CHAPTER 9

Honey Plant Resources

9.1 INTRODUCTION

Honeybees visit a variety of plant species to collect pollen and nectar which are the raw materials of the beekeeping industry. In the act of foraging for pollen and nectar, honeybees incidentally reciprocate by performing valuable pollination services for the plants. Honeybees and certain flowering plants have, therefore, evolved a well-adjusted system of interdependence, and such relationship is one of the most significant events of organic evolution (Deodikar, 1962; Martin, 1979). Pollen is practically the sole source of proteins, lipids, minerals and vitamins which is mostly used to feed the brood. Nectar contains mainly sugars in water. The main sugars of nectars are maltose, raffinose, melibiose, trehalose, and melezitose. Besides sugar, nectar also contains proteins, amino acids, other organic acids and volatile oils. Nectar acts as a main fuel for flight, foraging, hive activity and developing brood.

The present chapter deals with the significance of melissopalynology, bee botany, floral calendar and nectar secretion studies in relation to beekeeping in Asia. Studies on the pollen collecting behaviour of *Apis cerana*, eco-physiology of *Plectranthus* sp., major honey plants of the Hindu Kush-Himalaya, and linkages between beekeeping and social forestry have also been included. A list of common honey plants as well as those which act as medium and minor resources of honey is given in Tables 9.1 and 9.2.

Table 9.1: Common honey plants of the Hindu-Kush Himalayan region

Family/plant species	Common name	Honey potentiality	Flowering period	Distribution	Type (nature)	Other economic uses
1	2	3	4	5	6	7
Acanthaceae						
Adhatoda zeylanica Nees	Basuti	N^2P^2	APR-NOV	S.Tropical, S.Temperate, Temperate	Shrub (W)	Medicinal & Soil reclamation
Justicia pubigera Nees	Bankas	N^2P^2	AUG-OCT	S.Temperate, Temperate	Herb (W)	Medicinal
Rungia parviflora Nees	Rungia	N^3P^3	JUL-AUG	S.Tropical, S.Temperate,	Herb (W)	Medicinal weed
Strobilanthes wallichi Nees	Strobilanthes	N^3P^3	AUG-OCT	S.Temperate, Temperate	Shrub (W)	
Aceraceae						
Acer spp.	Great maple	N^2P^2	MAR-APR	S.Temperate, Temperate	Tree (W/C)	Timber
Agavaceae						
Agave americana L.	Century plant	N^3P^3	SEP-NOV	S.Tropical	Shrub (W)	Ornamental & Fibre
Amaranthaceae						
Amaranthus paniculatus L.	Amaranth	N^2P^2	JUN-JUL	S.Tropical, S.Temperate, Temperate	Herb (W)	Crop

Amaryllidaceae						
Allium cepa L.	Onion	N^3P^3	MAY-JUN	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal & Vegetable,
Allium sativum L.	Garlic	N^3P^3	MAY-JUN	S.Tropical, S.Temperate, Temperate	Herb (C)	Condiment & Medicinal
Anacardiaceae						
Mangifera indica L.	Mango	N^2P^3	MAR-APRIL	S.Tropical	Tree (C)	Fruit, Fuel & Timber
Odina woodier Roxb.	Karambal	N^2P^3	FEB-APR	S.Tropical, S.Temperate,	Tree (C)	Fodder, Confectionery &
Rhus spp.	Sumac	N^3P^3	MAY-JUN	S.Temperate, Temperate	Tree/Shrub (C)	Gum Tannin
Apiaceae						
Coriandrum sativum L.	Coriander	N^3P^3	MAR-JUN	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal, Alcoholic, Beverage & Condiment
Daucus carota L.	Carrot	N^2P^3	MAR-MAY	S.Tropical, S.Temperate, Temperate	Herb (C)	Fodder & Vegetable
Foeniculum vulgare Mill	Fennel	N^3P^3	AUG-SEP	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal, Fodder & Condiment
Heracleum spp.	Hogweed	N^3P^3	MAY-JUL	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Apocynaceae						
Carissa carandas L.	Karandas	N^2P^2	APR-MAY	S.Tropical, S.Temperate, Temperate	Shrub (W/C)	Preservation
Arecaceae						
Phoenix spp.	Wild date palm	N^2P^3	MAY-JUL	S.Tropical, S.Temperate	Shrub (W)	Fruit
Asclepiadaceae						
Asclepias curasscavica L.	Milkweed	N^2P^2	APR-JUN	S.Tropical, S. Temperate	Shrub (W)	Medicinal & Fibre
Aasteraceae						
Ageratum conyzodies L.	Ageratum	N^3P^3	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Ornamental
Artemisia maritima L.	Mugwort	N^3P^3	AUG-OCT	S.Temperate, Temperate	Herb (W/C)	Medicinal & Ornamental

Table 9.1 (Cont'd...)

1	2	3	4	5	6	7
Aster spp.	Star-wort	N^3P^3	OCT-NOV JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (C)	Ornamental
Bidens spp.	Spanish needle	N^3P^2	SEP-DEC	S.Tropical, S.Temperate, Temperate	Herb (W)	
Calendula arvensis L.	Marigold	N^3P^3	MAY-JUL	S.Tropical, S.Temperate,	Herb (C)	Medicinal & Ornamental
Cardus onopardiodes Fisch	Musk Thistles	N^2P^2	MAY-AUG	S.Tropical, S.Temperate, Temperate	Herb (W)	Fodder
Carthamus tinctorius L.	Safflower	N^2P^2	JAN-FEB	S.Tropical, S.Temperate	Herb (C)	Fodder, Oil & Dyeing
Centaurea cyanus L.	Corn-flower	N^2P^3	FEB-APR	S.Temperate, Temperate	Herb (C)	Medicinal & Ornamental
Chrysanthemum spp.	Chrysan-themum	N^3P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Insecticide & Ornamental
Cichorium intybus L.	Chicory	N^3P^3	MAY-AUG	S.Tropical, S.Temperate, Temperate	Herb (W)	
Cirsium spp.	Field Thistles	N^2P^3	MAY-AUG	S.Tropical, S.Temperate, Temperate	Herb (W)	
Cosmos sulphureus Cav.	Cosmos	N^3P^2	SEP-NOV	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Dyeing & Ornamental
Echinops echinatus Roxb.	Globe Thistle	N^3P^3	MAY-JUN	Temperate	Herb (W)	Medicinal
Eupatorium spp.	Through-wort	N^3P^3	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Helianthus annuus L.	Sunflower	N^2P^2	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C), (W)	Lubricant oilseed, Fodder Ornamental
Inula cappa	Inula	N^2P^2	SEP-NOV	Temperate	Herb (W)	
Mikania scandens Willd.	Mikania	N^2P^3	MAR-APR	S.Tropical	Climber (W)	Medicinal
Senecio spp.	Ragwort	N^3P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal

Solidago longifolia Schrad	Golden rod	N^2P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Medicinal & Ornamental
Sonchus spp.	Sow thistle	N^3P^3	JUN-OCT	S.Tropical, S.Temperate, Temperate	Herb (W)	
Tagetus spp.	Marigold	N^3P^3	JUL-OCT	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal, Aromatic & Ornamental
Taraxacum officinale Weber	Dandelion	N^2P^2	MAR-AUG	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Tussilago farfara L.	Coltsfoot	N^3P^3	APR-JUN	S.Tropical, S.Temperate	Herb (W)	Vegetable & Medicinal
Vernonia spp.	Ironweed	N^3P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal & Ornamental
Balsaminaceae						
Impatiens glandulifera Royle	Balsam	N^1P^2	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Ornamental & Medicinal
Berberidaceae						
Berberis lycium L.	Barberry	N^2P^1	MAY-JUN	S.Tropical, S.Temperate, Temperate	Shrub (W)	Medicinal, Root & Fruit
Betulaceae						
Alnus nitida (Spach) Endl.	Alder	N^3P^2	SEP-NOV	S.Tropical, S.Temperate, Temperate	Tree (W)	Timber & Dyeing
Corylus colurna Dence.	Hazelnut	P^2	MAR-MAY	S.Tropical, Temperate	Shrub (W/C)	Seeds Edible & Fuel
Bombacaceae						
Bombax ceiba L.	Silk cotton tree	N^2P^2	FEB-MAR	S.Tropical, S.Temperate, Temperate	Tree (W)	Fibre, Timber & Fodder
Boraginaceae						
Cynoglossum glochidiatum Wall.	Hounds tongue	N^3P^3	JUN-SEP	S.Tropical	Herb (W)	Ornamental
Ehretia acuminata R.Br.	Ivory wood	N^1P^2	FEB-APR	S.Tropical, S.Temperate	Tree (W/C)	Timber, Fodder & Fruit Edible

Table 9.1 (Cont'd...)

1	2	3	4	5	6	7
Brassicaceae						
Brassica juncea (L) Czern.	Indian mustard	N^2P^2	DEC-MAR	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable & Oilseed
Brassica napus L. var. *glauca* (Roxb) Schutz.	Mustard	N^1P^1	DEC-MAR	S.Tropical, S.Temperate, Temperate	Herb (C)	Oilseed, Vegetable & Lubricant
Brassica napus var *toria* L.	Toria	N^1P^1	DEC-MAR	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable, Oilseed & Lubricant
Brassica oleracea var. *capitata* L.	Cabbage	N^2P^3	MAY-JUL	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable
Brassica rapa L.	Turnip	N^2P^2	FEB-APR	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable & Fodder
Cardamine spp.	Cuckoo flower	N^2P^2	JAN-FEB	S.Tropical, Temperate	Herb (W)	Medicinal
Eruca sativa Mill	Rocket salad	N^1P^1	DEC-MAR	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal, Oilseed & Fodder
Raphanus sativus L.	Radish	N^3P^3	FEB-MAR	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable & Medicinal
Cactaceae						
Opuntia spp.	Prickly pear	N^2P^2	APR-MAY	S.Tropical, S.Temperate, Temperate	Shrub (W)	Medicinal
Caesalpiniaceae						
Bauhinia variegata Wight	Geranium tree	N^2P^3	FEB-APR	S.Tropical, S.Temperate, Temperate	Tree (W)	Vegetable, Fodder & Ornamental

Bauhinia vahli Wight	Camel's foot climber	N^2P^3	MAR-MAY	S.Tropical, S.Temperate, Temperate	Tree (W)	Fibre, Vegetable, Fodder & Fuel
Cassia spp.	Indian Laburnum	N^2P^2	APR-JUL	S.Tropical, S.Temperate,	Tree (W)	Confection & Medicinal
Caesalpinia spp.	American Surmach	N^3P^3	NOV-APR		Small Tree (W)	Timber & Tanning
Delonix regia Raf.	Gulmohr	N^3P^2	MAY-JUN	S.Tropical, S.Temperate	Tree (W/C)	
Tamarindus indica L.	Tamarind	N^3P^3	MAR-MAY	S.Tropical, S.Temperate, Temperate	Tree (C)	Medicinal, Condiment, Fruit, Fodder & Oil
Cannabacaceae						
Cannabis sativa L.	Hemp	N^2P^2	JUN-SEP	Temperate	Weed (W/C)	Oil, Medicinal & Alkaloid fibre
Capparaceae						
Capparis himalayensis Jafri	Kanthar	N^3P^3	APR-MAY	S.Tropical, S.Temperate, Temperate	Climber (W/C)	Medicinal
Capparidaceae						
Crataeva religiosa Forst	Barna	N^2P^2	APR-MAY	S.Tropical, S.Temperate	Tree (W/C)	Ornamental
Caprifoliaceae						
Lonicera sempervirens L.	Honey suckle	N^3P^3	MAY-AUG	S.Tropical, S.Temperate	Shrub (W/C)	Ornamental
Viburnum spp.	Vikurum	N^3P^3	MAY-JUN	S.Tropical, S.Temperate	Shrub (C)	Ornamental
Chenopodiaceae						
Chenopodium album L.	White goose foot	N^3P^3	MAR-MAY AUG-OCT	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Vegetable & Fodder

Table 9.1 (Cont'd. . .)

1	2	3	4	5	6	7
Combretaceae						
Terminalia arjuna Wight	Arjun	N^2P^2	MAY-JUL	S.Tropical, S.Temperate	Tree (C)	Timber, Fuel, Tanning & Dyeing
Terminalia chebula Retz	Yellow myrobalan	N^2P^2	MAY-JUN	S.Tropical, S.Temperate	Tree (W/C)	Fruit, Medicinal, Bark for Tanning & Dyeing
Con volvulaceae						
Convolvulus arvensis L.	Convol-vulus	N^3P^3	APR-SEP	S.Tropical, S.Temperate, Temperate	Weed (W)	
Ipomoea batatas Lam.	Sweet potato	N^2P^3	AUG-NOV	S.Tropical, S.Temperate, Temperate	Herb (C)	Tuber, Edible Vegetables & Medicinal
Ipomoea pulchella Roth	Railway creeper	N^3P^3	AUG-NOV	S.Tropical, S.Temperate, Temperate	Herb (W)	Seed, Purgative & Parantic
Cuscuta reflexa Roxb.	Amar-Vel	P^3	JUL-OCT	S.Tropical, S.Temperate, Temperate	Parasitic, Succulent, Herb (W)	Medicinal
Cucurbitaceae						
Citrullus vulgaris Schrad	Water-melon	N^2P^2	APR-MAY	S.Tropical	Climber (C)	Fruit & Medicinal
Cucumis spp.	Cucumber, Melon	N^2P^2	JUL-SEP	S.Tropical, S.Temperate	Climber (C)	Oil & Medicinal
Cucurbita maxima L.	Pumpkin	N^2P^2	APR-JUN	S.Tropical, S.Temperate	Climber (C)	Vegetable, Seed & Medicinal
Lagenaria siceraria L. Gourd	Bottle	N^3P^3	MAY-JUL	S.Tropical, S.Temperate	Climber (C)	Vegetables & Medicinal
Luffa echinata Roxb.	Ribbed Gourd	N^3P^3	MAY-JUL	S.Tropical, S.Temperate	Climber (C)	Vegetables, Medicinal & Purgative

Dipsacaceae Wall.						
Dispsacus inermis	Teasel	**N^3P^3**	JUL-OCT	S.Tropical, S.Temperate, Temperate	Herb (C)	
Scabiosa speciosa Royle	Scabious	N^2P^3	MAY-JUL	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Ornamental & Medicinal
Ericaceae						
Gaultheria fragrantissima Wall.	Fragrant winter-green	N^2P^2	MAY-JUN	Temperate	Shrub (W)	Fruit & Medicinal
Rhododendron spp.	Alpine Rose	N^3P^3	MAR-MAY	Temperate	**Tree (W)**	Medicinal & Flowers for Cold Drinks, Jams
Euphorbiaceae						
Emblica officinalis Gaertn.	Indian goose-berry	**N^2P^2**	MAR-MAY	S.Tropical	Tree (W)	Fruit, Tanning & Medicinal
Euphorbia royleana Bros.	Euphorbia	N^3P^3	APR-MAY	Temperate	Shrub, Juicy, Hedge plant (W/C)	Medicinal
Phyllanthus acida (L) Skeels	Star goose-berry	N^2P^2	APR-JUN	S.Tropical	Tree (W/C)	Fruit & Tanning
Ricinus communis L.	Caster oil-plant	P^2	MAY-AUG	S.Tropical, S.Temperate	Shrub (W/C)	Lubricant, Oilseed, Purgative & Medicinal
Fagaceae						
Castanea sativa Mill.	Sweet Chestnut	N^3P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Tree (W/C)	Timber, Seed & Nuts Edible
Quercus spp.	Oak	N^2P^3	APR-JUL	S.Tropical, S.Temperate	Tree (W/C)	Timber

Table 9.1 (Cont'd...)

1	2	3	4	5	6	7
Gentianaceae						
Gentiana pedicellata Wall.	Gentiana	N^3P^3	APR-JUL	S.Temperate, Temperate	Herb (W)	Medicinal
Swertia spp.	Swertia	N^3P^3	AUG-OCT	S.Temperate, Temperate	Herb (W)	Medicinal & Soil
Geraniaceae						
Erodium spp.	Erodium	N^2P^2	APR-JUN	S.Tropical, S.Temperate, Temperate	Herb (W/C)	
Geranium spp.	Crane's bill	N^3P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Medicinal & Ornamental
Iridaceae						
Iris nepalensis Don	Iris	N^2P^2	APR-MAY	Temperate	Herb (W/C)	Medicinal & Ornamental
Juglandaceae						
Juglans regia L.	Walnut	N^2P^2	FEB-APR	S.Temperate, Temperate	Tree (W)	Dyeing & Medicinal
Lamiaceae						
Calamintha spp.	Summer savory	P^3	SEP-OCT		Herb (W/C)	Medicinal
Lamium spp.	Dead nettle	N^2P^3	APR-OCT	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Leonurus cardiaca L.	Mother-wort	N^3P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Mentha spp.	Mint	N^3	JUL-OCT	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Carminative, Stimulant & Aromatic
Nepeta spp.	Catmint	N^3P^3	MAY-AUG	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal

Ocimum spp.	Tulsi	N^3P^3	JUN-SEP	S.Tropical, S.Temperate	Herb (W/C)	Medicinal
Origanum vulgare L.	Marjoram	N^2P^2	JUL-SEP	S.Tropical, S.Temperate	Herb (W)	Medicinal, Oil & Aromatic
Plectranthus rugosus Nall.	Shain	N^1P^2	AUG-NOV	S.Temperate, Temperate	Shrub (W)	
Plectranthus coetsa Benth.	Shain	N^1P^2	SEP-OCT	S.Temperate, Temperate	Under Shrub (W)	
Plectranthus gerardianus Benth.	Shain	N^1P^2	AUG-OCT	S.Temperate, Temperate	Under Shrub (W)	
Rosmarinus officinalis L.	Rosemary	N^2P^21	APR-JUN		Herb (W/C)	Ornamental & Medicinal
Salvia spp.	Sage	N^2P^2	JUL-OCT	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Ornamental & Medicinal
Stachys spp.	Wound-wort	N^2P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Teucrium spp.	Wood Sage	N^3P^3	AUG-SEP	S.Temperate, Temperate	Herb (W)	
Thymus spp.	Thyme	N^2P^3	MAY-OCT	S.Tropical, S.Temperate, Temperate	Shrub (W)	Medicinal & Aromatic
Lauraceae						
Litsea polyantha Juss.	Meda	N^3P^3	DEC-JAN	Temperate	Tree (W)	Medicinal
Liliaceae						
Allium cepa L.	Onion	N^2P^2	MAY-JUN	S.Tropical, S.Temperate	Herb (C)	Vegetable & Medicinal
Asphodelus tenuifolius Cav.	Piazi	N^3P^2	JUL-OCT	S.Tropical, S.Temperate, Temperate	Herb (W)	
Linaceae						
Linum spp.	Flax	N^3P^3	FEB-MAR	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Medicinal, Oilseed & Fibre
Lytheraceae						
Lagerstremoia indica L.	Pride of India	N^2P^2	JUL-SEP	S.Tropical, S.Temperate, Temperate	Small tree (W)	Purgative, Timber & Ornamental

Table 9.1 (Cont'd...)

1	2	3	4	5	6	7
Malvaceae						
Abelmoschus esculentus L.	Lady's finger	N^3P^3	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Vegetable & Fibre
Althaea rosea Cav.	Hollyhock	N^2P^2	JUN-OCT	S.Tropical, S.Temperate	Herb (C)	Dyeing & Ornamental
Gossypium arboreum L.	Cotton	N^3P^3	JUL-SEP	S.Tropical, S.Temperate	Shrub (C)	Fibre & Oil
Hibiscus cannabinus L.	Deccan-hemp	N^3P^3	JUL-AUG	S.Tropical, S.Temperate	Herb (C)	Fodder, Crop & Fibre
Malva sylvestris L.	Mallow	N^2P^3	JUN-OCT	S.Tropical, S.Temperate	Herb (C)	Medicinal & Ornamental
Meliaceae						
Azadirachta indica Brandis	Margosa	N^2P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Avenue tree, Forest tree (W)	Medicinal & Insecticide (Repellant)
Toona ciliata M.	Cedrella	N^1P^2	MAR-JUN	S.Tropical, S.Temperate	Tree (W)	Dyeing & Woody Furniture
Mimosaceae						
Acacia spp.	Acacia	N^2P^2	MAY-JUL	S.Tropical, S.Temperate	Tree (W)	Medicinal Dyeing, Tanning Industry & Timber
Albizia lebbek Benth.	Siris	N^2P^2	APR-MAY	S.Tropical, S.Temperate	Tree (W/C)	Fodder, Fuel Paper Industry & Timber
Mimosa pudica L.	Sensitive plant	N^2P^2	JUL-NOV	S.Tropical, S.Temperate	Herb (W)	Ornamental
Parkia roxburghli G. Don	Supota	N^3P^2	OCT-DEC		Tree (W/C)	Fruit

Moringaceae						
Moringa oleifera Lam.	Drumstick tree	N^3P^3	JAN-MAR	S.Tropical	Tree (W)	Medicinal & Perfumery & Lubricant
Moraceae						
Morus spp.	Mulberry	P^2	MAR-APR	S.Tropical	Tree (W/C)	Source of food for silkworm
Musaceae						
Musa sapientum L.	Banana	N^3P^3	MAR-DEC	S.Tropical, S.Temperate	Shrub (C)	Fruit & Medicinal
Myrtaceae						
Callistemon citrinus (Curt.) Skeels	Bottle Brush	N^2P^2	APR-MAY		Avenue tree (W/C)	Ornamental
Eucalyptus spp.	Eucalyp-tus	N^1P^1	FEB-APR OCT-DEC	S.Tropical, S.Temperate, Temperate	Avenue tree (W/C)	Paper Industry & Timber
Psidium guajava L.	Guava	N^3P^3	MAY-JUN	S.Tropical, S.Temperate	Tree (C)	Fruit,Leaves for Tanning& Dyeing
Syzygium cumini (L.) Skeels	Jambolan	N^1P^2	APR-JUN	S.Tropical, S.Temperate	Avenue tree (W/C)	Fruit, Fodder, Medicinal, Dyeing & Tanning
Onagraceae						
Epilobium spp.	Willow herb	N^2P^2	JUN-SEP	S.Tropical, S.Temperate	Roadside tree (W)	
Oxalidaceae						
Oxalis corniculata L.	Indian sorrel	N^3P^1	FEB-JUN	S.Tropical, S.Temperate, Temperate	Shrub (W)	Medicinal

Table 9.1 (Cont'd. . .)

1	2	3	4	5	6	7
Papaveraceae						
Argemone mexicana L.	Pivla-Dhotra	P^3	MAY-JUL	S.Tropical, S.Temperate, Temperate	Herb (W)	Lubricant & Medicinal
Papaver spp.	Poppy	N^3P^3	MAR-MAY	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal & Ornamental
Papilionaceae						
Butea monosperma (Lam.) Kuntze	Palas	N^2	MAY-SEP	S.Tropical, S.Temperate, Temperate	Tree (W)	Dyeing & Medicinal
Cajanus cajan L.	Pulse	N^3P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Shrub (W)	Crop, Food for Lac Insect & Fodder
Cicer arietinum L.	Gram	N^3P^3	FEB	S.Tropical, S.Temperate, Temperate	Herb (C)	Pluse, Crop & Fodder
Crotoloaria juncea L.	Sannhemp	N^3P^3	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb, under Shrub (C)	Crop, Fibre & Leaves, Good Manure
Dalbergia sissoo Roxb.	Sissoo	N^1P^2	MAR-MAY	S.Tropical, S.Temperate	Tree (W)	Timber, Fuel, Fodder, Shade & Paper industry
Erythrina suberosa Roxb.	Coral tree	N^2P^2	MAY-JUN	S.Tropical, S.Temperate, Temperate	Tree (W/C)	Fibre
Glycine max Merr (L.)	soybean	N^3P^3	JUL-AUG	S.Tropical, S.Temperate, Temperate	Herb (C)	Oilseed Crop, Fodder, Banking industry & Paints
Indigofera spp.	Indigo-fera	N^2P^2	JUN-AUG	S.Tropical, S.Temperate, Temperate	Shrub (W)	Fodder
Lespedeza spp.	Lespedeza	N^2	JUN-JUL	S.Tropical, S.Temperate, Temperate	Shrub (W)	Soil reclamation & Fodder
Medicago sativa L.	Lucerne Alfalfa	N^1P^2	MAY-AUG	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Fodder, Paints & Drying oil
Melilotus Mill. spp.	Mellilot	N^1P^2	MAR-JUL	S.Tropical, S.Temperate, Temperate	Herb (C)	Fodder

Phaseolus spp.	Pulses, Beans	N^3P^3	JUL-AUG	S.Tropical, S.Temperate, Temperate	**Herb (C)**	Crop, Food & Fodder
Pisum sativum L.	Garden pea	N^3P^3	MAR-JUL	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable & Green Manure
Robinia pseudoacacia L.	Black locust	N^1P^2	APR-JUN	S.Tropical, S.Temperate, Temperate	Tree (W/C)	Medicinal, Ornamental, Fuel & Timber
Sophora mollis L.	Pagoda tree	N^2P^2	MAR-JUL	S.Temperate	Tree (W)	Ornamental
Trifolium alexandrinum L.	Egyptian clover	N^1P^1	APR-JUL	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Green Manure & Soil/ Reclamation
Trifolium pratense L.	Red clover	N^2P^2	APR-JUL	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Fodder
Trifolium repens L.	White clover	N^1P^2	APR-JUL	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Green Manure, Fodder & Crop
Trigonella spp.	Methi	N^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Medicinal, Fodder & Vegetable
Vicia spp.	Field beans	N^3P^3	APR-AUG	S.Temperate, Temperate	Food (W/C)	Fodder
Pedaliaceae						
Sesamum indicum L.	Sesamum	N^3P^3	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb (C)	Crop, Oilseed Confectionary & Insecticidal
Plantaginaceae						
Plantago spp.	Plantago	N^2P^1	MAR-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal

Table 9.1 (Cont'd...)

1	2	3	4	5	6	7
Poaceae						
Bambusa bambos Druc.	Bamboo	N^3P^3	NOV-DEC	S.Tropical, S.Temperate	Treec (W)	Forest, Wood Furniture & Paper industry
Cynodon dactylon L.	Dub	P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Fodder (W)	
Sorghum vulgare Pers.	Cholam	N^3P^2	MAY-JUN SEP	S.Tropical, S.Temperate, Temperate	Crop, Grain Fodder (C)	Malting & Fermentation Industry
Zea mays L.	Maize	P^2	JUL-AUG	S.Tropical, S.Temperate, Temperate	Grain, Fooder (C)	Industrial alcohol & Corn starch
Polygonaceae						
Fagopyrum sagittatum Moench	Buck-wheat	N^1P^2	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb, Grain (C)	Flour
Polygonum spp.	Polygo-num	N^2P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Medicinal & Tannin
Rumex spp.	Rumex	N^3P^3	JUN-OCT	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Portulacaceae						
Portulaca glandiflora Hook	Portu-laca	N^2P^1	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (C)	Ornamental
Primulaceae						
Primula spp.	Primula	N^3P^3	MAY-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Ornamental
Proteaceae						
Grevillea robusta A. Cunn	Silver Oak	N^1P^1	MAR-JUN	S.Tropical	Tree (W)	Ornamental

Punicaceae						
Punica granatum L.	Pomegranate	N^2P^1	APR-MAY	S.Tropical, S.Temperate	Shrub/ Tree (C)	Fruit, Tanning & Medicinal
Punica nana L.	Wild Pomegranate	N^2P^1	APR-MAY	S.Tropical, S.Temperate	Shrub/ Tree (W/C)	Fruit, Tanning & Medicinal
Ranunculaceae						
Caltha spp.	Marsh Marigold	N^3P^2	APR-JUL	Temperate		
Clematis spp.	Clematis	N^2P^2	MAR-MAY		Shrub (W)	Ornamental
Ranunculus arvensis L.	Butter cup	N^3P^3	MAY-JUN	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Rhamnaceae						
Ziziphus jujuba Lam.	Chinese date	N^2P^3	JUL-SEP	S.Tropical, S.Temperate	Tree (W/C)	Fruit, Fodder & Oilseed
Rosaceae						
Eribotrya japonica Lindl.	Loquat	N^3P^3	FEB-MAR	S.Tropical, S.Temperate	Tree (C)	Fruit
Fragaria vesca L.	Fragaria	N^2P^2	MAY-SEP	Temperate	Herb (C)	Ornamental
Malus domestica Mill.	Apple	N^1P^3	MAR-APR	S.Temperate, Temperate	Tree (C)	Fruit
Malus pumile Mill.	Apple	N^1P^1	MAR-APR	S.Temperate, Temperate	Tree (C)	Fruit
Potentilla spp.	Silver weed	N^2P^3	JUN-AUG	S.Tropical, S.Temperate, Temperate	Herb/ Shrub (W/C)	Medicinal

Table 9.1 (Cont'd...)

1	2	3	4	5	6	7
Prinsepia utilis Royle	Bekhal	N^1P^2	SEP-NOV	S.Tropical, S.Temperate, Temperate	Shrub (W)	Fatty Oil & Hydrogenation
Prunus armeniaca L.	Apricot	N^1P^1	MAR-APR	S.Temperate, Temperate	Tree (C)	Fruit & Oil
Prunus amygdalus Batsch.	Almond	N^1P^1	MAR-APR	S.Temperate, Temperate	Tree (C)	Fruit, Edible Seeds, Oils in in Perfumery
Prunus avium L.	Cherry	N^1P^1	MAR-APR	S.Temperate, Temperate	Tree (C)	Fruits
Prunus cerasoides D.	Wild Cherry	N^1P^2	OCT-NOV	S.Temperate, Temperate	Tree (W/C)	Fruit & Ornamental
Prunus domestica L.	Plum	N^1P^1	FEB-MAR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit
Pyrus pashia Buch-Ham	Wild pear	N^1P^1	FEB-MAR	S.Tropical, S.Temperate, Temperate	Tree (W)	Fruit, Root-stock for Pear
Pyrus persica L. Batsch.	Peach	N^1P^1	FEB-MAR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit
Pyrus communis L.	Pear	N^1P^1	FEB-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit
Rosa macrophylla L.	Rose	N^3P^2	MAR-MAY	S.Tropical, S.Temperate, Temperate	Shrub (C)	Fruit, Hedge & Ornamental
Rosa moschata Mill	Wild Rose	N^2P^1	APR-JUN	S.Tropical, S.Temperate, Temperate	Shrub (W/C)	Ornamental
Rubus spp.	Berries	N^2P^2	APR-JUN	S.Tropical, S.Temperate, Temperate	Shrub Climber (W/C)	Hedges & Fruit
Rubiaceae						
Mussaenda frondosa L.	Bedina	N^2P^2	OCT-NOV	S.Tropical	Shrub (W)	Medicinal
Wendlandia exserta (Roxb.)	Chanlai	N^2P^1	NOV-FEB	S.Tropical	Tree (W)	Timber & Ornamental

Rutaceae						
Citrus aurantifolia Swing.	Lime	N^2P^2	MAR-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Oil for Cosmetics & Root-stock for Mandarins
Citrus limettoides L.	Mitha	N^2P^2	MAR-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit & Oil
Citrus maxima L.	Changotra	N^2P^2	MAR-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit
Citrus medica limonum L.	Lemon	N^2P^2	MAR-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit, &Flavouring Confectionery
Citrus reticulata L.	Manderin	N^2P^2	MAR-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit, Oil & Confectionery
Citrus sinensis L.	Sweet Orange	N^2P^2	MAR-APR	S.Tropical, S.Temperate, Temperate	Tree (C)	Fruit, Flavouring Food Products & Medicinal
Salicaceae						
Salix spp.	Willow	N^2P^2	FEB-MAR	S.Tropical, S.Temperate, Temperate	Tree/ Shrub (W/C)	Timber & Ornamental
Sapindaceae						
Aesculus indica Colebr.	Horse chestnut	N^2P^2	MAY-JUN	S.Temperate, S.Temperate	Tree (W)	Fodder, Nuts & Timber
Nephelium litchi Comb.	Litchi	N^1P^2	MAR-APR	S.Tropical, S.Temperate	Tree (C)	Fruit
Sapindus spp.	Soapnut	N^1	MAY-JUN	S.Tropical, S.Temperate	Avenue Tree (W/C) &Timber	Medicinal, Fruits as Soap

Table 9.1 (Cont'd. . .)

1	2	3	4	5	6	7
Scrophulariaceae						
Scrophularia spp.	Figwort	N^1P^2	JUL-SEP	S.Tropical, S.Temperate, Temperate	Herb, Weed (W/C)	
Solanaceae						
Capsicum spp.	Chillies	N^3P^3	JUL-AUG	S.Tropical, S.Temperate, Temperate	Herb (C)	Medicinal & Vegetable
Datura stramonium L.	Tharn Apple	P^3	JUN-SEP	S.Tropical, S.Temperate, Temperate	Herb (W)	Medicinal
Lycopersicum esculentum Mill	Tomato	N^3P^3	MAR-OCT	S.Tropical, S.Temperate, Temperate	Herb (C)	Vegetable
Nicotiana tabacum L.	Tobacco	N^3P^3	JUN-AUG	S.Tropical, S.Temperate, Temperate	Herb (W/C)	Insecticidal, Plant & Varnishes
Solanum spp.	Brinjal	N^3P^3	JUN-AUG	S.Tropical, S.Temperate, Temperate	Shrub (C)	Fruits & Ornamental
Theaceae						
Schima wallichii	Needle Wood	N^2P^2	MAY-JUN	S.Tropical	Tree (W)	Medicinal & Paper pulp
Thymelaeaceae						
Daphne oleoides Scherb.	Daphne	N^3P^3	JUL-SEP	S.Temperate, Temperate	Shrub (C)	Ornamental & Purgative

Tiliaceae						
Grewia oppositifolia Roxb.	Beol	N^3P^3	MAY-JUL	S.Tropical, S.Temperate, Temperate	Tree (W/C)	Fibre, Fruit, Timber & Fodder
Tilia spp.	Lime Basswood	N^1	JUN-AUG	S.Tropical, S.Temperate, Temperate	Avenue Tree (W/C)	Ornamental & Timber
Verbenaceae						
Vitex spp.	Bannah Voilet	N^2P^2	MAY-JUN	S.Tropical, S.Temperate, Temperate	Shrub (W)	Ornamental, Hedge & Medicinal
Violaceae						
Viola odorata L.	Sweet Violet	N^3P^3	JUN-AUG	S.Tropical, S.Temperate, Temperate	Herb (W)	Perfumery, Medicinal & Ornamental
Vitaceae						
Vitis vinifera L.	Grapes	N^3P^3	MAY-JUN	S.Tropical, S.Temperate, Temperate	Shrub (W)	Fruit & Fermented Fruit juice

N^1 = Major honey source
N^2 = Medium honey source
N^3 = Minor honey source

P^1 = Major pollen source
P^2 = Medium pollen source
P^2 = Minor pollen source

W = Wild
C = Cultivated

S.Tropical = Sub-Tropical
S.Temperate = Sub-Temperate

Source: Compiled from multiple sources.

Table 9.2: Medium and minor honey plant resources of Hindu Kush-Himalaya

Family	Plant species
Acanthaceae	*Dyschoriste* Nees
	Hemidelphis polysperma (Heyn ex Roth) Nees
	Hygrophila difformis (L.f.) Blume
	Hypestes spp.
	Phaulopsis imbricata (Forssk.) Sweet
	Pristrophe bicalyculata
	Ruellia spp.
Aizoaceae	*Glinus oppositifolius* (L.) A.D.C.
Alangiaceae	*Alangium salviifolium* (L.f.) Wangerin
Amaranthaceae	*Achyranthes indica* (L.) Mill
	Aerva lanata (L.) Juss. ex Schult
	Celosia arqentea L.
	Digera arvensis Forssk.
Anacardiaceae	*Anacardium occidentale* L.
	Holigarna grahamii (wt.) Hook. f.
	Lannea spp.
	Pistacia vera L.
	Schinus molle L.
	Spondias spp.
Annonaceae	*Annona* spp.
	Polyalthia longifolia (Sonn.) Thwaites
Apiaceae	*Anthriscus* spp.
	Bupleurum tenue Ham. ex Don
	Trachyspermum amni Sprague
Apocynaceae	*Allamanda cathartica* L.
	Alstonia scholaris (L.) R. Br.
	Cartharanthus roseus (L.) G. Don
	Holarrhena pubescens (L.) R. Br.
	Nerium indicum Nill.
	Rauvolfia serpentina (L.) Benth. ex Kurz
	Strophanthus gratus (Hook) Frach.
	Tabernaemontana divaricata (L.) R. Br.
	Thevetia peruviana (Pers.) K. Schum.
	Vinca rosea L.

Family	Plant species
Aquifoliaceae	*Ilex* spp.
Araliaceae	*Hedera nepalensis* K. Koch
	Schefflera spp.
Ascelepiadaceae	*Calotropis gigantea* Ait
	Cynanchum komayovii
Asteraceae	*Arctotis grandis*
	Blumea lacera DC
	Chicus arvensis
	Dahlia variabiles (Willd.) Desf
	Dentella repens (L.) J.R. & G. Frost
	Dimorphotheca aurantiaca
	Eclipta prostrata
	Enhydra fluctuans
	Gaillardia aristata
	Guizotia spp.
	Saussurea affinis
	Spilanthes acmella
	Synedrella nodiflora
	Tithonia tagetifolia
	Venidum fastuosum
	Vigulera helianthoides
	Xanthium strumarium
Begoniaceae	*Begonia* spp.
Berberidaceae	*Mohonia* spp.
Betulaceae	*Betula* spp.
Bignoniaceae	*Kigelia* spp.
	Markhamia stipulata
	Tecoma stans (L.) H. B. & K
Bombacaceae	*Durio zibethinus* Murr.
Boraginaceae	*Anchusa officinalis*
	Borago officinalis L.
	Brugmansia spp.
	Echium spp.
	Heliotropium indicum L.
	Paracarum spp.
	Tournefortia arqeutea
Brassicaceae	*Barbarea intermedia*
	Rorippa indica (L.) Hiern
	Sinapsis spp.
Caesalpiniaceae	*Cynometra alexandria*
	Delonix regia (Boj.) Ref.
	Saraca indica

Table 9.2 (Cont'd...)

Family	Plant species
Campanulaceae	*Campanula alsinodes*
	Lobelia spp.
Cannaceae	*Canna indica* L.
Capparidaceae	*Cleome viscosa* L.
Caprifoliaceae	*Caerulea* spp.
	Sambucus hookeri Rehder
Caricaceae	*Carica papaya*
Celastraceae	*Euonymus hamiltonianu*
Chenopodiaceae	*Spinacia oleracea* L.
Cochlospermaceae	*Cochlospermum insigne*
Combretaceae	*Quisqualis indica* L.
Commelinaceae	*Amischophacelus axillaris* (L.) Rao & Kammathy
Convolvulaceae	*Evolvulus nummularius* (L.) L.
	Jacquemontia nodiflora
	Merremia hederacea (Burm.f.) Hallier f.
	Mina lobata Cerv.
	Rivea corymbosa
Cucurbitaceae	*Benincasa hispida* (Thunb.) Cogn.
	Coccinia grandis (L.) Voigt
	Momordica spp.
	Sicyos deppei
Cyperaceae	*Caresa cruciata*
	Cyperus kyllingia
Datiscaeae	*Datisca* spp.
Dilleniaceae	*Dillenia* spp.
Dipterocarpaceae	*Shorea* spp.
Ebenaceae	*Diospyros* spp.
Ehretiaceae	*Cordia myxa*
	Ehretia spp.
Elaeocarpaceae	*Elaeocarpus tectonis*
Ericaceae	*Vaccinium* spp.
Euphorbiaceae	*Aleurites montana* (Lour) E.H. Wils.
	Antidesma ghesaembilla Gaertner
	Chrozophora rottleri (Geisel.) Juse & Sprengel
	Codiaeum variegatum (L.) Blume
	Croton bonplandianus Baill
	Gelonium multiflorum Juss.
	Hevea brasiliensis (Willd. ex. Adr. de Juss.) Mull-Arg
	Jatropha spp.

Family	Plant species
	Mallotus spp.
	Manihot glaziovii Muell-Arg
	Putranjiva spp.
	Sapium sebiferum (L.) Roxb.
	Securinega virosa (Roxb. ex Willd.) Baill
	Trewia nudiflora L.
Fagaceae	*Ilex* spp.
Flacourtiaceae	*Xylosoma* spp.
Fumariaceae	*Fumaria parviflora*
Geraniaceae	*Pelargonium zonale*
Grossulariaceae	*Ribes* spp.
Hippocastanaceae	*Aesculus* spp.
Hydrophyllaceae	*Hydrolea zeylanica* (L.) Vahl
Iridaceae	*Iris* spp.
Lamiaceae	*Clinopodium umbrosum*
	Dracocephalum moldavica
	Dysophylla spp.
	Eusteralis pumila (Graham) Rafin
	Hyptis suaveolens Poit.
	Leucas spp.
	Marrubium vulgare L.
	Perrila frutescens (L.) Britt.
Lauraceae	*Actinodaphne augustifolia*
	Machilus spp.
	Persea gratissima
Lecythidaceae	*Barringtonia acutangula* (L.) Gaertn.
	Careya arborea Roxb.
	Aspenaragus spp.
Liliaceae	*Lilium polyphyllum*
Loganiaceae	*Buddleia asiatica* Lour.
Lythraceae	*Lawsonia inermis* L.
	Lythrum spp.
	Punica granatum L.
Magnoliaceae	*Magnolia grandiflora* L.
Malpighiaceae	*Hiptage madablota*
Malvaceae	*Abutilon* spp.
	Sida acuta Burm. f.
	Urena lobata L.
Marantaceae	*Clinogyne dichotoma* Salisb
Meliaceae	*Aphanamixis polystachya* (Wall.) Parker
	Swietenia mahagoni Jacq.
Mimosaceae	*Enterolobium saman* prain ex King

Table 9.2 (Cont'd...)

Family	Plant species
	Leucaenia leucocephala
	Pithecellobium dulce (Roxb.) Benth
	Prosopis farcata
Moraceae	*Artocarpus* spp.
	Ficus spp.
	Streblus asper Lour
Myrsinaceae	*Embelia laeta*
Myrtaceae	*Cleistocalyx operculata* (Roxb.) Merr & Perry
	Melaleuca leucadendron L.
	Myrtus communis L.
Nyctaginaceae	*Boerhaavia diffusa* L.
	Bougainvillea spectabilis Willd.
	Mirabilis jalapa L.
Oleaceae	*Fraxinus excelsior* L.
	Jasminum sambac (L.) Aiton
	Liqustrum spp.
	Olea spp.
Onagraceae	*Ludwigia hyssopifolia* (G. Don) Excell
Oxalidaceae	*Averrhoa* spp.
Palmae	*Areca catechu* L.
	Borassus flabellifer L.
	Cocos nucifera L.
	Elaeis quineensis L.
	Phoenix sylvertris (L.) Roxb.
Papilionaceae	*Abrus precatorius* L.
	Arachis hypogaea L.
	Clitoria ternatea L.
	Desmodium gangeticum (L.) DC
	Lablab purpureus (1.) Sweet
	Lathyrus sativus L.
	Lenss culinaris Medik
	Lotus corniculatus L.
	Pongamia spp.
	Pterocarpus macrocarpus
	Sesbania grandiflora (L.) Poir
	Vigna mungo (L.) Hepper
Pinaceae	*Pinus roxburghii* Sar.
Polemoniaceae	*Phlox drummondii* Hook.
Polygonaceae	*Antigonon leptopus* Hook & Arn
	Coccoloba belizensis
Plumbaginaceae	*Limonium bicolor*
Ranunculaceae	*Anemone biflora*
	Nigella sativa L.

Family	Plant species
Resedaceae	*Reseda alba*
Rhamnaceae	*Berchemia edgeworthii*
	Gouania polyagama
	Paliurur spina cristi
Rhizophoraceae	*Bruguiera* spp.
	Rhizophora mangle
Rosaceae	*Crataegus oxyacantha* L.
	Sorbaria tomentosa
Rubiaceae	*Adina cordifolia* (Roxb.) Hook. f.
	Anthocephalus chinensis (Lam.) Rich. ex Walp
	Borreria verticilata
	Coffea arabica L.
	Dentella repens (L.) J.R. & G. Frost
	Galium asperifolium
	Ixora spp.
	Meyna laxiflora Robyns
	Morinda spp.
	Oldenlandia spp.
	Spermacoce hispida L.
Rutaceae	*Aeqle marmelos* (L.) Correa
	Feronia limonia Swingle
	Glycosmis arborea (Roxb.) DC
	Murraya spp.
Salicaceae	*Populus* spp.
Sapotaceas	*Aesandra butyracea*
	Madhura latifolia Roxb.
	Mimusops elengi L.
Sapindaceae	*Cardiospermum halicacabum* L.
	Dimocarpus longau
	Erioglossum spp.
	Lepisanthes rubiginosa (Roxb,) Leenh
	Litchi chinensis Sonn.
Scrophulariaceae	*Adendsma bilabiata* (Roxb.) Merr.
	Lindernia ciliata (Colsm.) Pennell
	Scoparia dulcis L.
Simaroubaceae	*Aignthus* spp.
	Ailanthus glandulosa
Solanaceae	*Cestrum nocturnum* L.
	Physalia minima L.
Sterculiaceae	*Dombeya mastersii* Hook.f.
Symplocaceae	*Symplocos spicata*

Table 9.2 (Cont'd...)

Family	Plant species
Tamaricaceae	*Tamarix aphylla* (L.) Karst
Theacea	*Eurya* spp.
	Thea sinensis L.
Tiliaceae	*Corchorus capsularis* L.
Tropaeolaceae	*Tropaeolum* spp.
Ulmaceae	*Celtis* spp.
Urticaceae	*Boehmeria requlosa*
Verbenaceae	*Caryopnteris wallichiana* Schau
	Clerodendrum spp.
	Duranta repens L.
	Lantana camara L.
	Lippia spp.
	Nyctanthes arbortristis L.
	Phyla nodiflora (L.) Greene
	Tectona grandis L.f.
	Verbena spp.
Vitidaceae	*Ampelocissus* spp.
Vitaceae	*Parthenocissus quinquefolia*
Zingiberaceae	*Hedychium* spp.
Zygophyllaceae	*Peqanum harmala* L.

Source: Compiled from multiple sources.

9.2 MELISSOPALYNOLOGY, BEE BOTANY AND FLORAL CALENDARS

Honeybees while foraging for nectar on flowers of different entomophilous plants also gather some pollen with it. This pollen is retained in the ripened honey even after extraction. The microscopical examination of these pollen grains in the honey is known as melissopalynology or "Pollen analysis of honey". Melissopalynological studies are helpful in both quantitative and qualitative pollen analysis of honey (Louveaux et al., 1978). Quantitative analysis is used for confirming the botanical origin of unifloral and multifloral honeys. For example, honey samples are considered as rich, poor and extremely poor in pollen if the number of pollen grains per 10 gm of honey samples are above 100,000, 20,000 to 100,000, and below 20,000 respectively. Similarly, for the presentation of frequencies of pollen grains in honey, Louveaux et al. (1978) adopted the following system: "Predominant pollen" (having more than 45 per cent of the pollen grains counted), "secondary pollen" (16–45 per cent), "Important minor pollen" (3–15 per cent) and "Minor pollen" (less than 3 per cent). Pollen analysis of honey also helps in the identification of the geographical origin of honey samples because local flora have characteristic plant associations that are reflected in the corresponding spectrum of pollen types represented in the local honeys (Maurizio, 1975; Nair, 1985). Such studies also help in the identification of plant sources of toxic honey, relative preferences by honeybees for individual plants flowering simultaneously and to find the season of honey extraction.

Besides melissopalynology, an other aspect of study which is of great importance to the beekeeping industry is "bee botany". This involves the mapping of the regional bee flora with emphasis on density, distribution, honey potentially, time and duration of bloom of honey plants.

Such floral calendars should be prepared for each ecological region where beekeeping is practised. These floral calendars are of special value for the development of beekeeping in the temperate Hindu Kush-Himalayan region where multiple bee flora exist. Moreover, in this region, due to very low temperatures and dearth of bee flora during winter, movement of bee colonies to lowland areas becomes essential. For such migratory beekeeping, floral calendars are of great help in selecting the most suitable places where bee should be moved during this period.

In India, melissopalynological studies were initiated by Deodikar and Thakar (1953) who conducted the pollen analytical study of major honey-yielding plants in Mahabaleswar hills of Maharashtra. They wanted to standardize those honeys which are marketed under the name of certain specific plants and identified pollen of 12 major nectar plants. Sen and Banerjee (1956) analysed the pollen content of a sample of honey obtained from a garden near Calcutta and observed an overabundance of one anemophilous sporomorph. Mittre (1958) examined the pollen contents of ten samples of Indian honeys known under the name Nepal honey, Almora honey, Kashmir honey, Lucknow honey, Lotus honey and Sunderbans honey. He observed that the commercial samples are made up of a mixture of several kinds of honeys. Phadke (1964), while studying the physico-chemical composition of major unifloral honeys of Mahabaleshwar, reported that *Carvia callosa* honey contained unusual amount of non-reducing sugars. *Carvia* sp., was considered a good source of honey in these hills. Chaubal and Deodikar (1965) studied pollen grains of poisonous plants in honey samples from the Western ghats and identified poisonous plants as: *Clematis* spp., *Datura arborea*, *Euphorbia geniculata*, *Lasiosiphon* sp. and *Lobelia nicotianaefolia*.

Nair (1964) made a comprehensive pollen analysis of 76 samples of Indian honeys collected from the peninsular region (Andhra

Pradesh, Karnataka, Tamil Nadu), Western region (Maharashtra and Rajasthan), Indo-Gangetic region (Uttar Pradesh and Punjab), Eastern region (Bihar and West Bengal) and Himalayan region including (Nepal, Jammu and Kashmir, and Assam). On the basis of this analysis, he prepared a list of important nectar and pollen yielding plants of these regions including *Eugenia* sp., *Nephelium* sp., *Sapindus* sp., *Citrus* sp., *Putranjiva* sp., *Plectranthus* sp., *Brassica* sp., *Holoptelea* sp., *Alnus* sp., *Borassus* sp., and some palms. It was inferred that the names given to various honeys are not corroborated by their pollen composition. Similar pollen analyses of 13 honey samples from Uttar Pradesh revealed the dominant pollen grains of Euphorbiaceae, *Nephelium* sp., Myrtaceae, Liliaceae, Rosaceae, Meliaceae, Brassicaceae and *Rumex* sp. (Sharma and Nair, 1965).

Chaubal and Deodikar (1965) carried out melissopalynological studies on different honey samples of the Western Ghats so as to identify the botanical sources of these samples. They found: *Rosa multiflora, Brugmansia candida, Paracarym malabaricum, Impatiens balsamina, Ocimum canum, Heracleum concanense, Polygonum chinensis* and *Litsea stocksii* as the best honey sources. Other minor honey sources were: *Justicia procumbens, Thelepaedale ixiocephala, Lobelia nicotianaefolia, Lasiosiphon eriocephalus, Scutia indica* and *Dysophylla salcifolia*. Sharma (1970) studied the bee flora of Kangra area of Himachal Pradesh by pollen load analysis from the month of June to August. Twenty pollen types were identified with the preference of bees for pollen the family Poaceae. Other anemophilous pollen plants visited by bees were from families Cyperaceae, Arecaceae, Chenopodiaceae and Urticaceae. Similar pollen load studies conducted in the month of September, revealed 13 more pollen types which included *Mimosa* sp. and *Phoenix* sp, in high frequencies. Chenopodiaceae, Poaceae and *Phoenix* sp. were the three anemophilous taxa represented in pollen loads. Sharma (1972) studied the pollen grains or *Datura stramonium* and suggested this to be an important honey plant besides its medicinal value in the temperate and warm regions of India.

Chaturvedi (1973) analysed 192 pollen loads from the Banthra area of Lucknow, collected during the months of January to April. During January, all loads were unifloral with the dominance of Brassicacae pollens but in February, *Asphodelus* sp. and Brassicacae pollens were the most common types. Asteraceae and Cucurbitaceae pollens were dominant during March. Cucurbitaceae pollens were also collected during April together with *Citrus* sp., and Poaceae pollens. Analysis of 213 pollen loads collected during July to October from Banthra (Lucknow) showed that all except six of the loads were unifloral. A total of 17 pollen types were identified with *Sesbania* sp., Poaceae, *Sesamum indicum* pollen being dominant (Chaturvedi, 1977).

Chaudhari (1977) evaluated 80 important bee plants of the Punjab by visual and microscopical analyses of pollen loads and honey samples. The major sources of pollen and nectar recorded were: *Trifolium* sp., *Fagopyrum* sp., *Polygonum* sp., *Medicago* sp. and *Melilotus* sp., etc. Shah (1978) described Break Mushik *(Salix aegyptica)* as the saviour bee plant of Kashmir. Whereas, Rao and Seethalakshmi (1978) confirmed honeybees foraging on sorti variety of paddy in Karnataka through microscopical analysis of pollen loads.

Suryanarayana (1978) gave general information on the distribution, flowering period and other botanical aspects of *Carvia callosa*. Microscopical analysis showed 13,000 to 21,000 pollen grains per 10 gm of Karvi honey. Pollens of *Senecio* sp., *Smithia* sp., *Impatiens* sp. and Poaceae were found to be associated with it. Pollen analysis of 14 samples from different parts of India revealed more pollen grains with reticulate than with non-reticulate surfaces. One of the samples contained pollen grains only from *Eucalyptus* sp. (Ganguly, 1979, Ganguly and Chanda, 1980). Seethalakshmi (1980) conducted melissopalynological studies on 12 honey samples from Maharashtra, Bihar, Jammu and Kashmir, Uttar Pradesh, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu States of India. These studies indicated that Indian honeys fall under the categories of Groups I to III of the International Commission of Bee Botany, i.e., honeys having an absolute pollen count from 10,000–5,00,000 per 10 gm of honey. A total of 44 pollen types were identified, and it is inferred that honeys from the same locality in the same season may have a similar pollen spectrum for the associated species but their percentages may differ. Important sources identified were: *Syzygium cumini, Nephelium litchi, Isodon rugosus, Brassica* sp., *Eucalyptus* sp., *Tamarindus indica, Hevea brasiliensis* etc. Chaubal (1980) conducted melissopalynological studies on different honey samples from Padgaon (Maharashtra). This study revealed that some members of families such as Myrtaceae, Combretaceae, Lamiaceae, Acanthaceae, Rubiaceae etc. are amongst the major bee plants of this region. He also gave the botanical description of plant sources, their flowering period, the value of the nectar source and honey colour. The honey from this area was mostly of unifloral type. Chaubal and Kotmire (1980) gave a floral calendar or bee forage plants of Sagaramal (Maharashtra) based on microscopical studies. Important plants recognized were: *Amaranthus* sp., *Zea mays, Vitex negundo, Albizia lebbeck, Eucalyptus* sp., *Oxalis* sp., *Impomoea* sp., *Plectranthus* sp., *Brassica* sp., *Bombax* sp., *Sapindus* sp., *Tamarindus* sp., etc. Mondal and Mitra (1980) carried out pollen analysis of six honey samples from the Sunderban area of West Bengal. All the samples contained pollen of *Phoenix* sp. *Bruguiera* sp., *Aegiceras* sp. and *Sonneratia* sp. Suryanarayana (1980) suggested *Hevea brasiliensis* as an important nectar source in the tropics. Suryanarayana et al. (1981) conducted melissopalynological studies on 15 honey samples from Pune. The absolute pollen count varied from 3,400 to 42,000 in Jamun honeys and 4,500 to 18,133 in Litchi honeys. The wide variation in the absolute pollen count in the same type of honey suggested that both regional and seasonal variations in pollen and nectar output existed. Chanda and Ganguly (1981) studied honey samples from different parts of India including Kerala, Karnataka, Andhra Pradesh, Orissa and West Bengal. Most of the samples had pollen of entomophilous plants with a small percentage of anemophilous types. On the basis of microscopical analysis of the honey samples, they identified the different biozones from where the samples originated. Chaturvedi (1983) carried out pollen analysis of autumn honeys of the Kumaon region of Uttar Pradesh. Both unifloral and multifloral honeys were identified. The main honey plants were: *Eucalyptus* sp., *Brassica* sp., etc. A similar palynological study was conducted by Sadruddin and Tripathi (1985) on the honey samples from eastern Uttar Pradesh. Microscopic analysis of honey samples showed 27 pollen types including *Emblica officinalis, Brassica compestris, Adhatoda zeylanica* sp., *Morus alba, Eucalyptus* sp., *Drypetes* sp., *Azadirachta indica* and *Moringa pterygosperma*. Nair (1985) reviewed the important pollen and nectar plants of India. Some of them are: *Mangifera indica*, *Berberis* sp., *Alnus nepalensis* and *Ricinus communis*. A graph was prepared showing seasonal forage and colony cycles. Singh (1962) reviewed the major and minor sources of pollen and nectar found in India. He classified the important plants according to their economic and botanical status. The following categories of bee forage have been discussed: fruits, vegetables, ornamentals, crops, herbs, bushes, shrubs and forest and avenue trees. Some of the major sources are: *Citrus* sp., *Pyrus* sp., *Syzygium* sp., *Plectranthus* sp., *Cedrela* sp., *Brassica* sp., *Rosa* sp., *Fagopyrum* sp., *Medicago* sp., *Melilotus* sp., *Trifolium* sp., *Taraxacum* sp., *Berberis* sp., *Eucalyptus* sp., *Ehretia* sp., *Salix* sp., *Sapindus* sp., etc.

Phadke (1965) found *Thelepaedale ixiocephala* widely distributed in the western ghats, forming dense growths at elevations above 500 metres. Octennial flowering occurs after the monsoon from November to January and proves to be an abundant source of nectar and pollen. As a bee plant, it is considered even more important than the related *Carvia callosa*. Bee forage studies on ornamental plants in the Mahabaleshwar hills showed *Phlox drummondii* as a good pollen source, but the little nectar produced by this plant is inaccessible to honeybees owing to its long corolla tube (Suryanarayana and Thakur, 1966). Similar studies by Deodikar and Thakar (1966a) stressed the need for the utilization and improvement of the local flora as bee pasturage. They also observed that during times of acute pollen shortage, bees collected fungal rust spores such as those of *Cystophora oleae*.

Suryanarayana (1966) attempted to evaluate the natural vegetation of the western highlands, foothills and eastern plains of Karnataka. Diwan and Rao (1969) surveyed the bee flora of Karnataka and reported that *Acacia* sp., *Dalbergia* sp., *Lagerstroemia entada* and *Grewia* sp., were the most important nectar and pollen sources. Deodikar (1970) studied the bee flora of Jammu and Kashmir region of northern India. The major honey plants listed during May-June were: *Sapindus* sp., *Acacia* sp., *Dalbergia* sp., *Grewia* sp., *Trifolium* sp., and *Rumex* sp., whereas, during September–October, *Zea mays, Ziziphus* sp., *Trifolium* sp., *Medicago* sp., were the important honey plants. In a similar attempt for the evaluation of bee flora for different species of *Apis* at Ludhiana it was revealed that *Trifolium alexandrinum, Eucalyptus* sp., *Terminalia arjuna, Brassica campestris, Eruca sativa, Medicago sativa, Acacia* sp., *Gossypium* spp. etc., were the important bee plants (Atwal et al., 1970). Narayana (1970) reported *Carvia callosa* as the best nectar plant in South India, whereas, Jayarathnam (1970) reported *Hevea brasiliensis* as another important honey source of South India.

Saraf (1972) reported 110 species of plants useful to bees in the Kashmir valley. Important species are: *Pyrus, Prunus, Brassica, Aesculus, Polygonum, Plectranthus, Impatiens, Fagopyrum* etc. *Plectranthus rugosus* was found as an excellent source of nectar during the autumn season. Similarly, Singh and Singh (1971) and Atwal and Goyal (1974) also identified *Plectranthus rugosus* as the major honey plant in the Kashmir and Kullu valleys respectively. Deodason (1972) reported the rubber plant *(Hevea brasiliensis)* as an important nectar source in South India and honey from this plant is white to golden yellow in colour. Chandran and Shah (1974) studied the major pollen and nectar plants of the Kodai hills of Tamil Nadu. Major sources were: *Prunus domestica, Bidens pilosa, Ageratum conyzoides, Coffea arabica, Pyrus communis, Syzygium cumini, Cedrella toona, Jambosa munronii, Eucalyptus globulus* and *Erythrina myosorensis*. Dhaliwal and Atwal (1974) identified *Trifolium alexandrinum* as the major honey plant in the Punjab. Phadke and Naim (1974) suggested *Nephelium litchi* as the best source of nectar and pollen in Pusa (Bihar), whereas Nair and Singh (1974) discussed the importance of *Antigonon leptopus* and *Moringa pterygosperma* as source of pollen and nectar. They described the flower morphology and pollen grains of both plants.

Shah (1975) described the main bee flora of the Kodai hills of Tamil Nadu. Major bee plants are: *Celtis cinnamome, Eriglossum* sp., *Bidens pilosa, Ageratum conyzoides, Olea diocia, Cedrella toona, Coffea arabica, Emblica officinalis, Eucalyptus* spp. etc. Salvi (1975) studied the bee flora of Pathankot and revealed berseem, litchi, mustard and a variety of fruit crops to be the important bee forage plants. Similarly, Satyanarayana (1975) reported *Syzygium cumini, Acacia sinuata* and *Vernonia* sp. as the major honey plants of Karnataka. Naim and Phadke (1976) investigated 40 nectar and pollen plants of Bihar. Some of the important plants are: *Syzygium cumini, Pongamia* sp., *Trifolium alexandrinum, Antigon* sp., *Cosmos* sp., *Sesamum orientale, Nephelium litchi, Moringa pterygosperma* etc.

Thakar et al. (1962) have divided India into four major regions from the beekeeping point of view, the southern peninsular region, Northeast region, Indo-Gangetic plains and northern hill region. In these regions, bee forage is mainly derived from wild arboreal species like *Terminalia* sp., *Dalbergia* sp., *Quercus* sp. Along the higher elevations, *Berberis* sp., *Rhododendron* sp., *Salix* sp., *Robinia* sp., *Aesculus* sp., etc. constitute major source of bee forage. A number of orchard crops like apples, pears, plums, almonds, peaches, walnuts and annual crops such as maize, *Brassica*, beans and a variety of vegetables and ornamentals are very useful during the buildup period. Shah and Shah (1976) discussing the bee forage of the Kashmir valley, suggested that *Brassica, Prunus, Pyrus, Fagopyrum, Impatiens, Rosa, Plectranthus, Robinia pseudoacacia* etc., were the major species of plants visited by honeybees in Kashmir valley. *Plectranthus* spp. were the sources of surplus honey during the autumn season. Uppin (1978) stressed the importance of planting *Eucalyptus* spp. in India for better honey production, whereas, Shah and Shah (1979) found *Robinia Pseudoacacia* and *Robinia ambigua* to be main sources of nectar in the Kashmir valley. Singh (1979) reported strawberry *(Fragaria vesica)* as an important honey plant in Jeolikote (Uttar Pradesh), whereas, Seethalakshmi and Percy (1979) found *Borassus flabellifer* to be an important pollen source in Tamil Nadu. Chandran et al. (1983) identified cardamom *(Elettaria cardamomum)* as a major bee plant in South India. Diwan and Vartak (1980) identified 400 species of bee forage plants in Karnataka and relevant information was given regarding the occurrence, abundance, distribution and flowering times of these plants. Major sources are: *Terminalia* sp., *Dillenia* sp., *Careya arborea, Nothopegia* sp., *Impatiens* sp., *Cania* sp., *Plectranthus* sp., etc. Rajan (1980) listed the important trees yielding pollen and nectar to the bees in Karnataka. Among them are: *Albizia* sp., *Eucalyptus* spp., *Mangifera indica, Nephelium litchi, Terminalia* sp., and *Syzygium cumini* to be the major nectar source (Srivastva and Tripathi, 1980). Krishnaswamy (1980) discussed the introduction and propagation of important bee plants in Chickmagalur area of Andhra Pradesh. Such plants were *Schefflera* and *Wendlandia* sp. and it was suggested that their plantation may increase the honey yield. Hazel nut, *Corylus colurna* was reported as the first bee forage source available after the long winter in the Kashmir valley. The flowers are yellow in colour and bloom from February to March (Shah, 1981). Suryanarayana and Mohana Rao (1982) reported *Dombeya mastersii* as an important ornamental bee plant in India, whereas, Dutta et al. (1983) reported that the *Amomum occuleatum* plant tranquilizes *Apis dorsata* in the Andaman islands.

Verma (1983) formulated a floral calendar of 58 bees plants of Jeolikote area of Uttar Pradesh. The best sources of nectar recorded are: *Madhuca* spp., *Berberis* sp., *Rubus niveus, Olea glandulifera, Allium cepa, Nephelium litchi* and *Prunus*. A similar survey of bee flora in Uttar Pradesh revealed *Nephelium* sp., *Trifolium* sp., *Rumex* sp., *Polygonum* sp., *Shorea robusta, Rosa moschata, Pyrus* sp., *Prunus* sp., *Eucalyptus* sp.,*Plectranthus* sp. etc. as the major honey plants (Singh, 1983; Singh et al., 1983). Mohana Rao and Suryanarayana (1983) also reported *Brassica* sp., *Helianthus annuus, Prunus* sp., *Pyrus* sp., *Melilotus* sp., *Fagopyrum* sp., *Trifolium alexandrinum* etc., as potential bee plants of Uttar Pradesh. Nehru et al. (1984) conducted studies on the off-seasonal bee forage of *Apis cerana* in Kerala. Their results revealed a synchrony in the activities of bees and the flowering periods of plants during various seasons of the year. The rubber plant *Hevea brasiliensis* provided forage from January to March and was the major source of pollen and nectar. Fifty-one off-seasonal bee plants have been listed that are useful to honeybees during the dearth period. Phytosociological studies on *Apis mellifera* and *Apis cerana* in the Punjab revealed that both species of honeybees collected pollen and nectar from 89 plant genera belonging to 42 families. Some potential sources of surplus honey are: *Eucalyptus* sp.,*Trifolium* sp., and *Phaseolus* sp., *Brassica* sp., *Helianthus annuus, Gossypium* sp. and *Citrus* sp. (Sarwan and Sohi, 1985).

Sharma and Raj (1985) have discussed the bee flora of the Kangra Shivaliks and its possible impact on the beekeeping industry. Important honey plants are: *Brassica campestris, Rosa moschata, Rubus* sp., *Eucalyptus* sp., *Dalbergia sissoo, Bauhinia variegata, Ehretia* sp., *Mangifera indica, Litchi chinensis, Adhatoda vasica, Sapindus detergens, Syzygium cumini* etc. Similarly, Saraf (1985a) has discussed the bee flora of Gurej region of Jammu and Kashmir. Some of the important floral resources are: *Taraxacum* sp., *Rumex* sp., *Fragaria* sp., *Medicago* sp., *Melilotus* sp., *Fagopyrum* sp., *Impatiens* sp., *Trifolium* sp., *Viola* sp., *Betula* sp., etc. About 75 per cent of the honey produced in this area is from *Fagopyrum sagittatum*. The honey obtained from this plant is amber coloured with a strong flavour (Saraf, 1985b). Mohana Rao (1985) reported Khesari as an important bee plant of Muzaffarpur (Bihar), whereas, Mohanrao and Nair (1985) found that several varieties of mango *Mangifera indica* are visited by *Apis cerana*. Mishra and Kumar (1987) have stressed the importance of planting certain bee plants such as *Acacia* sp., *Aesculus* sp., *Bauhinia* sp., *Dalbergia* sp., *Eucalyptus* sp., *Grevillea* sp., *Nephelium* sp., *Prunus* sp., *Salix* sp., *Sapindus* sp., *Toona* sp., *Terminalia* sp., etc. for social forestry programmes.

Sharma (1989) made an extensive melissopalynological and botanical study on the honey plants of Himachal Pradesh. Major nectar plants listed by her investigations as per norms of International Commission on Bee Botany are as follows:

Brassica napus, Impatiens glandulifera, Ehretia acuminata, Eruca sativa, Plectranthus spp., *Toona ciliata, Eucalyptus* spp., *Syzygium cumini, Dalbergia sissoo, Medicago sativa, Melilotus* spp., *Robinia pseudoacacia, Trifolium* spp., *Fagopyrum sagittatum, Malus domestica, Prinsepia utilis, Prunus* spp., *Pyrus* spp., *Nephelium litchi, Sapindus* spp., *Scrophularia* spp., and *Tilia* spp.

The major pollen plants included *Brassica napus, Berberis lycium, Eruca sativa, Eucalyptus* spp., *Trifolium* spp., *Plantago* spp., *Punica granatum, Portulaca glandiflora, Malus domestica, Prunus* spp., *Pyrus* spp., *Rosa moschata*. The pollen spectrum of honey samples of *Apis cerana* collected during different seasons in the Shimla hills is summarized in Table 9.3 and the seasonal frequency of the pollen grains of different bee plants of the Shimla hills of Himachal Pradesh is given in Table 9.4.

Shahid and Qayyum (1977) listed 13 major and 109 minor plants of the North-West Frontier Province of Pakistan. Major nectar flow was recorded from: *Trifolium* spp., *Plectranthus rugosus, Eriobotrya japonica, Campestris, Acacia modesta* and *Dalbergia sissoo*. Manzoor and Muhammed (1980) found *Helianthus annuus* as a important honey plant in Pakistan. Makhdoomi and Chohan (1980) surveyed the bee forage in West Punjab and North-West Frontier Province of Pakistan identifying the major nectar sources as: *Plectranthus rugosus, Eriobotrya japonica, Eucalyptus* spp., *Adhatoda vasica, Acacia modesta, Cedrella toona, Trifolium alexandrinum* and *Medicago sativa*.

Dewan (1980) identified 36 bee plants by visual observation in Bangladesh, the most important being: *Brassica* spp., *Zizyphus* spp., *Toona* etc. Dimshi a mustard-like crop is being introduced as a good source of pollen (Dewan, 1984). Similarly Alam and Zannat (1980) found *Shorea robusta, Acacia* sp., *Albizia* sp., *Helianthus annuus, Vitex* sp., *Brassica napus, Citrus*, sp., *Nephelium litchi* etc. as good nectar sources in Bangladesh.

Focke (1968) performed pollen analysis of 33 honey samples from China and found *Trifolium* sp., *Robinia* sp., *Frangula* sp., *Tilia* sp. and *Lamium* sp. as the major bee plants. Deh-Feng and Wen-Cheng (1981) have also discussed the honey resources of China identifying more than one thousand species of nectar plants. The most important being: *Brassica campestris, Astragalus, Vicia sativa, Robinia* sp., *Medicago* sp., *Melilotus* sp., *Tilia* sp., *Nephelium* sp., *Fagopyrum* sp., *Eucalyptus* sp. and *Citrus* sp. Yue-Zhen (1984) has discussed the important bee plants of China. Some of the major sources are: *Vicia* spp., *Brassica* sp., *Robinia* sp., *Tilia* sp., *Melilotus* sp., *Fagopyrum* sp., *Gossypium* sp., *Eucalyptus* spp., *Citrus* sp., *Zizyphus* sp.

According to Shikui and Zaiji (1989), *Eurya* sp. is a very important plant in the hilly areas of southern China. Beekeepers in China have yet to harness its full potential, and a few researchers working on this plant have proved that this is a very important source of nectar and pollen for honeybees. In China more than 80 species of *Eurya* are found, and they are scattered over the vast tropical and sub-tropical hilly areas. There are about 10 species of *Eurya* that flower during autumn, winter, and spring and they are important from the beekeeping point of view. The flowering period lasts for 10 to 15 days. *Eurya* honey is transparent or light amber. It does not granulate readily. Yield of *Eurya* honey per colony varies from 10 to 40 kg. The Chinese bees, *Apis cerana*, produce three times more honey from this plant than the European bees, *Apis mellifera*. *Eurya* honey is rated highly in China.

Honeys from a few plant species belonging to the family Ericaceae are poisonous to man. Crane (1989) reported *Arbutus unedo*, a strawberry tree containing arbutin (a glucoside): *Kalmia latifolia* a mountain laurel containing acetylandromedol, *Rhododendron ponticum* and *Rhododendron anthopogon* containing andromedotoxin/acetylandromedol, as toxic agents. According to Kafle (1984) many Rhododendron honeys in the Nepal Himalaya are not toxic except *Rhododendron anthopogon* which grows above 4200 m, so honeys harvested below this altitude should be safe. However, Kerkvliet (1981) studied studied components of toxic honey from the unknown *Rhododendron* species purchased at 1500 m, 40 m east of Lukla in Nepal, and reported grayanotoxin analogues as the toxic agents.

9.3 NECTAR SECRETION STUDIES

Nectar is secreted in various plant species from specialized structures called nectaries. The nectaries of nectiferous tissues may occur in many

Table 9.3: Pollen spectrum of the honey samples of *Apis cerana* collected during different seasons in Shimla hills, Himachal Pradesh, India

Season	Colour of honey	Unifloral or multifloral	Predominant pollen type	Secondary pollen types	Important minor pollen types	Minor pollen types
Spring	Yellowish brown	Unifloral	*Brassica* sp.	*Salix* sp.	*Chenopodium* sp., Rhamnaceae, Papilionaceae, Asteraceae, Tridaceae, Rosaceae and Plantaginaceae	*Trifolium* sp.
Summer	Yellowish brown	Multifloral	—	*Trifolium* sp.	*Rumex* sp., *Fagopyrum* sp. *Plantago* sp., *Ageratum* sp., *Taraxacum* sp., Berberidaceae, Amaranthaceae, Labiateae and Asteraceae	*Helianthus* sp.
Rainy	Dark brown	Multifloral	—	*Impatiens* sp., *Fagopyrum* sp., and *Polygonum* sp.	*Trifolium* sp., *Plantago* sp., *Rumex* sp. *Taraxacum* sp., *Medicago* sp., and Asteraceae	*Helianthus* sp.
Autumn	Brown	Unifloral	*Impatiens* sp.	*Taraxacum* sp., and Plantaginaceae	*Ageratum* sp., *Taraxacum* sp., *Aster* sp. *Fagopyrum* sp., *Polygonum* sp.,	*Salvia* sp., *Chenopodium* sp. and *Tagetes* sp.

					Scrophulariaceae, Papilionaceae, Asteraceae, Polygonaceae and Capparidaceae	
Early winter	Yellowish white	Unifloral	Rosaceae	*Taraxacum* sp.	*Chenopodium* sp., Geraniaceae and Gentianaceae	*Salvia* sp.
Late winter	Yellowish white	Unifloral	Rosaceae	Brassicaceae and Chenopodiaceae		

Source: Sharma, 1989.

Table 9.4: Seasonal frequency of the pollen grains of different bee plants of Shimla hills, Himachal Pradesh (India) as identified through honey analysis (expressed as percentage of total number of pollen grains)

Plant species	Season					
	Spring	Summer	Rainy	Autumn	Early winter	Late winter
Ageratum sp.	–	8.08	–	9.56	–	–
Amaranthus sp.	–	0.94	–	–	–	–
Amaranthaceae	–	8.60	–	–	–	–
Aster sp.	–	–	–	–	–	–
Asteraceae	6.99	7.11	15.71	5.66	–	–
Berberidaceae	–	10.29	–	–	–	–
Brassica sp.	54.74	–	–	–	–	–
Brassicaceae	–	–	–	–	–	32.00
Capparidaceae	–	–	–	3.38	9.52	–
Chenopodium sp.	9.04	–	–	2.28	24.63	–
Chenopodiaceae	–	–	–	–	–	33.00
Fagopyrum sp.	–	5.34	28.87	8.76	–	–
Gentianaceae	–	–	–	–	10.52	–
Geraniaceae	–	–	–	–	–	–
Helianthus sp.	–	0.76	0.93	–	–	–
Impatiens sp.	–	–	43.03	50.15	–	–
Iridaceae	5.12	–	–	–	–	–
Lamiaceae	–	8.53	–	7.40	–	–
Leguminosae	7.53	–	–	–	–	–
Medicago sp.	–	–	5.49	–	–	–
Plantago sp.	–	8.56	13.93	–	–	–
Plantaginaceae	4.09	–	–	16.08	–	–
Polygonum sp.	–	–	20.17	6.60	–	–
Polygonaceae	14.93	–	–	4.94	–	–
Rhamnaceae						
Rosaceae	4.14	–	–	–	52.00	67.00
Rumex sp.	–	14.22	10.08	–	–	–
Salix sp.	16.50	–	–	–	–	–
Salvia sp.	–	–	–	0.51	0.98	–
Scrophulariaceae	–	–	–	8.35	–	–
Tagetus sp.	–	–	–	1.93	–	–
Taraxacum sp.	–	6.24	9.03	43.85	–	–
Trifolium sp.	2.06	32.40	10.08	–	–	–

Source: Sharma, 1989.

parts of the flowers such as receptacle, petals, sepals, and bases of filaments and pistil. The total nectar content and sugar concentration in the floral and extra floral nectaries is of prime importance to the beekeeping industry because it acts as a precursor of honey and helps in deciding the honeybee preferences in favour of a particular plant species.

Some investigators have conducted studies on the nectars of various plant species in the Asian continent. Haragsim and Machna (1969) analysed the sugars present in the nectars of Japanese sophora *(Sophora japonica)* by paper chromatography. Glucose, fructose and sucrose were present in larger amounts than melazitose and maltose and this plant nectar was placed in the SFG groups. Similar studies by Suzuki et al. (1969) on *Thea sinensis* showed that only sucrose was present in the nectar of this plant. Echigo (1970) determined the sugar contents of pumpkins and milk vetch by gas-liquid chromatography using an internal standard. Results for pumpkin nectar were: glucose (27.29%), fructose (35.47%) and sucrose (30.61%), whereas milk vetch showed 29.25 per cent glucose and 35.42 per cent fructose with mannitol as the internal standard. Nectar sugar concentration studies on *Hevea brasiliensis* revealed that it was low in the early morning (30%) and high at 1000 hours (80%). The average concentration was 75 per cent in this plant (Wongsiri et al., 1985).

Fahn (1948) investigated the daily secretion of 66 indigenous and cultivated plants of Israel. The sugar contents of these species varied from 0.13 mg to 2.48 mg per flower. A definite relationship was found between the size of the nectary and the quality of nectar secreted, but no such relationship was established with the concentration of the nectar. He also found variations in the ratios of sucrose to glucose and fructose in different plant species. Temperature, humidity, soil moisture, time of the day, age of flower and root pressure were the important factors influencing nectar secretion (Fahn, 1949). Studies by Rowley (1976) on the sugars of 40 common Philippines nectars showed that, sucrose, glucose and fructose constituted 2–95 per cent of total sugars. Maltose was also detected in two species and confirmed by infrared spectroscopy.

In China, Ye and Zhong (1981) studied the nectar secretion of a citrus trees. They divided nectar secretion into three stages: initiation, nectar accumulation at the base of the flower, and withering. Maximum nectar production was during the first three days. Murrell and Nash (1981) investigated the nectar secretion by toria *(Brassica campestris)* in Bangladesh. Maximum nectar was secreted at about 0900 hours and decreased thereafter. Later on, Murrell et al. (1982) studied the nectar secretion in eight varieties of *Lotus corniculatus*. The volume produced per umbel ranged from 2.33 μl to 5.07 μl. It was concluded that aroma and nectar production were not always closely correlated, but nectar yield was directly related to the cross-sectional area of functional phloem in the peduncle.

In India, Montgomery (1958) evaluated 38 plant species for their nectar-sugar concentration. Species showing the highest average (50% or more) were: *Polygonum, Lonicera, Aster, Helianthus annuus* and *Bidens*. Working on similar lines, Sharma (1958) determined the sugar concentration of nectars of some Punjab honey plants. Sugar concentrations of the major sources of honey were: *Brassica* sp. (45–52%), *Citrus* sp. (40–44%), *Cedrella* sp. (36%) *Berberis* (48%) peach and pear (70%) and *Tecoma grandiflora* (14%). Raya (*Brassica juncea*) had the highest average sugar concentration of 52 per cent. Sharma (1972) conducted studies on the open and closed flowers of *Datura stramonium*. In open flowers, the nectar contained 3.96% sugar, whereas, in closed flowers it was 2.36%. Satyanarayana (1975) observed that sugar concentration in nectar of *Syzygium cumini* varied from 15 to 72% whereas, in *Allium cepa*, it ranged from 67% to 75% (Mohana Rao and Lazar, 1980).

Sharma (1980) conducted studies on nectar concentration of 23 different plant species and revealed that sugar concentration varied from as low as 14 per cent in *Tecoma grandiflora* to as high as 70 per cent in peach and pear. Silver oak *(Grevillea robusta)* nectar had the highest percentage of sugar, 79 per cent. Average sugar concentration of some of the major honey plants varied from 35 to 52 per cent. Diwan and Vartak (1980) suggested that moist soil, fine sunshine, a gentle cool breeze, humid weather and wider variations in daily temperature are beneficial for good nectar secretion. Nectars with sugar concentration of 20 to 40 per cent seem to be generally preferred by bees. Dhaliwal and Bhalla (1980) correlated honeybee numbers with nectar sugar concentration.

Gupta et al. (1984b) studied the nectar sugar production in different cultivars of cauliflower *Brassica oleracea* var. *botrytis*. Among the five cultivars, selection-25 and selection-1 produced the largest amounts of sugars. The maximum amount of nectar sugar accumulation in the flowers was 0.247 mg after 24 hours of flower opening. The activity of nectar gathering by honeybee was low during morning hours, but quite high during noon and evening hours. Similarly, in peach *Prunus persica*, the amount of sugar secreted in 24 hours ranged between 0.19 and 2.38 mg. Flordasun and jewel cultivars secreted the maximum sugar among all the cultivars (Mishra et al., 1985). False acacia *(Robinia pseudoacacia)* showed a nectar sugar concentration of 53 to 75 per cent and its honey potential has been estimated to be about 500 kg per hectare (Gupta and Dogra, 1987). Wild cherry *Prunus puddum* was also evaluated for its nectar properties and honey potentials by Reddy and Gupta (1987). Nectar sugar concentration in this species varied from 12.60 to 18.10 per cent. Honey potential of *Prunus puddum* is calculated to be 34 kg per 100 trees.

Some researchers have attempted to study the hourly fluctuations in the nectar sugar concentrations of different crops. Phadke (1964) observed that sugar concentration in the nectar of *Carvia callosa* increased from morning to around 1400 hours and then remained almost constant. He proposed that these variations were due to the fluctuations in temperature patterns. Similarly in *Thelepaepale ixiocephala*, sugar concentration in the nectar increased from 35 to 40 per cent at 0800 hours, to 64 per cent at about 1500 hours, and then decreased slightly after 1600 hours (Phadke, 1965). Tanda and Goyal (1977a,b) noted fluctuation in the sugar concentration of nectar of desi cotton (*Gossypium arboreum*). Sugar concentration increased from 24 per cent at 0900 hours to 33 per cent at 1500 hours. Similar studies by Chandran et al. (1983) on cardamom revealed an increase in sugar concentration from 37 per cent at 0700 to 43 per cent at 1400 hours. He concluded that sugar concentration increased with the increase in atmospheric temperature and decrease in relative humidity.

The pollination biology of *Ipomoea kentrokaulos* indicated an increase in sugar concentration from 52 per cent at 0900 hours to 71 per cent at 1700 hours. Extra floral nectar is produced at the junction of the pedicel with the flower at the rate of 8 μl per day (Reddy and Reddi, 1982). Shakuntala Nair and Wakhle (1983) investigated the nectar secretion in rubber trees *(Hevea brasiliensis)*. Sugar concentration in the nectar was determined by a hand refractometer from 0800 to 1030 hours daily for ten days. The sugar concentration increased from 39.50 per cent at 0800 to 73.0 per cent at 1030 hours and this increase followed a increase in temperature and a decrease in relative humidity. Working on the same lines, Shakuntala Nair (1983) evaluated the importance of litchi *(Nephelium litchi)* as a nectar source and revealed that sugar concentration ranged from 61 per cent at 0630 hours to 78 per cent at 1100 hours in this plant. The quality of sugar produced by a flower in 24 hours ranged from 0.75 to 12 mg with a mean of 5.078 mg. Gupta et al. (1984a) observed the variations in the sugar concentration of nectar of *Plectranthus rugosus* from 26.5 per cent in the morning to 54 per cent in the evening hours. The average nectar load of *Apis cerana* and *Apis mellifera* was 18 μl and 27 μl respectively from this plant species. Nectar sugar studies on raya *Brassica campestris* revealed that is sugar concentration increased from 0900 hours (15.2 per cent), reached a peak at 1400 hours (40.4 per cent) and later decreased (Tanda, 1984).

Some investigators have also estimated the reducing and non-reducing sugars of different plant species by chromatographic techniques. Prasannakumari (1963) showed that nectar of coconut belonged to Suc-Fru-Glu type with the dominance of fructose and glucose. Singh and Sharma (1972) estimated the reducing and non-reducing sugars of four phenotypes of *Impatiens balsamina*. White phenotype was the most efficient sugar producer (23.10 to 27 mg/g fresh weight) followed by red (19.80 to 25.80 mg/g); pink (19.05–23.80 mg/g) and purple (16–2.72 mg/g). Paper chromatography of nectar sugars showed that *Moringa* flowers contained 0.90 per cent of reducing and 11.81 per cent of non-reducing sugars (Nair and Singh, 1974). Studies on nectar of *Pyrostegia venusta* by Gowda and Anjaneyalu (1979) indicated that it contained sucrose, fructose and glucose in the ratio of 1.5 : 1 : 1. Stored nectar contained small amounts of oligosaccharides having RF values lower than sucrose. Reddy et al. (1980) studied the floral reward and honeybee visitation rates in the soapnut tree. Pistillate flowers produced nearly three times more nectar than staminate flowers. Nectar was sucrose predominant type (85.5 per cent) and glucose and fructose 7.25 per cent each. Analysis of nectar sugars of *Carvia callosa, Thelepaepale ixiocephala, Schefflira roxburghi* and *Grevillia robusta* was done by Wakhle et al. (1981). The common sugars recorded was done by Wakhle et al. (1981). The common sugars recorded in nectars were sucrose, glucose and levulose. The nectar of *Carvia* was richest in sugars.

Biochemical studies by Sharma (1989) on the nectars of some important honey plants revealed that sugar content was 0.132 to 0.397 mg in *Plectranthus rogosus*; 0.171 to 0.298 mg in *Plectranthus gerardianus*; 0.114 to 0.277 mg in *Plectranthus coetsa*; 0.132 to 0.251 mg in *Prunus cerasoides*; 0.064 to 0.238 mg in *Adhatoda zeylanica* 0.059 to 0.199 mg in *Prinsepia utilis*; 0.059 to 0.197 mg in *Prinsepia utilis*; 0.059 to 197 mg in *Rosa moschata*; 0.062 to 0.170 mg in *Berberis lycium* and 0.085 to 0.159 mg in *Rubus laxiocarpus*. Sugar content was more in *Plectranthus* spp. and *Prunus cerasoides* than other plants studied in the present investigators. In all the species of plants, the sugar content was more during the evening hours than in the morning hours (Table 9.5).

9.4 POLLEN COLLECTING BEHAVIOUR OF *APIS CERANA*

Earlier studies on the pollen-carrying capacity of *Apis cerana* were made by Cherian et al. (1966) in South India. The mean weight of pollen pellets carried by the Indian hive bee honeybee ranged from 24 to 25.4 mg on different plant species. The pollen-carrying capacities of the plain and hill strains of *Apis cerana* were also studied by Punjabi et al. (1969) in Kashmir. He reported that the percentage of pollen load to body weight was 29 per cent, 28 per cent, and 27.8 per cent for apple, maize and mustard crops respectively. The hill strain of *Apis cerana* carried heavier pollen loads in relation to their body weight than the strains in plain areas. Bisht and Naim (1979) reported the

Table 9.5: Hourly fluctuations in sugar content (mg/flower) of some important honey sources in Shimla hills, Himachal Pradesh, India

Plant species	0800 (X ± S.E.)	1100 (X ± S.E.)	1500 (X ± S.E.)	1700 (X ± S.E.)
	Time in hours			
Plectranthus rugosus	0.132± 0.016	0.212± 0.015	0.265± 0.080	0.397± 0.026
Plectranthus gerardianus	0.171± 0.026	0.217± 0.014	0.263± 0.060	0.298± 0.037
Plectranthus coetsa	0.114± 0.052	0.159± 0.049	0.240± 0.035	0.277± 0.043
Prunus cerasoides	0.132± 0.016	0.203± 0.077	0.197± 0.045	0.251± 0.033
Adhatoda zeylanica	0.064± 0.002	0.092± 0.002	0.218± 0.033	0.238± 0.027
Prinsepia utilis	0.059± 0.003	0.071± 0.005	0.066± 0.003	0.199± 0.014
Rosa moschata	0.059± 0.002	0.081± 0.002	0.155± 0.052	0.197± 0.077
Berberis lycium	0.062± 0.001	0.080± 0.002	0.166± 0.040	0.170± 0.069
Rubus lasiocarpus	0.085± 0.003	0.103± 0.005	0.119± 0.006	0.159± 0.007

X ± S.E. = Mean ± standard error about mean.
Source: Sharma, 1989.

average weight of pollen collected by *Apis cerana* from mustard crops as 8 mg.

The pollen load analyses from summer Hill and Navbahar apiaries of Shimla by Sharma (1989) revealed that heavier pollen pellets were collected in March (13.72 mg); April (13.07 mg); May (14.42 mg); June (14.72 mg); September (13.29 mg); and October (12.40 mg), whereas the pollen loads collected during July (7.24 mg); August (7.34 mg); November (8.25 mg); December (7.93 mg); January (5.66 mg); and February (7.17 mg) were lighter in weight. Thus, *Apis cerana* collected heavier pollen pellets during spring, summer and autumn as compared to the rainy and winter seasons. The percentage of pollen load in relation to body weight of the bee was maximum in May, and minimum

Table 9.6: Seasonal variations in the weight of pollen loads in relation to the body weight of *Apis cerana* (workers) during different months of the year in Shimla hills, Himachal Pradesh, India

Month	Body weight of the bee (mg) Mean ± S.E.	Weight of the pollen pellet (mg) Mean ± S.E.	Percentage ratio of pollen load to the body weight
March	58.84±0.67	13.72±0.22	23.32
April	59.35±0.67	13.07±0.23	23.10
May	59.97±0.49	14.42±0.21	24.04
June	59.75±0.47	14.72±0.20	24.64
July	58.21±0.49	7.24±0.16	12.45
August	58.02±0.48	7.34±0.21	12.65
September	59.27±0.80	13.29±0.19	22.42
October	58.95±0.46	12.40±0.20	22.73
November	57.38±0.86	8.25±0.14	14.39
December	56.80±0.54	7.93±0.11	13.96
January	56.91±0.53	5.66±0.09	9.94
February	58.51±0.80	7.17±0.18	12.26

S.E. = Standard error about mean
C.V. = Coefficient of variation
Source: Sharma, 1989.

in January (Table 9.6).

This may be due to favourable weather in the summer and autumn which results in the maximum honey flow conditions due to the availability of a large number of bee plants. Verma (1987b) reported that Kashmiri strain of *Apis cerana* carried significantly heavier pollen pellets (10.46 mg) than the Himachali strain of this species (7.95 mg). Verma and Dulta (1986) observed that worker bee of *Apis mellifera* (9.24 to 12.22 mg) carried significantly heavier pollen pellets as compared to *Apis cerana* (14.62 mg) on apple crops.

Some investigators have tried to study the colour of pollen loads collected by *Apis cerana* during different seasons of the year. Phadke (1964) reported that *Apis cerana* collected pink coloured pollen pellets from *Carvia callosa*. Deodikar (1964) emphasized that the characteristic colour shade of each pollen load helped to trace its floral origin. Suryanarayana and Thakar (1966) observed yellow coloured pollen loads in the corbicula of the Indian honeybee from *Phlox drummondii*. Studies on pollen loads of *Apis cerana indica* in the Kashmir valley indicated that yellow coloured pollen pellets were mostly collected as they came from *Trifolium* sp., and *Brassica* sp., *Helianthus annuus*, *Medicago* sp., *Meliotus* sp., and *Plantago* sp. (Shah and Shah, 1976).

In Pathankot area of Punjab, Chaudhari (1978) observed mixed pollen loads during December to March. However, Jhajj and Goyal (1979) did not find mixed coloured pollen pellets for this species at Ludhiana (Punjab). Mattu (1982) observed pollen pellets of different colours such as yellow, white, red, orange, brown and green, including those of mixed type in the Shimla hills, but the yellow coloured pollen pellets were collected predominantly throughout the year by *Apis cerana*.

Bisht and Pant (1968) reported that *Apis cerana* gathered pollen pellets throughout the year under Delhi conditions. The highest pollen-gathering activity was recorded from January to March, whereas May to June were periods of lesser activity. Later he also observed the pollen-gathering activity of *Apis cerana* and *Halictus* sp. as pollinators on roses. He reported very little preference of *Apis cerana* for rose flowers as compared to *Halictus* sp. The pollen-gathering activity of these pollinators was maximum in March and April (Bisht, 1975). Later Naim and Phadke (1976) divided the annual foraging cycle of *Apis cerana*, season-wise in Pusa, Bihar. January to March was the peak period of the pollen-collection activity, whereas honey-storing activity was maximum during March and April. Reddy (1980) noted the maximum foraging activity of the Indian honeybee in July and it was minimum in January at Bangalore. Singh (1981) found that pollen was collected throughout the year by *Apis cerana* at Saharanpur in Uttar Pradesh with the maximum activity in October. However, in the Shimla hills the peak period of foraging activity was in May and June (Mattu and Verma, 1985).

Rangarajan et al. (1974) studied the foraging acativity of *Apis cerana* and *Apis florea* on *Helianthus annuus* bloom, and reported maximum activity from 0600 to 100 hours, whereas 1200 to 1430 hours was the period of limited activity. Tanda and Goyal (1979 a,b) observed peak periods of pollen collection by *Apis cerana* and *Apis mellifera* in the morning and nectar collection in the afternoon on *Gossypium* sp. at Ludhiana. Subbareddi et al. (1980) found that both *Apis cerana* and *Apis florea* collected pollen and nectar until noon, and from then onwards they collected only nectar on *Sapindus marginatus* trees.

Verma (1983) found the peak period of pollen collection of *Apis cerana* was between 0800 and 1100 hours in February to March and July to September, while nectar collection was maximum between 1200 and 1400 hours during February to April and October to November in Jeolikote in (Uttar Pradesh) Gupta et al. (1984a) studied the foraging behaviour of *Apis cerana* and *Apis mellifera* on *Plectranthus* bloom at Rampur (Himachal Pradesh). The maximum number of pollen gatherers of *Apis cerana* was seen during 0700 to 0900 hours, whereas nectar collection activity reached a peak at 1200 hours. *Apis mellifera* showed peak pollen collection activity between 0900 and 1000 hours. Mattu and Verma (1985) conducted studies on the annual foraging cycle of *Apis cerana* in the Shimla hills. Foraging data showed the following hours of peak activity during the various seasons of the year: summer (0800, 1000 and 1600 hours); rainy (0900 and 1000 hours); autumn (0900, 1000 and 1200 hours); early winter (0900 and 1400 hours); late winter (1100 hours); and spring (0800 and 1100 hours).

Regarding the seasonal fluctuations in the proportion of different categories of bees, Cherian et al. (1947) found that the number of nectar collectors of *Apis cerana* was uniformly higher as compared to the pollen gatherers, and this proportion was maintained throughout the year in Coimbatore, South India. Reddy (1980) recorded pollen plus nectar collectors in greater number than pollen or nectar collectors in Bangalore. He further reported greater seasonal variations in pollen over nectar or water collectors. Foraging studies on *Apis cerana* in the Shimla hills revealed that the percentage of nectar collectors was greater than pollen, or pollen plus nectar collectors in all the seasons of the year and greater seasonal variations were observed in the percentage of nectar collectors as compared to other categories of foraging bee (Mattu and Verma, 1985). Similarly, Verma and Dulta (1986) while studying the foraging behaviour of *Apis cerana* and *Apis mellifera* on apple bloom, found that nectar collectors outnumbered pollen collectors in both the species.

Hamakawa and Morimoto (1967) compared the foraging activity of *Apis cerana* and *Apis mellifera* from April to November, in Japan. Foraging behaviour was similar in both the species, however, the former species foraged more frequently in the spring season. Hamakawa (1968) further studied the foraging behaviour of *Apis cerana japonica* and *Apis mellifera* on the flowers of *Parthenocissus tricuspidata* and did not find any differences in their foraging preferences. Tanda and Goyal (1979 a,b) also found similarity in the foraging behaviour of *Apis cerana* and *Apis mellifera* with only slight differences. They concluded that no bee of either species collected mixed pollen on all the foraging trips on the same day. Pollen availability was maximum in the morning and decreased in the afternoon because by that time some pollen foragers of both the species changed to nectar collection, however, they resumed the collection of original pollen next morning.

Peculiar foraging behaviour of *Apis cerana* and *Apis mellifera* was studied by Chaudhari (1977) in the Kangra valley. Both species of bees collected loads of wheat flour from different places such as godowns, houses, etc., but after some time this activity was stopped and the bees resumed their foraging activity on different crops. Fungal spores were not brought in by any of the honeybee species.

It is amply clear from this review of available literature on melissopalynology and ecophysiology that the Indian subcontinent is far less explored for its honey plant potential as compared to other continents of the world. The Hindu Kush-Himalayan refrain itself is bestowed with such enormous and diversified bee flora, because of its topography, that it can compete with any other region of the world for honey potential, if exploited properly. Many regions in the Himalayan belt are even much less explored for their bee flora. The present studies are aimed at bridging this gap in the knowledge of honey plants through melissopalynology supplemented by ecophysiological investigations on selected plants of melissopalynological importance.

9.5 ECOPHYSIOLOGY OF *PLECTRANTHUS* SP.

In the temperature and sub-temperature region of the Hindu Kush-Himalaya, *Plectranthus* sp. is a predominant and excellent source of nectar for honeybees. This common shrub is found in great abundance covering large naked hilly and semi-hilly areas, and honeybees collect surplus honey from this plant.

Plectranthus (Family: Lamiaceae) commonly called "Shain" has three common species in this region:

i) *Plectranthus rugosus*
ii) *Plectranthus geradianus*
iii) *Plectranthus coetsa*

Out of these, *Plectranthus rugosus* is the most abundant species particularly in the Himachal Pradesh region of northern India. This perennial shrub grows on stony hillsides at an altitude between 900 and 2400 m above sea level, and is gregarious in nature. It blooms from mid-August to November is a source of surplus unifloral honey in autumn.

Flowers of *Plectranthus rugosus* are about 0.4 cm long in small cymes forming racemes. Its calyx is bell-shaped and the corolla tube is two-lipped. It has four stamens arranged in unequal pairs, lying along the lower lip of the corolla (Collett, 1971). Ecophysiological studies on *Plectranthus rugosus*, an important honey plant of northern India suggest that 100 per cent germination of seeds of *Plectranthus rugosus* occurred at 25, 28 and 30°C after 168, 144 and 120 hours of incubation. Mean size of the bud and flowers of this species was 0.54 mm^2 and 0.98 mm^2 respectively. Average number of healthy flowers per plant was 38 mm^2 (Table 9.7). *Plectranthus* spp. help in rebuilding the deleted strength of honeybee colonies due to the rainy season, and good colonies can yield up to 20 kg of honey per colony from this source. This species of plant is very attractive to the Asian hive bee, *Apis cerana* because the bulk of honey produced comes from this plant species (Sharma, 1989).

Table 9.7: Floral data on different phenotypic characters of *Plectranthus rugosus*

S. No.	Phenotypic character	Mean ± S.E.
1.	Number of flowers/branch	6.10 ± 0.69
2.	Number of healthy flowers/plant	88.20 ± 0.51
3.	Time for the complete opening of flowers (hours)	78.45 ± 0.18
4.	Size of buds (mm^2)	0.54 ± 0.01
5.	Size of flowers (mm^2)	0.98 ± 0.01
6.	Number of branches with flowers	9.90 ± 0.79

S.E. = Standard error about mean.

Source: Sharma, 1989.

In the Himachal Pradesh and Kashmir regions, the annual honey yield depends upon environmental factors, especially good rainfall during the monsoon season, which in turn affects nectar production by the *Plectranthus* spp. Keeping in view the importance of this honey plant as a major source of honey, Sharma (1989) studied in detail the foraging behaviour of *Apis cerana* and *Apis mellifera* on this plant species and the results are summarized as follows:

Foraging data on *Apis cerana* and *Apis mellifera* in relation to *Plectranthus rugosus* bloom showed that peak hours of foraging activity were between 0900 and 1100 hours for *Apis cerana* and between 1000 and 1200 hours for *Apis mellifera*. Fluctuations in the percentage of pollen, nectar, and pollen plus nectar collectors were observed in both the species of honeybees. Nectar collectors outnumbered pollen collectors in both *Apis cerana* and *Apis mellifera*. The mean ratio of pollen and nectar collectors was 1:2:41 for *Apis cerana* and such ratio was 1:1:51 for *Apis mellifera*. Nectar collectors of *Apis cerana* were significantly more numerous ($P<0.01$) than those of *Apis mellifera*, whereas, the number of pollen collectors was significantly smaller ($P<0.01$, $P<0.05$) for *Apis cerana* than *Apis mellifera* during different hours of the day except at 0900 hours. There was no significant difference between pollen plus nectar collectors of both species of honeybees except at 1300 hours. *Apis cerana* spent on an average 3.18 seconds, whereas, *Apis mellifera* spent 2.41 seconds on each flower per visit. *Apis cerana* (18.38) visited significantly ($P<0.01$) smaller number of flowers per minute than *Apis mellifera* (22.79), however, the Indian honeybee (2.14 seconds) took significantly more ($P<0.01$) time to shift from one flower to another as compared to the European honeybee (1.50 seconds). There was no significant difference between these two species of honeybees with regard to; distance covered from flower to flower and number of branches visited per minute. A worker bee of *Apis mellifera* (Mean weight, 11.67 to 12.82 mg) carried significantly heavier pollen loads (P<0.01) than *Apis cerana* (Mean weight, 9.85 to 10.60 mg). The duration of a foraging trip was significantly longer (P<0.01) for *Apis mellifera* as compared to *Apis cerana* (see Tables 9.8 and 9.9).

Table 9.8: Foraging data of *Apis cerana* F. and *Apis mellifera* L. on *Plectranthus* bloom during the flowering season in Shimla hills, Himachal Pradesh, India

Parameter								
	Apis cerana (A)				*Apis mellifera* (B)			
Time spent per flower per bee per visit (seconds)	3.18±0.57				2.41±0.44			
Number of flowers visited per bee per minute	18.38±0.97				22.79±0.43			
Time taken to shift from one flower to another (seconds)	2.14±0.11				1.50±0.18			
Distance covered from flower to flower (cm)	1.63±0.34				1.85±0.21			
Number of branches visited per bee per minute	1.83±0.19				2.16±0.36			
Pollen load per bee at different hours X of the day (mg) S.E.	(0900) 10.65 ± 0.34	(1100) 10.60 ± 0.28	(1300) 9.85 ± 0.26	(1500) 10.27 ± 0.29	(0900) 12.15 ± 0.37	(1100) 12.82 ± 0.29	(1300) 12.05 ± 0.39	(1500) 11.67 ± 0.37
Duration of a foraging trip (minutes)	16.63±0.34				19.88±0.39			

Mean value for forty observations taken during the period of *Plectranthus* bloom for four colonies each of *Apis cerana* F. and *Apis mellifera* L.

S.E. = Standard error about mean.

Number of flowers visited per minute, pollen load and duration of a foraging trip: B >A (P < 0.01)

Time taken to shift from flower to flower: A >B (P < 0.01)

Time spent per flower, distance covered from flower to flower, number of branches visited by both the species did not differ significantly (P > 0.05).

P < 0.01 = highly significant
P > 0.05 = non significant

Source: Sharma, 1989.

Table 9.9: Percentage of pollen nectar and pollen plus nectar collectors of *Apis cerana* and *Apis mellifera* at different hours of the day during *Plectranthus* flowering in Shimla hills, Himachal Pradesh, India

Category of bee	0900 hours		1100 hours		1300 hours		1500 hours		1700 hours	
	Apis cerana	*Apis mellifera*	*Apis cerana*	*Apis mellifera*	*Apis cerana*	*Apis mellifera*	*Apis cerana*	*Apis mellifera*	*Apis cerana*	*Apis mellifera*
Pollen collectors (P)	40.00	39.00	29.50	42.50	22.50	35.50	21.00	33.50	21.50	26.50
Nectar collectors (N)	57.00	47.50	67.00	49.00	69.00	59.50	67.50	60.50	62.50	50.00
Pollen plus nectar collectors (PN)	3.00	5.50	3.50	2.50	6.00	1.50	5.50	3.00	9.00	8.00
Ratio of pollen collector and (P:N) nectar collector	1:1.43	1:1.22	1:2.27	1:1.5	1:3.07	1:1.68	1:3.21	1:1.81	1:2.91	1:1.89

Mean values for forty observations taken during the period of *Plectranthus* bloom for four colonies each of *Apis cerana* and *Apis mellifera*.
At 0900, 1100, 1300, 1500, 1700 hours, N > P for *Apis cerana* and *Apis mellifera* ($P < 0.01$)
At 1100, 1300, 1500 hours, (P) of *Apis mellifera* > (P) of *Apis cerana* ($P < 0.01$)
At 1700 hours, (P) of *Apis mellifera* > (P) of *Apis cerana* ($P < 0.05$)
At 0900, 1100, 1300, 1500, 1700 hours, (N) of *Apis cerana* > (N) of *Apis mellifera* ($P < 0.01$)
At 1300 hours, (PN) of *Apis cerana* > (PN) of *Apis mellifera* ($P < 0.01$)

Note: Other bees (1 to 5%) may be water collectors at different hours of the day.
$P < 0.01$ = highly significant
$P < 0.05$ = significant.

Source: Sharma, 1989.

9.6 LINKAGES OF BEEKEEPING TO SOCIAL FORESTRY

In many countries of the Hindu Kush-Himalaya, the concept of social forestry is at present being strongly advocated. This programme involves plantation of multipurpose tree species on private, marginal and submarginal lands which cannot support agriculture, and which will thus meet the fuel, fodder and manure requirements of rural populations. Social forestry programmes will not only help in generating income and employment for the rural poor but will also help to conserve natural resources and especially prevent over exploitation of forest resources.

One of the prerequisite for the development of beekeeping in the Hindu Kush- Himalaya is the expansion of bee forage areas so that nectar and pollen yielding resources are available throughout the year. Such expansion by planting exclusively good honey yielding plants may not always prove economical to farmers. The list of honey plants as shown in Table 9.1, however, clearly shows that there are certain plant species which, besides acting as good sources of pollen and nectar, have also other economic uses to the farmers. Such multipurpose plant species provide close linkages between beekeeping and social forestry.

In the Hindu Kush-Himalaya, the beekeeping industry is still mainly forest-based and more than 80 per cent of the honey produced in many countries comes from wild bee colonies through traditional honey-hunting methods. However, the present declining trend in total forest areas in the Hindu Kush- Himalaya is also posing a serious threat to the beekeeping industry because now sufficient flora is not available and as a result of this, population of wild species of honeybees is declining at an alarming rate and some of them are on the verge of extinction. In such a rapidly deteriorating situation, the only solution to save the beekeeping industry is to combine beekeeping with the social forestry programme by bringing more and more areas under plantation of such plants, which, besides their other economic uses, will also help in harvesting surplus honey.

As a matter of fact, both the beekeeping and social forestry programmes are complementary to each other. By including pollen and nectar yielding plants into social forestry programmes, it is possible to increase the total bee colony carrying capacity of an area which will enhance the total production of hive products such as honey, beeswax and royal jelly. These hive products are the sources of food and cash income to farmers living at or below subsistance levels and thus diversify the rural economy and broaden the food base.

Epilogue

The present book is one in ICIMOD senior fellowship series in which the status, scope and strategies for beekeeping (apiculture) development in south and southeast Asia in general, and the Hindu Kush-Himalaya countries in particular, have been reviewed. In the first five chapters in this book, the major concern is the importance of apiculture in providing food, nutritional economic and ecological security to rural people. In the last four chapters, the present status of the science and technology of beekeeping in this region, has been reviewed. The main conclusions and recommendations derived from each of these chapters are as follows:

MOUNTAIN PERSPECTIVE AND APICULTURE

Mountain areas due to their specific environmental and resource characteristic have comparative advantages in specific activities. Efforts, should therefore, be diverted to activities/options that fit in very well with mountain characteristics and also negate the side effects of processes and factors contributing to unsustainable situations in the mountains. Apiculture (beekeeping) possesses attributes that can satisfy these requirements. For example, inaccessibility as a major mountain characteristic, plays a less constraining role in apiculture because hive products are characterized by low weight, high value, non-perishability, high storage capacity and easy transportation. Beekeeping offers options for communities in the economically marginal category because it is a low investment activity (unless operated on a commercial scale). In addition, it is flexible enough to match any scale of operations or any category of manpower (children, women and old people) and hive products are in demand both locally and in foreign markets. It is, therefore, ideally suited for small farmers living at or below the subsistence level. Apiculture being a non-land based activity, does not compete with other resources demanding components of farming systems. At micro-level, apiculture is an additional income-generating activity and at macro-level, investment may be quite high but there is greater use of the temporal and spatial diversity of mountain resources that otherwise go unutilized. The pollination activities of honeybees are an important integration function, as they contributes to the sustainability and diversity of agriculture and botanical resources in general, and thereby contribute to increased productivity and environmental health.

Although, opportunities for apiculture occur in the mountain regions of all continents and at latitudes ranging from 0°, at the equator, to latitudes as high as 50°N and 30°S, still there are special difficulties in promoting and developing apiculture in many developing countries of Asia in general, and in many parts of the Hindu Kush-Himalayan region in particular. Constraints such as high altitude, severe climate, native bee genetic resources and bee forage do not limit apicultural development programmes in the region. Certain constraints such as poverty, remoteness, lack of education, and, in some regions, lack of apicultural traditions to some extent, come in the way of the development and promotion of beekeeping. Problems such as deforestation, soil erosion and degradation of watersheds are other factors responsible for the loss of natural habitats of honeybees and decline in honey plant resources.

In our attempts to alleviate poverty by using beekeeping as life-support system, we should concentrate our attention on aligning our proposals according to the background of the people we are trying to help. In areas where the educational level is higher and transport is easier, beekeepers can learn to work at a higher technological level and obtain good income from apiculture. But in poorer areas, we must promote types of apiculture, and of hives, that can conform to the general way of life of the people.

INTEGRATED RURAL DEVELOPMENT AND APICULTURE

In the overall context of human resource development in the Hindu Kush-Himalayan region, efforts must be made to raise the economic and social status of the neglected and underprivileged rural communities and integrate them into social and economic life of the whole rural population. In this task, small farmer's projects such as beekeeping can play an important role. Beekeeping has great self-help potentials as it offers varied possibilities, several advantages and great promises to a developing economy. Even rough estimates show that modern beekeeping can contribute millions of dollars through the sale of hive products and pollination services. For example, amongst the Hindu Kush-Himalayan countries, China is the second largest producer and the biggest exporter of honey in the world. In India, where major thrust in apiculture is on pollination of entomophilous crops by honeybees, more than 150 million bee hives are needed for the purpose. Similarly, initiative efforts are being made in other countries of this region to develop beekeeping industry on modern scientific lines.

Besides poverty, malnutrition among the underprivileged children and lowered workings capacity of the adult population offers serious constraints within the overall context of human resource development in the Hindu Kush-Himalayan region. In order to alleviate such nutritional problems, greater emphasis should be laid on food diversity through the production of supplementary foods. The different natural hive products such as honey, pollen, royal jelly not only broaden the food base of poor rural communities but also help in solving the problem of Protein-Energy Malnutrition (PEM) caused by an overall shortage of calories and proteins in the diet. These hive products along with beeswax, propolis and bee venom have also been used for centuries all over the world for medicinal and pharmacological purposes. Extensive research on the chemical and biological properties of different hive products in recent years has shown that these contain elements found in food and pharmaceutical products. Thus beekeeping technology which is low in investment, appropriate in scale and operations, safe and affordable, provides both food and nutritional security to the rural communities.

Yet another dimension of the beekeeping enterprise is the role it can play in the development of rural women and children because the work is not heavy, allows time flexibility, provides gainful employment close to home and financial independence to housewives. A few successful women entrepreneurs engaged in modern beekeeping in this region provide a good example for others to follow.

MOUNTAIN CROP PRODUCTIVITY AND APICULTURE

The vital role that honeybees play in enhancing the productivity levels of mountain crops such as temperate fruits, vegetable, oils, fodder and spice seeds has often been underestimated in the Hindu Kush-Himalayan region. On the contrary, bee pollination researchers carried out in western countries reveal that the main significance of honeybees and beekeeping is in cross-pollination, whereas hive products such as honey and beeswax are of secondary value. Many cultivated crops do not yield seeds or fruits without the cross-pollination of their flowers by honeybees or other insect pollinators. Other agronomic practices like manuring, fertilizers, biocides and irrigation are quite cost-effective and these may not yield the desired results without the use of honeybees for enhancing the productivity levels of different cultivated crops through pollination. It is not only self-sterile varieties/cultivars which require cross-pollination but also the self-fertile forms, which would also produce more and better quality seeds and fruits if pollinated by honeybees and other insects.

Himachal Pradesh in northern India is the only region which has taken a lead by adopting a planned bee pollination programme as the case of the essential inputs for improving the quality and yield of temperate fruit crops, particularly apples. However, in other temperate areas, it has not been adopted as an integral part of mountain crop production technology, despite the fact that all these hilly areas have rich traditions of beekeeping. The main reasons for this are ignorance and lack of technical know-how on the part of agricultural extension agencies and farmers. A small practical manual on the role of honeybees and other insect pollinators in modern farm management technology should be published in order to educate extension workers and farmers.

There is over-reliance in the developing countries of this region on the use of chemical methods for the control of pests and diseases of agricultural and horticultural crops. Farmers use blanket applications due to their lack of knowledge as to what to use and when. As a result of this, several beneficial pollinating insects are threatened with extinction by the excessive use of biocides. There is also lack of legislation to prohibit the use of pesticides in ways that kill bees. Keeping in view these constraints, protection and fostering of beneficial insects, particularly, honeybees in the Hindu Kush-Himalayan region, should be an integral part of every pest control programme. Necessary legislation should be introduced to regulate the use of biocides and methods of integrated pest management should be adopted.

STATUS AND ECONOMICS OF APICULTURE

Economic analyses carried out in the Hindu Kush-Himalayan countries reveal that beekeeping can be taken up both at the household and commercial level to generate additional income and employment. Beekeeping with native *Apis cerana*, required only low cost technology and even the poorest person can engage in this with very little support. On a commercial scale, beekeeping with exotic *Apis mellifera* does require higher investments, but there is wide margin of profit.

At present, there are no standard methods available for economic studies on apiculture. Economic studies carried out so far are based on data from pilot projects and personal experiences of bee specialists rather than by economists. The level of profits at the farm level may not be that high, as indicated in these studies. Also, in such studies, indirect benefits of honeybees as pollinators of cultivated and wild plant species have not been quantified. Thus there is a need for systematic studies of the economic and profitability of beekeeping for different target groups of the mountain areas of the Hindu Kush-Himalayan region. Such studies will help in determining the potential beekeeping areas and potential value of apicultural development for the mountain people.

TRADITIONAL AND MODERN APICULTURE

Apiculture is being carried out in the mountain regions of the Hindu Kush-Himalaya at all technological levels. In many of these regions, honey hunting has given way to traditional beekeeping with fixed comb hives and in some of them traditional apiculture has been wholly or partly replaced by the use of top-bar hives with movable combs or, more commonly of movable framehives. Honey collection from the wild nests of *Apis dorsata/laboriosa* is a very ancient art (about 12,000 years old) and still a common practice in the Hindu Kush-Himalayan region. Such honey hunting methods involve killing the entire brood as well large number of adult bees. As a result of this practice, and also due to mass deforestation, these wild species of honeybees face the danger of extinction with serious ecological consequences. In such areas, efforts should be made to introduce modern hive beekeeping as a substitute.

Different types of indigenous bee hives evolved under different beekeeping traditions show remarkable similarities in shape and designs throughout the Hindu Kush-Himalayan region. These traditional bee hives (hollowed logs and wall recesses and boxes of various dimensions, and designs) in use even today, reflect the remnants of the ancient bee knowledge and replica of honey collection techniques being practised by mountain farmers through centuries. However, use of these traditional hives has several disadvantages both to the beekeepers and honey consumers in terms of different bee management practices and quality control of different hive products. This has necessitated the need for the introduction of modern hive beekeeping which has its origin possibly in India among the Hindu Kush-Himalayan countries. As a result of continuous efforts for the last three decades, Indian Standard Institution (ISI) have laid down the design and specifications of Type A (Newton type) and Type B (Joelikote village type) hives for beekeeping with *Apis cerana*. These hive standards developed in India are now being used with modifications in other countries of the Hindu Kush-Himalaya, such as, Afghanistan, Bangladesh, Bhutan, Burma, Nepal and Pakistan. Similarly, the "national standard" bee hive for beekeeping with *Apis cerana* has been developed in China also.

HIVE PRODUCTS

All ancient literatures of the Hindu Kush-Himalayan countries give details of honey as man's first food and first available sweet. Honey produced in China is up to international standards in quality, consistency and packing. Chinese honey also meets the standards of foreign food laws, and the pricing policy is consistent and competitive. In recent years, India has also laid down specifications for quality control of honey in terms of physio-chemical properties. However, in other countries of the Hindu Kush-Himalaya, there is hardly any policy being adopted for the scientific processing and marketing of honey which can easily earn hard currency. There is a need to recognize centrifugally extracted honey as distinct from the honey collected by traditional squeezing methods. The former should be used as "table or medicine honey" and squeezed honey only for industrial purposes with a separate pricing policy for each of these two types. In this region publicity through different media is also needed to popularize this nutritious food among the different categories of consumers. Since developed countries are potential markets, for honey export, all producing countries should follow the examples of China for its quality control. National honey boards and honey cooperatives should be established to look after all aspects of honey handling from hive to market with the strategy that storage and transport time is reduced to an absolute minimum. With the introduction of the European honeybee *Apis mellifera*, in some countries of the Hindu Kush-Himalayan region, honey production is likely to increase tremendously and processing and marketing problems are likely to become more serious as is happening now in northern India. Time is now ripe that different Governments take up these problems so that the beekeeping industry in this region can develop in a scientific and planned way.

Beeswax is another hive product widely used for several commercial purposes. In the Hindu Kush-Himalayan region, beeswax production from *Apis dorsata / laboriosa* colonies offers great untapped potentials and technologies for harnessing these should be developed. Except in China, only insignificant quantities of beeswax are collected, processed and marketed in other countries of this region. This is due mainly to ignorance, lack of marketing information and adulteration with other artificial ingredients, and requires immediate attention to boost its production.

China has taken the lead in Asia in the production and marketing of other hive products such as royal jelly, pollen, propolis and venom. These hive products have multipurpose uses and are good sources of earning foreign exchange. Keeping this in view, initiative efforts are being made in other Hindu Kush-Himalayan countries to exploit these commercially.

HONEYBEE RESOURCES

The Hindu Kush-Himalayan region is rich in bee resources. There are at present four or more species of honeybees in this region. Among these, the Asian hive bee, *Apis cerana*, is equivalent of the European hive bee, *Apis mellifera* because both can be domesticated and can build parallel combs. *Apis cerana* has many valuable characteristics of biological and economic importance. These include docile and industrious nature, less prone to attacks of wasps and high level of resistance to nosema disease and parasitic Asian mites *(Varroa jacobsoni* and *Tropilaelaps clarae* that plague *Apis mellifera*. *Apis cerana* can co-exist with other native bee species and requires least chemical treatment of colonies to control epidemics. However, this native bee species has not yet become very popular among beekeepers because of its several behaviour characteristics. These include frequent swarming and absconding, proneness to robbing, production of large number of laying workers and lower honey yields. These negative traits of *Apis cerana* vary from apiary to apiary depending upon the bee race and management efficiency.

There is a current movement in Asia to import allopatric *Apis mellifera* for commercial exploitation. Such introductions in northern India, the Northwest Frontier of Pakistan, parts of China, Japan and Thailand is now the basis of a flourishing beekeeping industries. The exotic bee species produces three times more honey than the native *Apis cerana* and is more suited to modern bee management technology. However, many importations of the exotic *Apis mellifera* have proved disastrous because of its allopatric nature, the introduction of new diseases and parasitic mites. There is now apprehension that importation of *Apis mellifera* would lead to the decline of *Apis cerana* population in its native habitat to a level that threatens its extinction as a genetic resource. *Apis cerana* has already become a rare species in Japan and parts of China. Before this happens in the Hindu Kush-Himalayan region, a conservation strategy through the development and promotion of beekeeping with this native bee species needs to be adopted to help maintain its genetic diversity. Such strategies first require the exploration and evaluation of different sub-species/geographic ecotypes of this native bee species and then improvement of the best of them through selective breeding, appropriate apiary management practises and biotechnological research.

The genetic diversity of *Apis mellifera* has been organized into 24 sub-species having varied economic usefulness. So far only three sub-species of *Apis cerana* are recognized, although there may be several more because of the wide range of its geographic distribution. The northern and high altitude sub species/ecotypes of *Apis cerana* is likely to yield valuable honeybee germplasm which may have commercial applications not only throughout Asia, but also in the western hemisphere where beekeeping with *Apis mellifera* is threatened with parasitic Asian bee mites and spread of aggressive Africanized bees.

In south and southeast Asia, there are some countries where the exotic *Apis mellifera* has not yet been introduced and attempts are being made to improve beekeeping with native *Apis cerana* through technical and financial assistance from different national, bilateral and international donor agencies. Unfortunately, such efforts have not yielded *satisfactory* results. One of the obvious reasons for the failures for these projects has been the transfer and unsuccessful application of the western bee management technology and expertise to improve beekeeping with *Apis cerana* in this region. This native bee species certainly requires different beekeeping management-practices and equipment because of its smaller body size, nest building behaviour, colony cycle, temperature regulatory mechanisms, foraging, colony defense and other behavioural characteristics. Some attempts have been made in India and China to impróve the traditional methods of beekeeping with *Apis cerana* and in some parts of these countries *Apis cerana* matches *Apis mellifera* in honey production.

HONEY PLANT RESOURCES

The Hindu Kush-Himalayan region has very rich and diverse bee flora such as agricultural crops, temperate zone fruits, vegetable crops, grasses, bushes, shrubs, forests and avenue trees. However knowledge about the diversity of the native bee flora of this region is not yet comprehensive. Furthermore, there is continuous decline in bee floral resources in this region due to the degradation of forests and grassland ecosystems as well as changes in agricultural practices. This warrants greater attention on the part of the concerned national and international agencies involved in environmental management programmes. In order to improve the situations, honey plants should also be included wherever planting programmes are initiated with the threefold objectives of increasing surplus honey production, meet slack season needs during the dearth periods and to increase carrying capacity of a particular areas in terms of the number of bee hives it can sustain. Some efforts made in the past in this direction have yielded satisfactory results. For example, roadside plantations in Pakistan, the social-forestry programme in northwest India, and the community forestry plantation in Nepal, included several multipurpose plant species which included bee forage plants also. As a result of this, beekeeping has flourished in these areas. For commercial beekeeping, it may not be possible to have enough bee flora available at one particular locality, so beekeepers are migrating their colonies from one place to another in order to exploit these floral resources fully throughout the year and harvest additional honey crops. The best examples of such migratory beekeeping practices in the Hindu Kush-Himalaya are in the North West Frontier Province of Pakistan, Himachal Pradesh and the Kashmir region of northern India.

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

APICULTURAL TRAINING AND RESEARCH

The ecological resources of the Hindu Kush-Himalayan region offer great potential for the development of beekeeping. Due to ideal climatic conditions and diversity of bee and floral resources, this region can become a land of honey, provided there is adequate original planning on the part of policy makers as well as continuing commitment to the programmes. However, beekeeping in many countries of this region is still an old traditional household activity where native hive bee generally is kept in different traditional hives, honey is harvested by squeezing the whole comb and sold in pre-used utensils without any quality control standards. Although, beekeeping with *Apis cerana* has been closely linked with the cultural heritage of the mountain communities of this region, it has not developed on scientific lines as it has on a commercial scale with European honeybee, *Apis mellifera* is several advanced countries of the west. In the mountain parts of India (Kashmir and Himachal Pradesh) and China, modern methods of beekeeping have been adopted and basic infrastructural and technical knowhow also exists. However, in other countries of the Hindu Kush-Himalaya, beekeeping development programmes are still facing teething problems. Several countries in this region do not possess basic infrastructure, skilled manpower, extension and training facilities, or basic and applied research programmes for the advancement of apiculture. At present, scattered efforts being made for the promotion of the industry, particularly with the Asiatic species of honeybees, by different national and international agencies, have not yielded the desired results.

In order to fill these gaps, a coordinated effort is required. For this an International Centre for Apicultural Research and Training should be established in the region with the following mandate and objectives.

1) The overall objectives of this centre should be to generate and deliver improved beekeeping management technology through research and training on the Asiatic species of honeybees that would contribute to increased production and quality of different hive products as well as better bee pollination services—principally to the regional needs of south and southeast Asian countries—thereby providing cash income and nutritious food to the rural poor communities living at or below subsistence level.

2) To assist different Government agencies, beekeeping organizations and commercial enterprises to create a cadre of beekeeping experts by training them in both practical and scientific aspects of beekeeping.

3) To provide information and advisory services and also to act as a coordinating centre for international cooperation in beekeeping.

4) To assist different developing countries of this region to establish a national programme in beekeeping.

International Centre for Integrated Mountain Development (ICIMOD) located in Kathmandu, Nepal is possibly the most suitable platform to start initiating efforts to establish the proposed centre for apiculture. It should act as the coordinating agency and provide general liaison between different countries of the region, between aid agencies and Governments and thus help in the original planning of this centre.