*. The bees do not produce pure honey from this plant. Therefore, information on the physico-chemical characteristics of its honey is not available. Data on the pollen grain features are also not available.

179. The maple (*Acer accuminatum* Wall. ex D. Don) species is an elegant tree occurring in the forests and shady ravines of northwestern India, the North West Frontier Province of Pakistan, and central Nepal, i.e., at altitudes of from 2,100-3,000m. It blossoms during March-April and produces greenish flowers in short, flat-topped clusters appearing before or with the young leaves. It is a minor source of nectar and pollen and does not yield surplus honey. It is visited by both *Apis cerana* and *Apis mellifera*. Information on the pollen grain features of this plant is not available.

180. The maple (*Acer caesium* Wall. ex Brandis) species is a fairly large deciduous tree, growing to heights of up to 20m. It is distributed from Afghanistan to central Nepal, commonly occurring in forests and open grassy places from altitudes of from 2,200-3,000m. It blossoms from March to May and produces small (5mm in diameter), greenish yellow flowers in branched flat-topped clusters. It is a minor source of nectar and pollen and does not yield surplus honey. Its flowers are visited by both *Apis cerana* and *Apis mellifera*. Information on the pollen grain features of this plant is not available.

181. *Acer cappadocicum* Gled.; Syn. *A. pictum* auct. non Thunb. is a large to medium-sized tree distributed from Afghanistan to western Nepal and Bhutan, at altitudes of from 2,100 to 3,000m, occurring in forests. It blossoms during March-April and produces small (8mm in diameter), greenish yellow flowers in lax-branched hairless clusters. It is also a minor source of nectar and pollen and does not yield surplus honey. Its flowers are visited by both *Apis cerana* and *Apis mellifera*. There is no information about the pollen grain features of this plant.

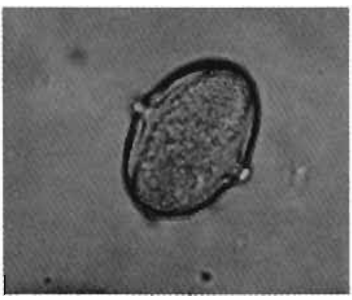
182. *Acer negundo* L. is found from Afghanistan to China, occurring in forests. It blossoms during April-May and is a medium source of nectar and pollen for bees in the Chinese Himalayas (Xu 1993). It is visited by both *Apis cerana* and *Apis mellifera*. There is no information on the physico-chemical characteristics and the pollen grain features of this plant.

183. *Acer pentapomicum* J.L. Stewart is a small, deciduous tree, distributed from Afghanistan to northwestern India, occurring in oak and pine forests at altitudes of from 1,000-2,100m. It blossoms during March-April and produces greenish white flowers in dense flat-topped clusters. It is also a minor source of both nectar and pollen but does not yield surplus honey. Its flowers are visited by both *Apis cerana* and *Apis mellifera*. Information about the pollen grain features of this plant is not available.

184. *Acer oblongum* Wall. ex DC. is a small- or medium-sized forest tree, distributed from Pakistan to southwestern China and Myanmar. It blossoms from February to April and produces greenish white flowers in dense, terminal-branched and hairy clusters. It is a major source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. Information is not available on the physico-chemical characteristics of its honey and the pollen grain features.

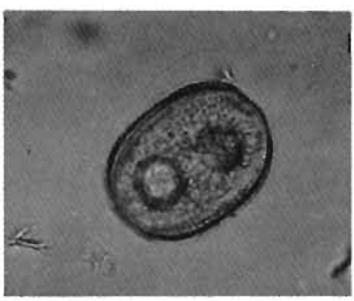
185. Basak (*Adhatoda vasica* Nees) is an evergreen, many branched shrub, growing to three metres in height. It is found in the tropical and subtropical Himalayan region. It grows on wastelands in the plains and in sub-mountainous tracts; in dry and moist deciduous forests, along river banks, on dry slopes, and on the margins of forests. This shrub is frost tender and requires 500-1,650mm of rainfall. It is also planted to reclaim wastelands. The leaves are used as green manure and also have pesticidal, herbicidal, and fungicidal properties. The leaves are also used medicinally as an expectorant for coughs, asthma, or chronic bronchitis. A yellow dye is obtained from the leaves. It blossoms during March-April. Its flowers are creamy white, streaked, and dotted with pink or

100a. Adhatoda vasica; Ref. **plant no. 185**



100b. Adhatoda vasica: OS (EV); Ref. **plant no. 185**

100c. Adhatoda vasica: SV (EV); Ref. **plant no. 185**



100d. Adhatoda vasica: OS (PV); Ref. **plant no. 185**

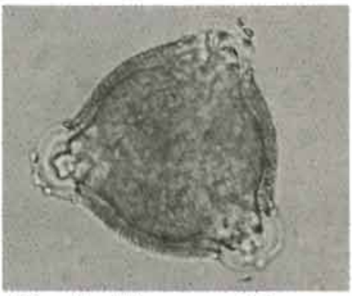
purple. These are crowded in 2.5-7.5cm-long stalked, axillary erect spikes, usually clustered towards the end of the branches. It is a medium source of nectar and pollen in the NWFP of Pakistan and in India and is visited by both *Apis cerana* and *Apis mellifera* (**Plate 100a**). Basak honey is white or very lightly tinged in colour and has a strong smell. Information on the chemical characteristics of its honey is not available. Its pollen is creamish yellow in colour. The pollen grains are large in size (40.4±0.9 µm long and 24.3±0.9 µm broad), elongated, and bi-porate with a granular or reticulate exine sculpture (**Plates 100b,c,d**).

101b. Aesculus indica. OS; Ref. ***plant no. 186***

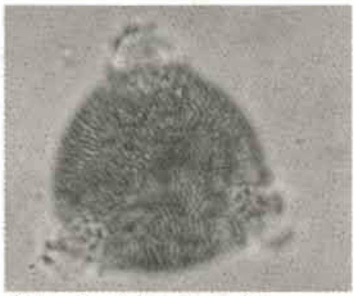
101a. Aesculus indica; Ref. ***plant no. 186***

186. The horse chestnut (*Aesculus indica* L.) is a large, deciduous timber tree distributed throughout the temperate northwestern Himalayan region from Afghanistan to Nepal at altitudes of from 1,300 to 3,500m. It occurs wild and is also planted for shade and amenity. Its seeds are used as fodder for cattle. A flour is also produced from the seeds which is used as food. The plant also has medicinal uses. It blossoms during May-June and produces white flowers in large erect, terminal, narrow pyramidal clusters. It is a major source of nectar and pollen and visited by both *Apis cerana* and *Apis mellifera* (**Plate 101a**). Information on the physico-chemical characteristics of its honey is not available. Horse chestnut pollen is reddish pink in colour. Its pollen grains are medium in size (25.1±3.1 µm long and 21.9±3.2 µm broad), oval, and tri-colporate with a granular exine sculpture (**Plate 101b**).

102a. Bauhinia purpurea; Ref. **plant no. 187**



102b. Bauhinia purpurea: OS; Ref. **plant no. 187**



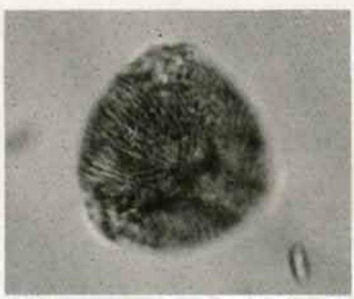
102c. Bauhinia purpurea: SV; Ref. **plant no. 187**

187. The pink bauhinia; geranium tree (*Bauhinia purpurea* L.) is a medium-sized deciduous tree, commonly planted near villages and lopped for fodder. It grows at altitudes of up to 1,600m. It blossoms during autumn, i.e., September-October, and produces pinkish flowers in pubescent racemes (**Plate 102a**). The flowers are 2.5-5.0cm across. It is a minor source of nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. Bees do not produce surplus honey from this plant. The pollen is pinkish white in colour. The pollen grains are large (67.8 ± 0.8 µm in diameter), oval, and tri-colporate with a reticulate exine sculpture (**Plates 102b,c**).

188. Camel's foot (*Bauhinia vahlii* Wight & Arn.) is a very large, evergreen forest climber, sometimes growing up to 35m long. It is distributed throughout the northwestern and northeastern Himalayas up to altitudes of 1,700m. This plant is put to more uses than any other plant, apart from bamboo. The large flat leaves are sewn together to make plates, cups, rough table cloths, umbrellas, and rain caps. The seeds are roasted and eaten. The fibre of the bark is made into ropes and from the stem a copious gum is obtained. It blossoms during May-June; the flowers are whitish-cream. It is a minor bee plant providing both nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. Bees do not produce surplus honey from this plant. Its pollen grains are large (64.5±5.8 μm long and 55.6±4.8 μm broad), oval, and tri-colporate with a reticulate exine sculpture.

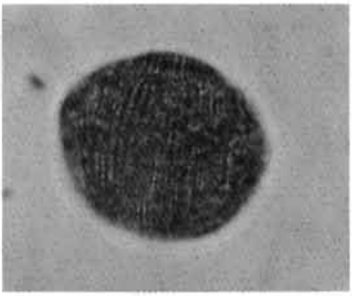
103a. Bauhinia variegata; Ref. ***plant no. 189***

103b. Bauhinia variegata: OS (PV); Ref. ***plant no. 189***



103c. Bauhinia variegata: SV (PV); Ref. ***plant no. 189***

189. Kachnar (*Bauhinia variegata* L.) is a medium-sized, multipurpose tree which is found planted near villages at altitudes of up to 1,600m. Its bark is used as a tonic and also for tanning and dying. Fresh flower buds are used as vegetables and dried ones are used for diarrhoea and worms. The tree provides timber and fuelwood and the leaves provide fodder. It blossoms during March-April and produces pink flowers. The flowers produce plenty of nectar and pollen but are mostly picked as

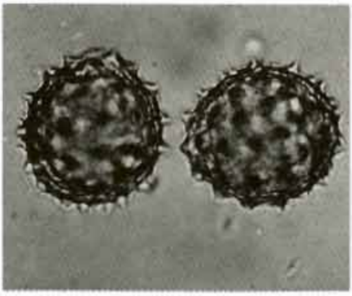


103d. *Bauhinia variegata: SV (EV); Ref.* ***plant no. 189***

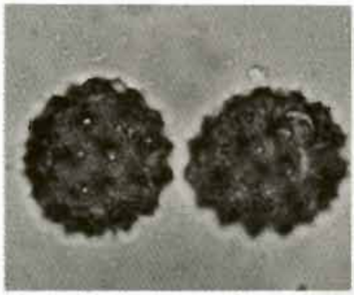
vegetables at the budding stage. Thus, it is only a minor source of nectar and pollen and does not yield surplus honey. Its flowers are visited by *Apis cerana* and *Apis mellifera* (**Plate 103a**). Its pollen grains are similar to those of *Bauhinia vahlii*, except that they are slightly smaller in size (59.8 ± 3.1 µm long and 52.3 ± 2.8 µm broad) (**Plates 103b,c,d**). Kachnar is recommended for beekeeping-oriented, multipurpose plantations.

104a. Cirsium verutum; Ref. ***plant no. 190***

190. The field thistle (*Cirsium verutum* (D. Don) Sprengel) is distributed throughout the subtropical to temperate Himalayan areas from Afghanistan to Bhutan at altitudes of from 740-2,200m. It is found as a weed in cultivated fields, forest clearings, and in open places. The plant blossoms from April to June and produces 2.0-2.5cm, solitary flowering heads, bearing small, unisexual, pinkish purple disc florets. The flowers are eagerly visited by *Apis cerana* and *Apis mellifera,* mainly for nectar (**Plate 104a**). In the Kathmandu Valley, Nepal, a colony of *Apis cerana* can produce five-10kg of honey from its nectar flow. Thistle honey is dark in colour. Information is not available on other physical and the



104b. Cirsium verutum. OS; Ref. **plant no. 190**



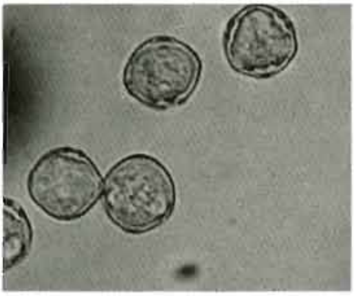
104c. Cirsium verutum. SV; Ref. **plant no. 190**

chemical characteristics of its honey. The pollen grains are medium in size (44.4±3.2 μm long and 41.4±3.9 μm broad), almost round, and tri-colporate with an echinate exine sculpture (**Plates 104b,c**).

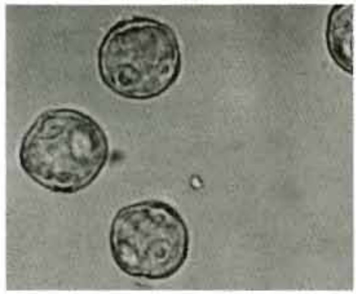
191. The thistle (*Cirsium wallichii* DC) resembles C. *verutum* and blossoms at the same time. It is distributed from Afghanistan to southwestern China at altitudes of from 1,200-3,300m and occurs in cultivated fields and forest clearings. It differs from C. *verutum* in having disc florets which are white in colour. It is a medium source of nectar and pollen and is visited by *Apis cerana* and *Apis mellifera*. There is no information on the physico-chemical characteristics of its honey. The structure of the pollen grains is also similar to that of the pollen grains of C. *verutum*.

105a. Duabanga grandiflora; Ref. **plant no. 192**

192. Duabanga (*Duabanga grandiflora* Buch.) is a large, deciduous timber tree, distributed throughout the low and middle hill areas of China,



105b. *Duabanga grandiflora*: OS; Ref. **plant no. 192**



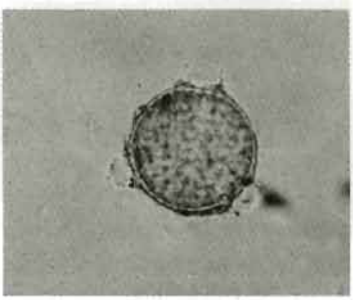
105c. *Duabanga grandiflora*: SV; Ref. **plant no. 192**

India, Nepal, and Pakistan, especially in the eastern Himalayas. It is planted as a roadside avenue tree. Its wood is moderately strong, hard and light, and is durable in contact with water. It takes a good finish. It blossoms during April and produces large, white flowers in terminal corymbs (**Plate 105a**). Its flowers secrete copious nectar and pollen and are visited eagerly by *Apis cerana* and *Apis mellifera*. It is of medium importance for beekeeping and, in densely-planted areas, it can yield surplus honey. Information on the physico-chemical characteristics of its honey is not available. *Duabanga* pollen is cream coloured and the pollen grains are very small. Each grain is 19.3±0.7 µm in diameter, round, tri-porate with a smooth exine sculpture (**Plates 105b,c**).

106. *Elaeocarpus sphaericus*; Ref. **plant no. 193**

193. Rudrakhsha (*Elaeocarpus sphaericus* (Gaertn.) K. Schum.; Syn. *E. genitrus* Roxb.) is a medium-sized tree, which is found in China, India, Nepal, and Pakistan at altitudes of up to 1,200m. It grows wild and is also planted as an ornamental tree. Its fruits are of great medicinal value and are used in head and epiletic fits. It blossoms during June and produces small, cream-coloured flowers in axillary racemes. The flowers are visited by *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 106**). The flow from this plant supports bee colonies during dearth periods. It is a minor source of nectar and pollen and the bees do not collect surplus honey from this plant. The pollen grains are medium in size (43.4 ± 2.1 µm in diameter), round, and tri-porate with a granular exine sculpture.

107a. *Murraya koenigii*; Ref. **plant no. 194**



107b. *Murraya koenigii*: OS (PV); Ref. **plant no. 194**

107c. *Murraya koenigii*: SV (EV); Ref. **plant no. 194**

194. The curry leaf plant (*Murraya koenigii* Spreng) is a wild shrub or small pubescent tree occurring in the sub-Himalayan tracts at altitudes of up to 1,600m. It is also cultivated for its leaves which are used for flavouring curries. Its leaves, bark, stem, and roots have medicinal properties. The juice of the leaves is given in diarrhoea and vomiting or for piles, and a decoction of roots is prescribed for stomach ache. It blossoms during spring (March-April) and produces small white flowers in axillary or terminal racemes. *Apis cerana* and *Apis mellifera* visit its flowers for nectar and pollen (**Plate 107a**). Since it blossoms during the main flow season, it helps in colony development as well as contributing to surplus honey production, but bees do not produce pure honey from this plant. *Murraya* pollen is off-white in colour; the pollen grains are medium in size (36.9 ± 1.1 μm in diameter), round/or triangular in shape, tri-colporate with a granular exine sculpture (**Plates 107b,c**).

108a. Prunus cerasoides; Ref. ***plant no. 195***

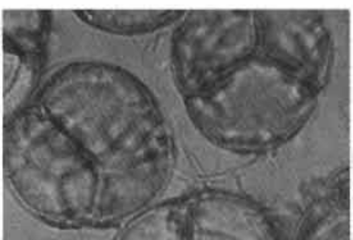
108b. Prunus cerasoides: OS (PV); Ref. ***plant no. 195***

108c. Prunus cerasoides: SV (EV); Ref. ***plant no. 195***

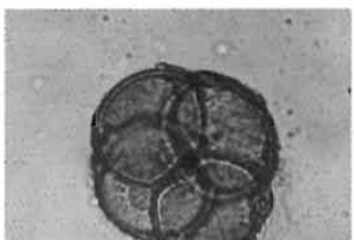
195. The wild cherry (*Prunus cerasoides* D. Don.) is a medium-sized deciduous tree, distributed throughout the subtropical to temperate Himalayan regions from northwestern India to western China at altitudes of from 1,200-2,400m. It is found in mixed forests and also planted at wayside resting places and along roadsides. It blossoms during

November for about two weeks and produces long stalked, white or pink flowers in a few flowered clusters which provide good amounts of nectar and pollen (**Plate 108a**). It is visited by both *Apis cerana* and *Apis mellifera*. The sugar concentration in the nectar is 13 per cent. Since it blossoms during late autumn or early winter, it is very important for the development of bee colonies. Despite the fact that the flowers of this plant secrete large amounts of nectar, the bees do not collect surplus honey from its flow because the colonies are very week during its blossoming season. Its pollen grains are medium in size (37.2±0.9 µm long and 31.2±3.4 µm broad), oval/or triangular in shape, and tri-colporate with a granulated exine sculpture (**Plates 108b,c**).

109a. Rhododendron arboreum; Ref. ***plant no. 196***

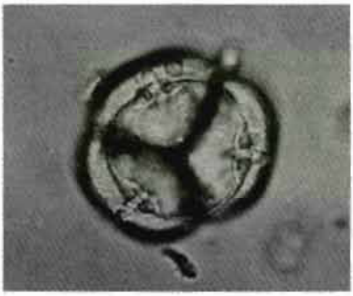


109b. Rhododendron arboreum: OS; Ref. ***plant no. 196***



109c. Rhododendron arboreum: OS (Tetrad); Ref. ***plant no. 196***

196. The Alpine rose (*Rhododendron arboreum* Smith) is a tree, about 15m tall, distributed throughout the temperate Himalayas from Pakistan to southeastern Tibet at altitudes of from 1,500-3,600m. Its flowers are made into squash and sauce. It blossoms during February-March



109d. *Rhododendron arboreum*: SV (Tetrad); Ref. **plant no. 196**

and produces bright red or pink flowers which yield large amounts of nectar (**Plate 109a**). It is visited by both *Apis cerana* and *Apis mellifera*. In the Chinese Himalayas, a colony of *Apis cerana* can produce five-10kg of honey from its flow. The information available on rhododendron honey shows that it is light in colour when liquid and becomes light yellow after granulation (Bangyu et al. 1996). Its granulation is coarse. There is no information on the chemical characteristics of its honey. The pollen grains are compound (polyads), four grains are aggregated to form a tetrahedral polyad. Each pollen grain in a tetrad is medium in size (36.7 ± 1.4 µm in diameter), round, and tri-colporate with a granular exine sculpture (**Plates 109b,c,d**).

197. Pyracantha (*Pyracantha crenulata* [D. Don] M. Roemer) is a spiny shrub which is distributed from Kashmir to southwestern China and Myanmar. It is found in shrubberies, open places, and cultivated areas at altitudes of from 1,200-2,400m. The plant usually bears crowded, narrow-oblong, blunt, and shining leathery leaves. It blossoms during April and produces numerous small white flowers in axillary clusters arranged along the branches. It is a medium source of both nectar and pollen and is visited by both *Apis cerana* and *Apis mellifera*. Since this plant blossoms during April, it contributes to the main flow, but bees do not produce pure honey from this plant. Therefore, information on the physico-chemical characteristics of its honey is not available. Its pollen is yellow in colour. Each pollen grain is small (29.7 ± 1.2 µm long and 28.5 ± 0.9 µm broad), oval/triangular in shape, and tri-colporate with a smooth exine sculpture.

198. The wild pear (*Pyrus pashia* Buch-Ham. ex D. Don) is a small or medium-sized deciduous tree, it sometimes has spines. It occurs in the subtropical to temperate Himalayas from Kashmir, India, to western China at altitudes of from 750-2,700m. This plant blossoms during February-March and produces white flowers which are 2.0-2.5cm across and produce good amounts of nectar and pollen. The flowers are visited

110. Pyrus pashia; Ref. **plant no. 198**

eagerly by *Apis cerana* and *Apis mellifera* (**Plate 110**). It is a medium source of nectar during spring and also contributes to surplus honey production by strong colonies. However, information on the physico-chemical characteristics of its honey is not available. Its pollen is yellow in colour. The pollen grains of this species are medium in size (30.1 ± 1.04 µm long and 27.3 ± 2.6 µm broad), oval, and tri-colporate with a smooth exine sculpture.

199. Sumac (*Rhus javanica* L.; Syn. *R. semialata* Murray; *R. chinense* Miller) is a five to eight metres tall, deciduous pubescent tree, distributed throughout the temperate Himalayas from Jammu and Kashmir (India) to Nepal. It is common in pine and oak forests. It is also planted as an ornamental plant for landscape decoration. It blossoms during September-October and produces small (0.3 cm), greenish white flowers which occur in 30-40cm-long axillary or terminal panicles. *Apis cerana* and *Apis mellifera* visit its flowers primarily for nectar, and they also collect pollen (**Plate 111**). It is a medium source of nectar and pollen. In the areas where it occurs abundantly, the strong colonies can produce surplus honey from its flow. There is no information on the physico-chemical characteristics of its honey. Its pollen is yellow and the pollen grains are medium in size, round, tri-colporate with a striated exine sculpture.

200. White rhus (*Rhus succedanea* L.) is a deciduous tree, from five to ten metres tall. It occurs in the temperate Himalayas from India to Bhutan, China, and Nepal at altitudes of from 1,500-2,000m. It blossoms during May-June and produces small, yellowish green flowers

111. *Rhus javanica*;
Ref. **plant no. 199**

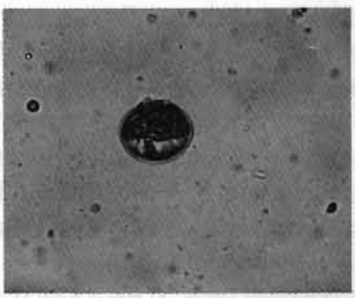
which secrete large amounts of nectar and pollen. It is also a medium source of these products. It is much sought after by *Apis cerana* and *Apis mellifera*. In the areas where it occurs in abundance, strong colonies can produce surplus honey from its flow. There is no information on the physico-chemical characteristics of its honey. The structure of its pollen grains is similar to that of *Rhus javanica*.

201. Rhus (*Rhus verniciflua* Stokes.) is a deciduous tree, seven-ten metres tall, with a rough, grey, and vertically fissured bark. It is found in southern Tibet and the Hengduan mountain range, occurring on slopes, in gullies, and along rivers at an altitude of 1,500m. It blossoms during May-June for about one month and secretes nectar for about 25 days (Bangyu et al. 1996). In the Chinese Himalayas, it is a major source of both nectar and pollen. It is visited by both *Apis cerana* and *Apis mellifera*. An *Apis cerana* colony can produce about 30kg of honey from its flow. The only available information on the characteristics of its honey shows that it is light yellow in colour and slightly bitter in taste (Bangyu et al. 1996). Data on the pollen grain features are not available.

202. Black rhus (*Rhus wallichii* Hook. F.) is a small, tomentose tree, about six metres tall. It is distributed throughout the temperate Himalayan zone from India to Nepal at altitudes of from 1,500-1,900m; it is common in open places. Its wood is used for saw frames, axe handles, and musical instruments. A varnish is made out of the juice tapped from the tree. The wax contained in the fruit is used for making candles (Dastur 1985). The plant blossoms during April-May and produces subsessile, greenish white flowers in long axillary panicles. Its flowers yield good amounts of nectar and pollen and are frequently visited by *Apis cerana* and *Apis mellifera*. It is a medium source of nectar and pollen. There is no information on the physico-chemical characteristics of its honey and the pollen grain features.

112a. Rubus ellipticus; Ref. ***plant no. 203***

112b. Rubus ellipticus. OS (PV); Ref. ***plant no. 203***



112c. Rubus ellipticus. SV; (EV); Ref. ***plant no. 203***

203. The raspberry species (*Rubus ellipticus* Smith) is an evergreen shrub with a stout stem covered with rufous bristles and recurved spines. It is distributed throughout the subtropical to temperate Himalayan areas of China, India, Nepal, and Pakistan at altitudes of up to 2,300m. It is found in shrubberies and cultivated areas and is also common around villages. It blossoms during March-April and produces white flowers in short, densely-branched clusters. Honeybees (*Apis cerana* and *Apis mellifera*) visit the flowers for nectar and pollen (**Plate 112a**). It is a medium source of nectar and pollen. In the areas where it grows in abundance, strong colonies can produce surplus honey. There is no information on the physico-chemical characteristics of its honey. Its pollen is light in colour and the pollen grains are small (21.3$\pm$1.0 µm long and 20.8$\pm$1.6 µm broad), almost round, and tri-colporate with a smooth exine sculpture (**Plates 112b,c**).

204. The raspberry species (*Rubus ulmifolius* Schott.) is a shrub, 1.5-2.0m in height, distributed throughout the temperate Himalayan zone. It is commonly found on hillsides and is also grown as a hedge plant. It blossoms during September-October and produces pink flowers which produce good amounts of nectar and pollen. It is visited by both *Apis cerana* and *Apis mellifera*. It is a major bee plant, yielding 21.5 kg of honey/colony/12 days with *Apis mellifera* (PARC 1977). There is only a little information on the physical characteristics of its honey which indicates that it is light in colour and granulates very rapidly, even in the combs. Its pollen grain structure resembles that of *Rubus ellipticus*.

205. The raspberry species (*Rubus setchuenensis* Bur. et Frach.) is a deciduous rambling shrub with dense grey-brown stems covered with fine hairs. It is found in the Hengduan mountain areas at altitudes of from 1,600-2,700m, occurring in sparse woods and on barren hills and slopes. It blossoms during July-August for about 25 days and produces purplish-red flowers in terminal or axillary clusters. Plants at higher altitudes blossom earlier than those at lower altitudes. The plant secretes good amounts of nectar and pollen. Nectar secretion is highest on a fine day just after rainfall. The most favourable temperature for nectar secretion is above 18°C. Since it blossoms at a time when there is a dearth, its flow is very beneficial for brood rearing and colony build-up as well as for honey production by strong colonies. It is visited by both *Apis cerana* and *Apis mellifera*. An *Apis cerana* colony can produce seven-10kg of honey from its flow and the honey is light in colour, thin, and has a sweet flavour (Bangu et al. 1996). Information is not available on the physico-chemical characteristics of its honey and the pollen grain features.

206. The white willow (*Salix alba* L.) is a tall tree, over 40m in height. It is distributed throughout the Himalayan region from Afghanistan to

China at altitudes of up to 1,500-3,000m. It is also planted as an amenity tree. It yields timber, fuelwood, and osiers for baskets. The tree blossoms during February and produces good amounts of nectar and pollen for bees. Since it blossoms early in the season, its flow helps to facilitate brood rearing and to increase colony strength. Strong colonies can collect surplus honey from its flow. It is a major source of nectar and pollen and is visited by *Apis cerana* and *Apis mellifera*. Its honey potential is estimated to be from 100-150kg/ha (cf statistics for Romania in Cirnu et al. 1976). However, information is not available on the physico-chemical characteristics of its honey and the pollen grain features.

It also produces honeydew which is collected by honeybees. Honeydew is produced from the *Tuberolachnus salignus* (Gmelin.) of the *Lachnidae f.* This honeydew flow may be very heavy. With *Apis mellifera,* it can yield up to 20kg of honey/colony (cf statistics on Romania in Cirnu et al. 1976). Another insect which produces honeydew is *Pterocomma salicis* L., of the *Aphidae* Family. *Salix* honeydew is not suitable for honeybees during winter.

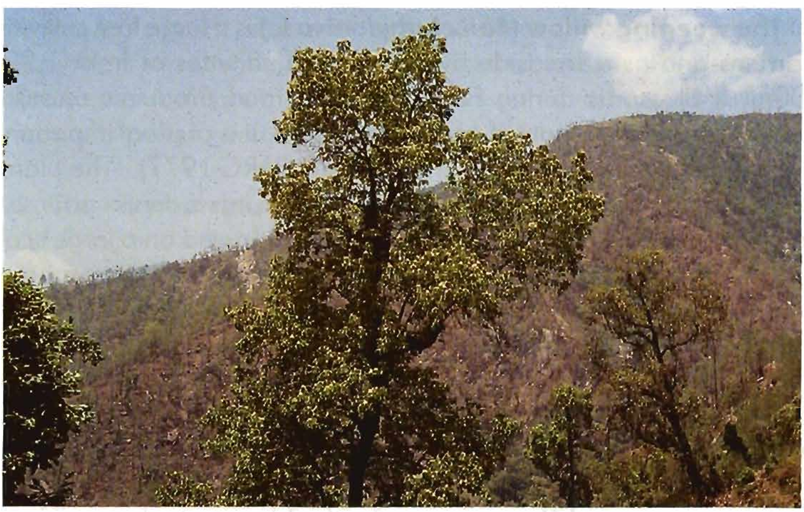
207. The weeping willow (*Salix babylonica* L.) is a large tree cultivated in gardens and as a roadside avenue tree at altitudes of from 1,200-2,000m. It blossoms during February-March and produces unisexual catkins which secrete plenty of nectar and pollen. It is of great importance for beekeeping in India, Nepal, and Pakistan (PARC 1977). The plant is visited by both *Apis cerana* and *Apis mellifera*. It is a major source of nectar and pollen, especially in areas where it is planted on a large scale, e.g., in the Kathmandu Valley. However, there is no information on the physico-chemical characteristics of honey and the pollen grain features of this plant.

208. The willow (*Salix denticulata* Andersson or Syn. *S. elegans* Wall. ex Andersson) is a shrub growing up to heights of three metres, distributed from Afghanistan to central Nepal at altitudes of from 1,800-3,700m. It is commonly found in forests, shrubberies, and open places. The shrubs blossom for a long period from March to May and produce unisexual catkins; the male catkins are about four centimetres long and the female catkins are two to five centimetres long, growing on short leafy shoots. These secrete good amounts of nectar and pollen and are of great importance for beekeeping. However, there is no information on the physico-chemical characteristics of its honey and the pollen grain features.

209. The crack willow (*Salix excelsa* S. Gmelin or Syn. *S. fragilis* auct. non L.) is a tree cultivated in gardens and as an avenue tree along roadsides at altitudes of from 1,200-2,000m. It blossoms during February-March and produces unisexual catkins which secrete plenty of nectar and pollen. It is of great importance for beekeeping. But information is not available on the physico-chemical characteristics of honey and the pollen grain features of this plant.

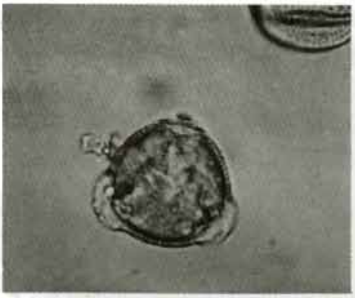
210. The crack willow species (*Salix acmophylla* Bioss.) is a tree cultivated in gardens and as an avenue tree along roadsides at lower altitudes below 1,000m. It blossoms during February-March and produces unisexual catkins which secrete plenty of nectar and pollen. It is reported to be of minor importance for beekeeping in Pakistan (PARC 1977). The bees do not collect surplus honey from this plant.

Other species of *Salix* which are reported to be of minor importance for beekeeping in countries of the HKH region include *S. caesia, S. flabellaris, S. julacea, S. karelinni, S. pychnostachya, S. tetrasperma, S. turanica,* and *S. viminalis* (PARC 1977).

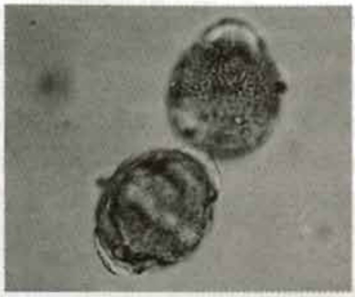


113a. *Schima wallichii*; Ref. **plant no. 211**

211. The needle wood (*Schima wallichii* (DC.) Korth) is a small or large evergreen tree with leathery foliage. It is distributed throughout the subtropical and temperate Himalayas from central Nepal to southwestern China at altitudes of from 1,200-2,000m. It is very common in forests and cultivated areas. It blossoms during May-June and produces showy terminal clusters of white fragrant flowers (**Plate 113a**). Its flowers are three to four centimetres across and yield good amounts of nectar and pollen, and it is visited by *Apis cerana* and *Apis*



113b. Schima wallichii. OS (PV); Ref. **plant no. 211**



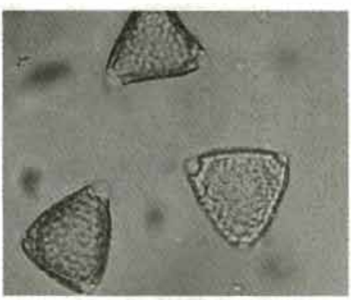
113c. Schima wallichii. SV (EV); Ref. **plant no. 211**

mellifera. It is a medium source of nectar and pollen and, in areas where it grows in abundance, strong bee colonies can produce surplus honey from its flow. Its pollen is yellow in colour. Information is not available on the physico-chemical characteristics of its honey. Needlewood pollen is yellow in colour, the pollen grains are medium-sized (37.4 ± 1.04 µm in diameter), round, and tri-colporate with a reticulate exine sculpture (**Plates 113b,c**).

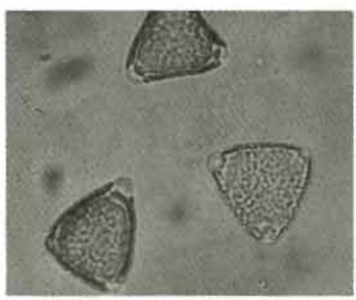
114. Shorea robusta; Ref. **plant no. 212**

212. Sal (*Shorea robusta* Gaertn F.) is a large gregarious timber tree. The mature leaves are glabrous, shining, and measure from 10-25cm long. It occurs in the subtropical and sub-temperate Himalayan areas at altitudes of up to 1,800m. Its bark is rich in tannin. A commercially valuable gum called *sal dammer* is obtained from the stem from which an oil called *chua* oil is distilled. Sal butter is obtained from the seeds and is used as a cooking agent and also as a substitute for cocoa butter in chocolates. It blossoms during March-April and produces yellowish flowers in panicled racemes (**Plate 114**). The flowers are visited by *Apis cerana* and *Apis mellifera* for both nectar and pollen. Bees produce surplus honey from its flow. The only information available on sal honey shows that it is slightly bitter in taste. There is no other information on the physico-chemical characteristics of its honey and the pollen grain features.

115a. Symplocos paniculata; Ref. ***plant no. 213***



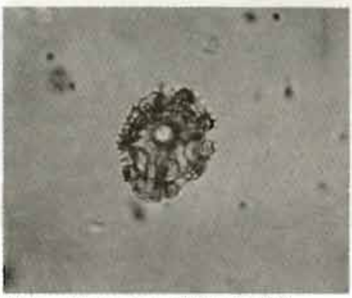
115b. Symplocos paniculata. OS; Ref. ***plant no. 213***



115c. Symplocos paniculata. SV; Ref. ***plant no. 213***

213. Symplocos (*Symplocos paniculata* (Thunb) Miq or Syn. *S. crataegoides* Buch-Ham ex D. Don) is large deciduous shrub or medium-sized tree, distributed throughout the subtropical to temperate Himalayan areas of Pakistan to southwestern China, Burma, and Nepal at altitudes of up to 1,000-2,700m. Its leaves are used for fodder and the bark gives a yellow dye. It blossoms during April-May and produces snow-white fragrant flowers in cylindrical, branched clusters on lateral stems. Its flowers are eight-10mm across and are visited in preference to others by both *Apis cerana* and *Apis mellifera* for nectar and pollen (**Plate 115a**). Information is not available on the physico-chemical characteristics of its honey. Its pollen grains are medium in size (34.2±3.1 µm long and 28.5±4.6 µm broad), oval, and tri-colporate with a reticulate exine sculpture (**Plates 115b,c**).

116a. *Taraxacum officinale*; Ref. **plant no. 214**

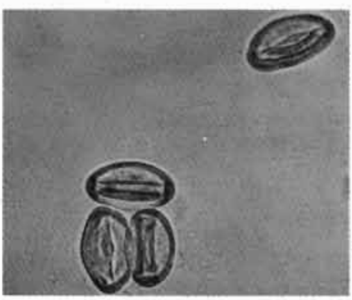


116b. *Taraxacum officinale*. OS; Ref. **plant no. 214**

116c. *Taraxacum officinale*. SV; Ref. **plant no. 214**

214. The dandelion (*Taraxacum officinale* Weber; Syn. *T. dens-leonis* Desf.) is a perennial herb, native to Europe. It is distributed throughout the Himalayan region of China, India, Nepal, and Pakistan at altitudes of up to 1,800m. It is commonly found in pastures, on lawns, and on wastelands. Dandelion leaves are used for salad, the flowers for making wine, and the roasted roots as a substitute for coffee. The whole plant is also used medicinally. It blossoms during spring and summer from February to May and produces bright yellow flowers (**Plate 116a**). It is a major bee plant in China, yielding both nectar and pollen (Tseng 1954). Nectar secretion is 1.0-19.0mg/flower/day and sugar concentration in the nectar ranges from 11.6-72.7 per cent (cf figures for Germany in Demianowicz 1979); the flowers are visited by both *Apis cerana* and *Apis mellifera*. Nectar secretion and sugar concentration in nectar vary depending upon the soil and climatic conditions. The honey yield with *Apis mellifera* from this plant is 50-90kg/colony/season (cf figures for Alberta, Canada in Lovell 1962). Dandelion honey is thick, an intense golden yellow in colour and has a sharp flavour. It granulates rapidly with coarse, hard grains (Crane 1975). It contains 40.1 per cent glucose, 49.1 per cent fructose, 6.3 per cent sucrose, 2.1 per cent maltose, 1.7 per cent fructomaltose, and 0.3 per cent melezitose. It is acidic and the pH value is 4.3. Dandelion pollen is orange in colour. The pollen grains are medium in size (34.2 ± 2.1 µm in diameter), round, have three pores, and have a fenestrate exine sculpture (**Plates 116b,c**).

117a. *Vitex negundo*; Ref. **plant no. 215**



117b. *Vitex negundo*: OS; Ref. **plant no. 215**

215. Indian privet or Vitex (*Vitex negundo* L.) is a large deciduous shrub or small tree of up to six metres in height with whitish hairy branches and digitate leaves. It is distributed throughout the Himalayas from Afghanistan to Bhutan, India, and China at altitudes of up to 2,000m.

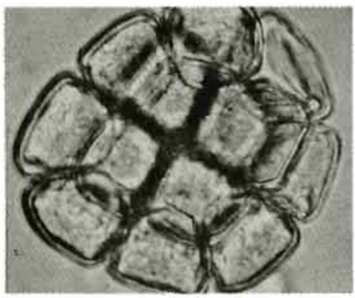
It is a common plant on wastelands; and it is often planted as a hedgerow plant on the borders of farmlands. Its branches are used for wattle work and baskets; the leaves are used in grain storage to keep insects away. The leaves, roots, and fruits are used medicinally. The plant also provides ground cover on steep slopes for checking soil erosion. Its blossoming period is very long, i.e., from April to October. It produces small, pale mauve flowers in branched clusters forming a long terminal, branched pyramidal inflorescence. It is visited by both *Apis cerana* and *Apis mellifera*. It is a major source of nectar (**Plate 117a**) in areas where it occurs in abundance. In such areas, an *Apis cerana* colony can produce 20-25kg of honey from its flow. Information on its physical characterictics shows that vitex honey is of good quality; it is light in colour and has a sweet flavour (Bangyu et al. 1996). There is no information on the chemical characteristics of its honey. Its pollen is off-white in colour and the pollen grains are small (25.1 ± 2.0 µm long and 14.9 ± 1.2 µm broad) and elongated, with three pores and a smooth exine (**Plate 117b**).

216. Polygonum (*Polygonum* spp) - More than fifteen species of *Polygonum* are distributed throughout the Hindu Kush-Himalayan region. These occur gregariously in forests, shrubberies, and in damp places. The leaves of some species are eaten as vegetables. *Polygonum* spp blossom from May to September and provide a good amount of nectar and some pollen to both *Apis cerana* and *Apis mellifera*. It is considered to be a minor source of nectar and pollen in Nepal (Kafle 1979) and the bees do not collect surplus honey .

217. The coral tree (*Erythrina suberosa* Roxb.) is a medium-sized tree with spiny, corky, and deeply-fissured bark. It is found in Bhutan, India, Nepal, and Myanmar, occurring in forests and cultivated areas at altitudes of from 900-1,200m. It blossoms during March-April and produces scarlet red flowers appearing before or with young leaves. It produces good amounts of nectar and pollen and is considered to be a medium source of both nectar and pollen. It is visited by both *Apis cerana* and *Apis mellifera*. Information is not available on the physico-chemical characteristics of its honey.

218. The Persian acacia (*Albizia julibrissin* Durazz. or Syn. *Albizia mollis* Wallich) is a medium-sized deciduous tree, found from Pakistan to Bhutan at altitudes of from 1,000-2,100m. It occurs in forests, on the sides of rivers, and in cultivated areas; it is often planted as a shade tree. The tree yields fodder and fuelwood. It blossoms during April-May and produces globular, stalked pink flower heads of numerous, small

118a. Albizia julibrissin; Ref. **plant no. 218**



118b. Albizia julibrissin: OS ; Ref. **plant no. 218**

fragrant flowers with long pink filaments which are 2.5-3.2cm-long. It is a minor source of nectar and pollen and bees do not produce surplus honey from its flow. Its flowers are visited by both *Apis cerana* and *Apis mellifera* (**Plate 118a**). Its pollen grains are aggregated (polyad). Each polyad is made up of sixteen single pollen grains (monads). Each monad (single grain) is small (26.9 ± 1.9 µm long and 24.8 ± 0.9 µm broad), almost round or oval, with three furrows and a granular exine sculpture (**Plate 118b**).

219. The black siris (*Albizia chinensis* (Osbeck) Merr. or Syn. *A. stipulata* Roxb.) is a large deciduous timber tree with a flat-topped crown, occurring in the tropical and subtropical Himalayas from Pakistan to northeastern India and China at altitudes of from 300-1,300m. It is planted as a shade tree in tea gardens, and its leaves are used as fodder. It blossoms during May-June and produces yellowish white flowers with long white filaments which are visited by both *Apis cerana* and *Apis mellifera*. It is also a minor source of nectar and pollen and helps sustain bee colonies during the dry summer months. Bees do not produce surplus honey from its flow. The structure of the pollen grain is similar to that of *Albizia julibrissin* except that it is slightly smaller in size (24.8$\pm$1.5 µm long and 19.8$\pm$1.8 µm broad).

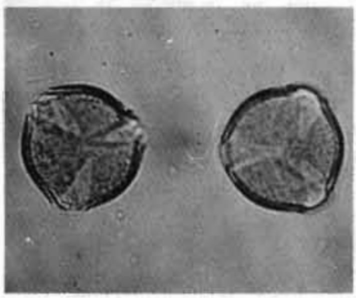
220. The white siris (*Albizia lebbek* Benth.) is a large deciduous tree, distributed throughout the subtropical and temperate Himalayas, up to altitudes of 2,000m. The tree yields fodder and fuelwood. It blossoms during May-June and produces fragrant yellow flowers in pedunculate heads which are solitary or in fascicles. It is a minor bee plant and bees do not produce surplus honey from its flow. The structure of the pollen grain is similar to that of *Albizia julibrissin,* except for the difference in size.

221. Siris (*Albizia odoratissima* Benth.) is a deciduous tree distributed throughout the subtropical and sub-temperate Himalayan areas. It blossoms during April-June, is a minor source of nectar and pollen, and bees do not produce surplus honey. The structure of the pollen grain is similar to that of *Albizia julibbrissin,* except for the difference in size.

119. Amaranthus spinulosus; Ref. ***plant no. 222***

222. The spiny amaranth (*Amaranthus spinulosus* L.) is an erect, glabrous herb distributed widely throughout the subtropical and warm temperate Himalayan zones up to altitudes of 1,500m. It grows in open sunny places on wastelands, on roadsides, and in cultivated areas. Once mature, this species blossoms continuously from June to August. Honeybees (*Apis cerana* and *Apis mellifera*) frequently visit its flowers (**Plate 119**). It is an important source of pollen and helps to sustain bee colonies during the slack summer period. The plant does not yield honey because it produces pollen only. Its pollen is creamy yellow; each grain is small in size (29.6 ± 1.3 μm in diameter) round/triangular, with many pores and a smooth exine sculpture.

120a. Cassia fistula; Ref. ***plant no. 223***

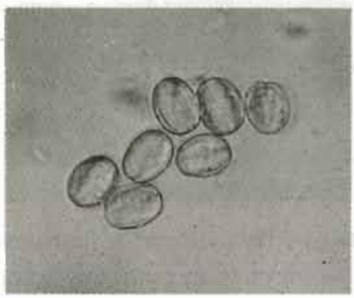


120b. Cassia fistula: OS; Ref. ***plant no. 223***

223. The Indian laburnum (*Cassia fistula* L.) is a moderately-sized deciduous tree; very showy when in flower. It is distributed throughout the subtropical and sub-temperate Himalayas up to altitudes of 1,400m. It occurs in the forests and is also planted as an ornamental and avenue tree along roadsides. The pulp of its fruit is used as a purgative. The wood is used for making agricultural implements, fence posts, etc and the bark is used for tanning and dyeing. It blossoms during April-May and produces long-stalked, yellow flowers in drooping racemes up to 60cm long (**Plate 120a**). It primarily yields pollen, though honeybees (*Apis cerana* and *Apis mellifera*) also collect nectar from extrafloral nectaries (Thakur 1991). It is a medium source of pollen and nectar. There is no information on the physico-chemical characteristics of its honey. Its pollen is yellow in colour and the pollen grains are medium-sized (30.5 ± 2.4 μm in diameter), round, and tri-colporate, with a granular exine sculpture (**Plate 120b**).

224. *Colebrookia oppositifolia* Sm. is a large shrub, about two metres in height. It is distributed throughout the Himalayan region of China, India, Nepal, and Myanmar, occurring on open and dry slopes. It blossoms for a long period from December to May and produces white flowers in dense spikes crowded in axillary and terminal panicles. It provides a good amount of pollen and supports bee colonies for a long period of about six months. It is a major pollen source in Nepal (Kafle 1984) and is visited by both *Apis cerana* and *Apis mellifera*. The flowers secrete little (which the bees do not collect) or no nectar.

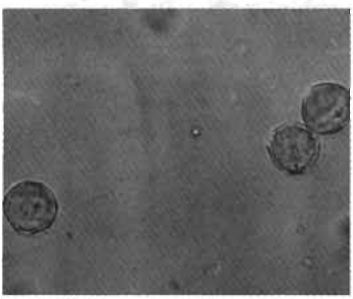
121a. Castanopsis indica; Ref. ***plant no. 225***



121b. Castanopsis indica: OS; Ref. ***plant no. 225***

225. Castanopsis (*Castanopsis indica* (Roxb.) A. DC.) is a large, many-branched evergreen forest tree about 10-15m tall. It is distributed throughout the subtropical and temperate Himalayas up to altitudes of from 300-2,900m. The tree yields fuelwood and timber and the fruits are edible. It blossoms during September- October. The flowering spikes are cream coloured, long, erect and clustered. The male spikes are panicled, 5-20cm long, and clustered and the female spikes are up to 20cm long and are not panicled. The flowers are visited by both *Apis* *cerana* and *Apis mellifera* to collect nectar and pollen (**Plate 121a**). It is a medium source of nectar and a minor source of pollen. Information is not available on the physico-chemical characteristics of castanopsis honey. The pollen grains are very small ($19.9\pm1.1\,\mu m$ long and $12.8\pm1.5\,\mu m$ broad), elongated, and tri-colporate with a smooth exine sculpture (**Plate 121b**).

122a. Woodfordia fruticosa; Ref. ***plant no. 226***



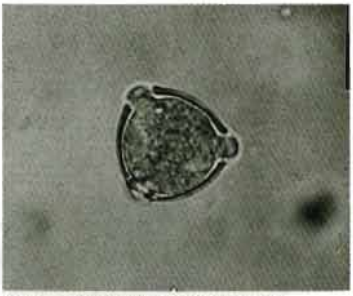
122b. Woodfordia fruticosa: OS; Ref. ***plant no. 226***

226. Dhawi (*Woodfordia fruticosa* (L.) Kurz) is an evergreen shrub, one to two metres in height with spreading branches, occurring in light forests and on open slopes. It is found in subtropical to temperate Himalayan areas of Pakistan to southwestern China, India, and Burma, at altitudes of from 300-1,800m. A yellow dye is obtained from its leaves and twigs and a red dye from the flowers. The bark and flowers also have medicinal properties. The leaves are used for fodder and the stems for fuelwood. It blossoms in March-April and produces short, dense clusters of bright red tubular flowers. The *Woodfordia* flowers produce large quantities of nectar, but its sugar concentration is low. Honeybees (*Apis cerana* and *Apis mellifera*) collect both nectar and pollen from its flowers (**Plate 122a**). It is a major source of nectar and pollen. Information on the physico-chemical characteristics of its honey is not available. Its pollen is yellowish brown in colour. Pollen grains are small (15.2±1.5 μm in diameter), round, and tri-colporate with a smooth exine sculpture (**Plate 122b**).

123. *Paulownia elongata*; Ref. **plant no. 227**

227. Paulownia (*Paulownia elongata* S.Y. Hu) is a fast-growing tree over 25m tall. It is found in subtropical to temperate areas in China at altitudes of from 1,400-2,000m; it is planted for timber and wood pulp. It blossoms during February-March and produces 3.3-4.0cm-long flowers yielding both nectar and pollen (**Plate 123**). It is a major bee plant in China (Xu 1993) and is visited by both *Apis cerana* and *Apis mellifera*. Information is not available on the physico-chemical characteristics of its honey. The pollen is greyish white in colour. Pollen grains of this species are small (21.3±1.8 μm long and 16.6±1.7 μm broad), elongated and oval, and tri-colporate with a smooth exine sculpture.

228. Prinsepia (*Prinsepia utilis* Royle) is a spiny green-stemmed shrub with a height of up to three metres. It is found from Pakistan to western China at altitudes of from 1,200-3,000m. It occurs on open and dry grassy slopes as well as in shady places. The high mountain farming communities of remote inaccessible areas use it as an edible oil source. Prinsepia oil has medicinal properties also. It blossoms during April-May and October-November and produces seven to 15mm white flowers in short axillary racemes. It is a medium source of nectar and pollen for honeybees (*Apis cerana* and *Apis mellifera*). Information on the physico-



124a. Prinsepia utilis: OS (PV); Ref. **plant no. 228**

124b. Prinsepia utilis: SV (EV); Ref. **plant no. 228**

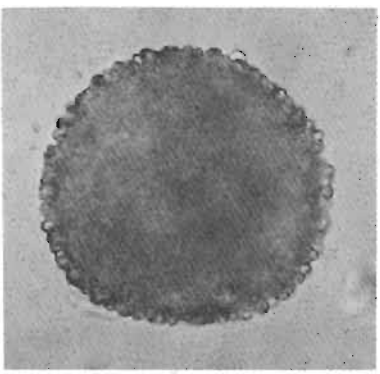
chemical characteristics of its honey is not available. Its pollen grains are small (26.6$\pm$1.9 μm in diameter), round, and tri-colporate with a smooth exine sculpture (**Plate 124a, b**).

229. *Maesa chisia* buch-ham ex d.Don. is a gregarious shrub or small tree found from western Nepal to southeastern Tibet and Myanmar. It occurs in forests and shrubberies at altitudes of from 1,200-2,400m. It blossoms during March-April and produces lax spikes of small fragrant, white flowers. Its flowers are four mm across, cup-shaped, and produce a good amount of nectar and pollen for honeybees (*Apis cerana* and *Apis mellifera*). It is a minor source and bees do not collect surplus honey from this plant.

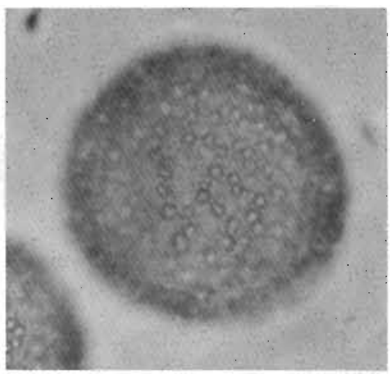
230. *Innula cappa* (Buch.-Ham. ex D.Don) DC is a gregarious, aromatic shrub with woolly or silky-haired branches, leaves, and inflorescence. It is found in the Himalayan region from India to southwestern China. It occurs gregariously in shrubberies and open places at altitudes of from 1,000-2,400m. It blossoms for a long period from September to February and produces small, yellow flower-heads in large, terminal-domed clusters, eight cm or more across. Honeybees (*Apis cerana* and *Apis mellifera*) collect both nectar and pollen. It is a major source of pollen and a minor source of nectar, therefore bees do not collect surplus honey from this plant. Data on the pollen grain features of this plant are not available.

231. Jatropha (*Jatropha curcas* L.) is a large shrub, three to four metres tall. It is found in the foothills of the Himalayan region of China, India, Nepal, and Pakistan. It is also grown as a hedgerow plant. Its seeds yield curcas oil or jatropha oil, which is used for illumination because it burns without emitting smoke. The oil is also used in soaps. A black or dark blue dye is obtained from the bark and the juice of the plant. The plant blossoms during April-May and produces monoecious flowers of

125a. Jatropha curcas; Ref. ***plant no. 231***



125b. Jatropha curcas: OS; Ref. ***plant no. 231***

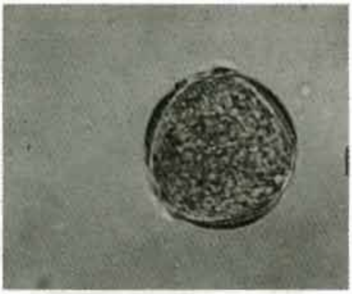


125c. Jatropha curcas: SV; Ref. ***plant no. 231***

a creamish yellow colour in loose panicles of cymes. Honeybees (*Apis cerana* and *Apis mellifera*) visit its flowers for nectar (**Plate 125a**). It is a minor source of support to bee colonies during the slack summer months. Bees do not collect surplus honey from this plant. Its pollen grains show great variations in size. Generally, these are large in size (76.1 ± 7.3 µm long and 66.7 ± 9.2 µm broad), oval, and tri-colporate with a clavate exine sculpture (**Plates 125b,c**).

232. Ipil-ipil (*Leucaena leucocephala* (Lam.) De Wit) is native to Mexico, and it is found in the subtropical to warm temperate Himalayan zones at altitudes of up to 1,600m. It is a small tree, growing up to five metres tall, commonly found on marginal or wastelands; it is also planted to stabilise slopes. It yields fuelwood and the leaves are used for fodder.

126a. *Leucaena leucocephala*; Ref. **plant no. 232**



126b. *Leucaena leucocephala*: OS; Ref. **plant no. 232**

The roots fix atmospheric nitrogen and help soil conservation. It blossoms during September-October. Its minute, creamy white fragrant flowers are produced in a ball-like inflorescence about 1.5-2.0 cm in diameter. These are visited by honeybees (*Apis cerana* and *Apis mellifera*), mainly for pollen (**Plate 126a**). The bees do not collect honey from this plant because the flowers do not secrete nectar. Ipil-ipil pollen is creamy white; each pollen grain is large (58.3 ± 2.3 µm in diameter), round, and tri-colporate with a granular exine sculpture (**Plate 126b**).

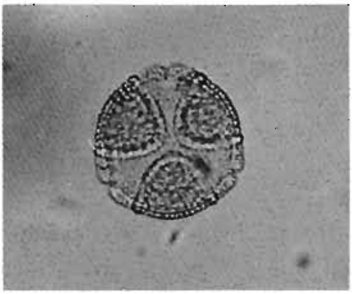
233. *Rosa brunonii* Lindley is a stout climber with hooked prickles, found from Kashmir to southwestern China and Myanmar at altitudes of from 1,200-2,400m. It blossoms from April to June and produces terminal clusters of many white, fragrant flowers, each 2.5-4.0 cm across. It is a major source of pollen and a minor source of nectar and is visited by both *Apis cerana* and *Apis mellifera*. Bees do not collect surplus honey from this plant. Its pollen grains are grey in colour, large in size (50.6 ± 1.6 µm long and 45.6 ± 2.7 µm broad), oval, and tri-colporate with a smooth exine sculpture.

234. *Rosa laevigata* Michaux is a native of China. It is distributed throughout the subtropical and temperate Himalayan regions at altitudes of up to 2,400m. It is a stout climber which blossoms from April to June and produces solitary, white, fragrant flowers. It is also a major source of pollen and a minor source of nectar, therefore bees do not collect surplus honey from it. It is visited by both *Apis cerana* and *Apis mellifera*. The pollen grains are similar to those of *Rosa brunonii*, except that they are smaller in size (41.1 ± 2.5 µm long and 34.2 ± 3.2 µm broad).

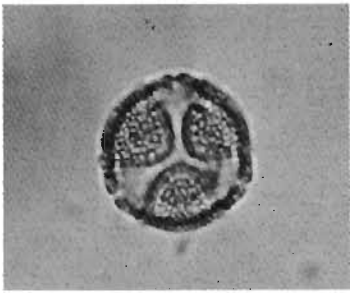
235. *Rosa macrophylla* Lindley is an upright shrub, three to five metres in height, with a dark purple stem bearing a few prickles. It is found from Pakistan to southwestern China at altitudes of from 2,100-3,500m in forests and shrubberies. It blossoms during June-July and produces large, often solitary, bright pink flowers which provide pollen to bees. It is a major source of pollen and a minor source of nectar, therefore bees do not collect surplus honey from it. The pollen grains are similar to those of *Rosa brunonii*, except that they are small in size (27.5 ± 1.4 µm long and 20.5 ± 0.7 µm broad).

127a. Rosa moschata; Ref. ***plant no. 236***

236. *Rosa moschata* Miller is similar to *Rosa brunonii* and is found in the northwestern Himalayas. It is distinguished by its smooth branches and leaf stalks without prickles. It blossoms from April to June and produces white flowers which are visited by both *Apis cerana* and *Apis mellifera* for pollen (**Plate 127a**). It is a major source of pollen and a minor source of nectar. The bees do not collect surplus honey from this



127b. Rosa moschata. OS; Ref. plant no. 236



127c. Rosa moschata. SV; Ref. plant no. 236

plant. The structure of its pollen grains is similar to that of *Rosa brunonii* except that it is small in size, i.e., 24.8±2.2 µm long and 22.6±2.2 µm broad (**Plates 127b,c**).

237. *Rosa sericea* Lindley is distributed throughout the temperate Himalayas from Himachal Pradesh (India) to China and Myanmar at altitudes of from 2,100-4,500m. It is found in forests, shrubberies, and cultivated areas. It is a stiff erect shrub with usually hairless twigs; leaves with small leaflets and a solitary axillary or drooping, white or cream flowers with four petals which are four to six centimetres across. It blossoms from May to August and provides pollen to bees. It is a major source of pollen and a minor source of nectar and is visited by both *Apis cerana* and *Apis mellifera*. Bees do not collect surplus honey from this plant. The structure of its pollen grains is similar to that of *Rosa brunonii,* except that it is small in size (33.5±1.9 µm long and 31.8±1.5 µm broad).

Plant Sources of Honeydew Honey

There are three legitimate sources from which honeybees collect the basic materials for making honey. These include the nectar which is produced by the floral and extrafloral nectaries, and these have already been discussed in previous chapters. The third source of nourishment from which bees can make honey is the secretions (honeydew) found on living parts of the plant. The plants on which honeydew is produced are called honeydew plants or sources of honeydew honey.

Honeydew is the sweet substance which is excreted on the plant surface by populations of small plant-sucking insects, which include aphids. These insects are adapted to penetrate the plant tissues by special feeding tubes or bristles through which they gain access to the plant sap. From this they extract the nutrients they require, while the remainder of the sap passes through their alimentary canals to be deposited on the plant surface.

Honeydew is a complicated substance and contains sucrose, fructose, glucose, higher sugars, amino acids, organic acids, and salts. It is attractive to bees, especially when good nectar plants are not available. Honeydew honey is dark in colour and strongly flavoured.

All the work on honeydew plants and their honey has been carried out only in Europe (Crane et al. 1984). These authors also compiled informat on abou the insects producing honeydew and the properties of honey. There are no reports from the countries of the HKH region. However, some plants on which honeydew is produced and the insects producing honeydew also found in this region are described below.

1. **The common larch or European larch (*Larix decidua* Miller or Syn. *Larix europea* DC.)** is a large timber tree, growing to heights of over 35m tall, planted widely in the temperate Himalayas at altitudes of from 2,400-4,000m for afforestation and amenities. The larch tree yields tannin from the bark and turpentine from its resin. It is also used for medicinal purposes. Honeydew is produced by the insect ***Cinara cuneomaculata* (del Guercio)**, previously known as ***C. boerneri* Hille Ris Lambers and *C. laricicola* Borner (*Lachnidae F.*)** (Crane et al. 1984). Honeydew flow from this insect species is important and occurs from July to October. Another insect, ***Cinara kochiana* (Borner),** previously known as ***Laricaria kochiana* (Borner) of *Lachnidae F***. also produces honeydew flow for a long period from June to November. A third insect producing honeydew is ***Cinara laricis* (Hartig)**, previously known as ***Lachnus muravensis* Arnhart and *Lachniella nigro–tuberculata* del Guercio *Lachnidae F.***. This flow also takes place from July to October. The honeydew and the honey it produces granulate very rapidly even on the tree itself and in combs. The honey contains 15.9 per cent glucose, 29.2 per cent fructose, 0.73 per cent sucrose, 0.5 per cent meso-inositol, 2.5 per cent turanose, 2.1 per cent raffinose, and 44.5 per cent melezitose.

2. **The Jerusalem pine (*Pinus halepensis* Miller)** is a large, evergreen timber tree, over 20m in height. It is distributed throughout the temperate Himalayas and is planted as a windbreak and for shade, afforestation, and amenity. The honeydew is produced by ***Marchalina hellenica* (Gennadius),** previously known as ***Monophlebus hellenicus***

(Gennadius), of *Margarodidae* F. Its honey yield is high, about five-10kg/colony/year. The flow is abundant in autumn, and a heavy flow occurs from late June to March. Honeydew is also produced by an **unidentified insect**. Its honey contains nitrogen (14mg/100g dry weight), 54 free amino acids, and protein (64 mg/100g dry weight. It is dark in colour, possesses a characteristic flavour, and does not granulate.

3. **The Scotch pine (*Pinus sylvestris* L.)** is a large, evergreen timber tree, over 40m in height. It is planted for afforestation and amenity. It yields rosin and turpentine from resin, tar pitch, and pine oil by distillation. Honeydew is produced by ***Cinara cembrae* (Seitner) of the *Lachnidae* F.**, from July to September; by ***Cinara nuda* (Mordvilko) of the *Lachnidae* F.** and by ***Cinara pinea* (Mordvilko), *Lachnidae* F.,** from June to July. Honeydew is also produced by ***Marchalina hellenica* (Gennadius), *Margarodidae*.** The flow is heavy and prolonged, i.e., from late June to the following spring. Another insect producing honeydew honey is *Schizolachnus pineti* F., *Lachnidae*. Its honey contains 20.2 per cent water, 30.1 per cent glucose, 38.3 per cent fructose, and 0.44 per cent ash.

4. **The poplar (*Populus* spp.)** is a deciduous, usually dioecious tree, occurring in the temperate Himalayas at altitudes of from 1,500-2,500m. The tree yields timber. Many species of populus are planted for pulp-wood. Honeydew is produced on ***Populus alba, P. nigra, and P. tremula* by *Chaitophorus populeti* (Panzer), *Chaitophoridae* F.**. Honeydew flow from this insect is heavy and is collected by honeybees. Other insects are ***Pterocomma salicis* (L.), *Aphidae* F.** and ***Chaitophorus populeti*.** Flows are also intense from late May to mid-June. Still another insect producing honeydew from poplar is ***Pachypappa vesicalis* Koch, *Pemphigidae* F.** This flow is from May to early June. Another flow of crystallised honeydew containing 40 per cent melezitose is produced by an **unidentified insect**.

5. **The common oak (*Quercus robur* L.)** is a large timber tree, over 45m in height. It occurs in the temperate Himalayas. Oak timber is very hard and is used for ship-making. Honeydew is produced by ***Kermes quercus* (L.), *Kermesidae* F.** This flow is from mid-April to May or June. The honeydew tastes only slightly sweet, yet bees collect it actively in the afternoon. Honeydew is also produced by ***Lachnus iliciphilus* (del Guericio),** previously known as ***Schyzodryobius longilostris* (Mordvilko),** *Lachnidae* F. during June; and also by ***Lachnus roboris* (L.), *Lachnidae* F.** from May to July. A heavy flow with peak in May or

June and continuing till autumn is produced by ***Thelexes dryiphila* (Schrank), *Thelaxidae*.** Another insect producing honeydew flow is ***Tuberculatus annulatus* (Hartig),** previously known as ***Tuberculoides annulatus* (Hartig), *Calliphididae* F.** Peak flow is during mid-June to July. This insect is the most important producer of honeydew on oak. This honeydew granulates rapidly, bees collect it while liquid in the morning. Its honey is less dark in colour than other honeydew honeys. The flavour is sweet, also slightly sharp. However, honey from ***Quercus* spp** is not suitable as winter food for bees (Francisc and Emeric 1965).

6. Sugarcane (*Saccharum officinarum* L.) is a perennial crop of the plains and low hill areas of the Hindu Kush-Himalayan region. It is cultivated for its stem juice which is used to make sugar and molasses. The plant does not produce any nectar, but the bees are reported to forage on the sap exuding from the cut stems (Crane 1982). The sugar concentration of the sap is 18-24 per cent. The honey potential is calculated as possibly 1.25kg/ha. There is no evidence of collecting pollen by honeybees. Honeydew is produced by ***Melanaphis sacchari* (Zehntner)**, previously known as ***Aphis sacchari*, *Aphidae* F.** Honeydew is also produced by another insect called ***Perkinsiella saccharicida* Kirkaldy, *Delphacidae* F.** Honeydew is also produced by an **unidentified insect.** Sugarcane honey has a high sucrose content. It is dark in colour, has a strong distinct flavour, and granulates rapidly.

In addition to the plants mentioned above, honeydew is also produced by other plants which have already been described in section 5.1. These include maize (Serial no. 15), apple (Serial no. 35), mango (Serial no. 52), False Acacia (Serial no. 115) and white willow (Serial no. 206).

Plant Sources of Toxic Nectar and Pollen

Plants Secreting Nectar and Pollen Toxic to Honeybees

The nectar and pollen of some plant species are toxic to bees. In the dry season, dead or paralysed honeybees or bumble bees are sometimes found in large numbers under some plant species, e.g., some species of flowering lime tree. The poisoning is caused by the presence of certain sugars in nectar and pollen that bees can absorb but which they are unable to metabolise. When this accumulates above a critical level, the normal carbohydrate metabolism of the insect is blocked and the muscular activity ceases so that flight becomes impossible and death ensues. The sugar which is mainly responsible for this is mannose. This sugar has the same chemical formula as glucose ($C_6H_{12}O_6$) but the structural configuration of the atoms differs. Some plant species in the HKH region which secrete nectar or pollen toxic to honeybees are given in the following passages.

1. **Monkshood (*Aconitum* spp)** - The genus *Aconitum* includes about 100 species that contain diterpenoid alkaloids which accumulate in honey. Of these, the chemical structure of aconitine is known (Crosby 1971). However, the honey from this genus seems to be less toxic to bees than humans (Dengg 1928).

2. **The marsh marigold (*Caltha palustris*)** is associated with dead worker bees. Bioassays with nectarophagus insects revealed lethal dosages of insecticidal material in the bee cadavers (Roussy 1975).

3. **The foxglove (*Digitalis purpurea* L.)** is planted as an ornamental plant. It contains about a dozen cardiac glycosides, of which five are well-known (Barker 1990). The aglycones are derivatives of cyclopentanophenanthrene and the sugars are unique methylpentoses (Kingsbury 1964). Its pollen poisons bees when the plant is visited extensively by them (Muck 1936).

4. **Black henbane (*Hyoscyamus niger* L.)** is cultivated as a medicinal plant. The plant contains three alkaloids, namely, hyocyamine, hyoscine, and atropine (Kingsbury 1964). It kills both adults and brood when the bees forage on its blossoms (Shaginyan 1956).

5. **Tobacco (*Nicotiana tabacum* L.)** contains the insecticides nicotine, nornicotine, and basine. Eremie (1932) described the depopulated honeybee colonies that visited tobacco blossoms. He found a great number of bee colonies dying on the ground in the tobacco fields, their legs coated with a viscous substance resembling that on the tobacco blossoms. Bees visiting the flowers got their feet, bodies, and finally their wings coated. However, the published descriptions do not resemble typical nicotine poisoning (Barker 1990).

6. **The opium poppy (*Papaver somniferum* L.)** is reported to cause the mortality of foraging bees (Betts 1929). The stigmatal exudate is believed to be poisonous. The pollen has not been checked for toxicity.

7. **Black nightshade (*Solanum nigrum* L.)** is distributed worldwide and known to poison livestock and poultry. It produces pollen but little nectar. Vansell (1935) reported that the plant is deadly poisonous to bees, wherever it occurs. Dead bees were found on the plant and on the soil beneath. The toxin identified from this plant is solanine (a glycoalkaloid) which is composed of a sugar (solanose) and an alkamine (solanidine). Chemists have identified several di- and tri-saccharides in solanose and have found at least six amines from solanidine (Kingsbury 1964). How these are related to the dead bees reported is not known.

8. ***Camellia oleifera* Abel.** is an evergreen tree growing to heights of six metres with grey-brown, smooth bark. It is planted widely in the south of the Hengduan mountain range. It blossoms for a long period from October to December and produces white or red flowers. It provides large amounts of nectar and pollen for honeybees. Since its blossoming period is long and the flowers are rich in both nectar and pollen, it constitutes a major honey source. A colony of *Apis cerana* can produce 15-25kg of honey from its flow, but its nectar is toxic to honeybees, especially *Apis mellifera*, resulting in heavy losses of colonies (Bangyu et al. 1996).

Plant Sources of Honey Toxic to Man

Some of the plant species secrete poisonous nectar and degrade the quality of honey. Honeybees collect the nectar from these plants and convert it to honey as it is not harmful to bees. However, the honey from these plants is toxic to man, because of a toxic component of the nectar. Some of those listed by Crane (1977;1989) and Kafle (1992) occur at high or fairly high altitudes and include the following.

1. **The strawberry tree (*Arbutus unedo*)** occurs above 3,000m. Nectar from this plant contains arbutin (a glucoside) which is toxic to man.

2. **Prickly poppy (*Argemone mexicana* L.)** is a small herb growing to heights of one metre, occurring in the low hill areas at altitudes of up to 1,600m. It blossoms during May-June and produces large (3-5cm in diameter) yellow flowers on short leafy branches. Honey from this species is toxic to man (Kafle 1992).

3. **Belladona; deadly nightshade (*Atropa belladona* L.)** is an erect herb occurring in the Himalayan region at altitudes of from 1,800-

3,600m. It blossoms during August-September and produces pale-purple flowers tinged with yellow or green. Nectar from this plant contains an alkaloid called atropine which makes its honey poisonous to man. Honey from this plant is recorded to be highly poisonous (Kafle 1992).

4. **Mountain laurel (*Kalmia latifolia*)** is a plant that contains the same toxins as *Rhododendron* and other members of *Ericaceae* F., i.e, andromedotoxin or acetylandromedol. These toxins accumulate in the honey and make it toxic to people (Barton 1866; Plugge 1891; Pellett 1976). However, it is not clear whether its nectar and honey are safe for bees.

5. **Pieris (*Pieris formosa* (Wall.) D. Don)** is a small, evergreen shrub with dark leathery leaves. It is found in forests and shrubberies in the Himalayas at altitudes of from 2,100-3,300m. It is found from central Nepal to southwestern China. It blossoms during March-May and produces spike-like clusters of small white, globular pendant flowers. Its flowers secrete good amounts of nectar which honeybees collect and convert into honey, but its honey is reported to be toxic to man (Kafle 1992).

6. **The Alpine rose (*Rhododendron anthopogon* D. Don)** is a small, strongly aromatic shrublet of about 60cm in height. It is found from Pakistan to southeastern Tibet at altitudes of from 3,000-4,800m. It is common and occurs gregariously in alpine shrubberies and on open slopes. It blossoms from May to July and produces compact clusters of white or yellow flowers tinged with pink. Its nectar contains toxic substances called andromedotoxin and acetylandromedol which make its honey toxic to man (Crane 1989).

7. **The Alpine rose (*Rhododendron cinnabarinum* Hook f.)** is a shrub, more than one metre tall. It is found from eastern Nepal to southeastern Tibet at altidues of from 3,000-3,600m, occurring in forests and shrubberies. It blossoms during May-June and produces deep red, drooping waxy flowers in clusters of five. This species also has the same toxin as R. anthopogon. This toxin accumulates in honey and makes it toxic to people (Barker 1990; Kafle 1992).

8. **The Alpine rose (*Rhododendron ponticum*)** also has the same toxin as *Rhododendron anthopogon* and *R. cinnabarinum*, i.e.,

andromedotoxin. This toxin accumulates in honey and makes it toxic to man.

9. Monkshood (*Aconitum* spp.) has been described earlier under section 5.3A, Serial no.1.

Annexes

Annex 1
Inventory of Miscellaneous Bee Flora

More than one thousand plant species of various agricultural, horticultural, and forage crops; ornamental plants; and various wild herbs, shrubs, and forest trees are known sources of nectar and pollen. Some of these plants are major sources of nectar and pollen and contribute to the main honey flows. Others act as medium sources and provide nectar and pollen for the development of bee colonies before the main flow season, e.g., during the early spring season. From this flow, brood- rearing is geared up and the colonies become strong. Under favourable soil and climatic conditions, these plants produce surplus nectar and beekeepers who have strong colonies can harvest a good crop of honey. There are still other plants which do not produce surplus nectar and pollen but provide enough forage for bees to survive during dearth periods (i.e., during dry summer and cold winter). These major, medium, and minor sources of nectar and pollen are useful for beekeeping. A general inventory of important plants of the Hindu Kush-Himalayan region, which are most commonly visited by honeybees for their nectar and pollen, is given below.

An Inventory of Important Honey Plants of the Hindu-Kush Himalayan Region (Families are arranged according to their importance as sources of bee food/honey)

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Acanthaceae			
Adhatoda vasica (Basak; Shrub)	S.Tropical, S.Temperate, Temperate	Mar-Apr	N^2P^2
Justicia pubigera (Bankas; Herb)	S.Temperate, Temperate	Aug-Oct	N^2P^2
Phlogacanthus pubinervis (Phlogacanthus, Shrub)	S.Tropical, S.Temperate	Jul-Aug	N^3P^3
Rungia parviflora (Rungia; Herb)	S.Tropical, S.Temperate	Jul-Aug	N^3P^3
Strobilanthes wallichi (Strobilanthes; Herb)	S.Temperate, Temperate	Aug-Oct	N^3P^3
Aceraceae			
Acer accuminatum (Maple; Tree)	S.Temperate, Temperate	Mar-Apr	N^3P^3
Acer caesium (Maple; Tree)	S.Temperate, Temperate	Mar-May	N^3P^3
Acer negundo (Maple; Tree)	S.Temperate, Temperate	Apr-May	N^2P^2
Acer oblongum (Maple; Tree)	S.Temperate, Temperate	Feb-Apr	N^1P^1
Acer pentapomicum (Maple; Tree)	S.Temperate, Temperate	Mar-Apr	N^3P^3
Acer pictum (Maple; Tree)	S.Temperate, Temperate	Mar-Apr	N^3P^3
Agavaceae			
Agave americana (Century Plant; Shrub)	S.Tropical	Sept-Nov	N^3P^3
Yucca sativa (Adam's Needle; Shrub)	S.Tropical	June-Sept	N^2P^2

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Amaranthaceae			
Amaranthus cruentus (Garden Amaranth; Herb)	S.Tropical,S.Temperate	Aug-Sept	N^3P^3
Amaranthus lividus (Wild Amaranth; Herb)	S.Tropical,S.Temperate	Jul-Aug	N^3P^3
Amaranthus paniculatus (Amaranth; Herb)	S.Tropical,S.Temperate,Temperate	June-Jul	N^3P^2
Amaranthus spinulosus (Spiny Amaranth; Herb)	S.Tropical,S.Temperate,Temperate	June-Jul	N^3P^1
Amaryllidaceae			
Allium cepa (Onion; Herb)	S.Tropical,S.Temperate,Temperate	Apr-May	N^2P^3
Allium sativum (Garlic; Herb)	S.Tropical,S.Temperate,Temperate	May-June	N^3P^3
Anacardiaceae			
Choerospondias axillaris (Lapsi; Tree)	S.Tropical,S.Temperate	Mar-Apr	N^2P^2
Mangifera indica (Mango; Tree)	S.Tropical	Feb-Mar	N^2P^3
Odina woodier (Karambal; Tree)	S.Tropical,S.Temperate	Feb-Apr	N^2P^3
Rhus javanica (Sumac; Tree)	S.Tropical,S.Temperate	Sept-Oct	N^2P^2
Rhus succedanea (Sumac; Tree)	S.Temperate,Temperate	May-June	N^2P^2
Rhus verniciflua (Sumac; Tree)	S.Tropical,Temperate	May-June	N^1P^1
Rhus wallichi (Sumac; Tree)	S.Tropical,Temperate	Apr-May	N^2P^2
Apiaceae			
Coriandrum sativum (Coriander; Herb)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^3P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Daucus carota (Carrot; Herb)	S.Tropical,S.Temperate,Temperate	Mar-May	N^2P^3
Foeniculum vulgare (Fennel; Herb)	S.Tropical,S.Temperate,Temperate	Aug-Sept	N^3P^3
Heracleum spp (Hogweed; Herb)	S.Tropical,S.Temperate,Temperate	May-Jul	N^3P^3
Apocynaceae			
Carissa caranda (Karandas; Shrub)	S.Tropical,S.Temperate,Temperate	Apr-May	N^2P^2
Arecaceae			
Phoenix spp (Wild Date Palm; Shrub)	S.Tropical,Temperate	May-Jul	N^2P^3
Asclepiadaceae			
Asclepias curassavica (Milkweed; Shrub)	S.Tropical,Temperate	Apr-June	N^2P^2
Asteraceae			
Ageratum conyzoides (Ageratum; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Nov	N^3P^3
Artemisia maritima (Mugwort; Herb)	S.Temperate,Temperate	Aug-Oct	N^3P^3
Aster spp (Starwort; Herb)	S.Tropical,S.Temperate,Temperate	Oct-Nov	N^3P^3
Bidens spp (Spanish Needle; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Dec	N^3P^2
Calendula officinalis (Marigold; Herb)	S.Tropical,S.Temperate	Feb-Apr	N^3P^3
Callistephus chinensis (Chinese Aster; Herb)	S.Tropical,S.Temperate,Temperate	Apr-May	N^3P^3
Cardus onopardiodes (Musk Thistles; Herb)	S.Tropical,S.Temperate,Temperate	May-Aug	N^2P^2
Carthamus tinctorius (Safflower; Herb)	S.Tropical,S.Temperate	Feb-Mar	N^1P^1
Centaurea cyanus (Cornflower; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Apr	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Chrysanthemum segetum (Chrysanthemum; Herb)	S.Tropical,S.Temperate,Temperate	Aug-Sept	N^3P^3
Cichorium intybus (Chicory; Herb)	S.Tropical,S.Temperate,Temperate	May-Aug	N^3P^3
Cineraria hybrida (Cineraria; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^3P^3
Cirsium verutum (Field Thistles, Herb)	S.Tropical,S.Temperate,Temperate	Apr-June	N^2P^2
Cirsium wallichi (Field Thistles, Herb)	S.Tropical,S.Temperate,Temperate	Apr-May	N^2P^2
Cosmos sulphureus (Cosmos; Herb)	S.Tropical,S.Temperate,Temperate	Oct-Nov	N^2P^2
Dahlia pinnata (Dahlia; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Jan	N^2P^2
Echinops echinatus (Globe Thistle; Herb)	Temperate	May-June	N^3P^3
Eupatorium glandulosum (Throughwort; Herb)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Guizotia abyssinica (Niger; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Oct	N^1P^2
Helianthus annuus (Sunflower; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Sept	N^1P^1
Helichrysum arenarium (Paper Flower; Herb)	S.Tropical,S.Temperate	Feb-June	N^2P^3
Inula cappa (Inula; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Feb	N^3P^1
Lactuca sativa (Lettuce; Herb)	S.Tropical,S.Temperate Temperate	June-Jul	N^3P^2
Mikania scandens (Mikania; Climber)	S.Tropical	Mar-Apr	N^2P^3
Senecio scandens (Ragwort; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^3P^3
Solidago longifolia (Golden Rod; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Oct	N^2P^3
Sonchus asper (Saw Thistle; Herb)	S.Tropical,S.Temperate,Temperate	June-Oct	N^3P^3
Tagetus erectus (Marigold; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Oct	N^3P^3
Taraxacum officinale (Dandelion; Herb)	S.Tropical,S.Temperate,Temperate	Feb-May	N^1P^1
Tussilago farfara (Coltsfoot; Herb)	S.Tropical,S.Temperate	Apr-June	N^3P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Veronia spp (Ironweed; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^3P^3
Zinnia elegans (Zinnia; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^2P^2
Araliaceae			
Schefflera impressa (Tree)	S.Temperate,Temperate	Aug-Sept	N^1
Schefflera octophylla (Small Tree)	S.Tropical,S.Temperate	Oct-Jan	N^1
Schefflera venulosa (Climbing Shrub)	S.Tropical,S.Temperate,Temperate	Jan-May	N^1
Balsaminaceae			
Impatiens balsamina (Pink Balsam; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Aug	N^1P^2
Impatiens glandulifera (Balsam; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Sept	N^2P^2
Berberidaceae			
Berberis aristata (Barberry; Shrub)	S.Tropical,S.Temperate,Temperate	Apr-June	N^2P^2
Berberis asiatica (Barberry; Shrub)	S.Tropical,S.Temperate,Temperate	Mar-May	N^2P^2
Berberis lycium (Barberry; Shrub)	S.Tropical,S.Temperate,Temperate	Apr-June	N^2P^2
Mahonia nepaulensis (Mahonia; Shrub)	S.Tropical,S.Temperate,Temperate	Dec-Feb	N^2P^2
Betulaceae			
Corylus colurna (Hazelnut; Tree)	S.Tropical,Temperate	Mar-May	P^2
Bignoniaceae			
Campsis grandiflora (Trumpet Vine; Climber)	S. Tropical,S.Temperate	May-Aug	N^2P^3
Jacaranda mimosifolia (Jacaranda; Tree)	S.Tropical, S.Temperate	May-June	N^3P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Bombacaceae			
Bombax ceiba (Silk Cotton Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Boraginaceae			
Borago officinalis (Borage; Herb)	S.Tropical,S.Temperate	Feb-Sept	N^1P^1
Cynoglossum amabile (Herb)	S.Tropical,S.Temperate,Temperate	Jul-Aug	N^1P^2
Cynoglossum glochidiatum (Hounds Tongue; Herb)	S.Tropical	Jul-Sept	N^3P^3
Echium vulgare (Blue Thistle; Herb)	S.Tropical,S. Temperate	Jan-June	N^1P^2
Ehretia acuminata (Ivory Wood; Tree)	S.Tropical,S.Temperate	Mar-Apr	N^1P^2
Symphytum peregrinum (Symphytum; Herb)	S.Tropical,S.Temperate	June-Sept	N^2P^2
Brassicaceae			
Brassica campestris (Mustard; Herb)	S.Tropical,S.Temperate,Temperate	Dec-May	N^1P^1
B. campestris var. *dichotoma* (Brown Sarson; Herb)	S.Tropical,S.Temperate,Temperate	Oct-Dec	N^1P^1
B. campestris var. *sarson* (Sarson; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Mar	N^1P^1
Brassica juncea (Indian Mustard; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Brassica napus var. *glauca* (Rape; Herb)	S.Tropical,S.Temperate,Temperate	Dec-Mar	N^1P^1
Brassica napus var. *toria* (Toria; Herb)	S.Tropical,S.Temperate,Temperate	Dec-Mar	N^1P^1
Brassica nigra (Black Mustard; Herb)	S.Tropical,S.Temperate,Temperate	Nov-May	N^1P^1
Brassica oleracea var *capitata* (Cabbage; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Brassica oleracea var. *botrytis* (Cauliflower; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Brassica rapa (Turnip; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Cardamine spp (Cardamine; Herb)	S.Tropical,S Temperate	Jan-Feb	N^2P^2
Eruca sativa (Rocket Salad; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Raphanus sativus (Radish; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Buddleiaceae			
Buddleia asiatica (Tree)	S.Tropical,S.Temperate	Feb-Mar	N^2P^3
Cactaceae			
Opuntia spp (Prickly Pear; Shrub)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Cannabinaceae			
Cannabis sativa (Hemp; Herb)	S.Temperate,Temperate	June-Sept	N^2P^2
Capparidaceae			
Cappararis himalensis (Kanthar; Climber)	S.Tropical,S.Temperate,Temperate	Apr-May	N^3P^3
Crataeva religiosa (Barna; Tree)	S.Tropical,S.Temeperate	Apr-May	N^2P^3
Caprifoliaceae			
Dianthus caryophyllus (Carnation; Herb)	S.Tropical,S.Temperate,Temperate	Apr-June	N^3P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Lonicera sempervirens (Honey Suckle; Climber)	S.Tropical,S.Temperate	May-Aug	N^3P^3
Viburnum spp (Vikurum; Shrub)	S.Tropical,S.Temperate	May-June	N^3P^3
Caricaceae			
Carica papaya (Papaya; Tree)	S.Tropical	May	N^1P^1
Chenopodiaceae			
Chenopodium album (Goose Foot; Herb)	S.Tropical,S.Temperate,Temperate	Mar-May	N^3P^3
Spinacea oleracea (Spinach; Herb)	S.Tropical,S.Temperate,Temperate	Mar-May	N^3P^3
Convolvulaceae			
Convolvulus arvensis (Convolvulus; Climber)	S.Tropical,S.Temperate,Temperate	Apr-Sept	N^3P^3
Ipomoea batatas (Sweet Potato; Climber)	S.Tropical,S.Temperate,Temperate	Aug-Nov	N^2P^3
Ipomoea pulchella (Railway Creeper; Herb)	S.Tropical,S.Temperate,Temperate	Aug-Nov	N^3P^3
Cuscuta reflexa (Amar-Bel; Parasitic Herb)	S.Tropical,S.Temperate,Temperate	Jul-Oct	P^3
Combretaceae			
Terminalia arjuna (Arjun; Tree)	S.Tropical,S.Temeperate	Apr-June	N^1P^1
Terminalia belerica (Myrobalan; Tree)	S.Tropical,S.Temeperate	Apr-May	N^1P^1
Terminalia chebula (Yellow Myrobalan; Tree)	S.Tropical,S.Temeperate	Apr-May	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Cucurbitaceae			
Benincasa hispida (Petha; Climber)	S.Tropical	Apr-May	N^2P^2
Citrullus vulgaris (Watermelon, Climber)	S.Tropical	Apr-May	N^2P^2
Cucumis sativus (Cucumber; Climber)	S.Tropical,S.Temperate	June-Sept	N^1P^1
Cucurbita pepo (Pumpkin; Climber)	S.Tropical,S.Temperate	Apr-May	N^1P^1
Cucurbita maxima (Pumpkin; Climber)	S.Tropical,S.Temperate	Feb-Apr	N^1P^1
Cucurbita moschata (Pumpkin; Climber)	S.Tropical,S.Temperate	Apr-Sept	N^1P^1
Lagenaria siceraria (Bottle Gourd; Climber)	S.Tropical,S.Temperate	Jul-Sept	N^3P^3
Luffa cylindrica (Ridged Gourd; Climber)	S.Tropical,S.Temperate	Jul-Sept	N^3P^3
Momordica charantia (Bitter Gourd; Climber)	S.Tropical,S.Temperate,Temperate	June-Sept	N^3P^3
Sechium edule (Chayote; Climber)	S.Tropical,S.Temperate	Jul-Nov	N^2P^2
Dipsacaceae			
Dispsacus inermis (Teasel; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Oct	N^3P^3
Scabiosa speciosa (Scabious; Herb)	S.Tropical,S.Temperate,Temperate	May-Jul	N^2P^3
Dipterocarpaceae			
Shorea robusta (Sal; Tree)	S.Tropical,S.Temperate	Mar-Apr	N^1P^1
Ebenaceae			
Diospyros kaki (Persimmon; Tree)	S.Temperate,Temperate	Mar-Apr	N^2P^2
Elaeagnaceae			
Elaeagnus angustifolia (Oleaster; Tree)	S.Tropical,S.Temperate,Temperate	Mar-June	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Elaeocarpaceae			
Elaeocarpus spp (Elaeocarpus; Tree)	S.Tropical,S.Temperate	June	N^3P^3
Ericaceae			
Gaultheria fragrantissima (Fragrant Gaultheria; Shrub)	Temperate	May-June	N^2P^2
Rhododendron arboreum (Alpine Rose)	S.Temperate; Temperate	Feb-Mar	N^1P^1
Euphorbiaceae			
Emblica officinalis (Indian Gooseberry;Tree)	S.Tropical	Mar-May	N^2P^2
Euphorbia royleana (Euphorbia; Shrub)	S.Tropical,S.Temperate	Apr-Jul	N^3P^3
Hevea brasiliensis (Rubber Tree)	S.Tropical	Mar-Jul	N^1P^3
Jatropha curcas (Jatropha; Shrub)	S.Tropical,S.Temperate	Apr-Jul	N^3P^3
Phyllanthus acida (Star Goose Berry; Shrub)	S.Tropical,S.Temperate	Apr-June	N^2P^2
Poinsettia pulcherrima (Poinsettia; Shrub)	S.Tropical,S.Temperate	Jan-Feb	N^3P^3
Ricinus communis (Caster Oil Plant; Shrub)	S.Tropical,S.Temperate	May-Aug	P^2
Sapium discolor (Small Tree)	S.Tropical	May-June	N^1P^3
Sapium sebiferum (Tree)	S.Tropical,S.Temperate	Jul-Aug	N^1P^3
Fagaceae			
Castanea sativa (Sweet Chestnut; Tree)	S.Tropical,S.Temperate,Temperate	May-Sept	N^3P^3
Castanopsis indica (Chestnut; Tree)	S.Tropical,S.Temperate,Temperate	Sept-Oct	N^2P^3
Quercus spp (Oak; Tree)	S.Tropical,S.Temperate,Temperate	Apr-Jul	P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Gentianaceae			
Gentiana pedicellata (Gentiana; Herb)	S.Temperate,Temperate	Apr-Jul	N^3P^3
Swertia spp (Swertia; Herb)	S.Temperate,Temperate	Aug-Oct	N^3P^3
Geraniaceae			
Erodium spp (Erodium; Herb)	S.Tropical,S.Temperate,Temperate	Apr-June	N^2P^2
Geranium spp (Geranium; Herb)	S.Tropical,S.Temperate,Temperate	May-Jul	N^3P^3
Hippocastanaceae			
Aesculus indica (Horse Chestnut; Tree)	S.Temperate,Temperate	May-June	N^1P^1
Hypericaceae			
Hypericum cordifolium (Shrub)	S.Tropical,S.Temperate,Temperate	Aug-Oct	P^1
Iridaceae			
Iris nepalensis (Iris; Herb)	Temperate	Apr-May	N^2P^2
Juglandaceae			
Juglans regia (Walnut; Tree)	S.Temperate,Temperate	March	P^2
Lamiaceae			
Calamintha spp (Summer Savoury; Herb)	S.Temperate,Temperate	Sept-Oct	P^3
Elsholtzia blanda (Elsholtzia; Herb)	S.Temperate,Temperate	Sept-Oct	N^1P^3
Elsholtzia bodinieri (Elsholtzia; Herb)	S.Tropical,S.Temperate,Temperate	Nov-Dec	N^1P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Elsholtzia ciliata (Elsholtzia; Herb)	S.Tropical,S.Temperate,Temperate	Oct-Nov	N^1P^3
Elsholtzia cypriani (Elsholtzia; Herb)	S.Temperate,Temperate.	Sept-Oct	N^1P^3
Elsholtzia dense (Elsholtzia; Herb)	S.Tropical,S.Temperate,Temperate	Aug-Sept	N^1P^3
Elsholtzia fruticosa (Elsholtzia; Herb)	S.Temperate,Temperate	Sept-Oct	N^2P^3
Elsholtzia rugulosa (Elsholtzia; Herb)	S.Temperate,Temperate	Oct-Dec	N^1P^3
Elsholtzia splendens (Elsholtzia; Herb)	S.Temperate,Temperate	Sept-Oct	N^2P^3
Laminum album (Deadnettle; Herb)	S.Tropical,S.Temperate,Temperate	Apr-Oct	N^2P^3
Leonurus heterophullus (Herb)	S.Tropical,S.Temperate,Temperate	June-Jul	N^2P^3
Leucosceptrum canum (Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Mentha viridis (Mint; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Oct	N^3
Nepeta spp (Catmint; Herb)	S.Tropical,S.Temperate,Temperate	May-Aug	N^3P^3
Ocimum basilicum (Basil; Herb)	S.Tropical,S.Temperate	Aug-Sept	N^2P^3
Origanum vulgare (Marjoram; Herb)	S.Tropical,S.Temperate	Aug-Sept	N^1P^2
Perilla frutescens (Perilla; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Oct	N^2P^3
Plectranthus coetso (Shain; Shrub)	S.Temperate,Temperate	Aug-Nov	N^1P^2
Plectranthus gerardianus (Shain; Shrub)	S.Temperate,Temperate	Aug-Sept	N^1P^2
Plectranthus rugosus (Shain; Shrub)	S.Temperate,Temperate	Aug-Oct	N^1P^2
Plectranthus striatus (Shain; Shrub)	S.Temperate,Temperate	Oct-Dec	N^1P^2
Pogostemon glaber (Shrub)	S.Temperate,Temperate	Jan-June	N^1P^1
Rosmarinus officinalis (Rosemary; Shrub)	S.Temperate,Temperate	Apr-June	N^2P^2
Salvia splendens (Sage; Herb)	S.Tropical,S.Temperate,Temperate	whole year	N^1P^3
Stachys melissaefolia (Woundwort; Shrub)	S.Tropical,S.Temperate,Temperate	June-Sept	N^2P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Lauraceae			
Litsea polyantha (Meda; Tree)	Temperate	Dec-Jan	N^3P^3
Liliaceae			
Asphodelus tenuifolius (Asphodelus; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Oct	N^3P^2
Linaceae			
Linum spp (Flax; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^3P^3
Lytheraceae			
Lagerstroemia indica (Pride of India; Tree)	S.Tropical,S.Temperate,Temperate	June-Jul	N^2P^2
Lagerstroemia parviflora (Jarul; Tree)	S.Tropical,S.Temperate,Temperate	Apr-May	N^1P^1
Cuphea micrantha (Cuphea; Perennial Herb)	S.Tropical,S.Temperate,Temperate	Feb-Nov	N^2P^3
Woodfordia fruticosa (Dhawi; Shrub)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Malvaceae			
Abelmoschus esculentus (Lady's Finger; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^2P^2
Althaea rosea (Hollyhock; Shrub)	S.Tropical,S.Temperate	Apr-June	N^2P^2
Gosssypium arboreum (Cotton; Herb)	S.Tropical,S.Temperate	Jul-Sept	N^1P^2
Gossypium barbadense (Egyptian Cotton; Herb)	S.Tropical,S.Temperate,Temperate	Sept-Oct	N^1P^2
Gossypium hirsutum (Upland Cotton, Herb)	S.Tropical,S.Temperate,Temperate	Sept-Oct	N^1P^2
Hibiscus canabinus (Decanhemp; Herb)	S.Tropical,S.Temperate	Jul-Aug	N^3P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Hibiscus rosa-sinensis (Chinese Rose; Shrub)	S.Tropical,S.Temperate	Mar-May	N^2P^2
Malva sylvestris (Mallow; Herb)	S.Tropical,S.Temperate	June-Oct	N^2P^3
Malvaviscus arboreus (Shrub)	S.Tropical,S.Temperate	Whole year	N^2P^2
Meliaceae			
Azadirachta indica (Margosa; Tree)	S.Tropical	Apr-May	N^1P^3
Cedrela toona (Cedrela; Tree)	S.Tropical,S.Temperate	April	N^1P^2
Moringaceae			
Moringa oleifera (Drumstick Tree; Tree)	S.Tropical	Jan-Mar	N^1P^1
Musaceae			
Musa sapientum (Banana; Giant Herb)	S.Tropical,S.Temperate	Whole Year	N^2P^3
Myrtaceae			
Callistemon citrinus (Bottle Brush; Tree)	S.Tropical,S.Temperate	Mar-Oct	N^1P^1
Eucalyptus camaldulensis (Eucalyptus; Tree)	S.Tropical	May-June	N^1P^1
Eucalyptus citriodora (Eucalyptus; Tree)	S.Tropical	June-July	N^1P^1
Eucalyptus excerta. (Eucalyptus; Tree)	S.Tropical	May-July	N^1P^1
Eucalyptus globulus (Eucalyptus; Tree)	S.Tropical,S.Temperate	October	N^1P^1
Eucalyptus grandis (Eucalyptus; Tree)	S.Tropical,S.Temperate	June-Aug	N^1P^1
Eucalyptus melliodora (Eucalyptus; Tree)	S.Tropical,S.Temperate	Oct-Dec	N^1P^1
Eucalyptus robusta (Eucalyptus; Tree)	S.Tropical,S.Temperate	June-Jul	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Psidium guajava (Guava; Tree)	S.Tropical,S.Temperate	May-June	N^1P^1
Syzygium cumini (Jambolan; Tree)	S.Tropical,S.Temperate	Apr-May	N^1P^1
Syzygium jambos (Rose Apple; Tree)	S.Tropical,S.Temperate	Feb-June; Sept-Nov	N^1P^1
Moraceae			
Morus spp (Mulberry; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	P^2
Myrsinaceae			
Maesa chisia (Small Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^3P^3
Oleaceae			
Fraxinus floribunda (Ash Tree)	S.Tropical,S.Temperate,Temperate	Apr-May	N^1P^3
Ligustrum indicum (Ligustrum; Tree)	S.Tropical,S.Temperate,Temperate	June-Jul	N^2P^2
Onagraceae			
Epilobium spp (Willow Herb; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^2P^2
Oxalidaceae			
Oxalis corniculata (Indian Sorrel; Herb)	S.Tropical,S.Temperate,Temperate	Feb-June	N^3P^3
Papaveraceae			
Argemone mexicana (Prickly Poppy; Herb)	S.Tropical,S.Temperate	May-Jul	P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Eschscholzia californica (Californian Poppy; Herb)	S.Tropical,S.Temperate	Mar-June	N^3P^1
Meconopsis spp (Herb)	Temperate	June-Aug	N^3P^3
Papaver rhoeas (Poppy; Herb)	S.Tropical,S.Temperate,Temperate	Mar-May	N^3P^3
Papilionaceae			
Acacia arabica (Acacia; Tree)	S.Tropical,S.Temperate	May-Jul	N^2P^2
Acacia catechu (Acacia; Tree)	S.Tropical,S.Temperate	Apr-Jul	N^1P^1
Acacia modesta (Acacia; Tree)	S.Tropical,S.Temperate	May-Jul	N^1P^1
Albizia chinensis (Albizia; Tree)	S.Tropical,S.Temperate	May-June	N^3P^3
Albizia julibrissin (Persian Acacia; Tree)	S.Tropical,S.Temperate,Temperate	Apr-May	N^3P^3
Albizia lebbek (Albizia; Tree)	S.Tropical	May-Jun	N^3P^3
Albizia odoratissima (Siris; Tree)	S.Tropical,S.Temperate	Apr-Jun	N^3P^3
Astragalus sinicus (Astragalus; Shrub)	S.Tropical,S.Temperate,Temperate	April	N^1P^2
Bauhinia purpurea (Geranium Tree; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^3P^3
Bauhinia vahlii (Camel's Foot; Climber)	S.Tropical,S.Temperate,Temperate	May-Jun	N^3P^3
Bauhinia variegata (Kachnar, Tree)	S.Tropical,S.Temperate,Temperate	Sept-Nov	N^3P^3
Butea monosperma (Palas; Tree)	S.Tropical,S.Temperate	Jan-Feb	N^1P^3
Caesalpinia spp (American Sumac; Tree)	S.Tropical,S.Temperate	Nov-Apr	N^3P^3
Cajanus cajan (Pigeon Pea; Shrub)	S.Tropical,S.Temperate,Temperate	May-Sept	N^3P^3
Calliandra calothyrsus (Red Calliandra; Tree)	S.Tropical,S.Temperate	Whole Year	N^1P^1
Cassia fistula (Indian Laburnum; Tree)	S.Tropical,S.Temperate	Apr-May	N^2P^2
Cicer arietinum (Bengal Gram; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Crotalaria juncea (Sannhemp; Shrub)	S.Tropical,S.Temperate,Temperate	Jul-Sept	N^3P^3
Dalbergia sissoo (Sissoo; Tree)	S.Temperate,S.Temperate	Mar-Apr	N^1P^1
Delonix regia (Gulmohr; Tree)	S.Tropical,S.Temperate	May-June	N^2P^2
Erythrina suberosa (Coral Tree; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^2P^2
Glycine max (Soybean; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Aug	N^3P^3
Indigofera spp (Indigofera; Shrub)	S.Tropical,S.Temperate,Temperate	June-Aug	N^2P^2
Lespedeza cuniata (Lespedeza; Herb)	S.Tropical,S.Temperate,Temperate	June-Jul	N^2
Leucaena leucocephala (Small Tree)	S.Tropical,S.Temperate	Sept-Oct	N^3P^1
Medicago falcata (Lucerne; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^3
Medicago laciniata (Lucerne; Herb)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^2P^2
Medicago lupulina (Lucerne; Herb)	S.Tropical,S.Temperate,Temperate	Apr-May	N^1P^2
Medicago sativa (Alfalfa; Herb)	S.Tropical,S.Temperate,Temperate	Aug-Sept	N^1P^2
Melilotus alba (White Mellilot; Herb)	S.Tropical,S.Temperate,Temperate	Mar-May	N^1P^1
Melilotus parviflora (Yellow Melilot; Herb)	S.Tropical,S.Temperate,Temperate	May-Jul	N^1P^2
Mimosa pudica (Sensitive Plant; Herb)	S.Tropical,S.Temperate	Jul-Nov	N^3P^2
Parkia roxburghii (Supota; Tree)	S.Tropical,S.Temperate	Oct-Dec	N^3P^2
Phaseolus spp (Pulses, Beans; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Aug	N^3P^3
Pisum sativum (Pea; Herb)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^3P^3
Robinia pseudoacacia (False Acacia; Tree)	S.Tropical,S.Temperate,Temperate	April	N^1P^2
Sophora mollis (Pagoda Tree; Tree)	S.Temperate	Mar-Jul	N^2P^2
Sophora viciifolia (Shrub)	S.Temperate	Mar-Apr	N^1P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Tamarindus indica (Tamarind; Tree)	S.Tropical,S.Temperate	Mar-May	N^3P^3
Trifolium alexandrinum (Egyptian Clover; Herb)	S.Tropical,S.Temperate,Temperate	May-June	N^1P^1
Trifolium pratense (Red Clover; Herb)	S.Tropical,S.Temperate,Temperate	Apr-Sept	N^1P^2
Trifolium repens (White Clover; Herb)	S.Tropical,S.Temperate,Temperate	Feb-June	N^1P^1
Trifolium resupinatum (Persian Clover; Herb)	S.Tropical,S.Temperate,Temperate	Apr-June	N^1P^1
Trigonella spp (Methi; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^3
Vicia faba (Broad Beans; Herb)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^3P^1
Vicia cracca (Field Beans; Herb)	S.Tropical,S.Temperate,Temperate	Apr-May	N^1P^1
Pedaliaceae			
Sesamum indicum (Sesame; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Aug	N^1P^1
Plantaginaceae			
Plantago spp (Plantago; Herb)	S.Tropical,S.Temperate,Temperate	Mar-Sept	N^2P^1
Poaceae			
Cynodon doctylon (Dub Grass; Herb)	S.Tropical,S.Temperate,Temperate	May-Sept	P^3
Sorghum vulgare (Sorghum; Herb)	S.Tropical,S.Temperate,Temperate	May-June	P^1
Zea mays (Maize; Corn; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Aug	P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Polygonaceae			
Antigonon leptopus (Coral Vine; Climber)	S.Tropical	May-Oct	N^1P^1
Fagopyrum esculentum (Buckwheat; Herb)	S.Tropical,S.Temperate,Temperate	Aug-Sept	N^1P^2
Polygonum spp (Polygonum; Herb)	S.Tropical,S.Temperate,Temperate	May-Sept	N^3P^3
Rumex spp (Rumex; Herb)	S.Tropical,S.Temperate,Temperate	June-Oct	N^3P^3
Portulacaceae			
Portulaca grandiflora (Portulaca; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^2P^1
Primulaceae			
Primula spp (Primula; Herb)	S.Tropical,S.Temperate,Temperate	May-Sept	N^3P^3
Punicaceae			
Punica granatum (Pomegranate; Tree)	S.Tropical,S.Temperate	Apr-May	N^3P^1
Punica nana (Wild Pomegranate; Tree)	S.Tropical,S.Temperate	May-June	N^3P^1
Proteaceae			
Grevillea robusta (Silky Oak; Tree)	S.Tropical	Apr-May	N^1P^1
Ranunculaceae			
Caltha spp (Marsh Marigold; Herb)	Temperate	Apr-Jul	N^3P^2
Clematis spp (Clematis; Climber)	S.Tropical,S.Temperate	Mar-May	N^2P^2

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Delphinium roylei (Larkspur, Herb)	S.Tropical, Temperate	Mar-May	N^3P^3
Ranunculus arvensis (Buttercup; Herb)	S.Tropical,S.Temperate, Temperate	May-Jul	N^3P^3
Rhamnaceae			
Ziziphus jujuba (Chinese Jujube; Tree)	S.Tropical,S.Temperate	Jul-Oct	N^1P^3
Ziziphus incurva (Wild Jujube; Tree)	S.Tropical,S.Temperate	June-Jul	N^1P^3
Zizyphus mauritiana (Indian Jujube; Tree)	S.Tropical,S.Temperate	Sept-Oct	N^1P^3
Zizyphus numularia (Jujube; Shrub)	S.Tropical,S.Temperate	Apr-June	N^1P^3
Zizyphus oxyphylla (Jujube; Shrub)	S.Tropical,S.Temperate	June-Sep	N^1P^3
Rosaceae			
Eriobotrya dubia (Tree)	S.Temperate,Temperate	Feb-Mar	N^1P^3
Eriobotrya japonica (Loquat; Tree)	S.Temperate,Temperate	Feb-Mar; Sept-Oct	N^1P^1
Fragaria vesca (Strawberry; Herb)	S.Temperate,Temperate	Feb-May	N^2P^2
Malus domestica (Apple; Tree)	S.Temperate,Temperate	Mar-Apr	N^1P^1
Malus pumila (Apple; Tree)	S.Temperate,Temperate	Mar-Apr	N^1P^1
Potentilla spp (Silverweed; Herb)	S.Temperate,Temperate,	June-Aug	N^2P^3
Prinsepia utilis (Bekhal; Shrub)	S.Tropical,S.Temperate,Temperate	Oct-Nov	N^2P^2
Prunus amygdalus (Almond; Tree)	S.Temperate,Temperate	Mar-Apr	N^1P^1
Prunus armeniaca (Apricot; Tree)	S.Temperate,Temperate	Feb-Mar	N^1P^1
Prunus avium (Cherry; Tree)	S.Temperate,Temperate	February	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Prunus domestica (Plum; Tree)	S.Temperate,Temperate	Feb-Mar	N^2P^1
Prunus cerasoides (Wild Cherry; Tree)	S.Temperate,Temperate	November	N^1P^1
Prunus persica (Peach; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Pyracantha crenulata (Shrub)	S.Tropical,S.Temperate,Temperate	April	N^2P^2
Pyrus communis (Pear; Tree)	S.Temperate,Temperate	Feb-Mar	N^2P^1
Pyrus pashia (Wild Pear; Tree)	S.Temperate,Temperate	Feb-Mar	N^2P^2
Rosa brunoni (Wild Rose; Shrub)	S.Temperate,Temperate	Apr-June	N^3P^1
Rosa laevigata (Wild Rose; Shrub)	S.Temperate,Temperate	Apr-June	N^3P^1
Rosa macrophylla (Wild Rose; Shrub)	S.Temperate,Temperate	Apr-June	N^3P^1
Rosa moschata (Wild Rose; Shrub)	S.Temperate,Temperate	June-Jul	N^3P^1
Rosa sericea (Wild Rose; Shrub)	S.Temperate,Temperate	May-Aug	N^3P^1
Rubus ellipticus (Raspberry; Shrub)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^2P^2
Rubus paniculatus (Raspberry; Shrub)	S.Tropical,S.Temperate,Temperate	Apr-May	N^2P^2
Rubus setchuenensis (Raspberry; Shrub)	S.Tropical,S.Temperate,Temperate	Jul-Aug	N^1P^1
Rubus ulmifolius (Raspberry; Shrub)	S.Temperate,Temperate	Sept-Oct	N^1P^1
Rubiaceae			
Wendlandia exserta (Chanlai; Tree)	S.Tropical	Nov-Feb	N^2P^1
Wendlandia tinctoria (Tree)	S.Tropical	Feb-Apr	N^1P^1
Rutaceae			
Citrus aurantifolia (Lemon; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Citrus grandis (Pumelo; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Citrus limetta (Sweet Lemon; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Citrus medica (Citron; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Citrus paradissi (Grape Fruit; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Citrus reticulata (Mandarin Orange; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Citrus sinensis (Sweet Orange; Tree)	S.Tropical,S.Temperate,Temperate	Mar-Apr	N^1P^1
Murraya koenigii (Curry Leaf Plant; Shrub)	S.Temperate,S.Tropical	Mar-Apr	N^2P^2
Salicaceae			
Salix acmophylla (Willow; Tree)	S.Temperate,S.Tropical,Temperate	Feb-Mar	N^2P^2
Salix alba (White Willow; Tree)	S.Temperate,S.Tropical,Temperate	February	N^2P^2
Salix babylonica (Weaping Willow; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^1P^1
Salix calyculata (Willow; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Salix elegans (Willow; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Salix excelsa (Willow; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Salix fragilis (Willow; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Salix sikkimensis (Willow; Tree)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^2
Salix wallichiana (Willow; Tree)	Tropical,S.Temperate,S.Temperate	Feb-Mar	N^2P^2
Sapindaceae			
Litchi chinensis (Litchi; Tree)	S.Tropical,S.Temperate	Feb-Mar	N^1P^1
Sapindus detergens (Soapnut; Tree)	S.Tropical,S.Temperate	May-June	N^1P^1

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Sapotaceae			
Aesandra butyracea (Indian Butter Tree)	S.Tropical,S.Temperate	Sept-Feb	N^1P^1
Madhuca latifolia (Tree)	S.Tropical,S.Temperate	Feb-Mar	N^1P^1
Saurauiaceae			
Saurauia nepaulensis	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Scrophulariaceae			
Paulownia elongata (Paulownia; Tree)	S.Tropical,S.Temperate	Feb-Mar	N^1P^1
Scrophularia spp (Figwort; Herb)	S.Tropical,S.Temperate,Temperate	Jul-Sept	N^1P^2
Solanaceae			
Capsicum annum (Chillies; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	N^3P^3
Datura stramonium (Thorn Apple; Herb)	S.Tropical,S.Temperate,Temperate	June-Sept	P^3
Lycopersicum esculentum (Tomato; Herb)	S.Tropical,S.Temperate,Temperate	Mar-Oct	N^3P^3
Sonnertiaceae			
Duabanga grandiflora (Duabanga; Tree)	S.Tropical	April	N^2P^2
Symplocaceae			
Symplocos paniculata (Symplocos; Tree)	S.Tropical,S.Temperate,Temperate	Apr-May	N^2P^2
Symplocos sumunita (Symplocos; Tree)	S.Tropical,S.Temperate,Temperate	October	N^2P^2

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Theaceae			
Camellia sinensis (Tea, Shrub)	S.Tropical,S.Temperate	Oct-Nov	N^1P^1
Camellia oleifera (Tree)	S.Tropical,S.Temperate	Oct-Dec	N^1P^1
Eurya accuminata (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Eurya alata (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Eurya brevistyla (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Eurya chinensis (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Eurya groffi (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Eurya muricata (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Eurya nitida (Wild Osmanthus; Shrub)	S.Tropical,S.Temperate	Sept-Oct	N^1P^1
Schima wallichii (Needle Wood; Tree)	S.Tropical	May-June	N^2P^2
Tiliaceae			
Grewia optiva (Bhemal; Tree)	S.Tropical,S.Temperate,Temperate	May-June	N^1P^1
Tilia spp (Lime Basswood; Tree)	S.Tropical,S.Temperate,Temperate	June-Aug	N^1
Thymelaeaceae			
Daphne oleoides (Daphne; Shrub)	S.Temperate,Temperate	Jul-Sept	N^3P^3
Violaceae			
Viola odorata (Viola; Herb)	S.Tropical,S.Temperate,Temperate	June-Aug	N^3P^3

Family/Plant Species	Ecological Habitat	Flowering Period	Nectar/ Pollen Potential
Verbenaceae			
Caryopteris odorata (Caryopteris; Shrub)	S.Tropical,S.Temperate,Temperate	Feb-Mar	N^2P^3
Verbena officinalis (Verbana; Perennial Herb)	S.Tropical,S.Temperate,Temperate	June-Jul	N^1P^2
Vitex negundo (Indian Privet; Shrub)	S.Tropical,S.Temperate,Temperate	Apr-Oct	N^1P^2
Vitaceae			
Vitis vinifera (Grapes; Climber)	S.Tropical,S.Temperate,Temperate	May-June	N^3P^3

N^1 = Major nectar source	P^1 = Major pollen source	S.Tropical = Subtropical
N^2 = Medium nectar source	P^2 = Medium pollen source	S.Temperate = Sub-Temperate
N^3 = Minor nectar source	P^3 = Minor pollen source	

Source: Compiled from multiple sources

Annex 2
Glossary of Important Terms

Alternate: leaves placed singly, at different heights on a stem.

Annual: a plant completing its life cycle in one season or one year.

Anthers: part of the stamen on which pollen grains are produced.

Axil, axillary: the angle between the leaf and the stem; hence axillary flower, or bud.

Bee flora: plants visited by bees to collect either nectar, pollen or both.

Biennial: a plant which completes its life cycle in two seasons or years of growth.

Bipinnate: of a leaf divided into two pinnae, which are further divided into leaflets.

Bract: a little leaf or scale like structure from the axil of which a flower often arises.

Brood: a collective term for the eggs, larvae and pupae of the bees.

Bulbs: underground storage organ consisting of one of many fleshy scales arising from the basal plate of tissue and encircling a growing point.

Catkin: a crowded spike of tiny flowers, usually hanging and tassel-like.

Colony: a social community of several thousand worker bees usually containing a queen and few drones.

Deciduous: falling off, as with leaves in the dry season or autumn, and leaving a leaf scar.

Dehiscence (of anthers): opening of the anthers to release the pollen grains.

Dioecious: having male and female flowers on different plants.

Disc-florets: the central regular five-lobed florets in contrast to the strap-shaped ray-florets, as in the Compositae.

Evergreen: plants which retain their green leaves throughout the year.

Female flower: flowers with fertile ovary but without fertile stamens.

Floret: a small flower usually one of a dense cluster or a head, as in the Compositae.

Flower head: a densely packed group of flowers or florets.

Fodder: food for cattle.

Forage: food (nectar and pollen) for the bees. Also the collection of food by the bees.

Fruit: a general term for the ripened ovary bearing the seeds.

Herbaceous: plant without woody stems, drying down each year or season; also referring to shoots before they become woody.

Hermaphrodite: with both fertile stamens and ovaries present in the same flower.

Inflorescence: flowering branch including bracts, flower stalks and flowers.

Introduced: a plant brought into a country or region by man, or not native.

Male flower: a flower having fertile stamens but no fertile ovary.

Native: found wild in a country or locality since recorded time; not known to be introduced by any human agency.

Naturalised: thoroughly established and self-propagating in an area, but originally introduced from elsewhere.

Nectar: sugary liquid secreted by a special gland present on flower, leaves, or stem.

Nectary: A nectar secreting gland often present on flower, leaves or stem.

Panicle: a branched inflorescence, or more precisely a branched racemose inflorescence.

Perennial: living for more than two years. A herbaceous perennial has non-woody stems which are produced anew every season or year. Many perennials die down above ground in the cold or dry season, and persist below ground until the next growing season.

Pollen: granular mass (of spores) present in the anther of a flower.

Pollen load: amount (weight) of pollen pellets carried by honeybees on its corbiculae.

Pollination: the transfer of pollen grains from the anther to the stigma of the same or a different flower of the same or different plant of the same species.

Raceme: a simple, unbranched, elongate inflorescence with stalked flowers at the apex or axils.

Ray-floret: one of the strap shaped florets in the flower-head of many compositae.

Reticulate or netted: with a network.

Shrub: a perennial plant with woody stems; usually with branched, or several woody branches arising from the base.

Spike: a slender, elongate cluster of spikelets of numerous stalkless flowers.

Spikelet: one or more florets subtended by one or more sterile bracts, as in Graminae.

Terminal: at the tip, apical; also an organ borne at the end of a stem and limiting its growth.

Tree: a long lived woody plant with a single trunk branching only from above.

Umbel: a cluster of flowers whose spreading stalks or rays from the apex of the stem resembling the spokes of an umbrella. Compound umbels have secondary umbels born at the ends of the rays of the primary umbels.

Undershrub: a general term for a low shrub usually less than one meter tall.

Unisexual: either with male or female fertile sexual organs only.

Variety/cultivar: individuals of the same species differing from one another regarding their size, form, colour etc. Thus variety is the classification below species level and the variety that is cultivated is called a cultivar.

Weed: an unwanted plant that interferes with the growth of favoured species.

Annex 3

Annex to Chapter Three

A Key for the Identification of Major Himalayan Pollen Types

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
		Pollen Grain Features					
	Acanthaceae						
01	*Adhatoda vasica*	8	4	2	1	2/6	1
02	*Barlaria cristata*	9	9	2	1	6	1
03	*Godlfussia capitata*	9	9	8	2	6	1
04	*Justicia procumbens*	5	4	3	3	2	1
	Aceraceae						
05	*Dobinea vulgaris*	2	2	3	2	6	1
	Amaranthaceae						
06	*Amaranthus spinulosus*	5	5	8	1	1	1
07	*Amaranthus cruentus*	4	4	8	1	1	1
	Amaryllidaceae						
08	*Allium cepa*	5	3	2	2	1	1
09	*Zephyranthus spp*	9	8	1	2	6	1
	Anacardiaceae						
10	*Mangifera indica*	4	4	3	3	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Apiaceae						
11	*Coriandrum sativum*	5	2	3	3	1	1
12	*Buplerum meniginatum*	2	2	3	3	3	1
13	*Selenium tenuifolium*	4	2	3	3	1	1
	Apocynaceae						
14	*Holerrhena antidysentrica*	4	4	3	2	1	1
15	*Vinca rosea*	9	8	3	3	2	1
	Astreraceae						
16	*Ageratum conyzoides*	3	3	3	3	3	1
17	*Anaphalis cinnamonica*	3	3	3	3	3	1
18	*Aster himalenicus*	4	3	3	3	3	1
19	*Aster hodsonii*	6	6	3	3	3	1
20	*Bidens bipinnata*	4	4	3	3	3	1
21	*Calendula officinalis*	6	6	3	3	3	1
22	*Chrysanthemum segetum*	7	6	3	3	3	1
23	*Cirsium wallichi*	8	8	3	3	3	1
24	*Cosmos suphureus*	5	4	3	3	3	1
25	*Dahlia spp*	7	7	3	3	3	1
26	*Eupatorium glandulosum*	4	4	3	3	3	1
27	*Guizotia abyssinica*	5	5	3	3	3	1
28	*Helianthus annuus*	6	5	3	3	3	1
29	*Senecio scandens*	5	5	3	3	3	1
30	*Solidago longifolia*	3	3	3	3	2	1
31	*Taraxacum officinale*	6	6	3	1	7	1
	Balsaminaceae						
32	*Impatiens balsamina*	7	4	4	2	2	1
33	*Impatiens glandulifera*	6	4	4	2	2	1
	Berberidaceae						
34	*Berberis asiatica*	8	8	2	2	2	1
35	*Mahonia nepaulensis*	8	8	2	2	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Begoniaceae						
36	*Begonia picta*	2	1	3	3	1	1
	Betulaceae						
37	*Alnus nepalensis*	4	4	4	1	1	1
	Bignoniaceae						
38	*Campsis grandiflora*	6	6	3	2	6	1
39	*Incarvillea argeta*	8	8	6	2	2	1
40	*Jacaranda mimosifolia*	8	8	3	3	6	1
	Bixaceae						
41	*Bixa orellona*	6	5	4	2	2	1
	Boraginaceae						
42	*Borago officinalis*	5	5	8	3	2	1
43	*Cynoglossum zeylanicum*	8	7	3	3	2	1
44	*Echium vulgare*	3	3	3	3	1	1
45	*Eristrychium cirnuum*	3	3	3	3	1	1
46	*Symphytum peregrinum*	5	4	5	3	1	1
47	*Trichodesma indica*	4	4	3	3	2	1
	Brassicaceae						
48	*Brassica campestris*	4	4	3	3	6	1
49	*Brassica juncea*	4	4	3	3	6	1
50	*Brassica rapa*	3	3	3	3	2	1
51	*Brassica oleracea botrytis*	3	3	3	3	6	1
52	*Entrema spp*	4	4	3	3	2	1
53	*Eruca sativa*	3	3	3	3	2	1
54	*Erysimium hierciifolium*	5	4	3	3	2	1
55	*Raphanus sativus*	3	3	3	3	6	1
	Budleiaceae						
56	*Budleia asiatica*	2	2	3	3	1	1

The column group L, B, AN, AT, ES, AGGS. is headed "Pollen Grain Features".

S. No	Family/PlantSpecies	Pollen Grain Features L	B	AN	AT	ES	AGGS.
Cactaceae							
57	*Opuntia spp*	9	9	6	1	6	1
Campanulaceae							
58	*Cynanthus lobatus*	6	6	8	2	1	1
59	*Campanula corolata*	4	4	3	1	2	1
Capparidaceae							
60	*Capparis spinosa*	3	2	3	3	1	1
Caprifoliaceae							
61	*Leycesteria formosa*	9	8	3	3	3	1
62	*Lonicera myrtillus*	5	4	3	3	2	1
63	*Lonicera angustifolia*	8	8	3	2	6	1
64	*Sambucus canadensis*	3	3	3	3	1	1
65	*Viburnum eurbescence*	5	5	3	3	6	1
66	*Viburnum cylindricum*	4	4	3	3	2	1
67	*Viburnum mullaha*	3	3	3	3	2	1
68	*Viburnum punctatum*	2	2	3	3	6	1
Caryophyllaceae							
69	*Cerastium glomeratum*	6	5	6	1	6	1
70	*Dianthus caryophyllus*	7	5	3	3	6	1
71	*Silene gonosperma*	3	3	3	3	6	1
72	*Stellaria latifolia*	5	5	6	1	6	1
Chenopodiaceae							
73	*Chenopodium album*	5	5	8	1	2	1
Commelinaceae							
74	*Commelina polludosa*	9	6	4	2	6	1
75	*Cynotis vaga*	7	5	3	2	1	1
76	*Tradescantia spp*	8	6	1	2	2	1

S. No	Family/PlantSpecies	Pollen Grain Features					
		L	B	AN	AT	ES	AGGS.
Convolvulaceae							
77	*Ipomea nil*	9	9	8	1	3	1
78	*Porana grandiflora*	4	4	3	2	2	1
Coriariaceae							
79	*Coriaria nepalensis*	4	4	3	1	1	1
Cucurbitaceae							
80	*Cucurbita moschata*	9	9	6	1	3	1
81	*Cucurbita pepo*	9	9	6	1	3	1
82	*Cucurbita maxima*	9	9	8	1	3	1
83	*Luffa cylindrica*	9	9	3	1	2	1
84	*Cucumis sativus*	9	9	3	1	1	1
85	*Momordica charantia*	9	9	3	1	2	1
86	*Sechium edule*	9	9	8	1	2	1
Dipsacaceae							
87	*Dipsacus inermis*	9	9	3	2	2	1
88	*Dipsacus mitis*	9	9	3	2	3	1
Ebenaceae							
89	*Diospyros kaki*	8	8	3	2	1	1
Elaeagnaceae							
90	*Elaeagnus angustifolia*	8	8	3	3	6	1
91	*Elaeagnus latifolia*	8	8	3	1	2	1
Ericaceae							
92	*Gaultheria fragrantissima*	3	3	3	3	1	1
93	*Pieris ovalifolia*	6	6	3	3	6	4
94	*Rhododendron arboreum*	7	7	3	3	2	4

S. No	Family/PlantSpecies	Pollen Grain Features L	B	AN	AT	ES	AGGS.
	Euphorbiaceae						
95	*Emblica Officinalis*	3	3	3	3	6	1
96	*Jatropha curcas*	9	9	3	3	4	1
97	*Phyllanthus clarki*	4	4	3	3	2	1
98	*Poinsettia pulcherrima*	7	7	3	3	2	1
	Fagaceae						
99	*Castanopsis indica*	3	2	3	3	1	1
	Fumariaceae						
100	*Corydalis chaerophylla*	6	6	3	2	2	1
101	*Corydalis govaniana*	5	5	3	2	2	1
	Gentianaceae						
102	*Swertia angustifolia*	4	4	3	3	2	1
103	*Swertia dilatata*	5	5	3	3	2	1
104	*Swertia nervosa*	5	4	3	3	2	1
	Geraniaceae						
105	*Geranium nepalensis*	9	9	3	1	2	1
	Gesnariaceae						
106	*Chirita urticifolia*	4	4	3	2	2	1
107	*Didymocarpus leucocalyx*	3	3	3	2	1	1
	Graminae						
108	*Zea mays*	9	9	2	1	2	1
109	*Cynodon dactylon*	4	4	9	1	2	1
	Hypericaceae						
110	*Hypericum elodeoides*	3	3	3	3	1	1
111	*Hypericum japonicum*	3	3	3	3	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Hydrangeaceae						
112	*Dichroa febrifuga*	2	2	3	3	1	1
113	*Hydrangea anomala*	2	3	3	2	1	1
	Hippocastanaceae						
114	*Aesculus indica*	4	4	3	3	2	1
	Iridaceae						
115	*Freesia refracta*	6	5	2	2	2	1
116	*Gladiolus tristus*	9	9	2	2	6	1
117	*Iris decora*	4	3	3	2	2	1
118	*Iris nepalensis*	9	9	2	2	6	1
	Labiatae						
119	*Ajuga macrosperma*	5	5	3	2	6	1
120	*Colebrookia macrophylla*	6	5	3	2	2	1
121	*Clinopodium longicaule*	8	6	6	2	2	1
122	*Elsholtzia blanda*	3	3	6	2	2	1
123	*Leucas mollissima*	4	3	3	2	1	1
124	*Leucosceptrum canum*	5	4	3	2	6	1
125	*Mentha arvensis*	2	1	3	3	2	1
126	*Nepeta nervosa*	6	6	6	2	6	1
127	*Ocimum basilicum*	9	9	6	2	6	1
128	*Origanum vulgare*	5	5	6	2	6	1
129	*Plectranthus rugosus*	6	5	6	2	2	1
130	*Salvia splendens*	9	8	8	2	6	1
131	*Stachys melisifolia*	4	3	3	3	2	1
	Lauraceae						
132	*Cinnamomum camphora*	4	4	3	3	6	1
133	*Lindera pulcherrima*	5	4	3	2	1	1
	Leguminosae						
134	*Acacia arabica*	4	3	3	3	2	5
135	*Albizia chinensis*	4	3	3	3	6	8

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
136	*Albizia julibrissin*	5	4	3	3	1	8
137	*Bauhinia vareigata*	9	9	3	3	2	1
138	*Bauhinia vahlii*	9	9	3	3	6	1
139	*Caesalpinia decapetala*	5	5	3	3	2	1
140	*Cajanus cajan*	4	4	3	3	2	1
141	*Cassia fistula*	5	5	3	3	2	1
142	*Cicer arietinum*	7	5	3	3	2	1
143	*Delonix regia*	9	9	3	1	6	1
144	*Desmodium coccinum*	6	6	3	1	1	1
145	*Flemingia strobilifera*	6	5	3	3	1	1
146	*Indigofera cylindracea*	5	4	3	3	2	1
147	*Lathyrus odoratus*	7	7	3	2	1	1
148	*Lupinus albus*	7	7	3	3	2	1
149	*Medicago sativa*	3	3	3	3	1	1
150	*Melilotus alba*	4	3	3	3	1	1
151	*Mimosa pudica*	1	1	3	3	1	1
152	*Pisum sativum*	8	5	3	3	2	1
153	*Robinia pseudoacacia*	3	3	3	3	2	1
154	*Sophora moorcroftiana*	8	6	3	2	2	1
155	*Trifolium repens*	4	4	3	3	2	1
156	*Trigonella emodi*	5	4	3	2	2	1
157	*Vicia faba*	8	5	1	1	2	1
	Liliaceae						
158	*Lilium nepalense*	9	9	1	2	6	7
159	*Yucca spp*	9	9	1	2	6	1
	Linaceae						
160	*Linum usitatisimum*	7	7	3	3	6	1
161	*Teucrium quadrifarium*	5	5	3	2	1	1
	Lobeliaceae						
162	*Lobelia pyramidalis*	5	4	3	3	2	1
	Lythraceae						
163	*Cuphea micrantha*	3	3	3	3	1	1
164	*Lagestroemia indica*	6	5	3	3	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Magnoliaceae						
165	*Michelia champaca*	8	5	3	2	1	1
	Malvaceae						
166	*Abelmoschus esculentus*	9	9	8	1	3	1
167	*Althea rosea*	9	9	0	1	3	1
168	*Hibiscus rosa-sinensis*	9	9	8	1	3	1
169	*Malvaviscus arboreus*	9	9	8	1	3	1
170	*Urena lobata*	9	9	0	1	6	1
	Melastomaceae						
171	*Osbeckia chinensis*	4	4	6	2	1	1
	Meliaceae						
172	*Azadirachta indica*	7	7	4	3	1	1
173	*Cedrela toona*	4	4	4	3	1	1
174	*Melia azedarach*	8	7	4	3	2	1
	Myrsinaceae						
175	*Maesa chisia*	2	2	3	3	2	1
	Myrtaceae						
176	*Callistemon citrinus*	3	3	3	1	1	1
177	*Eucalyptus lanceolatus*	3	3	3	1	1	1
178	*Syzygium cumini*	3	3	3	1	1	1
	Oleaceae						
179	*Jasminum humile*	8	8	3	3	1	1
180	*Ligustrum indicum*	5	5	3	3	6	1
	Onagraceae						
181	*Epilobium cylindricum*	9	9	3	1	2	1
182	*Goditia grandiflora*	9	9	3	1	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Oxalidaceae						
183	*Oxalis corniculata*	6	6	1	2	1	1
	Papaveraceae						
184	*Argimone mexicana*	7	7	3	3	2	1
185	*Eschscholzia californica*	5	4	3	1	1	1
186	*Papaver rhoeas*	6	6	8	2	6	1
	Passifloraceae						
187	*Passiflora spp*	9	9	3	1	2	1
	Plantaginaceae						
188	*Plantago spp*	4	4	4	2	2	1
	Plumbaginaceae						
189	*Plumbago capensis*	9	9	3	2	6	1
	Polygonaceae						
190	*Aconogonum molle*	4	3	3	2	2	1
191	*Bistorta amplexicaulis*	8	7	3	3	2	1
192	*Fagopyrum esculentum*	8	6	3	3	2	1
193	*Persicaria chinensis*	8	7	3	3	6	1
194	*Rumex spp*	4	3	3	3	1	1
	Primulaceae						
195	*Androsace strigellosa*	3	2	3	2	1	1
196	*Primula arummondana*	2	2	3	3	1	1
197	*Primula sikkimensis*	5	4	3	2	1	1
	Proteaceae						
198	*Grevillea robusta*	9	8	3	3	2	1
	Punicaceae						
199	*Punica granatum*	4	4	3	3	1	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Rannunculaceae						
200	*Anemone rivularis*	6	6	3	2	2	1
201	*Anemone vitifolia*	4	3	3	2	2	1
202	*Caltha palustris*	7	7	4	2	2	1
203	*Clematis* spp	4	3	3	2	2	1
204	*Delphinium roylei*	5	5	3	3	1	1
205	*Ranunculus diffusus*	6	6	0	2	6	1
206	*Ranunculus hirtellus*	5	5	3	2	2	1
207	*Ranunculus muricatus*	5	5	5	1	2	1
208	*Ranunculus nepalensis*	6	5	3	2	1	1
209	*Thalictrum chelidonii*	2	2	3	2	2	1
	Rhamnaceae						
210	*Rhamnus nepalensis*	3	2	3	2	1	1
211	*Zizyphus incurva*	4	4	3	3	1	1
	Rosaceae						
212	*Agrimonia pilosa*	6	4	4	1	2	1
213	*Eriobotrya dubia*	4	4	3	3	2	1
214	*Eriobotrya japonica*						
215	*Fragaria indica*	5	5	3	3	2	1
216	*Fragaria vesca*	7	6	1	2	2	1
217	*Malus domestica*	6	6	3	3	1	1
218	*Potentilla trucosa*	3	3	3	2	2	1
219	*Potentilla nepalensis*	5	4	3	2	2	1
220	*Prinsepia utilis*	5	5	3	3	1	1
221	*Prunus cerassoides*	2	2	3	3	1	1
222	*Prunus domestica*	5	5	3	3	5	1
223	*Prunus persica*	8	7	3	3	5	1
224	*Pyracantha crenulata*	5	5	3	3	1	1
225	*Pyrus communis*	5	4	3	3	1	1
226	*Pyrus pashia*	5	5	3	3	1	1
227	*Rosa laevigata*	8	6	3	3	1	1
228	*Rosa macrophylla*	5	3	3	2	1	1
229	*Rosa moschata*	4	4	3	3	1	1
230	*Rosa sericea*	5	5	3	3	1	1
231	*Rubus diffusus*	7	6	3	3	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
232	*Rubus ellipticus*	4	4	3	3	1	1
233	*Spiraea arcuata*	2	2	3	3	2	1
234	*Spiraea micrantha*	3	3	3	3	1	1
235	*Stranvaesia nussia*	6	5	3	2	1	1
	Rubiaceae						
236	*Galium aparine*	2	2	5	2	2	1
237	*Hedyotis scandens*	5	4	4	3	6	1
238	*Rubia cardifolia*	3	3	5	2	1	1
239	*Rubia manjitha*	8	8	6	2	2	1
	Rutaceae						
240	*Citrus aurantifolia*						
241	*Citrus grandis*	6	6	4	3	6	1
242	*Citrus limon*	6	5	4	1	6	1
243	*Citrus reticulata*	5	4	4	3	2	1
244	*Citrus sinensis*	5	4	4	2	2	1
245	*Zanthoxylum armatum*	8	7	3	3	1	1
	Salicaceae						
246	*Salix denticulata*	3	3	3	1	6	1
	Santalaceae						
247	*Osyris wightiana*	4	3	3	2	1	1
	Sapindaceae						
248	*Aesculus indica*	5	4	3	3	2	1
249	*Litchi chinensis*	4	4	3	3	1	1
250	*Sapindus detergens*	3	2	4	3	1	1
	Saurariaceae						
251	*Sauraria nepaulensis*	2	2	3	3	1	1
252	*Houttuynia cordata*	3	3	3	2	2	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Saxifragaceae						
253	*Bergenia ciliata*	4	4	3	2	1	1
254	*Deutzia hookeriana*	2	2	3	3	1	1
255	*Saxifraga* spp	3	2	3	3	1	1
	Scrophulariaceae						
256	*Antirrhinum majus*	4	3	3	3	1	1
257	*Lindenbergia grandiflora*	3	2	3	2	1	1
258	*Paulownia elongata*	4	3	3	3	1	1
259	*Pedicularis bifida*	3	3	3	3	2	1
	Smilacaceae						
260	*Smilax aspera*	2	2	3	2	2	1
	Solanaceae						
261	*Capsicum annum*	5	5	3	1	1	1
262	*Datura alba*	8	8	3	3	2	1
263	*Petunia hybrida*	6	5	3	3	2	1
	Stachyuraceae						
264	*Stachyurus himalensis*	4	4	3	3	2	1
	Symplocaceae						
265	*Symplocos paniculata*	6	5	3	3	6	1
	Theaceae						
266	*Camellia kissi*	6	6	3	3	1	1
267	*Eurya accuminata*	2	2	3	1	1	1
	Thymelaeaceae						
268	*Stellera* spp	3	3	9	1	6	1

S. No	Family/PlantSpecies	L	B	AN	AT	ES	AGGS.
	Urticaceae						
269	*Lecanthus peduncularis*	5	5	3	1	1	1
270	*Pilea symmerina*	1	1	4	1	1	1
271	*Boehmeria rugulosa*	2	2	3	2	1	1
	Verbinaceae						
272	*Callicarpa macrophylla*	5	5	3	2	2	1
273	*Caryopteris foetida*	8	8	3	2	2	1
274	*Duranta repens*	6	6	3	1	2	1
275	*Lantana camara*	6	5	3	2	2	1
276	*Vitex negundo*	4	2	3	2	2	1
	Violaceae						
277	*Viola indica*	5	4	3	3	1	1
	Zingiberaceae						
278	*Hedychium spp*	4	4	3	3	2	1
279	*Roscoea purpurea*	8	8	6	3	3	1

(Pollen Grain Features: L, B, AN, AT, ES, AGGS.)

Note

L Length
B Breadth
AN Aperture Number
AT Aperture Type
ES Exine Sculpture
AGG Aggregation

Source: Studies by Author

Annex 4
Annex to Chapter Four

Multipurpose Bee Plants of Different Climatic Regimes of the HKH for Plantation on Common Property Land and Roadside

Species	Uses	Remarks
A. Temperate region comprising mostly of high mountain area		
Eucalyptus saligna (Sydney Blue Gum Tree)	Timber, fuel	Medium-sized trees - Can be grown by entire transplanting as well as by direct sowing - Can be planted on gentle slopy roadsides
Juglans regia (Walnut, Akhrot)	Timber, furniture, and carving, gun-stock, fruits	Large tree -Grown by entire Transplanting and also by direct sowing
Morus serrata (Mulberry, Kimu)	Fodder, sports goods, toys	Large tree - Suitable for furniture, growing on marginal slopy lands and on roadsides passing through farmlands - Can be grown by branch cuttings and direct sowing.
Prunus cerasoides (Wild Cherry, 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.

Species	Uses	Remarks
Prunus persica (Peach, Aru)	Fruits, timber, fuel	Small tree - Suitable for near habitations, gentle stable slopes and plain valley areas - Grown by entire transplanting.
Pyrus malus (Apple)	Fruits	Small trees - Suitable for growing near habitations, farming areas in valleys and marginal lands - Grown by entire transplanting
Prunus armeniaca (Apricot)	Fruits, oil from seeds, timber, fuel	Small tree - suitable near habitations, farmlands- grown by branch cuttings.
Robinia pseudoacacia (Black Locust)	Fuel, fodder, soil conservation	Medium tree - Suitable for marginal lands and for stabilising marginal 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 foothills of the western Himalayan and central Himalayan mountains

Albizia lebbek (Siris)	Timber, fuel, fodder, medicinal	Large trees - Suitable for open roadside lands and along narrow pathways - Grown by entire transplanting, direct sowing, and cuttings.
Bauhinia purpurea (Geranium Tree)	Gum, fuel, fodder	Medium tree - Suitable for roads passing through farms - Grown by entire transplanting and direct sowing.
Bauhinia variegata (Kachnar)	Gum, fuel, fodder	Medium tree - Suitable for roads passing through farms - Grown by entire transplanting and direct sowing.
Dalbergia sissoo (Shisham)	Timber, furniture, plywood fuel, fodder	Large or medium tree - Suitable for growing in lower to mid-hill plantations, on village roads.

Species	Uses	Remarks
		Grown by entire transplanting, root and shoot - Suitable on slopy sites.
Emblica officinalis (Emblica, Amla)	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 its socioeconomic value.
Eucalyptus camaldulensis (River Red Gum)	Timber, fuel, charcoal, gum, medicinal	Large tree - Suitable for both dry and swampy areas - Grown by entire transplanting.
Grevillea robusta (Silky Oak)	Ornamental, timber, cabinet making, toys, fuel, panelling, shade tree in tea gardens	Large tree - Suitable for shade or as an avenue tree - Grown by direct sowing.
Grewia optiva (Bhimal)	Timber, cot frames, fibre, fodder	Medium tree - Suitable for farming areas - Good for fodder, fibre, and fuel - Grown by entire transplanting.
Morus alba (Mulberry, Tut)	Fruits edible, timber, sports goods, fodder, leaves for silkworm feeding	Medium tree - Suitable for fodder on marginal lands - Grown by entire transplanting, direct sowing or branch cuttings.
Prunus armeniaca (Apricot, Zardalu)	Fruits, timber, fuel	Small tree near habitations, farmlands, roadsides - Grown by branch cuttings
Prunus persica (Peach, Aru)	Fruits, timber, fuel	In valleys and on stable land near habitation, roadsides.
Pyrus communis (Pear, Nashpati)	Fruits, fuel	Small tree - Suitable for homesteads and field edges - Grown by grafting.

Species	Uses	Remarks
C. Sub-tropical climate of central and eastern Himalayas		
Albizia lebbek (Siris)	Timber, fuel, fodder, medicinal	Large trees - Suitable for open roadside lands and along narrow pathways - Grown by entire transplanting, direct sowing, and cuttings.
Bauhinia purpurea (Geranium Tree)	Timber, fuel, fodder	Large tree - Suitable for growing on village commons, marginal lands, and roadsides - Grown by entire transplanting and direct sowing - Good for areas requiring fuel and fodder.
Grevillea robusta (Silky Oak)	Essential oils, fuel, charcoal, timber	Medium tree - Suitable for slopy and plain roadsides - Grown by entire transplanting.
Grewia elastica (Dhaman)	Ornamental, timber, toy-making, fuel, fodder	Medium tree - Suitable for slopy and plain roadsides - Grown by entire transplanting.
Morus serrata (Mulberry, Kimu)	Fodder, sports' goods, furniture, toys, fodder, leaves fed to silk worms	Large tree - Suitable for growing on marginal slopy lands and on roadsides passing through farmlands - Can be grown by branch cuttings and direct sowing.
D. Tropical Region		
(i) *High rainfall areas of Nepal and northeastern parts of India*		
Dalbergia latifolia (Rosewood)	Timber, furniture, cabinets	Large tree - Suitable for growing on village, state, and national highways - Grown by entire transplanting.
Lagerstroemia speciosa (Jarul)	Timber, constructional purposes, furniture, agricultural implements, telegraph poles, fodder, medicinal	Large tree - Suitable along pathways, grown by entire transplanting.

Species	Uses	Remarks
Mangifera indica (Mango)	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).
Parkia roxburghii (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		
Acacia auriculiformis (Akashmuni)	Timber, fuel, ornamental	Medium trees - Suitable for slopy lands - Grown by entire transplanting and direct sowing.
Acacia nilotica (Babul, Kikar)	Timber, fuel, fodder, tannin, gum	Medium tree - Suitable for slopy lands, marginal lands and village commons - Grown by direct sowing.
Aegle marmelos (Bel Tree, 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		
Salix spp (Willow Tree)	Fuel, baskets and building	A popular tree of the trans-Himalayas.
Prunus armeniaca (Apricot, Khurmani)	Fruits, timber, fuel	Small tree near habitation, farmland, roadsides - Grown by branch cuttings - A popular oil seed and fruit tree, wild as well as domesticated.
Hippophae spp (Seabuckthorn)	Fruits, fuel, timber, nitrogen fixation, soil fertilization	Shrub and tree both suitable for dry sandy or rocky locations, riverside, moist areas - Good for roadsides passing through farm lands.
Prunus persica	Fruits, fuel	Wild forms for roadside plantations.

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Keyword Index

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Participating Countries of the Hindu Kush-Himalayan Region

- Afghanistan
- Bhutan
- India
- Nepal
- Bangladesh
- China
- Myanmar
- Pakistan

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