MELISSOPALYNOLOGICAL INVESTIGATIONS OF NATURAL HONEY SAMPLES FROM SIKKIM AND SUB-HIMALAYAN WEST BENGAL, INDIA.

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By

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TO WHOM IT MAY CONCERN

This is to certify that **SRI SAMIR KUMAR MUKHOPADHYAY** has carried out his work under our joint supervision. His thesis entitled **"MELISSOPALYNOLOGICAL INVESTIGATIONS OF NATURAL HONEY SAMPLES FROM SIKKIM AND SUB-HIMALAYAN WEST BENGAL, INDIA"** is based on his original work and is being submitted for the award of ***Doctor of Philosophy (Science)*** degree in **Botany** in accordance with the rules and regulations of the **University of North Bengal**.

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Dedication

.... *In the everlasting memory of my respected father,*
Late Aditya Pada Mukhopadhyay
whose inspirational words and art of self-motivation
have added fuel at every step of life since my
childhood to the path of success.

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Chapter One

Introduction

Honey is a miraculous gift of mother nature. It is the distillation of beauty, a golden treasure hoarding sunlight and the perfume of a million spring blossomes or the aromatic fragrance of a herb-carpeted hill-side in summer. It is truly one of the perfect things both in itself and in its associations (Ray, 1999).

Melissopalynology is the qualitative and quantitative analysis of palynoflora of honeys. This analysis helps us to evaluate the pollen sources to the bees.

1.1. THE HONEY

It is an aromatic, sweet, viscous, edible fluid produced by honeybees, obtaining nectar and pollen from flowers. Because of its multifarious utilities this amber liquid has been rendered a special status in most of the ancient literature.

1.1.1. ANCIENT USES OF HONEY

Honey is necessary in different religious rites and sacrifices among the people with diverse types of faiths and beliefs. Reference of honeybees is found in Rig Veda (4500 B.C. approx.), the oldest repository of human knowledge, composed long before the arrival of Aryans in India. The use of honey has also been mentioned in Ayurveda (Knowledge of 'Ayu' means healthy and long life), a part of Atharva Veda (1500 - 1200 B.C.) composed by Indian sages. Charaka and Sushruta attributed specific medicinal properties to different varieties of honey (Charaka Samhita and Sushruta Samhita, 1000 B.C.): (see Abrol, 1997) Charaka mentioned two thousand remedies derived mostly from vegetable sources in his book and Sushruta Samhita represented a well organized classification of medicinal plants).

The Koran recommends honey as a wholesome food as well as remedy for many diseases. Prophet Mohammad once said, "Honey is a remedy for illness and the Koran for illness of soul."

Jews literature mentioned the use of honey in preparing special cakes during certain festivals.

Christians also prepare mead (a special alcoholic drink made by fermentation of honey) from honey for similar purpose. Bible also referred the good availability of milk and honey in a area as the potent symbol of plentitude.

Saxons would toast a new bride and groom for a month with this above mead, a practice that is said to be the origin of the word "Honeymoon".

Buddha recommended honey as one of the pure foods "full of soul qualities" and devoid of faults.

The Romans and Greeks loved their hippocras (a honey wine and water concoction); while the Polish honey drink Krupnik and the Moroccan Tej, both can boast of ancient lineages.

Aristotle, the father of NATURAL HISTORY (Greek 344 - 342 B.C.) believed that honey possessed peculiar properties of prolonging life and keeping the body fit. His book contains a variety of direct observation on the uses of honey (Abrol, 1997).

The Greek philosopher, Democritus ascribed his longevity to daily doses of honey and at the age of 109, when he grew tired of life, he said to have simply stopped his habitual ration, the sweet liquid and diet.

Hieroglyphic descriptions of the use of honey as food and as medicine on pyramids and obelisks monuments of ancient Egypt bear testimony of its unique qualities.

In India, cave paintings near Bhopal dating back to 6000 B.C. depict men despoiling beehives built on rocks. Indian literature are rich with references of honey, both as a food and as a symbol of purity and plenty (Ray, 1999).

1.1.2. NECTAR COLLECTION AND ITS TRANSFORMATION INTO HONEY

The honeybees collect nectar from nectaries of flowers and put into their alimentary canals (Ahsan and Sinha, 1991). This nectar is then modified into honey, a denser liquid through diastase enzymatic activity during the course of digestion. This semi - digested product, the honey, is regurgitated in honeycombs of beehives where it is ripened and sealed for future use.

Honey is, however, a complex substance, varying considerably in composition from vegetation to vegetation and agro climatic conditions of the place from where the nectar collection is made (Naim and Phadke, 1972). Nectaries, the sources of nectar are located at the base of the flowers but may be found elsewhere in some cases.

Nectar varies considerably in its sugar content but honeybees are aware of this and prefer nectar of higher sugar concentration. This dilute liquid nectar is a solution of sucrose and various other ingredients in aqueous medium. In quest of a single load of nectar and pollen a honey - bee visits 500 to 1000 blossoms of a particular plant. The nectar thus collected are firstly stored in their honey sac, a tiny compartment of the alimentary canal, where it undergoes further changes by several enzymes. In honey sac, due to enzymatic action the sucrose or cane sugar of the nectar is converted into honey mainly consisting of simple sugars predominantly dextrose and levulose. On the way back to their hives, the full load of nectars which the bee has stored in the honey sac and that has already undergone change, is transferred to the waiting house bee in case of heavy honey flow, otherwise, deposited herself into the cells of the comb, and hurried back to the field for another trip (Naim and Phadke, 1972). The honey thus stored in cells is unripe and awaits heaheir wings do the regulation of temperature in the hive. The enzyme plays the main role in converting nectar into honey is invertase, which breaks down sucrose into dextrose and levulose. Diastase converts starch to dextrin. Catalase and phosphatase decompose hydrogen peroxide and glycerophosphate respectively. Loss of considerable amount of these enzymes takes place when honey is stored for a longer period, whether processed or unprocessed (H.A.L. Wahdan, 1998).

1.1.3 Chemical Composition of Honey

In general, an average honey contains the following (Phadke, 1967): -

Water - - - 18-20%
Sugars - - - 75-80%
Proteins - - - 0.26%
Lipids - - - 0.1%
Minerals & other elements - - 0.17%
Organic acids - - 0.57%
Minor components (Vitamins, Enzymes and various
other substances like pigment, flavour etc.) - 2.21%

Regarding the sugar component, honey contains 40 percent fruit sugar (levulose or fructose), 34 percent grape sugar (dextrose or glucose), 2 percent cane sugar (sucrose) and Maltose and other disaccharides 7-8%.

Maltose, a reducing disaccharide, is initially not present in honey but is formed by the conversion of other sugars with the action of enzymes and acids and its amount increases with storage (Paine et al, 1934). Precise analytical methods have shown the presence of other lesser common sugars viz. isomaltose, trehalose, genitibiose, maltulose, panose and furanose etc.

Mineral composition of honey is very complex and wide, consisting of potassium, calcium, phosphorus, sodium, magnesium, manganese, copper, sulphur, silica, silicon, iron etc. Besides, more than

17 trace elements are also present in honey (Phadke, 1967). Chaudhury in 1994 identified about 11 minerals and 17 trace elements in normal honeys.

Different vitamins present in honey include thiamine (B1), riboflavin (B2), nicotinic acid, ascorbic acid, vitamin K, folic acid, biotin, pyridoxine, pantothenic acid and carotene. Loss of vitamins takes place during storage. Kalimi and Sohonie (1965) recorded the amount of losses of vitamins like thiamine, riboflavin, niacin and ascorbic acid in different unifloral honeys.

In their studies of four unifloral honeys like Syzigium cumini, Terminalia chebula, Randia dumetorum, Actinodaphne hookeri percent loss of Thiamine varied from 12.5 to 20.5, Riboflavin from 9.0 to 20.0, Niacine from 7.3 to 11.4 and Ascorbic acid from 15.0 to 22.7.

Minor Compounds as found in honey: -

Organic acids : Citric, Malic, Succinic and Tartaric acid.

Amino acid : Traces of Cystine, Aspargin, Lysin, Glycine, Aspartic acid, Glutamic acid, Alanine, Tyroxine, Valine, Methionine, Leucine.

Enzymes : Invertase for conversion of Sucrose to Simple sugars. Diastase for conversion of Starch to dextrines. Catalase for decomposition of Hydrogen Peroxide. Phosphatase for decomposition of Glycerophosphate.

Pigments : Chlorophyll, Carotene and Xanthophyll.

Flavours and aroma : Flavour is the result of the combination of Several substances. Apart from sugars, it includes amino acids and others acids (especially Gluconic), Proline, tannins, Glycosidic and Alkaloidal compounds and also specifically diacetyl (or other diketoalkane) and Methyl Anthranilate in Orange honey. In general, most pleasing aroma components of honey are those with low boiling points which are most evanescent. But these are lost during extraction of honey. Generally, components with higher boiling points including H.M.F. (Hydroxy Methyl Furfural) seem to be responsible for its characteristic aroma.

Inhibine : Renders antibacterial effects to the honey. (Wahdan, 1998)

1.1.4. Physical properties of honey

These are very important to determine the purity standards of honey.

(i) Hygroscopicity

Honey is hygroscopic in nature and absorbs moisture from air. In the area where humidity is high, the honey will be spoilt if not properly processed and stored. Moisture in honey is in equilibrium to particular relative humidity level. For instance, 21.3% moisture in honey is in equilibrium with 66% relative humidity. Evidently, hygroscopicity of the honey has practical application to the beekeeper.

(ii) Viscosity

Honey is a viscous liquid and the viscosity determines its flowability, heating reduces its viscosity. Viscosity is also dependent upon protein content, which in turn is dependent upon the source of nectar. Honey with higher protein content tends to be more viscous (Pryce - Jones, 1936, 1944).

(iii) Specific Gravity

Pure honey should have the specific gravity of 1.35 - 1.44.

(iv) Colour

It depends on the pigments present in the honey. The colour varies from light yellow to dark amber.

According to Phadke's comparative observation in 1967, honeys in North Indian hot plains have lesser moisture content as compared to Western and Eastern Ghats and areas with very humid climates.

The compositional criteria of a standard honey have been presented in the table 1.1.1.

According to the Indian Standard Institution, 1969 (No.: IS: 4941 - 1968:18), certain specifications for honey have been made depending upon the types of honey available. These are presented in table 1.1.2, 1.1.6. From the nutritional point of view, Crane's observation in 1975 has been presented in Table 1.1.3.

However, the quality and quantity of honey varies with the type of floral source from which the honey is obtained (Crane, 1975).

1.1.5.KINDS OF HONEYS

On the basis of the mode of extraction, honeys are of two types *viz.* Extracted or Apiary honey and Squeezed honey.

Extracted Honey:- It is extracted by centrifugation of the honey frames of the super portion of the hive of *Apis cerena indica* F. and *A. mellifera* L. (also discussed in the chapter 1.6.3).

Squeezed Honey:- It is obtained by pressing and squeezing the honey storing portion of wild comb. The pollen contents found in

Table 1.1.1. **Compositional criteria of standard honey**

Component	Percentage
Moisture content	Not more than 21%
Apparent reducing sugar content	Not less than 65%
Apparent sucrose content	Not more than 5%
Water-soluble solids content	Not more than 0.1%
Mineral Content (ash)	Not more than 0.6%
Acidity	Not more than 40 m. eq. acids/ kg.
Eructose / glucose ratio	Not less than 0.95%
Diastase and Hydroxy Methyl Furfural content	Not less than 8%

Table 1.1.2. **Specifications of different types of honeys**

Property	Apiary Honey Grades			Squeezed Honey
	Special	A Grade	Normal	
Sp. Gravity (min.)	1.41	1.39	1.37	1.37
Moisture content (max.)	20.0	22.0	25.0	25.0
Reducing sugars (min.)	70.0	65.0	55.0	65.0
Non-reducing sugars (max)	5.0	5.0	5.0	5.0
Pollen count (per gram.)	----	----	----	50,000
Ash percentage (max.)	0.5	0.5	0.5	0.5

Table 1.1.3. : **Nutrients in honey in relation to human requirements.**

Nutrient	Unit	Average amount In 100 g. honey	Recommended Daily dose in U.S.A.
Energy equivalent	Kcal	304	2800
Vitamins A	IU		5000
B1 (Thiamine)	mg	0.004-0.006	1.5
B2 complex			
Riboflavin	mg	0.02-0.06	1.7
Nicotinic acid	mg	0.11-0.36	20
B7 (Pyridoxine)	mg	0.008-0.32	2.0
Pantathenic acid	mg	0.02-0.11	10
Folic acid	mg	-	0.4
B12	µg	-	6.0
C (Ascorbic acid)	mg	202-2.4	60
D	IU	-	400
E	IU	-	30
H (Biotin)		-	0.3
Minerals			1.0
Calcium	mg	0.004-.003	-
Chlorine	mg	0.002-0.02	2.0
Copper	mg	0.01-0.1	0.15
Iodine	mg	-	18
Iron	mg	0.1-3.4	400
Magnesium	mg	0.7-13	1.0
Phosphorus	g	0.002-.006	-
Potassium	g	0.01-0.47	-
Sodium	g	0.0006-0.04	15
Zinc	mg	0.2-0.5	

squeezed honey generally higher in percentage than that found in extracted honey.

Honeydew Honey:- It is the sugary secretion of various plat sucking insects (aphids). Dextrin content is more in honeydew. It consists of trisaccharide melezitose and very active enzyme (Maurizio, 1962). Pollen grains are very poor in honeydew honey when compared to fungal elements (spores of rusts, uredinaeceae, smuts and hyphal shreds) and algal elements like myxophyceae (Louveaux *et al.,* 1978). Some of the fungal spores and hyphae found in honey samples have been presented in photoplate XVI, fig. 20a, b, c and text figure 2.6.1. It is darker in colour and has a more pronounced flavour. Coniferous forest of Northern Europe are one of the main areas where honeydew honeys are produced. In tropics and subtropics little or nothing is known about the honeydew honey (FAO, Agricultural series bulletin No. 68, 1986).

1.1.6. USES OF HONEY

Honey is used for various purposes. These areas as follows: -

(i) Honey, as an energy food.

Honey consumption per year is related to the standard of living. In Switzerland and Germany per annum per capita honey consumption is one Kilogram. In USA it is 500gm. And in France, UK, Japan and Italy it is 250 gm, whereas in India it is less than 5 gm/person/year. In India it is mostly taken as medicine and its use as an energy food is yet to be realised. One teaspoonful of honey gives 100 calories of energy. Its regular use is recommended in cases of severe malnutrition.

It provides more wholesome nourishment as compared to other foods. Energy value of 1 Kg of honey is estimated to be equal to 65 eggs / 13 Kg of milk / 8 Kg of plums / 19 Kg of green peas / 12 Kg of apples or 20 Kg of carrots. The levulose and dextrose sugars present in honey are readily accepted in our blood stream, thus providing immediate source of energy. This helps to remove fatigue without taxing the digestive system.

(ii) Honey as a tonic.

It has been found that (i) honey is non-irritating to the delicate membranes of the digestive tracts, (ii) honey is assimilated easily and rapidly, (iii) honey spares kidneys lessening tissue destruction, (iv) honey renders maximum energy units with minimum shock to the digestive system, (v) honey has a natural and gentle laxative effect, (vi) honey enables athletes to recuperate rapidly from the severe exertion. Within 15 or 20 minutes of its administration, dextrose of honey is found to have entered in the blood vessels. Our bodies need certain elements in traces and their deficiency leads to many diseases or disorders. Honey can supply many of these rare elements.

(iii) Anti-bacterial effects.

The bacteria like Micrococcus flavus, Sarcina lutea, Bacillus cereus & B. subtilis are killed by the effect of Inhibine of honey. Hydrogen peroxide is produced and accumulated in dilute honey by the enzyme glucose-oxidase during its action on glucose of honey to form Glucono-lactone (which equilibrates with Gluconic acid). It is heat sensitive. Because of high density and acidity of the honey, the non-spore forming organisms that cause human diseases cannot live in it (Mitro, 1996; Wahdan, 1998).

(iv) Honey as a medicine.

In Ayurvedic and Unani system of medicine, honey is extensively used.

(a) It is used as a laxative, a blood purifier, a preventive agent against cold, cough and fever and a curative for eye sores, for ulcers of tongue, throat and burns.

(b) Honey mixed with cod-liver oil has been used to alleviate pain and to hasten healing process of all kinds of wounds, cuts, bruises, laceration and sores. This healing power of honey is clue to the fact that it is highly hygroscopic as a result of which the disease carrying organisms cannot thrive in its presence for want of water.

(c) Honey reduces weight when taken regularly before breakfast along with lemon juice.

(d) Honey has a bleaching effect and for this reason it is used as a prime ingredient of facial cleanser for oily skin.

(v) Honey in infant feeding.

(i) Honey is recommended in infant feeding because it does not produce acidosis, its rapid absorption prevents the alcoholic fermentation, its free acids favour the absorption of fats, it complements the iron deficiency in humans and cow's milk, it increases appetite and peristalsis.

(ii) In case of anaemic children, haemoglobin content of the blood increases when honey and milk are fed together.

(iii) Other benefits include relief from constipation, weight gains, a decrease of diarrhoea and vomiting, more rapid increase in blood sugars than after sucrose administration etc. (Crane, 1975).

(vi) Honey in palatable preparations.

Different items like honey-chocolate, honey ice cream, honey "chikki", honey candy, honey jam, honey squash, comb lemon squash, etc. are some of the palatable preparations using honey.

(vii) Miscellaneous uses of Honey.

Honey finds its use in many other cases: (Abrol, 1997)

(1) It is used in making alcohol, drinks, beauty lotions etc.

(2) For stimulating milk yield in dairy cows.

(3) For increasing the stamina of racehorses.

(4) For flattening poultry and fish.

(5) As an ingredient of tobacco cigarette etc., for improving flavour.

(6) As a preservative for meat and various vegetables.

(7) As a component of many commercially manufactured pharmaceutical products.

(8) As a clarifying agent in fresh or fermented juices.

(9) For making face pack made of honey, lemon and egg, which servers as an invaluable beauty aid.

1.1.7. Granulation of honey

It is not a sign of impurity. On storage, granulation depends upon glucose to fructose ratio. Granulation is due to dextrose present in honey, which forms crystals and separates as solids, whereas levulose continues to remain in liquid form. Processing and removing pollen and other foreign particles can reduce granulation. All granulated honey liquefy when kept in warm water.

1.1.8. Moisture content and fermentation.

Consumers always insist on "Agmark" honey, which is processed and packed scientifically.

In "Agmark", three grades of honey are available with respect to maximum moisture content: -

'Special' - - 20%
'A' - - 22%
'Standard' - - 25% (Agmark, 1959)

Honey contains certain enzymes. In presence of extra moisture, these enzymes cause decomposition of honey. This is fermentation, which is undesirable because the alcoholic vapour is likely to burst open the containers. Also, the nutritive value of honey is lost on its fermentation. But scientifically processed honey does not ferment.

1.1.9. Honey Processing.

Various types of osmophilic yeasts belonging to Anthomyces, Saccharomyces, Zygosaccharomyces, Mycotorula, Torulopsis cause fermentation of honey making its normal utilization impossible. These species can tolerate high concentration of various sugars amounting to 80% of total dissolved solids in honey. Honey may ferment if harvested prematurely when its water content exceeds 20%. (Jimenez et al, 1994)

In order to avoid fermentation and spoilage, processing of honey is essential. For this purpose, marketed honey is subjected to thermal pasteurisation at a critical temperature (60 - 70°C) for a specific duration (Kaushik, 1993).

If it is heated to higher temperature or longer duration, there is caramalisation, degradation of sugars and formation of undesirable components like Hydroxy Methyl Furfural (H.M.F.). As this H.M.F. is normally present in synthetic honeys and artificially inverted sugars, it becomes difficult to differentiate even genuine butoverheated honeys from spurious ones adulterated with artificially inverted sugars. Therefore, processing of honey is essential. Central Bee Research Institute, Pune has designed a honey processing unit, which has the capacity of processing 40 to 80 kg of honey per hour within specified range of temperature (60 to 70°C) (Agmark, 1959).

1.1.10. Valuable Bee-Hive Products.

Bee Wax:

It is a complex chemical compound containing hydroxycarbons, monohydric alcohols, diols, hydroxy acids, etc. It is produced by 12 to 16 days old worker honeybees from wax glands, which are situated on the four segments of the ventral side of the abdomen. John Hunter in 1964 confirmed that wax is produced by wax - glands of worker bees. One kilogram of wax is produced by consuming 10 - 15 kilogram of honey by bees. It has been found that 1 kg of wax can support 22 kg of honey, i.e., over 20 time its own weight. (Abrol, 1997)

Uses: It is used for many purposes like manufacture of cosmetics, polishes, cold creams, ointments, lotions, pharmaceutical preparations, confectionary, different types of inks, etc. It is also used in telescopic lenses, in the preparation of adhesives, chewing gums and basketball mouldings. A large quantity of bee - wax is also used in ammunition factories.

Propolis: It is also a complex chemical compound made of Resin and Balsam, scented ethereal oils, wax, pollen, valuable esters and many flavonic components. Bees collect sticky, gummy, resinous material from buds or from bark (particularly conifers). Propolis is used by bees in reducing the size of the entrance and to plug the cracks and crevices. Comb cells are also polished by propolis.

Uses: It has antibiotic properties and hence is used as an ointment for healing wounds. It is also effective against influenza, neurodermatitis, scab and burns (Crane, 1975).

Pollen in honey:

Pollen adheres to the body of the bees when they visit flowers for nectar or pollen. It is used by the bees for brood rearing. It is the chief source of proteins, fats and minerals in the honeybee diet. Chemically, in respect of percentage of dry matter, pollen contains water (20 - 25%), ash (1.8 - 3.7%), carbohydrates (13 - 37%), fibres (5.3%), proteins (6 - 28%) and lipid (1.2 - 3.7%).

Uses: In folk medicine, pollen is considered as an all purpose remedy. Pollen mixed with honey can be used for the treatment of hypertension, nerve and hormonal disorders.

Royal jelly:

It is a complex chemical substance containing moisture (66.05%), protein (12 - 34%), total lipid (5.46%), total reducing substances (12.49%), ash (minerals) (0.82%), undetermined factors (2.84%), vitamin B & C and a substance 10 - hydroxytrans - 2, decanoic acid

(Oka, Hisao, Yoshitomo et al, 1993), secreted by the hypopharyngeal gland of worker bees normally 5 - 15 days of age. It is fed to queens throughout their larval and sadult lives and also to the young workers and drone larvae. It is synthesised during the digestion of pollen being high in protein content.

Uses: It is highly nutritive in nature and extensively used in many countries for human general health. Medically, it is used for malfunctioning of liver, low blood pressure, mental depression. It also shows some antibiotic activity due to the presence of the chemical 10 - hydroxytrans - 2 decanoic acid. (Wahdan, 1998)

1.2. Toxic and Allergic Honeys.

Honey from some plants of Ericaceae, e.g., Rhododendron, Azalea sp., Andromeda sp., Kalmia sp., Ledum sp. had been reported to be toxic from ancient time (Kabler, 1896, Palmer - Jones, 1947, Howes, 1949, Carey et al, 1959, Ganguly, 1981, Kerkvlit, 1981, Sutlupinar and Mat, 1993)

Miedizohrodzka et al (1977), reported the presence of allergic properties in honey. Honeys from Sunflower, Sycamore, Dandelion, etc., containing specific protein bodies to which they have been proved to be hypersensitive (Bosquet et al, 1985, Hebling Wnethrich, 1987). Hebling et al (1992), reported that honey allergic sensitisation may be due to either to the honey itself or to the airborne component like pollen or even to cross reacting bee - venom components (see Malakar, 1999).

According to Bauer *et al.,* (1996), both proteins derived from the secretion of pharyngeal and salivary glands of honeybee and pollen protein contained in the honey are responsible for the allergic reactions of honey.

1.3 THE HONEY BEES

Honeybee is perhaps the most studied insect. Many biologist and naturalist have unfolded strange and amazing facts about honeybees which include: (i) discovery of bee dance language (Von Frisch 1953); (ii) queen substance (Butler, 1954); (iii) caste differentiation (Haydak, 1943; Beetsma 1983); (iv) Social behaviour (Ribbands, 1953; Michener, 1974); (v) Artificial insemination (Watson 1927,1928) and (vi) Utility of bees as Pollinators (Free 1993; Kapil and Jain 1980,Abrol 1992, 1993); (vii) Foraging behaviour of honey bees in sesame (Rao *et al.,* 1981), on paddy (Rao *et al.,* 1978), on Alfalfa (Kanffeld *et al.,* 1980); (viii) Behaviour and management (Batra, 1977) are a few examples to mention.

Honeybees have provided humanity with the very basis of civilization because of their highly evolved social behaviour. They not only assist in crop productivity; maintenance of ecological balances, conservation of biodiversity but also provide honey, bee-wax and bee-venom which are useful products from medicinal and commercial points of view. Honeybees thus contribute immensely to the welfare and economy of mankind.

1.3.1. Systematics of honeybees

In the well-accepted classification of insects as proposed by [Colonel and Bingham, 1897 (1975)]- (1), the systematic position of honeybee is as follows: -

Phylum	; Arthropoda	Sub - phylum	; Mandibulata
Class	; Hexapoda or Insecta	Sub-class	; Ptergota
Division	; Endopterygota	Order	; Hymenoptera
Sub-order	; Petiolata	Tribe-	; Anthophila
Family	; Apidae	Genus	; *Apis*
Species	; *Apis cerana* Fabricius		

A. dorsata Fabricius,
A.. florea Fabricius,
A. mellifera Linnaeus,
A. laboriosa Smith,
A. andreniformes Smith

In the present work, author's citations Fabricius and Linneaus have been abbreviated as F. and L. respectively.

***Apis cerana* F.:** The oldest honeybee which is found in India probably originated in the Indo – Malayan region during Pleistocene glaciations and spread to other parts of the world. In the long run, it gradually differentiated into advanced *Apis mellifera* L. and its different races. It seems probable that *Apis cerana* F. is an ancestral stock from which *Apis mellifera* L. has been derived through gradual differention (Doedikar *et al,* 1961). According to Verma (1990) three sub-species of *Apis cerana* have been recognised which exhibit significant difference in size. These are *Apis cerana*, *A. cerana himalaya* and *A. cerana indica.*

Common honeybees of this area of Sikkim and Sub – Himalayan West Bengal include *Apis cerana indica* F. (photoplate I) and the Strain *picea* is most common. It makes hives at places upto 2000m altitudes. However, at low places, *A. dorsata* F. is most dominant and common upto 500m and can move upto 2000m during summer. It is the largest Indian variety with an average length of c.20 mm. It builds large hives with an average size of 0.90 x 1.5 m on the branches of trees (photoplate II, fig. 1), under caves or under roofs of tall buildings (photoplate II, fig. 2). It is a migratory species as during June and July they swarm to the plains (Abrol, 1992). This variety is yet to be successfully cultivated.

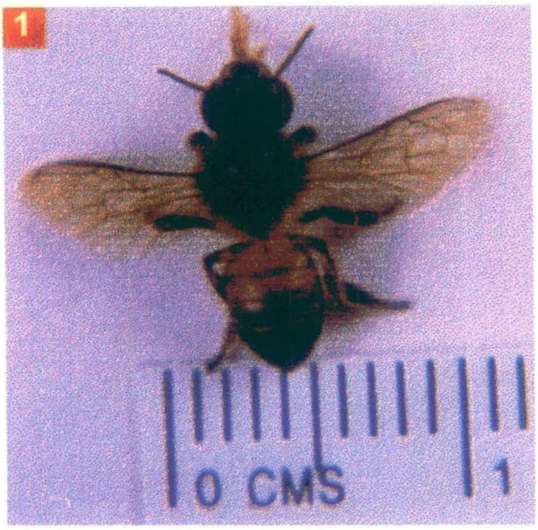
This variety has the highest honey yield (average 15 kg per colony per annum) amongst Indian bees. Sometimes the yield exceeds 30 kg per colony per annum. This bee is notorious for its ferocity and tendency to make unprovoked, sometimes fatal mass attack on persons who approach its hive.

PLATE I

A. WORKER HONEY BEES OF :

Fig. 1 : *Apis cerana indica* F.

Fig. 2 : *Apis florea* F.



B. DIFFERENT HONEY SAMPLES OF *APIS CERANA INDICA* F. AND *A. FLOREA* F. SHOWING COLOUR VARIATIONS :

Fig. 1 : GANH (Gangtok honey), *Apis cerana indica* F.

Fig. 2 : DUDH (Dudhia tea estate honey), *Apis cerana indica* F.

Fig. 3 : DGHH-3 (Dr. Graham's Homes Area, Kalimpong honey), *Apis cerana indica* F.

Fig. 4 : SFH-1 (Seed farm area honey, Kalimpong), *Apis cerana indica* F.

Fig. 5 : SURH (Suruk honey), *Apis cerana indica* F.

Fig. 6 : CH (Chalsa honey), *Apis cerana indica* F.

Fig. 7 : KHAMH (Khamdong honey), *Apis cerana indica* F.

Fig. 8 : DAMH-2 (Damthang honey), *Apis cerana indica* F.

Fig. 9 : LPH (Lathpancher honey), *Apis florea* F.

Fig. 10 : PABH (Pabong honey), *Apis florea* F.

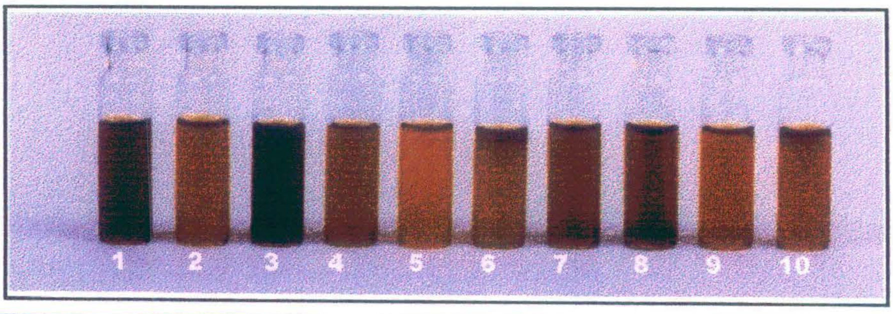
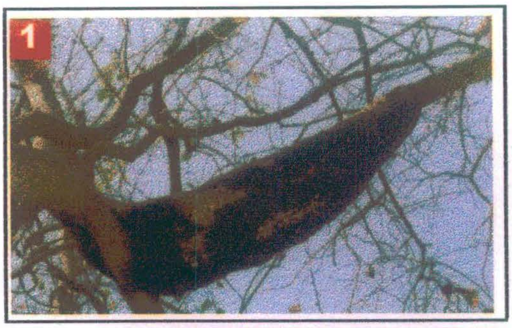


PLATE II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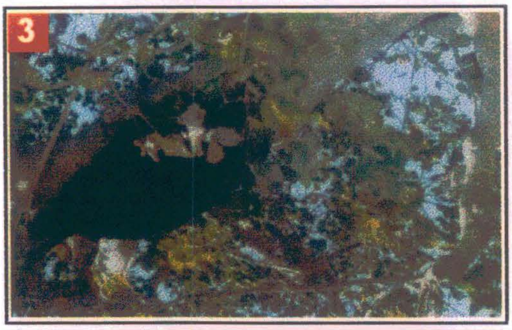
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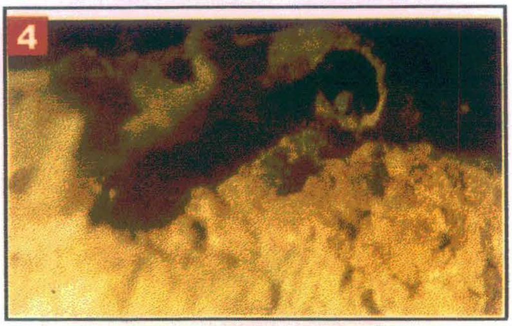
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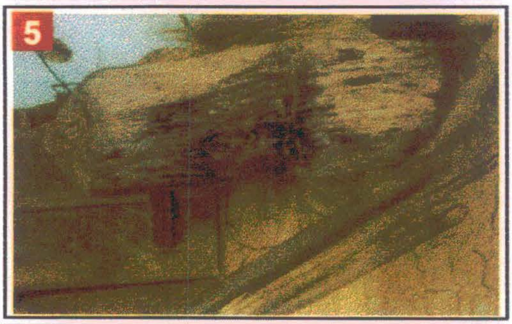
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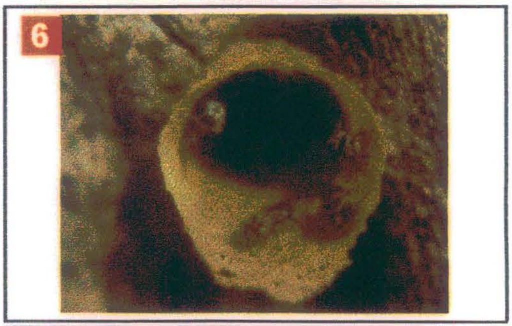
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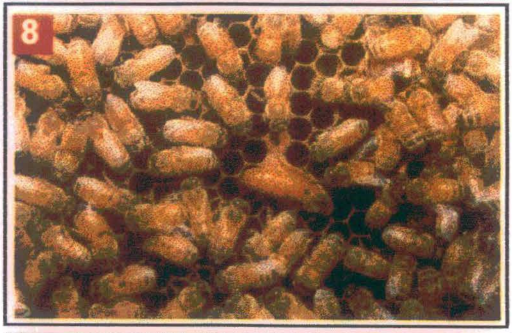
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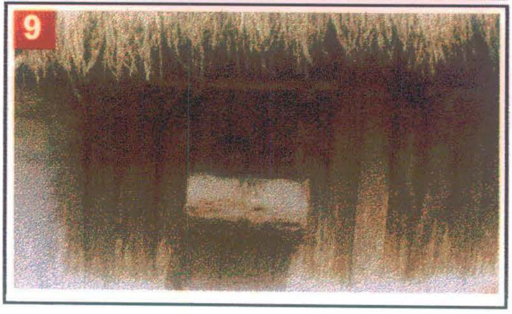
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Fig. 1 : Bee-hive in wild condition hanging from the branch of tree (*Apis dorsata* F.)

Fig. 2 : Bee-hive hanging from the roof of building (*A. dorsata* F).

Fig. 3 : Bee-hive in wild condition hanging from the branch of tree (*Apis cerana indica* F).

Fig. 4 : Bee-hive in hollow of tree trunk (*Apis florea* F.)

Fig. 5 : 'Dnur', a cylindrical hollow wooden box containing the hives of *Apis florea* F. within it.

Fig. 6 : 'Tuti', a lateral exit for *A. florea* F. on the 'Dnur' in closer view.

Fig. 7 : Production of honey on commercial scale in wooden frame hive of *A. cerana indica* F.

Fig. 8 : *A. cerana indica* F. in close view with queen at the centre surrounded by the worker bees on the comb cells.

Fig. 9 : A 'Dnur' of *A. cerana indica* F. (Kept in hanging condition) with a small lateral opening for the bee.

Fig.10: Several parallel beehives of *A. cerana indica* F. being smoked inside the 'Dnur' before extracting the honey by 'squeezing technique'.

Apis florea F.: (photoplate I) On the other hand, a very small bee produces less but best quality honey (Fenemore and Prakash, 1992). This species with an average length of c.3.5 mm lives in plains and rarely occurs 2300m above m.s.l. It builds small hives of the size c.15.24 cm across on the branches of trees or in bushes or under the roof of buildings. Yield of honey (average 100 – 200 gm per colony per annum) does not compensate the labour for its cultivation.

Apis cerana indica **F.:** Popularly known as Indian bee of commonest occurrence on the plains and forests of India (Chaudhary, 1978). There are several regional strains of it of which plain, transition and hill varieties are three recognised types. Strain *Picea* is found in hills at an altitude upto 2000m, whereas pironi is distributed along the transition between altitudes of 1000 to 1200m. With an average length of 9 –10 mm, *A. cerana indica* F. builds several parallel hives (photoplate II, fig. 10) (c.30 cm across) in protected places like hollow on tree – trunks, caves, in rocks and in other such cavities (Naim & Phadke, 1972). Due to their mild nature and average output of honey between 3 kg to 5 kg per colony per annum, they are amongst the best of Indian varieties to be hived in artificial conditions. The bee-hive patterns of the above three species, *A. dorsata, A. cerana indica* and *A. florea* in both wild and domestically cultivated condition have been shown in plate II.

Apis mellifera **L.:** Also called European bee, is very common all over the Europe. This bee is similar to *A. cerana indica* F. in its habitats. There are several such varieties and strains of this bee, amongst them the Italian variety is the best. It yields an average of 25 – 180 kg of honey per colony per annum. An attempt to domesticate this bee in India on large scale is yet to be proved a success (Deodikar et al, 1961).

Crossbreeds have developed and experiments are going on at Patampur campus of Punjab Agricultural University. The cross between Indo – Italian swarms have yielded 51 kg of honey per colony per annum. But all these are in experimental conditions and at present we can only hope for a brighter future in the field of agriculture (Singh et al, 1974; Singh, 1982).

Comparisons of four species of honeybees (Drescher & Crane, 1982) have been shown in the following table: 1.3.1

1.3.2. Colony Organisation of Honey Bees

Honeybees are social insects, which live in colonies. A bee colony comprises three different castes, which perform different duties. They include one queen, several thousands of workers and a few hundreds of drones or males. Beetsma in 1983, studied that hormones also play some role in caste differentiation and adult behaviour of the female honeybee of *Apis mellifera* L.

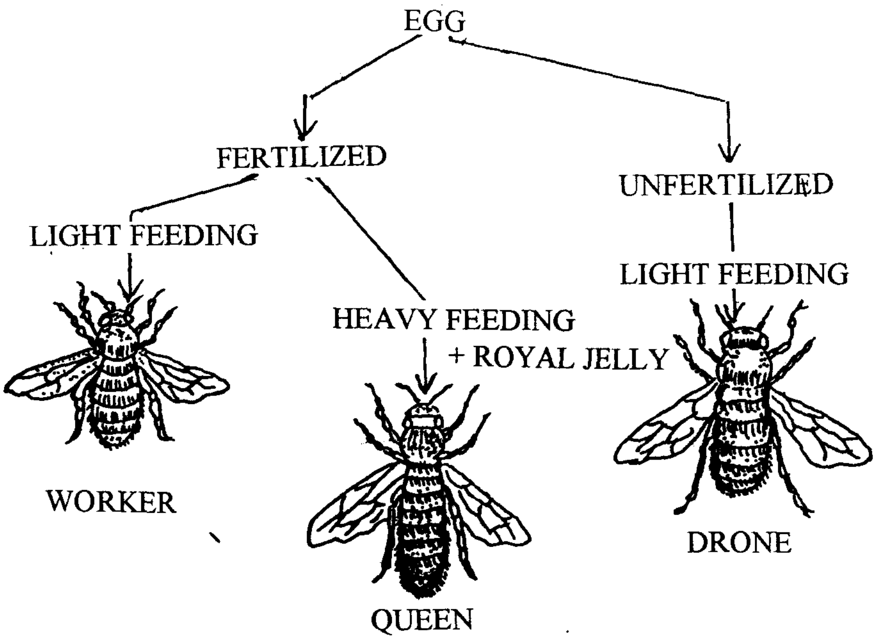
Duration (in days) after egg laying essential for the development of different castes of honeybees is shown in the following table 1.3.2.

The differences among three castes of honey bees queen, worker and drone are summarised in the table: 1.3.3. and 1.3.4.

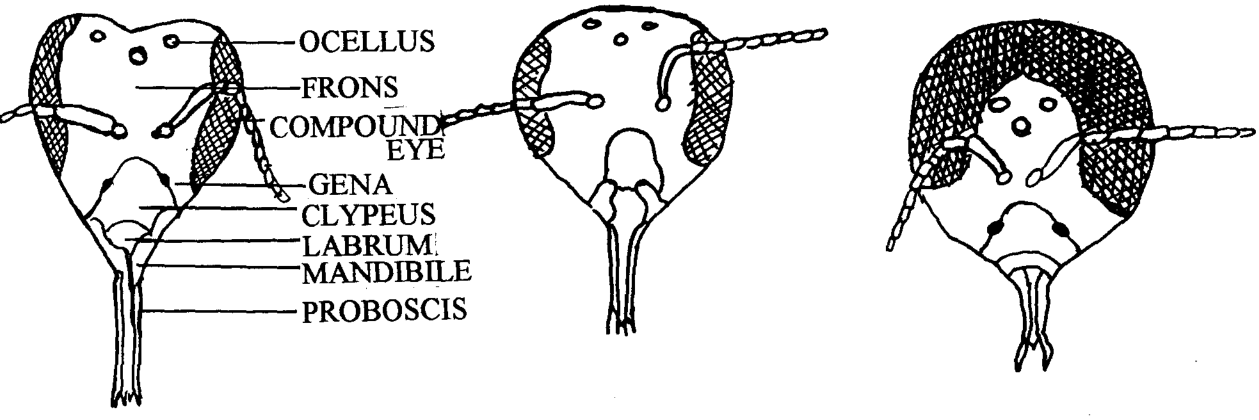
Table 1.3.2.

Caste	Egg hatching	Cell sealing	Adult emergence
Queen	3rd	8th	16th
Worker	3rd	8th	21st
Drone	3rd	8th	24th

The structural differences in respect of body plan and head capsules among the above three castes of honey bees are shown in fig. 1.3.3 and 1.3.2 respectively.



[Fig. 1.3.1. Differentiation of queen-laid eggs into worker, queen or drones according to determining factors.]



WORKER BEE

QUEEN BEE

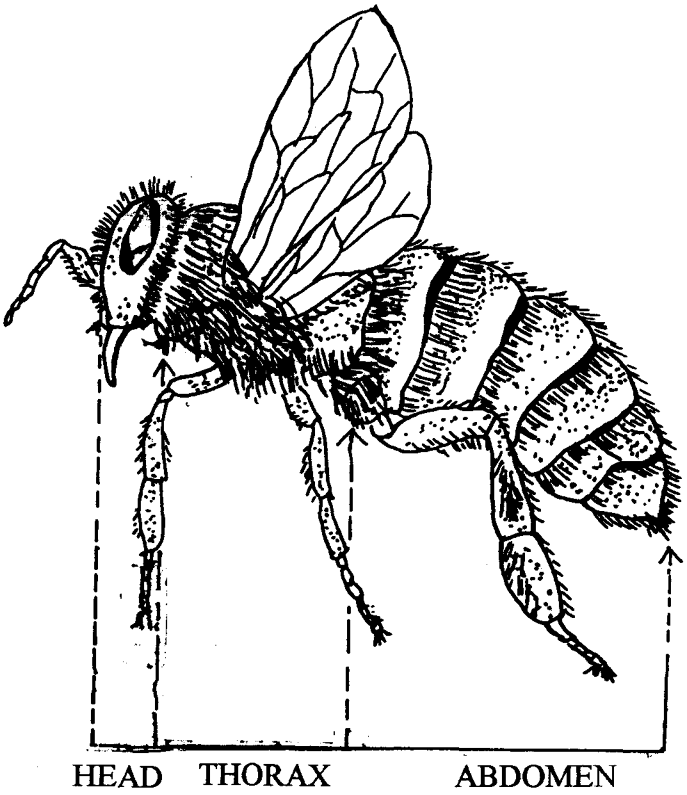
DRONE

[Fig. 1.3.2. Differences among the head capsules of Worker, Queen and Drone honeybees.]

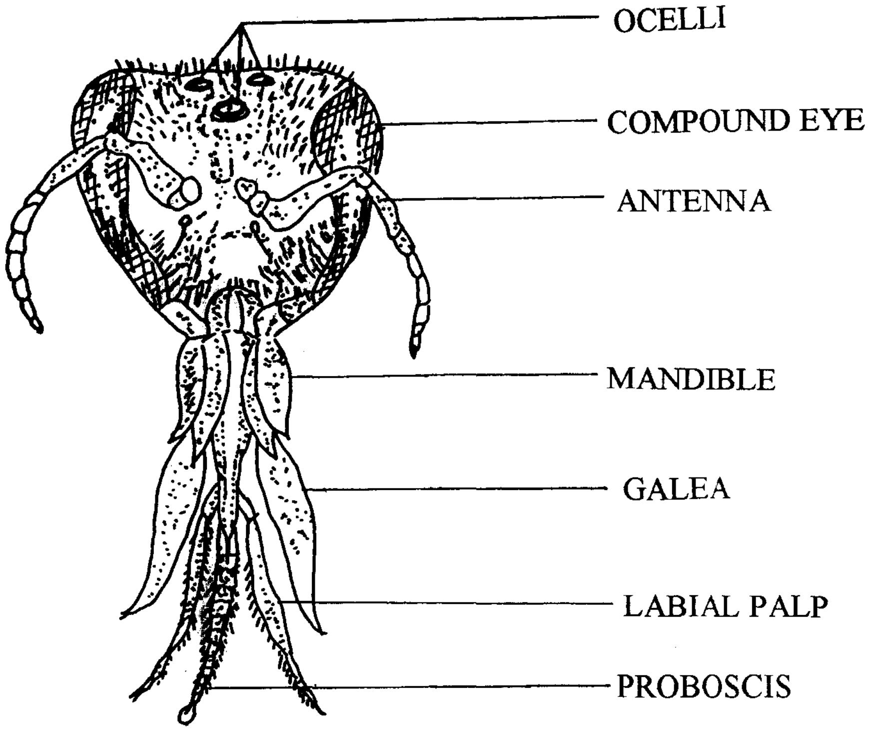
Table 1.3.1. **Comparisons of 4 species of honey bees**

Property	*A. florea*	*A. cerana*	*A. mellifera*	*A.. dorsata*
Nest location branch	Twig or Small Branch	Cavity	Cavity	Large or rock
Nest protection (Trees, etc)	Hidden in Vegetation	Cavity in walls	Cavity in walls	High above ground Under-roof,
Number of combs Per nest	1	3 – 8	5 – 8	1
Nest dispersion Aggregated	Solitary	Solitary	Solitary	
Colony population	< 5,000	< 10,000	> 10,000	> 20,000
Worker size (length)	Small	Medium	Medium	Large
Body weight (mg)	22.6	43.8	77.2	118.0
Cells / worker (Worker / Cell)	0.80 (1.25)	3.56 (0.28)	3.99 (0.25)	0.74 (1.35)
Brood / Worker (Worker / Brood)	0.59 (1.69)	1.88 (0.53)	1.77 (0.59)	ND ND
Time from eggs to Adult (days)	21	19	20 – 22	16 - 20
Longevity (max. days)	> 50	< 38	30 – 40	ND
Age of the start of Foraging (days)	=20	=14	=20	ND
Workers foraging (percentage)	10-23	7-25	ND	ND

* ND=Not Determined; - = Nil



[Fig. 1.3.3. The body plan of honeybee worker.]



[Fig. 1.3.4. The head of a honeybee worker (After Snodgrass, 1956).]

Table 1.3.3. **Differences among three castes of honeybees.**

Queen	Worker	Drone
Number Only one queen per Colony under normal Conditions	20,000 to 60,000 workers per colony	Few hundred drones at the time of mating
Development Period from egg to adult 16 days	21 days	24 days
Sex Perfect female	Imperfect females; Reproductive structures ill developed	Perfect males
Size Large	Small	Medium
Wing Expanse Wings don't cover the Entire abdomen	Wings cover the Entire abdomen	Wings cover the Entire abdomen
Sting Slightly curved and Longer	Small	Sting absent
Thorax Broad	Short	Broad
Abdomen Pointed V-shaped	Pointed V-shaped	Blunt
Pollen baskets Absent	Present	Absent
Wax glands Absent	Present	Absent
Food supply Dependent on worker	Independent	Dependent on workers

Table 1.3.4: **Some structural differences among worker, queen and drone castes in honey bees**

Characteristics	Worker	Queen	Drone
Sensory Structures			
No. of facets of compound eyes	4,000–6,900	3,000–4,000	7,000–8,600
Optic lobes of brain	Medium	Small	Large
No. of antennal plate organs	3,000	1,600	30,000
Ratio of antennal surface	2	1	3
Glandular structures			
Hypo pharyngeal	Present	Vestigial	Absent
Mandibular Large	Very large	Small	
Head salivary (labial)	Large	Large	Vestigial
Thoracic salivary (labial)	Large	Large	Small
Wax gland	Present	Absent	Absent
Nasonov	Present	Absent	Absent
Alkaline (Dufour)	Reduced	Large	Absent
Keshavnikov	Reduced or Absent	Present	Absent

Contd...

Characteristics	Worker	Queen	Drone
Reproductive and sting structures			
Ovaries or testes	Reduced	Enlarged	Normal
No. of ovaries	2 – 12	150 – 180	None
Spermatheca	Rudimentary	Large	None
Sting barbs	Strong	Minute	None
Sting plates	Loosely attached	Strongly attached	None
Mouthparts (fig. 1.3.2)			
Mandibles	Slender	Robust	Absent
Mandibular groove	Present	Absent	Absent
Proboscis	Long	Short	Short
Leg and wing			
Pollen press and combs	Present	Absent	Absent
Pollen basket	Present	Absent	Absent
Wing sensilla	Medium	Fewest	Most

[Source: Data from Ribbands, 1953; Snodgrass, 1956; Michener, 1974; Dade, 1977; Winston, 1987.]

1.3.3. Morphological and anatomical modifications of worker honeybee in relation to the production of honey and other by – products

With a complex combination of parts integrated into a finely tuned organism, the honeybee is capable of performing a broad range of athletic, graceful and purposeful tasks.

The body of honeybee is divided into 3 regions – the head, the thorax and abdomen, each of which has number of segments (Fig. 1.3.3). Thorax is the principal locomotary region of a bee's body and contains powerful muscles for flight, walking and specialised functions and as pollen collecting.

(i) The Proboscis / Tongue

It is a complicated structure, which has the main function of sucking and ingesting liquid materials such as nectar, honey and water. The extended worker proboscis can be 5.3 – 7.2 mm long depending upon the race of the bee and this length of proboscis partly determines which flower the workers can visit for nectar (Fig. 1.3.4).

(ii) Legs

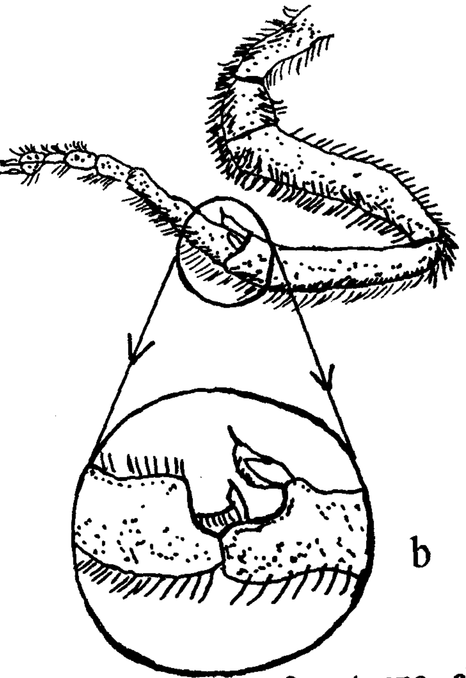
Each pair of leg has its own importance. The forelegs have hairy brushes on the enlarged basitarsus, which are used to clean dust, pollen and other foreign materials from the head (Fig. 1.3.5a, b).

The middle legs are used to clean the dirt and pollen and to transfer materials from the front to the hind legs (Fig. 1.3.6a).

The hind legs are highly modified for the pollen and propolis transporting functions. The most prominent structure is the Pollen basket or corbicula, which are essential for collecting pollen from the flowers (Fig. 1.3.6b).

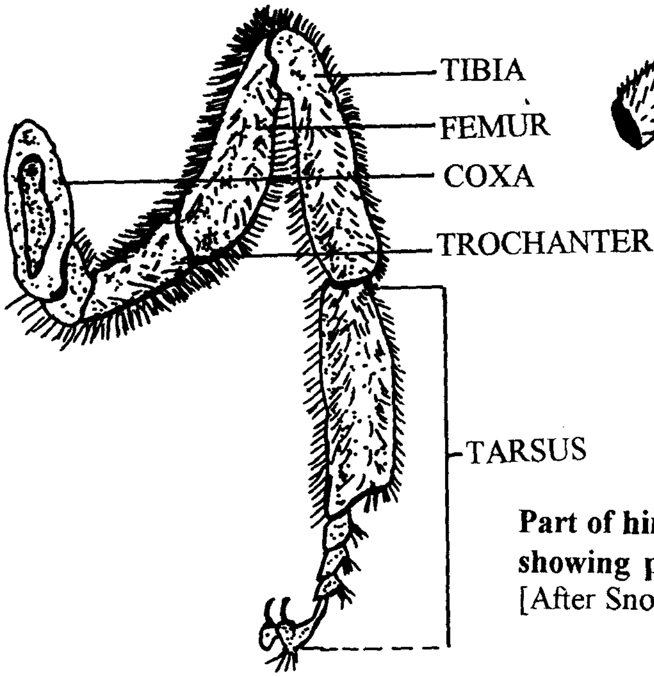
(iii) Digestive system

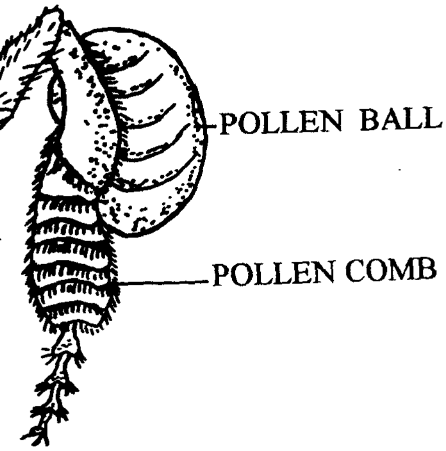
The posterior end of the oesophagus opens into the crop or honey stomach (Dade, 1977), which holds honey ingested in the hive used for the energy during flight and nectar or water collected in the field by workers for transport back to the nest. The honey crop occupies most of the abdominal



Enlarged views of antanna cleaner found on Pretarsal (Foreleg) leg of worker honeybee [After Snodgrass, 1956]

[Fig. 1.3.5. Pretarsal leg segment, showing tarsal pad and claws meant for walking and manipulating wax & Propolis. (After Snodgrass, 1956)]





Part of hind leg of a worker honey bee showing pollen ball and pollen comb. [After Snodgrass, 1956].

[Fig. 1.3.6. Outer view of the middle leg of the worker honey bee. (After Snodgrass, 1956)] cavity. The contents of the crop can be regurgitated when the surrounding muscles contracts (fig. 1.3.7).

(iv) Wax glands

These glands are meant for the production of bee wax located ventrally on the fourth to seventh abdominal segments (fig. 1.3.8).

(v) The Nasonov or the scent gland

It is situated beneath the tergite of the last abdominal segment produces a scent which is a mixture of seven chemicals including geraniol, nerolic acid, geranic acid, (E) – citral, (Z) citral, (E,E) – farnesol and nerol (Pickett et al, 1980). This nasonov scent is used for orientation, particularly at nest entrance, in swarm clustering, at water collection site and possibly at flowers (Butler, 1954; Butler & Fairey, 1964) (fig. 1.3.8).

(vi) Hypopharyngeal glands

"Royal jelly" is produced by these glands situated on the upper forehead of the honeybee (Butler & Fairey, 1964) (fig. 1.3.8).

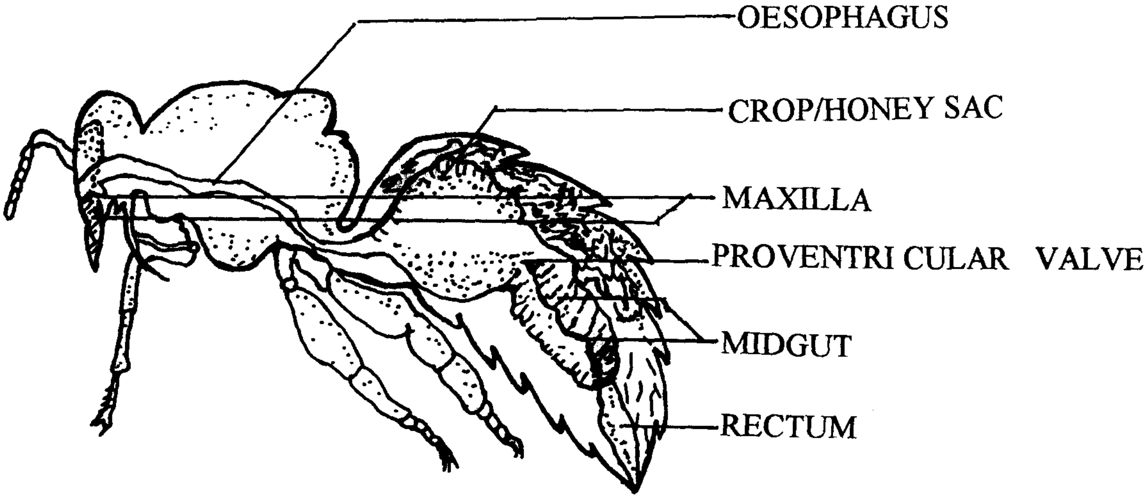
1.3.4. Social Behaviour of honeybees related with seasonal and foraging activities.

In respect of honey production :-

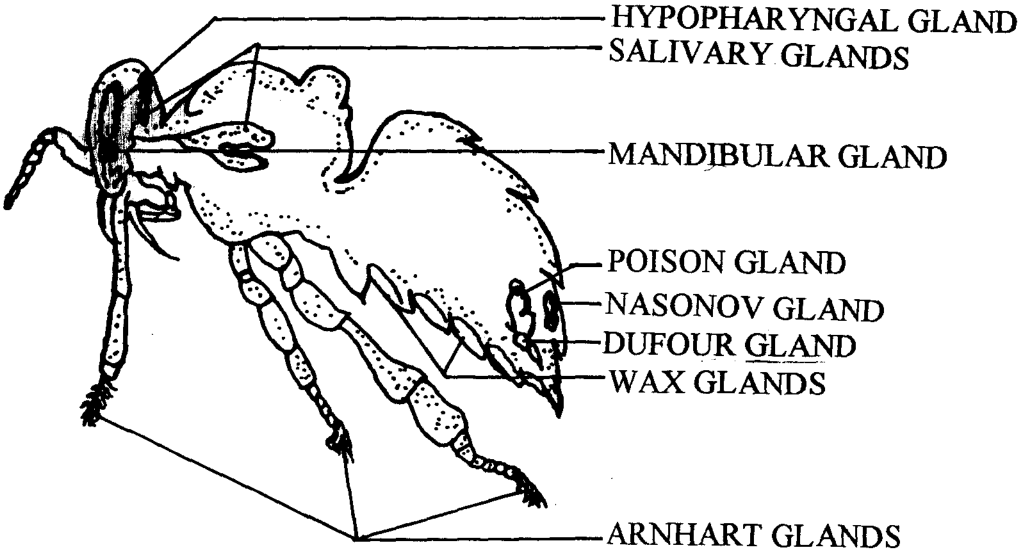
Social behaviour of honeybees was studied thoroughly by Ribbands in 1952, 1953.

(i) Division of labour

Worker bee during the first three weeks perform the indoor duties like regulating the temperature of the comb upto 35.5°C (Lindaner, 1954), nursing larvae by feeding honey, pollen and also with secreted royal jelly from their mandibular glands. At the age of 14 days, the same worker bees develop wax glands and starts secreting wax to build comb. During the last three weeks they perform outdoor duties like foraging nectar and pollen from flowers (Michener, 1974).



[Fig. 1.3.7. Digestive and Excretory system of a worker bee
(After Michener, 1974 and Dade, 1977)]



[**Fig. 1.3.8. Glandular system of worker bee** (After Michener, 1974)]

(ii) Dance language

According to Frisch (1953,1967), worker bees perform "round dance" to convey the information about the source of food when the source of food is c.100m away from the hive, and "wag tail dance" to indicate the distance, direction as well as the quantity of the food when the source of food is greater than c.100m away from the hive (Fig. 1.3.9).

Weaver also studied the foraging behaviour of honeybees in 1957. Dr. Adrian Wenner of California University rather claimed in 1964 that the foragers communicate to the other inmates not only by their dance, but also by the vibration of wings. The intensity of sound is directly proportional to the distance of food from hive also the quantity of the food.

(iii) Visual system

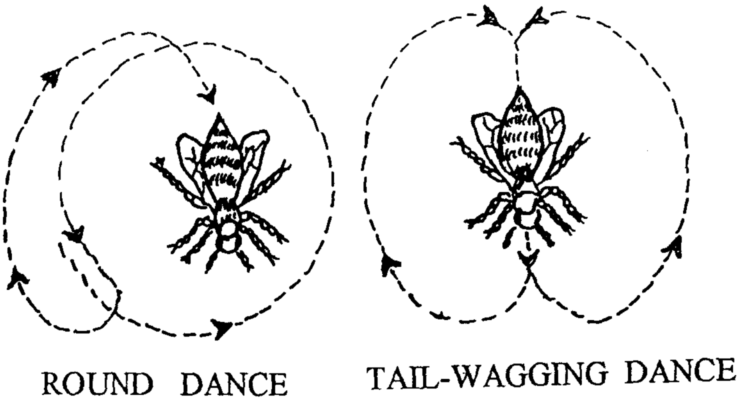
Worker bees are particularly good at seeing columns, patterns and movements, all characteristics necessary to recognize food sources (Wehner, 1972). Bees have far superior visual system than that of human. They can even see in ultraviolet light, whereas humans cannot. The bees can distinguish green, blue, yellow and violet flowers but are insensitive to red flowers (Menzel, 1973).

(iv) Chemical communication

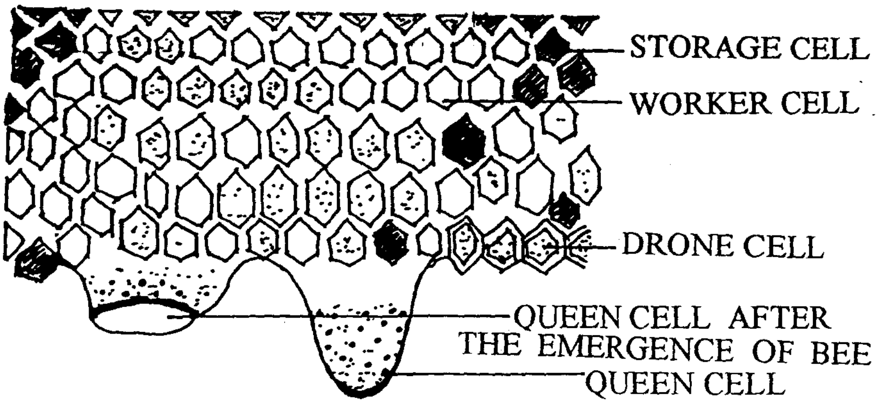
Worker honeybees expose the nasonov gland and dispose the odors by fanning in number of orienting situations, which include nest entrance finding, forge marking and swarming (Butler and Fairey, 1964; Ferguson *et al.,* 1981). Queen bee – produced odor that stimulates foraging for nectar is 9 – 0x0 decanoic acid (9 – ODA) (Jaycox, 1970). The other queen substance 9 – hydroxy – (E) – 2 – decanoic acid (9 HAD) along with 9 – ODA is responsible for differentiation between fellow workers and queen (Simpson, 1979).

(v) Maintenance of hive temperature

According to Lindaner (1954), the maximum internal temperature of hive never exceeds 36°C. Workers fanning over the cells increase the coding evaporative power of the disturbed water. More rapid evaporation can be induced by what has been named as "tongue lashing" behaviuor in which



[**Fig. 1.3.9. Two different types of bee-dance of worker honey bee.**
(After Von Frisch, 1967)]



[**Fig. 1.3.10. A portion of honey comb.**]

workers hanging over brood cells repeatedly extend and contract their proboscis, pressing a drop of water from their mouths into a thin film which can evaporate quickly.

(vi) Foraging range

Bees generally visit flowers within a radius of 1 to 3 km. *Apis Cerana* F. Normally forages 1 to 1.5 km while *A. mellifera* L. may forage upto 3 km (Michener, 1974). The actual recognition of the source of food or nectar is influenced by various factors like colour, flavour and taste ((azdazi and Agarwal, 1997).

(vii) Foraging time and span of foraging

Apis cerana indica F. shows wide range of foraging time at daytimes. It ranges from 8:00 am to 3:00 pm and most suitable time for foraging found from 11:00 am to 1:30 pm.

The foraging time span to *Apis cerana indica* F. on different flowers varies from plant species to species. In most of the foraged species it ranges from 5 second to 8 seconds. But in a few species like Torenia peduncularis, Tropaeolum majus etc. the bees forage flowers exceeding 10 seconds at a time.

(viii) Foraging activities

These provide necessary raw materials for the hive, which include nectar, pollen, water and propolis. Nectar load is normally 15 – 30 mg in *A., cerana* F. and 30 – 40 mg in *A. mellifera* L. Each bee may bring 10 – 20 load full of nectar / day. A load of pollen may vary from 10 – 20 mg and may be collected from 50 to 200 flowers depending upon the quantity of pollen per flower. Water foragers can bring a trip of water in 5 minutes and make 50 such trips / day depending upon the needs of the colony (Abrol & Kapil, 1937).

(ix) Climatic factors related with foraging activity

Climatic factors like temperature, light intensity, radiation time of the day, wind velocity along with concentration of nectar in flowers and density of flowers have considerable impact on the foraging activity of honeybees. Speed of flight, flowering productivity and availability of nectar and pollen are normally influenced by meteorological factors (Abrol, 1987, 1988, 1992).

1.3.5. STRUCTURE OF A BEE – HIVE

The workers form the hive and comb of the bees. A comb is a vertical sheet of wax, consisting of a double layer of hexagonal cells projecting in both directions from central wax – sheet. Comb hangs vertically downwards, while cells are horizontal in position. The hexagonal shape of cells accumulates maximum space in minimum use of wax and labor (Kapil, 1970).

The cells of the comb are of various types. The “storage cells” containing honey and pollen are generally built on the margin and at the tip of the comb. The “brood cells” containing the young stages are built in the center and the lower part of the comb (fig. 1.3.10).

Separate brood chambers for rearing developing worker, drone and queen from larvae are present. There is no special chamber for adults. They move on the surface of the comb.

1.4. HISTORICAL BACKGROUND OF THE STUDY

Until the 16th century honey bees were confined to the old world, where they had evolved and were widely distributed long before man appeared on the earth. Primitive man learnt to get honey by robbing the bee's nests in hollow trees or rock crevices.

The earliest hive was log from fallen tree. The cork and other types of hives were also made mostly during the stone age. Pottery vessels were also made during the Neolithic Period from perhaps 5000 BC onwards and water pots are still used as hives in some Mediterranean lands. In ancient Egypt and adjoining areas pipe hives were used. Basket and bone arol hives were used in some regions. But at that time it was known as the "large king bee" was in fact a female and mother of the other bees. Sexes of the workers and drones were not known (Abrol, 1997).

Sexes of bees were identified, the queen bee as a female which laid eggs was published in Spain by Luis Mendez de Torresim in 1586. Then in England Charles Butler (1609) showed that drones were male bees and Richard Remnant (1637) showed that worker bees were females.

The fact that queen bee can be raised from eggs were demonstrated by Hickel Jacob in 1568 in Germany and the queen mates with drones was discovered by Anton Janascha in Slovenia in 1771. The pollen which bees collect from flowers is the "male seed" of the flower which fertilise the ovum was discovered in England by Arthur Dobbs in 1750. The part played by bees in fertilising flowers was established clearly by C.K. Sprengel in 1793 (see Abrol, 1997).

Between 1650 and 1850 many hives with top bars and frames were invented. But after these two centuries of efforts there was still failure whatever bars of frames were used, the bees attached their combs to the walls of the hive as well and combs therefore could be removed from the hive by cutting them out.

During 1851 a remarkable invention in bee keeping was made by Lorenzo Langotroth an American born in Philadelphia. He introduced the concept of bee space. He deepened the grooves on which bars rested leaving about 3/8 inch between the cover and the bars. This led to the formation of movable frames as honeybees did not build across the space and the frames.

The use of movable frames led directly to the invention of bee-wax foundation by Johannes Merhring in Germany in 1857. Then there were attempts to extract the honey without destroying the comb. This led to the invention of the centrifugal honey extractor in Austria in 1865 by Major F. Hrusekha possibly in France. The perfection of the queen excluder by Abbe Collin of France 1865 enabled the beekeepers to keep the queen and hence the brood, out of the honey chamber. By using the bee escape produced in 1891 by E.C. Porter in the United States he could get the honey chamber free from bees before he removed the frames of honey.

1.4.1. MELISSOPALYNOGICAL STUDIES OUTSIDE INDIA

Some of the major works related to honey analysis in different countries outside India may be mentioned as follows:

ARGENTINA

Telleria & Maria in the year 1988 on their work on palynological analysis of honeys from the North-East of the province of Buenos Aires found that out of 53 samples of honey 90 morphological types corresponding to different taxonomic levels, most of them to a species level were identified. They made the investigations on the honey pollen from North-West part of the same province in 1995.

Costa, Maria *et al.,* 1995 analysed pollen in honey samples from Northern San Luis Province of Argentina.

Valle *et al.,* 1995 made pollen analysis of honey from SouthWest Buenos Aires Province of Argentina.

AUSTRALIA

Black and Roff. (1956) made significant studies on bee forage plants of South Eastern Queensland.

Van Der Moezel *et al.,* 1987 worked on the pollen selection by honeybees in Shrublands of the Northern Sandplains of Western Australia. Analysis of pollen loads showed that among a total of 44 species exploited by the bees for pollen, the most commonly exploited were *Leucopogon conostephioids, L. striatus, and Acacia stenoptera.* Stoddard in the year 1991 while working on pollen vectors and pollination of faba beans in Southern Australia found that the effectiveness of honeybees as pollen vectors constrains with their ineffectiveness in colder climates partly because in Mediterranean climate beans flower in late winter and early spring when bees are in search of pollen.

BANGLADESH

Hossain *et al.,* 1988 on their work on Bee keeping potentials of Bangladesh: Studies on the important honey and pollen sources of Northen Chittagong region enumerated 141 honey and pollen source plants. This is indicative of its high potential for apiculture in this region and the richness of honey sources in Bangladesh flora.

BRAZIL

Iwoma and Melhem (1979) recorded the dominant pollen types in 23 *meliponia* honeys in Brazil. *Eichornia, Eucalyptus, Schinus, Petroselinium* were recorded by them.

Kerr *et al.,* 1986 and 1987 on their work nectariferous and polliniferous species used by the bee *Melipona compreripes fasciculata* (*Meliponinae,* Apidae) in Maranbao (Anorhern stae, Brazil) enumerated 79 species of plats used by the above species. Most of these plants are also visited by *Apis mellifera* L.

Cortopassi-Lawrino and Rawalho in 1988 on their work pollen harvest by Africanazed *Apis mellifera* and *Trigona spinipes* in San Paulo, Botanical and Ecological views observed a great number of pollen types in each of the samples (app 40).

Barth in 1990 investigated into pollen in monofloral honeys from Brazil. Ramalho *et al* 1989 studied the utilization of floral resources by species of *Melipona* (*Apidae, Meliponinae*) in Southern Brazil. They found that the plants of families Melastomataceae, Myrtaceae, Solanaceae, Leguminosae are the main pollen and nectar sources.

CANADA

Austin (1958) collected nine honey samples from Province of Alberta in Canada and reported that Melilotus honeys as characteristic of Alberta. Jamieson in 1958 studied the facts about bee keeping in Canada. Feller-Demasy *et al* in 1987 in their work on miscroscopic analysis of honeys from Saskat-Chewan, Canada taking 42 samples of honey collected in 1983 enumerated five characteristic pollen types Brassicaceae (Mustard family), Melilotus (sweet clover), *Trifolium hybridum,* (*T. repens,* white clover), *Medicago sativa* (Alfalfa) and *Brassica kaber* (wild mustard). Almost all the honeys studied were unifloral with two cultivated pollen types.

Boyle-Makowski in 1988 while studying on the importance of native pollinators in cultivated orchards: their abundance and activities in relation to weather conditions found that *Apis mellifera* L. was the most frequent pollinator for the years but was less efficient as it carried less pollen and less fruit than the Andrenidae.

CALIFORNIA

G. H. Vansell worked on the nectar and pollen plants of california in the year 1931.

CHINA

Tzu-Chang *et al.,* 1994 investigated into the content of honey from wild and kept honeybees.

DENMARK

O. Hammer worked on the effect of distance on honey production in the year 1961 and O. Svendsen worked on the pollen harvest of colonies during red clover bloom in 1964.

EGYPT

Y. M. Allen worked on European bee plants in the year 1935. M.B. Shawer while working on major pollen sources in Kafr in 1987. El- Sheikh, Egypt and the effect of pollen supply on broad area and honey yield found that the major pollen sources in Karf. El-Sheikh region of Egypt are broad bean (*Vicia faba* L.), wild mustard (*Brassica kaber* Koch.), yellow sweet clover (*Melilotus siculus*_Turra), Egyptian clover *Trifolium aloxandrinum* L.) and maize (*Zea mays* L.).

ENGLAND

Percival (1947) studied pollen loads gathered by bees. Harwood (1947) made significant studies on bee forage plants. Evacrane (1980) published a book entitled with "A book of Honey". She listed 232 imported plants of tropical and sub-tropical areas. Lateron Evacrane *et al.,* (1984) listed and published bee plants in "Director of important world honey sources". J. Louveanx investigated into the collection of pollen by bees in the years 1958, 1959.

Louveanx, Maurizio and Vorwohl established the methods of melissopalynology in the year 1978.

R. Melville studied on the sources of London Honey in the years 1944, 1945 and found *Ailanthus* as a source of a peculiar London honey.

Other pioneer workers were F.N. Howes 1945, (plants and beekeeping), D. Hodges, (The pollen loads of honey bee, 1952 and A calendar of bee plants 1958). She also provided in her book (Hodges, 1952) entitled "The pollen loads of the honey bees" natural colour illustrations of the pollen loads.

FRANCE

Soler *et al.,* 1995 made analysis on flavonoid patterns of French honeys with different floral origin.

GERMANY

Maurizio (1949) analyzed pollen in honey and pollen loads collected by bees in Switzerland and Germany.

Behn, Vonderohe and Henrich while working on the reliability of pollen analysis in honey in a1996 established that the legal confirmity of the declaration of type or origin of honey can be checked by its pollen distribution.

Kirchner, wolfgang *et al.,* worked on the cause of the tremble dance of the honey bee, *Apis mellifera* in the year 1994. The ultimate cause of tremble dance is according to seelay (1992), an imbalance between the nectar intake rate and the nectar processing capacity of the colony.

Gonazalea et al had made investigations on the flower choice by honey bees (*Apis mellifera* L.) and sex phase of flowers and preferences among nectar and pollen foragers in the year 1995.Von Derohe & Werner in 1994 made investigations on unifloral honey from the angle of chemical conversion and pollen reduction.

GHANA

K.Yeboan-Gyan and E.K. Marfo in 1998 while analysing the colour and mineral composition of honeys produced in major vegetation areas of Ghana by Atomic Absorption Spectrophotometry (AAS) detected the mineral elements like Calcium, Phosphorus, Magnesium, Potassium, Iron, Manganese and Copper in all samples. Sodium was not detected in the light honey samples. The concentration of all the elements was generally much higher in the dark samples than in the light ones.

HAWAII (USA)

Moniz, Lorna et al in 1989 while studying on quality and colour types of polen collected by honey bees in a hive in Panaewa, Hawaii (USA) found a total of 7 colour types eg. Leige, yellow, white, orange, green rust and purple.

HOLLAND

Snowdon and Cliver in 1996 investigated into the microorganisms in honey. Kerkvliet and Putter (1975) made pollen spectra of 41 Dutch honey samples. They reported the presence of the pollen of *Trifolium repens* in combination with *Brassica rapus, Tilia, Ligustrum* and *Prunus* in these honeys.

IRELAND

Coffey *et al* observed the seasonal variation in pollen and nectar sources of honey bees in Ireland in 1997.

ISRAEL

Lupo and Eisikowiteh while working on '*Eucalyptus erythrocarys*: A source of nectar and pollen for honey bees in Israel' in 1990 found that there was a high correlation between the foraging behavour of the honey bees and the stages of nectar secretion and pollen release.

ITALY

Albore and Reciardelli during their three year investigation, 1988 (1990) in high quality honey of chestnut (*castanea sativa)* and Locust

(*Robinia psendocacia*) in the province of varese (Lambardy) (Italy) showed typical pollen spectra of these honeys. Ferrazzi, Paola and their co-worker Bruno Botasso during their research on the foraging activity of *Apis mellifera* L. in the Malia valley (Italy) in 1989 and Bormida valley (Italy) in 1990 established that altogether 288 bee plants have been surveyed in the former case and 200 melliferous and polliniferous plant species in the latter.

Ferrazzi et al in 1990 carried out botanical and physico-chemical analyses on honey samples from Mavia \valley (western Alps, Italy). They found unifloral honeys of fruit trees (Prunus and Pyrus groups), sweet chestnut (*Castanea sativa*), Rhododendron along with multifloral and honeydew honeys. Ferrazi, Paola and Gerlero in 1995 have made melissopalynological characterization of the honeys from Val Pellice.

Serini, Bolchi and Graziella in 1986, 1987 during their qualitative observation on pollen forages of *Apis mellifera* L. in orchards found that the bees forage frequently anemophilous and entomophioous blossoms which are near the orchards and often neglect crops.Persano, Piazza, Sabatin and Accorti in 1995 characterised unifloral honeys.

JAPAN

Oka *et al.,* 1993 identified residual tetracyclines in honey by TLC/FABMS.

KOREA

Cho *et al.,* made investigation on purification and characterization of honey sucrose in the year 1994. Wen, Hwei, Jiang-Cluan and Su-Hwa in 1995 investigated into the quality survey of commercial honey products.

MEXICO

Chemas and Rico-gray in 1991 while studying on Apiculture and management of associated vegetation by the Maya of Tixea caltuyub, yucatan, Mexico found that apiary establishment depends on number of apiaries established at a minimum distance of 3 Km, water availability combination of old and young vegetation etc. They obtained finest and larger quantities of honey from *Gymnopodium floribundum* followed by *Viguiera dentata.* The worst honey is obtained from *Lysiloma latisiliquan.*

Cienfuegos, Edith et al investigated on carbon isotopic composition of Mexican honey in the year 1997. Villanueva and Rogel in 1994 made investigations on nectar sources of European and Africanazed honey bee (*Apis mellifera* L.) in the yucatan Peninsula, Mexico.

NEW ZEALAND

Moar (1985) studied 119 honey samples from various regions of New Zealand. He observed that white colour furnished the important nectar source for the bees in New Zealand.

Pearson and Braiden in 1990 while working on seasonal pollen collection by honey bees from grass/shrub highlands in Canterbury, New Zealand found that indigenous anemophilous sources supplied over 80% of the pollen during the first two months in spring where as the entomophilous species were virtually the sole source over the 5 months.

Butz Hweyn and Vivian in 1995 made their research works on use of native New Zealand plants by honey bees (*Apis mellifera* L.). Harries and Flimmer (1948) published a brief report on the pollen in honey and bee loads.

NIGERIA

Sowunmi (1976) made pollen analysis of the honeys of Southern Nogeria and mentioned the significance of pollen spectra on reflecting the botanical and geographical origins of honeys.

Agwn and Akanbi worked on ' A Palynologival study of honey froj four vegetation zones of Nigeria pollen spores' in the year 1985.

Schulz, Erhard and Lueke in 1994 made a two year pollen calendar for traditionally produced honey types from Gaya (Southern Nigeria).

PAKISTAN

Muzaffar *et a.,* in 1991 while working on integrated management of the oriental honeybee *Apis cerana* F. in Pakistan established that integration of the management practices like maintenence of high bee population, queen production, disease control, supplimental feeding during dearth period, prevention of swarming of maximum honey production, management of temperature and shortage of bee flora proved very useful for increasing honey yield.

PHILIPPINES

Lande *et al.,* 1991 while studying on the physio-chemical properties of some Phillipine honeys taking 55 honeys collected from local apiaries and commercial outlets found that the standard of quality of Phillipine honeys is not high. By comparing the parameters like moisture, ash, glucose, free acidity and HMF with the limits proposed by the codex Alimentarius commission, conformity to single parameters were as followes: moisture content 41, ash content 53, sucrose content 35, free acidity 26 and HMF content 31. Only 6 out of 55 samples conformed to all 5 parameters.

POLAND

Bulinski Ronald *et al* in 1995 studied on some trace element content in Polish made food products. The presence of heavy metals like lead, cadmium, chromium, zinc, manganese, copper, nickel and iron content in some bee honey grades was also investigated by them.

RUSSIA

E. D. Bozina worked on the bees and their forage plants in the year 1971. O. A. Zaurolov in 1981 worked on the floral specimen in homey bees. Petkova and Olga during their investigation in 1983-87 on pollen collected from the honey bees in two regions of Smolijian district determined the seasonal tendencies in the carrying of pollen from the colonies and the factors that influence thin carrying.

Stanimirovic, Markovic *et al.,* have made investigations on selection of honey bees (*Apis mellifera* L.) in 1997. O. A. Zaurolov in the year 1981 studied the floral speciation in honey bee.

SARDINIA/CORSINIA

Alamanni and Cossu in their recent studies in 1997 on residues of cabamic acid in honey samples from Sardinia through HPLC of the residues of 4 pesticides belonging to the class of esters of carbamic acid; carbofuran, carbamyl, ethiofencarls, mercaptodimethur detected no trace of the pesticides in question. Alamanni in 1995 also made his research for the presence of isoglucose in Sardinian honey sample. Prota *et al* 1997 made comparison the chemical and physical characteristics between the Sardinian and Corsinian honeys.

SERBIA

Danjon and Blazncic in 1988 while studying on the floristic characteristics of bee from the aspect of a search for new source of melliferous flora investigated eight meadow and grassland communities producing records of 158 melliferous plants. The most common were the plants from the families Fabaceae (42), Lamiaceae (23) and compositae (18) Vitorovic, Gordana *et al.,* 1996 made investigations on concentration of radio-nuclides in different types of bee pastures and in honey in Serbia.

SPAIN

Serra Bonhevi *et al.,* (1988) while studying the composition, physicochemical properties and pollen spectrum of some monofloral honeys of Spain like 22 citrus honey, 17 of rosemary, 28 of lavenda (*Lavendula latifolia*) and 16 of forest (*Quercus* sp) found that the pollen content is variable depending on the residual contamination by previous bloomings giving HDE/P average index of 0.060 variable between 0.013-0.130. Forest honey is characterized by the furanose content as well as hgh raffinose and melazitose.

Hidalgo *et al* studied in 1991 on the floral sources of pollen loads collected by *Apis mellifera* L. in Alora (Malaga, Spain). The microscopical analysis of the pollen loads collected by *Apis mellifera* during the pollen harvesting has shown 22 pollen types of the families mainly cistaceae, Fabaceae and Rutaceae.

Rodriguez-otero *et al.,* in 1995 while analysing Silicon, phosphorous, sulphur, chlorine and ash contents of spanish commercial honeys found that the values for phosphorus and chlorine were high with respect to honeys from other regions.

Sancho *et al.,* 1991 (1992) during their provincial classification of Basque country (Northern Spain) honey by their chemical composition found that five most discriminatory variables were total acidity, for mol acidity, index, sucrose, fructose/glucose and glucose water/fructose.

P. L. Ortiz in 1990 while studying on the contribution to the knowledge of the flora of apicultural interest in the province of Cadiz showed that the nectar from flowers is the main honey source in the region through locally honey dew is more important. Salinas *et al.,* in 1994 determined the mineral elements in honey from different floral origines by flow injection analysis coupled to atomic spectroscopy. Detection limits (in μg/g) were Ca 1.6; Mg 4.8; Mn 0.8; K 27.0; Na 3.6; and Zn 0.4. Precision values (in percentage) were Ca 4.3; Mg 7.4; Mn 7.2; K 1.4; Na 2.7; and Zn 9.8 and recovery percentage values were Ca 92±3; Mg 125±7; Mn 98±9; K 65±3; Na 101±4 and Zn 99±41. Rodriguez-otero *et al.,* in 1995 investigated into Silicon phosphorous, sulphur, chlorine, and ash contents of Spanish commercial honeys. Salinas *et al* also studied physio-chemical parameters of honey from extremadura by Rosch model in the same year 1994. Saa *et al.,* in 1993 studied the statistics of the representativity of pollen content of honey samples of Orause (Spain).

Iglesias *et al.,* in 1993 had made palynological study of mountain honey on the orense province (North-Western, Spain). Valencia in 1994 studied the pollen spectra of honey from different phytogeographical regions of Leon Province of North-West Spain. Perez *et al.,* in 1995 made physico-chemical attributes and pollen spectrum of some unifloral Spanish honeys.

Mateo *et al.,* in 1998 in their work classified Spanish unifloral honeys by discriminant analysis of electrical conductivity, colour, water content, sugar and pH Seifo, Jato, Aira and Iglesias in 1997 have made investigation on unifloral honeys of Galicia (North-Western, Spain).

Lozana *et al.,* in 1994 determined mineral elements in honey from different floral origines by flow injection analysis coupled to atomic spectroscopy.

SWEDEN

Schwan and Martinovs worked on the studies of pollen collection by honey bees in Sweden in the year 1954.

TANGANYIKA

F. G. Smith in 1956 made sufficient studies on Bee keeping observations in Tanganyika. He recognised the botanical and geographical origins of honeys from Tanganyika. Gadbin (1980) worked out sigficant studies of bee forage plants of Africa.

TAIWAN

Lin *et al.,* in 1994 during their study on bee collected pollen loads in Nanton, Taiwan identified 106 pollen taxa belonging to 56 angiospermic families, one lycopodium spore and one fungal spore.

UNITED STATES OF AMERICA

Significant studies of bee forage plants in the USA have been made by F. C. Pellet in 1947. Jones *et al* had made their investigation on Melissopalynology in the United States in the year 1992.

Pena crecente and Herrero Latorre in 1993 made pattern recognition analysis applied to classification of honeys from two geographic origins.

Lieux (1975) analysed 54 commercial honey samples from the major bee keeping areas of Lovisiana during 1967-68 and reported *Trifolium repens,* white clover, *Rubus* sp., black berry or dew berry, *Verchemia seandens, Rattan vine, salix* sp., willow, Asteraceae, *Sapium sebiferum* pollen grains.

Although the United States of America ranks third in the world in honey production but for the lack of pollen and chemical statistical data much of its honey can not be verified for consumer consumption or effectively exported.

Severson and Perry (1981) reported *Quercus* sp. and *Zea mays* as the major sources of pollen which are wind pollinated species for the bees studied in Wincosin, USA.

VENEZUELA

Pesante *et al.,* in 1987 during their analysis on differentiated pollen collection by Africanized and European honeybees in Venezuela found that Africanalized honeybees have larger proportion of the foraging force thus, collecting significantly larger quantities of pollen which provide the protein necessary to support increased brood production.

Vit Patricia *et al.,* in 1998 during their studies on flavonoids in Meliponinae honeys from Venazuela related to their botanical, geographical and entomological origin to assess their putative anticataract activity found that the honeys produced in Savannas were richer in flavonoids compared with honeys from the forests. It is proposed that analysis of stingless bee honey eyedrops in terms of their flavonoid content can be used as a basis of authenticating and controlling for their geographical origin.

Vit *et al.,* in 1994 made investigation on the composition of Venezuelan honeys from stingless bees. In the same year Vit *et al* made investigation on Melissopalynology for stingless bees (Apidae: Meliponinae) from Venenzuela.

YUGOSLAVIA

Danon *et al.,* in 1990 in their investigation on Melliferous flora of the meadows and pastwees of Suva Planina (Yugoslavia) found that on the basis of the coenotic coefficient of nectar production plant communities were classified with regard to their significance for bee pasture.

H. A. L. Wahdan in 1998 during the investigations into the causes of the antimicrobial activity of honey had found that in addition to hydrogen peroxide acting as inhibines are the flavonoids and the phenolic acids (caffeic acid and ferulic acid).

1.4.2 IN INDIA

Some of the major works done in different parts of India in bee keeping and melittopolynilogy may be mentioned as follows:-

In South India, Bee Keeping was thoroughly observed by Ramachandran in the year 1936. He also studied South Indian flora.

Deodikar and Thakar in 1955 made a pollen study of major honey yielding plants of Mahabaleswar hills (Western Ghats). They also investigated into morphological characterization of pollen grains of some major bee plants of the same area in the year 1958 along with S. R. Salvi. A floral calender of major and minor honey yielding plants of the area was made by Thakar, Diwan and Salvi in 1962. P. D. Chaubal made palynological studies of some bee forage plants from Sagarmal (Maharastra) in 1982. Chaubal and Deodikar in 1965 made investigations on morphological characterization of pollen grains of some major honey yielding plants of Western Ghats. Kamat, Pandya, and Narayana made investigations on specific floral honeys of Mahabaleshwar in 1956. R. P. Phadke in 1957 observed the higher nectar concentration in floral nectaries of Silver Oak. He studied the physio-chemical composition of major unifloral hoheys from Mahabaleshwar (Western Ghats) in 1962, 1967. In his research findings it was established that Karvi and Pisa honeys contain high non-reducing sugar content, high percentage of minerals, proteins and undermind factor which are responsible for the high nutritive value of the above two honeys.

Surya Narayan, Seethalakshmi and Phadke in 1981 made pollen analysis of India honeys. Moses, Singh, Joshi and Narayana in 1987 studied the evaluation of sources of pollen to honey bees at Vijayarai (Andhra Pradesh). T. S. Seethalakshmi in 1980 made melittopalynological investigations on some India honeys. Before that he in the year 1978 during the analysis of pollen load along with his co-investigator Rao reported that

A. cerana indica F. bees visit a local variety 'Sorti' of paddy (*Oryza sativa*) for pollen.

P. Jhansi who submitted Ph. D. thesis on analysis of honey from Andhra Pradesh in 1987 had also made investigations on pollen analysis of extracted and squeezed honey of Hyderabad (Andhra pradesh) along with investigations on pollen analysis of some honey samples from Andhra Pradesh in the year 1990. It was revealed that *Borassus flabellifer* is the predominant pollen type of Vetapalan (Guntur) honey and *Leea* is the predominant pollen type of Peddavalase (Vishakhapatanam) sample while samples from Nalgonda contain Graminaceous pollen as predominant type.

In 1989 Fatima *et al.*, made pollen analysis of two multifloral honeys from Hyderabad.

In Tamilnadu Agashe and Mary Scinthia (1995) collected 69 *A. cerana* F. pollen loads from three centres (Belalam, Hosahalli and Marapalli) of thaly block, Dharmapuri district during August 1989 to April 1990. In their study *Cocos nucifera* formed the predominant pollen source for *A. cerana.* The major pollen source comprised of Asteraceae, *Brassica nigra, Mallotus phippensis, Ricinus communis, Mimosa pudica,*etc. They reported *Mallotus philippensis, Parthenium hysterophorus* and *Artocarpus heterophilus* for the first time as a pollen source to honey bees.

In Maharstra Soman, Lakshmi andf Mahindre (1995) studied many rock bee colonies in Barshi area (Sholapur district), Latur and Osmanabad district from August to March and reported the presence of Typha pollen based on the microscopic analysis of pollen storage regions.

T. P. Kalpana and C. G. K. Ramanujam made a melittopalynological investigation of Nawabpet mandal of Ranga Reddy district of Andhra Pradesh in 1989 and same on honeys from *Apis florea* and *Apis dorsata* in 1991.

Researches on pollen analysis of *Apis cerana* F. and *Apis florea* F. honeys from Adikmet area, Hyderabad by Kalpana,Khatijia and Ramanujan in 1990 revealed that *Mangifera indica* (68.70%) formed the predominant pollen type in *A. cerana indica* F. sample while *Tridax procumbens* (62.00%) and *Phoenix sylvestris* (61.00%) constituted the predominant pollen types in *Apis florea* F. and *Apis florea* F. samples respectively.

The same authors made researches on melittopalynology and recognition of major nectar and pollen sources of honey bees in some districts of Andra Pradesh in 1992 taking 164 honey samples and 5046 pollen loads from Ranga Reddy, Mahboobnagar and Guntur districts. *Carum copticum, Prosopis juliflora, Phoenix sylvestris, Ageratum conyzoides, Tamarindus indica, Mimosa pudica, Sapindus emarginatus, Borassus flabellifer, Hygrophila auriculata* are some of the major bee forage plants in different seasons in the said districts.

Carum copticum was found as a major source of winter honey in Ranga Reddy district of Andra Pradesh in their further research publication in 1994. *Sesamum indicum* L. an important source of nectar and pollen for Rock bees (*Apis dorsata* F.) in Ranga Reddy district of Andra Pradesh was found by C. G. K. Ramanujam in 1994 through his investigation. In 1996, he made a thorough study on botanical origin of apiary honeys from Hayatnagar Mandal, Ranga Reddy district, Andra pradesh taking 25 apiary honeys from Sahebnagar (Hayatnagar mandal). He found 19 of these samples as unifloral and 6 as multifloral. The unifloral honeys were represented by *Prosopis juliflora, Psidium guajava, Hyptis suaveolens,* etc.

Pollen analysis of Rock bee summer honeys from the Prakasan district of Andhra Pradesh was made by Jhansi, kalpana and Ramanujam in 1990 and 1991.

Microscopic analysis of honeys from a coastal district of Andhra Pradesh was made by C. G. K. Ramanujan and T. P. kalpana in 1995 and the same from Kondavaram apiaries of East Godavari district in 1993. Further, researches were made by authors in 1996 on sugarcane honey and its significance.

IN OTHER PARTS OF INDIA

P. K. K. Nair in 1964 made pollen analytical studies of Indian honeys. He and his co-worker M. Sharma made pollen analysis of some honeys honeys from Utter Pradesh in 1965. Before this, Sen and Banerjee made a pollen analysis of India honeys in the year 1956. In 1951 Viswanathan had made a brief report on the possibilities of developing bee keeping in and around Mount Abu. Vishnu in 1958 studied the pollen content of some Indian honeys. Some light has been focused on history, present status and future of bee keeping in India by Shende *et al.,* in 1995. Jana *et al.,* in 1984 recorded some data on pollination and melissopalinology. A study on bee flora of Kashmir was made by Saraf in 1972.

A comparative analysis of the pollen content of Indian honeys with reference to Chanda and Ganguly in 1981.

Investigations on bee flora of Karnataka and Kerala was made by S. K. Kallapur in 1959 while that in North India was made by N. Kohli in 1958. Mutto (1041, 1953) examined bee plants of Jeolikote situated in Nainital district of Uttar Pradesh.

An analysis of honey bee pollen loads from Banthra, Lucknow was made by M. Chaturvedi in 1973. He made pollen analysis of autumn honeys of Kumaon region in 1983 and of Spring honeys from the Western Himalayan region of Utter Pradesh in 1989. In Garhwal Himalayas, the Melittological studies were made by Gaur in 1979 and 1984.

An analysis of pollen loads of honey bees from Kangra was made by M. Sharma in 1970. S. C. Jay in 1974 investigated into the nectar and pollen collection by honeybees from coconut flowers.

Investigations on nectar and pollen plants of the Punjab and some authentic honey yields from *Apis cerana indica* F. bee colonies in the Punjab were made by A. Rahaman Khan in 1941, 1944.

A study on scope of migratory bee keeping in North Western India was made by P. L. Sharma in 1958. Investigations on important plant species for apiculture in Jammu region were made by D. P. Abrol and B. L. Abrol in 1995. D. P. Abrol in 1985 submitted his Ph. D. thesis (Harayana Agricultural University, Hisar) on "Analysis of biophysical interactions in causing foraging behaviour of some bees - a study in bioenergetics".

Chaudhari (1979) published a floral calender of Pathankot and adjacent villages. He listed 84 plants which supplies nectar and /or pollen for the bees.

A study on nectar sugar production and flower visitors of *Rubus ellipticus* (Rosaceae) at Solan was made by J. K. Gupta and R. K. Thakur in 1987. A study on nectar secretion, amount and type of nectar sugars and insect foraging in *Woodfordia floribunda* Salisb was made by Mishra, Gupta and Jitendra Kumar in 1987. An investigation on foraging behaviour of *Apis cerana indica* F. and *A. mellifera* L. in pollinating apple flowers was made by L. R. Verma and P. C. Dutta in 1986.

A study on Sundarbans honey and the mangrove swamps was made K. Chakraborty in 1987. M. Mondal and K. Mitra in 1980 made pollen analysis of Sunderbans honeys. Recently in 1997, A. Malakar studied on "Comparative pollen and chemical analysis of West Bengal Honey" in 1998 and awarded Ph. D. degree.

A melissopalynological study of honey samples of Kailasahar and Agartala, Tripura was made in 1983 by P. Ganguly and A. Pal. Chanda and Ganguly in 4th International Palynological Conferance held in Lucknow in 1976-1977 have shown that honey is also contaminated by anemophilons pollen which may be due to larger production of pollen and deliberate collection by the visiting bees.

An analysis of the pollen load from a honey sample from Salt Lake City, Calcutta was made by Ganguly, Gupta, Bhattacharya and Chanda in 1983. In their work, two pollen types of allergic significance were identified *viz., Azadirachta indica* (18.30%) and *lantana camara* (3.30%).

A comparative pollen spectra of honey samples from West Dinajpur and Jalpaiguri districts of West Bengal was made by the same authors in 1984. The represented types mostly originated from entomophilous plants except *Croton bonplandianum* and *Casurina equisetifolia.* These two amphiphilous types were recorded from Jalpaiguri sample only.

A study on bee pollination and Melissopalynology was made by J. Majumdar and S. Chanda in 1984. In their work, it has been studied that bees have often been observed to collect fungal spores of *Cystospora oleae,* a rust infecting the leaves of *Olea dioica* during the floral gap periods around February in the Western Ghat forests. The various "nectar yeasts" so far observed by the authors in nectars, honey combs or in gastric tracts of the bees include species of Anthomyces, Saccharomyces, Zygosaccharomyces, Mycotorula, Torula and Torulopsis.

A pollen and chemical analysis of three selected honey samples from the areas Midnapore, Madhyamgram and Sunderbans of West Bengal was made by Malakar, Chattopadhyay, Ghosh and Chanda in 1995. The protein and lipid analysis of three honey samples showed that Sundarban sample was different from the others. According to the authors, if the difference is due to pollen or other factors that needs further investigation. Recently in 1998, it has been found through the research findings made by Arti Garg that *Ageratum conyzoides* L. an important bee forage plant in kumaon Region, Utter Pradesh. Melittopalynological study on apiary honeys from Pauri Garhwal, U. P. was made by Gaur and Nanwani (1989). Thay listed pollen types of 30 taxa of which *Coriandrum sativum,* Asteraceae group, *Rhus palviflora, Sesamum indicum, Amaranthus* sp., *Brassica* sp., *Impatients* sp., Lamiaceae, Myrtaceae group and *Prunus* sp. were predominent pollen types in the honey samples.

In Bihar the floral biology and utility of the mango tree to honey bees was studied by Mohana Rao and evident from their observation that bees foraged more for nectar than pollen on this plant. In Punjab and Bihar, *Parthenium hysterophorus* provides chief pollen source for *Apis mellifera* which was reported by Suryanarayana and Singh (1989).

Studies on honey bee pollination and their utility in crop production was made by different investigators on various crop yielding plants at different times. Some examples may be cited as follows:

Onion (Jhdhav and Ajri, 1981; Kumar *et al.,* 1989; Mohana Rao and Suryanarayana, 1989), litchi (Mohana Rao *et al.,* 1984), safflower (Deshmukh *et al.,* 1985), watermelon (Mohana Rao and Suryanarayana, 1988) and cotton (Bhale and Bhat, 1989).

In all the above cases, the honey bees (*A. cerana indica* F. in particular) were most efficient pollinating agents which results consistently in enhanced crop production.

1.5 INDIA'S POSITION AND SCOPE FOR ADVANCEMENT OF APICULTURE

Very recently in the year 1981, the Indian Council of Agricultural Research sanctioned an All India Co-ordinated Project on Bee Research and Training for implementation from sixth plan period with the headquater at CBRI, Pune and eleven centres at various universities and research institutions including Indian Agricultural Research Institute, Division of Entomology, New Delhi.

At present, bee keeping is an unconventional rural industry in our country. There are today over ten lakh bee colonies of *Apis cerana* F., spread over thirty six thousand tons of honey with an average of 7 kg per colony and fifteen tons of wax. Besides these an equal or more quantity of honey are produced from *Apis dorsata* F. bees from forest and other areas and a substancial amount of honey from exotic honeybees at Punjab and Himachal Pradesh.

FUTURE OF *APIS MELLIFERA* L. IN INDIA

The Italian honey bee, *Apis mellifera* L. being best strain has been introduced in many parts of the world. It has achieved considerable success in USA and Canada with an average of 50-100 kg of honey per colony. In Northern China, Corea, and Jsapan it has almost replaced *Apis cerana* F. But in Philippines varraoa mites unsettled their establishment.

Since 1880, considerable intrerest has been taken in the importation of Italian bees in to India but withoutany success as they not survive for long. Some important efforts made in 1938, 1945 and 1952 to establish *Apis mellifera* L. in Punjab and Jammu and Kashmir also failed. Renewed efforts were again made in 1962 at Punjab Agricultural University, Ludhiana where mated Italian queen bee of *Apis mellifera* L. were imported and introduced in dequeened *Apis cerana* F. colonies. After a decade of endevour *Apis mellifera* L. has fully established itself and has spread all over the state and at Nagrota (Himachal Pradesh) under Indian Council of Agricultural Research sanctioned Operational Research Project on *Apis mellifera* L. in 1976.

The difficulties faced in their establishment were failure of mating of virgin queen bee and attack of actoparacitic mite *Tropilaclaps clereae.* However, these problems were solved and average yield recently reported is 10-15 kg per hives in this region. The egg laying rate of green bee during most active period lasting for three weeks ranged from 871 to 1368 eggs per day (Adlakhs, 1972).

In our country as regards bee forage and fauna there is no dearth of any kind of varied vegetation and climates from temperate to tropical types are available. Consquently, different echo-types of strains of indigenous *Apis cerana* F. are present in different regions of the country. The bee breed found in Kashmir and hilly tracts of Himalayaas are very near to *Apis mellifera* L. in respect of honey yield and colony strength. Hence, they are also being kept in langstroth hives (biggest in size) as that of *Apis mellifera* L.

The native varoa mites are the peaceful parasite of *Apis cerana* F. but are very deadly on *Apis mellifera,* causing serious "varoasis" disease (Kshirsagar, 1968). Varoasis is probably on of the reasons for destabilising *Apis mellifera* in some Asiatic regions (Morse, 1969). Acarine disease cused by *Acarapis woodie,* a native of Europe is very serious on both *A. mellifera* L. and *A. cerana* F. It was first reported in India in 1957 and is probably an imported disease.

The resistance of both imported and indegenous bees in India seems to be very difficult because of non-mating problems of virgin queens of imported honey bee in presence of native bees. The other hurdle in most regions is the limitation of forage which may initiate struggle for existance not only among them but with those of other native honey bees, *e.g., Apis dorsata* F. and *A. flora* F. and non-*Apis* stingless bees as a result of which their population may be reduced due to competition for food.

The problem of non-mating *Apis mellifera* L. virgin queen in Punjab was probably due to non-accessibility of their drones to them. In nature, there is no dearth of drones of indigenous *Apis cerana* F. and as the sex-pheromones that attracts drones being the same for these two species (Evaerane, 1982) during the mating season, *Apis mellifera* L. drones must have been left behind and could not reach the queen by the outnumbered *Apis cerana* L. drones which surrounded the queen but could not mate because of their smaller size.

It may thus be infered that the success of *Apis mellifera* L. in any area is possible only at the cost of native *Apis cerana* F. which may be completely wiped out from the region. The non-prefderance of indegenous bees by bee keepers and farmers in lure of higher honey yield from important bees will hasten this process of extinction. Moreover it would also, not be very easy to establish important bee in the region of native bees, because of mating failures for the success of which elimination or reduction of indigenous bees is essential in that region. A beginner of bee keeping of *Apis mellifera* L. will thus, have to bring fresh colonies every year which is economically feasible. Bee keeping is Asia with European bees has been unsuccessful largely because of two mites, *Tropilaelaps clareae* and *Voroa dacobsour* (Morse, 1975).

The idea of crossing Apis mellifera with A. cerana is also not feasible as disclosed ny Ruttner and Maul, 1969 at XXII International Bee-keeping Congress at Munich, who reported genetically sustained impossibility of cross-breeding between them.

In view of the above mentioned facts, it is evident that a very cautious step is needed in propagation of A. mellifera L. in India, only in those parts where it is feasible and may prove a success without any adverse effect on local population of native honey bees. In addition it would be most appropriate to gear up sincere efforts for improvement of native bee Apis cerana F. through selection or hybridization of better strain or biotypes found in the country itself.

The Indian bees have great potentialities for higher yields as they are the outcome of natural selection and hence are well adapted to the region and tolerant to pests and diseases and require only proper management according to time and locality to prove their capability (Naim, 1988).

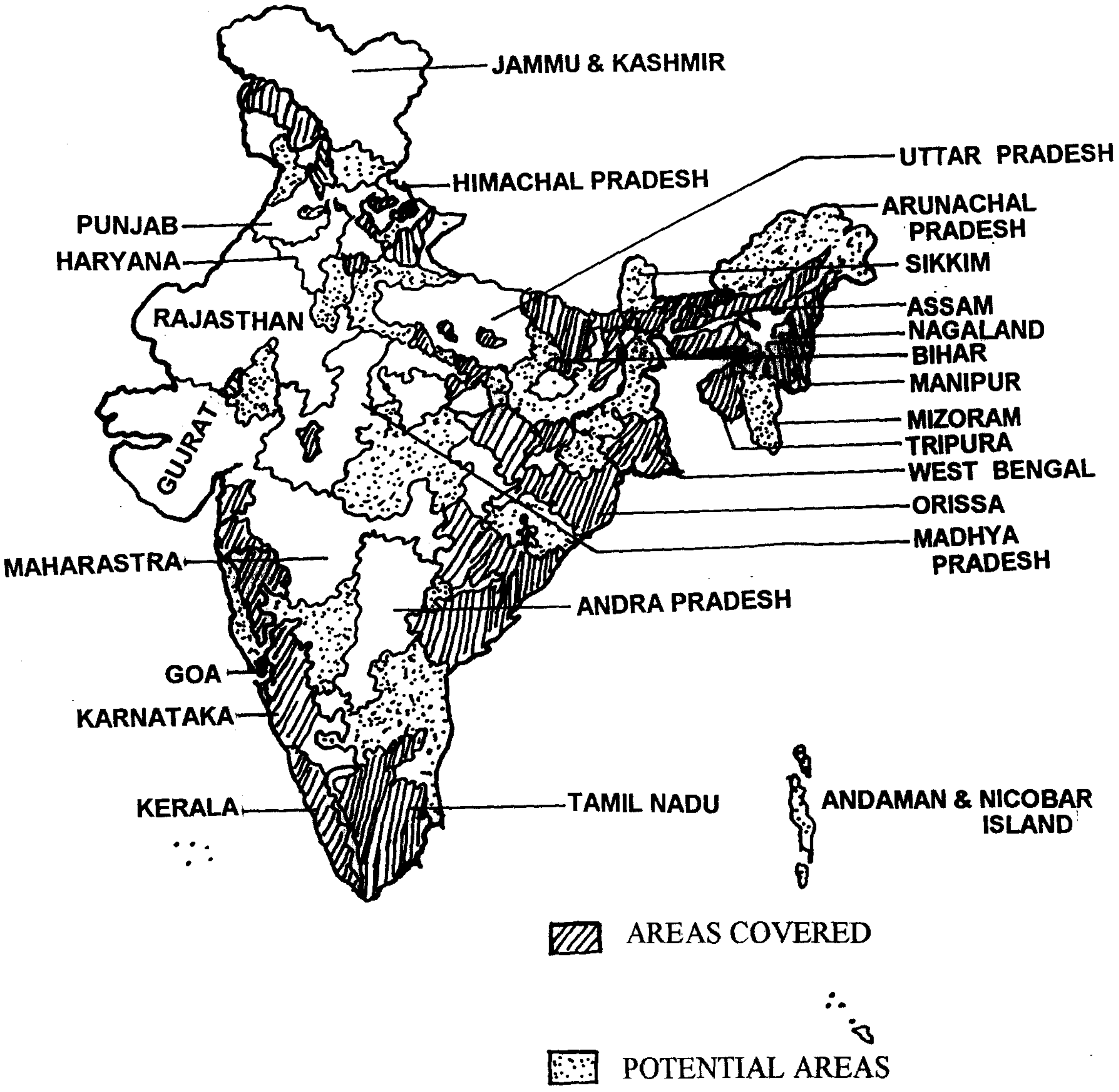
CO-ORDINATED EFFORTS IN THE DEVELOPMENT OF BEEKEEPING INDUSTRY IN INDIA

In Maharashtra regular bee farms have been established at several places. The government has invested about Rs 272.22 lakhs for the development of this industry between 1953 to 1972. The national output 1972-73 wasw 23.68 lakhs Kg. Valued at about Rs 142 lakhs and it increased slightly to about 24.4 lakhs Kg. Valued at 170.8 lakhs in 1973-74. Among the honey producing states statistical data shows that Tamil Nadu is at the top followed by Kerala and Karnataka respectively. A rough estimate places the total output of honey in India presently at about 5 million Kg per annum. (Ahsan Haid & Sinha Subhas Prasad, 1991).

Bee Research centres have beeen established at several places in India. Karnataka University near Hebbar is conducting a course in api-culture. The Punjab Agricultural University has the facility of granting PRD to research scholars in api-culture. Besides this, a vigorous drive is required to popularise this cottage industry, particularly in persuation of reluctant villagers into trainees willing and ultimately into bee farmers.

In India although bee-keeping is being done throughout the country, the significant belt for this purpose in the coastal belt of the peninsula, the western ghat, the eastern ghat, and the eastern plains. Tamil Nadu, Kerala, Karnataka, Andhra Pradesh and Maharashtra are the most fertile land for this purpose. Other areas areas are Madhya Pradesh, Assam, West Bengal, Orissa, Kashmir, Himachal Pradesh and the Punjab. (Fig.1.5.1)

In the last few years Government of India has shown a very keen interest in this eco-friendly activity and launched a number of newschemes



[**Fig. 1.5.1. Bee-keeping industry and localities having good potential for bee-keeping shown in the map of India.** (After Thakur, 1976)] to promote the development of beekeeping and honey production in the country.

All India Co-ordinated Projects on Honey bee Research and Training are aimed to identgy the potential of beekeeping in different agroclimatic zones of the coountry, confronting problems and their possible remedies . Necessary funding allocations are being made in different five year plans for the development of this sector by increased production of colonies, development of infrastructure and promotion of research activities. To boost agricultural production, bees have been identified as a key input in improving crop productivity. Despite the above mentioned efforts, the congenial climates and floristic conditions the growth of bee keeping in India is not encouraging and the number of bee hive colonies and also the honey production remains miserably low. Even at present the number of bee colonies in India is about one million (Abrol, 1997).

Most serious problem for Indian bee keeping has been the decreasing honey plants during the past few decades but during the recent years national and state governments, environmental protection agencies, social forestry, local and social organisations have helped to expand the planted areas for bee forages, prevented deforestation and thus, stopped the reduction in bee flora. It is estimated that most of floral resources in India still remain under utilised. The spread of diseases is yet another most crucial factor that at times have played havoc with bee keeping in India resulting annihilation of entire bee stocks. Therefore, besides proper management of bee diseases, plantation of bee flora and the strategies for bee keeping development need to reoriented and channellised to achieve fast progress. Bee keeping with Indian honey bee was virtually unknown in the state of Punjab and Haryana. Bee keeping with *A. mellifera* was taken up in Punjab in 1977. The industry grew up very fast and today Punjab is one of the leading states in honey production. In 1995 there were 12,500 bee keepers, 1,25,000 bee colonies giving a great boost in states like

Himachal Pradesh, Jammu and Kashmir and Harayana where *A. mellifera* L. is now used in commercial bee keeping.

The development of bee keeping industry under Khadi and Village Industries Commission was also studied by Shender and Phadke in 1995 (Table 1.5.1). The number of colonies reached highest highest in the year 1990-91 with maximum quality of honey production as shown in the table.

In recent years (1991-94) due to spread of Thai sac brood disease in indegenous honey bee *A. cerana indica* F. , *A. mellifera* L. has been introduced in almost all the states of the country.

Table: 1.5.1. **Development of bee keeping industry in India under Khadi and Village Industries Commission (Shender and Phadke, 1995)**

Year	Number of bee keepers	Nomber of bee colonies	Honey production (tons)	Value of honey (lakh Rs.)	Average production/ Colony (kg)
1953-54	232	800	128	0.02	1.50
1963-64	57,198	164,597	713	37.63	4.33
1973-74	150,421	522,714	2,435	365.26	4.65
1984-85	200,000	868,000	5,500	950.00	6.33
1990-91	246,000	1,061,000	9,288	2,322.00	8.75
1993-94*	236,000	6,78,000	5,529	1,382.00	8.15

* About 3,00,000 bee colonies were lost due to "Thai Sac Brood Diasease"

1.6 THE STUDY AREA

The study area comprises of the state of Sikkim and Sub-Himalayan, West Bengal, one of the floristically richest areas in Indian Sub-continent. From apicultural point of view this zone has been recognised as one of the potential zones as has been shown in the map of India (Thakur, 1976) (Fig. 1.5.1). The courses of different rivers, streams, location of some important places, places of collection of honey samples with their respective code numbers and honey codes of the study area have been shown in figure 1.6.1A and 1.6.1B (I & II). The characteristic features of the study area with geographic location, brief history, topography, climate, forests, etc. are discussed under separate headings as follows:

A. SIKKIM

Sikkim is the second smallest state of the Republic of India, located in the North of the North-Eastern part of India located at 88° 30' to 89° 30' E longitude and 31° 30' to 27.5° 30' N latitude. The state covers an area of 7096 sq km with a population of around 4,06,457 (Shresta, 1991) (Table 1.6.1). It is separated from Bhutan in the East by Dezonkya range, from Nepal in the West by Singalila Range and from Tibet in the North by Central Himalayan Range, of which it is a part. It is dependent on India only from the South and hence it is the only access for the state from the rest of the India.

In 1975, Sikkim became the state of India, before which it was a kingdom ruled by a king, the Late "Chogyal". There are four districts in the state *viz.*, North (Mangan), South (Namchi), East (Gangtok) and West (Gyalsing). Gangtok is the prime and the capital city of Sikkim with a population of about 80,000 in the urbanised area.

Because of the geographical location, Sikkim has an interesting blend of different ethnic groups and cultures. There are three main ethnic groups living in Sikkim *viz.*, Lepcha, Bhutia and the tribes of Nepali origin.

THE MAP OF DARJEELING AND SIKKIM SHOWING COURSES OF DIFFERENT RIVERS AND STREAMS AND THE LOCATION OF SOME IMPORTANT PLACES

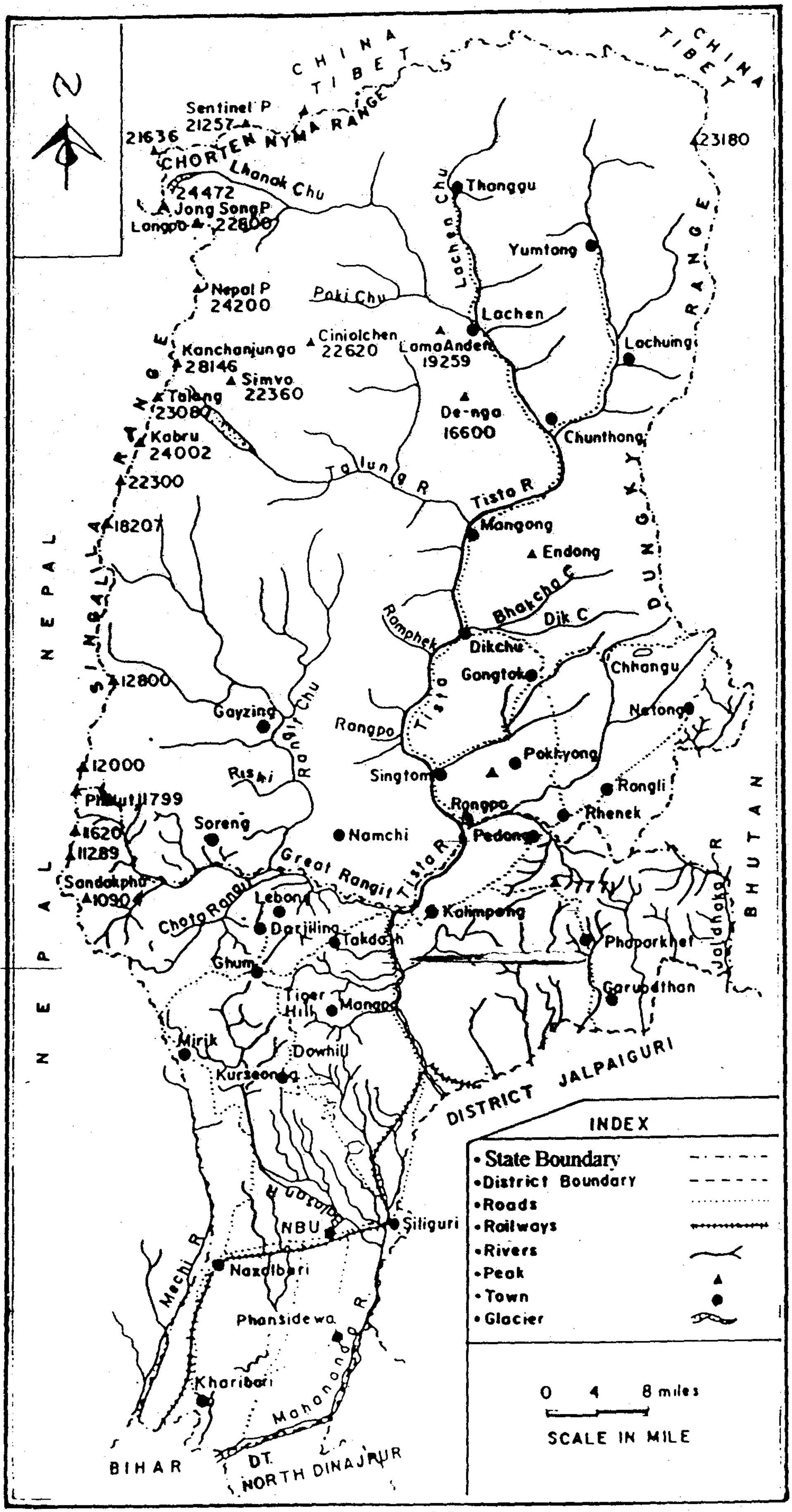
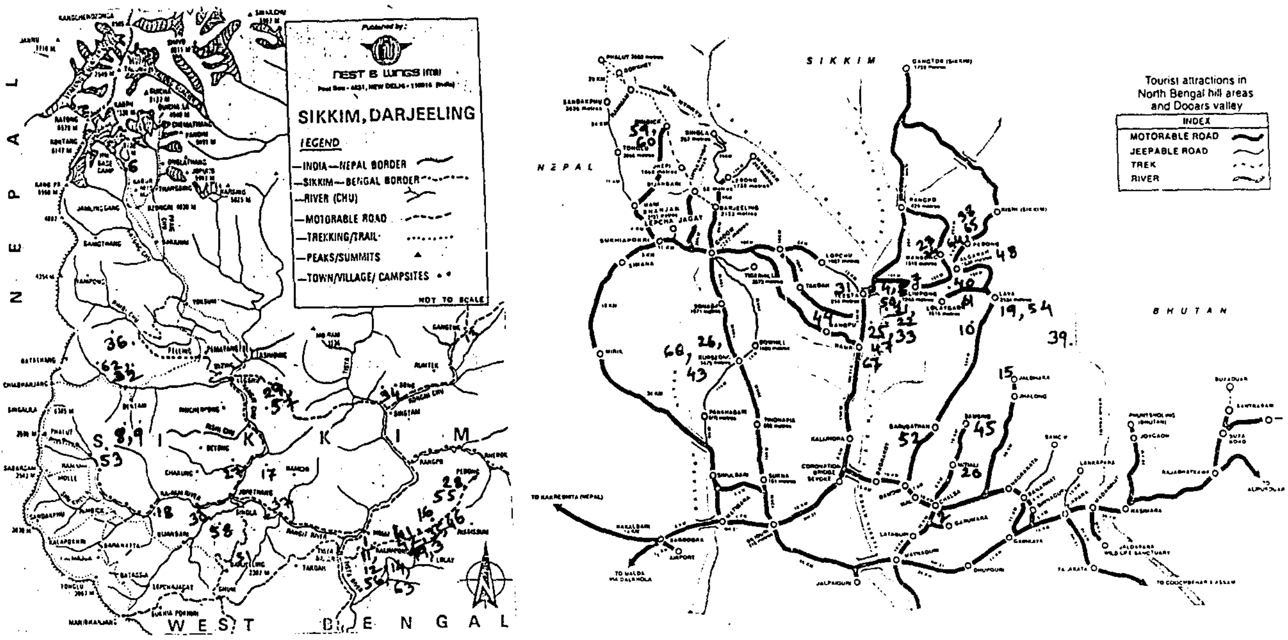


Fig. 1.6.1 A

Map of the study area showing different places (with altitudes in metres) of collection of honey samples with their corresponding Code Numbers and Honey Codes.



(I)

(II)

Algarah,Kalimpong Sub-Div.,(1308 m) –48(AH),
Bhakukhop Busty, Kalimpong, (1180m)-1 (BBH),
Chalsa, Jalpaiguri, (200 m) - 2(CH),
Chibo Busty,Kalimpong (1090 m) - 49,3 (CHIB-1,2)
Damthang, South Sikkim (1500 m)- 8,9 (DAMH-1,2)
Dr. Graham's Homes Area,Kpg (1220 m)4,5,50(DGHH-1,2,3)
Deolo Hills,Kalimpong (1250 m)-7 (DH)
Dudhia Tea Estate,Kurseong(1405 m)- 26(DUDH)
Duka , Kalimpong Sub-Div. (2000 m)- 10 (DUKH)
Dungra Busty,Kalimpong (1152 m) - 41(DUNGH)
Dzongu, North Sikkim (2300 m) - 6(DZH)
Ecchey Busty,Kalimpong(1080 m)- 42 (EBH)
Eleventh Mile,Kalimpong(1200 m)- 11(ELEH)
Fifth Mile, Kalimpong (1160 m) - 12 (FH)
Gangtok, East Sikkim (1547 m)- 13 (GANH)
Gorubathan, Kalimpond Sub Div(220m)- 52(GORH)
Ging Tea Estate, Darjeeling (2070 m) - 51(GTEH)
Hill Top , Kalimpong (1210 m) - 14(HTH)
Jaldhaka, Kalimpong Sub-Div(500 m)- 15(JH)
Kaw, South Sikkim (1575 m) - 17(KAWH)
Kagay, Kalimppong Sub-Div (945 m)- 16(KH)
Khamdong, West Sikkim (1045m) –53(KHAMH)
Kurseong (1440m) - 43(KURH)
Lava, Kalimpong Sub-Div.(2050 m)-19,54(LH 1,2)
Lingee,South Sikkim (700m) - 18(LINH)
Lathpancher,Kurseong Sub-Div.(550m)-66(LPH)
Makhum Busty, Kalimpong Sub-Div.(980m) –25(MB

Mitiali,Jalpaiguri Dist.(275 m)- 20 (MH)
Middle Bong Busty, Kalimpong(1090m)- 21,22(MIBH 1,2)
Mungpoo,Kalimpong Sub-Div.(1300m) – 44(MONGH)
Monsong,Kalimpong Sub-Div.(1280 m)- 23,24(MONSH 1,2)
Nehaborong,Sikkim (988m) – 27 (NEH)
Pabong,Kalimpong Sub-Div.(490 m)- 67 (PABH)
Pedong, Kalimpong Sub-Div. (1000m)- 28,55(PEDH 1,2)
Pudung Busty,Kalimpong Sub-Div.(1040m)- 56 (PUDH)
Payong, Sikkim (1445m)- 29,57(PH 1, 2)
Rabitar, South Sikkim (850 m) - 58(RABH)
Ravangla,South Sikkim (785 m) – 30 (RH)
Rimbick, Darjeeling (2400 m) – 59,60 (RIMH 1,2)
Sadam, South Sikkim (1400m)- 37(SADH)
Sakyone,kalimpong Sub-Div.(1270m)-61(SAKH)
Samdong,East Sikkim (750m)- 34(SAMDH)
Samsing, Jalpaiguri Dist.(275 m)- 45 (SAMH)
Sangsay,Kalimpong Sub-Div.(1192m) – 64,65,38 (SANGH,1,2,3)
Solak Busty, Kalimpong Sub-Div.(480m)-33(SBH)
Seed Farm Area, Kalimpong(1160 m)- 35,46 (SFH 1,2)
Sumbuk,West Sikkim(820 m)- 62,32 (SH 1,2)
Sindebong Busty,kalimpong(1102 m) 63(SINH)
Soreng Busty,Kalimpong Sub-Div.(220 m)- 31(SORBH)
Sumbaria ,West Sikkim (820 m)- 36 (SUMBH)
Suruk, Kalimpong Sub-Div.(490 m)- 47 (SURH)
Tendrabong,Kalimpong Sub-Div.(900m)- 40(TH)
Todey,Kalimppong Sub-Div.(2450m)- 39 (TODH)

Fig 1.6.1 B

Lepchas call themselves "Rongkup" meaning the dwellers of rocky land. They are generally found dwelling in the valleys of Central and West Sikkim. The Bhutias and the Tibetans are mostly found in the North and North Eastern high lands. It is believed that the Bhutias gave the state its name "Sikkim", meaning `A new home' (Dhamala, 1970). Today the Nepalese dominated the population of Sikkim and outnumber the Bhutias and Lepchas by three to one. They constitute about 70% of the total population of Sikkim.

The major towns of Sikkim are Gangtok, Singtam, Rangpo, Jorthang, Naya Bazar, Mangan, Gezing, Namchi, Rhenok, Chungthang and Melli. Essentially, Sikkim has an agrarian economy with 63% of the work force depending upon agriculture inspite of the limited land available for cultivation (11%). Rice is the major crop in the Southern part of the state and other most important cash crop include cardamom and ginger in Sikkim contribute 70% of the total cardamom production in India.

Sikkim's scenic beauty offers great potential for tourism which is fast becoming a major including for the state. The government of Sikkim intends to promote tourism widely in the state. The newly formed body, the Eastern Himalayan Association, Gangtok has taken the responsibility on 31st August, 1998 to develop the state more and more attractive for tourists centering Gangtok in the Eastern and Northern Sikkim, Namchi in the southern Sikkim and Pelling in the western Sikkim. Kanchendzonga Biosphere Research (Biosphere Reserve) of Sikkim holds place within the top ten among the high altitude regions in the country. This protected area is a rich reservoir of the bio-diversity and a gene-pool endowed with one of the most magnificent high altitude ecosystem of the world.

The floristic wealth of the state is rich and diverse, both in composition and importance. Similarly, the resources of faunal wealth is also magnificent and induce many rare and endangered species.

Table 1.6.1; **POPULATION DATA OF SIKKIM**

Items	Year	Unit	State	North	East	South	West
1, Population	1991	Person	406457	31240	178452	98604	98161
2, Decannial growth	1981-91	Percentage	28.47	18.09	28.60	29.78	30.55
3, Density of population	1991	Per sq km	57	7	187	131	84
4, Sex ratio	1991	Females/ 1000 males	878	828	859	892	915
5, Urban population	1991	Percentage	9.10	2.57	17.86	2.61	1.80
6, Scheduled Caste	1991	Percentage	5.93	3.36	6.99	5.64	5.02
7, Scheduled Tribe	1991	Percentage	22.36	55.36	21.09	16.91	19.66
8, Literacy Rate	1991	Percentage	56.94	53.47	65.13	54.08	45.62

One of those which is unique to the area and most precious asset of Sikkim is the "Shapi of Sikkim" (*Hemitragus jemlahicus schaeferil*), a sub species of the Himalayan Thar from Sikkim.

The beauty of rivers can be wonderfully felt in Sikkim. Teesta, Great Rangit, Ramsang, Kalej, Rathong and Ryangang are the most important rivers in Sikkim.

The varied shapes and colours of flowers like orchids, Rhododendron etc. enthrall nature lovers and their fragrance gives us ecstatic delight. "Solitude is a good place to visit but a poor place to stay", does not apply to Sikkim as it is both a beautiful visiting spot as well as worthy place to study, including philosophical and scientific.

1.6 A1 TOPOGRAPHY

The main range in Sikkim is the chola, which divides Sikkim from Tibet in the North-East and Bhutan in the South-West. Another range, the Singalila range separates it from Nepal in West, with the East-West axis-forming barrier between Sikkim and Tibet in North. Mainly two rivers Teesta and Rangeet flow in Southern direction and creates some ridges and slopes. These are the most suitable habitable areas in Sikkim. Main routes from Sikkim initiates either from Melli or from Rangpo. From Melli (500m), the left part leads to Jorthang (300m and above), stretches up to Namchi (above 1450m) and then to Damthang (above 200m)Another route from Nayabazar (beside Jorthang) of West Sikkim leads to Soren and Yumgthang (above 3600m) and the third route from Jorthang stretches through Gyalshing to Pelling (1900m) and then to Yaksum (about 1800m) and Dzongri (4000m). From Melli another route extends up to Gangtok in the East District *via* Rangpo (800m) and Singtam (above 800m). There is one route from Gangtok (1665m and above) stretching towards Changgu (3500m), North Dikchn (869m), Mangan (1310m), Phudong (1400m) and Chungthang (1631m and above) and other areas in the North.

Altitudes of different places of Sikkim with their respective district are presented in the table No. 1.6.2 and profile of land elevation has been shown in table No. 1.6.3 (Samanta, 1998).

Table 1.6.3; **PROFILE OF LAND ELEVATION**

Type of land	Level of elevation
Lower hills	Altitude ranging from 270 to 1500 m
Mid hills	Altitude ranging from 1500 to 2000m
Higher hills	Altitude ranging from 2000 to 3000m
Alpine zone	Altitude ranging from 3000 m with vegetation
Snow line	Very high mountains without vegetation and with perpetual snow cover up to 8580m

1.6.A2 CLIMATE

Climate of Sikkim Himalaya varies greatly in different areas based on altitude, exposure and location. Its climate varies from nearly tropical at lower altitude (above 900 m) to alpine at higher altitude (above 4000m). The alpine zone is perpetually snow around. Four main seasons are recognisable in this area;

(i) Winter (mid-November to mid-March)

(ii) Springs or summer (mid-March to Mid-June)

(iii) Monsoon (mid-June to mid September)

(iv) Autumn (mid-September to mid-November).

1.6A2.1 TEMPERATURE

During winter, temperature comes down to 4°C quite frequently around Gangtok. The summer or better to say spring is quite warm when the warm day temperature varies between 12.5 to 26.2°C. During

Table 1.6.2; **ALTITUDE OF DIFFERENT PLACES OF SIKKIM WITH THEIR RESPECTIVE DISTRICTS (SAMANTA, 1998)**

Station/place	District	Height (m)
Chungthang	North	1631
Lachen	North	2697
Mangan	North	1310
Thangu	North	3812
Kabi	North	-
Singhik	North	1402
Lachung	North	2633
Phudang	North	1400
Yumthang	North	3673
Namchi	South	1677
Jorthang	South	300
Rabongla	South	2439
Ranglee	East	823
Rhenock	East	100-1100
Pakyong	East	1200-1500
Rangpo	East	800
Gnathang	East	3752
Changu	East	3500
Gangtok	East	1665
Bikchu	East	869
Singtam	East	816
Serathang	East	4114
Gyalsing	West	1524
Geyzing	West	-
Yaksum	West	1780
Dentam	South	1372
Damthang	South	1981
Pelling	West	1900
Dzongri	West	4000
Melli	East	500

monsoon, the mean temperature varies between 17-27°C. Detailed charts of recorded temperature are provided in table 1.6.7 and 1.6.8.

1.6A2.2 PRECIPITATION AND GLACIERS

The highest recorded mean rainfall in Gangtok between the period 1996-98 770.85 mm in June and the lowest mean rainfall is 0.20 mm in December (Table 1.6.7). The total number of rainy days in Gangtok, Sikkim was 209. Comparative study of average rainfall and temperature from 1996 to 1998 of Gangtok has been represented in the ombrothermic diagram (fig. 1.6.2a).

The frequency of rainfall is maximum where there is no barrier for penetration of monsoon clouds eg. Chungthang and Lachen (Chopra, 1985). There are about 12 snow peaks in Sikkim rising above 6000 m. Besides Kanchendjonga, other tall peaks in Sikkim are Twins (8032m), Nepal peak (7803m), Tent peak (8050m), Jonsong (8130m), Lhonak (7338m), Pakhanri (7795m), etc. These snow covered regions are quite important because of the originators of major rivers in Sikkim the main glaciers of Sikkim are Zemu (3978-7000m), Chansang (5200-6000m), Lhonak, Jonsang, Rothong, etc. Regions above 3000m remain covered with snow for 1-8 months of the year.

1.6.A.2.3 WIND VELOCITY

It is reverse in afternoon. Their direction is generally South-East early in the morning and sometimes North-West early in the evening (Chopra, 1985) places in higher altitude generally experience high velocity of wind specially in the afternoon.

The highest velocity of wind is recorded in April and lowest August in Gangtok (Table 1.6.7).

1.6.A2.4 SUNSHINE/CLOUDINESS

Due to high precipitation and humidity with as high as 218 rainy days per annum, the region is expected to be a low sunshine area. Not only monsoon, even in summer and winter the sunshine is highly disturbed with the formation of dense fog which sometimes create a zero visibility situation (Chopra, 1985). Sunshine is more commonly disturbed in the morning and also in the afternoon. During monsoon, rain continues for quite a few days without allowing the sun to shine its face for those days.

The average highest sunshine as has been recorded for the month of May in Gangtok is (9.20hr/day) and the lowest (4.90) hr/day) (Table 1.6.7). for June

1.6.A2.5 RELATIVE HUMIDITY

This zone generally have relative humidity, specially the North facing slopes remains humid through out the year. Humidity becomes high during morning and afternoon (Chopra, 1985). The mean highest humidity recorded is 96.50 in Gangtok (Table 1.6.7).

During monsoon month, the clouds are heavy and rest of the period remains moderately cloudy but their intensity increases during the afternoon (Chopra, 1985).

1.6.A2.6 FOREST (Table 1.6.4)

Total area under forest 2650 sq km

a) Reserved forest - ; 2261 sq km
b) Khasmahal - ; 285 sq km
c) Goucharan - ; 104 sq km
d) Percentage of forest area to total area ; 36.3% of total geographical area.

Table 1.6.4; **Forest Park/National Park/Sanctuary**

Name of park	Location/District	Year of initiation	Area
Kanchendjonga National Park	North Sikkim	August 1977	850 sq km
Kanchendjonga Biosphere Reserve			
Fabong Lho Wildlife Sanctuary	East Sikkim	April 1984	5176 ha
Shingbaa Rhododendron Sanctuary	North Sikkim	August 1984	32.5 ha
Kyagnosla Alpine Sanctuary	East Sikkim	August 1984	481 ha
Macnam Wildlife Sanctuary	South Sikkim	March 1987	3534 ha

Table 1.6.7; **AVERAGE (1996-1998) MONTHLY CLIMATOLOGICAL DATA GANGTOK, SIKKIM**

Month	Rainfal (mm)	No. of rainy days	Temperature (°C)			Relative humidity (%)		Vapour pressure (mb)		Sunshine brightnes s (hr/day)	Wind velocity (km/hr)
			Max	Min	Mean	6.37	13.37	6.37	13.37		
January	27.15	7	10.65	5.00	7.83	78.00	86.00	7.85	9.15	6.40	3.0
February	81.80	11	14.80	7.35	11.07	74.00	89.00	10.30	10.85	8.70	2.3
March	212.90	17	17.27	9.65	13.46	59.50	77.50	12.10	13.05	8.90	5.5
April	221.10	16	21.05	19.15	20.10	70.00	73.00	13.75	17.10	8.90	6.0
May	645.45	24	22.50	15.30	18.90	69.50	86.50	16.50	18.35	9.20	5.0
June	770.85	30	21.80	17.25	19.52	86.50	92.50	20.10	21.35	4.90	3.0
July	695.10	31	20.10	10.75	15.42	95.00	96.00	20.95	21.85	6.40	1.5
August	557.90	30	21.25	17.70	19.48	89.50	96.50	20.70	22.50	6.10	1.0
September	377.80	27	21.90	16.70	19.30	80.00	88.00	18.40	20.00	6.45	2.0
October	360.80	13	20.60	14.40	17.50	71.50	91.50	14.10	16.70	8.40	2.0
November	03.60	2	18.25	11.10	14.67	68.50	78.00	12.80	13.00	8.15	2.3
December	00.20	1	15.55	7.60	11.58	49.50	67.00	7.95	8.70	6.55	3.0
Total	3924.65	209	-	-	-	-	-	-	-	-	-
Average	327.05	-	18.81	12.66	-	74.29	85.12	14.62	16.05	7.42	3.09

Table 1.6.8; **AVERAGE MONTHLY CLIMATOLOGICAL DATA OF OTHER AREAS OF SIKKIM FOR THE 1997**

Month	Dentam (West)	Dikchu (East)	Rongli (East)	Singhik (North)	Lachen (North)	Lachung (North)
January	0.0 (0)	30.6 (5)	0.0 (0)	NA	NA	23.0 (3)
February	29.8 (4)	122.4 (10)	78.4 (9)	NA	NA	62.0 (12)
March	54.8 (6)	103.6 (11)	13.6 (1)	NA	NA	403.0 (24)
April	99.0 (9)	300.4 (17)	53.2 (26)	110.5 (14)	110.5 (14)	179.2 (17)
May	114.2 (14)	399.4 (16)	145.2 (23)	153.5 (17)	153.5 (17)	186.0 (18)
June	707.4 (29)	863.2 (24)	233.2 (27)	334.1 (25)	334.1 (25)	379.0 (25)
July	480.4 (23)	253.2 (19)	219.8 (28)	NA	NA	NA
August	422.8 (21)	461.4 (23)	NA	217.0 (21)	217.0 (21)	2.8 (14)
September	456.0 (21)	648.4 (23)	NA	NA	NA	NA
October	91.8 (6)	25.8 (8)	NA	NA	NA	NA
November	0.00 (0)	23.80 (1)	NA	NA	NA	24.0 (4)
December	81.6 (4)	78.0 (6)	NA	NA	NA	NA

[NA; Not Available. The figures in the brackets indicates the Number of Rainy Days]

1.6.A2.7 CROPS

Rice, wheat, maize, finger millet, barley, buckwheat, pulses, rape seed, mustard, soybean, potato, large cardamom, ginger.

HORTICULTURAL CROPS

Citrus (orange, lime, etc.), banana, mango, guava, papaya, avocado, apple, peach, plum, turmeric, cassava, sweet potato, dioscorea, tomato, chillies, brinjal, tree tomato, cabbage, cauliflower, khnol-khol, lady's finger, radish, turnip, cucumber, pumpkin, bottle gourd, sponge gourd, ridge gourd, snake gourd, bitter gourd, amaranthus, spinach, methi, chayote.

B. THE SUB-HIMALAYAN WEST BENGAL

Sub-Himalayan West Bengal includes mostly the district of Darjeeling and part of the district of Jalpaiguri which shares with the former at its Southern boundary. The district of Darjeeling is located between 26°30' 05" and 26°27' 10" Lattitude and between 88°53' 00" and 87°59' 30" longitude. The plain area of the district lies between 26°30' and 26°45' Northand between 88° and 88°30' East. The total area of the district is 3254.7 sq km while the hilly region alone covers an area of 2320 sq km. The district occupies 3.68% of the total area of the state of West Bengal. Out of 934.6 sq km area falling in the terai and plains, 837.4 sq km is counted under the Siliguri Sub-Division.

Among the four sub-divisions, the other three have their area as follows: Darjeeling 935.5 sq km, Kurseong 425.3 sq km and the largest sub-division Kalimpong 1056.5 sq km.

Of all the frontier districts of India, Darjeeling has the most complicated boundaries. It shares its boundaries with international frontiers with Nepal in the West, Bhutan in the East. The state of Sikkim separated by river Teesta forms the Northen boundary and districts of Jalpaiguri and Purnea of Bihar state in South.

The boundaries of Nepal , Sikkim and Darjeeling meet at the peak of Phallut (3600 m) forming a trujunction . Another similar trijunction is formed aat Rach'ela (at Tinsiman ,3100 m) by the boundaries of Bhutan , Kallimpong sub-division and Sikkim from where down runs the river Jaldhaka separating the countries Bhutan and India.

The accessibility to Darjeeling is offered from the southern part only through the districts of Jalpaiguri , North Dinajpur and Purnea (Bihar state) and plains of Nepal across River Mechi.

The district consists of 4 sub-divisiion from administrative view point. These are Darjeeling, Kursong, Siliguri and Kalimpong. Out of total 591 villages included within the district 55 are uninhabitated. This is lowest figure among all the districts of West Bengal. Darjeeling district occupies 3.68% of the total area of the state of West Bengal ranking 13th area wise with 17 Police stations and 11 blocks under development plans. The total population of the district is 1,335,618 (census 1991) which happens to be 0.13 % of the total population of India.

1.6.B1 TOPOGRAPHY

The altitudinal variation from as low as 130 m. at Siliguri to as high as 3600 m. (at Sandakphu) and 3800 m. (at Phalut Gosha) has direct impact on the vegetational pattern in the region . This renders the district a special status from agricultural , horticultural , sericultural , tea industry and apicultural point of view.

Ranging from a trijunctional boundary of Purnea, North Dinajpur and Darjeeling (140-180 m) to Siliguri (180 m) ,Sukuna (200-300 m), Bagrakote (250 m) and Jholung – Gairibus ((200-300 m.) the areas constitute the Tarai and plains of the district with a western boundary of River Mechi to Nepal. The river Teesta separates Kalimpong sub-division from the rest of the district and Sikkim while river Rangeet does so to Darjeelling and Sikkim . Kursong (1450 – 1600 m.) is situated on the western hill most of which are covered with tea —estate . To the north of Kurseong the ridges form Dowhill (1900 m) and Mahalidram (1800 m). The ridge that bifurcates at Ghoom leads to another course to Mirik

(1200 – 1500 m) through Sukiaphokhari-Jorepokhari (2000-2350 m.) and Simana (2300 m).

The ridge at Simava gives to an end to Tea garden and a way to the crest of Singalila Mountains.

Kalimpong sub-division on the east of River Teesta has more than one base to the hills such as Bagrakote, Samsing , jholung and River valley itself . The slopes from Mangpong –Pankhaban forest rise to Yangmakum (1000-1600 m.) and further to charkholay (1600 m.) , where it meets its sister ridge from Bagrakote (250 m.) across Nimbong (1000-1200 m.) .Together they head to Lolay goan (Kafer 1800-2200 m.) and to Labha (2100-2300 m.) . The ridge coming from Sepkhola –kamshi forest transverse across Durpin (1500 m.),Kalimpong town (1200-1450 m.) along Algrah (1500-1900 m.) to Labha. The river Neora flows down along Jaributti (2190-2300 m.) from Jorephokeri . The Eastern slopes head down to Tangata (2805m), Today (2000 m. – 2600m.) and Godak (1200 m.) to Jholung.

1.6.B2 CLIMATE

The wide differences in altitude and powerful effect of monsoon on Himalayas deflect wind and effect local temperature and rainfall. Local climate largely depends on the elevation ranging from 300 m to 3660 m in the Northern part of the district. The climate of lower hills, Terai, and plains are similar to the neighbourong districts of West Bengal.

Four climate seasons can be recognised within this region, (1) Monsoon/rainy season, (2) Autumn, (3) Winter and (4) Summer (Spring). Thespring and summer cannot be taken separately (Bhujel, 1996).

The monsoon usually ranging from June to September is marked by continuous rain, clouds, fog, and mist. The relative humidity is highest from September when the region is one of the dampest in India, It ranges from 95-100%. The autumn is very short and usually stays from last quarter of September to first half of November. It is marked by clear sky, free from clouds, dusts and mists. It extends upto the immediate first few weeks of winter. The temperature from December to February on an average is quite low causing a cold winter.

1.6B2.1 TEMPERATURE

The temperature begins to fall more rapidly from the month of November throughout the region. Normally January is the coldest month and the daily temperature at Darjeeling and Sonada often go down to as low as -30°C and to -8°C at Sandakphu-Phalut. The lowest ever recorded temperature at Darjeeling town was -5°C on 11th February 1905 and -6°C at Kalimpong on 27th December 1922 (Bhujel, 1996).

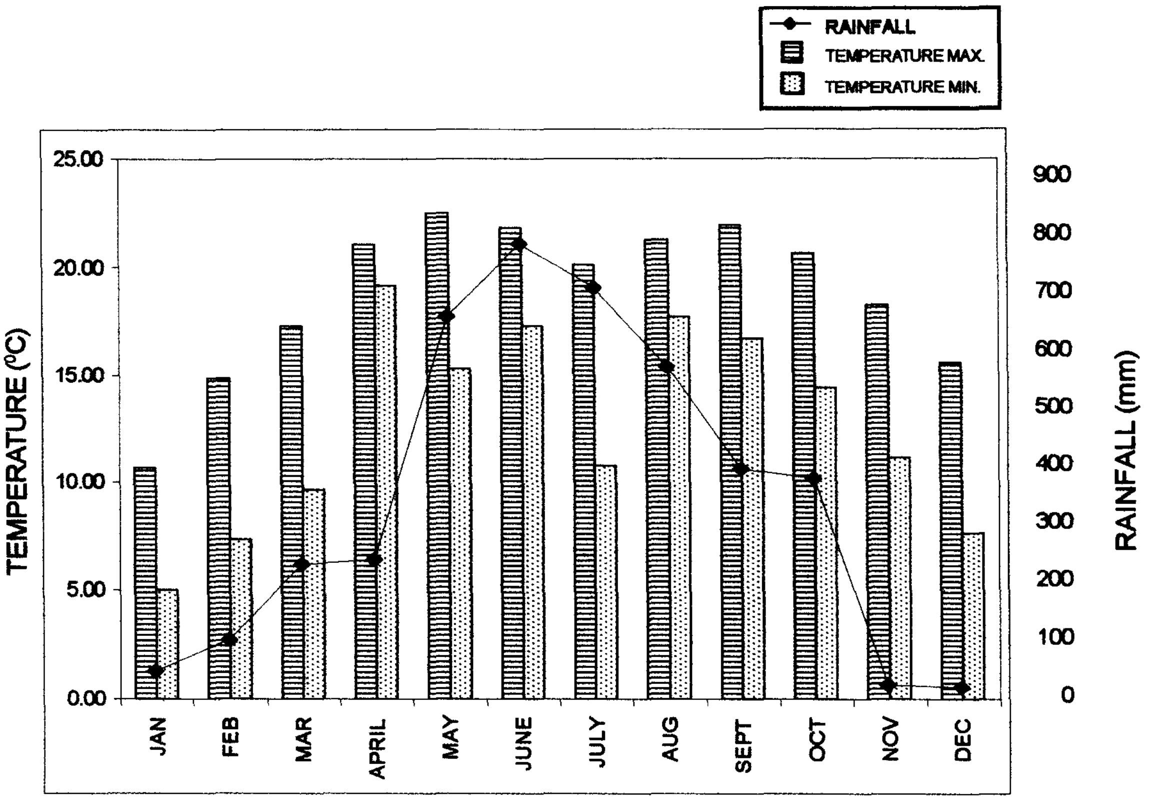
The highest mean maximum temperature within the period 1995-98 recorded in the month of January in the hills were Sonada 15.2°C, Kalimpong18.90°C and minimum 1.5°C and 8.48°C respectively (Table 1.6.9 and 1.6.10). It has been found that there is decrease in 1°C temperature for every 100 m, 110 m and 125 m rise in elevations between 1850 and 3050 m, 3050 m and 4270 m and 4270and 5490 m respectively. The last elevation being the one from the perpetual snow range commences (Bhujel, 1996). Comparatively study of rainfall and temperature of Sonada (1995-97) and Kalimpong (1995-98) has shown in ombrothermic diagram (fig. 1.6.2).
b,c

1.6.B2.2 PRECIPITATION AND GLACIER

The upper mountains such as Sandakphu and Phalut at an elevation of about 3600 m receive frequent snowfall than the lower hills. Winter is followed by a rather hot summer in the month of April and May especially in the lower hills.

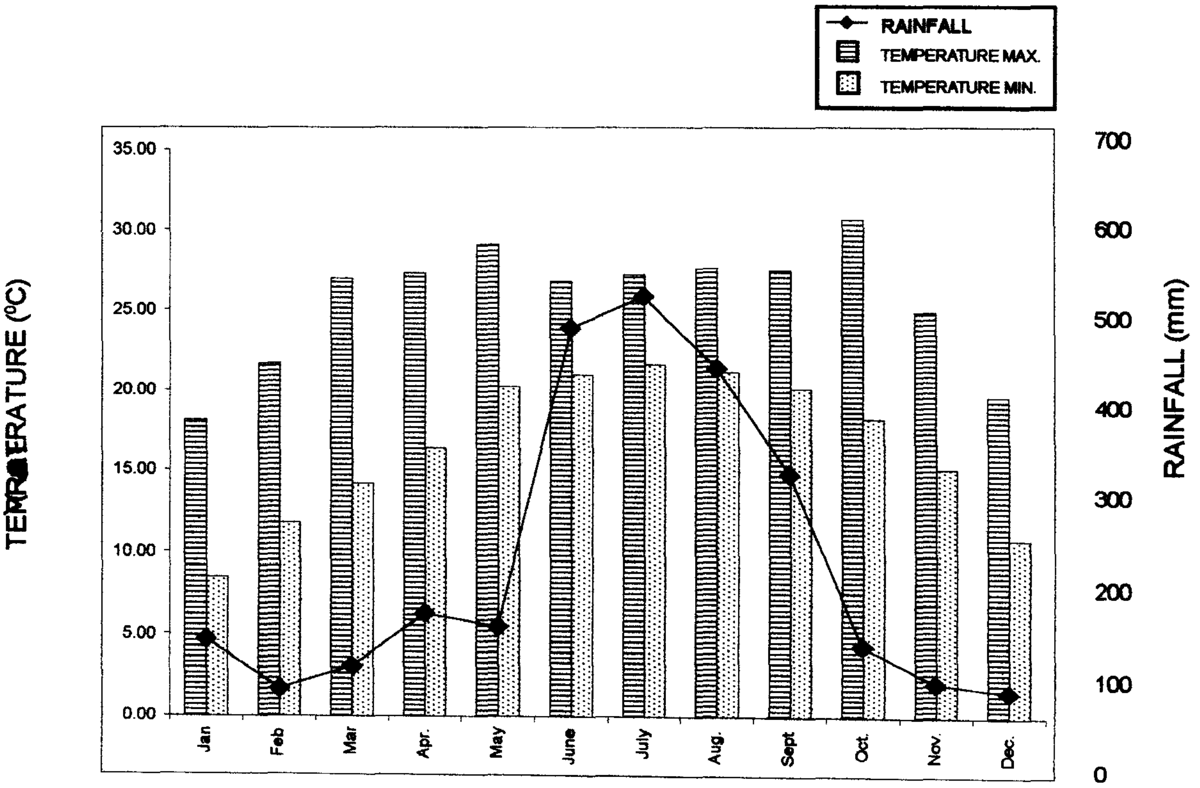
The hilly configurations bring about sharp changes in rainfall. It is heaviest in South facing ridges of Kurseong sub-divisions which receives an annual rainfall of 4699.5 mm (1987, highest in 11 years). Darjeeling received 3269.89 mm while Munsong (North facing) received 2901.8 mm in the same year (Bhujel, 1996).

OMBROTHERMIC DIAGRAM FOR THE STATION GANGTOK, SIKKIM
YEAR 1996-1998 (AVERAGE)



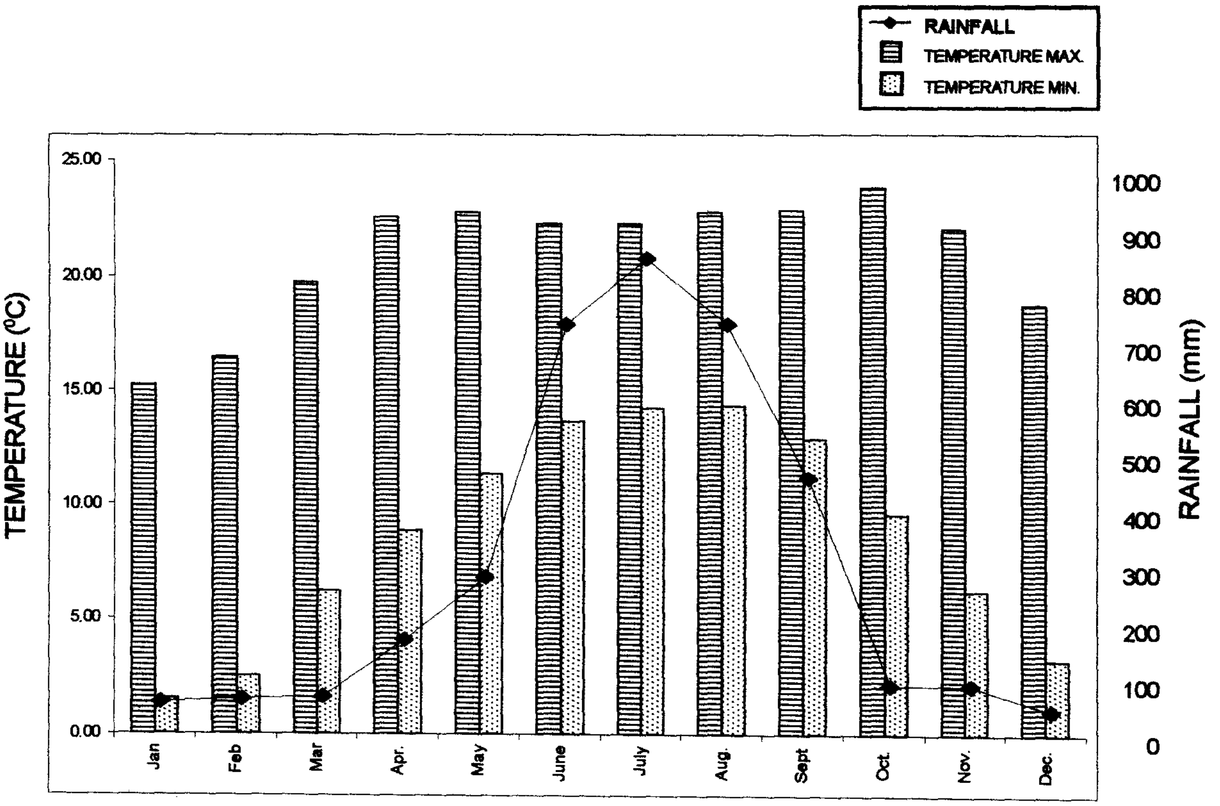
[Fig. : 1.6.2a]

OMBROTHERMIC DIAGRAM FOR KALIMPONG, DARJEELING
YEAR 1995-1998 (AVERAGE)



[Fig. : 1.6.2b]

OMBROTHERMIC DIAGRAM FOR SONADA, DARJEELING
YEAR 1995-1997 (AVERAGE)



[Fig. : 1.6.2c]

1.6B2.3 WIND VELOCITY

The region faces higher wind velocity during November to May, the later two months being more so. In the higher hills above 3000 m the wind speed is very strong which often rise to hurricane force. The calm conditions are frequent in lower hills around 2000 m and regularly so below to the terai and plains. Average wind speed at Darjeeling does not exceed 9.65 km per hour (Dash 1947). The record of Sonada between 1995 – 1997 shows that the average wind speed ranges from 1.80 to 2.29 km/hr (table 1.6.9). However the stormy (rain mixed) wind gives a frequent threat at the peeled summit of Phalut (3600m). Kalimpong faces the highest velocity of wind than any other place of the district and remain windy rather than calm. This may particularly have its bearing to the presence of river Teesta at its foot, nearby. The air in the river valley of Teesta and others change direction diurnally and there occurs occasional draught of air.

1.6B2.4 SUNSHINE AND CLOUDINESS

The fog and mist are very common during July and August in Darjeeling, Kalimpong, Kurseong and higher above and frequent in June and September. Towards the monsoon season the sky is relatively overcast with clouds. The other season are moderately clouded while winter mornings are frequently filled with lifted fog. The clean sky and sunny days are frequent in autumn. The summer (or spring) exhibits a smogy sky throughout the region with variation in sunlight. The average sunlight (hr/day) recorded in Sonada shows a range between 1.1-4.9 (1995-97) (table 1.6.9).

1.6B2.5 HUMIDITY AND VAPOUR PRESSURE

The atmosphere in the North facing slopes of the region remains humid almost throughout the year. In the higher hills (around 2000 m) the relative humidity ranges between 93 and 95 during rainy season (Table 1.6.9). The relative humidity decreases towards lower and Southern hills. Throughout the region the drier months are March and April when the relative humidity ranges between 52-88 (Table 1.6.10).

Table 1.6.9; **AVERAGE (1995-1997) MONTHLY CLIMATOLOGICAL DATA OF EXPERIMENTAL WATER SHADE SONADA, DARJEELING**

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)			Relative humidity (%)		Vapour pressure (mb)		Sunshine brightness (hr/day)	Wind velocity (km/hr)
			Max	Min	Mean	6.37	13.37	6.37	13.37		
January	38.7	13	15.2	1.5	8.5	83	90	06.60	11.50	3.8	2.05
February	43.5	13	16.4	2.5	9.4	89	92	07.33	11.90	3.2	1.85
March	47.3	10	19.7	6.2	12.9	89	90	09.55	14.79	3.7	2.00
April	155.4	13	22.5	8.8	15.4	86	89	11.33	17.78	4.6	2.30
May	271.5	26	22.7	11.3	17.0	92	94	14.85	19.56	3.3	1.83
June	747.7	28	22.2	13.6	17.8	95	95	16.69	20.45	1.3	1.94
July	871.2	30	22.2	14.2	18.1	95	95	17.53	20.89	1.1	1.80
August	748.4	29	22.7	14.3	18.5	95	94	17.57	21.45	1.6	2.07
September	457.7	28	22.8	12.8	17.8	94	95	16.23	20.57	2.0	1.92
October	69.6	15	23.8	9.5	16.6	89	90	12.44	18.66	4.8	1.87
November	70.5	4	22.0	6.2	14.2	86	88	10.09	16.75	4.9	2.29
December	22.7	4	18.7	3.2	10.9	85	88	07.75	13.29	4.7	2.26
Total	3544.0	213	-	-	-	-	-	-	-	39.0	1.85
Average	-	-	20.9	8.7	14.8	90	92	12.33	17.29	3.2	2.00

Table 1.6.10; AVERAGE (1995-1998) MONTHLY CLIMATOLOGICAL DATA OF KALIMPONG, DARJEELING

Month	Rainfall (mm)	No. of rainy days	Temperature (°C)			Relative humidity (%)		Vapour pressure (mb)		Sunshine brightness (hr/day)	Wind velocity (km/hr)
			Max	Min	Mean	6.37	13.37	6.37	13.37		
January	76.5	2	18.09	8.48	13.28	55.60	86.76	-	-	-	-
February	15.2	1	21.69	11.79	16.74	60.20	79.86	-	-	-	-
March	43.7	4	26.98	14.21	20.59	52.68	85.68	-	-	-	-
April	108.5	5	27.28	16.43	21.84	55.20	88.26	-	-	-	-
May	92.7	7	29.06	20.21	24.63	56.28	86.25	-	-	-	-
June	462.6	15	26.83	20.98	23.90	54.38	92.85	-	-	-	-
July	502.4	28	27.20	21.64	24.42	78.29	93.46	-	-	-	-
August	412.5	24	27.63	21.14	24.38	85.29	92.86	-	-	-	-
September	278.6	15	27.51	20.08	23.79	60.46	92.37	-	-	-	-
October	68.7	6	30.64	18.17	24.40	75.23	91.73	-	-	-	-
November	22.7	2	24.88	15.06	19.97	76.25	86.25	-	-	-	-
December	12.5	2	19.54	10.80	15.17	62.32	89.23	-	-	-	-
Total	2096.6	111	-	-	-	-	-	-	-	-	-
Average	174.72	-	25.52	21.09	64.34	88.80	-	-	-	-	-

The normal vapour pressure ranges from 6.60 (min) to 21.45 (max) as recorded in Sonada hill station (Table 1.6.9).

1.6.B2.6 FOREST

Regarding the forest picture of the district it was observed in the census 1991 that total area of reserve forest of the district was 1168.4 sq km except the Siliguri Sub-Division (Table 1.6.5).

On the administrative ground Darjeeling district forests have been divided into 3 forest division under the Government of West Bengal . These are Kalimpong, Darjeeling and Kurseong. The Siliguri Sub-Division does not have such a forest division.

Combined forest bio-data of the above three hill sub-division are prescribed in the table 1.6.6.

Recent surveys indicate that the area under actual forest cover in the district is below 35 %.

Table 1.6.5. **Forest picture of the area**

Forest Division	Reserve Forest (sq.km.)	Protected Forest (sq. km.)	Unclassified (Darjeeling Gorkha Hill Council) (sq km)	Forest Villages	
				Area (sq km)	No.
Darjeeling	295.17	13.34	1.9	310.41	36
Kursong	290.63	2.4	8.3	395.33	26
Kalimpong	582.59	1.15	7.5	5901.31	29
(Total)	1168.39	16.89	17.77	1203.06	91

(1991 census)

Table 1.6.6. **Combined forest biodata of 3 hill sub-divisions**

Total Gepgraphical area	2417.30 sq. km.
Forest area	1203.03 sq.km
Agricultural area	37.00 sq.km
West land area (Including that of Siliguri) (ie. 36.2% of the total geographical area)	1178.20 sq. km
Area under cultivation of Medicinal plants	50.00 sq. km.
Land area degraded by soil erosion	470 sq. km. (1973 – 74)
Forest area degraded by soil erosion	382.63 sq. km. (ie. 31.8% of the total forest area 1203.03sq. km.)

1.6.1 FLORA AND VEGETATION

Altitude has become a prominent factor in determining the range of distribution of plant species and association that they form at different elevation ranges.

The authors like Gamble (1875), Hooker (1906), Cowan (1929), Champion (1936) and Kanai (1967) have made the classification of vegetation of the region according to attitudinal ranges. Bhujel in his latest studies has classified the vegetation type in 1996 as follows:-

NOS	VEGETATION TYPES	ALTITUDINAL RANGES
1	Tropical and Plants	Plains to 300m (500m)
2	Subtropical	500 - 1200m
3	Sub temperate	1200 - 1850m
4	Temperate	1850 - 3200m (3500m)
5	Sub alpine	3200 - 3700m (3500m)

The sub tropical and plains represent the vegetation of the plants in part but the remaining four form the hill forests.

1. The Tropical and plains vegetation [plains to 300m (500m)]

It is characterised by the presence of deciduous forests.This can be divided into following sub-types-

a) Riverain forest b)sal forest c) Dry mixed forest d) wet mixed forest.

a) The Riverain forests can be observed in small patches in the river beds of Teesta. Rangit, Balasan, Mahanadi, Sukuna, Relli, Chel, Lesh, Gish, Jaldhaka, Sevoke and Mechi.

The common species of the region are *Melipinnata osma, Albizia procera, A. lebbeck, Acacia pennata, Mikania micrantha, Clerodendrum viscosum, Acacia catechu, Dalbergia sissoo.*

b) Sal (*Shorea robusta*) forest forms associations with *Terminalia alata, Schima wallichii, Dillenia pentagyna, Lagerstroemia parviflora,* *Anthocephalus chinensis, Clerodendrum japonicum, Milletia extense, Combretum decandrum, Phyllanthus urinaria.*

C) Dry mixed forest consists of *Gmelina arborea, Tetrameles nudiflora, Erythrina stricta, Macaranga pustulata, Artocarpus lacucha.*

d) The wet mixed forest is characterised by the presence of semi-evergreen species occurring in the sheltered pockets in the valleys and streams. The conspicuous tree species are *Terminalia myriocarpa, Michelia champaca, Syzygium formosum, Litsea monopetala* etc.

2) Sub- tropical forests (500-1200m)

These are observed in the valley of rivers Teesta, Rangit, Relli, Balasan, Jaldhaka, Neora, Lesh and Chel on the ridges and spurs. In addition to several species extending from the tropical and plains zone the type is characterised by the presence of *Schima wallichii* (dominant in this forest), *Dhabanga grandiflora, Gynocardia odorata, Ailanthus integrifolia, Terminalia alata, T. bellirica, Castanopsis indica, Michelia champaca, Litsea cubeba, Aesandra butyracea, Spondias pinnata,* etc.

The forest is characterised by the presence of a good number of climbers such as *Bauhinia vahlii, Entada rheedii Combretum decandrum, Tinospora cordifolis, cissampelos pareira, Milletia pachycarpa, Thunbergia fragrans, Mucuna pruriens, Cissus simplex.*

The common herbs are *Commelina benghalensis, Cyanodon dactylon, Elatostema lineolatum, Ageratum conyzoides, Bidens bipinnata, Hydrocotyle sibthorpioides, Drymaria villosa, Oxalis corniculata, Urena lobata, Triumfetta rhomboidea.*

3. Sub temperate vegetation (1200-1800m)

The zones can be located at places like Kursoeng- Toong, Kalimpong-Algarah, Kuwapani-Labha, Godak-Todey, Nimbong, Pedong, Peshok-Takdah, Mungpoo-Sittong, Bijanbari-Rimbick and Soureni-Mirik, Gangtok, Rabhangla (Bhujel, 1996).

The type is characterised by the extension of some temperate species to thesis point such as *Leucosceptrum canum, Daphne sureil, Edgeworthia gardneri* at their lowest range of distribution; while subtropical species such as *Schima wallichii, Phyllanthus emblica, Gmelina arborea, Boehmeria rugulosa* show their distinct absence above this zone.

The typical members of this vegetation are as follows-

Engelhardia spicata var. *acerifolia, Schizandra propinqua, Clematis smilacifolia, C. gouriana, Camellia kisii, Viola diffusa, Buddleja asiatica, Ficus oligodon, Grewia sapida, Cestrum aurantiacum, Macaranga indica, Persicaria thunbergii, Torenia diffusa, Cynoglossum glochidiatum, Solanum erianthum, Indigofera dosna, Conyza japonica, Agapetes sikkimensis* etc.

4. Temperate vegetation [1850m-(3200m) 3500m]

As remarked by J.D. Hooker (1907) the temperate vegetation of this zone "is roughly divisible into lower non-coniferous and upper coniferous and Rhododendron belt, but the line of demarcation between these varies so greatly with the exposure and humidity of the locality that they cannot be dealt apart,"

The vegetation can be classified into following three subtypes [Kanai (1966), Grierson & Long (1983)]-

a) Temperate Deciduous forest
b) Evergreen oak forest
c) Hemlock-Rhododendron

a) Temperate Deciduous Forest

The members present in this zone include *Betula alnoides, Acer campbellii, A. sterculiaceum, Persea fructifera, Magnolia campbellii, Michelia doltsopa, Alnus nepalensis, Castanopsis hystrix, Rhododendron arboreum, R. grande* etc.

b) **Evergreen Oak Forest**

The forest consists of the species like *Quercus lamellosa, Lithocarpus pachyphyllus, Rhododendron falconeri, Pentapanax fragrans, Acer thomsonii, A. hookeri, Symplocos theaefolia, Cinnamomum impressinervium, Litsea elongata, L. albescens, Juglans regia.*

The undergrowths include *Aconogonum molle, Rubus splendidissimus, R. lineatus, R. paniculatus, Diechroa febrifuga, Astilbe rivularis, strobilanthus thomsonii, Rubia manjith, Pentapanax racemosus, Leycesteria formosa, Helwingia himalaica, Zanthoxylum armatum, Daphne bholna, Agapetes hookeri, Vaccinium retusum, Viburnum erubescens, V. mullaha.*

The common climbers are *Edgaria darjeelingensis, Herpetospermum pedunculosum, Mucuna macrocarpa, Thunbergia lutea, Clematis nepalensis, Schizandra grandiflora, Lonicera glabrata, Dicentra scandens, Smilax spp., Jasminum dispermum.*

The dense mass of herbaceous flora consists of *Galinsoga parviflora, Gynura cusimbua Anaphalis contorta, Capsella bursa-pastoris, Plantago erosa Clinopodium umbrossum, Prunella vulgaris, Mazus surculosus, Chirata urticifolia, C. macrophylla, Elsholtzia fruticosa, Gentiana spp., Elatostema hookerianum, E. sessile, Pilea symmeria, Scrophularia urticaefolia, Torenia peduncularis, Cyanotis barbata, Commelina benghalensis, Cyperus rotundus, Carex spp., Persicaria runcinata, P. capitata.*

c) Hemlock-Rhododendron forest (2800-3200m)

The common trees and shrubs are *Betula utilis, Rhododendron decipiens, R. falconeri, R. arboreum var. roseum, R. hodgsoni, Cotoneaster microphyllus, Rosa sericea, Rubus pentagonus, R. treutleri, Neillia rubiflora, Berberis insignis, Buddleja colvillei, Daphne bholna* var. *glacialis, Hypericum hookerianim, Salix salwinensis, Tsuga dumosa, Taxus baccata, Abies densa, Juniperus psundosabina, Larix graffithiana* and densely undergrowing *Arundinaria griffithiana, A. aristata.*

Common climbers are *Actinidia strigosa, Holboelia latifolia* var. *Latifolia, Rosa macrophylla* along herbaceous flora characterised by *Vaccinium nummularia, Gaultheria trichophylla, Panax pseudoginseng, Viola spp., Primula listeri, Lysimachia ramosa, Gentiana capitata, Swertia dilatata, Aconitum spicatum, Meconopsis nepalensis, Hackelia uncinata*. The trees such as *Lithocarpus pachyphyllus, Taxus baccata* from lower temperate region and *Lyonia ovalifolia* from subtropical region extend commonly upto this zone.

5) Sub alpine vegetation [3200m (3500m)-3800m]

This region has been categorised by some as alpine region (Biswas 1959, Mitra 1951), while as temperate region by others (Gamble 1875, Kanai 1966). The upper ridges of the temperate zone of Singalila mountains display a sub-alpine character with conspicuous stunted dwarf habit of the flora, a habit principally prevalent in alpine precipitation zones. The presence of typical alpine meadow that runs from Sandakphu (3600m) along the upper ridge to Phalut (3600m) and Gosha (3800m) distinctly stays apart from the nearby temperate zone in the floristic forms as well as geographical morphology.

The common plant species observed in this zone are *Abies densa, Cotoneaster sandakphuensis, Sorbus microphyllus, Viburnum nervosum, Rhododendron spp., Acer caudatum, Salix sikkimensis, Lyonia villosa, Gaultheria trichophylla, Juniperus Pseudosabira Skimmia lanreola.*

The herbs in the forests and meadows are *Rubus fragarioides, Potentilla arnuscula, Primula sikkimensis, Thalictrum rostellatum, Ranunculus ficariifolins, Aconitum spicatum, Meconipsis nepalensis, Viola biflora, Stellaria lonata, Arenaria debilis, Geranium polyanthes, Impatiens kingii, Saxifraga hispida, Gentiana bryoides, Pedicularis flexnosa, Pilea racemosa* and the rare herb *Rheum acuminatum.*

6) Plantation forests

a) major plantation

These consist of *Acacia catechu, Alnus nepalensis, Albizia spp., Betula alnoides, Castanopsis hystrix, Chukrasia tabualaris, Cryptomeria japonica, Dalbergia sissoo, Eucalyptus globulosus, Juglans regia, Pinus spp., Michelia champaca, M. doltsopa, Shorea robusta, Taxus baccata, Tectona grandis, Terminalia myriocarpa, Toona ciliata, Thuja spp.*

b) Minor plantation

These consist of *Cymbopogon nardus, Dendrocalamus hookeri, Edgewarthia gardneri, Thysanolena maxima, Ammomum subulatum.*

1.6.2 PAST FLORISTIC STUDIES

Sikkim and sub-Himalayan West Bengal are floristically rich and have attracted the botanists, researchers and plant explorers at different times since the 18th century (Samanta, 1998). Some of the plant explorers from far away countries setting foot at different times in this region include J.D. Hooker (1849-51, 1855. 1872-1897); G.A. Gammie (1893); C.B. Clarke (1876,1885); H. Hara (1963, 1966, 1971); S. Nakao (1964) H. Ohashi (1975); A.J.C. Grierson and D. G. Long (1983) and Polunin and Stainton (1984).

Some of the Indian contributors to the floristic study of this region worth mentioning are A. K. Mikherjee (1988), K.P. Biswas (1940, 1956, 1967), G.S. Yonzone (1976), A.P. Das and Chanda (1987, 1990); B.M. Rai (1983-85), A.P. Das and R. B. Bhujel (1983); N.C. Mazumdar, B. Krishna and M.C. Biswas (1984); K.K. Tamang and G.S. Yonzone (1982), U. C. Pradhan (1983).

Other contributors like J.S. Gamble (1875) etc. have published floras from Darjeeling Himalayas from forestry point of view. Recently a number of works have been reported from ethnobotanical aspects. Some such references are Bhujel (1995), Bhujel *et al.*, (1984), Biswas (1956), Yonzone et al (1984, 1985), Rai *etal.,* (1998).

Apparently this region is well explored. But on scrutiny of literature (including travel itineraries) and specimens, it can be easily realised that large tracts of vegetation mainly forested, are yet to be surveyed. Moreover, rapid increase of habitational areas, steadily dwindling forest cover, naturalisation of numerous exotics, pollution, many fold increase in grazing etc. are exerting tremendous pressure on the natural vegetation of this area (Samanta, 1998) resulting into the loss of many species and keeping many others endangered.

1.6.3 PRESENT STATUS OF HONEY COLLECTION IN THE STUDY AREA

Bee-keeping in the study area is neglected, although first attempt to keep bees was made in 1882 in Bengal (Singh, 1962).

Sikkim and Sub-Himalayan West Bengal are floristically a very rich region but use of this floristic region through apiary industry is meagre. Only in Kurseong and Kalimpong sub-divisions and few places of Sikkim there are some apiaries exploiting the rich local flora.

Darjeeling district beekeepers' co-operative society in Kurseong, Comprehensive Area Development Corporation (CADC) in Kalimpong under Darjeeling Council Rural Development Association (DCRDA) and Khadi Village Industries in both Sikkim and the district of Darjeeling of West Bengal are encouraging the local people in this respect by supplying bee-keeping equipments, loans, economic subsidy from time to time on behalf of the Government. Even these organisations have some better plans from bee- keeping point of view for the economic development of the local farmers (beekeepers) as evidenced by the certificate from the Project Director of CADC, Kalimpong (Xerox copy of the beekeeping programme attached). The conducted training programme in 1992, the no. of beneficiaries and amount of subsidy are also presented in the same certificate.

Khadi village industries department in Sikkim had distributed only five number of scheme to the beneficiaries of East, West and South districts of Sikkim uptil now. The procedure of the scheme details are presented in the following table 1.6.3.1:

West Bengal
Comprehensive Area Development Corporation
(A Govt. of West Bengal Undertaking)
Kalimpong Project, Kalimpong-734301 Darjeeling (W. B.)

STD. 03552
Phone : 55588 (O)
55416 (SSI)

Memo No.. Date 23/8/99.

Bee-Keeping programme conducted by CADC.

In 1992 Kalimpong CADC conducted a training prog. on BeeKeeping with 9 beneficiaries located at Newar Gaon near Tirpai. They were given training with the help of Kurseong Bee-keeping Society at CADC office and Garubathan.

They were given Bee-keeping equipments ~~through~~ on Subsidy (75%) of which details are as follow.

No. of beneficiary	Total amt per unit	Subsidy given by Kurseong Beekeeping Society	Beneficiary's contri.	Total amt for 9 benefi.
9	Rs. 500=00 (approx.)	75%	25%	4500/-

Future Plan: CADC is planning to procure the honey from hills area with remunerative price to be given to the Beekeeper (farmer) and to sell it through CADC's marketing centre ("PALLISHRI") at Calcutta. In 2nd phase CADC is planning to train ~~more~~ [illegible] for more production.

...DIRECTOR
W.B.C.A.D.C.
Kalimpong Project

23/8/99

Table No.1.6.3.1; **[Source : Khadi Village Industries Dept., Gangtok, Sikkim]**

District	Grant (Rs.)	Capital expenses	Work expenses (Rs.)	Total (Rs.)	No of unit	Distribution with date (Rs.)
South	4795/-*	2905/-**	-	7700/-	1 No.	31.3.1992
East	-do-	-do-	-	-do-	1 No.	-do-
	-do-	-do-	43,900/-	51,600/-	1 No.	4.5.1994
West	-do-	-do-	-do-	7700/-	1 No.	19.6.1993
	-do-	-do-	-do-	51,600/-	1 No.	4.5.1994

Khadi village industries dept, granting Rs. 4795/- for establishing of bee-keeping to beneficiary.

* Khadi village industries Dept. is charging 4% interest on Rs.2905/- per annum. If the beneficiary does not perform according to the condition of Khadi Dept. *i.e.,*. if the bee-keeping is not established after taking the scheme, Khadi Dept. charges extra 5 % interest on Rs. 2905/- per annum. A total of 9 % interest is charged on the beneficiary in that case.

In the present investigation honey samples (150 gm. Each) had been collected from different localities of the study area by 3 methods:

1) squeezing method
2) extraction method
3) 'leaking ' method (specially in case of honey from *Apis florea* F. 'Putka" honey)

SQUEEZING METHOD

It is followed in extracting honey in both wild and domestic conditions. In wild condition the bee hives are found to develop on the branches of big trees, under the outer roof of building etc.

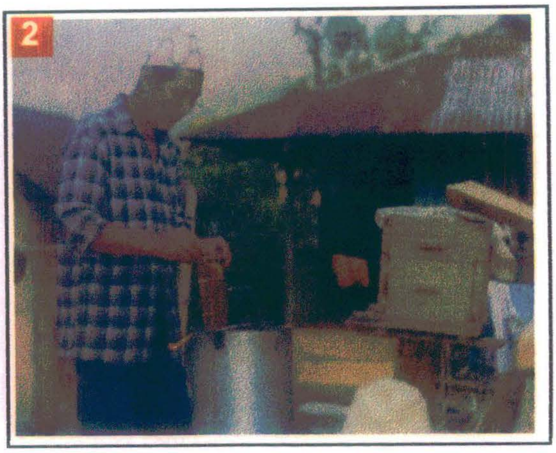
While in domestic condition 'Dunr', a special cylindrical wooden box is maintained. The one end of this box is permanently closed while the other end is plugged by a round wooden block of suitable size and junctional ends are closed by cow-dung (Photoplate II, fig.5 & 9).

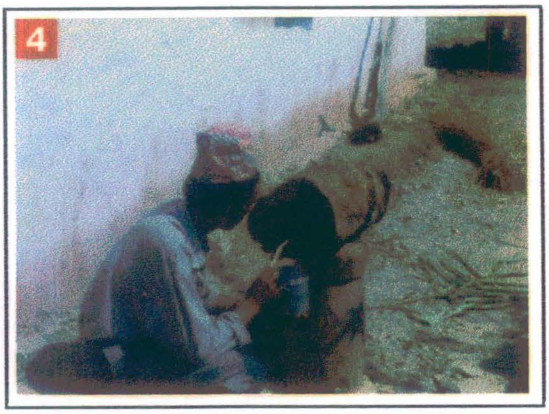
In the lateral wall of the 'Dunr' there is a small hole for the passage of the honey bees within the box. During the full season of honey before its collection the round plug in opened. Smoke is applied to remove the bees (Photoplate IV, fig. 1. & 3). The combs are taken out and the honey is squeezed out next, without disturbing the queen's cell (Photoplate III, fig. 5). Once the honey is obtained the queen's cell is placed in the original position. The box is resealed with cow dung. The small passage (hole) is kept open so that the worker bees prepare the combs in the same way.

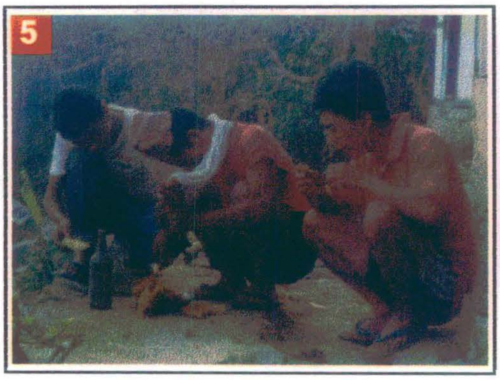
According to the local bee keepers process of extraction of honey by damaging the comb cells is rather primitive and less fruitful from the commercial point of view. Once the honey combs are broken sufficient time is wasted in re-preparing the same by the worker bees within that Dunr (the cylindrical wooden box).

The squeezing of honey from the comb was made under personal care. The honey storage portion of the comb was subjected to squeezing. Though the honey thus obtained represents virtually the pure honey there is a possibility of slight mixing of one or two pollen loads.

PLATE III







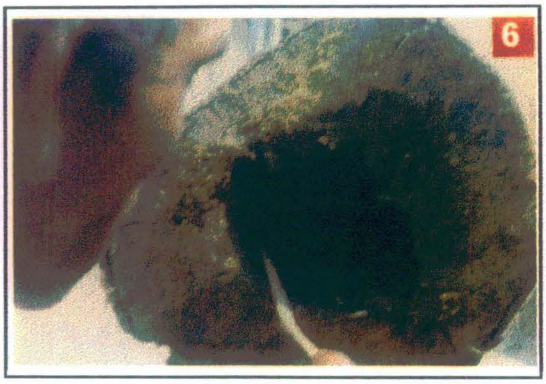


Fig. 1 : Wooden frame with half-developed honey comb (*Apis cerana indica* F.) being examined by a local bee-keeper.

Fig. 2 : Honey filled combs in wooden frame being placed in honey extracting drum by the same bee-keeper for extraction of honey (of *Apis cerana indica* F.).

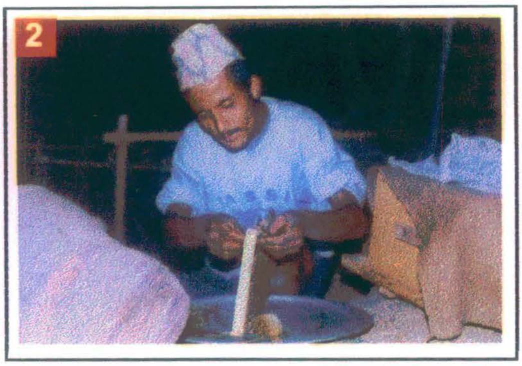
Fig. 3 : 'Dnur', the hollow, cylindrical wooden box with bee-hives inside (of *Apis florea* F.) being unsealed from one side before extraction of honey.

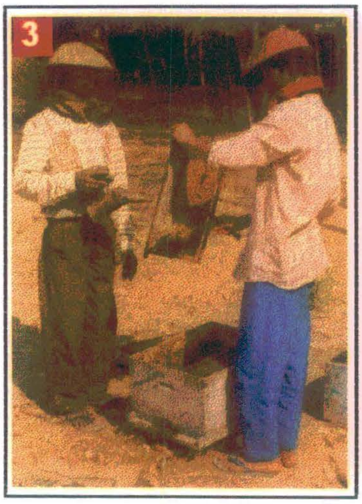
Fig. 4 : Honey (of *Apis florea* F.) being extracted through a bent hollow stick without damaging the comb cells ('leaking technique')

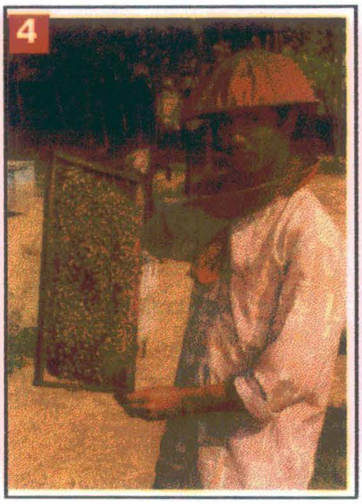
Fig. 5 : Honey (of *Apis cerana indica* F.) being extracted by squeezing the comb cells.

Fig. 6 : Extraction of honey through 'Leaking technique' above in closer view.

PLATE IV







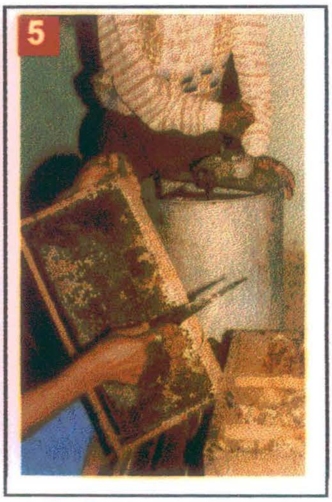


Fig. 1 : Honey comb (of *Apis cerana indica* F.) being smoked before squeezing, for getting the honey extracted from it.

Fig. 2 : Honey comb cells in wooden frame being repaired by a local bee-keeper.

Fig. 3 : 'Smoking' being applied to honey filled comb cells (of *Apis cerana indica* F.) in wooden frame before extraction of honey.

Fig. 4 : Honey filled comb (of *Apis cerana indica* F.) before smoking (in close view).

Fig. 5 : Extraction of honey (of *A. cerana indica* F.) in close view. (Modern technique).

Fig. 6 : 'Cleansing' of honey filled frame (of *A. cerana indica* F.) (in close view) before extraction of honey.

EXTRACTION METHOD

It is rather scientific modern and more fruitful from honey-yield point of view. The wooden frames which are placed in rectangular boxes (super) are taken out when these are full of honey. Each frame is placed inside a large cylindrical drum. The drum contains inside it the honey extraction unit with a movable central axis /rod fitted with a handle outside the drum. The honey frame is next moved in circular rotation (Photoplate III, fig. 2, Plate IV, fig. 5). As soon as the honey frame starts rotating inside the drum round the central rod the honey is extracted out from combs due to centrifugal force. This honey gets deposited at the bottom of the drum. Once the honey is extracted from the frames these are placed in the original position within the rectangular box.

Sufficient care is taken before taking out of the honey frames eg. Smoking. Using of gloves, bee veil to save from the worker bees.

From on bee keeping box 4-5 kg of honey (approx.) can be extracted. There are eight no. of frames within each bee keeping box.

'LEAKING' METHOD IN 'PUTKA' HONEY (*APIS FLOREA* F.)

During extraction by this method a long, narrow, hollow wooden stick is inserted (Plate III, fig. 4) into the honey filled comb after opening the seal of the 'Dunr' from one side as mentioned in case of *Apis cerana indica* F. honey. Honey is leaked through that hollow stick and stored in collecting pot without damaging the comb. A special 'nozzle' locally known as 'Tuti' (Plate II, fig. 6) is made on the lateral side of the cylindrical wooden 'Dunr' in this case so that worker bees of *Apis florea* F. get free passage for their entry and exit.

According to the local bee keepers it requires about one year for the production of 500 gm of this honey from one small hive of *Apis florea* F.

1.7 OBJECTIVES OF THE STUDY

Sikkim and Sub-Himalayan West Bengal containing the Northern most districts are one of the richest floral resources in India. The rich floral resources can profitably be exploited by the bee keeping enterprises for enhanced and sustained honey production. This zone has got enormous natural potential for organised apiary industry and production of commercial quantities of single source (unifloral) and multiple source (Multifloral) honeys. It can not be denied that the bee-keeping industry thrives solely upon bee-plant interaction which depends on a favourable bee flora constituting of both rectar and pollen sources.

Pollen contents of honey serve as indices of nectar sources of the bees and those of the pollen loads the pollen sources. So the first objective of the present study of melissopalynological investigation is to identify all such plants that offer abundant nectar and pollen to the bees, in order to recognise the unifloral and multifloral honey nectar of this region and there by evaluate its potential in the apiary industry.

It is true that bee keeping in this part of the country has not become so much popular except in some parts of tea gardens. So the second objective of the present study is that the development planners may be persuaded effectively if there are enough data in hand about the importance and potentiality of apiary industry in such floristically rich region of Eastern Himalaya. This will improve the socio-economic set up of the local people in the region. From that viewpoint, the development of bee keeping industry in such a region where most of the economically backward hill people like Lepcha, Tamang, Rai, Limbu, Sharpa and other tribes live, is enormously significant and also a long felt need for the region.

Honey bees have a major role in crop pollination. From that viewpoint it would also result in increased crop production because of the higher percentage of pollinated flowers. It may be included as the third objective of the study.

And lastly, the biochemical analysis of honey samples will determine the quality of the honey. The physiochemical properties are the indices of nutritive value. Hence the present study incorporates both qualitative and quantitative pollen analysis and biochemical investigation of squeezed honey and extracted samples from the forests and nearby agricultural areas of Sikkim and the Sub-Himalayan West Bengal for the first time.

Chapter Two

Materials and Methods

2.1 COLLECTION & IDENTIFICATION OF BEES STUDY OF FORAGING BEHAVIOUR OF WORKER BEES; COLLECTION, IDENTIFICATION OF BEE-PLANTS AND THEIR PRESERVATION

It is evidenced that one type of forager may need more than one floral source for feeding and the plants are also exposed to more than one type of forager during the blossoming period (Anantha Krishnan, 1992). The bees may collect pollen from a few related flowers in the the esame genus even in a single species. These are termed as oligolectic & monlectic type. Other type collecting pollen from many different or unrelated kinds of flowers are termed polylectic. Futuyma (1983) recognised following categories of foragers based on the nature of foraging activities :

1. Indiscriminate forager : which have few behavioural or morphological links with flowers.
2. Facultative specialist : which encounter a dense cluster of flowers.
3. Obligatory specialist : capable of identifying rewarding flowers with nectar.
4. Efficient forager : which are generically predisposed for visits to a particular species of flowers.

2.1a COLLECTION & IDENTIFICATION OF BEES

Among the flower foraging insects the workers of *Apis cerana indica* F. and . *A. florea* F. were sampled daily during the study period with the help of insect net and immediately preserved in the vials containing 70 % alcohol mentioning names of their respective foraging plants.

Identification of bees was made in the department of Zoology, North Bengal University under the supervision of the entomologist Dr. A. Mukhopadhyay.

2.1 b. FORAGING BEHAVIOUR :

Colours, shapes , forms, scents of foraged flowers, span of foraging and time of foraging were noted.

2.1 c COLLECTION AND PRESERVATION OF BEE PLANTS

During field trips almost all the plants bloomed during different seasons were surveyed. Among these the bee plants had been isolated. Some bee plant in full bloom have shown in photoplate VII & VIII. Specimen with healthy flowering twigs from such plant were collected in polythene bag and recorded in Field Note Book. Specimen were cleaned and trimed to the size and transferred to wooden plant press for drying. In some cases specimen were dipped in formalin for a few minutes or some amount of formalin were added directly on the blotters to check fragmentation of different parts, mainly leaves & flowers. During rainy season for quick drying a hot air oven was also used.

In most cases specimen were completely dried within ten days. However after proper drying, all specimen were poisoned by soaking with 4 % solution of mercuric chloride in rectified spirit, dried again under pressure using blotting papers.

Dried and poisoned specimen were then pasted on standard herbarium mounts, labelled properly and temporarily stored in a cabinet in the plant toxonomy laboratory, N. B. U. and plant Taxonomy Laboratory, Kalimpong College.

2.1 d THE FIELD NOTE BOOK

All the collected specimen were recorded in a field note book which include specimen location, date of collection, availability, habit and habitat structure, flower colour, aroma, pecularities etc. Field notes were transferred to herbarium labels for ready reference.

2.1 e IDENTIFICATION

Specimen were identified in the plant taxonomy laboratory of Kalimpong College and North Bengal University, using literature and matching with the available predetermined specimen in the respective herbarium.

2.1 f DEPOSITON OF SPECIMEN

A set of specimen will be stored at N. B. U. Herbarium.

2.2 FLOWERING CALENDAR OF MAJOR AND MINOR BEE-FORAGE PLANTS IN PRESENTLY INVESTIGAED AREA

A flowering calendar depicts the reproductive phase of different elements of the flora which have direct bearing in many branches of Botany including quarternary pollen analysis palynology, etc. (Das and Chandra , 1987)

The study of flowering periods of plants is quite important in respect of foraging of bees to collect nectar and pollens from the flowers to produce honey.

Repeated visits to different localities in various seasons were made while collecting the honey samples throughout the period from 1995 to 1998 and a comprehensive flowering calendar was prepared covering the same period.

Two categories of plants have been made for the present calendar: 1) All the recorded plants with different species under different families foraged by bees 2) plants with " * " (asterisk) sign indicating the taxa whose pollen have been found in the honey samples.

By simple study of pollens in honey, it is quite difficult to identify the taxa upto the level of species where there are a number of species under the same genus. So, in that case " * " sign has been used on the genus with 'spp' to indicate all or any of the species under the same genus.

The herbarium sheets of some of the relevant species were prepared and identified with the help of literature and comparing with the voucher specimens at the herbarium of North Bengal University and herbarium of Kalimpong College, Kalimpong, Darjelling.

The flowering have been broadly classified under three categories according their mode of pollination namely – 1) Anemophiphilous 2) Entomophilous and 3) Amphiphilous (i.e. pollinated by both wind and insect).

Habit of different plants were also recorded because plants of different habit groups occupy different strata of vegetation and corresponding altitude where they release pollen grains.

Frequencies, with respect to the availability of the taxa during the flowering periods were made under four categories –

1) abundant (with 100 % availability in different localities)
2) common (with 50 – 60 % availability in different localities)
3) rare (with 5 – 10 % availability in the different localities)
4) very rare (below 5 % availability in the different localities).

The families, under which the bee forage plants have been grouped are arranged alphabetically in the present calendar.

During field survey honey bees were also found to sit on leaf nectaries of the fern *Pteridium aquilinum* (Pteridaceae) (Photoplate VI, fig. 13).

Similar observation was also made by Olesen in 1988. According to him the leaf nectaries of *Pteridium aquilinum* are known to produce sugar, which attract honey bees. The nectaries were observed to attract many bees during the summer despite the presence of traditionally good bee plants.

A total of approximately 310 plant species under ± 77 families had been found to be foraged by honey bees during the field survey. Out of these, pollen of ± 166 plants had been recovered from the honey samples. Of the total ± 310 bee forage plants, ± 262 plants were found to be entomophilous, ± 41 were of amphiphilous (*i.e.,* pollinated by both insects and air) and rest ± 7 were of anemophilous type. Bee forage plants under different families with their flowering periods, habit and mode of pollination have been presented in table 2.2.1.

Table 2.2.1 : Flowering Calendar of Major and Minor Bee-Forage plants in presently investigateed area.

[ABBREVIATINOS USED :

I. Habit : HA = Annual herb, T= Tree, S= Shrub, SU= Under Shrub, G= Geophyte, HS = Suffrutescent Herb, HP = Perennial Herb, CS = Shruby Climber, L = Liana, CA = Climber Annual, CG = Climber Geophyte.

II Mode of Pollination : A= Anemophily, E= Entomophily, A/E= Amphiphily.

III. Flowering Period : J= January, F= February, M= March, A= April, M = May, J= June, J=July, A= August. S = September, O = October, N = November, D = December.

IV. Frequency : @ = Abundant, © = Common, ® = Rare, v = Very rare, * = Pollen found in Honey Samples.]

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
* *Acanthus carduaceous* Griff.	Acanthaceae	©	©	©	©					©	©	©	©	S	E
* *Asystasia macrocarpa* Nees	do			@	@	@								S	E
* *Hypoestes triflora* Roem et Schultes	do								©	©	©	©	©	HA	E
* *Justicia* spp.															
Justicia procumbens L.	do								©	©	©			HP	E
J. adhatoda L.	do	®	®	®	®							®	®	SU	E
* *Strobilanthus* spp.															
* *Strobilanthius pectinatus* T. Anders	do								©	©	©			SU	E
* *S. thomsonii* T. Anders	do	©								©	©	©	©	SU	E
* *S. urophyllus* (Walt.) Nees	do									©	©			SU	E
* *Thunbergia coccinea* Wall. ex.Don	do								©	©	©	©	©	CS	E
* *Rungia pectinata* (L.) Nees	do	®	®	®										HA	E
Zephyranthes carinata Herb.	Amaryllidaceae			®	®	®								SU	E
* *Mangifera indica* L.	Anacardiaceae	©	©	©										T	E
* *Coriandrum sativum* L.	Apiaceae	®	®									®	®	HA	E
* *Hydrocotyl himalaica* P. K. Mukherjee	do	©	©	©	©	©	©	©	©					HP	E
* *Oenanthe thomsonii* C. B. C.	do	©	©											HA	E
* *Pimpinella diversifolia* D C	do										©	©	©	HA	E
* *Selinum tenuifolium* Wall. ex C.B.C.	do							©	©	©				HP	E
* *Holarrhena pubescens* (Buch. -Ham.) Wallich ex Don	Apocynaceae	®	®	®	®	®								S	E
* *Thevetia peruviana* Pers.	do	v	v	v	v									S	E
* *Catharanthus roseus* (L.) G. Don.	do								v	v	v	v	v	HP	E

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
* *Aristolochia* spp.	Aristolochiaceae														
A. elegans Mast.	do							v	v	v	v			CS	E
A. griffithii Hook. f. & Thoms	do						v	v						L	E
A. tagala cham.	do						©	©						CS	E
* *Ageratum conyzoides* L.	Asteraceae	@	@						@	@	@	@	@	HAA/E	
* *Artemisia* spp.	do														
A. dubia Wall. ex DC.	do						©	©	©					SUA/E	
A. indica Willd.	do									©	©	©	©	SUA/E	
A. vulgaris auct. Non. L., Roxb.	do									©	©	©	©	HPA/E	
* *Bellis perennis* L.	do	®	®	®										HAA/E	
* *Bidens pilosa* L.	do	@	@	@	@	@	@	@	@	@	@			HAA/E	
* *Calendula officinalis* L.	do	@					@	@	@	@	@	@	@	HAA/E	
* *Centaurea* spp.	do														
C. iberica Stev.	do								©	©	©	©	©	HAA/E	
C. melitensis L.	do								©	©	©	©	©	HAA/E	
* *Chrysanthemum* spp.	do														
Chrysanthemum indicum L.	do								©	©	©	©	©	HAA/E	
C. morifolium Ramat	do									®	®	®	®	HAA/E	
* *Cineraria* spp.	do														
C. grandiflora	Asteraceae			©	©	©								HAA/E	
C. chinensis Spreng.	do			©	©	©								HAA/E	
* *Dahlia imperialis* Roezl	do										@	@	@	S	E
* *Erigeron karwinskianus* DC.	do	@	@	@	@	@	@	@	@	@	@	@	@	HA	E
* *Eupatorium adenophorum* Spreng.	do		@	@	@									S	A/E
* *Galinsoga parviflora* Car.	do	©					©	©	©	©	©	©	©	HAA/E	
* *Mikania micrantha* Kunth	do						©	©	©					CA	E
* *Solidago virga-aurea* L.	do									®	®	®	®	HSA/E	
* *Tithonia diversifolia* (Hemsl.) A. Gray	do									@	@	@	@	HSA/E	
Tagetes patula L.	do									©	©	©	©	HA	E
Montanoa bipinnatifida C. Koch	do									©	©	©	©	S	E
Cheiranthus spp.	do														
Cheiranthus cheiri L.	do									©	©	©	©	S	E
C. himalaicus Hook.f.& T.	do									©	©	©	©	S	E
* *Anaphalis* spp.	do														
Anaphalis adnata DC.	do									©	©	©	©	HA	E
A. contorta (D. Don) HK.f.	do								©	©	©	©	©	HS	E
A. busua (Ham.) Hand Maz.	do					©	©	©	©					HA	E
* *Begonia* spp.	Begoniaceae														
Begonia flaviflora Hara	do											©	©	HP	E
B. dioica Ham ex D. Don.	do										©	©		G	E
B. sikkimensis A. DC.	do											©	©	HP	E
B. palmata D. Don.	do										©	©	©	HP	E

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
* *Berberis* spp.	Berberidaceae														
Berberis insignis Hook.f. et. Thoms.	do			®	®									S	E
B. aristata DC.	do			®	®									S	E
* *Jakaranda* sp.	Bignoniaceae			®	®	®								T	E
* *Bombax malabaricum* D.C.	Bombacaceae										®	®	®	T	E
* *Myosotis sylvatica* Hoffm.	Boraginaceae				®	®	®	®						HA	E
* *Brassica* spp.	Brassicaceae														
Brassica juncea (L.) Czern	do		©	©	©	©	©							HA	E
Brassica campestris L.	do		©	©	©	©	©							HA	E
B. oleracea L.	do		©	©	©	©								HA	E
* *Raphanus sativus*	do		©	©	©	©								HA	E
* *Cardamine hirsuta* L.	do			©	©	©								HA	E
* Iberis amara L.	do			©	©	©								HA	E
* *Buddleja asiatica* Lour.	Buddlejaceae		©	©	©	©								S	E
Parodia sp.	*Cactaceae		©	©	©	©								S	E
Opuntia sp.	do			©	©	©								S	E
Rebutia sp.	do			©	©	©								S	E
* *Caesalpinia bonduc* (L.) Roxb.	Caesalpinaceae						®	®						T	E
* *Cassia* spp.	do														
Cassia fustula L.	do				®	®	®	®	®					S	E
C. sophera L.	do							®	®	®	®			S	E
* *Bauhinia* spp.	do														
Bauhinia purpurea L.	do								©	©	©			T	E
B. vallii W. & A.	do			©	©	©								T	E
B. vareigata L.	do			©	©	©								T	E
* *Campanula pallida* Wall.	Campanulaceae			®	®	®	®							HA	E
* *Codonopsis* spp.															
Codonopsis affinis Thoms.	do					®	®	®						HA	E
C. javanica (Blume.) Hook. f.	do					®	®	®						HA	E
* *Canna* spp.	Cannaceae														
Canna edulis Ker-Gawer	do					®	®	®	®					G	E
C. indica L.	do	®	®	®	®	®	®	®	®	®	®	®	®	G	E
* *Cleome* spp.	Capparaceae														
Cleome gynandra L.	do							©	©	©	©			HA	E
C. viscosa L.	do							©	©	©	©	©		HA	E
* *Leycesteria* spp.	Caprifoliaceae														
Leycesteria formosa Wall.	do			©	©	©								HA	E
L. gracilis (Kuntz.) Airy-shaw	d0									©	©	©	©	HA	E
**Spergula arvensis* L.	Caryophyllaceae				©	©								HAA/E	
**Drymeria* spp.	do														
Drymeria diandra Bl.	do			©	©	©	©	©	©	©				HPA/E	
D. villosa Chamis ssp. Villosa	do		©	©	©	©	©	©	©	©				HAA/E	

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
Terminalia spp.	Combretaceae														
T. chebula Retzins	do			®	®	®								T	E
T. belerica Roxb.	do			®	®	®								T	E
T. arjuna W. & A.	do			®	®	®								T	E
* *Porana* spp.	Convolvulaceae														
Porana grandiflora Wall.	do								©	©	©			CA	E
P. racemosa Roxb.	do								©	©	©			CA	E
**Ipomoea purpurea* (L.) Roth.	do			©	©	©	©	©	©	©	©	©	©	CA	E
* *Merremia* spp.	do														
**Merremia emarginata* (Burm. f.) Hallier f.	do					©	©							HA	E
M. hederacea (Burm. F.) Hallier f.	do					©	©							HA	E
* *Sedum multicaule* Wall. ex Lindl.	Crassulaceae						©	©	©					HA	E
**Coccinea grandis* (L.) voigt.	Cucurbitaceae			©	©	©	©	©	©	©	©	©		CA	E
* *Cucurbita maxima* Duch.	do				©	©	©							CA	E
**Edgaria darjeelingensis* C.B.C	do				®	®	®	®	®					CA	E
**Luffa* spp.	do														
L. acutangula (L.) Roxb.	do									©	©			CA	E
L.cylindrica auct. (L.) Roem	do								©	©	©			CA	E
**Momordica charantia* L.	do		©	©										CA	E
*Sechium edule (Jacq.) Swart.	do					©	©	©	©	©	©			CG	E
**Rhododendron* spp.	Ericaceae														
Rhododendron arborium Smith	do	©	©	©	©									T	E
R. dalhousiae Hook. f.	do	©	©	©	©									S	E
R. falconeri Hook. f.	do			©	©	©								T	E
R. wallichii Hook. f.	do			©	©	©								T	E
R. grande Wt.	do	©	©	©										T	E
* *Croton* spp.	Euphorbiaceae														
Croton bonplandianum Baill	do	®	®	®	®	®	®	®	®	®	®	®	®	HP	E
C. caudatus Geiseb.	do								®	®	®	®	®	HP	E
Emblica officinlis Gaertn.	do										©	©	©	S	E
**Euphorbia* spp.	do														
Euphorbia pulcherrima Willd.ex. Klotzsch	do							©	©	©	©			S	E
E. himalayansis Klot.	do			©	©									S	E
Macaranga pustulata King	do		©	©										T	A
**Crotalaria* spp	Fabaceae														
Crotalaria spectabilis Roth	do						©	©	©					HA	E
C. siamica Williams	do				©	©								HA	E
C. acicularis Ham. ex Benth.	do			©	©									HA	E
C. albida Hyne ex Roth	do			©	©									HA	E
C. sessiliflora L.	do				©	©								HA	E
C. alata Ham. ex D. Don	do				©	©								HP	E
C. anagyroides Kunth	do			©	©	©	©							SU	E

Name of Plants	Families	Flowering Period												Habit	Mode of Pollination
		J	F	M	A	M	J	J	A	S	O	N	D		
	Fabaceae														
* *Dalbergia sissoo* Roxb.	do	®	®	®										T	A
* *Desmodium* spp.	do														
Desmodium elegans DC.	do				©	©								T	E
D. heterocarpon (L.) DC.	do	®	®	®										T	E
D. laxiflorum DC.	do								©	©				SU	E
D. multiflorum DC.	do						©	©						S	E
**Lathyrus aphaca* L.	do		©	©	©									HA	E
**Milletia pulchra* (Benth.) Kurz.	do						©	©						CS	E
**Mucuna* spp.	do														
Mucuna macrocarpa Wall. ex Baker	do					©	©	©						L	E
M. pruriens (L.) DC.	do										@	@	@	L	E
**Milletia pulchra* (Benth.) Kurz	do					©	©							CS	E
**Pueraria sikkimensis* Prain	do	@	@											HA	E
* *Trifolium repens* L.	do	@	@	@	@	@	@	@	@	@	@	@	@	HP	E
**Wisteria chinensis* DC.	do				®	®									
* *Phaseolus* spp.	do														
Phaseolus vulgaris L.	do								©	©	©	©		CS	E
P. lunatus L.	do									©	©	©		CS	E
P. coccineus L.	do								©	©	©			CS	E
P. mungo Roxb.	do									©	©	©		CS	E
* *Castanopsis* spp.	Fagaceae														
Castanopsis hystrix D. Don	do			©	©	©								T	A
C. tribuloides (Sm.) A.D.C.	do				©	©								T	A
**Gynocardia odorata* R.Br.	Flacourtiaceae			©	©	©								S	E
**Aesculus indica* (Camb.) Hook.	Hippocastanaceae						®	®	®	®				T	A/E
**Dichroa febrifuge* Lowr.	Hydrangeaceae									©	©	©	©	HA/	E
**Nemophilla menziensii*	Hydrophyllaceae					©	©	©						HP	E
**Hypericum* spp.	Hypericaceae														
Hypericum eladioides Choisy	do				®	®	®	®	®					HP	E
H. himalaicum N. Robson	do				®	®	®	®	®					HP	E
H. japonicum Thunb. ex Murray	do					®	®	®	®					HA	E
H. Uralum Ham. ex D. Don	do			®	®	®	®	®	®	®				S	E
Craneotome versicolor Reichb	Lamiaceae			©	©	©	©	©						HS	E
**Leucosceptrum canum* Sm	do	©	©	©									©	T	A
**Leucus* spp.	do														
Leucus indica (L.) Br.	do										©	©		HA	E
L. mollissium Wall.	do								©	©				HA	E
* *Ocimmum* spp.	do														
Ocimum basilicum L.	do	©	©	©	©	©	©	©	©	©	©	©	©	HA	E
O. sanctuma L.	do	©	©	©	©	©	©	©	©	©	©	©	©	HA	E
**Plectranthus* spp.	do														
Plectranthus mollis (Ait.) Spreng.	do				©	©	©							HA	E

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
	Lamiaceae														
P. gerardianus Benth.	do				©	©	©							HA	E
**Salvia* spp.	do														
Salvia coccinea L.	do				©	©	©							HA	E
S. leucantha Cav.	do				©	©	©	©						HA	E
**Holboelia latifolia* Wall.	Lardizabalaceae				©	©								CS	E
* *Allium* spp.	Liliaceae														
Allium cepa L.	do										©	©	©	G	E
A. sativum L.	do										®	®	®	G	E
Gladiolus gondavincus	do				©	©	©	©						G	E
**Hemerrocallis* spp.	do														
Hemerocallis disticha Donn.	do	©	©	©										HA	E
H. fulva L.	do	©	©	©										HA	E
**Woodfordia fruticosa* Kurz.	Lythraceae						©	©	©					CS	E
Lagerstroemia regine Roxb.	do									©	©	©		T	E
**Magnolia* spp.	Magnoliceae														
Magnolia campbelliHook. f. et Thoms *Hook. f. et* Thoms	do			©	©									T	E
M. globosa Hook. f. et Thoms	do						©	©						T	E
**Michelia* spp.	do														
Michelia exelsa (Wall.) Blume ex Wightt	do						©	©	©					S	E
M. doltsopa DC.	do						©	©	©					S	E
**Aspidopterys nutans* (Roxb.) Hook. f.	Malpighiaceae											©	©	CS	E
**Abutilon indicum* (L.) Sweet	Malvaceae	©	©	©					©	©	©	©	©	S	E
**Abelmoschus esculentus* Moen.	do			©	©	©								HA	E
**Osbeckia* spp.	Melastomataceae														
Osbeckia chinensis L.	do	©						©	©	©	©	©	©	HP	E
O. nepaulensis Hook.	do	©									©	©	©	HP	E
O. sikkimensis Craib.	do								©	©	©	©		S	E
O. stellata D. Don.	do										©	©	©	S	E
**Leucaena leucocephala* (Lamk.) De Wit	Mimosaceae								©	©	©			S	E
**Mimosa* spp.	do														
Mimosa himalayana Gamble	do										©	©	©	HP	E
M. pudica L.	do										©	©	©	HP	E
**Morus* spp.	Moraceae														
Morus australis Poiret in Lamk.	do		©	©										S	E
**Moringa oleifera* Lamk.	Moringaceae	©	©	©										S	E
**Embelia* spp.	Myrsinaceae														
Embelia floribunda Wall.	do				©	©								CS	E
E. ribes Burm. f.	do				©	©								CS	E
Maesa chisia Ham.ex D. Don	do	®	®	®	®									T	E

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
* *Eucalytpus saligna* Sm.	Myrtaceae											©	©	T	E
* *Syzygium cumini* (L.) Skeels	do					©	©							T	E
* *Jasminum* spp.	Oleaceae														
Jasminum dispernum Wall.	do	@	@	@	@	@							@	CS	E
J. humile L.	do					©	©	©	©					S	E
J. mesneyi Hance	do		©	©	©	©								S	E
* *Ligastrum* spp.	do					©	©							T	E
Ligastrum confusum Decaisnt.	do					©	©							S	E
L. lucidum Aiton f.	do														
* *Clarkia pulchella*	Onagraceae			©	©	©								HP	E
* *Fuchsia dependens* Hook.	do	®	®									®		HA	E
* *Oxalis* spp.	Oxalidaceae														
Oxalis acetosella L. var griffithii (Edgw. et. Hook. f.) Hara	do	@	@	@	@	@	@	@	@	@	@	@	@	HA	E
O. corniculata H. B. K.	do					©	©	©	©	©	©	©	©	G	E
O. latifolia H. B. K.	do					©	©	©	©	©	©	©	©	G	E
* *Papaver* spp.	Paparveraceae														
Papaver paniculata D. Don.	do			v	v	v								HA	A/E
P. rhoeas L.	do				v	v	v							HA	A/E
P. somniferum L.	do			v	v	v								HA	A/E
* *Passiflora* spp.	Passifloraceae														
Passiflora edulis Sims.	do				©	©	©	©	©	©				CS	E
P. foetida L.	do					©	©							CS	E
P. geminiflora D. Don.	do				©	©	©							CS	E
* *Plantago erosa* Wall.	Plantaginaceae	©	©	©	©	©	©	©	©	©	©	©		HP	A
* *Zea mays* L.	*Poaceae						©	©	©					HA	A
* *Aconogonum* spp.	Polygonaceae														
Aconogonum campanulatum (Hook. f.) Hara	do								©	©				HS	A/E
A. molle (D. Don) Hara	do						©	©	©	©				S	A/E
* *Fagopyrum* spp.	do														
Fagopyrum debotrys (D.Don.) Hara	do			©	©	©	©	©	©	©	©	©	©	SU	A
F. esculentum Moench.	do								©	©	©			HA	A
* *Persicaria* spp.	do														
Persicaria capitata (Ham.) H.Gross	do								©	©				HP	A/E
P. chinensis (L.) H. Gross	do	©								©	©	©	©	SU/AU	
P. hydropiper (L.) Spach	do				©	©	©							HP	A/E
P. microcephala (D. Don) H. Gross.	do				©	©	©							HP	A/E
P. nepaulensis (Meisn.) H. Gross	do			©	©	©	©	©						HP	A/E
P. perfoliata (L.) H. Gross	do			©	©	©	©	©						HA	A/E
P. posumbu (D. Don.) H. Gross	do				©	©	©							HP	A/E
P. praetermissa (Hook. f.) Hara	do			©	©	©	©	©						HP	A/E

Name of Plants	Families	Flowering Period J	F	M	A	M	J	J	A	S	O	N	D	Habit	Mode of Polli-nation
Polygonaceae															
P. runcinata (Ham.) H. Gros	do	©	©	©	©	©	©	©	©	©	©	©	©	HP	A/E
Polygonum amplexicaule var.							©	©						S	A/E
Speciosa (Meisn.) Hook. f.	do														
**Lysimachia* spp.	do														
Lysimachia alternifolia Wall.	do				©	©	©							HP	A/E
L. congestifolia Hemsley	do				©	©	©	©						HA	A/E
L. debilis Wall.	do	©	©	©										HP	E
L. evalis Wall.	do	®	®	®										HP	E
L. japonica Thumb.	do				®	®	®							HP	E
L. prolifera Klatt	do	®	®	®										HP	E
**Primula* spp.	Primulaceae														
Primula denticulata Smith	do			©	©	©								HP	E
P. edgwarthii (Hook. f.) Pax	do			©	©									HP	E
P. melacoides Franc.	do	©	©	©	©						©	©	©	HA	E
P. petiolaris Wall.	do			©	©									HA	E
Pteridium aquilinum (L.)Kuhn (Pteridophytic member)	Pteridaceae					©	©	©	©					HA	-
Punica granatum L.	Punicaceae				®	®	®							S	E
**Clematis* spp.	Ranunculaceae														
Clematis buchananiana DC.	do								©	©	©			CS	E
C. montana Ham. ex DC.	do							©	©					CS	E
C. nepaulensis DC.	do			©	©									CS	E
C. sikkimensis (Hook. f. et Thoms.) Drum. ex Burkill	do							©	©	©				CS	E
Delphinium ajacis L.	do			®	®	®								HA	E
**Fragaria* spp.	Rosaceae														
Fragaria nubicola Lindl.	do				©	©	©	©						HP	E
F. rubiginosa Lacaita	do				©	©	©	©						HP	E
F. vesca Hook. f.	do					©	©							HP	E
**Potentilla* spp.	do														
Potentilla fulgens Wall.	do						©	©	©	©	©			HP	E
P. polyphylla Wall. ex Lehm.	do						©	©	©	©	©			HP	E
**Prunus* spp.	do														
Prunus cerasoides D. Don	do									©	©	©		T	E
Prunus cerasus L.	do			©	©									T	E
P. nepaulensis (Ser.) Steudel	do			©	©									T	E
P. persica (L.) Batsch	do	©	©	©										T	E
**Pyrus japonica* Thunb.	do	©	©	©	©								©	S	E
**Rosa* spp.	do														
R. bruninii Lindl.	do						©	©						CS	E
R. roxburghii Trattin.	do										®	®		S	E
R. sericea Lindley	do			@	@	@								S	E

Name of Plants	Families	Flowering Period												Habit	Mode of Pollination
		J	F	M	A	M	J	J	A	S	O	N	D		
**Rubus* spp.	Rosaceae														
Rubus acuminatus Smith	do						©	©	©					S	A/E
R. calycianus Wall. ex D. Don	do						©	©	©					SU	A/E
R. ellipticus Smith	do	©	©	©	©							©	©	S	A/E
R. gigantiflorus Hara	do			©	©	©	©							SU	A/E
R. lineatus Rinwardt	do					©	©	©						S	A/E
R. paniculatus Smith	do						©	©	©	©				S	A/E
R. rugosus Smith	do						©	©	©	©				S	A/E
**Spirea* spp.	do														
S. canescens D. Don	do	©	©	©										S	E
S. cantoniensis Lour.	do				©	©	©							S	E
S. micrantha Hook. f.	do				©	©	©							S	E
Coffea bengalensis Roxburgh	Rubiaceae		®	®	®	®								S	E
**Galium* spp.	do														
Galium asperifolium Wall.ex Roxb.	do							©	©	©				CA	E
G. hirtiflorum Req. ex DC.	do			©	©	©	©	©	©					CA	E
**Rubia* spp.	do														
Rubia manjith Roxb. ex Flem	do							©	©	©	©	©	©	CA	E
R. wallichiana Decn.	do					©	©	©	©					CA	E
* Cinchona spp.	do														
C. succirubra Pav.ex Klotz.	do			©	©	©								S	E
C. excelsa Roxb.	do			©	©	©								S	E
C. calisaya Wedd.	do			©	©	©								S	E
C. ledgeriana Moens ex Trimen	do			©	©	©								S	E
**Citrus* spp.	Rutaceae														
Citrus aurentifolia (Christmann) Swingle	do							®	®					S	E
C. aurantium L.	do						©	©	©					T	E
C. limon (L.) Burman f.	do						®	®	®					T	E
C. maxima (Burma) merill	do						®	®	®					T	E
C. medica L.	do						©	©	©					T	E
C. reticulata Blanco.	do						©	©	©					T	E
C. sinensis (L) Osbeck	do					©	©	©						T	E
**Todalia asiatica* (L.) Lam.	do							©	©	©	©	©		S	E
**Zanthoxylum acanthopodium* DC.	do					©	©	©	©	©	©	©	©	T	E
Z. oxyphyllum Edgw.	do					©	©	©	©					S	E
**Sabia* Spp.	do														
Sabia campanulata Wall.Sabiaceae	do											©	©	CS	E
S. leptandra Hook.f.et Thoms.	do			©	©									CS	E
**Sambucus* spp.	Sambucaceae														
Sambucus canadensis L.	do	©	©	©	©	©	©	©	©	©	©			S	E
S. hookeri Rehder	do				©	©	©							S	E

Name of Plants	Families	Flowering Period												Habit	Mode of Polli-nation
		J	F	M	A	M	J	J	A	S	O	N	D		
Cardiosper mum halicacabum L.	Sapindaceae	®	®	®										CA	E
**Basia butyracea* Roxb	Sapotaceae			©	©	©								T	E
**Hottuynia cordata* Thunb.	Saururaceae				®	®	®							HP	A
**Bergenia* spp.	Saxifragaceae														
Bergenia ciliata (Haw.) Sternb.	do			©	©	©								HP	E
Bergenia purpurascens (Hook. f. et. Thoms.) Engler	do			©	©	©								HP	E
* *Saxifraga sarmontosa* L.	do					©	©	©	©	©				HP	E
**Schisandra* spp.	Schisandraceae														
Schisandra grandiflora (Wall.) Hook. f . et Thoms.	do						©	©						CS	E
S. neglecta A. C. Smith	do					©	©	©						CS	E
S. propinqua (wall.) Ball	do								©	©				CS	E
**Digitalis purpurea* L.	Scrophulariaceae				©	©	©	©						HP	E
**Linaria* spp.	do														
Linaria cymbalaria (L.) Mill.	do								©	©				CS	E
L. odorata Firch.	do					©	©	©	©					HS	E
**Lindenbergia* spp.	do														
Lindenbergia grandiflora (Ham.) Benth.	do	©	©	©	©					©	©	©	©	HA	E
L. Indica (I.) Vatke	do								©	©	©	©	©	HA	E
**Mazus* spp.	do														
Mazus pumilus (Burm. F.) van Steenis	do							®	®	®	®	®	®	HP	E
M. surculosus D. Don.	do				®	®	®	®	®	®	®	®	®	HP	E
**Pedicularis mollis* Wall.	do											©	©	HA	E
**Torenia* spp.	do														
Torenia asiatica L.	do								©	©	©	©		HA	E
T. violacea (Azeola ex Blaco) Pennell	do								©	©	©	©		HP	E
**Veronica* spp.	Scrophulariaceae														
Veronica juvanica Bl.	do			®	®	®	®	®	®	®	®	®		HA	E
V. persica Poir.	do			®	®	®								HA	E
V. serpyllifolia L.	do				®	®	®	®	®	®	®			HP	E
Capsicum frutescens L.	Solanaceae	©	©	©										HP	E
**Cestrum* spp.	do														
Cestrum aurantiacum Lindl.	do	©	©	©				©	©	©	©	©	©	HP	E
C. elegans Schlecht	do	©	©						©	©	©	©	©	S	E
C. nocturnum L.	do								©	©	©	©	©	S	E
* *Cyphomandra betacea* (Car.) Sendt.	do					©	©	©	©	©				S	E
**Datura* spp.	do														
Datura metel L.	do	®			®	®	®	®	®	®	®	®	®	S	E
D. stramonium	do	®			®	®	®	®	®	®	®	®	®	S	E
D. suaveolens Humb. et Bonpl ex Willd.	do	©					©	©	©	©	©	©	©	S	E
**Lycopersicon esculentum* Miller	do			®	®	®								HA	E
**Nicotiana tabacum* L.	do				®	®	®							HA	E

Name of Plants	Families	Flowering Period												Habit	Mode of Pollination
		J	F	M	A	M	J	J	A	S	O	N	D		
**Petunia hybrida*	Solanaceae	©	©								©	©	©	HA	E
**Solanum* spp.	do														
Solanum jasminoides Paxton	do			©	©	©	©	©	©	©				CS	E
S. mauritianum Scopoli	do	©	©	©										S	E
S. melongena L.	do	©	©	©	©									S	E
S. myrianthum Scopoli	do		©	©	©									S	E
S. nigrum L.	do	©	©	©	©	©	©	©	©				©	S	E
*Streptosolen jamesonii Miers	do	©	©	©	©	©	©	©	©				©	S	E
Schizanthus sp.	do		©	©	©									S	E
* *Duabanga* spp.	Sonnerettiaceae														
Duabanga sonneratioides Hamilt.	do				©	©	©							T	E
D. grandiflora (Dc.) Walpers.	do				®	®	®							T	E
**Sterculia foetida* L.	Sterculiaceae	®	®											T	E
**Symplocos* spp.	Symplocaceae														
Symplocos cochinchinensis (Lour.)	do				©	©	©							T	E
S. Minor clarke	do				©	©	©							T	E
S. glomerata King ex C.B.C.	do			®	®	®								T	A/E
S. lucida (Thunb.) Sieb. et Zucc.	do	®	®											T	A/E
S. ramosissima Wall. ex G. Don	do			®	®	®								T	A/E
S. theaefolia D. Don	do	®	®	®	®						®	®	®	T	A/E
**Camellia* spp.	Ternstroemiaceae														
Camellia kissi Wall.	do						©	©						S	A/E
C. sinensis (L.) o. Kuntze	do				©	©	©							S	A/E
**Schima wallichii* (DC.) Korthals	do				@	@	@	@						T	A/E
**Tropaeolum majus* L.	Tropaeolaceae						©	©	©	©				HA	E
**Clerodendrum* spp.	Verbenaceae														
Clerodendrum colebrookianum Walp.	do							©	©	©				S	E
C. infortunatum L.	do							®	®	®				S	E
C. japonicum (Thunb.) Sweet	do						®	®						S	E
C. squamatam Vahl	do						®	®						S	E
**Duranta repens* L.	Verbenaceae								®	®	®			S	E
**Gmelina arborea* L.	do			©	©	©								T	E
**Lantana camara* L.	do	@	@	@	@					@	@	@	@	S	E
* *Viola* spp.	Violaceae														
Viola canescens Wall.	do				®	®								S	E
V. diffusa Gingins	do				®	®	®							HP	E
V. glaucescens Oudem.	do				®	®	®							HP	E
V. hamiltoniana D. Don	do		®	®	®									HP	E
V. hookeri Thoms.	do							®	®					HP	E
V. pilosa Bl.	do	®	®	®	®	®	®	®						HP	E
V. sikkimensis W. Backer	do					®	®	®	®					HP	E
V. thomsonii Ouden.	do					®	®	®	®					HP	E

Name of Plants	**Families**	**Flowering Period**												**Habit**	**Mode of Pollination**
		J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**		
**Vitis dubia* Laws. in Hook. f.	Vitaceae						®	®						CS	E
**Tetrastigma* spp.	do														
Tetrastigma dubium (Laws.) Planch.	do						®	®						CS	E
T. obtectum (Wall. Ex Laws.) Planch ex Franch.	do					®	®	®						CS	E
T. rumicispermum (Laws.) planch.	do							®	®					CS	E
T. serrulatum (Roxb.) planch	do							®	®	®	®	®		CS	E
**Ammomum subulatum* Roxb.	Zingiberaceae						©	©						G	E
**Cantleya* spp.	do														
Cautleya gracilis (Sm.) Dandy var. gracilis Var. cathcartii (Baker) A. P. Das et chanda	do							©	©	©	©	©		G	E
C. spicata (Sm.) Backer	do									©	©	©		G	E

2.3 COLLECTION OF HONEY SAMPLES INCLUDING THE INVENTORY

The honey samples OF *Apis cerana indica* F. were collected by removing the honey chambers from the movable frame hives and squeezing out the honey. Thus, pure honey was obtained. Extraction ('Leaking Process') through nozzle tips was followed only in case of *A. flora* F. samples (Photoplates III & IV). Possibility of slight mixing up of the honey with a few pollen loads from pollen store could not be ruled out. This could result in somewhat higher figures of absolute pollen count. However, it would not alter qualitatively the totality of the picture of pollen type categories of each honey sample (Kalpana and Ramanujam, 1991). The different localities of Sikkim and Sub-Himalayan West Bengal from where honey samples were collected, their respective location or altitude and the respective month of collection have been represented in the attached inventory (Table 2.3.1A & 2.3.1B).

Sixty seven honey samples had been collected during the period of 1995-98 from this zone out of which 16 samples of *A. cerana indica* F. (4 Autumn and 12 Summer honeys) include in the state of Sikkim, 49 samples of *A. cerena indica* F. included in the Sub-Himalayan West Bengal [different areas of Darjeeling (45 samples having 6 Winter, 25 Summer and 14 Autumn honeys) and Jalpaiguri district (4 samples having including 3 Summer and 1 Winter honeys)]. Rest two samples of *A. flora* F. include summer honeys only.

Out of these total 67 honey samples 42 constitute the Summer or Spring honeys collected during the period of March to June. 18 constituted the Autumn honeys collected during the period of July to October. The month of July and August may be the crisis period. Due to continuous rains as the worker bees can not come out of their hives for foraging purpose. But this period can not be treated as complete dearth period (Bhujel, 1996) as weather fluctuation and seasonal flowers influence the worker bees enormously for foraging the nectar and pollen sources in the vicinity of the hives. The number of winter honeys was 7, collected during the period of November to February. During the months of January and February excessive low temperature (1° - 3°C) sometimes affect the foraging response of worker bees but sunny weather during the period react positively towards their foraging behaviour.

Honey samples with proper code names and serial number, places of collection with altitudes, dated of collection, method of collection, their Absolute Pollen Pollen Count (APC), Ratio of Honey Dew Elements and pollen (HDE/P) and respective groups have been represented in the inventory table 2.3.1A & 2.3.1B. (The sample code names have been arranged in alphabetical order in the present table.)

Table 2.3.1A; **HONEY SAMPLES OF *Apis cerana indica* F.**

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/ month of collect-ion	Method of collect-ion	APC (No of pollen grains/10 gm of honey)	HDE/ P	Group*
48	AH	Algarah (Kalimpong Sub-Division)	Amber	1308	August 1996	Squeez-ing	3529	0.07	Gr-I
1	BBH	Bhalukhop Busty Kalimpong	Pale yellow	1180	June 1997	Extract-ion	830	0.001	Gr-I
2	CH	Chalsa (District of Jalpaiguri)	Pale Yellow	200	May 1996	Squeez-ing	27369	0.006	Gr. – II
49	CHIBH-1	Chibo Busty Kalimpong	Yellow Amber	1090	Octob-er 1996	-do-	1059	0.009	Gr. – I
3	CHIB-2	Chibo Busty Kalimpong	Pale Yellow	1090	April 1997	-do-	198	0.08	Gr-I
8	DAMH-1	Damthang (South Sikkim)	-do-	1500	April 1996	-do-	40200	0.02	Gr-II
9	DAMH-2	-do-	Pale Yellow	-do-	May 1997	-d0-	50700	0.004	-do-
4	DGHH-1	Dr. Graham's Homes area Kalimpong	-do-	1220	May 1996	-do-	188	0.01	Gr-I
5	DGHH-2	-do-	Dark Amber	1220	March 1996	-do-	1052	0.02	-do-

Contd...

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/ month of collect-ion	Method of collection	APC (No of pollen grains/10 gm of honey)	HDE/ P	Group*
50	DGHH -3	Dr. Graham's Homes Kalimpong	Dark Amber	1220	September 1996	Squeezing	2012	0.021	Gr.-I
6	DZH	Dzongu (North Sikkim)	Amber	2300	June 1996	-do-	11765	0.012	Gr-III
7	DH	Deolo Hills Kalimpong	Dark Amber	1250	April 1996	-do-	180	0.001	-do-
26	DUDH	Dudhia Tea Estate Kurseong	Light Yellowr	1405	April 1998	-do-	38054	0.01	GR-II
10	DUKH	Duka (Near Lava)	Amber	2000	May 1996	-do-	1125	0.03	Gr.-I
41	DUNGH	Dungra Busty Kalimpong	Amber	1152	December 1995	-do-	1078	0.01	-do-
6	DZH	Dzongu (North Sikkim)	Yellow	2300	June 1996	-do-	11765	0.012	-do-
11	ELEH	Eleventh Mile Kalimpong	Yellow	1200	April 1996	-do-	1092	0.01	GR-II
42	EBH	Echhey Busty Kalimpong	Amber	1080	January 1996	-do-	23377	0.009	-do-
12	FH	Fifth Mile Kalimpong	Dark Amber	1160	June 1996	-do-	9475	0.001	GR-I

Contd…

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/moth of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group *
13	GANH	Gangtok (East Sikkim)	Light Amber	1547	March 1997	Squeezing	5556	0.017	Gr-I
52	GORH	Gorubathan Kalimpong Sub-Division	Yellow	220	September 1996	-do-	3910	0.001	-do-
51	GTEH	Ging Tea Estate Darjeeling	Amber	2070	August 1997	-do-	18292	0.002	-do-
14	HTH	Hill Top Kalimpong	Amber	1210	June 1996	-do-	1032	0.01	-do-
15	JH	Jaldhaka Kalimpong	Amber	500	April 1996	-do-	3328	0.02	-do-
53	KHAMH	Khamdong West Sikkim	Pale Yellow	720	July 1997	Squeezing	25500	0.031	Gr-II
43	KURH	Kurseong	Amber	1440	November 1996	-do-	5500	0.011	Gr-I
16	KH	Kagay Kalimpong Sub-Division	Light Yellow	945	May 1997	-do-	27439	0.01	Gr-II
17	KAWH	Kaw South Sikkim	Light Yellow	1575	March 1997	-do-	8444	0.008	Gr-I
18	LINH	Lingee South Sikkim	Light Yellow	700	May 1996	-do-	3067	0.003	-do-
19	LH-1	Lava Kalimpong Sub-Division	Creamy white	2050	May 1996	-do-	1795	0.01	-do-
54	LH-2	-do-	Yellow	2050	July 1996	-do-	1886	0.01	-do-

Contd…

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/moth of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group *
20	MH	Mitiali Jalpaiguri District	Yellow	275	June 1996	Squeezing	3059	0.04	Gr-I
21	MIBH-1	Middle Bong Busty Kalimpong	Amber	1090	March 1996	-do-	1082	0.02	Gr-I
22	MIBH-2	Middle Bong Busty (Berbot) Kalimpong	Amber	1100	June 1996	-do-	785	0.01	Gr-I
44	MONGH	Mongpoo Kalimpong Sub-Division	Light Yellow	1300	December 1995	-do-	926	0.01 (Alternaria)	Gr-I
23	MONSH-1	Monsong Kalimpong Sub-Division	Light Yellow	1280	March 1996	-do-	1022	0.01	Gr-I
24	MONSH-2	-do-	Cream White	1280	April 1996	Extraction	978	0.02	Gr-I
25	MBH	Makum Busty (Yangma Kung, Kalimpong Sub-Division)	Dark Amber	980	May 1997	Squeezing	77700	0.007	Gr-II

Contd...

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/month of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group*
27	NEH	Nehaborong Sikkim	Amber	988	June 1997	Squeezing	1650	0.041	Gr-I
28	PEDH-1	Pedong Kalimpong Sub-Division	Pale Yellow	1000	June 1996	-do-	4172	0.03	-do-
55	PEDH-2	-do-	Light Yellow	1000	July 1996	-do-	3472	0.012	-do-
56	PUDH	Pudung Busty Kalimpong	Amber	1040	September 1997	-do-	16960	0.02	-do-
29	PH-1	Payong South Sikkim	Creamish White	1445	June 1996	-do-	11351	0.009	-do-
57	PH-2	-do-	Amber	-do-	July 1997	-do-	34100	0.017	Gr-II
58	RABH	Rabitar South Sikkim	Pale Yellow	850	July 1997	-do-	21500	0.01	-do-
59	RIMH-1	Rimbick Darjeeling	Light Yellow	2400	August 1996	-do-	4938	0.001	Gr-I
60	RIMH-2	-do-	Dark amber	2400	October 1997	-do-	13158	0.001	-do-
30	RH	Rabhangla South Sikkim	Light Yellow	785	June 1996	-do-	1913	0.03	-do-

Contd...

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/month of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group*
61	SAKH	Sakyone Kalimpong Sub-Division	Amber	1270	September 1996	Squeezing	2895	0.02	Gr-I
31	SORBH	Soreng Busty (Near Teesta Bazar) Kalimpong Sub-Division	Pale Yellow	220	June 1996	-do-	1800	0.01	-do-
62	SH-1	Sumbuk (South Sikkim)	Light Yellow	1082	October 1996	-do-	11346	0.012	-do-
32	SH-2	-do-	Yellow	1082	April 1997	-do-	1084	0.06	-do-
47	SURH	Suruk Kalimpong Sub-Division	Yellow	490	November 1996	-do-	2386	0.008	-do-
63	SINH	Sindebong Busty Kalimpong	Amber	1102	July 1997	-do-	714	0.06	-do-
33	SBH	Solak Busty Kalimpong	Yellow	480	May 1997	-do-	54000	0.008	Gr-II
34	SAMDH	Samdong (East Sikkim)	Amber	750	June 1997	Extraction	420	0.031	Gr-I

Contd....

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/month of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group*
35	SFH-1	Seed Farm (BCKV, Kalimpong)	Amber	1160	April 1996	Squeezing	350609	0.001	Gr-III
46	SFH-2	-do-	Light Yellow	1160	January 1997	-do-	3382	0.008	Gr-I
36	SUMBH	Sumbaria (West Sikkim)	PaleYellow	820	March 1997	-do-	39000	0.009	Gr-II
45	SAMH	Samsing (Jalpaiguri District)	Yellow	275	January 1997	-do-	1754	0.02	Gr-I
37	SADH	Sadam (South Sikkim)	Light Yellow	1400	May 1997	-do-	3943	0.007	Gr-I
64	SANGH-1	Sangsay (Kalimpong Sub-Didivision)	Light Yellow	1192	July 1996	-do-	1548	0.07	Gr-I
65	SANGH-2	-do-	Creamish White	-do-	August 1996	-do-	7895	0.03	Gr-I
38	SANGH-3	-do-	Light Yellow	-do-	June 1997	-do-	26400	0.008	Gr-II

Contd...

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/moth of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group *
40	TH	Tendrabong (Kalimpong Sub-Division)	Amber	900	May 1996	Extraction	120	0.001	Gr-I
39	TODH	Todey (Kalimpong Sub-Division)	Light Yellow		March 1997	Squeezing	86900	0.003	Gr-II

Table 2.3.1B; HONEY SAMPLES OF *Apis florea* F. ("PUTKA HONEY")

Sl. No.	Sample code	Place of collection	Colour	Altitude (m)	Date/moth of collection	Method of collection	APC (No. of pollen grains/10 gm)	HDE/P	Group *
66	LPH	Lath Pancher (Kurseong Sub-Division)	Amber	550	April 1996	Extraction through 'Nozzle' pipe	25862	0.002	Gr-II
67	PABH	Pabong (Sannyasidanra Busty Near Singi Kalimpong Sub-Division)	Light Amber	490	March 1998	Extraction through 'Nozzle' pipe	463767	0.001	Gr-III

GRADATION:- * Group-I <20,000 HDE/P=No of Honey Dew Elements/ No of pollen (Louveaux *et al.*, 1978)
GR-II 20,000 – 1,00,000
GR-III 1,00,000 0 5,00,000
GR-V > 10,00,000
GR-IV 5,00,000 – 10,00,000

2.4 REFERENCE SLIDE PREPARATION

Acetolysis method had been followed for this part of work (Erdtman, 1960). Dry or fresh polliniferous materials were crushed on a finely washed brass sieve (0.11 sq mm) resting on a funnel, set on a hard-glass centrifuge tube. After each treatment, the brass sieve was burnt on a flame to avoid sample to sample contamination. Acetolysed mixture was prepared in a measuring cylinder by slowly adding one part of concentrated sulphuric acid to nine parts of acetic anhydride.

Ten ml. of acetolysis mixture was added in each tube containing the sample and stired with clean and dry glass rod. The tubes were placed in water bath and kept in steaming condition or in an oven at 60° C temperature. The mixture turned brown and it was allowed to cool down. It was then centrifuged and the supernatant was decanted.

Distilled water was added to the sediment and shaken vigorously. The mixture was centrifuged at 4000r.p.m for 5 minutes and decanted.

The washing was repeated twice or thrice. Distilled water was added once again and shaken, if foaming then a few drops of acetone were added and sieved twice through a finely meshed steel-net, centrifuged and decanted.

10ml. Of distilled water was added in each tube and half of the mixture was transferred to another set of centrifuge tube.

One set was centrifused and 2 ml of 50% glycerine was added. 5 ml of glacial acetic acid was added in each tube of the other set and then a few drops of freshly prepared concentrated sodium chlorate solution and a few drops of concentrated hydrochloric acid, centrifuged and decanted (chlorinating was avoided for thin walled pollen)The sediment was washed with distilled water, centrifuged at 4000r.p.m. for 5 minutes and decanted.50% glycerine was added.

Both the sets were mixed, centrifuged and decanted. The tubes were kept inverted on a piece of blotting paper for over night.

A minute piece of glycerine jelly (kisser, 1935) at the tip of a clean platinum needle was taken and and it was touched with the sediment at the bottom of the tubes.

The piece of jelly with acetolysed sediment was placed at the centre of the slide and a round cover-glass was placed over it. A piece of sealing wax (melting point 60°-62°C) was placed touching the margin of the cover glass.

The slide was heated over a microflame just below the jelly.

The melted jelly (with specimen) occupied the central position and gradually was surrounded by melted wax.

The slide was kept on a flat and horizontal surface and allowed to cool down.

The excess wax was scraped off from the surface and then cleaned with a piece of soft cloth (no solvent was used).

The prepared slide was labelled properly.

2.5 COLOUR GRADING OF HONEY SAMPLES

Colour grading of honey samples was done following Lipp, 1994 as presented in table 2.5.1.

Table 2.5.1.

The colour results	Pounde grade (mm)
Water white	0 - 8
Extra white	8 - 16.5
White	16.5 - 34
Extra light amber	34 - 50
Light amber	50 - 85
Amber	85 - 114
Dark	Above 114

The millimetre data denotes the gradation measured by an international honey colour measuring instrument where standardised pounde colour grades are as above. Different colours of some honey samples of *Apis cerena indica* F. and *A. flora* F. collected from different zones of the study have been shown in the photoplate I.

2.6 POLLEN ANALYSIS OF HONEY SAMPLES

Before the identification of the pollen types within the honey samples following procedures were maintained.

i) **Pollen recovery:**

One ml. of honey sample was dissolved in 10ml. of distilled water and centrifuged. The sediment obtained was treated with 5 ml of acetolysed mixture (Acetic anhydride : concentrated Sulphuric acid 9:1 v/v) and subjected to acetolysis (Erdtman, 1960). For analysing the pollen content in honeys qualitatively and quantitatively three pollen slides were prepared for each sample. Chlorinated and non chlorinated acetolysed grains in glycerine jelly (Kisser, 1935) were studied under a trinocular microscope (Magnus MRX) at the Department of Botany, Presidency College, Calcutta; and Department of Botany, University of North Bengal and University College of Science and Technology, Calcutta where the photographs were taken with Olympus SC – 35 Type – 12 camera.

The recorded pollen types were identified upto the generic and specific level as far as practicable with the help of reference slide collection and relevant literature. During the period of survey, sometimes difficulties were met in respect of identification of pollen on simple eye observations through comparisons of pollen found in honey samples with those from reference slides.

As there is no enough available identification keys of pollen upto generic and specific level of a family taking the help of reference slides to compare the pollen found in the latter with those found in honey slides might not always ensure complete correctness of the process. Still sufficient care had been taken during the microscopic observation in respect of all parameters (eg. exine, intine, aperture, LO-analysis, NPC-system, size, shape, etc.) for the identification of pollen.

ii) **Determination of frequency class of pollen types:**

For quantification of pollen types recorded a total of 300 pollen grains were counted at random from the three palyno-slides prepared from each sample. Based on their frequencies the pollen types recovered were placed under the pollen frequency classes recommended by International Commission of Bee Pollen Botany (Louveaux *et al,* 1978) *viz.,* Predominant Pollen Type (>45%), Secondary pollen types (16-45%). Important Minor Pollen Types (3-15%) and Minor Pollen Types (<3%). The pollen types represented below 1% were stated as present. Samples with one predominant type was categorised as unifloral while that with no single predominant pollen species as multifloral. The pollen purity in the unifloral pollen loads was up to 95%.

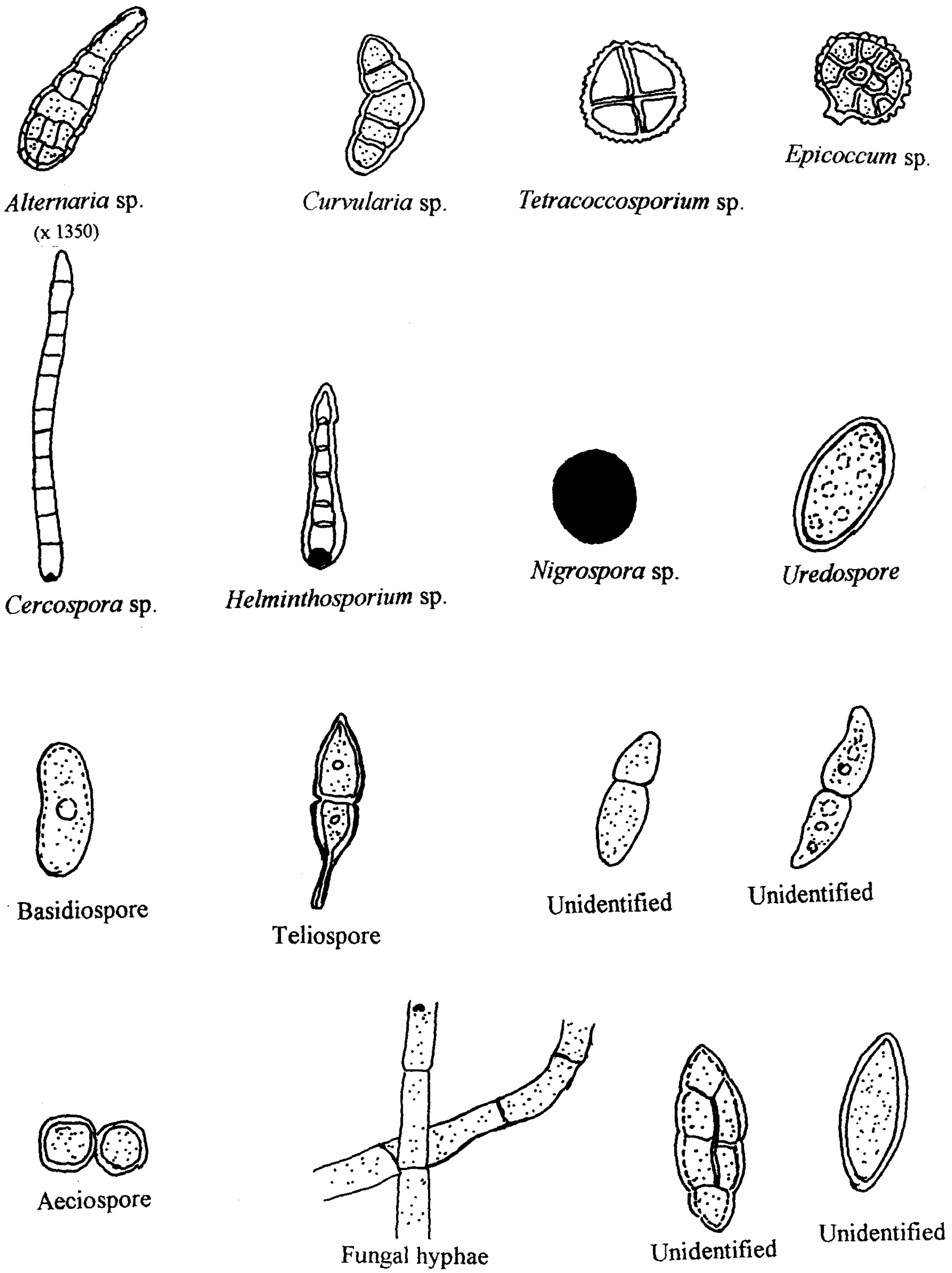
Non-melliferous (anemophilous) pollen types were excluded while determining the frequencies of melliferous pollen types (ICBB, 1978).

iii) **Determination of HDE/P ratio:**

Unacetolysed samples of honey were examined for computing the ratio of honey dew elements (fungal spores and hyphae, algae and wax particles) and pollen grains of nectariferous plants (HDE/P).
Different fungal spores were identified in the Department of Botany, Presidency College, calcutta under the supervision of Dr. A. K. Das and also through reference studies (Ellis, 1971) (photoplate XVI, fig. 20a, b, c and text figure 2.6.1).

iv) **Absolute pollen count:**

The absolute pollen counts (APC) of the honey samples (*i.e.,* the number of pollen grains per 10gm of honey) were calculated using a haemocytometer (Suryanarayana *et al,* 1981). Accordingly, the samples



Alternaria sp. (x 1350)

Curvularia sp.

Tetracoccosporium sp.

Epicoccum sp.

Cercospora sp.

Helminthosporium sp.

Nigrospora sp.

Uredospore

Basidiospore

Teliospore

Unidentified

Unidentified

Aeciospore

Fungal hyphae

Unidentified

Unidentified

[Fig. 2.6.1. Different types of fungal spores found in honey samples.
(All figures are magnified x 1000 unless otherwise mentioned)]

were categorised under various groups in conformity with the universally followed grading parameters provided by Louveaux *et al.,* (1978) *viz.*

Group I	(<20000),
Group II	(20,000 - 1,00,000),
Group III	(1,00,000 - 5,00,000),
Group VI	(5,00,000 - 10,00,000),
Group V	(>10,00,000)

v) **Determination of pollen frequencies:**

The frequency distribution (frequency of occurrence) of pollen types was determined from the total complement of honey samples and four discrete classes were recognised namely, (1) very frequent (present in >50% of the samples), (2) Frequent (20 - 50%), (3) Infrequent (10 - 20%), and (4) Rare (<10%) (Feller-Demalsy *et al.,* 1987).

vi) **Calculation of degree of similarity index of pollen types**

The degree of similarity of honey samples collected more than one in number either during the same period or during different periods was measured by using a similarity index. It is calculated by the formula 2c/ (a + b) where, a and b represents the number of pollen types in each of the samples and c represents the number of pollen types common to all the samples taken in calculation (Kalpana and Ramnujam, 1989).

2.7 PHYSICO-CHEMICAL ANALYSIS OF HONEY SAMPLES

The following methods were adopted for physicochemical characterisation of collected honey samples (the methods are common for all honeys).

i) **Protein Estimation (water soluble) (Lowry *et al.,* 1951) (mg/ml or mg/gm)**

To 1 ml honey sample was added 5ml mixture of 5% $CuSo_4$ in 1% Rochelle salt and 2% Na_2Co_3 and 0.2 ml of Folin's reagent. The colour was measured after 30 minutes at 500 nm in high sensitivity.

ii) **Estimation of total Amino Acids (mg/ml or mg/gm) (Lee and Takahashi, 1966)**

To 0.1 ml of honey sample, Ninhydrin reagent [1% Ninhydrin in 0.5 M citrate buffer (pH 5.5)] + pure glycerol + 0.5 M citrate buffer (pH 5.5) in 5:12:2 ratio] was added. The mixture was shaken vigorously and heated in boiling water bath for 12 minutes. After cooling the tubes under running water to room temperature the colour intensity was measured in systronics spectrophotometer at 500 nm. The blank set was prepared by distilled water.

iii) **Estimation of total sugar (mg/gm) (Samogyi, 1945)**

To 2 ml. aliquot of honey sample in test tube 4 ml of anthrone was added. After a few minutes, mixture was measured by spectrophotometer at 690 nm in medium sensitivity. [Preparation of Anthrone reagent- 300mg of Anthrone +150ml of conc. H_2SO_4].

iv) **Phenol Estimation (mg/gm) [Malik and singh, 1980]**

To 0.5ml. of honey sample 0.5ml. of Folinphenol reagent (3 Folin's reagent) was added. The mixture was shaken vigorously.

After 3 minutes 1 ml of 35% Na_2CO_3 solution was added and shaken. The mixture was kept for one hour.

Percentage transmission was recorded at 630 mm of medium sensitivity.

v) **Specific gravity**

The specific gravity of honey was measured by hydrometer and pH of same by pH meter (Digital)

vi) **Moisture content Estimation**

The moisture content was determined by taking constant amount of honey on filter paper and keeping the same in hot air oven for certain period about 2 hours in high temperature (150°C) until water was completely vaporised. The difference in initial and final weight indicate the moisture content in the honey sample.

vii) **Ash value Estimation**

The ash values of honey samples were determined by taking certain amount of honey in crucible in each case. It was then subjected to high temperature (600°C) in Maple furnace for creation Period (about one hour) until the honey was completely burnt to ashes. The ash same was now collected on filter paper and weighted in electric balance (digital), the Percentage of ash was calculated with respect to the original amount of honey.

2.8 ATOMIC ABSORPTION SPECTROMETRY FOR DETERMINATION OF SOME HEAVY METALS IN HONEY SAMPLES.

Atomic Absorption Spectrometry is based on the principle that a light beam is directed through the flame, into a monochromator and onto a detector that measures the amount of light absorbed by the atomized element in the flame (Greenberg *et al.,* 1992). For some metals, atomic absorption exhibits superior sensitivity over flame emission because each metal has its own characteristic absorption wave length. A source lamp composed of that element is used; this makes the method relatively free from spectral or radiation interference.

The amount of energy at the characteristic wavelength absorption in the flame is proportional to the concentration of the element in the sample over a limited concentration range. Most atomic absorption instruments also are equipped for operation in an emission mode.

Determination of low concentration of Cadmium, Lead, Manganese, Zinc and Copper was done by chelation with Ammonium pyrrolidine dithio - carbamate (APDC) extraction into Methyl isobutyl ketone (MIBK) and aspiration into an air acetylene flame.

The above determination was done at Regional Sophisticated Instrumentation Centre (RSIC), Bose Institute, Calcutta. The Model No. of the Instrument used for the purpose was Varian AA 575 ABQ.

Digestion technique:

Before the determination of the amount of the expected metal elements present in the honey samples the latter were digested following Nitric Acid Digestion Method. (Greenberg et al., 1992). The procedure is mentioned as follows:-

One milli litre of each honey sample was mixed with distilled water and a suitable volume (50 – 100 ml) was transferred to a 125 ml conical flask or beaker. 5 ml conc. HNO_3 and a few boiling chips, glass beads or Hengar granules were added. The mixture was brought to a slow boil and evaporated on hot plate to the lowest volume possible (about 10 – 20 ml) before precipitation occurs. Heating was continued and Conc. HNO_3 was added as necessary until digest was complete as shown by a light coloured, clear solution. Sample was not allowed to dry during digestion. The wall of the flask was washed down with distilled water and filtered. The filtrate was transferred to a 100 ml volumetric flask with two 5 ml portion of water adding these rinsings to the volumetric flask. The solution was cooled and diluted to mark with distilled water and mixed thoroughly. Portions of this solution were taken for required metal determination. The above digestion of honey samples was performed at ESS (Environmental Science Section) Lab. Bose Institute, Calcutta.

Amount of the element was measured with the help of the following formula;

Amount of the element present in the honey sample (microgram/ml of honey) = Sample reading /Standard reading X Standard PPM X Dilution factor of the honey sample.

2.9 COLLECTION OF INFORMATIONS RELATED TO ETHNIC USE OF HONEY

The villages or 'Busty' areas having significant tribal strength (Table 1.6.1 & 3.6.1) were surveyed during 1995-1999. The local village headmen were contacted first and with their co-operation the herbalists in the respective villages were contacted. The herbalists locally are called 'Jhankri' or 'Gunin'. (photoplate IX, fig. 1 & 2).

Language was a problem as different communities of hilly tribal people like Lepcha, Sherpa, Bhuita, Dukpa, Kagatya, Yolmo etc. of this part of Eastern Sub-Himalayan area used different types of local languages. The accent of the languages during conversation was also difficult to understand. This was overcome by taking the help of interpreter guide either from the township area or from the local areas giving proper remuneration. The procedure adopted was based on interviews, collection and recording of comparative data from house to house survey and from herbalists ('Jnankri') living at different hilly 'Busty' areas or villages located at different altitudes.

From the medicinal point of view of honey as admixture with other local ayurvedic medicines the local medicine men or so-called 'Jhankri' hold sometime superstition in their minds,. They are of the view that if they disclose the method of preparation and use of drug their power of treatment will be lost. In such cases special religious talkes of their belief were made to convince them as far as practicable. Sometimes rendering proper remuneration to this poor medicine men or encouraging them to be highlighted in the newspaper or radio etc. solved the problem to a great extent in making them convinced to express the methods of use of honey in herbal drug utilization.

Chapter Three

Results

3.1 STUDY OF FORAGING BEHAVIOUR OF WORKER BEES

FORAGING TIME

During field trips, foraging time of *Apis cerana indica* F. and *A. florea* F. were noted which ranged from 8.00 A. M. to 3.00 P. M. The most suitable time for foraging was found to be from 11 A. M. to 1.30 P. M.

SPAN OF FORAGING

The time of foraging by *Apis cerana indica* F. on different flowers varied from plant species to species. In most of the foraged species it ranged from 5 sec to 8 sec. There were only a few species where the foraging time ranged from 8 to 10 seconds or even more eg. *Torenia penduncularis*, *Tropaeolum majus*, etc. Time span of foraging by *A. florea* F. was found to be less in comparison to *A. cerana indica* F.

FLOWER COLOUR & SHAPE

The colour and shape of the flowers of bee plants were specially noted as the former have the enormous role to attract the bees for foraging. Different colours like yellow, white, violet, orange, blue, pink were preferred but frequency of yellow and white coloured flowers were maximum (table 3.1.1).

Diverse shapes of flowers were foraged by the worker bees. Among these 4-5 parted to 5-pointed star-shaped flowers were preferred (Bera *et al.,* 1999).

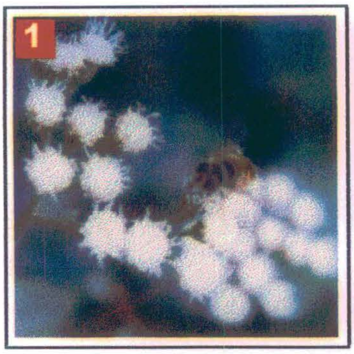
A brief list of different colours of the flowers, their shapes, nature and span of foraging along with time of foraging by both the species of *A. cerena indica* F. and *A. florea* F. has been represented in the table 3.1.1.

An attempt has been made to show the nature of foraging by worker honey bees on different flowers when in full bloom and some of the bee-forage-plants during their full bloom condition in the photoplates V – VIII.

Table 3.1.1. : Field data of some Bee-Forage-Plants viz. colour, shape, scent of flowers, bee-foraging time, span of foraging etc.

Name of the plant on which worker bees were observed foraging	Family	Colour of the flower	Form of corolla	Shape of the flower (from upper view)	Nectariferous or Polliniferous	Scent, if any	Date of collection	Foraging time during the day	Span of foraging (mean of 6 counts) (seconds)
Erigeron karwinskianus	Asteraceae	White + Yellow centre	Disc floret tubular	5-pointed star	N	No scent	18.11.96	12.30	7
Bidens pilosa	Do	Yellow + White	Do	Do	N	Do	Do	12.30	6
Dahlia imperialis	Do	Yellow + White	Do	Do	N	Lightly Sweet scented	Do	9.00	10
Tithonia diversifolia	Do	Yellow + White	Do	Do	N	Do	19.11.96	9.30	8
Ageratum conyzoides	Do	White + Blue	Do	Do	N	Do	22.11.96	12.00	6
Cineraria grandiflora	Do	Pink + White	Do	Do	N	Do	21.03.97	12.30	8
Brassica nigra	Brassicaceae	Yellow	Cruciform	4 clawed	N	Oily	14.02.97	10.30	8
Rubus ellipticus	Rosaceae	White	Rosaceous	5 pointed	N	Scented	15.02.97	10.30	6
Rhododendron hirsutum	Ericaceae	Violet	Campanulate	bell shaped	N	Slightly scented	05.04.97	11.30	6
Papavar rhoeas	Papavaraceae	Red	Rosaceous	Round	P	No scent	05.04.97	12.30	8.5
Trifolium repens	Fabaceae	White	Papilionaceous	Boat shaped	N	Do	14.03.96	Do	9
Tropaeolum majus	Tropaeolaceae	Yellow + Orange	Campanulate	Bell shaped	N	Sweet	03.05.96	1.30	11.5
Schima wallichii	Ternstroemiaceae	White	Rosaceous	Round	N	Slightly scented	08.05.96	12.30	9.
Camellia sinensis	Do	Do	Do	Do	N	Do	18.06.96	12.00	8.5
Citrus spp.	Rutaceae	Do	Do	Do	N	Sweet scented	18.05.96	9.30	10.5
Sechium edule	Cucurbitaceae	Yellow	Tubular	Bell shaped	N	Slightly scented	09.05.97	10.30	9.5
Luffa spp.	Do	Do	Do	Do	N	Do	09.06.97	10.30	9.5
Cyphomandra betacea	Solanaceae	Whitish pink	Do	Do	N	Do	10.06.96	11.30	9
Fragaria spp.	Rosaceae	White	Rosaceous	Round	N	Do	11.04.96	10.30	6.5
Ipomoea purpurea	Convolvulaceae	Bluish pink	Campanulate	Bell	N	No scent	05.11.97	12.00	8
Pteridium aquilinum	Pteridaceae	—	—	—	N	Do	10.05.97	12.00	8.5

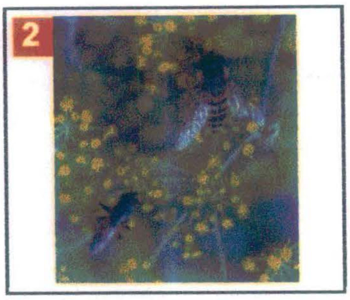
PLATE V

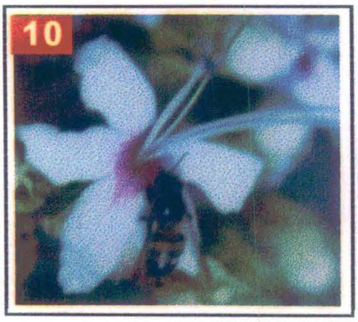


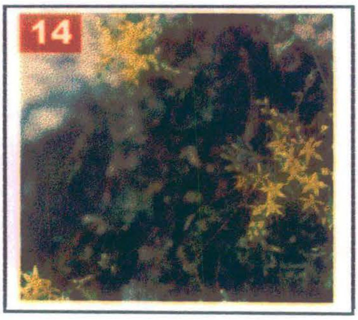
Apis cerana indica **F. foraging on :**

Fig. 1 : *Ageratum conyzoides.*
Fig. 2 : *Citrus* sp.
Fig. 3 : *Schizanthus* sp.
Fig. 4 : *Erigeron karwinskianus.*
Fig. 5 : *Galinsoga parviflora.*
Fig. 6 : *Lantana camara.*
Fig. 7 : *Euphorbia pulcherrima.*
Fig. 8 : *Clarkia pulchella.*
Fig. 9 : *Centaurea cyanus.*
Fig.10 : *Cineraria grandiflora.*
Fig.11 : *Rungia pectinata*
Fig.12 : *Tagetes patula.*
Fig.13 : *Trifolium repens.*

PLATE VI



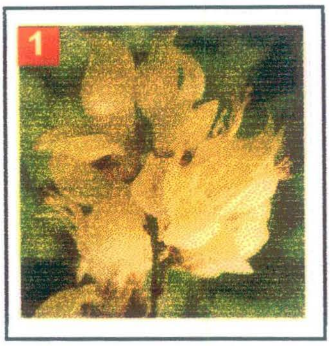


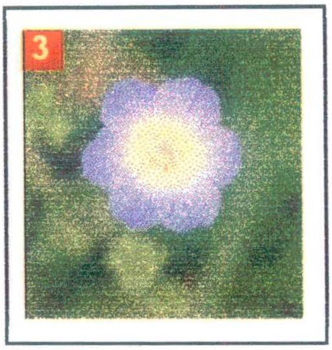


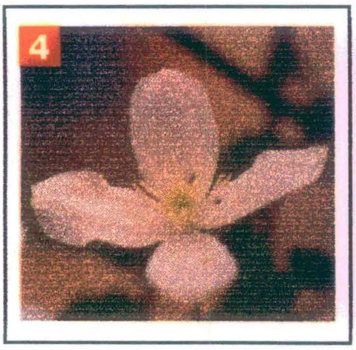
***Apis cerana indica* F. foraging on :**

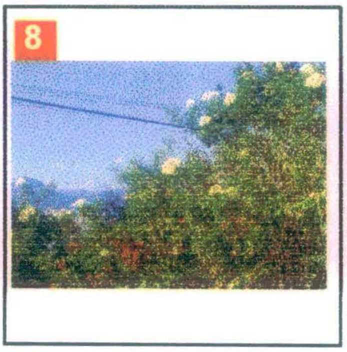
Fig. 1 : *Cheiranthus* sp.
Fig. 2 : *Foeniculum* sp.
Fig. 3 : *Brassica oleracea.*
Fig. 4 : *Bidens pilosa.*
Fig. 5 : *Calliandra hybrida.*
Fig. 6 : *Cineraria* sp.
Fig. 7 : *Tropaeolum majus.*
Fig. 8 : *Papaver somniferum.*
Fig. 9 : *P. rhoeas.*
Fig.10 : *Clerodendrum* sp.
Fig.11 : *Chrysenthemum* sp.
Fig.12 : *Iberis amara*
Fig.13 : *Pteridium aquilinum.*(Pteridophytic member)
Fig.14 : *Sedum multicaule.*
Fig.15 : *Persicaria runcinata*

PLATE VII





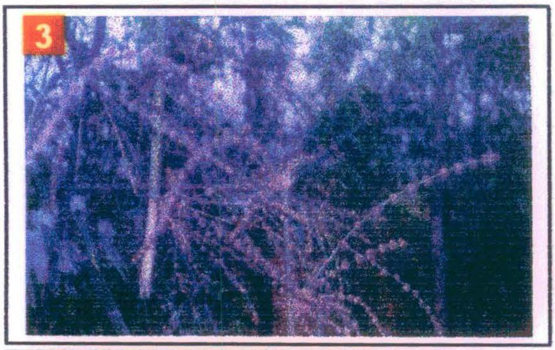


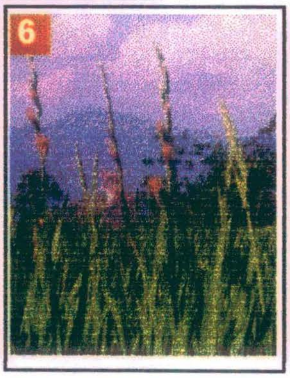


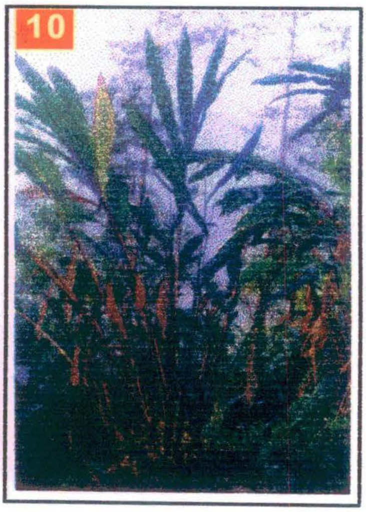
Bee-forage plants in full bloom for *Apis cerana indica* F. and *A. florea* F. (Nectar / Pollen source)

Fig. 1 : *Mucuna macrocarpa*
Fig. 2 : *Tithonia diversifolia*
Fig. 3 : *Nemophilla menziensii*
Fig. 4 : *Clematis montana*.
Fig. 5 : *Cestrum aurentiacum*
Fig. 6 : *Zephyranthes carinata*
Fig. 7 : *Montanoa bipinnatifida*
Fig. 8 : *Sambucus canadensis*
Fig. 9 : *Euphorbia pulcherrima*
Fig.10 : *Centaurea* sp.

PLATE VIII







Bee-forage plants in full bloom for *Apis cerana indica* F. and *A. florea* F. (Nectar / Pollen source).

Fig. 1 : *Gynocardia odorata*
Fig. 2 : *Fagopyrum esculantum*
Fig. 3 : *Bambusa* sp. (Poaccae)
Fig. 4 : *Cyphomandra betacea*
Fig. 5 : *Brassica* sp.
Fig. 6 : *Gladiolus* sp.
Fig. 7 : *Citrus* sp.
Fig. 8 : *Datura* sp.
Fig. 9 : *Buddleja asiatica*
Fig. 10 : *Ammomum subulatum*

3.2 MORPHOLOGICAL CHARACTERISATION OF COMMON POLLEN GRAINS RECOVERED FROM HONEY SAMPLES

The morphological characters of pollen like shape and size, thickness and construction of exine of pollen wall, shape, size, complexity of apertural configuration and pattern of surface ornamentation are a useful tool in deciphering or substantiating various taxonomic problems (Samanta,1998). The importance of palynological data in such works have been stressed even by numerous early and such workers like Erdtman (1944, 1952), Rudenko (1959) and wodehouse (1928). Currently, the use of this is very wide and has been used for numerous taxa of variable rank (Blackemore, 1984, Chanda *et al.,* 1988, Manna *et al.*, 1988, Gupta, 1989).

The study of the morphological characters of the pollen grains recovered from the honey samples in the present work has become a useful tool for better understanding and identifying the special group of plants foraged by the worker bees during the flowering periods of the former.

Following are the descriptions of some common pollen grains recovered from honey samples of this biozone. Pollen description was made from reference slides which was later on matched with the pollen found in honey samples. Descriptions of the morphologically similar pollen types recovered from honey samples have not been repeated. Such cases are marked with an asterisk.

Pollen of some amphiphilous (pollinated by both insects and air) and anemophilous (pollinated by air) taxa were recovered from some honey samples to a large extent. In addition to the major honey yielding plants, a large number of such species may be visited by the bees, usually, either for nectar or for pollen or both. (Chaubal and Deodikar,1965). The amphiphilous plants include *Aconogonum, Erigeron, Eupatorium, Solidago, Bidens, Tithonia, Drymeria, Camellia, Symplocos,* etc., whereas the anemophilous plants include *Castanopsis, Hottuynia, Fagopyrum, Morus* and some other pollen grain of grasses.

Structure of different pollen (single and assemblages) as recorded from honey samples have been shown in photoplates X – XVII.

ACANTHACEAE

Asystasia macrocarpa - 4-5 colporate, spheroidal, ± 46.0 µm in diameter, pores circular with a crown like fimbriate margin (7.0 long), ± 11.5 µm in diameter memberane granular. Pores alternating with two colpal streaks, L/B of colpi ± 31.5/ 4.0µm, exine 4.5µm thick, crassisexinous, sexine 3.5 µm thick , finely reticulate (plate XIV, fig. 19).

Rungia pectinata - 2-colporate, prolate, PA x ED L/B ± 30.5 x 20.5µm L/B of colpi 21.5/2.5µm, exine ± 4.8 µm thick, sexine equal in thickness with nexine, simply baculate, sexine equal in thickness with nexine, simply baculate, bacula 1.5µm spaced, surfaced finely reticulate, ora la-longate (Plate XIII, fig. 5).

Strobilanthus thomsonii – 3 – colporate with alternating pseudocolpi, prolate to perprolate, PA x ED , ± 84.0 x 56.5 µm L/B of colpi 72.0/ 4.0µm, ora circular, 9.5 µm in diameter. Exine 5.5 µm thick, sexine 4.0 µm thick, reticulate, lumina angular, 5.0µm. (plate XI, fig. 2).

Thunbergia coccinea – Spiraperturate, and circular, prolate – spheroida, PA x ED , ± 81.0 x 78.0 µm; width of aperture , ± 15.99 µm, margin aperture irregular, membrane with granules, sexine , ± 7.9 µm thick, sexine , ± 5.2 µm thick, consisting of piloid elements, densely granulated, sexine , ± 2.4 µm thick (plate XVI, fig. 14).

APOCYNACEAE

Holarrhena sp. – 3 - colporate, prolate, PA x ED , ± 10.2 x 6.8µm, L/B of colpi 7.5 µm / 1.2 µm exine , ± 1.1 µm thick at the equatorial region, gradually thinner towards the pole, ora circular, 1.0 µm in diameter psilate (plate XIV, fig. 14).

ARISTOLOCHIACEAE

Aristolochia sp. – 1- sulcate, wavy, spheroidal, average diameter , ± 58.5µm, L/B of sulca 46.5 / 1.8µm; exine , ± 3.0 u thick, sexine as thick as nexine, simplibaculate, tegillate, granulated (plate XVI, fig. 14).

ASTERACEAE

Chrysanthemum sp. – 3 – colporate, prolate-spheroidal, PAxED ± 32.4 x 30.8 µm, L /B of colpi ± 20.0/1.8 µm, exine ± 4.3 µm thick, multilayered, spinulose, spines ± 2.4 µm distantly spaced, ± 1.5 µm long and ± 2.8 µm broad at base, ora constricted, sexine baculate. (plate XIII, fig. 14).

Cineraria grandiflora – 3 – colporate, prolate – spheroidal, PA x ED ± 27.0 x 25.8 µm, L / B of colpi ± 18.5 / 1.2 µm, exine ± 3.5 µm thick, crassisexinous, sexine ± 2.9 µm thick, nexine ± 0.6 µm thick, echinate, spines ± 3.2 µm distantly placed, ± 1.5 µm long and ± 2.2 µm broad. (plate XIII, fig. 10).

Centaurea sp. – 3 – colporate, prolate, PA x ED ± 60.5 x 35.5 µm, L /B of colpi ± 44.5 / 2.4 µm , exine ± 5.2 µm thick, crassisexinous, sexine ± 3.8 µm thick and nexine ± 1.4 µm thick, simply baculate, bacula ± 0.7 µm distantly placed, sexine stratified. (plate XIII, fig. 11).

Calendula officinalis –3 – colporate, oblate – spheroidal, PA x ED ± 29.4 x 30.8 µm, L/B of colpi ± 19.4/2.9 µm, ora lalogate, L/B of ora ± 1.5/7.8, exine ± 4.2 µm thick, gradually thinner towards apertur, sexine ± 2.9 µm thick, spinulate, spines ± 3.9 µm long and ± 2.8 µm broad at the bases (plate XVII, fig. 14).

Galinsoga parviflora – 3-colporate, prolate-spheroidal, PA x ED ± 14.5 x 13.9 µm, L/B of colpus ± 7.8/2.5 µm, ora constricted, exine ± 3.5 µm thick, echinate L/B of spine ± 2.9/0.9 µm (at base), space between two spines ± 2.8 µm (plate XIII, fig. 18).

Bidens pilosa – 3 – colporate, oblate – spheroidal, PA x ED , ± 21.0 x 22.5μm, L/B of colpi 15.0 / 3.5 μm thick, echinate, length of spine 5.0μm, 3.0 μm broad at the base and 1.0 μm at the tip (plate XVII, fig. 12) .

Erigeron karwinskianus – 3 – colporate, subprolate, PA x ED , ± 22.5 x 19.5μm, L/B of colpi , ± 14.0 /1.5 μm ora circular, exine 1.5 μm thick, sexine 1.0 μm thick, echinate, L/B of spines 3.0 / 2.0 μm, (at base) (plate XIV, fig. 15).

Tithonia diversifolia – 3 – colporate, prolate-spheroidal, PA x ED, ± 35.0 x 34.0μm x L/B of clopi , ± 27.5 μm 3.5μm, ora constricted, exine 6.0 μm thick, echinate, L/B of spine 7.0 / 3.0 μm (at base) (plate XV, fig. 19).

Ageratum conyzoides –3 – colporate, prolate-spheroidal, PA x ED, ± 13.6 μm x 11.9μm, L/B of colpus , ± 8.2 μm / 2.5 μm ora constricted, exine 3.4 μm thick, spinulose, L/B of spine , ± 1.7 / 0.6 μm (at base), the space between two spines 3.4μm (plate XVII, fig. 19).

Solidago virga-aurea – 3- colporate, prolate – spheroidal PA x ED , ± 16.8 x 15.9μm, L/B of colpus , ± 10.1 μm / 2.8 μm exine , ± 4.2 μm thicm, multilayered, spinulose, spines , ± 1.7 μm long and 3.1 μm thick at the base, spines are , ± 1.2 μm distantly spaced (plate XVII, fig. 6).

Dahlia imperialis – 3- colporate, spheroidal , PA x ED , ± 33.6 x 33.6μm, L/B of colpus , ± 22.2 μm / 3.2μm, sexine , ± 5.2 μm thick, echinate, spines , ± 0 6.1 μm long and , ± 2.1 μm broad at the base, exine multilatered, nexine as thick as sexine (plate XVII, fig. 13).

BEGONIACEAE

Begonia spp. – 3-colporate, perprolate, PA x ED , ± 24.0 x 11.0μm, L/B of colpi , ± 21.0 / 1.5μm, ora lalongate, L/B , ± 3.5 x 5.0 μm. Exine 1.5 μm thick, sexine 1.0 μm thick, faintly striate (plate XVII, fig. 5).

BERBERIDACEAE

Berberis sp. – Spiraperturate, spheroidal, , ± 38.5 µm in diameter, breadth of aperture , ± 2.0µm. Exine 2.0 µm thick, sexine 1.5 µm thick, faintly and finely reticulate (plate XVII, fig. 4).

BOMBACACEAE

Bombax malabaricum – 3 – colpoate, prolate- spheroidal, PAxED ± 48.2 x 45.0 µm, L / B of colpi 30.0 x 2.5 µm, ora circular, with 5.8 µm in diameter, exine ± 5.6 µm thick, crassisexinous, sexine ± 4.5 µm thick, nexine ± 1.1 µm thick, psilate. (plate XV, fig. 14)

BORAGINACEAE

Myosotis sylvatica – 3 – colporate, prolate, dumbell shaped, PA , ± 7.0µm, ED , ± 3.0 µm and ends , ± 5.0 µm in diameter L/B of colpi , ± 5.0 / 1.0 µm long, ora lalongate, exine , ± 0.4 µm thick, nexine cannot be differentiated, sexine with obscure pattern (plate XVII, fig. 7).

BRASSICACEAE

Cardamine hirsuta – 3- colporate, spheroidal, PAXED , ± 28.5 x 26.5µm, L/B of colpi 22.5 / 3.0µm, exine 2.5 µm thick, sexine 2.0 µm thick, simplibaculate, punctitegillate, reticulate, lumina 5-6 angled, , ± 3.0 u in diameter (plate XIV, fig. 16).

* *Brassica* sp. – 3- colporate , sub-prolate, PA X ED , ± 32.0 x 28.0µm, L/B of colpi , ± 22.0 x 1.5µm, exine ±- 3.0 µm thick, sexine , ± 2.5 µm thick, reticulate, reticulus homo-brochate (plate XIV, fig. 16).

Iberis amara - 3-colporate, prolate-spheroidal, PA x ED ± 10.9 x 10.5 µm, L/B of colpi ± 7.5/1.2 µm, ora circular, ± 2.5 µm in diameter, exine 2.9 µm thick, sexine ± 2.1 µm thick, reticulate (plate XIII, fig. 15).

BUDDLEJACEAE

**Buddleja asiatica* – Amb circular, 3- colporate, spheroidal, PA x ED 11 x 11.9μm, ora circular, 1.7 μm in diameter, exine 1.5 μm thick, psilate, intine thinner than exine, L/B of colpi 8.2 / 2.0μm (plate XVII, fig. 18).

CACTACEAE

3 – colpate, spheroidal, ± 72.0 μm in diameter, L/B of colpi ± 40.5 / 2.5 μm, exine ± 4.2 μm thick, intine ± 1.2 μm thick, crassisexinous, sexine ± 3.5 μm thick, nexine ± 0.7 μm thick, psilate. (plate XV, fig. 17)

CAESALPINACEAE

Bauhinia purpurea: 3 colporate, sub-prolate, PAxED, ± 47.6 x 38.4μm. L/B of colpi 30.2 μm / 3.7 μm exine 1.7 μm thick, psilate. Ora 3.9 μm in diameter, circular lumina rectangular, average size , ± 2.8 x 2.1 μm nexine , ± 1.2 μm thick.*Jakarranda* sp.:- 3 – colporate, prolate, PA x ED ± 42.0 x 25.2μm, L/B of colpi ± 29.2 / 2.4μm, exine ± 2.1 μm thick, psilate, ora circular, ± 1.2 μm in diameter, intime thinner than exine (plate IV, fig. 15).

CAMPANULACEAE-

Codopnopsis sp. – pantoporate with about 20 pores, spheroidal, ± 32.0 μm in diameter pores circular, ± 5 μm in diameter annulus, ± 1.0 μm thick, operculum granulated, exine, ± 4.0 μm thick, sexine 3.0 μm thick, punctitegillate, granulate (plate XVI, fig. 16).

CANNACEAE

Canna indica – Papilla absent, prolate, PA X ED , ± 29.4 x 16.8μm, 3- colpate, L/B of colpi , ± 51.4 / 3.8μm, exine , ± 2.8 μm thick, psilate, simplibaculate, bacula 1.7 μm spaced (plate XV, fig. 11).

CAPPARACEAE

Cleome sp. 3 – colporate, prolate – spheroidal, PA X ED , ± 25.5 x 22.4µm, L/B of colpi , ± 18.1 µm / 2.2 µm. Exine , ± 1.7 µm thick, psilate, intine equal in thickness with the exine, ora circular , ± 2.2 µm in diameter (plate XVII, fig. 3).

CARYOPHYLLACEAE

**Drymaria diandra* – Dodecocolpate (i.e. 12 – colpate), spheroidal ± 26.0 µm in diam. L/B of colpi , ± 4.5 / 1.5µm, brevicolpate, Exine 2.2 µm thick, sexine 1.5 µm thick, punchitegillate with fine supratectal processes, crassisexinous (plate XVI, fig. 19).

CONVOLVULACEAE

**Porana graudiflora*: 3 - colpate, prolate, PAXED , ± 29.5 / p. RACEMOSA x 23.0µm, L/B of colpin 21.0/ 2.5 µm thick, negatively reticulata sexine 2.0 µm thick (plate XVI, fig. 19).

CRASSULACEAE

Sedum multicaule: 3 – colporate, prolate – spheroidal, PAXED, ± 25.0 x 17.0µm, L/B of colpin 18.0/2µm, ora lolongata, , ± 4.0 x 2.5µm, Exine 1.5 µm thick, Sexine 1.0 µm thick, duplibaculata, tegillate with obscure pattern (plate XIII, fig. 16).

CUCURBITACEAE

Cucurbita sp. – pantoporate, prolate-spheroidal, PAxED ± 180.0 X 170.0 um, pores circular, ±20 µm in diaameter, exine ±0 10.2 µm thick, sexine thicker than nexine, spiniferous, spines ± 9.5 µm long and ± 5.2 µm broad at the base. (Photoplate : XI, fig. 4)

Sechium edule: 9 – colporate, syncolporate, oblate –spheroidal PA x ED, ± 75.6 x 75.6µm, L/B of colpi 42.0 / 8.4µm, pores circular, 8.9 µm in diameter, exine 6.4 µm thick, clavate, sexine thicker than exine, spiniferous, spines , ± 4.2 μm long with a small hole near the top (plate XVI, fig. 2).

Coccinia grandis – grains 3 – colporate, sub-prolate, ± 40.5 x 34.5μm, L/B of colpi , ± 19 / 2.25 μm, ora circular, ± 1.8μm, psilate, exine, ± 4.5 μm thick sexine ± 3.0 μm and nexine 1.5 μm thick (plate XVI, fig. 2).

Edgaria darjeelingensis – Pantoporate, amb. Circular, spheriodal average diameter , ± 94.5μm, number of pores numerous, ± 3.2 x 1.5 μm, retipilate, L/B of spines , ± 4.8 / 2.4 μm. Exine , ± 6.0 μm thick, sexine , ± 4.5 μm thick, surface granulated, nexine, ± 1.5 μm thick, crassisexinous (plate XVI, fig. 11).

Momordica charantia – 3 – colporate, subprolate, PA x ED, ± 37.5 x 31.5 μm, diameter of outer aperture, ± 4.5μm. Exine 3.0 μm thick, reticulate, lumina, ± 1.8 μm in diameter., nexine 1.5 μm thick (plate XVI, fig. 9).

EUPHORBIACEAE

Croton sp. – 3 – colpate, spheroidal, with avery diameter ± 32.9 μm, L/B of colpi 12./2.2. μm, exine 3.2 μm thick, verrcate bacula 2.9 μm distantly spaced crassisexinous, sexine 2.1 μm thick nexine 1.1 μm thick untine ± 1.2 μm thick. (plate XVI, fig. 18).

Euphorbia pulcherima – 3- colporate, prolate, spheriodal PA x ED, ± 34.0 x 34.0μm, L/B of colpi 13.0 / 1.7μm. Exine 3.4 μm thick, verrucate, bacula are 3.4 μm distantly spaced, ora 2.5 μm in diameter (plate XVI, fig. 1).

ERICACEAE

Rhododendron spp.- Pollen in tetrad, prolate-spheroidal, PA X ED , ± 51.0 x 48.0μm, each grain 3 – colporate crassinexinous, sexine, ± 1.1 μm while nexine, ± 2.7 u thick, psilate ora lalongate, dark narrow streaks present in the ectosexine (plate XVI, fig. 20).

FABACEAE

Phaseolus sp. 3 – colporate, prolate-spheroidal, PaxED ± 31.5 x 29.8 um, L/B of colpi 22.6/2.2 µm, exine ± 3.5 um thick, ora circular, 2.4 µm in diameter, intine thiner than exine, surface reticulate (plate XV, fig. 21).

Trifolium repens – 3- colporate, prolate, PAxED ± 15.2 x 10.2 µm, L/B of colpi, ± 8.5/2.0 µm, exine ± 2.5 µm in thickness, ora constricted, intine thiner than exine, psilate (plate XIII, fig. 7).

Crotolaria spectabilis – 3 – colporate, prolate PA x ED, ± 27.2 x 17µm, L/B of colpi 15.2 / 2.9µm, exine , ± 2.7 µm in thickness, ora circular 1.2 µm in diameter, psilate, intine thinner than the exine (plate XV, fig. 1).

Milletia pulchra – 3 – colporate, sub-prolate, PA x ED, ± 27.2 x 17µm, L/B of colpi 15.2 / 2.9µm, exine, ± 2.7 µm in thickness, ora circular ± 1.5 µm in diameter, exine ± 2.25 µm thick, sexine ± 1.5 µm thick surface granulated nexine ± 0.75 µm thick (plate XIV, fig. 11).

Mucuna prurita: 3 – colporate, prolate, PA x ED, ± 26.7 / 22.8µm, L/B of colpi 53.2 / 3.7µm, ora circular, ± 1.6 µm in diameter, Exine ± 3.0 µm thick, sexine , ± 1.5 µm thick, surface reticulate, nexine as thick as sexine (plate XIV, fig. 6).

Pueraria sikkimensis – 3 – colporate, prolate spheroidal PA x ED, ± 47.4 x 45.9µm, L/B of colpi, ± 18.0 / 2.0µm, ora circular, diameter, ± 4.5 µm in diameter. Exine , ± 3.0 µm thick, sexine ± 1.5 µm thick, surgace psilate, crassinesinous, nexine , ± 3.0 u thick (plate XIV, fig. 8).

Wisteria chinensis – 3- colporate, prolate-spheroidal, PA X ED , ± 28.0 x 27.0 µm, L/B of colpi 24.0 / 1.8µm, ora circular, ± 1.5 µm in diameter, exine, ± 3.0 μm thick, surface granulated, nexine, ± 0.75 μm thick (plate XIV, fig. 4).

FAGACEAE

Castanopsis sp.- 3 – colporate, prolate, PA x ED ± 14.9 x 9.5 μm L /B of colpi ± 9.5 / 1.8 μm, exine ± 2.2. μm thick, sexine as thick as nexine, ora circular,, ± 2.2 μm in diameter, surface finely reticulate, psilate. (plate XIII, fig. 4).

FLACOURTIACEAE

Gynocardia odorata – 3- colporoidate, amb. Circular, prolate-spheroidal, PA x ED, ± 40.5 μm x 38.5μm, fovolate, lumina 2.2 μm in diameter, exine , ± 8.5 μm thick, intine, ± 1.5 μm thick, crassisexinous, surface finely reticulate, ora lalongate (plate XV, fig. 5).

HYDRANGIACEAE

Dichroa febrifuga – 3 – colpate, prolate, PA x ED , ± 24.5 x 19.0μm, L/B of colpi , ± 16.5 / 3.0μm, ora lalongate, L/B of os 2.0 / 4.0μm, exine 2.0 μm thick, sexine 1.5 μm thick, reticulate, clavate (plate XIII, fig. 1).

HYDROPHYLLACEAE

Nemophilla menziensii – 3 – colporoidate, prolate – spheroidal, PA x ED ± 13.5 x 13.2 μm, exine ± 2.2 μm thick, sexine as thi8ck as nexine or slightly thicker, reticulate , colpi tenuimarginate, their membranes usually granulate, constrictocolpate. (plate : XIII, fig. 9).

HYPERICACEAE

Hypericum sp. – 3 – colporate, sub-prolate, PA x ED, ± 21.0 x 16.8μm, L/B of colpi - 15.2 / 3.2μm, ora circular, , ± 2.8 μm in diameter, exine , ± 4.0 µm thick, intine is equal in thickness with the exine, surface psilate (plate XVII, fig. 15).

HIPPOCASTANACEAE

Aesculus indica – 3 – colporate, sub-prolate, PA X ED , ± 25.5 x 20.4µm, L/B of colpi , ± 16.2 / 1.2 µm, exine 1.7 µm thick, psilate, ora circular, , ± 2.1µm in diameter (plate XV, fig. 6).

LAMIACEAE

Leucoceptrum canum – 3 – colpate, prolate, PA X ED , ± 31.0 x 22.0 µm, L/B of colpi 26.5 / 3.5 µm, Exine 2.5 µm thick, sexine 1.5 µm thick, verucate (plate XVII, fig. 16).

Salvia sp. – 3 colpate, sub-oblate, PA x ED ± 50.0 x 60.0 µm, L/B of colpa ± 31.5 / 4.5 µm, exine 14.7 µm thick, sexine ± 3.2 µm thick, crassisexinous, psilate, (plate XI, fig. 5).

Ocimum sp. - 3 –colporate, prolate – spheroidal, PA x ED ± 98.5 x 97.5 µm oral lalongate, L/B of os 2.0 / 5.2 µm, exine ± 4.8 µm thick, sexine ± 3.5 µm thick, nexine ± 1.3 µm thick, intine thiner than exine, verrucate (plate XV, fig. 9).

LARDIZABALACEAE

Holboellia latifolia – 3 – colporate, amb triangular, prolate, PA X ED , ± 26.1 x 16.2 µm, L/B of colpi , ± 16.5 / 1.5µm, colpal membrane granular, ora circular, , ± 1.5 µm in diameter, sexine ± 0.8 µm thick, psilate, nexine as thick as sexine (plate XIV, fig. 10).

LILIACEAE

Hemerocallis sp. – Monosulcate, prolate, PA X ED , ± 71.4 x 37.8µm, inaperturate, L/B of sulcus, ± 58.8 x 3.8µm, exine , ± 4.2 u thick, finely reticulate, intine thinner than exine (plate XIII, fig. 21).

Gladiolus sp. – Inaperturate, per prolate, PA X ED , ± 75.6 x 12.6μm, 3 – colpate, L/B of colpi , ± 51.4 / 3.8 μm, exine , ± 2.8 μm thick, psilate, simplibaculate, bacula 1.7 μm spaced (plate XV, fig. 11).

MAGNOLIACEAE

Michelia sp. – 1- sulcate, prolate-spheroidal, PA X ED ± 75.6 x 42 μm ora , ± 7.4 μm in diameter, exine , ± 4.2 μm in thickness, L/B of colpi, ± 40.2 X 3.4μm, lumina round, , ± 3.7 μm in diameter, psilate (plate XVII, fig. 10).

MALPIGHIACEAE

Aspidopterys nutans – 3 – colporate, spheroidal, average diameter , ± 28.5μm, width of aperute , ± 6.0μm, Exine 3.0 μm thick, sexine , ± 0.75 μm thick, surface granulated, nexine , ± 2.25 μm thick (crassinexinous) (plate XVI, fig. 15).

MORINGACEAE

Moringa oleifera - 3- colporate, prolate – spheroidal, PA x Ed ± 29.0 x 27.5 um, L / B of colpi 15.0 / 2.1 μm, exine ± 4.8 μm thick, sexine as thick as nexine, simply baculate, bacula ± 1.5 μm spaced, psilate. (plate XIII, fig. 20).

OLEACEAE

Ligastrum sp. – 3 – colporate, prolate, PA x ED ± 3o.5 x 20.6 μm, L /B of colpi ±18.5 / 4.8 μm, ora circular ± 2.8 μm in diamete, exine ± 3.8 l, thick , sexine ± 2.5 μm thick, simply baculate, L /B of bacula ± 1.5 / 0.8 μm, nexine ± 1.3 μm thick, psilate. (plate XV, fig. 13)

Jasminum sp. – 3 – colporate, prolate-spheroidal, PA x ED, ± 49.35 x 45.79μm, L/B of colpi , ± 22.5 / 1.95μm, Exine , ± 3.7 μm thick, sexine , ± 3.0 μm thick, simply baculate, L/B of bacula, ± 2.2 / 1.2 μm diameter of lumina, ± 3.49μm, surface reticulate, lumina with L/B, ± 7.0 / 3.49μm, hexagonal, floor of lumina granulated, muri, ± 1.8 μm wide, nexine, ± 0.7 mm thick (plate XVI, fig. 13).

ONAGRACEAE

Fuchsia dependens – 3 porate, each pore ± 3.2 μm in diameter, sub-spheroidal to sub-prolate, PA x ED ± 10.2 x 11.9 μm, exine ± 1.7 μm thick, thicker than intine, surface psilate (plate XIII, fig. 22).

Clarkia pulchella –3 colporate, oblate – spheroidal, PA x ED ± 19.5 x 20.6 μm, pore circular ± 2.5 μm in diameter, exine ± 3.5 μm thick, crassisexinous, sexine ± 2.8 μm thick and nexine ± 0.7 μm thick, surface psilate (plate XIII, fig. 17).

OXALIDACEAE

Oxalis sp. – 3-4 colpate, prolate, PA X ED , ± 51.5 x 43.0 μm, L/B of colpi , ± 44.0 / 4.5μm, exine , ± 3.5 μm thick, sexine 2.0 μm thick, simplibaculate, reticulate (plate XIV, fig. 18).

PAPAVERACEAE

Papaver sp. – 3 – colporate, prolate – spheroidal PA x ED ± 12.8 x 11.8 μm, L/B of colpi 9.2 / 1.2 μm, ora circular, ± 2.2 μm in diameter, exine ± 2.5 μm thick, crassisexinous, sexine ± 1.9 μm thick and nexine ± 0.6 μm thick, psilate. (plate : XIII, fig. 12).

PASSIFLORACEAE

Passiflora foetida- 3 – colpoids, circular, prolate, PA X ED , ± 52.5 x 43.5μm, colpi indistict, aperture , ± 7.5 μm wide (in polar view), exine, ± 9.0 μm thick, sexine , ± 4.5 μm thick, crasisexinous, tectum diameter of lumina , ± 8.2μm, thickness of muri , ± 1.5μm, lumina studded with small granules or rods, duplibaculate, reticulate (plate XVI, fig. 8).

POLYGONACEAE

**Persicaria capitata* - 3 - colpate, spheroidal, ± 30.0 μm in diameter, L/B of colpi , ± 26.0 / 3.5μm. Exine , ± 7.0 μm thick, sexine 6.0 μm thick, tectum with clavate processes, claves , ± 4.0 μm long, lumina 5-6 angled, , ± 6.0 μm broad (plate XIV, fig. 9).

Aconogonum molle: 3 – Colpate, prolate – spheroidal, average diam., ± 25.2μm, L/B of colpi 15.75/2.25 μm, colpal membrane granulated, Exine , ± 3.0 μm thick, sexine ± 1.5 μm thick, simplibacculate, surface faintly reticulate, nexine , ± 0.75 μm thick (plate XIV, fig. 5).

PRIMULACEAE

Primula sp.- 3 – colporate, sub-prolate-spheroidal, PA x ED, ± 15.0 x 12.0μm, L/B of colpi , ± 11.0/1.0μm, ora circular, 1.0 μm in diam. Exine 1.5 μm thick, sexine 1.2 μm thick, very finely reticulate (plate XIV, fig. 17).

POACEAE

Monoporate, prolate PA X Ed , ± 105.0 x 63.0μm. L/B of colpi , ± 50.4 / 4.2μm, exine 2.1 μm thick, intine very thinly differentiable, surface psilate (plate XI, fig. 3).

PUNICACEAE

Punica sp. – 3 – colporate, prolate – spheroidal, PA x ED ± 18.2 x 16.2 μm, L / B of colpi 13.5 / 2.2 μm, exine ± 2.5 μm thick, intine ± 1.1 μm, ora circular, ± 1.5 μm in diameter (plate : XV, fig. 4).

RUBIACEAE

**Cinchona* sp. –3 – colporate, prolate – spheroidal, PA x ED ± 18.0 x 17.5 μm, L/B of colpi ± 10.5 / 1.5 μm, ora lalongate, exine ± 3.5 μm thick, sexine as thick as nexine, simplibaculate, bacula ± 2.2 μm spaced, psilate (plate XIII, fig. 2).

Galium asperifolium: -3 – colpate, circular, subprolate, PA x ED, ± 40.5 x 33.3μm, L/B of colpi , ± 28.5μm, exine , ± 1.2 μm thick, sexine, ± 0.75 μm thick, negatively reticulate, nexine , ± 0.45 μm thick (plate XIV, fig. 7).

**Rubia manjith*: -3 – colpate, subprolate, PA X Ed , ± 18.0 x 15.75, L/B of colpi , ± 12.0/ 1.5μm. Exine , ± 4.5 μm thick, sexine , ± 3.0 μm thick, reticulate, humina , ± 3.0 μm in diam. Circular, nexine , ± 1.5 μm thick (plate XIV, fig. 12).

RANUNCULACEAE

**Clematis* sp.: 3 – colpate, prolate, PA X Ed , , ± 27.0 x 20.0μm, L/B of colpi , ± 20.0 / 4.5μm. Exine 2.5 μm thick, sexine 2.0 μm thick, baculate process forms a negative reticulation, L/B of bacula , ± 1.8 / 0.7μm, lumina rounded, nexine , ± 0.42 μm thick (plate XVI, fig. 5).

RUTACEAE

**Citrus* sp. 3 colporate, prolate-spheroidal, PA x Ed , ± 28.9 x 28.9μm. Ora circular 3.2 μm in diameter, exine 3.7 μm thick, sexine simplibaculate, bacula 3.4 μm spaced, crassisexinous (plate XV, fig. 12).

Toddalia asiatica: 3 – colparate, prolate, PA X Ed , ± 24.3 x 16.8μm, L/B of colpi , ± 18.7 / 2.2μm, ora circular, , ± 1.5 μm in diam., exine , ± 2.25 μm thick, sexine , ± 1.2 μm thick, surface reticulata, lumina angular, , ± 1.2 μm in diameter, nexine , ± 0.75 μm thick (plate XVI, fig. 12).

Zanthoxylum oxyphyllum 3 – colporate, triangular, prolate, PA x ED , ± 28.4 / 19.5μm, L/B of colpi , ± 24.0 / 1.83μm, ora circular, , ± 1.5 μm in diam., exine , ± 3.0 μm thick, sexine , ± 2.2 μm thick, simply baculate, surface reticulate, lumina ± 1.5 μm in diam., muri very thin, nexine , ± 0.8 μm thick (plate XVI, fig. 10).

ROSACEAE

**Prunus Cerasoides*: 3 – Colporate, spheroidal, PA x ED , ± 29.4 x 29.4 U, L/B of colpi 12.4 / 3.1μm, ora circular, 2.9 μm in diameter, exine 2.4 μm thick, sexine finely reticulate (plate XV, fig. 2).

**Rosa* spp.: 3 – colpate, prolate-spheroidal, PA x ED , ± 21.0 x 17.5μm, L/B of colpi 16.2 μm 1.8μm, exine 3.4 μm thick, psilate, intine is equal in thickness with the exine, pore circular, 1.0 μm in diameter (plate XIV, fig. 13).

Rubus paniculatus: 3 – colpate, circular, subprolate, PA X Ed , ± 26.7 x 20.4μm, L/B of colpi 21.4 / 1.5μm, exine , ± 2.25 μm thick, sexine , ± 1.5 μm thick, surface granulated, nexine , ± 0.75 μm thick (plate XIV, fig. 3).

SAMBUCACEAE

Sambucus sp. – 3 – colporate, prolate – spheroidal PA x ED ± 14.9 x 14.2 μm, L /B of colpi 8.5 / 1.2 μm, ora circular, ± 3.2 μm in diameter, exine ± 3.8 thick, crassisexinooius, sexine ± 2.6 μm thick and nexine ± 1.2 μm thick, simply baculate, bacula 1.2 μm distantly placed, surface psilate. (plate XIII, fig,. 8)

SAPINDACEAE

Cardiospermum halicacabum – 3 – colporate, triangular, wavy, triangular, prolate-spheroidal, PA x ED , ± 45.0 x 42.0μm, average length of an arm , ± 42.53μm, diameter of outer aperture 3.0μm, inner aperture diameter , ± 1.5μm, L/B of colpi , ± 39.0 / 2.25μm, exine , ± 3.0 μm thick, sexine as thick as nexine, surface punctireticulate, lumina , ± 1.2 μm in diameter, circular, muri, ± 0.75 μm wide (plate XVI, fig. 6).

SAPOTACEAE

Basia butyracea – 3 – colporate, sub-prolate, PA x ED ±_ 39.5 X 30.5 μm, L / B of colpi ± 20.5 / 3.5 μm, exine ± 4.8 μm thick, sexine as thick as nexine, finely reticulate, psilate, ora circular, ± 5.2 μm in diameter. (plate XIII,, fig. 3).

SCHISANDRACEAE

Schisandra sp. – 3 – colporate, circular, suboblate, PA X ED , ± 28.5 x 34.5μm, colpi narrow indistict, exine , ± 3.0 μm thick, sexine , ± 1.5 μm thick, surface reticulate, L/B of lumina , ± 4.5 / 3.0μm, muri wall , ± 0.3 μm wide, nexine , ± 1.5 μm thick (plate XIV, fig. 2).

SCROPHULARIACEAE

**Digitalis purpurea* – 3 – colporate, prolate – spheroidal, PA x ED , ± 32.5 x 29.5μm, L/B of colpi , ± 26.0 / 2.5μm, ora circular, exine , ± 2.0 μm thick, sexine undifferentiated from nexine, punctitegillate, very finely reticulate (plate XI, fig. 10 & plate XI, fig. 1).

**Linaria* sp. – 3 – colporate, sub-prolate – spheroidal, PA x ED , ± 10.5 x 8.8μm, L/B of colpi , ± 7.5 μm / 1.2μm, ora circular, , ± 1.5 μm in diameter, exine 1.2 μm thick, crassisexinous, psilate (plate XVII, fig. 9).

Antirrhinum cymbalaria – 3 – colporate, sub-prolate – spheroidal, PA x ED , ± 18.7 x 15.3μm, L/B of colpi , ± 10.2 / 1.2μm, ora circular, , ± 2.9 μm in diameter, exine v 1.2 μm in thickness, simplibaculate (plate XVI, fig. 3).

SOLANACEAE

**Cestrum* sp. – 3 – colporate, prolate, PA x ED , ± 56.0 x 39.0μm, L/B of colpi , ± 52.0 / 5.0μm, ora lalongate, L/B of os 9.0 / 5.0μm, exine 3.0 μm thick, sexine 2.0 μm thick, faintly striato – reticulate (plate XVII, fig. 1).

Datura sp. – 3 – colporate, oblate, PA x ED , ± 35.0 / 2.0μm, ora lolongate, L/B of os 4.2 / 3.0μm, exine , ± 3.0 μm thick, sexine 2.0 μm thick, striato – reticulate (plate XI, fig. 2).

Petunia sp. – 3 – colporate, prolate spheroidal, PA x ED , ± 15.0 μm / 2.3μm, , ± 21.0 μm x 16.8 u, L/B pf colpii , ± 15.0 μm / 2.3μm, exine 3.2 μm thick, psilate, exine gradually attenuated towards the ora, ora circular , ± 2.1 μm in diameter (plate XVII, fig. 6).

Cyphomandra betacea – 3 – colporate, psilate, PA x ED , ± 12.6 x 10.6μm, L/B of colpi , ± 9.8 μm / 1.9μm, exine 2.1 μm thick, psilate, ora circular, 1.2 μm in diameter, intine thinner than exine (plate XVII, fig. 11).

SONERETTIACEAE

Duabanga sp. –3 colporate, oblate – spheroidal, PA x ED ± 12.6 x 14.1 μm, L/B of colpi, + 8.2 /1.1 μm , exine ± 2.7 μm thick in the middle but gradually thinner towards ora, ora slightly lalongate, intine as thick as exine (plate XV, fig. 8).

SYMPLOCACEAE

Symplocos sp. – 3.colporate, prolate-spheroidal, PaxED ± 22.0 x 20.0 μm, L/B of colpi ± 15.5 ? 2.5 μm, ora circular with ± 5.0 μm in diameter, exine ± 3.5 μm thick, crassisexinous, finely reticulate, psilate. (Photoplate : XV, fig.3).

TERNSTROEMIACEAE

Schima wallichii – 3 – colporate, sub- prolate, PA x ED, ± 29.6 x 23.8μm, L/B of colpi , ± 18.6 / 1.7 μm, exine ± 3.4 μm thick, baculate, bacula ± 1.7 μm, spaced, nexine equal in thickness with the sexine, surfaced psilate with fine reticulation, ora constricted (plate XV, fig. 18).

**Camellia* sp. –3 colporate, prorate – spheroidal, PA x ED ± 28.7 x 27.5 μm, L/B of colpi ± 19.5/ 2.8 μm exine ± 4.2 μm, nexine as thick as sexine, baculate, bacula ± 1.6 μm spaced, ora lolongate, surfaced psilate, finely reticulate (plate XVI, fig. 17).

TROPAEOLACEAE

Tropaeolum majus – 3 – colporate, prolate, PA x ED , ± 20.4 x 16.2μm, exine 2.2 μm thick, baculate, bacula 2.8 μm spaced, ora circular, 1.7 μm in diameter, intine thinner than exine (plate XVII, fig. 20).

VERBENACEAE

Gmelina arborea – 3 – colporate, prolate sheroidal, PA x ED 24.9 x 21.8 μm, L / B of colpi ± 15.8 / 2.1 μm, ora circular, 3.8 μm in diameter, exine ± 3.5 μm thick, sexine ± 2.8 μm thick, nexine ± 0.7 μm thick, simplibaculate, bacula 1.2 μm spaced, psilate. (Photoplate : XIII, fig. 6)

Clerodendrum sp. – 3 – colporate, prolate – spheroidal, PA x ED, ± 79.8 x 68.2μm, L/B of colpi , ± 54.6 x 4.2μm, exine, ± 4.7 μm in thickness, psilate (plate XV, fig. 7).

Duranta repens – 3 – colporate, prolate spheroidal, PA x ED , ± 23.8 x 20.4μm, syncolporate, ora circular, , ± 1.8 μm in diameter, L/B of colpi , ± 15.8 μm / 1.2μm, exine , ± 1.7 μm thick, psilate (plate XVII, fig. 20).

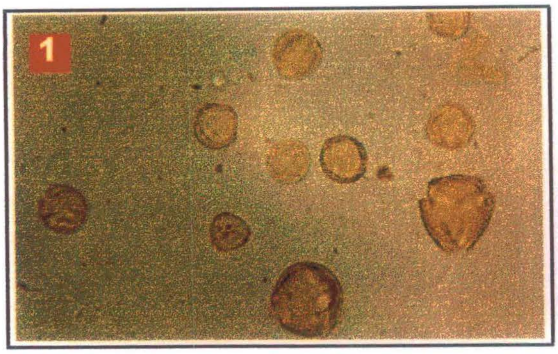
VITACEAE

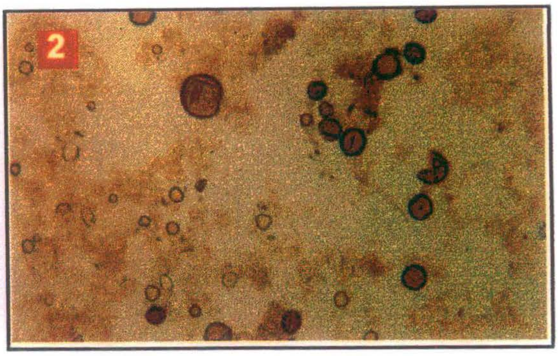
Tetrastigma spp. – 3 – colporate, subprolate PA x ED , ± 20.74 x 17.74μm, L/B of colpi , ± 18.0 x 2.25μm, tips, ± 0.84 μm wide, ora lalongate with L/B 0.75/ 1.75 μm, exine , ± 2.25 μm thick, sexine , ± 1.5 μm thick, surface granulated, nexine (plate XIV, fig. 20).

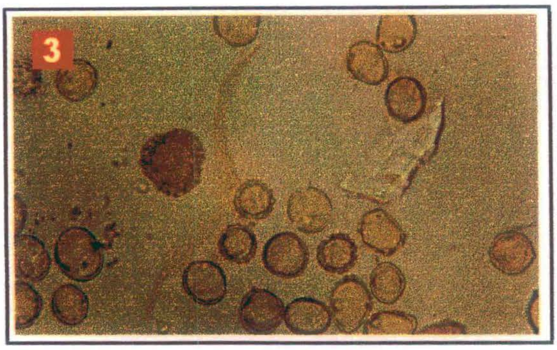
ZINGIBERACEAE:

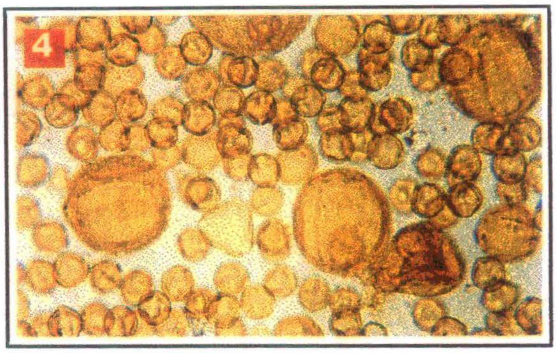
Ammomum subulatum – 1 sulcate, prolate- spheroidal, PAxED ±75.2x72.4µm, L/B of sulcus ± 42.5 / 2.5 µm , exine ± 5.8 µm in thickness, sexine ± 4.2 µm thick and nexine ± 1.6 thick, lumina round, ± 2.8 µm in diameter, (photoplate : XVII , fig. 21).

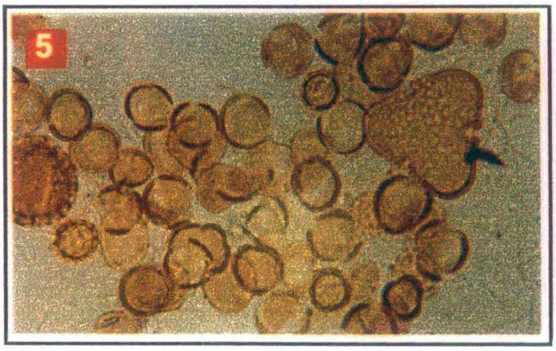
PLATE X

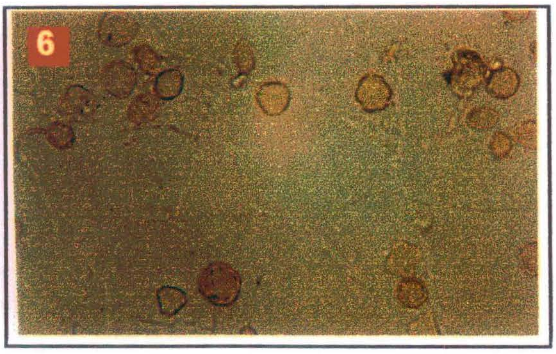


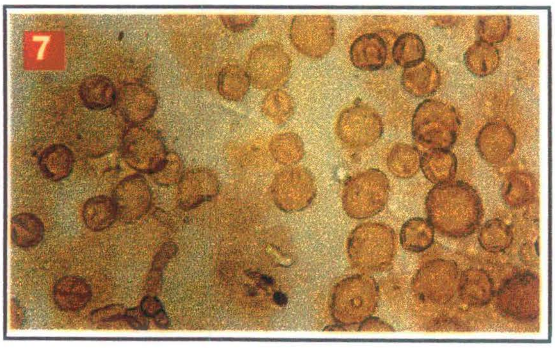


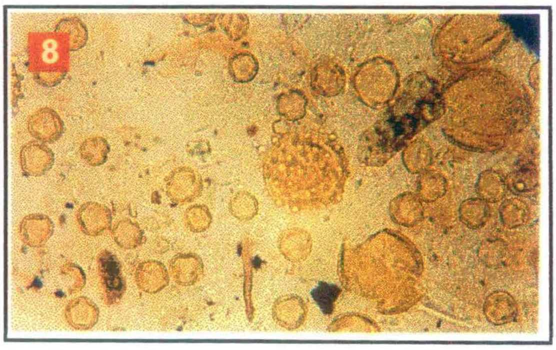












Pollen assemblages, as recovered from the following honey samples :
[All figures are magnified x250 unless otherwise mentioned :

Fig. 1 : Multifloral honey sample of Payong, South Sikkim (PH-1).
Fig. 2 : Multifloral honey sample of Gangtok, East Sikkim (GANH) (x100).
Fig. 3 : Multifloral honey sample of seed farm area, Kalimpong (SFH-2).
Fig. 4 : Unifloral honey sample of the same area collected in different season (SFH-1).
Fig. 5 : Unifloral honey sample of Kagay area of Kalimpong sub-division, Darjeeling (KH).
Fig. 6 : Multifloral honey sample of chalsa area of the district of Jalpaiguri (CH).
Fig. 7 : Unifloral honey sample of Solak Busty of kalimpong Sub-division, Darjeeling along with fungal spore (SBH).
Fig. 8 : Unifloral honey sample of Sakyone (SAKH), Kalimpong Sub-division, Darjeeling.

PLATE XI

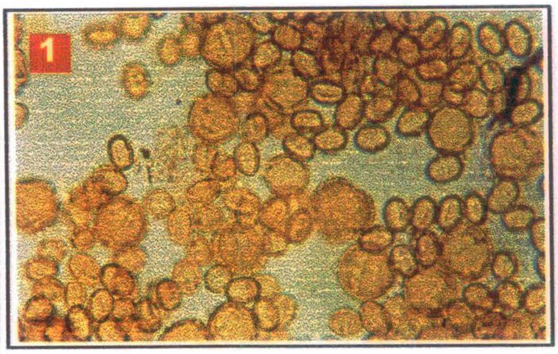
Some pollen assemblages as recovered from the following honey samples :
[All figures are magnified x250 unless otherwise mentioned]

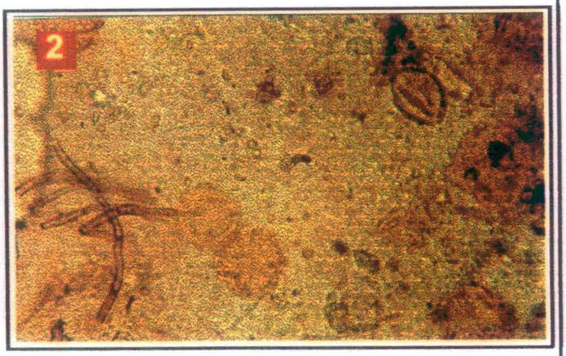
Fig. 1 : Unifloral honey sample of Damthang, South Sikkim (DAMH-2)

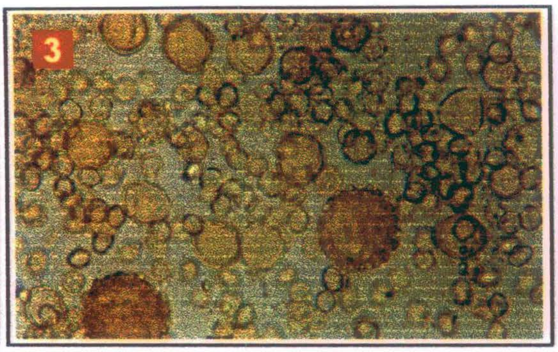
Fig. 2 : Multifloral honey sample of Dr. Graham's Homes area, Kalimpong (DGHH-1) with fungal hyphae.

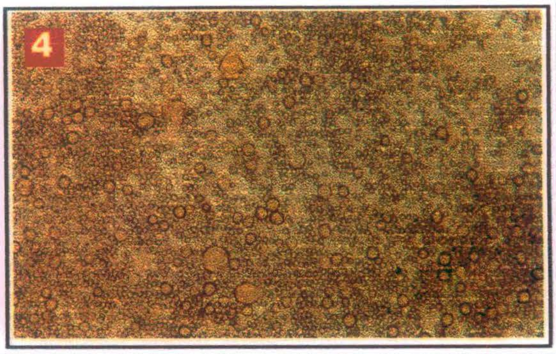
Fig. 3 : Unifloral honey sample of Dudhia tea eastate of Kurseong sub-division, Darjeeling (DUDH).

Fig. 4 : The same under low magnification [x100].



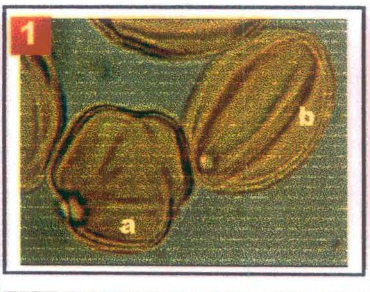


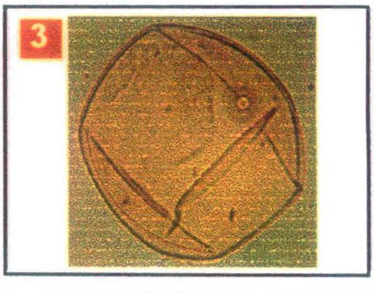


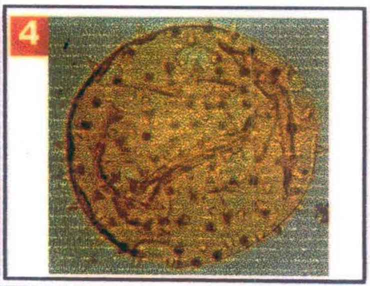


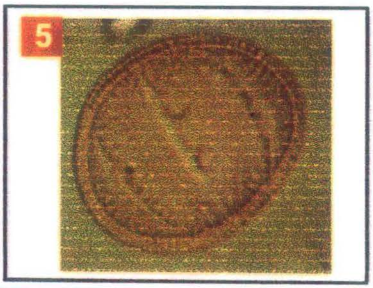
Some pollen types as recovered from honey samples
[All figures are magnified x400 unless otherwise mentioned]

Fig. 1 : *Digitalis purpurea* (Both polar (a) and equatorial views (b) showing apertures and surface ornamentation) x750
Fig. 2 : *Strobilanthus* sp. (Equatorial view in optical section showing apertures and exine ornamentation)
Fig. 3 : Poaccae (Equatorial view)
Fig. 4 : *Cucurbita* sp. (Polar view in optical section showing apertures and surface ornamentation.
Fig. 5 : *Salvia* sp. (Equatorial view in optical section showing exine ornamentation)
Fig. 6 : *Datura* sp. (Polar view in optical section showing apertures and surface ornamentation).









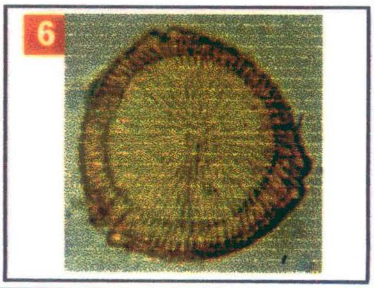
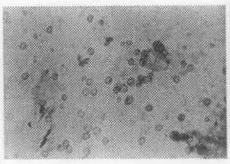


PLATE XII

1



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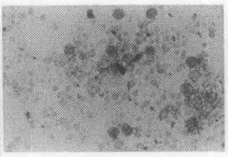

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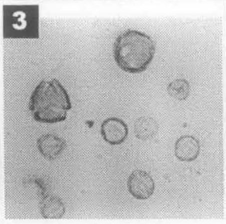

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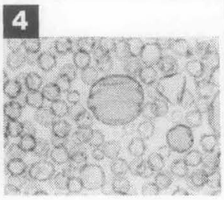

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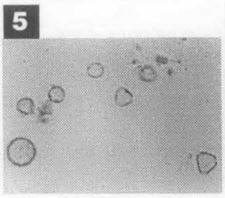

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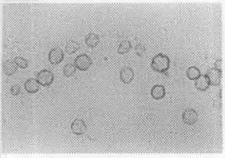

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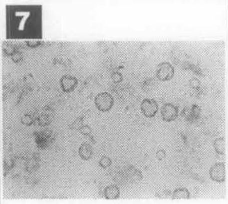

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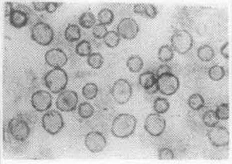

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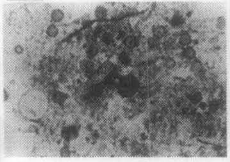

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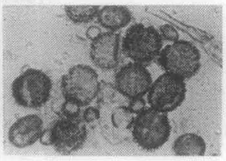

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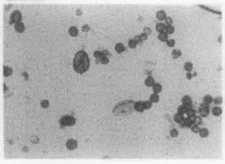

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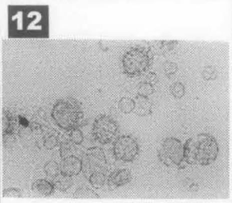

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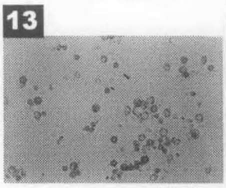

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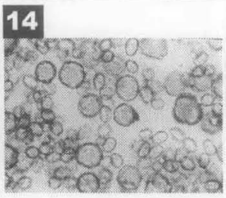

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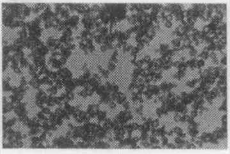

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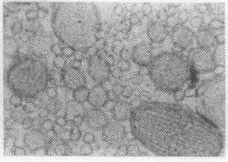

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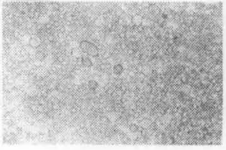

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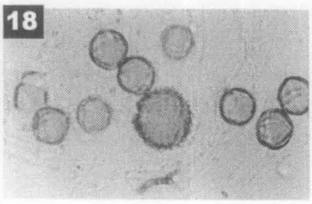

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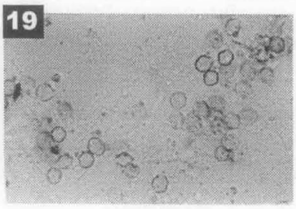
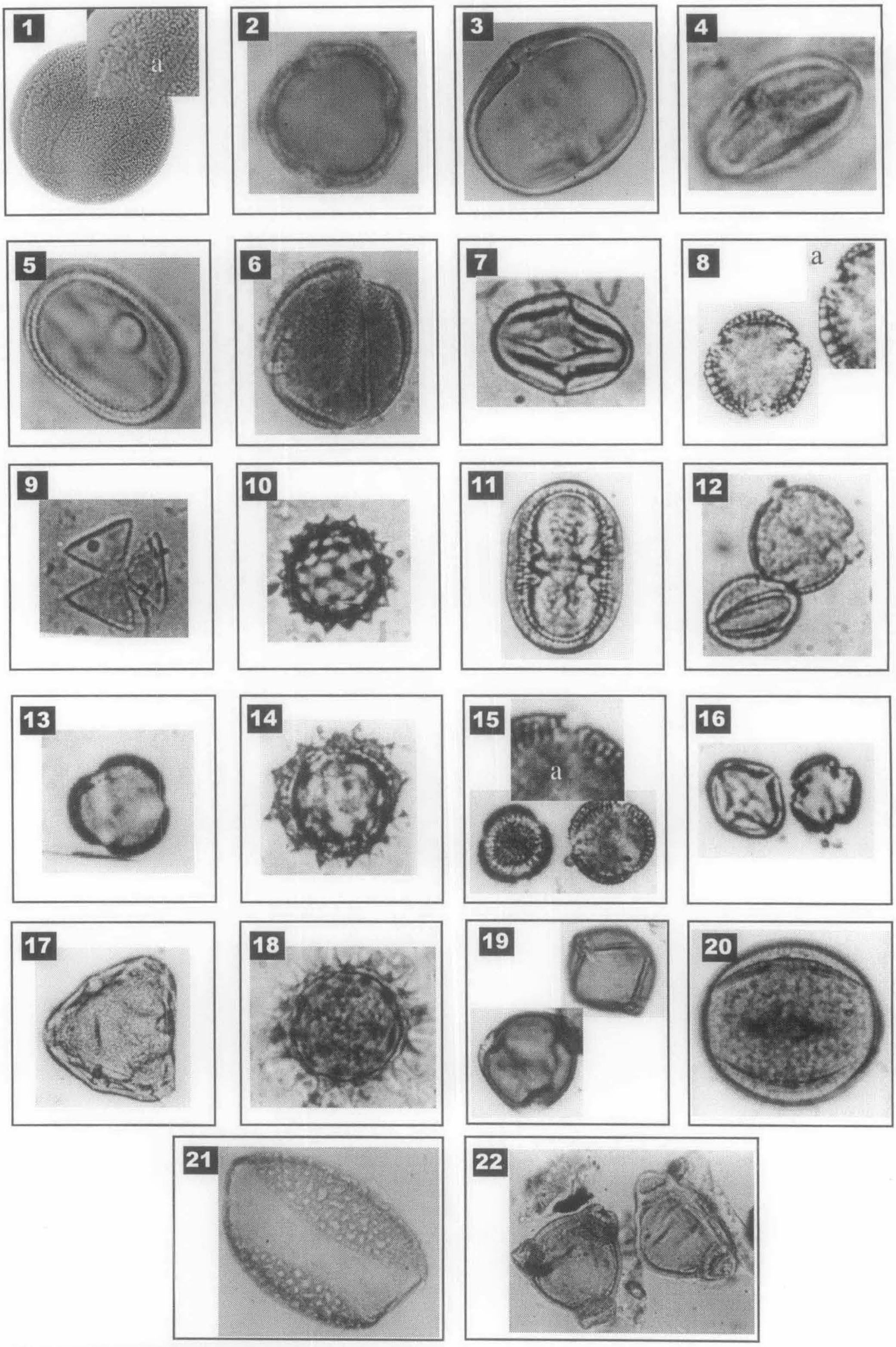


Pollen assemblages, as recovered from the following honey samples :
[All figures are magnified x250 unless otherwise mentioned]

Fig. 1 : PEDH-1-[Pedong, Kalimpong Sub-division, Darjeeling] x60]
Fig. 2 : SAKH-[Sakyone, Kalimpong Sub-division, Darjeeling] x60
Fig. 3 : PH-1-[Payong, S. Sikkim]
Fig. 4 : SFH-1-[Seed farm area, Kalimpong]
Fig. 5 : MH-[Mitiali,Jalpaiguri]
Fig. 6 : CH - [Chalsa, jalpaiguri]
Fig. 7 : SURH - [Suruk, Kalimpong Sub-division, Darjeeling]
Fig. 8 : SBH- [Solak Busty, Kalimpong Sub-division, Darjeeling]
Fig. 9 : SAMDH -[Samdong, S. Sikkim] x60
Fig.10 : SANGH -1 [Sangsay (near Pedong) of Kalimpong Sub-division]
Fig.11 : The same honey sample (SANGH) x60
Fig.12 : SADH - [Sadam (S. Sikkim)]
Fig.13 : The same sample (SADH) x60
Fig.14 : DAMH - [Damthang (S. Sikkim)]
Fig.15 : The same sample (DAMH) x60
Fig.16 : DUDH - [Dudhia tea estate of Kurseong Sub-division]
Fig.17 : The same sample (DUDH) x60
Fig.18 : DZH - [Dzongu (N. Sikkim)]
Fig.19 : LINH - [Lingee (S. Sikkim)]

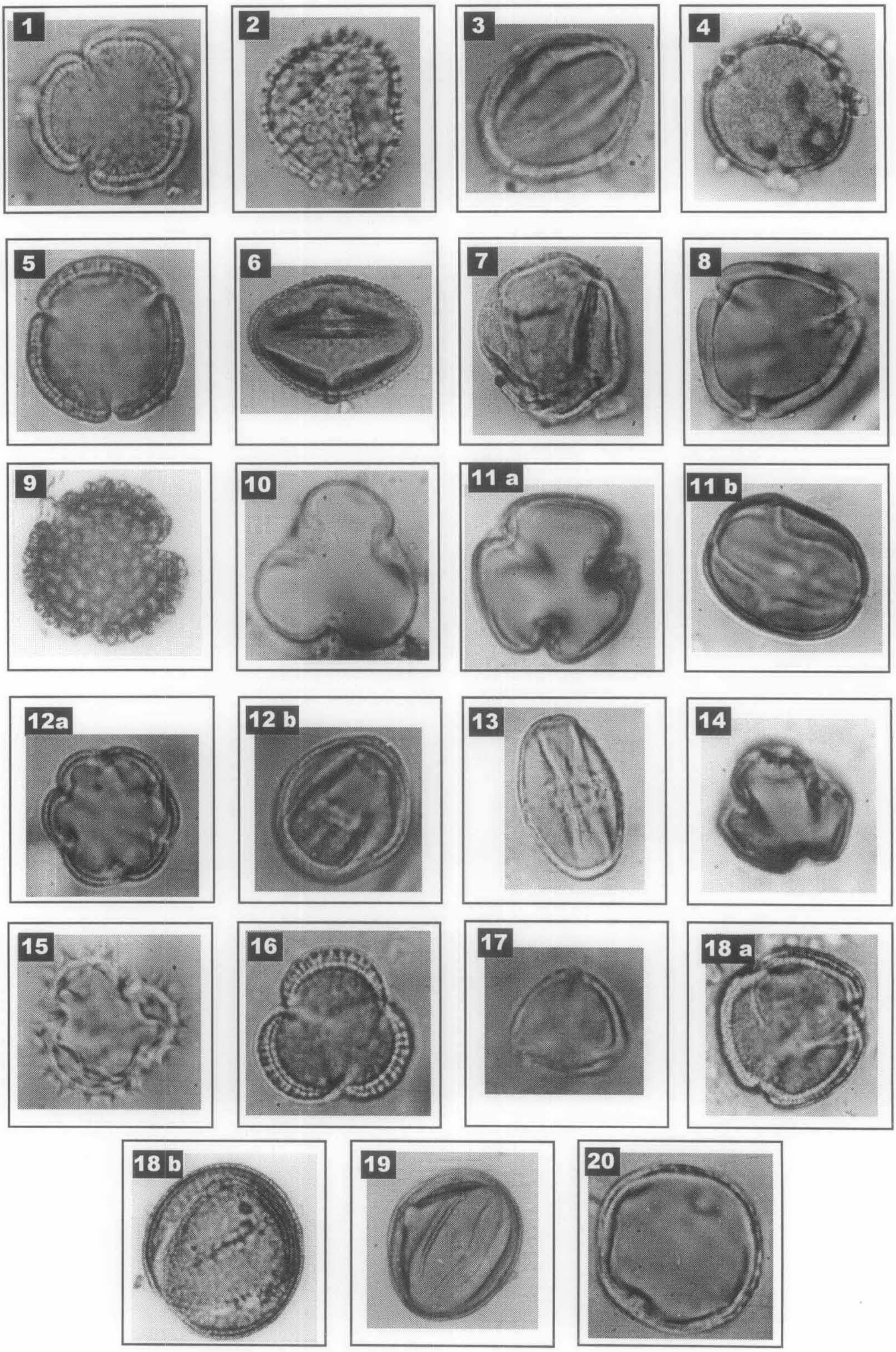
PLATE XIII



Some pollen types recovered from honey samples
[All figures are magnified x850 unless otherwise mentioned]

Fig. 1 : *Dichroa febrifuga,* (a) part of wall in close view.
Fig. 2 : *Cinchona* sp.
Fig. 3 : *Bassia butyracea*
Fig. 4 : *Castanopsis* sp.
Fig. 5 : *Rungia pectinata*
Fig. 6 : *Gmelina arborea*
Fig. 7 : *Trifolium repens*
Fig. 8 : *Sambucus* sp. (a) part of wall in close view.
Fig. 9 : *Nemophilla menziensii*
Fig.10 : *Cineraria grandiflora*
Fig.11 : *Centaurea* sp.
Fig.12 : *Papaver* sp.
Fig.13 : *Cardamine* sp.
Fig.14 : *Chrysenthemum* sp.
Fig.15 : *Iberis amara*
Fig.16 : *Sedum multicaule*
Fig.17 : *Clarkia pulchella*
Fig.18 : *Galinsoga parviflora.*
Fig.19 : *Persicaria capitata*
Fig. 20: *Moringa oleifera*
Fig. 21: *Hemerocallis* sp. x500
Fig. 22: *Fuchsia dependens* x500

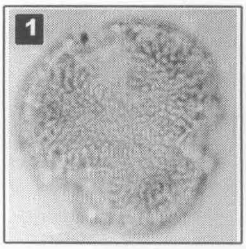
PLATE XIV



Some pollen types recovered from honey samples
[All figures are magnified x850 unless otherwise mentioned]

Fig. 1 : *Porana grandiflora.*
Fig. 2 : *Schisandra* sp.
Fig. 3 : *Rubus* sp.
Fig. 4 : *Wisteria chinensis.*
Fig. 5 : *Aconogonum molle*
Fig. 6 : *Mucuna* sp. x500.
Fig. 7 : *Galium asperflorum.*
Fig. 8 : *Pueraria sikkimensis.*
Fig. 9 : *Persicaria capitata* x500.
Fig.10 : *Holboelia latifolia.*
Fig.11 : *Milletia pulchra (a)* polar view (b) Equatorial view
Fig.12 : *Rubia* sp. (a) polar view (b) Equatorial view.
Fig.13 : *Rosa* sp.
Fig.14 : *Holarrhena* sp.
Fig.15 : *Erigeron karwinskianus*
Fig.16 : *Brassica* sp.
Fig.17 : *Primula* sp. x1000
Fig.18 : *Oxalis* sp. (a) polar view (b) Equatorial view.
Fig.19 : *Asystasia macrocarpa* x500.
Fig. 20: *Tetrastigma* sp.

PLATE XV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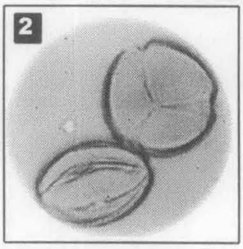
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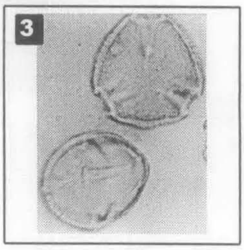
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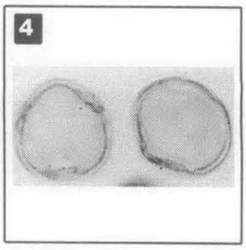
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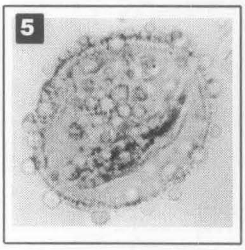
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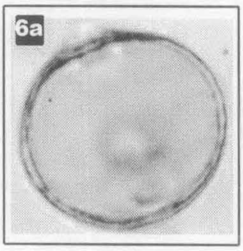
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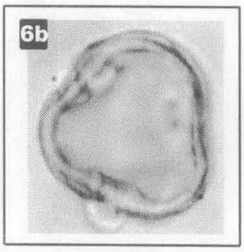
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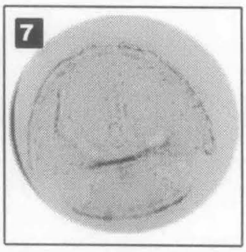
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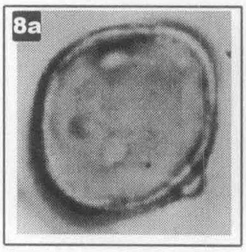
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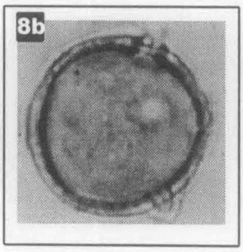
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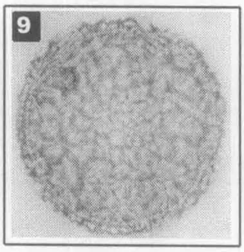
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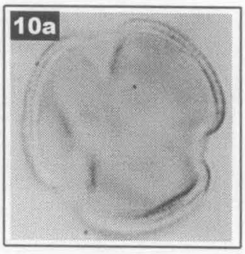
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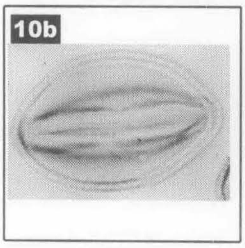
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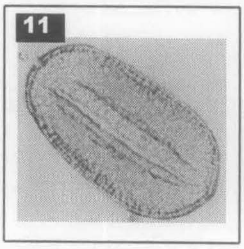
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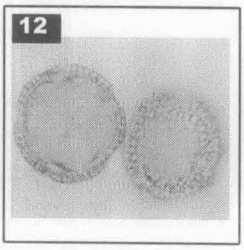
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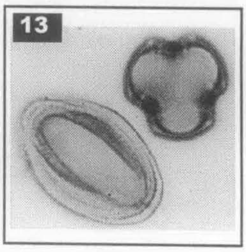
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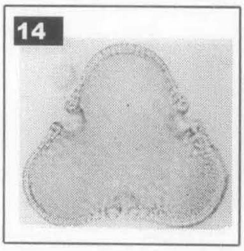
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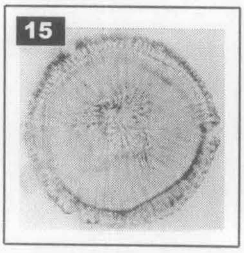
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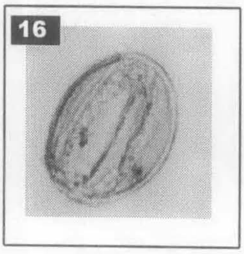
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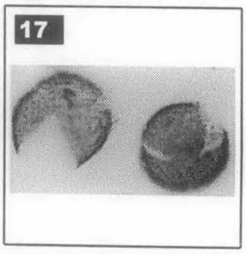
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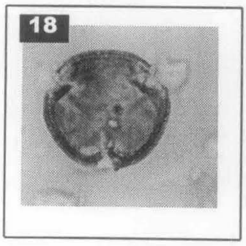
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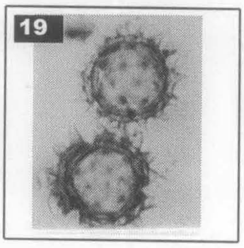
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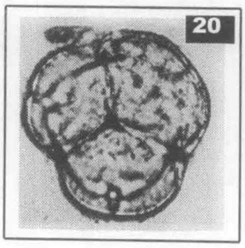
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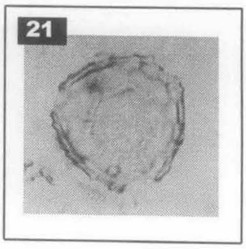
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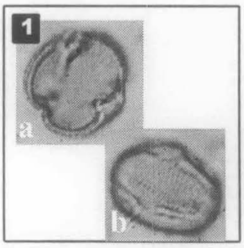
Some pollen types as recovered from honey samples (All figures are magnified x850) unless otherwise mentioned)

Fig.1 : *Euphorbia pulcherrima* (Polar view showing apertures and surface ornamantation)
Fig. 2 : *Prunus* sp. (Polar and Equatorial views showing apertures)
Fig. 3 : *Symplocos* sp. (Polar and Equatorial views showing apertures and surface arnamentation)
Fig. 4 : *Punica* sp. (Polar and Equatorial view)
Fig.5 : *Gynocardia odorata* (Equatorial view showing apertures and surface ornamentation)
Fig. 6 : *Aesculus* sp., (a) Equtorial view), (b) The same in polar view showing apertures
Fig. 7 : *Clerodendrum* sp.
Fig. 8 : (a) *Duabanga* sp. (Equatorial view), (b) The same in polar view showing apertures
Fig. 9 : *Ocimum* sp. (Polar view in optical section showing surface ornamentation)x500.
Fig. 10 : (a) *Digitalis purpurea* (a) Polarview (b) Equatorial view
Fig. 11 : *Gladiolus* sp. x500
Fig. 12 : *Citrus* sp. (Polar view in optical section showing apertures and surface ornamentation)
Fig. 13 : *Ligastrum* sp. (Polar and Equatorial views showing apertures)
Fig. 14 : *Bombax* malabaricum (Polar view in optical section showing apertures, and exine ornamentation)
Fig. 15 : *Bauhinia* sp. (Polar view in optical section showing apertures and exine ornamentation).
Fig. 16 : *Jakaranda* sp. (Equatorial view)
Fig. 17 : Cactaceae (Polar view showing apertures) x 500
Fig. 18 : *Schima wallichii* (Polar view showing apertures) x500
Fig. 19 : *Tithonia diversifolia* (Polar view showing apertures and surface ornamentation) x 500
Fig. 20 : *Rhododendron* sp. (Polar view in tetrad) x500
Fig. 21 : *Phaseolus* sp. (Polar view showing apertures and surface ornamentation) x500.

PLATE XVI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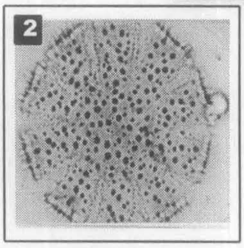
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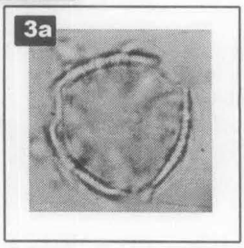
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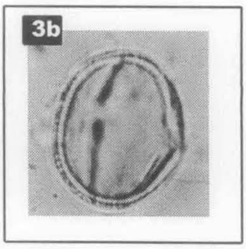
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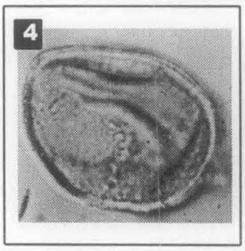
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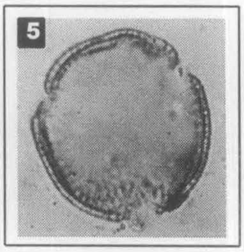
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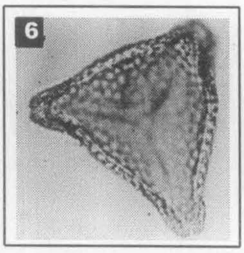
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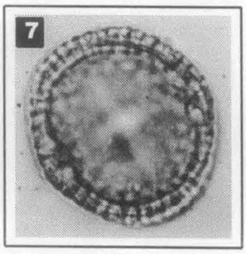
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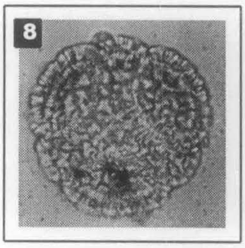
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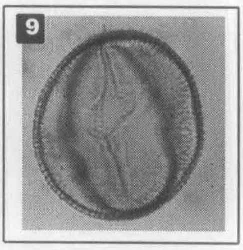
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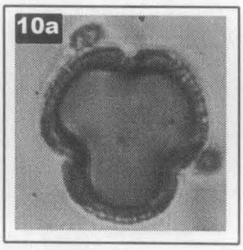
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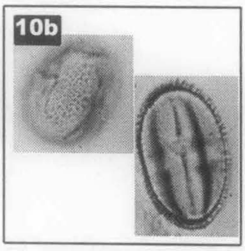
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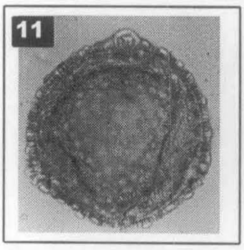
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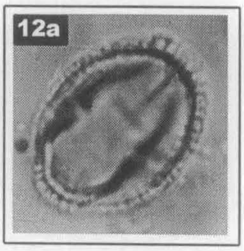
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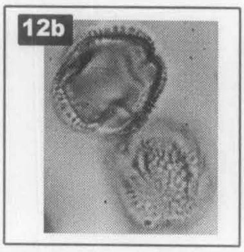
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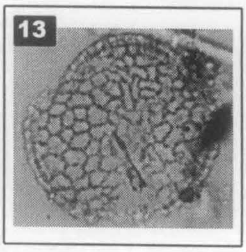
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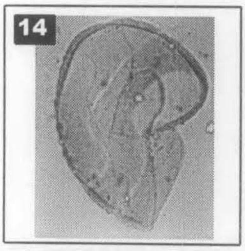
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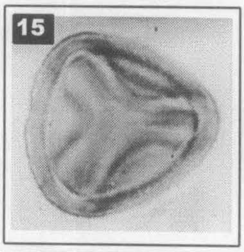
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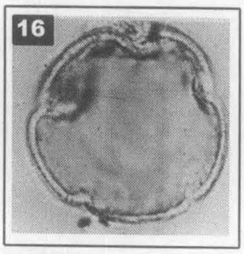
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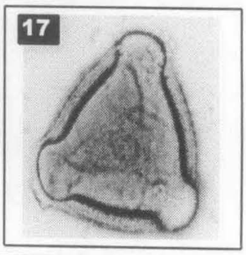
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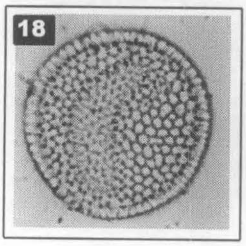
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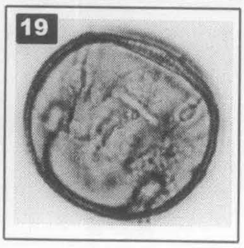
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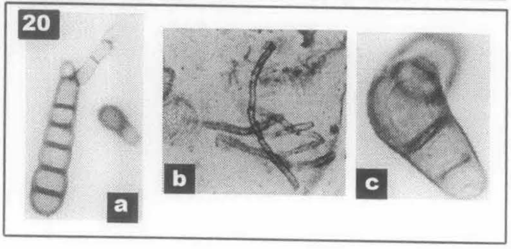

20

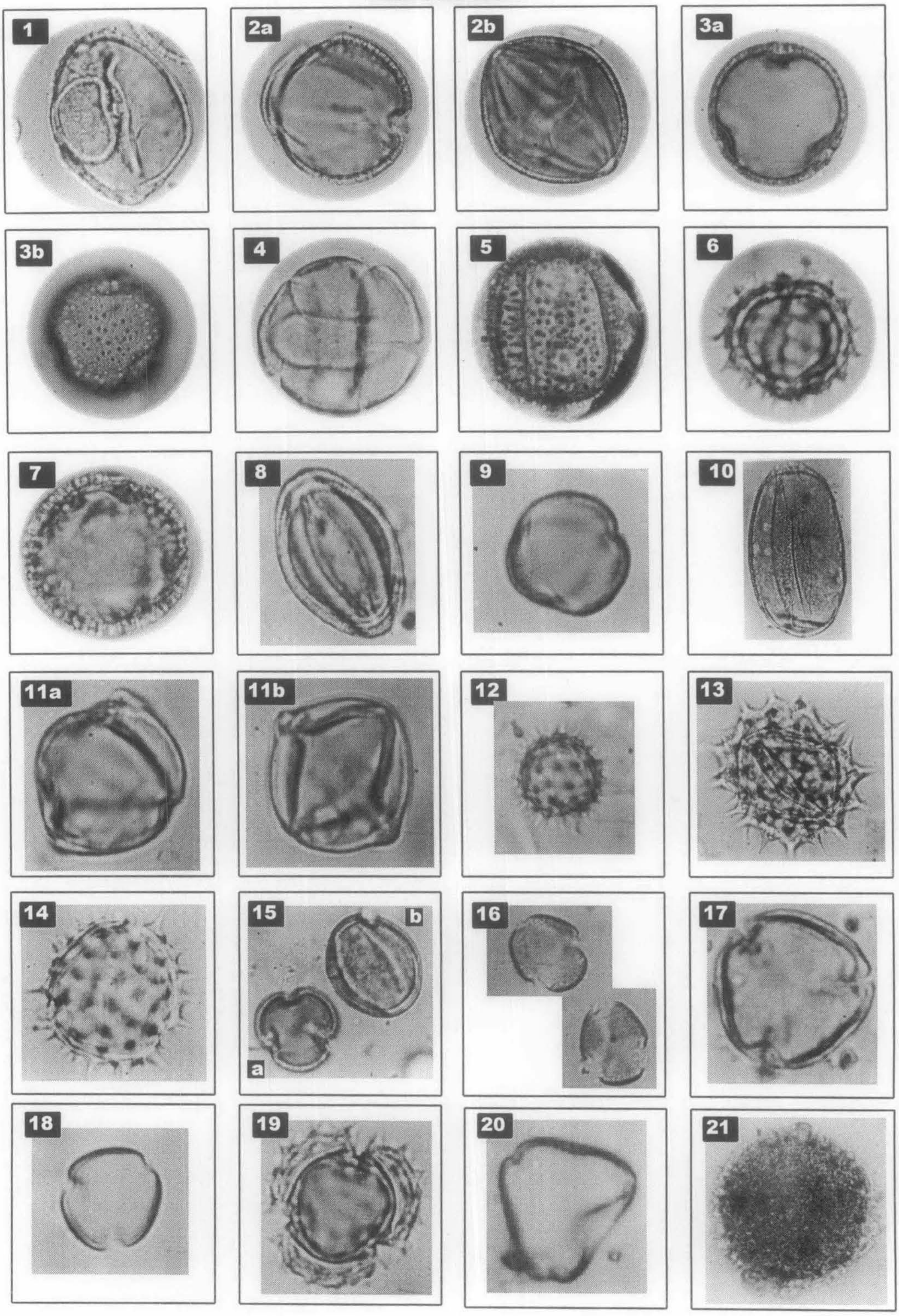
Some pollen types as recovered from honey samples (All figures are magnified : x850 unless otherwise mentioned) :

Fig. 1 : *Crotolaria* sp. (a) Polar view b. Equatorial view.
Fig. 2 : *Sechium edule* (Polar view)
Fig. 3 : *Antirrhinum* sp. (a) Polar view (b) Equatorial view.
Fig. 4 : *Aristolochia* Sp. (Equatorial view)
Fig. 5 : *Clematis* sp. (Polar view)
Fig. 6 : *Cardiospermum halicacabum*
Fig. 7 : *Coccinea grandis*
Fig. 8 : *Passiflora* sp. x 500
Fig. 9 : *Momordica* sp. x500
Fig. 10 : *Zanthoxylum* sp. (a) Polar view, (b) Equatorial view (x500)
Fig. 11 : *Edgaria darjeelingensis* x500
Fig. 12 : *Todalia* (a) Equatorial view (b) Polar view.
Fig. 13 : *Jasminum* sp. x500
Fig. 14 : *Thunbergia coccinea* x500
Fig. 15 : *Aspidopterys nutans* (Polar view)
Fig. 16 : *Codonopsis* sp.
Fig. 17 : *Camellia* sp. (Polar view)
Fig. 18 : *Croton* sp.
Fig. 19 : *Drymaria* sp.

Some fungal spores (airborne) and fungal hyphae. recovered from honey samples (All figures are magnified x500 unless otherwise mentioned).

Fig. 20 : (a) *Alternaria* sp. (From SORH, Soreng Busty sample)
(b) Fungal hyphae (From DGHH-1, Dr. Graham' Homes Area sample) x250
(c) *Curvularia* sp.

PLATE XVII



Some pollen types as recovered from honey samples (All figures are magnified x 850 unless otherwise mentioned) :

Fig. 1 : *Cestrum* sp. x500
Fig. 2 : *Petunia* sp. (a) Polar view (b) Equatorial view
Fig. 3 : *Cleome* sp. (a) Polar view (b) Same with ornamentation
Fig. 4 : *Berberis* sp.
Fig. 5 : *Begonia* sp. x500
Fig. 6 : Solidago *virga-aurea*
Fig. 7 : *Myosotis sylvatica.*
Fig. 8 : *Canna* sp.
Fig. 9 : *Linaria* sp.
Fig. 10 : *Michelia* sp. (Equatorial view) x500
Fig. 11 : *Cyphomandra betacea* (a) Polar view, (b) Equatorial view
Fig. 12 : *Bidens pilosa* x500
Fig. 13 : *Dahlia imperialis*
Fig. 14 : *Calendula officinalis*
Fig. 15 : *Hypericum* (a) Polar view (b) Equatorial view.
Fig. 16 : *Leucosceptrum canum* x500
Fig. 17 : *Duranta repens*
Fig. 18 : *Buddleja asiatica*
Fig. 19 : *Ageratum conyzoides*
Fig. 20 : *Tropeolum majus*
Fig. 21 : *Ammomum. subulatum* x 500.

3.3 MICROSCOPIC ANALYTICAL DATA ON THE DISTRIBUTION OF PALYNOMORPHS IN DIFFERENT HONEY SAMPLES

A total of sixty-seven honey samples were collected from different areas of the Sikkim and Sub-Himalayan of West Bengal. Out of these, *Apis cerana indica* F. samples were in 65 in number and *Apis florea* F. ('Putka' honey) samples were two in number. These two were from Sub-Himalayan West Bengal only. Out of 65 *A. cerana indica* F. samples, 17 samples were collected from different areas of Sikkim and rest 48 samples from different areas of Sub-Himalayan West Bengal of which district of Darjeeling constituted 44 sample and district of Jalpaiguri constituted 4 samples. Two samples of *A. florea* F. were from Sub-Himalayan West Bengal only.

The results of microscopic analysis of all the above samples have been presented in tables 3.3.2A and 3.3.2B. Their analysed discussion may made as follows:

HONEY SAMPLES OF SIKKIM [*A. cerana indica* F.]

Out of the 17 samples 13 constituted the summer/spring honeys and the remaining 4 constitute the autumn honeys. Microscopic analysis of these 13 Summer honeys revealed that 5 samples eg. DAMH-2 (Damthang, S. Sikkim), DZH (Dzongu, North Sikkim), SH-2 (Sumbuk, South Sikkim), LINH Lingee, (South Sikkim), and SUMBH (Sumbaria W> Sikkim) constituted unifloral honeys. The predominant (>45%) nectar yielding taxa were found to be *Rosa* spp. (66.66%), *Citrus* spp. (54.22%), *Calendula* spp. (55.94%), *Buddleja* spp. (51.09%) and Calendula (66%) respectively. The rest 8 summer honeys were found to be multifloral. The pollen types of *Rosa* spp, were found in 7 samples ranging from 66.66% to 2.2%; *Citrus* spp. Were found to be present 13 samples ranging from 54.22% to 1.6%, *Buddleja* spp, in 4 samples from 51.09% to 1.2% and *Calendula* spp, in 6 samples from 66 to 0.44%.

Some of the secondary pollen types ranging from 16-45% present in these summer honey samples were *Prunus* spp., *Centaurea* spp., *Datura* spp., *Cardamine hirsuta, Raphanus* sp., *Fragaria* sp., *Trifolium repens., Trapaeolum majus., Streptosolen jamesonii., Ammomum subulatum., Schima wallichii.* The important minor pollen types ranging from 3-15% recovered in these honeys were *Spirea micrantha, Clematis* spp., *Eupatorium* sp., *Michelia* sp., *Milletia* sp., *Sambucus* sp., *Torenia* sp., *Magnolia* sp., *Asystasia* sp., *Strobilanthus* sp., *Acanthus* sp. Some of the taxa encountered upto 3% category were *Potentilla fulgens, Camellia* spp., Poaceae. *Begonia flaviflora, Pyrus japonica* (chenomalis).

Of the 4 autumn honeys samples 3 constituted the unifloral honeys. These were from Khamdong (West Sikkim) (KHAMH), Payong (South Sikkim) (PH-2) and Rabitar (East Sikkim) (RABH) with pollen types *Michelia* spp. (85.36%), *Prunus* spp. (50.22%) and *Brassica* spp. (58.29%) respectively. The rest one sample constituted multifloral type.

Michelia spp. are present in 7 honey samples from 85.36%-0.8%, *Prunus* sp. In 10 samples from 50.22-0.3% and *Brassica* sp. in 5 samples from 58.29 -0.5%. *Ammomum subulatum* and *Drymaria villosa* constitute the secondary pollen types in Payong (PH-2) and Sumbuk (SH) honeys respectively. The important minor pollen types (3-15%) encountered *were Hypoestes triflora, Acanthus carduaceous, Thunbergia* sp., *Begonia flaviflora., Porana racemosa., Frageria* sp., *Citrus* spp., *Linaria* sp., *Galinsoga parvif;pra., Artemisia vulgaris.* The frequencies of pollen types (up to 3%) recorded from each honey sample presented are given Table 3.3.2A & 3.3.2B.

One pollen type found as “minor pollen” in 12 samples was treated as “unidentified type”. In two instances the pollen types could be identified only up to family level eg. Poaceae and Cactaceae.

Of the 13 summer honeys 2 (15.4 %) samples had 6-10 pollen types 8 (61.5 %) samples had 11-15 pollen types and the rest 3 (23.08 %) had 16-20 pollen types.

Of the 4 autumn honeys 1 (25 %) sample had 7 pollen types and 3 (75 %) samples had 11 - 15 pollen types.

The degree of similarity in the cases of two honey samples (collected more than one in number) was determined by using the formula (Kalpana and Ramanujam, 1989) as discussed in the chapter 2.6.

An index value of more than 0.5% represented a close degree of similarity between the samples. The lower the similarity index, higher would be the diversity between samples and vice-versa.

Table 3.3.1A. **Similarity index values among various honeys collected during same/different periods from same place**

Honey samples		Total No. of pollen types	No. of pollen types common to the samples	Similarity index
Code No.	Sl. No.			
(M) DAMH 1 (Apr)	8	13	2	$\frac{2 \times 2}{13 + 10} = 0.17$
(U) DAMH 2 (May)	9	10		
(M) SH 1 (Oct)	62	12	3	$\frac{2 \times 3}{12 + 16} = 0.21$
(U) SH 2 (Apr)	32	16		

[M=Multifloral
U=unifloral]

For the determination of the degree of similarity (see table 3.3.1A). The first pair of honey samples were collected from the same place

(Damthang, South Sikkim) during the same season. The index value was found to be lower than 0.5 clearly indicating that there is different floristic composition within the perimeter of the bees foraging range.

The second pair of the samples collected from Sumbuk (South Sikkim) during different seasons also showed similarity index value lower than 0.5. This is attributable to not only different collection periods but also different floristic composition within the perimeter of the bees foraging range as was observed in the first case.

Absolute pollen counts of all the seventeen (17) Sikkim honey samples revealed that 5 samples were under Group II, out of which Damthang and Sumbaria honeys were found unifloral as have been already mentioned. The remaining 12 samples were found under Group I (Inventory Table 2.3.1A).

Honey dew elements (HDE) represented by fungal spores (uredospores of *Puccinia,* spores of *Alternaria, Fusarium* conidia) and hyphal shreds were recovered only from DAMH-1 (Damthang) and KHAMH (Khamdong) samples in very small amount. HDE/P ratio ranged from 0.001 – 0.05 and so the honey dew elements were practically none (Louveaux *et al.,* 1978).

A.HONEY SAMPLES OF SUB-HIMALAYAN WEST BENGAL [*Apis cerana Indica* F.]

DARJEELING DISTRICT

Of the total 44 honey samples collected from different areas of the district of Darjeeling 24 samples were summer or spring honeys, 14 autumn and the remaining 6 were winter honeys. Microscopic analysis of these 24 summer honeys revealed that 8 samples were unifloral honeys. The predominant pollen types were found to be *Rubus* spp. (52.15%) in KH, *Millettia pulchra* (70.73%) in MBH, *Primula* spp. (51.21%) in SORBH, *Schima wallichii* (57.9%) in SBH, *Fragaria* spp. (54.91%) in SFH-1, *Potentilla* spp. (45.06%) in TODH, *Prunus* spp. (88.8%) in TH and *Trifolium repens* (51.5%) in DUDH.

The secondary pollen types (16-45%) encountered in these honeys were *Brassica* spp., *Schima wallichii, Solidago virga-aurea, Bidens pilosa, Cardamine hirsuta, Tothonia diversifolia, Centaurea* spp., *Calendula officinalis, Fragaria spp., Jasminum dispernum, Poaceae, Chrysenthemum* spp., *Raphanus sativus.*

Some of the important minor pollen types (3-15%) encountered were *Trapaeolum majus, Embelia ribes, Nicotiana* spp., *Ammomum subulatum, Magnolia* spp., *Clematis* spp., *Gladiolus* sp., *Berberis* spp., *Aspidopteris nutans, Asystasia macrocarpa, Strobilanthus thomsonii, Streptosolen jamesonii, Erigeron karvinskianus, Coccinea grandis, Euphorbia pulcherrima, Sedum multicaule, Begonia* spp., *Lantana camara, Toddalia asiatica, Papaver* spp., *Rosa* spp., *Pueraria sikkimensis, Spiraea* spp., *Sambucus* spp., *Iberis* sp., *Leucosceptrum cannum, Torenia* sp., *Spergula arvensis, Pyrus* sp., *Hypoestes triflora.*

The other nectar-yielding taxa (upto 3% level) are mentioned in Table 3.3.2A & 3.3.2B.

Out of 14 autumn honeys 5 samples were found to be unifloral with the predominant pollen types *Ageratum* spp. (55%) in CHIBH-1, *Sedum multicaule* (50 %) in RIMH-2 and *Schima wallichii* in three samples viz., DGHH-3 (60.15%), SAKH (51.63%) and SANGH-2 (68.6%).

The secondary pollen types (16-45%) encountered in these honeys were *Calendula officinalis, Bidens pilosa.. Camellia* spp., *Ammomum subulatum, Dalbergia sisoo, Symlocos cochinchinensis, Selinum tenuifolium, Drymaria villosa, Fragaria* spp.

The important minor pollen types (3-15%) encountered were *Passiflora* spp., *Trifolium repens, Buddleja asiatica, Lindenbergia* spp., *Solanum* spp., *Poaceae, Strobilanthus* sp., *Cestrum* spp., *Saxifraga sermentosa Linaria* sp., *Duranta* sp., *Phaseolus* sp., *Citrus* spp., *Eupatorium* spp., *Holboelia latifolia, Rubus ellipticus, Tithonia diversifolia, Datura* spp., *Erigeron karwinskianus, Plantago* sp., *Macaranga* sp., *Sambucus* spp., *Clerodendrum* sp.

Some of the minor pollen types (up to 3% level) recorded *were Oxalis* sp., *Nicotiana* sp., *Persicaria perfoliata, Artemisia vulgaris, Zanthoxylum, Cassia* spp. *Leucus* sp., *Berberis* sp.

Out of 6 winter honeys 1 was found to be unifloral with the predominant pollen type *Aristolochia* spp. (52 %) in the sample EBH (Ecchey Busty, Kalimpong)

The secondary pollen types (16 - 45 %) in these samples isolated were *Brassica* spp., *Bidens pilosa, Trapaeolum majus, Dahlia* spp., *Nicotiana* spp., *Rosa* spp., *Clematis* spp., *Porana grandiflora, Majus surculosus, Cardamine hirsuta, Streptosolen* sp., *Bellis perennis, Chrysenthemum* spp., *Bauhinia* spp.

The important minor pollen types (3 - 15 %) were *Solanum* spp., *Holboelia latifolia, Cardiospermum helicacabum. Spergula arvensis, Lindenbergia indicum, Asystasia macrocarpa, Pimpinella diversifolia, Erigeron karwinskianus, Euphorbia* spp., *Ocimum* spp., *Crotolaria* sp., *Edgaria darjeelingensis.*

The minor pollen types (upto 3% level) were *Duabanga* spp., *Dichroa febrifuga, Luffa* sp., *Thunbergia* sp., *Macaranga* sp., *Leucus* sp., *Abelmoschus* sp., *Coriandrum* sp., *Momordica* sp., *Justicia* sp., *Desmodium* sp., *Allium* sp., *Moringa* sp.

One pollen type found as “minor pollen” in 19 samples out of 24 summer honeys was treated as “unidentified type”. In almost all the autumn honeys (14) the “unidentified type” was recognized but it was below 3% level only. Similarly out of 6 winter honeys only in the sample SURH from Suruk area of Kalimpong sub-division 100% pollen types were identified. In two instances the pollen types could be identified only upto family levels eg. Poaceae and Cactaceae.

JALPAIGURI DISTRICT

Out of 4 samples collected from the foothill region of the district, 3 constituted the summer honey and 1 constituted the winter honey. Microscopic analysis of the 3 summer honeys revealed that sample MH from Mitiali and sample JH from Jaldhaka were unifloral with their predominant pollen types *Prunus* spp (56.79 %) and *Ageratum* spp (50 %) respectively.

Tropaeolum majus, Rosa spp. *Brassica* spp, *Syzygium* sp., *Embelia ribes* are the secondary pollen types as encountered within the range of 16 – 45 %.

The important minor pollen types (3 – 15 %) were found *Brassica* spp, *Phaseolus* sp, *Holarrhena pubescens, Lagerstromi* sp., *Sterculia* sp., *Oxalis* spp., *Bidens pilosa, Potentilla* spp., *Tithonia diversifolia, Chematis* spp.

The minor pollen types (upto 3 % level) encountered were *Adhatoda* sp., *Thevetia* sp., *Mangifera* sp., *Caesalpinea* sp., *Allium* sp., *Jakaranda* sp., *Cestrum* spp., *Symplocos cochinchinensis, Aconogonum molle, Clerodendrum* sp., *Spirea* spp., *Trifolium repens, Croton* sp.

The single winter honey (SAMH) from Samsing was found to be uniforal with its predominant pollen type *Rosa* spp. (78.5 %). No secondary pollen type was encountered in this sample. The important minor pollen type was found to be *Ageratum* spp. (7.8 %). The minor pollen types as encountered were *Brassica* spp. (2.45 %), *Cleome* sp. (2.4 %), *Lindenbergia* sp (2.4 %), *Desmodium* sp. (1 %), *Coriandrum* sp. (1 %), *Allium* spp. (0.8 %), *Moringa* sp. (1 %).

Unidentified pollen type was found to be 0.7 %.

Of the total 27 summer honeys of Sub-Himalayan West Bengal (Darjeeling 24 and Jalpaiguri 3), 6 samples had 6 – 10 pollen types, 10 samples had 11 – 15 pollen types, 6 samples had 16 – 20 pollen types, 4 samples had 21 – 25 pollen types and one sample (TH) from Tendrabong (Kalimpong Sub-Division) had only 4 pollen types.

Of the 14 Autumn honeys of the region 4 (28.6%) samples had 6-20 pollen types and 7 samples had 11-15 pollen types, 2 samples had 16-20 pollen types and one sample 22 pollen types.

Similarly of the 7 winter honey of the region 2 samples had 6-10 pollen types, 3 samples had 11-15 pollen types,1 sample, (MONGH) from Mongpu (Kalimpong Sub- Division) had 17 and the remaining 1 sample, (SFH-2) from Seed farm area, Kalimpong had 25 pollen types. The similarity index values among various honey samples collected during same/different periods from same place have been represented in table 3.3.1B.

The absolute Pollen counts (APC) of all these 48 Sub-Himalayan honey samples *Apis cerana indica* F. revealed that one sample ,SFH-1 (Seed farm area,kalimpong)was under Group-III with APC value 350609/10 gm of honey.9 samples were found under Group-II and the remaining 38 samples were under Group-I (Inventory table 23.1A & 2.3.1B).

Honey dew elements (HDE) represented by fungal spores (Uredospores of *Puccinia,* spores of *Alternaria, Fusarium* conidia and hyphal shreads were recovered from SORH (Soreng Busty), MONGH (Mongpu), SBH (Solak Busty, Kalimpong) and DGHH-1 (Dr. Graham's Homes, kalimpong) samples in very small amount . HDE/P ratio was found within the range of 0.001-0.06 . So the honey dew elements were practically none (Lou[illegible]aux *et al.,* 1978) (plate XVI, fig. 20 a, b, & c and text fig. 2.6.1).

Table 3.3.1B; SIMILARITY INDEX VALUES AMONG VARIOUS HONEYS DURING SAME/DIFFERENT PERIODS FROM SAME PLACES

Honey samples			Total No. of pollen types	No. of pollen types common to samples	Similarity index
Code No.	Month of collection	Sample No.			
M SANGH-1	July	64	15		
U SANGH-2	August	65	22	3	0.12
M SANGH-3	June	38	12		
M RIMH-1	August	59	6	1	0.08
U RIMH-2	October	60	6		
U SFH-1	April	35	18	2	0.04
M SFH-2	January	46	25		
M MONSH-1	March	23	12	2	0.09
M MONSH-2	April	24	10		
M MIBH-1	March	21	15	8	0.21
M MIBH-2	June	22	23		
M LH-1	May	19	13	2	0.07
M LH-2	July	54	14		
M DGHH-1	May	4	10		
M DGHH-2	March	5	10	2	0.09
U DGHH-3	Sept.	50	12		
U CHIB-1	Octo.	49	8	1	0.06
M CHIB-2	April	3	7		

M= Multifloral, U= Unifloral

The similarity index values in all these above cases are lower than 0.5. This is attributable to different floristic composition within the perimeter of the bees foraging range. The diversity between the samples SFH-1 and SFH-2 is maximum due to different collecting seasons. The similarity values between these two samples is minimum among all the above samples.

Table 3.3.2A : Enumeration of Microscopic Analytical Data of Honey Samples from the study area. [*Apis cerana indica* F.].

Sl. No.	**Sample Code and collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
48	AH (Algarah Honey) August 1996.		*Calendula officinlis* 28.26 (Asteraceae) *Buddleja asiatica* 19.57 *Bidens pilosa* 15.22 (Asteraceae)	*Cestrum* spp. 13.04 (Solanaceae) *Schima wallichii* 10.37 *Tetrastigma obtectum* 4.35 (Vitaceae)	*Cyphomandra betacea* 2.17 (Solanaceae) *Vitis dubea* 2.17 (Vitacea) *Rosa* spp. (Rosaceae) 2.17 *Aristolochia* spp. 2.17 (Aristolochiaceae) Unidentified 0.51%	Multifloral
1	BBH (Bhalukaop) June 1997		*Phseolus* spp. 19.17 (Fabaceae)	*Michelia* spp. 11.11 (Magnoliaceae) *Saxifraga sarmontosa* (Saxifragaceae) 14.81 *Milletia* sp. 14.81 (Fabaceae) *Magnolia* spp. 1.1 (Magnoliaceae) *Aspidopterys nutans* 7.4 (Malpighiaceae) *Nicotiana tabacum* 3.1. (Solanaceae) *Ageratum* spp. 3.7 (Asteraceae) *Camellia* spp. 3.7 (Ternstroemiaceae) *Nemophilla menziensii* 11.11 (Hydrophyllaceae) *Poaceae* 10		Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
2	CH (Chalsa Honey) May, 1996		*Tropaeolum majus* 17.25 (Tropaeolaceae) *Rosa* spp. 22.08 (Rosaceae) *Brassica* spp. 23.18 (Brassicaceae) *Embelia ribes* 12.39 (Myrsinaceae)		*Trifolium repens* 1.34 (Fabaceae) *Spirea micrantha* 2.15 (Rosaceae) *Cestrum* spp. 1.07 (Solanaceae) *Michelia excelsa* 1.07 (Magnoliaceae) *Spergula arvensis* 2.42 (Polygonaceae) *Clerodendrum* spp. 3.07 (Verbenaceae) *Sterculia* sp. 3 (Sterculiaceae) *Thevetia* sp. 2 (Apocynaceae) *Justicia adhatoda* 1 (Acanthaceae) *Mangifera* sp. 1.39 (Anacardiaceae) *Aconogonum molle* 0.8 (Polygonaceae) *Symplocos* spp. 0.4 (Symplocaceae) *Pyrus* sp. 0.26 (Rosaceae) *Centaurea* sp. 0.4 (Asteraceae) Unidentified 0.13	Multifloral

Sl. No.	**Sample Code and collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
49	CHIBH-1 (Chibo Busty Honey) October 1996	*Ageratum* spp. 55.0 (Asteraceae)	*Bidens pilosa* 33.3 (Asteraceae)	*Rosa* spp. 3.3 (Rosaceae)	*Centaurea* spp. 2.2 (Asteraceae) *Lysimachia* spp. 2.2 (Primulaceae) *Cestrum* spp. 1.1 (Solanaceae) *Sechium edule* 1.1 (Cucurbitaceae) Unidentified 1.8	Unifloral
3.	CHIBH-2 April 1997		*Aconogonum molle* 23.2 (Polygonaceae) *Asystasia macrocarpa* 16.6 (Acanthaceae) *Calendula officinalis* 16.6 (Asteraceae) *Gladiolus* spp. 16.6 (Liliaceae) *Rosa* spp. 16.6 (Rosaceae)	*Nicotiana tabacum* 10.0 (Solanaceae)	Unidentified 0.4	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
8	DAMH-1 (Damthang, Sikkim) April 1996		*Prunus* spp. 31.0 (Rosaceae)	*Brassica* spp. 5 (Brassicaceae) *Schima wallichii* 12 (Ternstroemiaceae) *Clematis* spp. 8 (Ranunculaceae) *Eupatorium adenophorum* 5 (Asteraceae) *Rosa* spp. 15 (Rosaceae) *Michelia* spp. 6 (Magnoliaceae) *Syzigium* spp. 4 (Myrtaceae) *Ageratum conyzoides* 3 (Asteraceae) *Berberis* spp 3 (Berberidaceae) *Citrus* spp. 5 (Rutaceae)	*Nemophilla menziensii* 2 (Hydrophyllaceae) *Phaseolus* spp. 1 (Fabaceae) Unidentified 2.99	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
9	DAMH-2	*Rosa* spp. 66.66 (Rosaceae)		*Centaurea* spp. 12.11 (Asteraceae) *Schima walichii* 6 (Ternstroemiaceae) *Citrus* spp. 8.5 (Rutaceae)	*Symplocos* 1.00 (Symplocaceae) *Strobilanthus thomsonii* .04 (Acanthaceae) *Ammomum subulatum* 0.5 (Zingiberaceae) *Gynocardia odorata* 0.5 (Flacourtiaceae) *Emblica officinalis* 2.0 (Euphorbiaceae) *Rhododendron* spp. 1 (Ericaceae) Unidentified 0.65	Unifloral
4.	DGHH-1 (Dr. Graham's Homes Area		*Schima wallichii* 39.9 (Ternstroemiaceae)	*Fragaria* spp. 6.6 (Rosaceae) *Erigeron karwinskianus* 6.6 (Asteraceae) *Strobilanthus thomsonii* 9.5 (Acanthaceae) *Abutilon* sp. 13.3 (Malvaceae) *Cyphomandra betacea* 8.5 (Solanaceae) *Petunia hybrida* 3.8 (Solanaceae) *Gynocardia odorata* 10.5 (Flacourtiaceae)	Poaceae -1 Unidentified 0.3	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
5	DGHH-2 March 1996		*Solidago virga-aurea* 43.0 (Asteraceae) *Tithonia diversifolia* 35.8 (Asteracea)	*Primula* spp. 6.4 (Primulaceae) *Hydrocotyl himalaica* 4.4 (Apiaceae)	*Prunus* spp. 1.47 (Rosaceae) *Michelia* spp. 0.5 (Magnoliaceae) *Raphanus sativus* 2.2. (Brassicaceae) *Coccinea grandis* 1.47 (Cucurbitaceae) *Ageratum conyzoides* 0.7 (Asteraceae) *Schima wallichii* 1.0 (Ternstroemiaceae) *Potentilla* spp. 0.7 (Rosaceae) *Hypericum* spp. 0.7 (Hypericaceae) *Citrus* spp. 0.7 (Rutaceae) *Bidens piloss* 0.7 (Asteraceae) *Datura* spp. 0.7 (Solanaceae) *Poaceae* 0.2 Unidentified 0.06	Multifloral

Sl. No.	**Sample Code and collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
50	DGHH-3 September 1996	*Schima* Wallichii 60.15 (Ternstroemiaceae)		*Trifolium repens* 6.75 (Fabaceae) *Buddleja asiatica* 6.25 (Buddlejaceae) *Magnolia* spp. 3.25 (Magnoliaceae) *Centaurea* spp. 3.1. (Asteraceae) *Sechium edule* 3.1 (Cucurbitaceae) *Ipomoea purpurea* 4.4 *(*Convolvulaceae) Poaceae 3 *Luffa* spp. 4.4 (Cucurbitaceae)	*Erigeron karwinskianus* 1.2 (Asteraceae) *Fragaria* spp. 1.2 (Rosaceae) *Dichroa febrifuga* 2.0 (Hydrangeaceae) Unidentified 1.2	Unifloral
7	DH (Deolo Hills Honey) June 1996	*Fragaria* spp. 23.8 (Rosaceae)		*Brassica* spp. 14.7 (Brassicaceae) *Tropaeolum majus* 3.75 (Tropaeolaceae) *Streptosolen jamesonii* 4.64 (Solanaceae) *Euphorbia pulcherrima* 7.69 (Euphorbiaceae) *Sedum multicaule* 7.69 (Crassulaceae) *Tithonia diversifolia* 7.9 (Asteraceae) *Thunbergia* sp. 3.75 (Acanthaceae) *Prunus* spp. 7.9 (Rosaceae) *Ageratum conyzoides* 4.25 (Asteraceae)	*Clematis* spp. 2.5 (Ranunculaceae) *Papaver* spp. 1 (Papavaraceae) *Buddleja asiatica* 1.4 (Buddlejjaceae) *Emblica* sp. 1.5 (Euphorbiaceae) Unidentified 0.05	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
26	DUDH (Dudhia Tea Estate Honey) April 1998	*Trifolium repens* 51.5 (Fabaceae)		*Prunus* spp. 9.2 (Rosaceae) *Camellia* spp. 10.2 (Ternstroemiaceae) *Petunia* spp. 11.2 (Solanaceae) *Primula* spp. 7.3 (Primulaceae)	*Spirea* spp. 2.0 (Rosaceae) *Rosa* spp. 0.9 (Rosaceae) *Coffea bengalensis* 2.7 (Rubiaceae) *Cestrum* spp. 1.3 (Solanaceae) *Leycesteria* spp. 0.5 (Caprifoliaceae) *Brassica* spp. 0.26 (Brassicaceae) *Veronica* spp. 0.5 (Scrophulariaceae) *Streptosolen jamesonii* 1.54 (Solanaceae) *Erigeron karwinskianus* 0.8 (Asteraceae) Unidentified 0.14	Unifloral
10	DUKH (Duka Honey) May 96		*Citrus* spp. 25 (Rutaceae) *Buddleja asiatica* 25 (Buddlejaceae) *Jasminum* spp. 25 (Oleaceae) Poaceae 20	*Clerodendrum* spp. 3.75 (Verbenaceae) Unidentified 0.25	*Cestrum elegans* 1 (Solanaceae)	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
41	DUNGH (Dungra Busty Honey) December 1995		*Cardamine hirsuta* 18.5 (Brassicaceae) *Bidens pilosa* 20 (Asteraceae) *Brassica* spp. 36 (Brassicaceae)	*Macaranga* sp. 4.5 (Euphorbiaceae) *Leucus* sp. 3.5 (Lamiaceae) *Abelmoschus* sp. 10 (Malvaceae) *Coriandrum* sp. 4 (Apiaceae)	*Justicia* spp. 1 (Acanthaceae) *Momordica* sp. 1 (Cucurbitaceae) Unidentified 1.5	Multifloral
6	DZH (Dzongu Honey N. Sikkim) June 1996	*Citrus* spp. 54.22 (Rutaceae)		*Fragaria* spp. 7.69 (Rosaceae) *Pyrus japonica* 7.69 (Rosaceae) *Rosa* spp. 3.84 (Rosaceae) *Prunus* spp. 3.84 (Rosaceae) *Spiraea* spp. 3.84 (Rosaceae) *Gynocardia odorata* 3 (Flacourtiaceae)	*Berberis* sp. 2.6 (Berberidaceae) *Streptosolen jamesonii* 2.5 (Solanaceae) Unidentified 1.3	Unifloral

Sl. No.	**Sample Code and collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
42	EBH (Echhey Busty Honey) January 1996	*Aristolochia* spp. 52 (Aristolochiaceae)		*Buddleja asiatica* 4 (Buddlejaceae) *Raphanus sativus* 4.5 (Brassicaceae) *Oenanthe thomsonii* 8.8 (Apiaceae) *Tropaeolum majus* 5.9 (Tropaeolaceae) *Oxalis tetraphylla* 3.2 (Oxalidaceae) *Primula glabra* 4.6 (Primulaceae) *Brassica* spp. 5.6 (Brassicaceae) *Spiraea* spp. 4.4 (Rosaceae) *Erigeron karwinskianus* 3.14 (Asteraceae)	*Rosa* spp. 0.5 (Rosaceae) *Schisandra* spp. 1.48 (Schisandraceae *Cardamine hirsuta* 0.5 (Brassicaceae) Unidentified 1.38	Unifloral
11	ELEH (Eleventh Mile Honey, Kalimpong) April 1996		*Clematis* spp. 32.7 (Ranunculaceae) *Papaver* spp. 17.7 (Papavareceae) *Tithonia diversifolia* 24.7 (Asteraceae)	*Ageratum conyzoides* 8.9 (Asteraceae) *Brassica* spp. 3.5 (Brassicaceae) *Cautleya lutea* 4.4 (Zingiberaceae)	*Eupatorium adenophorum* 1.7 *Prunus* spp. 2.6 (Rosaceae) *Cestrum* spp. 1.7 (Solanaceae) *Rosa* spp. 0.9 (Rosaceae) Unidentified 0.2	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
12	FH (Fifth Mile Honey) June 1996		*Streptosolen jamesonii* 18.22 (Solanaceae)	*Rossa* spp. 8.00 (Rosaceae) *Tropaeolum majus* 3.88 (Tropaeolaceae) *Coccinea grandis* 8.33 (Cucurbitaceae) *Sedum multicaule* 8.33 (Crassulaceae) *Datura* spp. 12.66 (Solanaceae) *Centaurea* spp. 3.0 (Asteraceae) *Raphanus sativus* 8.9 (Brassicaceae) *Spiraea* spp. 5.55 (Rosaceae) *Basia butyracea* 4.8 (Sapotaceae)	*Primula* spp. 2.22 (Primulaceae) *Zanthoxylum oxyphyllum* 1.66 (Rutaceae) Poaceae 2.6 *Galinsoga parviflora* 2.0 (Asteraceae) *Ipomoea* sp. 2.2 (Convolvulaceae) *Hottuynia cordata* 0.8 (Saururaceae) *Cyphomandra betacea* 2.6 (Solanaceae) *Wisteria chinensis* 1.2 (Fabaceae) *Emblica* sp. 1.5 (Euphorbiaceae) *Morus* sp. 1.5 (Moraceae) Cactaceae 0.8 *Rubia* spp. 2.5 (Rubiaceae) *Linaria* sp. 2.0 (Scrophulariaceae)	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
13	GANH (Gangtok Honey) March 1997		*Bauhinia* spp. 19.78 (Caesalpinaceae)	*Datura* spp. 10.00 (Solanaceae) *Milletia pulchra* 8.79 (Fabaceae) *Nemophilla menziensii* 10.43 (Hydrophyllaceae) *Sambucus* spp. 9.89 (Sambucaceae) *Iberis* spp. 3.29 (Brassicaceae) *Erigeron karwinskianus* 4.64 (Asteraceae) *Magnolia* spp. (Magnoliaceae) *Rosa* spp. 4.03 (Rosaceae) *Asystacia macrocarpa* 3.84 (Acanthaceae) *Ammomum subulatum* 11.6 (Zingiberaceae)	*Gynocardia odorata* 1 (Flacourtiaceae) *Antirrhinum* spp. 1.09 (Scrophulariaceae) *Brassica* spp. 1.57 (Brassicaceae) *Trifolium repens* 2.54 (Fabaceae) *Tropaeolum majus* 1.8 (Tropaeolaceae) *Calendula officinalis* 2.19 (Asteraceae) *Desmodium* spp. 2.00 (Fabaceae) Unidentified 1.57	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
52	GORH (Gorubathan Honey) September 1996		*Ageratum conyzoides* 41.8 (Asteraceae) *Dalbergia sissoo* 17.06 (Fabaceae)	*Centauria* spp. 8.18 (Asteraceae) *Rosa* spp. 3.48 (Rosaceae) *Sterculia* sp. 6.5 (Sterculiaceae) *Primula* spp. 7.00 (Primulaceae)	*Porana* spp. 2.32 (Convolvulaceae) *Momordica* sp. 0.5 (Cucurbitaceae) *Cassia* sp. 1 (Caesalpinaceae) *Lantana camara* 2.44 (Verbenaceae) *Symplocos* 2.2 (Symplocaceae) *Woodfordia fruticosa* 2.0 (Lythraceae) Unidentified 1.	Multifloral
51	GTEH (Ging Tea Estate Honey, Darjeeling) April 1997		*Camelia* spp. 34.57 (Ternstroemiaceae) *Fragaria* spp. 20 (Rosaceae)	*Clematis* spp. 5 (Ramunculaceae) *Bidens pilosa* 6.16 (Asteraceae) *Rosa* spp. 5.68 (Rosaceae) *Calendula officinalis* 4 (Asteraceae) *Eupatorium adenophorum* 5.76 (Asteraceae) *Datura* spp. 3.05 (Solanaceae)	*Ammomum subulatum* 1.00 *Mazus surculosus* 1.03 (Scrophulariaceae) *Jasminum dispemum* 0.68 (Oleaceae) *Primula* spp. 1.35 (Primulaceae) *Plantago* spp. 0.69 (Plantaginaceae) *Edgaria darjeelingensis* 1.0 (Cucurbitaceae) Unidentified 0.05	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
14	HTH (Hill Top Honey, Kalimpong) June 1996		*Datura* spp. 24.3 (Solanaceae)	*Sambucus spp.* 9.4 (Sambucaceae) *Gladiolus* sp. 7.1 (Liliaceae) *Nemophilla menziensii* 7.6 (Hydrophyllaceae) *Prunus* spp. 6.75 (Rosaceae) *Buddleja asiatica* 5.4 (Buddlejaceae) *Michelia* spp. 4 (Magnoliaceae) *Cyphomandra betacea* 3.5 (Solanaceae) *Rubia* sp. 6.5 (Rubiaceae)	*Tropaeohnm majus* 2.7 (Tropaeolaceae) *Calendula officinalis* 2.7 (Asteraceae) *Dahlia imperilis* 2.7 (Magnoliaceae) *Pueraria sikkimensis* 2.7 (Fabaceae) *Rosa* spp. 1.35 (Rosaceae) *Plectranthus mollis* 1.35 (Lamiaceae) *Rosa* spp. 1.35 (Rosaceae) *Leucosceptrum canum* 1.35 (Lamiaceae) *Eucaoyptus* sp. 2.4 (Myrtaceae) *Hottuynia cordata* 0.5 (Saururaceae) *Salvia* spp. 0.6 (Lamiaceae) *Eupatorium adenophorum* 1.00 (Asteraceae) Poaceae 1.3 Cataceae 0.3 Unidentified 0.35	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
15	JH (Jaldhaka Honey) April 1996	*Ageratum Conyzoides* 50 (Asteraceae)		*Potentilla* spp. 11.1 (Rosaceae) *Rosa* spp. 11.1 (Rosaceae) *Bidens pilosa* 5.5 (Asteraceae) *Tithonia diversifflora* 5 (Asteraceae) *Oxalis* spp.11.1 (Oxalidaceae)	*Sterculia* sp. 1 (Sterculiaceae) *Justicia adhatoda* 1.1 (Acanthaceae) *Thevetia peruviana* 1 (Apocynaceae) *Mangifera* sp. 1.1 (Anacardiaceae) *Caesalpinea* sp. 0.9 (Caesalpinaceae) *Allium* sp. 1 (Liliaceae) Unidentified 0.1	Unifloral
17	KAWH (Kaw Honey) March 1997		*Rosa* spp. 41.8 (Rosaceae) *Cardamine hirsuta* 38.93 (Brassicaceae)	*Brassica* spp. 5.72 (Brassicaceae) *Citrus* spp. 7.00 Rutaceae	*Sambucus* spp. 1.63 (Sambucaceae) *Saxifraga sarmontosa* 1.22 (Saxifragaceae) *Cestrum* spp. 0.37 (Solanaceae) *Bidens pilosa* 1.63 (Asteraceae) *Hypoestes triflora* 0.4 (Acanthaceae) *Michelia* spp. 0.8 (Magnoliaceae) *Porana* sp. 0.4 (Convolvulaceae) Unidentified 0.1	Multifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
16	KH (Kagay Honey) May 1996	*Rubus* spp. 52.15 (Rosaceae)		*Schima wallichii* 10.27 (Ternstroemiaceae) *Bellis perennis* 10.0 (Asteraceae) *Calendula officinalis* 5.01 (Asteraceae) *Prunus* spp. 5.01 (Rosaceae)	*Jasminum* spp. 1.38 (Oleaceae) *Clematis* spp. 1.38 (Ranunculaceae) *Centaurea* spp. 1 (Asteraceae) *Cestrum* spp. 0.46 (Solanaceae) *Trifolium repens* 0.41 (Fabaceae) *Fragaria* spp. 1.85 (Rosaceae) Poaceae 1.77 *Desmodium* sp. 1.00 (Fabaceae) *Bombax malabaricum* 1.11 (Bombacaceae) Unidentified 0.26	Unifloral
53	KHAMH (Khamdong Honey, West Sikkim)	*Michelia* spp. 85.36 (Magnoliaceae)		*Schima wallichii* 8.13 (Ternstroemiaceae)	*Clematis* spp. 2.03 (Ranunculaceae) *Jakaranda* sp. 0.4 (Bignoniaceae) *Magnolia* spp. 2.43 (Magnoliaceae) *Streptosolen jamesonii* 0.8 (Solanaceae) *Polygonum* spp. 0.8 (Polygonaceae) Unidentified 2.02	Unifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
43	KURH (Kurseong Honey) November 1996		*Tropaeolum majus* 25 (Tropaeolaceae) *Nicotina tabacum* 25 (Solanaceae)	*Streptosolen jamesonii* 12.5 (Solanaceae) *Majus surculosus* 11.2 (Scrophulariaceae) *Dahlia imperialis* 12.5 (Asteraceae) *Camellia* spp. 12 (Ternstroemiaceae)	*Potentilla* spp. 0.5 (Rosaceae) Unidentified 1.5	Multifloral
19	LH-1 (Lava Honey) May 1996		*Calendula officinalis* 20.02 (Asteraceae) *Rosa* spp. 16.9 (Rosaceae)	*Primula* spp. 7.6 (Primulaceae) *Trifolium repens* 7.6 (Fabaceae) *Eupatorium adenophorum* 9.2 (Asteraceae) *Fragaria* spp. 3.0 (Rosaceae) *Ageratum conyzoides* 12.3 (Asteraceae) *Raphanus sativus* 9.2 (Brassicaceae) *Cestrum* spp. 5.2 (Solanaceae) *Bidens pilosa* 3.6 (Asteraceae)	*Citrus* spp. 1.5 (Rutaceae) Unidentified 0.83	Multifloral

Sl. No.	**Sample Code and collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
54	LH-2 (Lava Honey) July 1996		*Cestrum* spp. 16.20 (Solanaceae) *Tropaeolum majus* 18.6 (Tropaeolaceae) *Passiflora* spp. 17.4 (Passifloraceae)	*Trifolium repens* 3.10 (Fabaceae) *Spirea* spp. 10.8 (Rosaceae) *Saxifraga sarmontosa* 4.65 (Saxifragaceae) *Holboelia latifolia* 9.30 (Lardizabalaceae) *Sedum multicaule* 4.3 (Crassulaceae) *Coronopus didymus* 3.87 (Brassicaceae) *Streptosolen jamesonii* 4.65 (Solanaceae) Poaceae 5	*Papaver* spp. 0.77 (Papavarceae) *Tetrastigma obtectum* 1.55 (Vitaceae) Unidentified 0.77	Multifloral
18.	LINH (Lingee Honey)	*Buddleja asiatica* 51.09 (Buddlejaceae)	*Raphamus sativus* 39.74 (Brassicaceae)	*Tropaeolum majus* 4.73 (Tropaeolaceae)	*Prunus* spp. .032 (Rosaceae) *Cestrum* spp. 0.3 (Solanaceae) *Rosa* sp. 2.20 (Rosaceae) *Citrus* spp. 1.6 (Rutaceae) Unidentified	Unifloral

Sl. No.	Sample Code and collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
25	MBH (Makum Busty	*Millettia pulchra* 70.73 (Fabaceae)		*Rosa* spp. 10.65 (Rosaceae) *Trifolium repens* 4.39 (Fabaceae) *Clematis* spp. 3.41 (Ranunculaceae) *Prunus* spp. 3.00 (Rosaceae)	*Cestrum* spp. 0.97 (Solanaceae) *Spergula arvensis* 0.48 (Caryophyllaceae) *Iberis amara* 0.48 (Barassicaceae) *Porana* spp. 0.48 (Convolvulaceae) *Primula* spp. 1 (Primulaceae) *Sterculia* sp. 1.36 (Sterculiaceae) *Justicia adhatoda* 1 (Acanthaceae) *Mangifera indica* 0.5 (Anacardiaceae) *Gmelina arborea* 0.5 (Verbenaceae)	Unifloral
20	MH (Mitiali Honey) June 1996	*Prunus* spp. 56.79 (Rosaceae)		*Brassica* spp. 6.17 (Brassicaceae) *Rosa* spp. 4.93 (Rosaceae) *Phaseolus* spp. 6.0 (Fabaceae) *Holarrhena pubescens* 3.53 (Apocynaceae) *Lagerstroemia* sp. 3.0 (Lythraceae)	*Fragaria* spp. 6.17 (Rosaceae) *Trifolium repens* 1.23 (Fabaceae) *Cestrum* spp. 2.46 (Solanaceae) *Jakaranda* sp. 2.46 (Bignoniaceae) *Nicotiana tabacum* 2.46 (Solanaceae) *Caesalpinia* sp. 1 (Caesalpinaceae) *Clematis* spp. 0.5 (Ranunculaceae) *Cassia* spp. 2.5 (Caesalpinaceae) *Croton bonplandianum* 1 (Euphorbiaceae)	Unifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
21	MIBH-1 (Middle Bong Busty Honey) March 1996		*Eupatorum adenophorum* 18.6 (Asteraceae) *Nemophilla menziensii* 16.2 (Hydrophyllaceae) *Pimpinella diversifolia* 18.9 (Apiaceae)	*Potentilla fulgens* 11.76 (Rosaceae) *Primula* spp. 9.3 (Primulaceae) *Rosa* spp. 4.6 (Rosaceae) *Brassica* spp. 4.6 (Brassicaceae) *Prunus* spp. 9.3 (Rosaceae)	*Pyrus japonica* (Rosaceae 2.3) *Datura* spp. 1.2 (Solanaceae) *Eucalyptus* sp. 2.4 (Myrtaceae) *Clematis* spp. 2.3 (Ranunculaceae) Unidentified 1.24	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
22	MIBH-2 (Middle Bong Busty Honey) June 1996		*Fragaria* spp. 20.72 (Rosaceae)	*Cyphomandra betaceae* 3.7 (Solanaceae) *Trifolium repens* 3.4 (Fabaceae) *Rosa* spp. 3.4 (Rosaceae) *Iberis amara* 3.4 (Brassicaceae) *Michelia* spp. 6.8 (Magnoliaceae) *Ageratum conyzoides* 3.9 (Asteraceae) *Prunus* spp. 3.4 (Rosaceae) *Clematis* spp. 3.1 (Ranunculaceae) *Tropaeolum majus* 3.4 (Tropaeolaceae) *Ipomoea* spp. 4.0 (Convolvulaceae) *Hypoestes triflora* 3.4 (Acanthaceae) *Nemophilla menziensii* 5.9 (Hydrophyllaceae) *Basia butyraceae* 3.4 (Sapotaceae) *Linaria* sp. 8.8 (Scrophulariaceae) *Rubia* spp. 9.2 (Rubiaceae)	*Potentilla* spp. 1.2 (Rosaceae) *Schima wallichii* 1.2 (Ternstroemiaceae) *Primula* spp. 1.2 (Primulaceae) *Erigeron karwinskianus* 0.28 (Asteraceae) *Eupatorium adenophorum* 2.4 (Asteraceae) *Galinsoga parviflora* 0.2 (Asteraceae) Cactaceae 0.5 *Salvia* spp. 0.5 (Lamiaceae) Unidentified 1.9	

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
44	MONGH (Mongpu Honey)		*Bellis perennis* 24.5 (Asteraceae) *Rosa* spp. 22.6 (Rosaceae)	*Bidens pilosa* 9.32 (Asteraceae) *Primpinella diversiflia* 11.32 (Apiaceae) *Tropaeolum majus* 7.54 (Tropaeolaceae) *Trifolium repens* 3.7 (Fabaceae)	*Michelia* spp. 2.16 (Magnoliaceae) *Euphorbia* spp. 1.8 (Euphorbiaceae) *Ocimum* spp. 1.8 (Lamiaceae) *Datura* spp. 1.8 (Solanaceae) *Erigeron karwinskianus* 1.57 (Asteraceae) *Cinchona* spp. 2.0 (Rubiaceae) *Brassica* spp. 1.8 (Brassicaceae) *Clematis* spp. 1.8 (Ranunculaceae) *Luffa* sp. 1.8 (Cucurbitaceae) *Crotalaria* spp. 2.07 (Fabaceae) *Galinsoga parviflora* 2.00 (Asteraceae) *Fuchsia dependens* 1.00 (Onagraceae) Unidentified 1.09	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
23	MONSH-1 (Monsong Honey) March 1996		*Prunus* spp. 34.2 (Rosaceae) *Pyrus japonica 25.7* (Rosaceae)	*Hypoestes triflora* 5.3 (Acanthaceae) *Papaver* spp. 8.5 (Papaveraceae) *Rosa spp. 5.7* (Rosaceae) *Michelia* spp. 5.7 (Magnoliaceae) *Begonia* spp. 5.7 (Begoniaceae)	*Centaurea* spp. 2.85 (Asteraceae) *Brassica* spp. 2.85 (Brassicaceae) *Tropaeolum majus* 1.65 (Tropaeolaceae) *Digitalis* spp. 1.65 (Scrophulariaceae) Unidentified 0.2	Multifloral
24	MONSH-2 (Monsong Honey) May 1996		*Brassica* spp. 20 (Brassicaceae) *Lantana camara* 19.5 (Verbenaceae) *Clerodendrum* spp. 24 (Verbenaceae)	*Schima wallichii* 8 (Ternstroemiaceae) *Trifolium repens* 8 (Fabaceae) *Rosa* spp. 8 (Rosaceae)	*Aesculus* spp. 0.5 (Hippocastanaceae) *Magnolia* spp. 0.5 (Magnoliaceae) Poaceae 2.5 *Cinchona* spp. 1.0 (Rubiaceae)	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
27	NEH (Nehaborong Honey) Sikkim June 1997		*Trifolium repens* 22.95 (Fabaceae) *Citrus* spp. 40 (Rutaceae)	*Buddleja asiatica* 8.19 (Buddlejaceae) *Prunus* spp. 9.83 (Rosaceae) *Torenia peduncularis* 6.65 (Scrophulariaceae)	*Strobilanthus* spp. 0.6 (Acanthaceae) *Tropaeolum majus* 0.6 (Tropaeolaceae) *Magnolia* spp. 0.6 (Magnoliaceae) *Begonia* spp. 1.6 (Begoniaceae) *Pyrus japonica* 1.6 (Rosaceae) *Camellia* spp. 1.6 (Ternstroemiaceae) *Gynocardia odorata* 1.0 (Flacouratiaceae) Poaceae 1.0 *Ammomum subulatum* 1.0 (Zingiberaceae) *Potentilla* spp. 2.62 (Rosaceae) Unidentified 0.16	Multifloral

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
28	PEDH-1 (Pedong Honey) June 1996		*Buddleja asiatica* 21.07 (Buddlejaceae) *Prunus* spp. 17.7 (Rosaceae)	*Rosa* spp. 13.23 (Rosaceae) *Trifolium repens* 11.15 (Fabaceae) *Michelia* spp. 5.56 (Magnoliaceae) *Ammomum subulatum* 3 (Zingiberaceae) *Gynocardia odorata* 5.19 (Flacourtiaceae) *Erigeron karwinskianus* 4.0 (Asteraceae)	*Brassica* spp. 1.06 (Brassicaceae) *Fagopyrum* spp. 0.82 (Polygonaceae) *Cleome* spp. 0.41 (Capparaceae) *Hemerocalis* spp. 0.82 (Liliaceae) *Abutilon indicum* 1.23 (Malvaceae) *Raphanus sativus* 2.47 (Brassicaceae) *Rubus* spp. 0.41 (Rosaceae) *Symplocos* spp. 0.82 (Symplocaceae) *Duranta repens* 1.0 (Verbenaceae) *Fragaria* spp. 1.23 (Rosaceae) *Citrus* spp. 1.0 (Rutaceae) *Magnolia* spp. 1 (Magnoliaceae) *Leycesteria* spp. 0.3 (Caprifoliaceae) Unidentified 1.23.	Multifloral

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
55	PEDH-2 (Pedong Honey) July 1996		*Citrus* spp. 17.3 (Rutaceae) *Primula* spp. 16.0 (Primulaceae)	*Lindenbergia grandiflora* 12.8 (Scrophulariaceae) *Buddleja asiatica* 12.8 (Buddlejaceae) *Bidens pilosa* 5.6 (Asteraceae) *Phaseolus* spp. 5.6 (Fabaceae) *Prunus* spp. 5.6 (Rosaceae) *Gynocardia odorata* 12.8 (Flacourtiaceae)	*Aristolochiua* spp. 2.8 (Aristolochiaceae) *Clerodendram* spp. (Verbenaceae) *Trifolium repens* 2.8 (Fabaceae) *Magnolia* spp. 1.2 (Magnoliaceae) Unidentified 1.9	Multifloral
56	PUDH (Pudung Honey) Septermber 1997		*Fragaria* spp. 18.81 (Rosaceae) *Tropaeolum majus* 20.79 (Tropaeolaceae)	*Primula* spp. 12.6 (Primulaceae) *Rubus* spp. 5.94 (Rosaceae) *Nemophilla menziensii* - 11.88 (Hydrophyllacee) *Pedicularis mollis* 4.92 (Scrophulariaceae) *Tithonia diversifolia* 5.3 (Asteraceae) *Cardiospermum helicacabum* 3.9 (Sapindaceae) *Solanum* spp. 3.9 (Solanaceae)	*Plectranthus mollis* 2.97 (Lamiaceae) *Pyrus japonica* 0.9 (Rosaceae) *Galinsoga parviflora* 2.98 (Asteraceae) *Hydrocotyl himalaica* 0.9 (Apiaceae) *Thumbergia* sp. 0.9 (Acanthaceae) *Trifolium repens* 0.9 *(Fabaceae)* *Clematis* spp. 0.9 (Ranunculaceae) Unidenfied 1.25	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
29	PH-1 (Payong Honey) June 1996		*Cestrum* spp. 33.2 (Solanaceae) *Fragaria* spp. 21.53 (Rosaceae)	*Citrus* spp. 13.8 (Rutaceae) *Buddleja asiatica* 9.8 (Buddlejaceae) *Clematis* spp. 3.3 (Ranunculaceae) *Michelia* spp. 12.0 (Magnoliaceae)	*Erigeron karwinskianus*- 0.3 (Asteraceae) *Spirea* spp. 1.38 (Rosaceae) *Schima wallichii* 1.29 (Ternstroemiaceae) *Rhodendron* spp. 1.0 (Ericaceae) Unidentified 2.4	Multifloral
57	PH-2 (Payong Honey) July 1997	*Prunus* spp. 50.22 (Rosaceae)	*Ammomum subulatum* 25 (Zingiberaceae)	*Toddalia asiatica* 3.88 (Rutaceae) *Datura* spp. 3.61 (Solanaceae) *Rosa* spp. 3.88 (Rosaceae) *Hypoestes triflora* 3.16 (Acanthaceae)	*Schima wallichii* 1.8 (Ternstromiaceae) *Calendula officinalis* 1.85 (Asteraceae) *Magnolia* spp. (Magnoliaceae) *Centaurea* spp. 0.9 (Asteraceae) *Erigeron Karwinskianus* 2.00 (Asteraceae) *Citrus* spp. 2.00 (Rutaceae) *Sambucus* spp. 0.79 (Sambucaceae)	Unifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
58	RABH (Rabitar Honey) July 1997	*Brassica* spp. 58.29 (Brassicaceae)	*Iberis amara* 17.84 (Brassicaceae)	*Porana* spp. 6.72 (Convolvulaceae) *Rosa* spp. 6.72 (Rosaceae)	*Pyrus japonica* 1.79 (Rosaceae) *Centaurea* spp. 0.44 (Asteraceae) *Tropaeolum majus* 2.69 (Tropaeolaceae) *Galinsoga parviflora* 0.44 (Asteraceae) *Clarkia pulchella* 0.89 (Onagraceae) *Erigeron karwinskianus* 2.69 (Asteraceae) *Calendula officinalis* 0.44 (Asteraceae) Unidentified 0.51	Unifloral
30	RH (Rabhangla Honey) South Sikkim		*Centaurea* spp. 32.35 (Asteraceae) *Chysenthemum* spp. 23.52 (Asteraceae)	*Prunus* spp. 11.76 (Rosaceae) *Trifolium repens* 5.88 (Fabaceae) *Citrus* spp. 6.5 (Rutaceae)	*Clerodendrum* spp. 2.94 (Verbenaceae) *Pyrus* spp. 1.79 (Rosaceae) *Erigeron karwinskianus* 2.94 (Asteraceae) *Cestrum* spp. 2.94 (Solanaceae) *Gynocardia odorata* 2.94 (Flacourtiaceae) *Leycesteria* spp. 2.94 (Caprifoliaceae) *Buddleja asiatica* 1.2 (Buddlejaceae) *Myosotis sylvatica* 0.8 (Boraginaceae) Unidentified 1.5	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
59	RIMH-1 (Rimbick Honey) August 1996		*Schima wallichii* 37.5 (Ternstroemiaceae) *Symplocos* spp. 25 (Symplocaceae)	*Trifolium repens* 12.5 (Fabaceae) *Solanum* spp. 12.5 (Solanaceae) *Fragaria* spp. 11.2 (Rosaceae)	Unidentified 1.3	Multifloral
60	RIMH-2 (Rimbick Honey) October 1997	*Sedum multicaule*50 (Crassulaceae)	*Selinum tenuifolium* 37.5 (Apiaceae)	*Plectransthus* spp. 4.5 (Lamiaceae) *Begonia* spp.4.4 (Begoniaceae)	*Solanum* spp.2.4 (Solanaceae) Unidentified 1.2	Unifloral
37	SADH (Sadam Honey) South Sikkim May 1997		*Bidens pilosa* 24 (Asteraceae) *Prunus* spp. 14.9 (Rosaceae)	*Ageratum conyzoides* 7.63 (Asteraceae) *Primula* spp. 9.45 (Primulaceae) *Embelia ribes* 4.72 (Myrsinaceae) *Michelia* spp. 7.63 (Magnoliaceae) *Tropaeolum majus* 5.09 (Tropaeolaceae) *Toddalia asiatica* 9.09 (Rutaceae) *Nemophillia menziensii* 9.81 (Hydrophyllaceae) *Citrus* spp. 3.36 (Rutaceae)	*Galium asperifolium* 0.7 (Rubiaceae) *Cardiospermum helicacabum* 0.35 (Sapindaceae) *Pyrus japonica* 0.35 (Rosaceae) *Aristolochia* spp. 1.00 (Aristolochiaceae) *Passiflora foetida* 1.45 (Passifloraceae) *Holboelia latifolia* 0.35 (Lardizabalaceae) Unidentified 0.12	Multifloral

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
61	SAKH (Sakyone Honey) September 1996	*Schima walichii* 68.6 (Ternstroemiaceae)		*Tropaeolum majus* 3.6 (Tropaeolaceae) *Rosa* spp. 5.4 (Rosaceae) *Pyrus japonica* 4.2 (Rosaceae) *Passiflora foetida* 6.1 (Passifloraceae) *Berberis* spp. 3.6 (Berberidaceae)	*Prunus* spp. 1.9 (Rosaceae) *Spirea* spp. 2.12 (Rosaceae) *Oxalis* spp. 0.04 (Oxalidaceae) *Nemophilla menziensii* 0.05 (Hydrophyllaceae) *Symplocos* spp. 0.02 (Symplocaceae) *Nicotiana* spp. 1.8 (Solanaceae) *Datura* spp. 1.8 (Solanaceae) *Magnolia* spp. 1.75 (Magnoliaceae) *Persicaria perfoliata* 2.5 (Polygonaceae) Unidentified 1.78	Unifloral
34	SAMDH (Samdong Honey) East Sikkim June 1997		*Fragaria* spp. 18.42 (Rosaceae) *Tropaeolum majus* 17.10 (Tropaeolaceae) *Ammomum subulatum* 35 (Zingibearceae)	*Prunus* spp. 5.2 (Rosaceae) *Magnolia* spp. 9.21 (Magnoliaceae) *Michelia* spp. 4.57 (Magnoliaceae) *Citurs* spp. 8 (Rutaceae)	*Clarkia pulchela* 1.31 (Onagraceae) *Mikania micrantha* 0.31 (Asteraceae) *Centaurea* 2.00 (Asteraceae) *Gynocardia odorata* 0.52 (Flacourtiaceae) *Osbeckia* spp. 1.00 (Melastomataceae) *Potentilla* spp. 0.94 (Rosaceae)	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
45	SAMH (Samsing Honey) January 1997	*Rosa* spp. 78.5 (Rosaceae)		*Ageratum conyzoides* 7.8 (Asteraceae)	*Brassica* spp. 2.43 (Brassicaceae) *Cleome* spp. 2.4 (Capparaceae) *Asystasia macrocarpa* 2 (Acanthaceae) *Lindenbergia indica* 2.4 (Scrophulariaceae) *Desmodium* sp. 1.3 (Fabaceae) *Coriandrum* sp. 1.0 (Apiaceae) *Allium* spp. 0.8 (Liliaceae) *Moringa* sp. 1.0 (Moringaceae) Unidentified 0.7	Unifloral
64	SANGH-1 (Sangsay Honey) July 1996		*Clandula officinalis* 20 (Asteraceae) *Bellis perennis* 18.82 (Asteraceae) *Desmodium* sp. 14.11 (Fabaceae) Poaceae 5	*Chrysenthemum* spp.10.58 (Asteraceae) *Papaver* spp. 4.7 (Papaveraceae) *Zanthoxylum oxyphyllum* 8.23 (Rutaceae) *Schima wallichii* 8.1 (Ternstroemiaceae) *Veronica* spp 3.52 (Scrohulariaceae)	*Prunus* spp. 1.17 (Rosaceae) *Canna* spp. 1.17 (Cannaceae) *Potentilla* spp. 1.17 (Rosaceae) *Galinsoga parviflora* 1.17 *(Asteraceae)* *Magnolia* spp. 0.88	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
65	SANGH-2 (Sangsay Honey) August 1996	*Schima walichii* 51.63 (Ternstroemiaceae)		*Bidens pilosa* 5.88 (Asteraceae) *Gynocardia odorata* 10.45 (Flacourtiaceae) *Cestrum* spp. 5.55 (Solanaceae) *Centaurea* spp. 6.20 (Asteraceae) *Desmodium* sp. 4.2 (Fabaceae)	*Prunus* spp. 0.33 (Rosaceae) *Aconogonum molle* 1.63 (Polygonaceae) *Buddleja asiatica* 0.32 (Buddlejaceae) *Lysimachia* spp. 0.32 (Primulaceae) *Selinum tenuifolium* 0.98 (Apiaceae) *Rosa* spp. 0.65 (Rosaceae) *Primpinella diversifolia* 1.3 (Apiaceae) *Asystasia macrocarpa* 0.31 (Acanthaceae) *Oenanthe thomsonii* 1.5 (Apiaceae) *Lindenbergia indica* 0.32 (Scrophulariaceae) *Pyrus japonica* 0.98 (Rosaceae) *Primula* spp. 2.61 (Primulaceae) *Canna* spp. 1.5 (Cannaceae) *Craniotome* spp. 2.00 (Lamiaceae) Poaceae 0.3 *Berberis* spp. 0.98 (Berberidaceae) Unidentified 0.88	Unifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
38	SANGH-3 (Sangsay Honey) May 1996		*Gynocardia odorata* 28.81 (Flacourtiaceae) *Plectranthus mollis* 27.11 (Lamiaceae)	*Schima wallichii* 6.68 (Ternstroemiaceae) *Clematis* spp. 10.16 (Ranunculaceae) *Milletia pulchra* 10.16 (Fabaceae) *Buddleja asiatica* 10.16 (Buddlejaceae)	*Magnolia* spp. 0.6 (Magnoliaceae) *Jakaranda* sp. 1.6 (Bignoniaceae) *Prunus* spp. 1.6 (Rosaceae) *Calendula officinalis* 1.6 (Asteraceae) Poaceae 1 Unidentified 0.52	Multifloral

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
33	SBH (Solak Busty Honey) May, 1997	*Schima wallichii* 57.9 (Ternstroemiaceae)		*Streptosolen jamesonii* 8.9 (Solanaceae) *Spirea* spp. 9.64 (RosaceaeO *Terminalia* spp.3 (Combretaceae) *Buddleja asiatica* 6.2 (Buddejaceae)	*Torenia peduncularis* 0.5 (Scrophulariaceae) *Pedicularis mollis* 0.5 (Scrophulariaceae) *Rubus* spp. 1.0 (Rosaceae) *Bergenia* spp. 0.3 (Saxifragaceae) *Fragaria* spp. 1.2 (Rosaceae) *Prunus* spp. 2.00 (Rosaceae) *Woodfordia fruticosa* 1.00 (Lythraceae) *Basia butyracea* 0.86 (Sapotaceae) *Justicia adhatoda* 1.0 (Acanthaceae) *Castanopsis* spp. 1.5 (Fagaceae) *Gmelina arborea* 1.00 (Verbenaceae) *Mangifera* sp. 1.00 (Anacardiaceae) *Thevetia* sp. 0.5 (Apocynaceae)	Unifloral

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
35	SFH-1 (Seed Farm Honey) Apirl 1996	*Fragaria* spp. 54.91 (Rosaceae)		*Schima wallichii* 11.96 (Ternstroemiaceae) *Rosa* spp. 10.16 (Rosaceae) *Trifolium repens* 3.27 (Fabaceae) *Viola* spp. 3.9 (Violaceae)	*Michelia* spp. 1.63 (Megnoliaceae) *Gladiolus* sp. 0.65 (Liliaceae) *Jakaranda* sp. 0.98 (Bignoniaceae) *Delphinium* sp. 1.14 (Ranunculaceae) *Prunus* spp. 2.45 (Rosaceae) *Syzygium* spp. 0.32 (Myrtaceae) *Oxalis* spp. 0.16 (Oxalidaceae) *Erigeron Karwinskians* 0.16 (Asteraceae) *Galium asperifolium* 0.16 (Rubiaceae) *Rungia* sp. 0.16 (Acanthaceae) *Eucalyptus* sp. 1.8 (Myrtaceae) *Acanthus carduaceous* 2.8 (Acanthaceae) *Allium* sp. 1.5 (Liliaceae) Unidentified 2.64	Unifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
46	SFH-2 (Seed Farm Honey) January 1997		*Brassica* spp. 24.03 (Brassicaceae) *Calendula officinalis* 32.45 (Asteraceae)	*Spergula arvensis* 3.36 (Polygalaceae) *Cestrum* spp. 3.5 (Solanaceae) *Porana* spp. 4.90 (Convolvulaceae0 *Nicotiana tabacum* 5.04 (Solanaceae) *Dichroa febrifuga* 4.9 (Hydrangeaceae) *Luffa* sp. 5.1. (Cucurbitaceae)	*Rosa* spp. 0.48 (Rosaceae) *Plectranthus mollis* 0.48 (Lamiaceae) *Prunus* spp. 0.48 (Roaaceae) *Lindenbergia* sp. 2.2 (Scrophulariaceae) *Lantana camera* 1.09 (Verbenaceae) *Michelia* spp. 2.4 (Magnoliaceae) *Centaurea* 1.0 (Asteraceae) *Magnolia* spp. 0.48 (Magnoliaceae) *Desmodium* sp. 1.0 (Fabaceae) *Moringa oleifera* 0.5 (Moringaceae) *Momordica* sp. 1.00 (Cucurbitaceae) *Justicia* sp. 1.00 (Acanthaceae) *Macaranga* sp. 0.5 (Euphorbiaceae) *Leucus* sp. 1.00 (Lamiaceae) *Abelmoschus* sp. 1.00 (Malvaceae) Unidentified 0.09	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
62	SH - 1 (Sumbuk Honey) South Sikkim October 1996		*Drymaria* spp. 28.57 (Caryophyllaceae)	*Linaria odorata* 12.24 (Scrophulariaceae) *Calendula officinalis* 12.24 (Asteraceae) *Thunbergia* sp. 6.12 (Acanthaceae) *Porana* spp. 10.2 (Convolvulaceae) *Bidens pilosa* 9.18 (Asteraceae) *Begonia* spp. 3.08 (Begoniaceae) *Rosa* spp. 4.08 (Rosaceae) *Citrus* spp. 10 (Rutaceae)	*Galinsoga parviflora* 1.02 (Asteraceae) *Berberis* spp. 0.14 (Berberidaceae) Unidentified 1.1	Multifloral
32	SH-2 (Sumbuk Honey) South Sikkim April 1997	*Calendula officinalis* 55.94 (Astetraceae)		*Trifolium repens* 14.68 (Fabaceae) *Solanum* spp. 3.71 (Solanaceae) *Eupatorium adenophorum*-5.24, (Asteraceae) *Erigeron karwinskianus*-4.39 (Asteraceae)	*Symplocos* spp. 0.69 (Symplocaceae) *Jasminum* spp. 0.69 (Oleaceae) *Raphanus sativus* 2.79 (Brassicaceae) *Hypericum* spp. 1.74 (Hyperciaceae) *Leucaena leucocephala* 1.39 (Caesalpinaceae) *Porana* spp. 0.69 (Convolvulaceae) *Brassica* spp. 0.69 (Brassicaceae) *Prunus* spp. 1.02 (Rosaceae) *Dahlia imperialis* 1.74 (Asteraceae) Unidentified 1.86	Unifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
63	SINH (Sindebong busty Honey) July 1996		*Schima wallichii* 28.57 (Ternstroemiaceae) *Trifolium repens* 19.04 (Fabaceae) *Michelia* spp. 23.8 (Magnoliaceae)	*Pyrus japonica* 4.76 (Rosaceae) *Cineraia grandiflora* 9.52 (Asteraceae) *Clematis* spp. 4.76 (Ranunculaceae) *Sambucus* spp. 5.52 (Sambucaceae) *Datura* spp. 4.00 (Solanaceae)	Unidentified 0.03	Multifloral
31	SORBH (Soreng Busty Honey) June 1996	*Primula* spp. 51.21 (Primulaceae)		*Jasminum* spp. 4.8 (Oleaceae) *Rosa* spp. 4.51 (Rosaceae) *Brassica* spp. 73 (Brassicaceae) *Buddleja asiatica* 7.3 (Buddlejaceae) *Fragaria* spp. 7.3 (Rosaceae) *Bauhinia* sp. 3.4 (Caesalpinaceae) *Coffea bengalensis* 3.4 (Rubiaceae) *Duabanga* spp. 3 (Sonerettiaceae)	*Castanopsis* spp. 2.2 (Fagaceae) *Gmelina arborea* 2.0 (Verbenaceae) *Pyrus japonica* (Rosaceae) *Woodfordia fruticosa* 1.00 (Lythraceae) Unidentified 0.32	Unifloral

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
36	SUMBH (Sumbaria Honey) West Sikkim March 1997	*Calendula Officinalis* 66 (Asteraceae)	*Solidago virga-aurea* 18.2 (Asteraceae)	*Ageratum conyzoides* 4.95 (Asteraceae) *Ocimum* spp. 3.3 (Lamiaceae)	*Gynocardia odorata* 0.33 (Flacourtiaceae) *Mucuna pruriens* 0.3 (Fabaceae) *Sabia* sp. 2.3 (Sabiaceae) *Camellia* spp. 0.33 (Ternstroemiaceae) *Aristolochia* spp. 0.33 (Aristolochiaceae) *Porana* spp. 1.32 (Convolvulaceae) *Strobilanthus* sp. 0.33 (Acanthaceae) Unidentified 0.64	Unifloral
47	SURH (Suruk Honey) November 1996		*Clamatis* spp. 20.0 (Ranunculaceae) *Rosa* spp. 24 (Rosaceae) *Brassica* spp. 22.2 (Brassicaceae)	*Holboelia latifilia* 7.0 (Lardizabalaceae) *Solanum* spp. 7.5 (Solanaceae) *Bauhinia* spp. 10. (Caesalpinaceae)	*Trifolium repens* 1.06 (Fabaceae) *Coccinea grandis* 0.02 (Cucurbitaceae) *Porana* spp. 0.01 (Convolvulaceae) *Gynocardia odorata* 0.31 (Flacourtiaceae) *Desmodium* sp.1.00 (Fabaceae) *Osbeckia* sp. 1.0 (Melastometaceae)	Multifloral

Sl. No.	Sample Code & collection period	Predominant pollen type (>45%)	Secondary pollen type (16-45%)	Important minor pollen type (3-15%)	Minor pollen type (<3%)	Nature of honey
40	TH (Tendrabong Honey) May 1996	*Prunus* spp.88.8 (Rosaceae)		*Erigeron Karwinskianus* 3.5 (Asteraceae) *Calendula officinalis* 4.2 (Asteraceae) *Rosa* spp. 3.5 (Rosaceae)		Unifloral
39	TODH (Todey Honey) March 1997	*Potentilla* spp. 45.00 (Rosaceae)	*Prunus* spp. 39.1 (Rosaceae)	*Brassica* spp. 7.14 (Brassicaceae) *Spirea* spp. 4.42 (Rosaceae)	*Ligastrum* spp. 0.34 (Oleaceae) *Gynocardia odorata 0.2* (Flacourtiaceae) *Codonopsis affinis* 2.5 (Campanulaceae) *Ammomum subulatum* 1 (Zingiberaceae) Unidentified 0.24	Unifloral

B.HONEY SAMPLES OF *Apis florea* F.

The two collected honey samples of *Apis florea* F. ('Putka' Honey), one from Lathpancher, Kurseong Sub-Division and another from Pabong, Kalimpong Sub-Division constitute the Summer honeys.

Microscopic analysis of both the samples revealed that Pabong honey was the unifloral in nature with the Predominant Pollen type *Trifolium repens* (82.7 %) whereas Lathpancher honey was multifloral in nature. The Secondary Pollen types ranging from 16 to 45 % in the latter was found to be *Primula* spp. (18.03 %), *Spirea* sp. (43.28 %), *Buddleja* sp. (20.10 %). Other important minor (3 – 15 %) and minor pollen (< 3 %) types found in both of the above samples were *Holarrhena* sp., *Desmodium* sp., *Anaphalis* sp., *Bidens pilosa, Asystasia* sp., *Calendula* sp., *Sambucus* sp., *Cestrum* spp., *Erigeron karwinskianus, Clerodendrum* sp., *Rosa* spp., 'unidentified' Pollen types in Lathpancher and Pobong honeys were found to be 2.01 % and 2.02 % respectively. (Tab. 3.3.2B)

Table 3.3.2B: *(Apis florea* F.)

Sl. No.	**Sample Code & collection period**	**Predominant pollen type (>45%)**	**Secondary pollen type (16-45%)**	**Important minor pollen type (3-15%)**	**Minor pollen type (<3%)**	**Nature of honey**
66	LPH (Lathpancher Honey) April 1996		*Primula* spp. 18.03 (Primulaceae) *Spirea* spp. 43.28 (Rosaceae) *Buddleja asiatica* 20.10 (Buddlejaceae)	*Desmodium* sp. 14.02 (Fabaceae)	*Rosa* spp. 2.56 (Rosaceae) Unidentified 2.01	Multifloral
67	PABH (Pabong Honey) March 1998	*Trifolium repens* 82.7 (Fabaceae)		*Holarrhena pubescens* 5.44 (Apocynaceae)	*Anaphalis* spp. 1.6 (Asteraceae) *Bidens pilosa* 1.2 (Asteraceae) *Asystasia* sp. 1.47 (Acanthaceae) *Calendula officinalis* 2.02 (Asteraceae) *Sambucus* spp. 1.62 (Sambucaceae) *Cestrum* spp. 0.38 (Solanaceae) *Clerodendrum* sp. 0.2 (Verbenaceae) *Erigeronkarwinskianus* 1.17 (Asteraceae) Unidentified 2.02	Unifloral

3.3.1. FREQUENCY CLASSES OF POLLEN TYPES

A total of ± 166 pollen types referable to 78 families have been recognised in 67 honey samples collected from Sikkim and Sub-Himalayan West Bengal. The pollen types were recognised in three different honey flow periods (HFP) separately under four different frequency classes viz. Predominant (P,> 45%), Secondary (S,16-45%), Important minor (I, 3-15%) and Minor (M, <3%). The number of total pollen types as enumerated in three honey flow periods were found to be :

HFP - I (Winter honeys) — 60.

HFP - II (Summer honeys) — 142

HFP - III (Autumn honeys) — 91.

The various pollen types recovered from each honey sample of three different honey flow period (HFP) and their frequency classes have been shown in table 3.3.1.1A, 3.3.1.1B, 3.3.1.1C.

List of abbreviations of honey samples corresponding to the serial No. used in following tables :

[1 = BBH
2 = CH
3 = CHIB-2
4 = DGHH-1
5 = DGHH-2
6 = DZH
7 = DH
8 = DAMH-1
9 = DAMH-2
10 = DUKH
11 = ELEH
12 = FH
13 = GANH
14 = HTH
15 = JH
16 = KH
17 = KAWH
18 = LINH
19 = LH-1
20 = MH
21 = MIBH-1
22 = MIBH-2
23 = MONSH-1
24 = MONSH-2
25 = MBH
26 = DUDH
27 = NEH
28 = PEDH-1
29 = PH-1
30 = RH
31 = SORBH
32 = SH-2
33 = SBH
34 = SAMDH
35 = SFH-1
36 = SUMBH
37 = SADH
38 = SANGH-3
39 = TODH
40 = TH
41 = DUNGH
42 = EBH
43 = KURH
44 = MONGH
45 = SAMH
46 = SFH-2
47 = SURH
48 = AH
49 = CHIB-1
50 = DGHH-3
51 = GTEH
52 = GORH
53 = KHAMH
54 = LH-2
55 = PEDH-2
56 = PUDH
57 = PH-2
58 = RABH
59 = RIMH-2
60 = RIMH-2
61 = SAKH
62 = SH-1
63 = SINH
64 = SANGH-1
65 = SANGH-2
66 = LPH
67 = PABH

HFP = Honey flow period
P = Predominant pollen types (>45%)
S = Secondary pollen types (16-45%)
I = Important minor pollen types (3-15%)
M = Minor pollen types (<3%)]

Table 3.3.1.1A : Frequency Classes of Pollen Types of **Winter Honeys** (HFP-1) (November - February)

	Sample No.						
Pollen types	**41**	**42**	**43**	**44**	**45**	**46**	**47**
Acanthaceae							
Asystasia macrocarpa					I		
Justicia spp.	M					M	
Acanthus carduaceous							
Apiaceae							
Coriandrum spp.	M				M		
Pimpinella diversifolia				I			
Oenanthe thomsonii		I					
Aristolochiaceae							
Aristolochia spp.		P					
Asteraceae							
Bellis perennis				S			
Ageratum spp.					I		
Bidens pilosa	S			I			
Erigeron karwinskianus		I		I			
Dahlia imperialis			I			M	
Galinsoga parnviflora				M			
Calendula officinalis						S	
Centaurea spp.						M	
Brassicaceae							
Cardamine hirsuta	S	M					
Brassica spp.	S	I		M	M	S	S
Raphanus sativus		I					
Buddlejaceae							
Buddleja asiatica		I					
Caesalpinaceae							
Bauhinia sp.							I
Capparaceae							
Cleome spp.					M		
Convolvulaceae							
Porana racemosa						I	M

Contd...

Pollen types	Sample No.						
	41	42	43	44	45	46	47
Cucurbitaceae							
Coccinea grandis							M
Luffa spp.				M		I	
Euphorbiaceae				M			
Croton spp.							
Macaranga sp.	I					M	
Fabaceae							
Trifolium repens				I			M
Desmodium spp.					M	M	M
Crotalaria spp.				M			
Flacourtiaceae							
Gynocardia odorata							M
Hydrangiaceae							
Dichroa febrifuga						I	
Lamiaceae							
Ocimum basilicum				M			
Plectranthus mollis						M	
Leucus sp.	I					M	
Liliaceae							
Allium spp.					M		
Magnoliaceae							
Magnolia spp.						M	M
Michelia spp.				M		M	M
Malvaceae							
Abelmoschus sp.						M	
Moringaceae							
Moringa oleifera					M	M	
Oxalidaceae							
Oxalis sp.		I					
Primulaceae							
Primula spp.		I					

Contd...

	Sample No.						
Pollen types	**41**	**42**	**43**	**44**	**45**	**46**	**47**
Ranunculaceae							
Clematis spp.				M			S
Rosaceae							
Rosa spp.		M		M	P	M	S
Prunus spp.						M	
Potentilla fulgens			M				
Spirea micrantha		I					
Rubiaceae							
Cinchona spp.				M			
Sapindaceae							
Cardiospermum helicacabum							M
Schisandraceae							
Schisandra sp.		M					
Scrophulariaceae							
Veronica spp.							M
Lindenbergia indica					M	I	
Mazus surculosus			I				
Solanaceae							
Datura spp.				M			
Cestrum spp.						I	
Streptosolen jamesonii			I				
Solanum spp.							I
Nicotiana tabacum			S			I	
Sonerettiaceae							
Duabanga spp.							I
Ternstroemiaceae							
Camellia spp.			I				
Tropaeolaceae							
Tropaeolum majus		I	S	I			
Verbenaceae							
Lantana camara						M	

Table 3.3.1.1B : Frequency Classes of Pollen Types of **Summer Honeys** (HFP-II) (March - June)

Pollen types	Sample No.																																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Acanthaceae																																										
Strobilanthes spp.				I		I			M																		M															
Justicia spp.		M													M										M								M									
Asystasia macrocarpa																																										M
Acanthus carduaceous						M																												I								
Thunbergia sp.							I																																			
Rungia pectinata																																			M							
Anacardiaceae																																										
Mangitera sp.		M													M										M								M									
Apiaceae																																										
Hydrocotyl spp.					I																																					
Pimpinella diversifolia																					I																					
Apocynaceae																																										
Holarrhena pubescens																				I																						I
Thevetia sp.		M													M										M								M									
Aristolochiaceae																																										
Aristolochia spp.																																				M	M					
Asteraceae																																										
Bellis perennis																I																										
Tithonia diversifolia						S	I				S				I																					I	I					
Ageratum spp.	I				M		I	I			I				P				I			I															S					
Bidens pilosa					M										I		M		I																	S						M
Solidago virga-aurea					S																															S						
Erigeron karwinskianus				I									M									M				M		I	M	M		I			M					I		M
Dahlia imperialis														M																		M										
Eupatorium adenophorum								I			M			M					I		S	I										I										

Contd...

	Sample No.																																									
Pollen types	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Galinsoga parnviflora												M										M																				
Mikania micrantha																																		M								
Calendula officinalis													M	M		I			S													P				P		M		I		
Chrysenthemum spp.																														S												
Centaurea spp.		M							S			I				M							M							S				M								
Anaphalis spp.																																										M
Cineraria grandiflora																																										M
Begoniaceae																																										
Begonia flaviflora																							I				M															
Berberidaceae																																										
Berberis insignis						M																										M										
Bignoniaceae																																										
Jakaranda sp.																				M															M			M				
Bombacaceae																																										
Bombax malabaricum																M																										
Boraginaceae																																										
Myosotis sylvatica																														M												
Brassicaceae																																										
Cardamine hirsuta																	S																									
Brassica spp.		S					I	I			I		M				I			I	I		M	S	M			M			I	M							I			
Raphanus sativus					I							I						S	I	M											M											
Iberis amara													I						I			I			M																	
Buddlejaceae																																										
Buddleja asiatica							M			S				I				P									I	S	I	M	I		I					I			S	
Cactacae												M		M								M																				

Contd...

	Sample No.																																									
Pollen types	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Caesalpinaceae																																										
Cassia sp.																				M																						
Bauhinia sp.																															I											
Caesalpinea sp.															M					M																						
Campanulaceae																																										
Codonopsis spp.																																							M			
Capparaceae																																										
Cleome spp.																												M														
Caprifoliaceae																																										
Leycesteria sp.																										M		M		M												
Caryophyllaceae																																										
Spergula arvensis																									M																	
Combretaceae																																										
Terminalia spp.																														I												
Convolvulaceae																																										
Porana racemosa																	M								M							M				M						
Ipomoea spp.												M										I																				
Crassulaceae																																										
Sedum multicaule							I					I																														
Cucurbitaceae																																										
Coccinea grandis					M							I																														
Ericaceae																																										
Rhododendron spp.									M																				M													

Contd...

Pollen types	Sample No.																																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Euphorbiaceae																																										
Emblica spp.							M		I			M																														
Croton spp.																				M																						
Euphorbia pulcherrima							I																																			
Fabaceae																																										
Milletia pulchra	I												I												P																	
Trifolium repens		M											M			M			I	M		I		I	I		S	I		I		I			I							P
Phaseolus spp.	S							M												I																						
Desmodium spp.													M			M																			M						I	
Pueraria sikkimensis									M					M																												
Wisteria chinensis												M																														
Mucuna pruriens																																				M						
Fagaceae																																										
Castanopsis spp.																															M		M									
Flacourtiaceae																																										
Gynocardia odorata				I		I			M				M														M	I						M		M		S	M			
Hippocastanaceae																																										
Aesculus indica																								M																		
Hydrophyllaceae																																										
Nemophilla menziensii													I	I							S	I															I					
Hypericaceae																																										
Hypericum spp.					M																					M						M										

Contd...

	Sample No.																																									
Pollen types	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Lamiaceae																																										
Ocimum basilicum																																				I						
Salvia spp.														M								M																				
Leucosceptrum cannum														M																												
Plectranthus mollis							I							M																								S				
Liliaceae																																										
Allium spp.															M																				M							
Hemerocallis disticha																												M														
Gladiolus sp.			S											I																					M							
Lythraceae																																										
Lagerstroemia reginae																				I																						
Woodfordia fruticosa																									M						M		M									
Magnoliaceae																																										
Magnolia spp.	I												I	M										M			M	M						I				M				
Michelia spp.	I	M			M			I					M	I			M					I	I					I	I					I	M		I					
Malpighiaceae																																										
Aspidopterys spp.	I																																									
Malvaceae																																										
Abutilon indicum				I																								M														
Mimosaceae																																										
Leucaena leucocephala																																M										
Moraceae																																										
Morus alba												M																														

Contd...

	Sample No.																																									
Pollen types	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Myrsinaceae																																										
Embelia ribes		I																																			I					
Myrtaceae																																										
Syzygium cumini		I						I																											M							
Eucalyptus sp.													M								M														M							
Oleaceae																																										
Jasminum spp.										S						M															I	M										
Ligastrum sp.																																							M			
Oxalidaceae																																										
Oxalis sp.															I																				M							
Papavaraceae																																										
Papavar spp.							M				S												I																			
Passifloraceae																																										
Passiflora spp.																																					M					
Primulaceae																																										
Primula spp.					I							M							I		I	M		I	I	I					P						S				S	
Poaceae	I				M					S		M		M		M								I			M	I								M		M				
Ranunculaceae																																										
Clematis spp.							M	I	S							M				I	M	I			I				I									I				
Dephinium ajacis																																			I							

Contd...

Pollen types	Sample No.																																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Rosaceae																																										
Rosa spp.		S	S			I	S	I	P		M	I	I	M	I	I	S	M	S	I	I	I	I	I	I	M		I			S				I					I	M	
Frageria spp.				I		I	S									M			I	M		I						M	S		I		M	S	P							
Prunus spp.					M	I	I	S	M					I		I		M		P	I	I	S		I	I	I	S		I		M	M	M	M		I	M	S	E		
Potentilla fulgens					M.										I						I	M					M							M					P			
Rubus ellipticus																P				M								M					M									
Spirea micrantha		M				I						I														S			M				I						I		M	
Pyrus spp.																				M	M		S				M			M	M						M					
Rubiaceae																																										
Rubia sp.												I		I								I																				
Galium spp.																																			M		M					
Coffea bengalensis																										S					I											
Cinchona spp.																								M																		
Rutaceae																																										
Citrus spp.					M	P		I	I	S							I	M	M								S	M	I	I				I			I					
Toddalia asiatica																																					I					
Zanthoxylum oxyphyllum												M																														
Sabiaceae																																										
Sabia campanulata																																				M						
Sambucaceae																																										
Sambucus spp.													I	I	M																											
Sapindaceae																																										
Cardiospermum helicacabum																																					M					
Sapotaceae																																										
Basia butyracea												I										I										M										

Contd...

	Sample No.																																									
Pollen types	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Saxifragaceae																																										
Saxifraga sp.	I																M																									
Saururaceae																																										
Hottuynia cordata												M		M																												
Schisandraceae																																										
Schisandra sp.																																										
Scrophulariaceae																																										
Veronica spp.																										M				M												
Linaria spp.												M	M									I																				
Digitalis purpurea																							M																			
Torenia spp.																											I						M									
Pedicularis mollis																																	M									
Solanaceae																																										
Datura spp.					M							I	I	S							M	M																				
Cestrum spp.		M								M	M		M			M	M	M	I	M					M	M			S	M												M
Streptosolen jamesonii						M	I					S														M							S									
Solanum spp.																																I										
Cyphomandra betacea				I								M		I								I																				M
Nicotiana tabacum	I		I																	M																						
Petunia sp.				I										I												I																
Sonerettiaceae																																										
Duabanga spp.																															I											
Sterculiaceae																																										
Sterculia sp.		I																							M								M									

Contd...

	Sample No.																																									
Pollen types	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	66	67
Symplocaceae																																										
Symplocos sp.		M						M																				M				M										
Schima wallichii				S												I						M		I					M				M		I			I				
Camellia spp.	I																									I	M									M						
Tropaeolaceae																																										
Tropaeolum majus		S					I					I	M	M				I				I	M				M							S			I					
Verbenaceae																																										
Clerodendrum spp.		I								I														S						M												
Duranta repens																												I														
Lantana camara																								S																		
Gmelina arborea																									M						M		M									
Violaceae																																										
Viola sp.																																			M							
Zingiberaceae																																										
Cautleya spp.											I																															
Ammomum subulatum									M				I														M	I						S					M			

Table 3.3.1.1C : Frequency Classes of Pollen Types of **Autumn Honeys** (HFP-III) (July - October)

	Sample No.																	
Pollen types	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Acanthaceae																		
Hypoestes triflora										I								
Asystasia macrocarpa																		M
Thunbergia sp.									M						I			
Apiaceae																		
Hydrocotyl spp.									M									
Selinum tenuifolium													S					M
Pimpinella diversifolia																		M
Oenanthe thomsonii																		M
Aristolochiaceae																		
Aristolochia spp.	M							M										
Asteraceae																		
Bellis perennis																	S	
Tithonia diversifolia									I									
Ageratum conyzoides		P			S													
Bidens pilosa	I	S		I	M			I								I		I
Erigeron karwinskianus			M							M	M							
Artemisia vulgaris															I			
Eupatorium adenophorum				I														
Galinsoga parnviflora									I		M				M		M	
Cineraria spp.																I		
Calendula officinalis	S	S	I							M	M				I		S	
Chrysenthemum indicum																	I	
Centaurea spp.		M	I		I					M	M							I
Begoniaceae																		
Begonia spp.															I			
Berberidaceae																		
Berberis insignis															M			M
Bignoniaceae																		
Jakaranda sp.						I												
Brassicaceae																		
Brassica spp.											P							
Coronopus didymus							I											
Iberis amara											S							

Contd...

	Sample No.																	
Pollen types	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Buddlejaceae																		
Buddleja asiatica	S		I					I										I
Caesalpinaceae																		
Cassia sp.					M													
Cannaceae																		
Canna indica																	M	M
Caryophyllaceae																		
Drymaria spp.															S			
Convolvulaceae																		
Porana spp.					M						I				I			
Ipomoea spp.			I															
Crassulaceae																		
Sedum multicaule							I						P					
Cucurbitaceae																		
Momordica spp.					M													
Edgaria darjeelingensis				I														
Sechium edule		M	I															
Luffa spp.			I															
Fabaceae																		
Dalbergia sissoo					S													
Trifolium repens			I				I	M	M			I				S		
Phaseolus spp.								I										
Desmodium spp.																	I	I
Flacourtiaceae																		
Gynocardia odorata								I										
Hydrangiaceae																		
Dichroa febrifuga			I															
Hydrophyllaceae																		
Nemophilla menziensii									I					M				
Lamiaceae																		
Craneotome versicolor																		M
Plectranthus spp.									M				I					
Leucus spp.					M													

Contd...

	Sample No.																	
Pollen types	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Magnoliaceae																		
Magnolia spp.			I			M		M		M				M			I	
Michelia spp.						P										S		
Oleaceae																		
Jasminum sp.				M														
Oxalidaceae																		
Oxalis sp.														M				
Papavaraceae																		
Papavar spp.							M										I	
Passifloraceae																		
Passiflora spp.							S							I				
Plantaginaceae																		
Plantago erosa				M														
Primulaceae																		
Lysimachia japonica		M																M
Primula spp.				M				M	I									M
Poaceae			I			M	I							M			I	M
Ranunculaceae																		
Clematis spp.				I		M			M							I		
Rosaceae																		
Rosa spp.	M	I		I	I					M	I			I	I			M
Fragaria spp.			M	S					S			I						
Prunus spp.								I		P				M			M	M
Potentilla fulgens																	M	
Rubus ellipticus									I									
Spirea micrantha							I							M				
Pyrus japonica									M					I		I		M
Rutaceae																		
Citrus spp.								S		M					I			
Toddalia asiatica										I								
Zanthoxylum oxyphyllum																	I	

Contd...

	Sample No.																	
Pollen types	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Sambucaceae																		
Sambucus spp.										M						I		
Sapindaceae																		
Cardiospermum helicacabum									I									
Saxifragaceae																		
Saxifraga spp.							I											
Scrophulariaceae																		
Veronica spp.																	I	
Lindenbergia spp.								I										I
Linaria spp.															I			
Mazus surculosus				M														
Pedicularis mollis									I									
Solanaceae																		
Datura spp.				I						I	M			M		I		
Cestrum spp.	I	M					S											I
Streptosolen jamesonii						M	I											
Solanum spp.												I						
Cyphomandra betacea	M																	
Nicotiana tabacum														M				
Symplocaceae																		
Symplocos spp.					M							S		M				
Ternstroemiaceae																		
Schima wallichii	I		P			I				M		S		P		S	I	P
Camellia spp.				S														
Tropaeolaceae																		
Tropaeolum majus							S		S		M			I				
Verbenaceae																		
Clerodendrum spp.								M										
Lantana camara					M													
Vitaceae																		
Vitis sp.	M																	
Tetrastigma spp.	I																	
Zingiberaceae																		
Ammomum subulatum				M						S								

3.3.2 FREQUENCY DISTRIBUTION OF POLLEN GRAINS IN DIFFERENT (SUMMER, AUTUMN, WINTER) HONEYS.

Four classes of pollen types were recognised based on the frequency distribution of the pollen types in various honeys. These may be represented as follows:

1. “very frequent” (> 50%)
2. “frequent” (20 – 50%)
3. “Infrequent” (10 – 20%)
4. “rare” (<10%)

(Feller-Demalsy *et al.,* 1987)

Season wise pollen types under the above 4 classes as recovered from the honey samples may be grouped accordingly.

SUMMER HONEYS: (142 pollen types) (Table – 3.3.1.1 b)

i). “Very frequent” class (9 pollen types) *Prunus* spp., *Citrus* spp. *Rubus* spp., *Trifolium repens, Buddleja asiatica, Potentilla* spp., *Rosa* spp., *Milletia pulchra, Schima wallichii.*

ii). “Frequent” class (17 pollen types)

Strobilanthus spp., , *Solidago virga-aurea Frageria vesca*, Poaceae, *Ageratum conyzoides, Calendula officinalis, Centaurea* spp., *Bidens pilosa, Clematis* spp., etc.

iii) Infrequent” class (17 pollen types)

Michelia spp., *Tropaeolum majus, Asystasia macrocarpa, Nicotiana tabacum, Nemophilla wenziensii, Syzygium* spp., *Gladiolus* sp. etc.

v) “Rare class (99 pollen types)

Euphorbia pulcherrima, Eupatorium sp., *Simplocos* sp., *Pueraria sikkimensis, Ammomum subulatum, Zanthoxylum oxyphyllum, Sambucus* spp, *Leucosceptrum canum, Hypoestes triflora, Digitalis purpurea, Dahlia imperialis* etc.

AUTUMN HONEYS: (91 pollen types) (Table 3.3.1.1 c)

i) "Very frequent') (6 pollen types)

Prunus spp., *Schima wallichii, Brassica* spp., *Ageratum conyzoides, Michelia* spp., *Sedum multicule.*

ii) "Frequent" (9 pollen types) *Ammomum subuletum*

iii) *Camellia* spp, *Bidens pilosa, Dalbergia sissoo, , Frageria vesca. Drymaria* spp., *Calencula officinalis,* Simplocos spp., *Selinum* sp.

iv) "Infrequent" (19 pollen types)*Spirea* spp., *Citrus* spp., *Duranta repens, Solanum* spp., Linaria sp.*, Chrysanthemum* spp., *Strobilanthus thomsonii, Cestrum* spp., *Primula* spp. etc.

v) "Rare (57 pollen types) *betacea, Vitis*

vi) *Lantana* camara, *Clerodendrum* am ara sp.*, Solanum* spp.*, Papaver* spp., *Pedicularis mollis, Hydrocotyl* spp., *Toddlia* spp., *Hypoestes triflora, Sambucus* spp., *Clarkia pulchella, Begonia* spp.*, Ammomum subulatum, Erogeron karwinskianus, Eupatorium adenophorum, Rubus* spp., *Cyphomandra* sp., *Sechium edule,* Poaceae etc.

WINTER HONEYS: (60 pollen types) (Table 3.3.1.1 A)

i) "Very frequent" (2 pollen types)

Rosa spp.*, Aristolochia* spp.

ii) "Frequent" (9 pollen types)

Brassica spp.*, Bidens pilosa, Tropaeolum majus, Nicotiana tabacum, Calendula officinalis, Porana* spp., *Clematis* spp., *Dahlia imperialis, Bellis perennis*

iii) "Infrequent " (7 pollen types)

Cardamine hirsuta, Porana spp., *Streptosolen jamesonii, Mazus surculosus, Camellia* spp., *Bauhinia* spp., *Chrysenthemum* spp.

iv) "Rare" (42 pollen types)

Holboelia latifolia, Coccinea grandis, Michelia spp., *Solanum* spp.*, Magnolia* spp., *Buddleja asiatica, Oxalis* spp., *Primula* spp.*, Dichroa febrifuga, Luffa* spp., *Edgaria darjeelingensis, Thunbergia coccinea Trifolium repens, Spergula arvensis, Lindebergia* spp., *Prunus* spp., *Euphorbia* etc.

3.3.3 FREQUENCY OF SOME POLLEN GRAINS IN HONEY SAMPLES FROM ENTOMOPHILOUS PLANTS

On overall study of total 67 honey samples from Sikkim and Sub-Himalayan West Bengal. *Buddleja asiatica* pollen type was recovered from 16 mostly in summer samples. Out of these as 'Predominant' (>45 %) was found in 1sample as 'Secondary '(16-45 %) in 3 as 'important minor' (3-15 %) type in 9 samples as 'minor' (<3 %) type in remaining in 3 samples (fig. 3.3.3.1). *Brassica* spp. had been recognised in 22 samples as predominant in 1, as secondary in 5, as important minor in 8 and as minor in remaining 8 samples (fig. 3.3.3.5). A few other pollen types were analysed in similar manner and have been presented in Table-3.3.3.1.

Table 3.3.3.1.

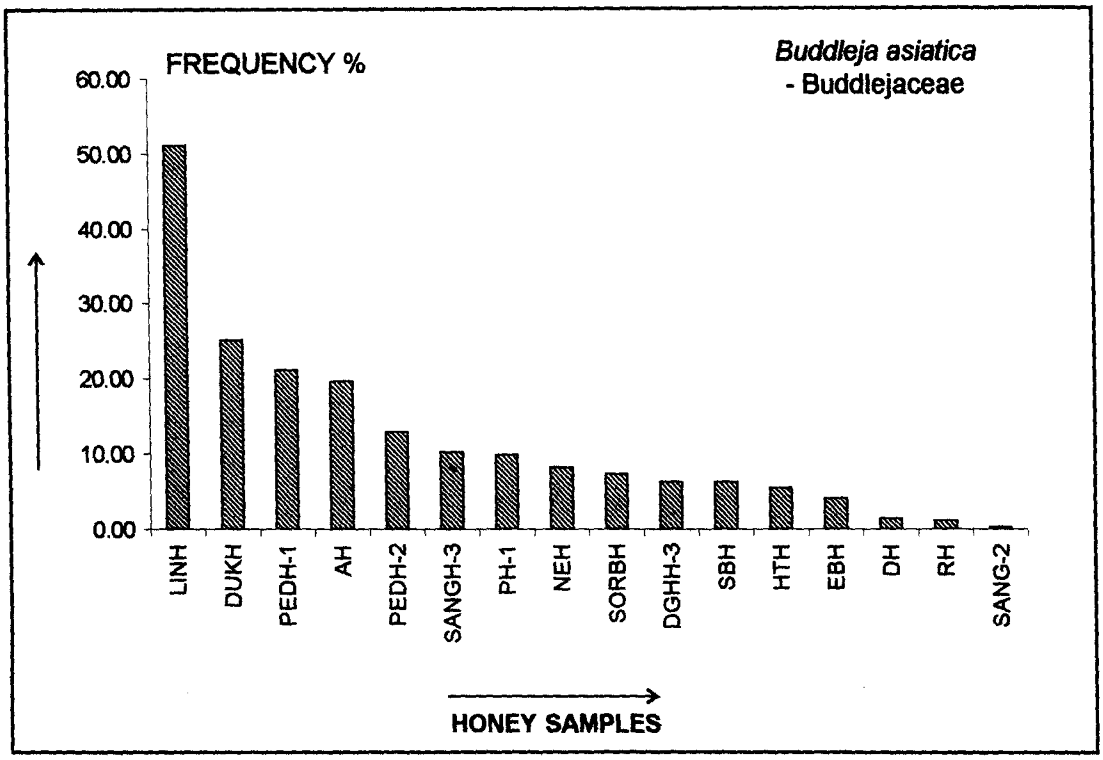
Pollen types recovered	Number of honey samples	Predominant (> 45 %)	Secondary (16–45 %)	Important minor (3-15 %)	Minor (< 3 %)
Buddleja asiatica	16	1	3	9	3
Brassica spp.	22	1	5	8	8
Rosa spp.	38	2	6	22	8
Prunus spp.	30	3	4	13	10
Citrus spp.	17	1	3	8	5
Trifolium spp.	23	2	2	12	7
Tropeolum sp.	18	*0*	*5*	*8*	*5*
Ammomum subulatum	*08*	*0*	*2*	*2*	*4*
Clerodendron sp.	05	0	2	0	3
Datura spp.	12	0	2	4	6
Frageria vesca	16	1	6	5	4
Streptosolen jasmesonii	08	0	3	3	2
Gynocordia odorata	12	0	1	4	7
Nemophila menziensii	7	0	1	5	1
Berberis spp.	4	0	0	0	4

Further representation of the above entomophilous pollen types in different honeys has been made graphically (frequency percentage)in the figures 3.3.3.1 – 3.3.3.15.

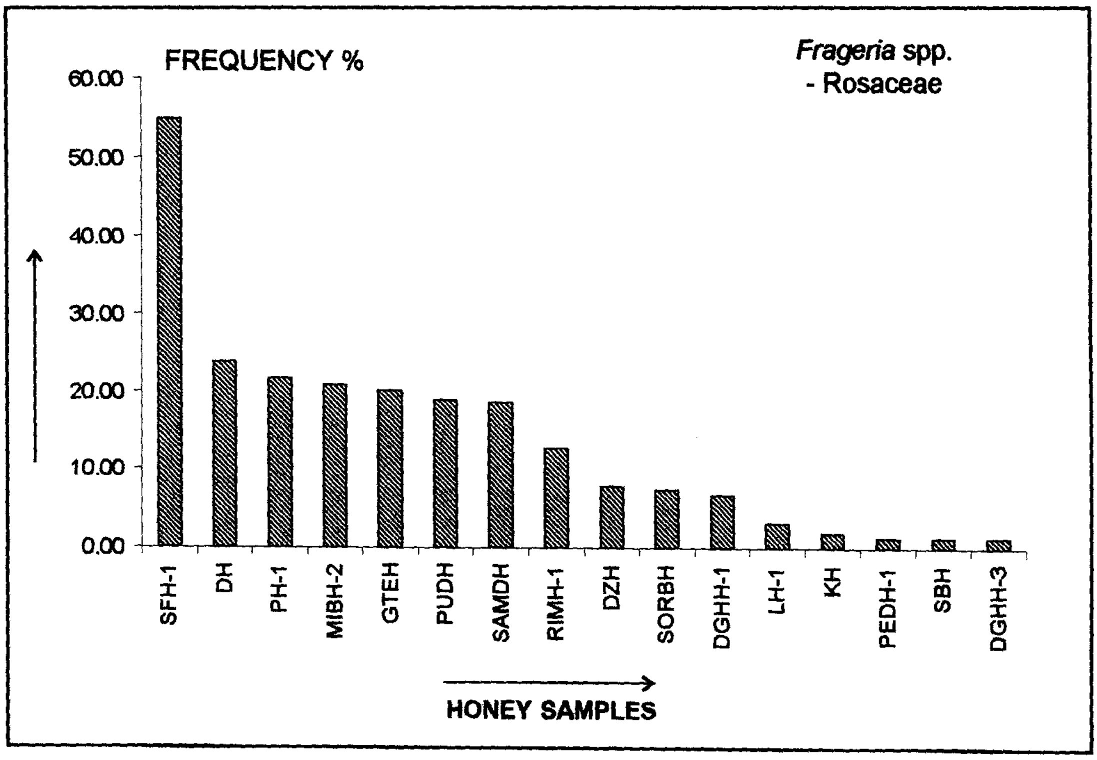
Abbreviation/codes (in respect of places of collection) used for honey samples :-

AH = Algarah Honey (Kalimpong Sub-division)
BBH = Bhalukhop Busty Honey (Kalimpong)
CH = Chalsa Honey (Jalpaiguri)
CHIB-1,2 = Chibbo Busty Honey (Kalimpong)
DAMH-1,2 = Damthang Honey (Sikkim)
DGHH-1,2,3 = Dr. Graham's Homes area honey (Kalimong)
DH = Deolo Hills (Kalimpong)
DUDH = Dudhia (Tea Estsate) Honey (Kurseong)
DUKH = Duka Honey (Kalimpong sub-division)
DUNGH = Dungra Busty Honey (Kalimpong)
DZH = Dzongu Honey (Sikkim)
EBH = Ecchey Busty (Kalimpong)
ELEH = Eleventh Mile Honey (Kalimpong)
FH = Fifth Mile Honey (Kalimpong)
GANH = Gangtok Honey (Sikkim)
KURH = Kurseong Honey
GORH = Gorubathan Honey (Kalimpong Subdivision)
GTEH = Ging Tea Estate Honey (Darjeeling)
HTH = Hill Top Honey (Kalimpong)
JH = Jaldhaka Honey (Kalimpong Subdivision)
KAWH = Kaw Honey (Sikkim)
KHAMH = Khamdong Honey (Sikkim)
KURH = Kurseong Honey
LH-1,2 = Lava Honey (Kalimpong sub-division)
LINH = Lingee Honey (Sikkim)
LPH = Lathpancher Honey (Kurseong sub-division)
MBH = Makum Busty Honey (Kalimpong sub-division)
MH = Mitiali Honey (Jalpaiguri)
MIBH 1,2 = Middle Bong Busty Honey (Kalimpong)
MONGH = Mongpu Honey (Darjeeling)
MONSH - 1,2 = Monsong Honey (Kalimpong sub-division)
NEH = Nehaborong Honey (Sikkim)
PABH = Pabong Honey (Kalimpong sub-division)
PEDH = Pedong Honey (Kalimpong sub-division)
PH-1,2 = Payong Honey (Sikkim)
PUDH = Pudung Busty Honey (Kalimpong sub-division)
RABH = Rabitar Honey (Sikkim)
RH = Ravangla Honey (Sikkim)
RIMH-1,2 = Rimbick Honey (Darjeeling)
SADH = Sadam Honey (Sikkim)
SAKH = Sakyone Honey (Kalimpong sub-division)
SAMDH = Samdong Honey (Sikkim)
SAMH = Samsing Honey (Jalpaiguri)
SANGH - 1,2,3 = Sangsay Honey (Kalimpong sub-division)
SBH = Solak Busty Honey (Kalimpong sub-division)
SFH-1,2 = Seed Farm Honey (Kalimpong)
SH - 1,2 = Sumbuk Honey (Sikkim)
SINH = Sindebong Busty Honey (Kalimpong)
SORBH = Soreng Busty Honey (Kalimpong sub-division)
SUMBH = Sumbaria Honey (Sikkim)
SURH = Suruk Honey (Kalimpong sub-division)
TH = Tendrabong Honey (Kalimpong sub-division)
TODH = Todey Honey (Kalimpong sub-division)

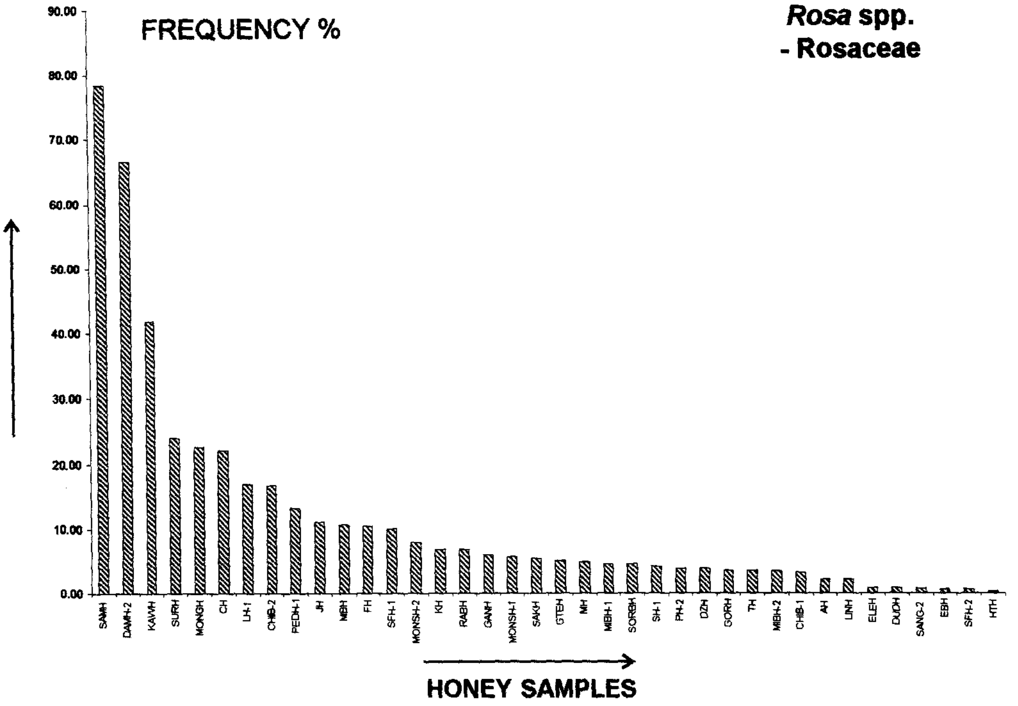
FREQUENCY OF SOME POLLEN GRAINS IN HONEY SAMPLES FROM ENTOMOPHILOUS PLANTS



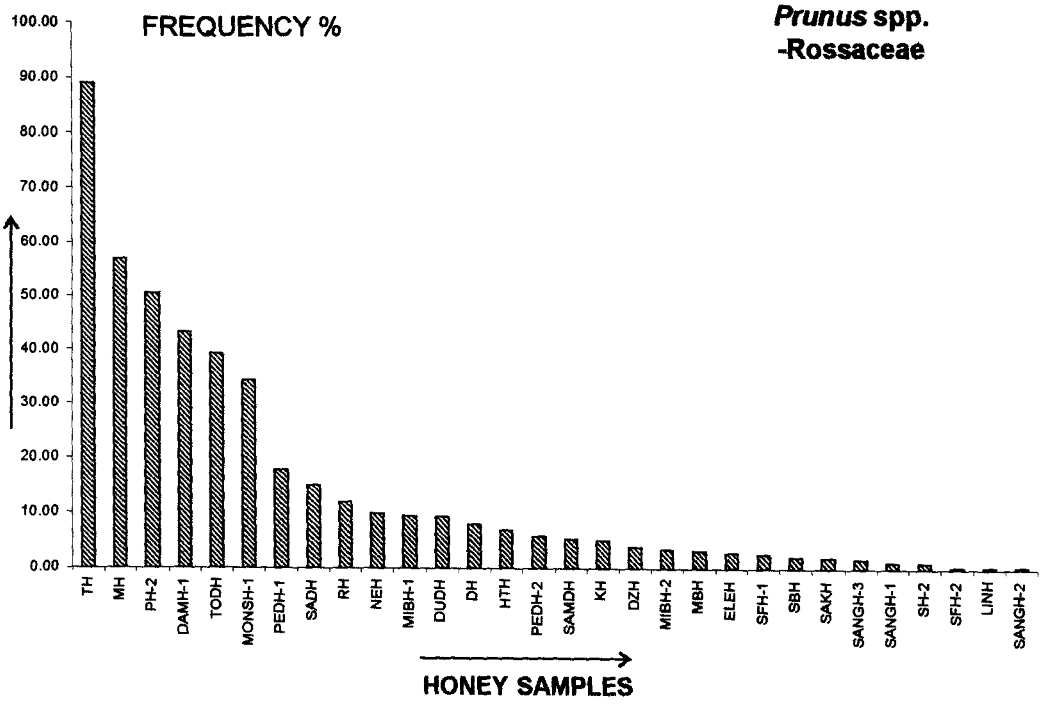
[Fig :- 3.3.3.1]



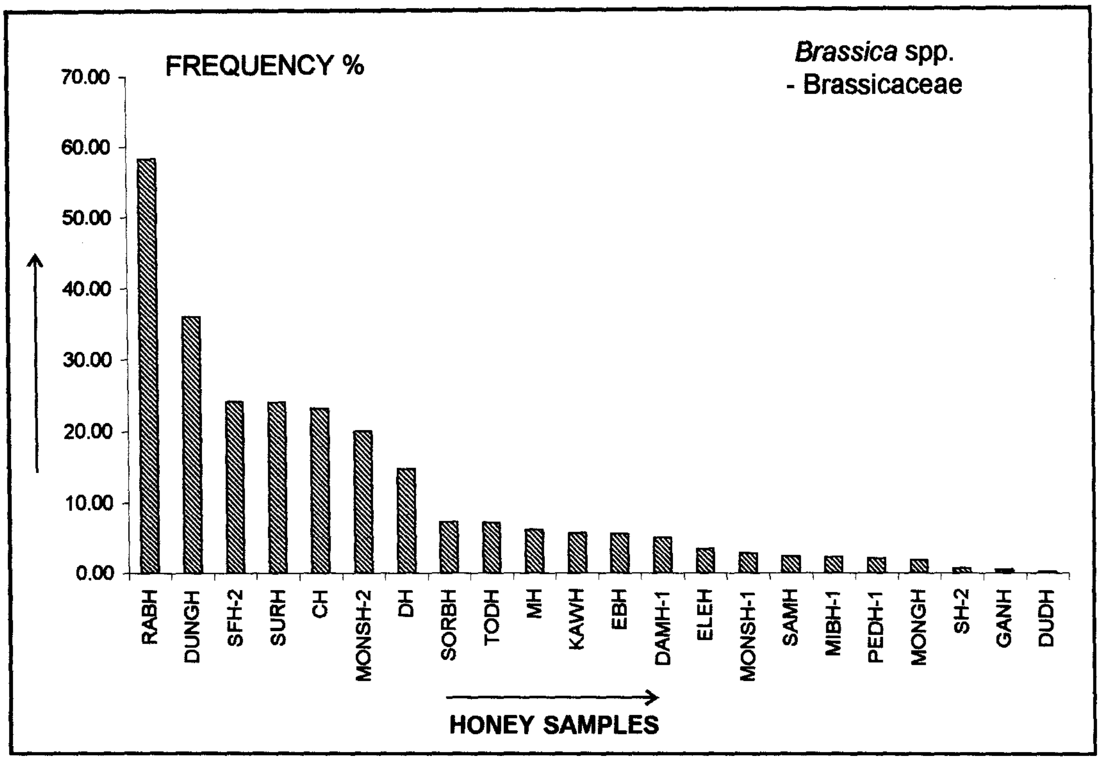
[Fig :- 3.3.3.2]



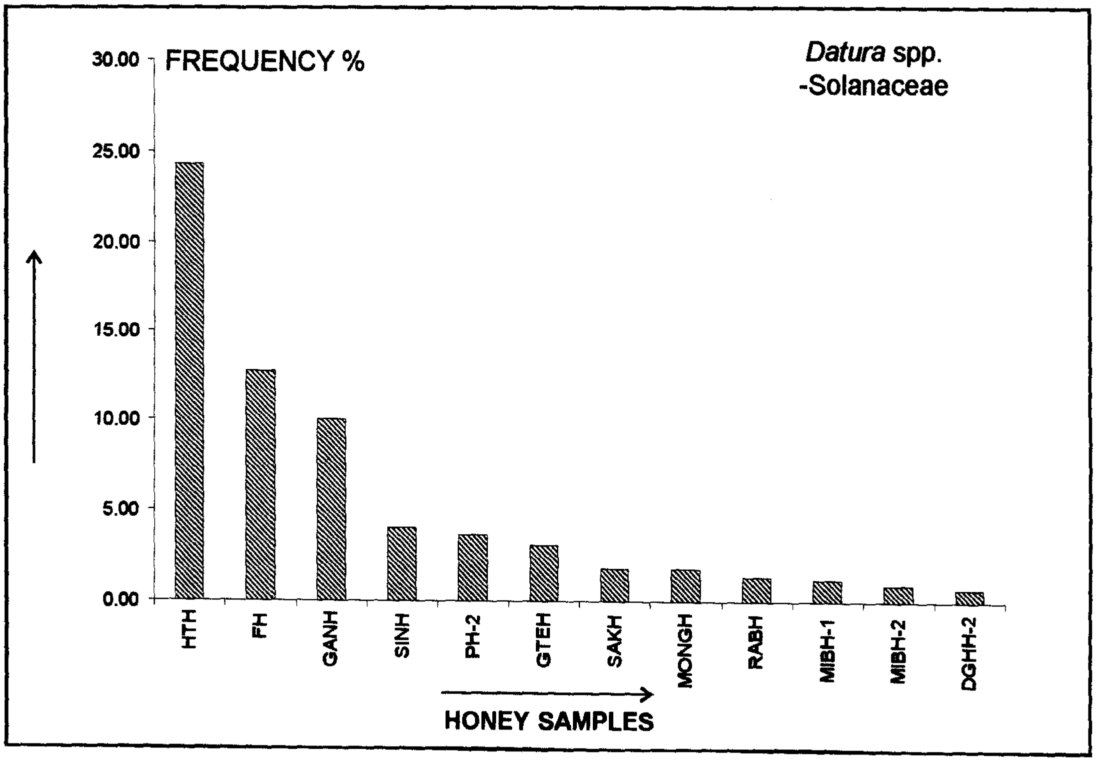
[Fig :- 3.3.3.3]



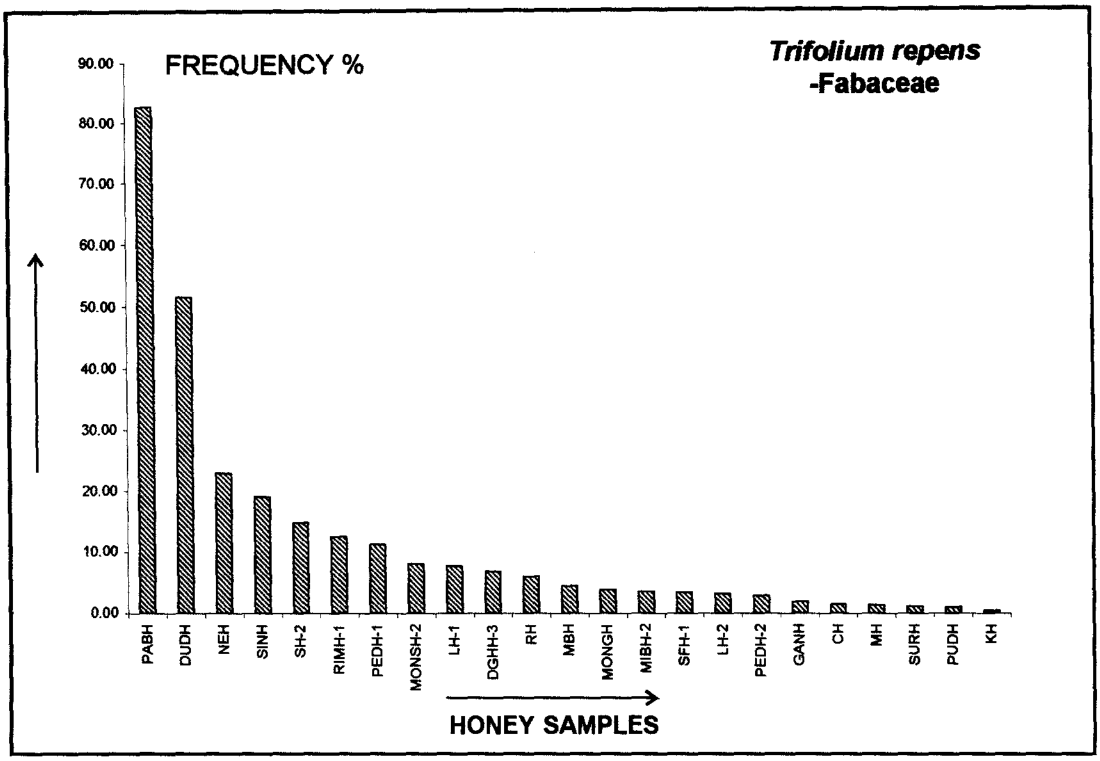
[Fig :- 3.3.3.4]



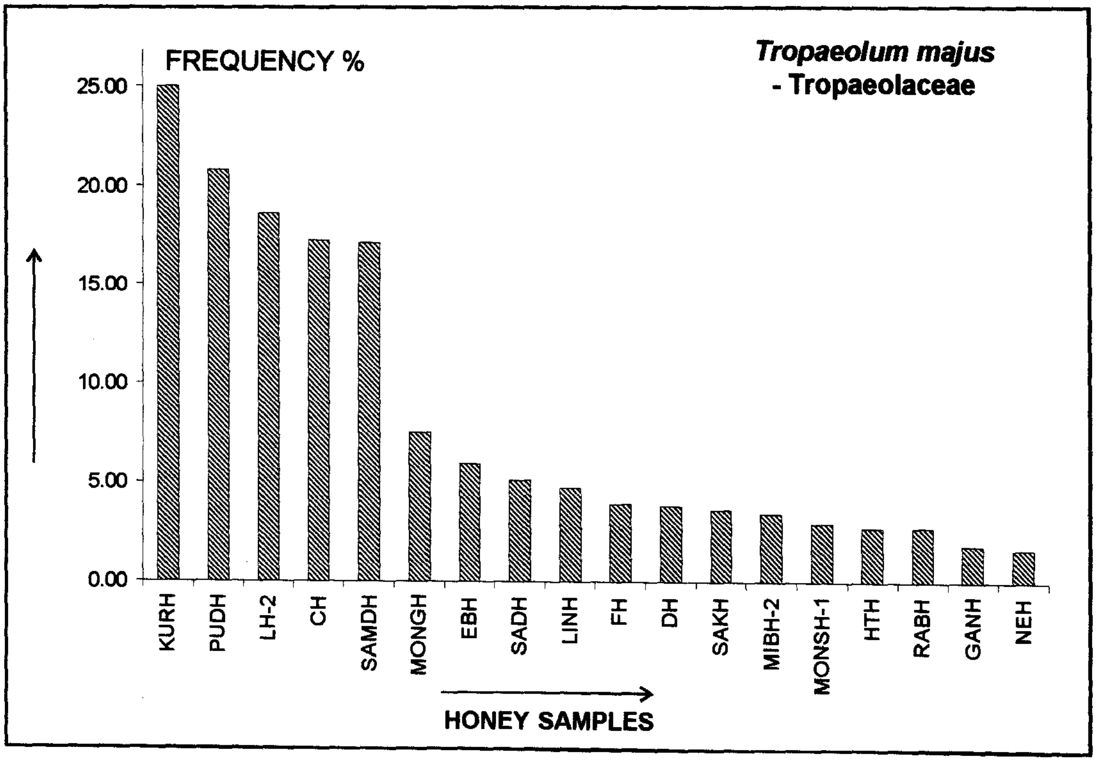
[Fig :- 3.3.3.5]



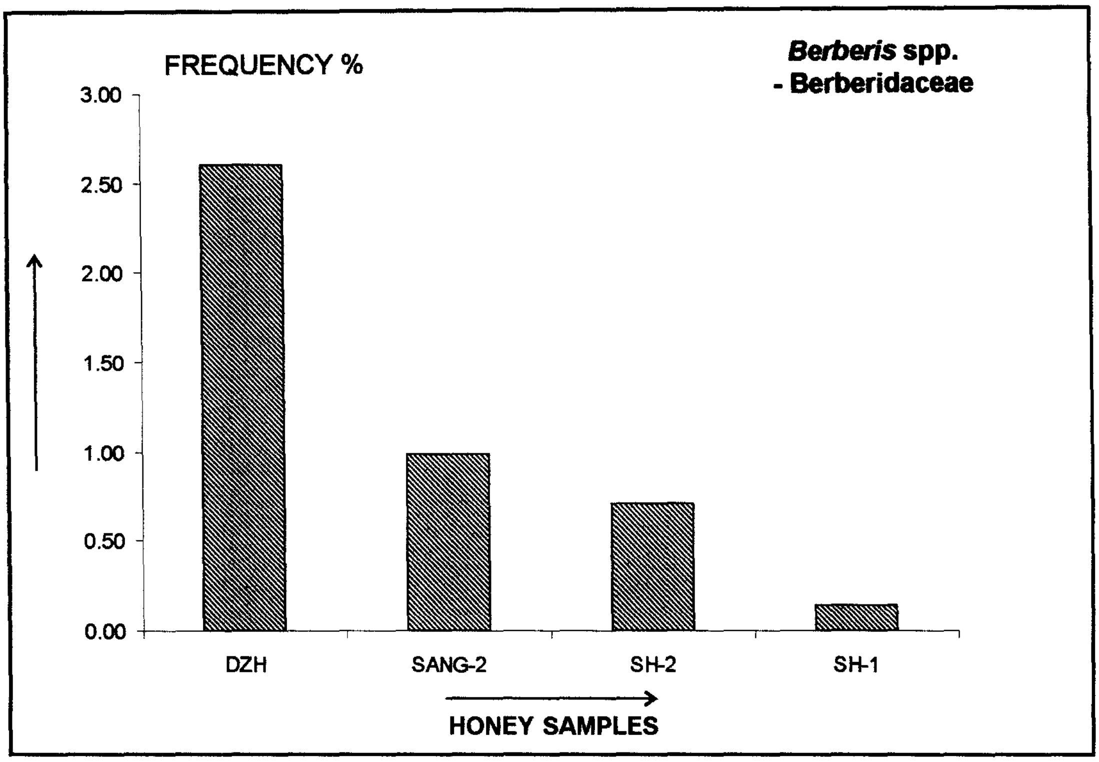
[Fig :- 3.3.3.6]



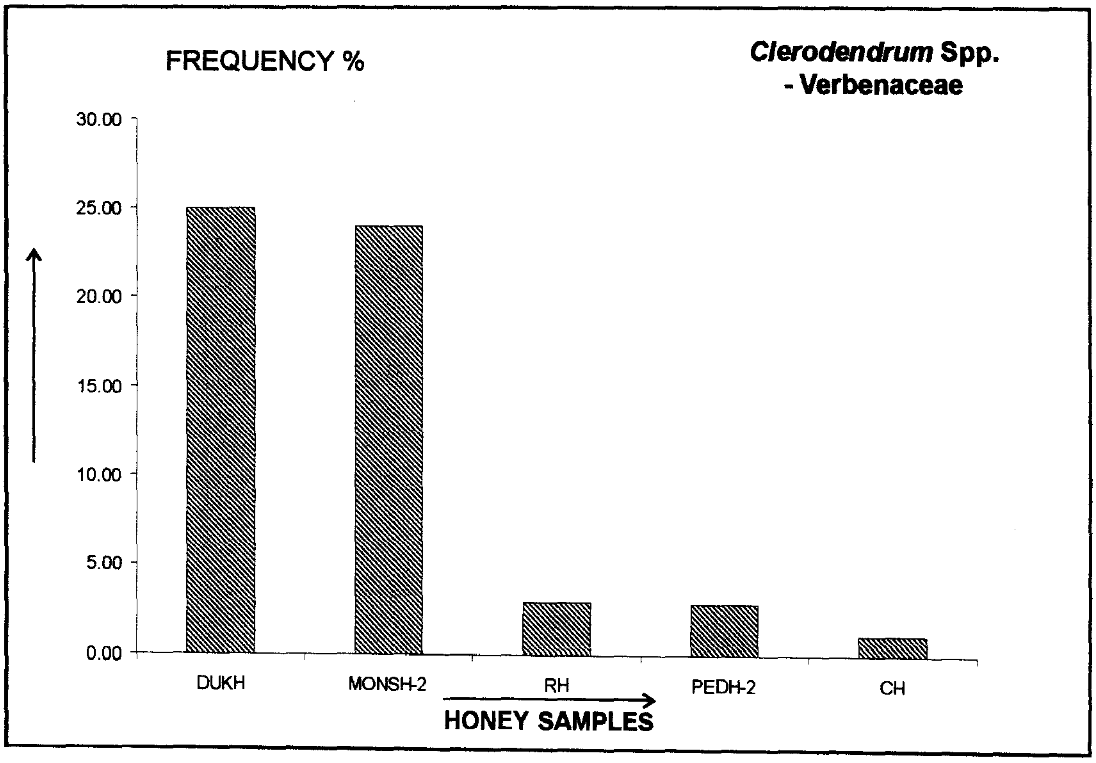
[Fig :- 3.3.3.7]



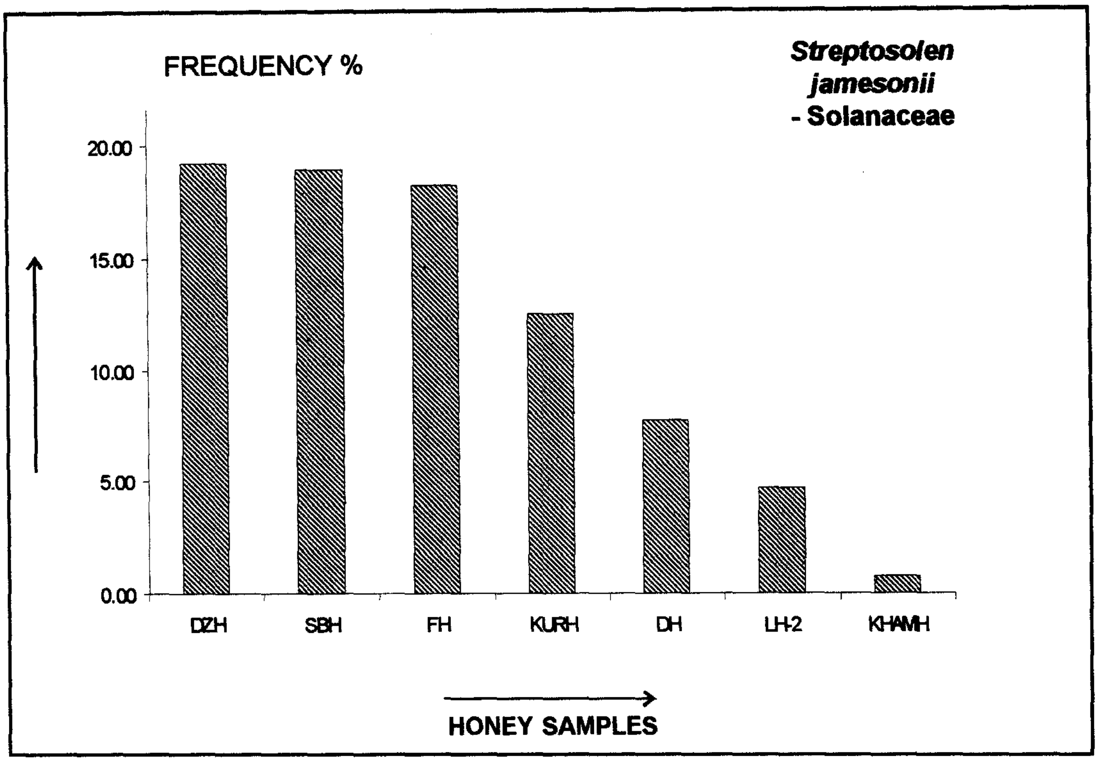
[Fig :- 3.3.3.8]



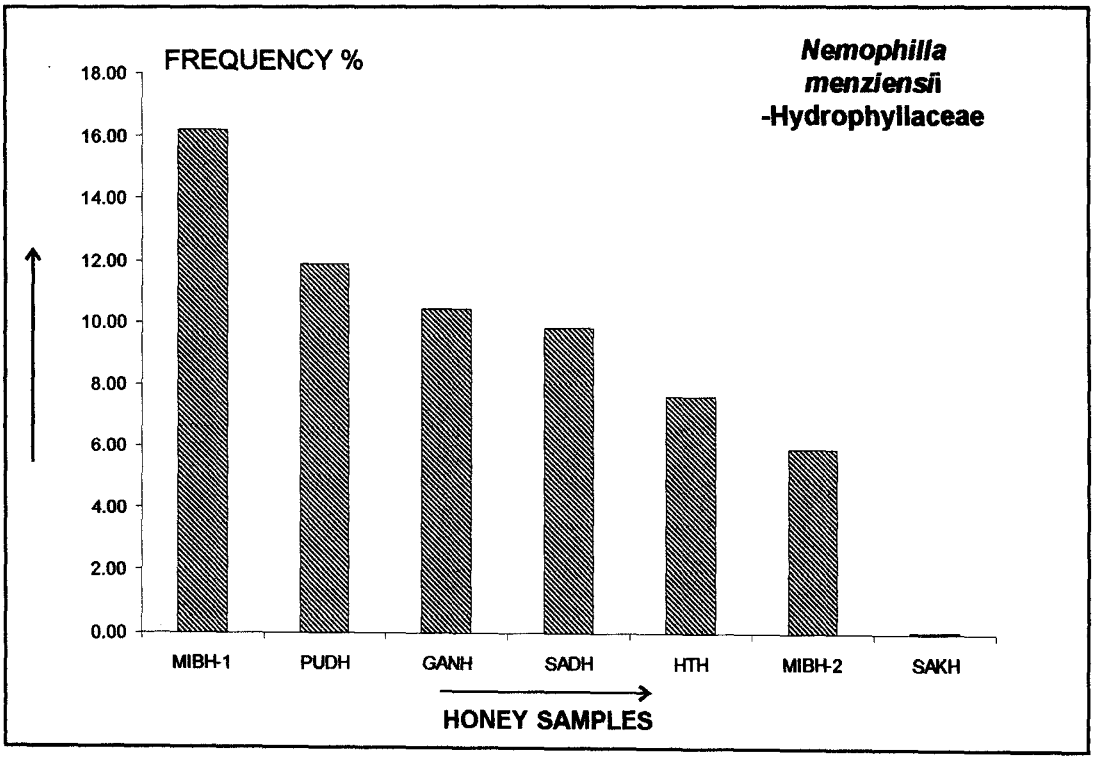
[Fig :- 3.3.3.9]



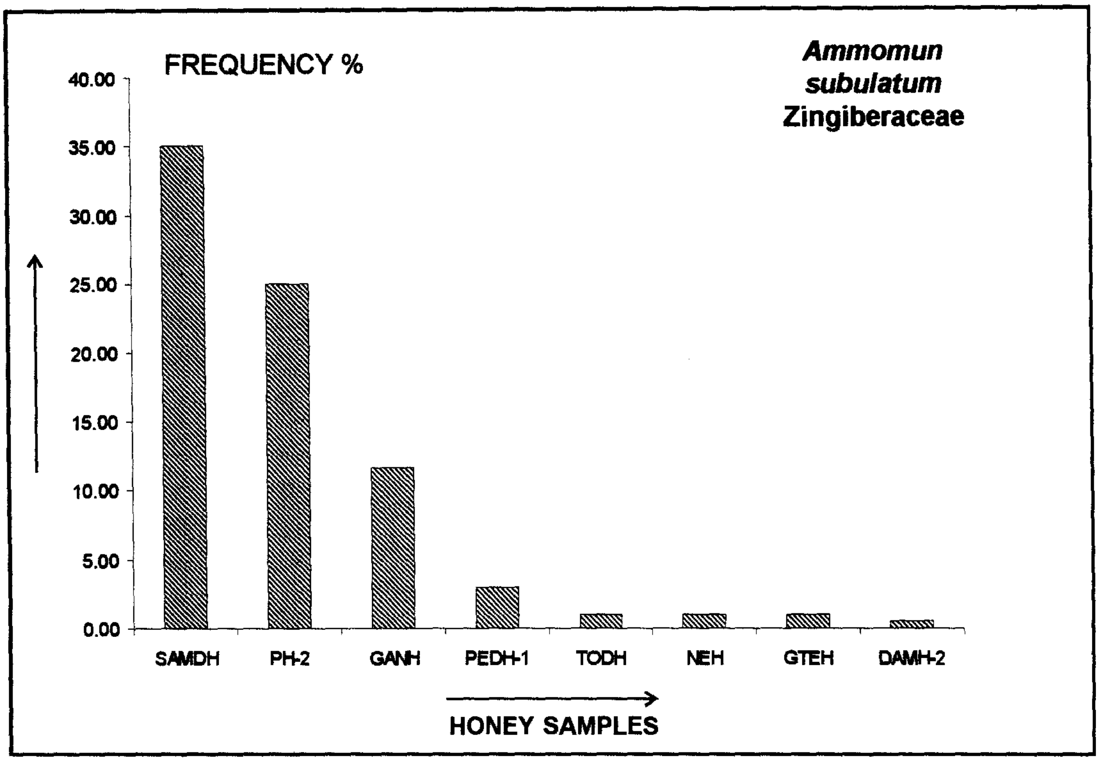
[Fig :- 3.3.3.10]



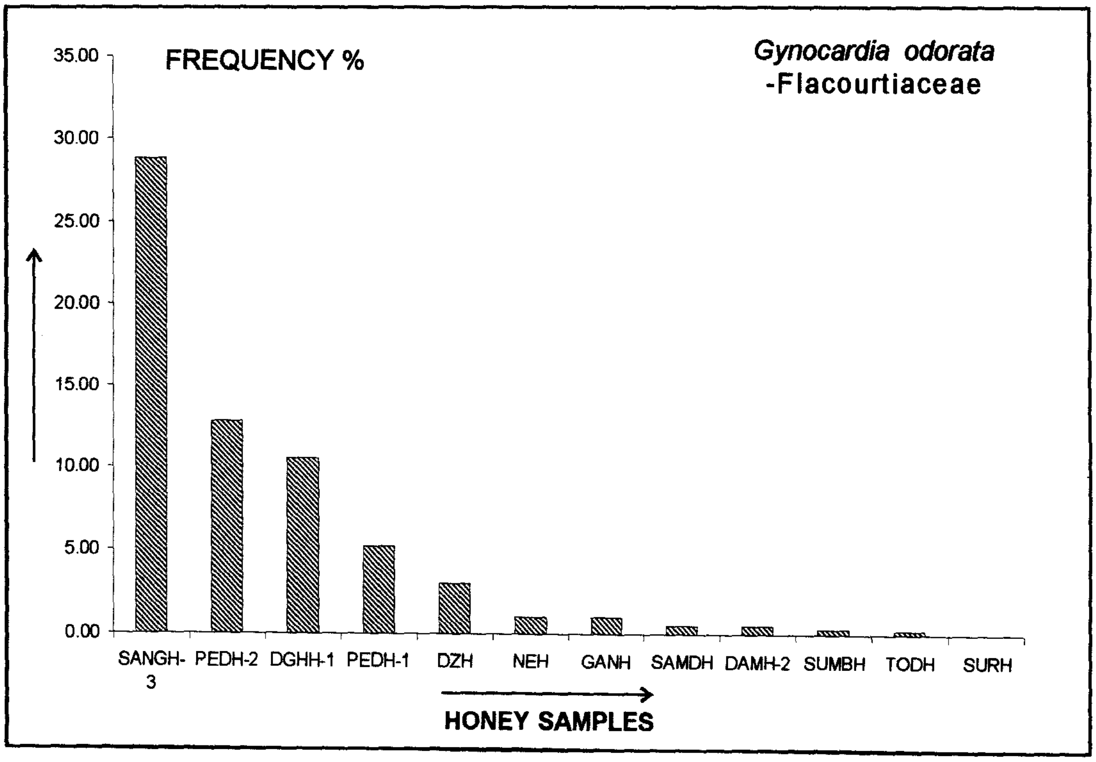
[Fig :- 3.3.3.11]



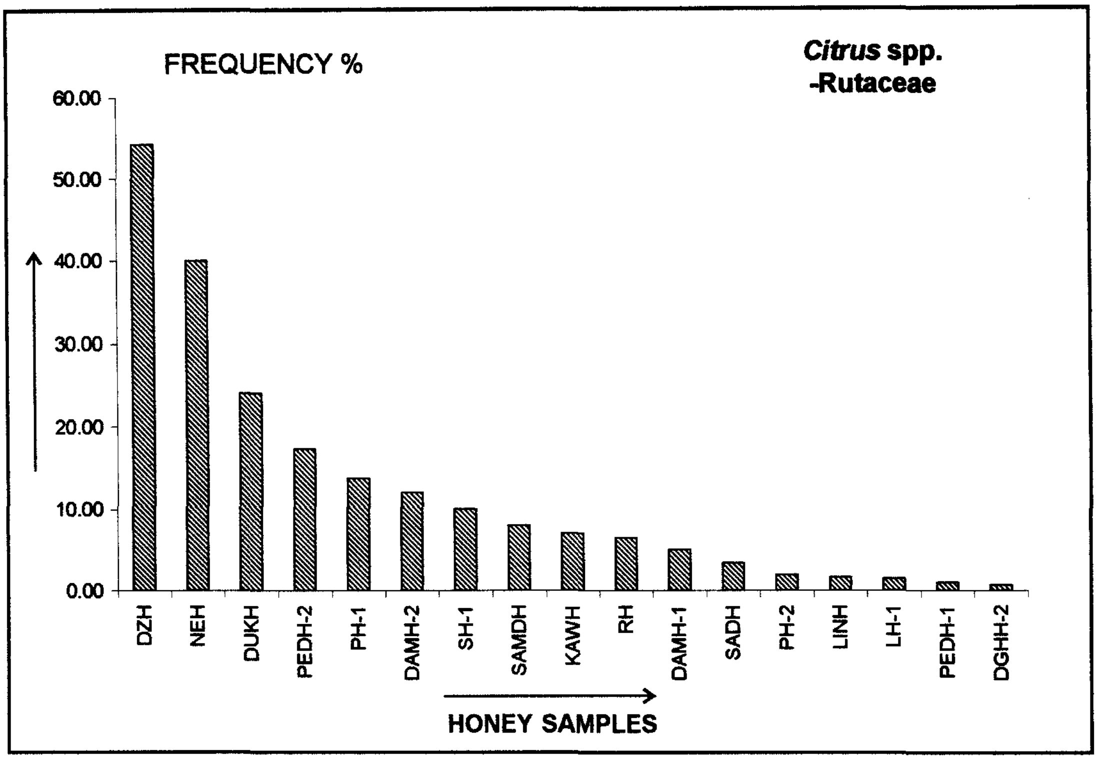
[Fig :- 3.3.3.12]



[Fig :- 3.3.3.13]



[Fig :- 3.3.3.14]


FREQUENCY %
Citrus spp.
-Rutaceae
60.00
50.00
40.00
30.00
20.00
10.00
0.00
DZH
NEH
DUKH
PEDH-2
PH-1
DAMH-2
SH-1
SAMDH
KAWH
RH
DAMH-1
SADH
PH-2
LINH
LH-1
PEDH-1
DGHH-2
HONEY SAMPLES

[Fig :- 3.3.3.15]

3.3.4 FREQUENCY OF SOME POLLEN GRAINS IN HONEY SAMPLES FROM AMPHIPHILOUS / ANEMOPHILOUS PLANTS

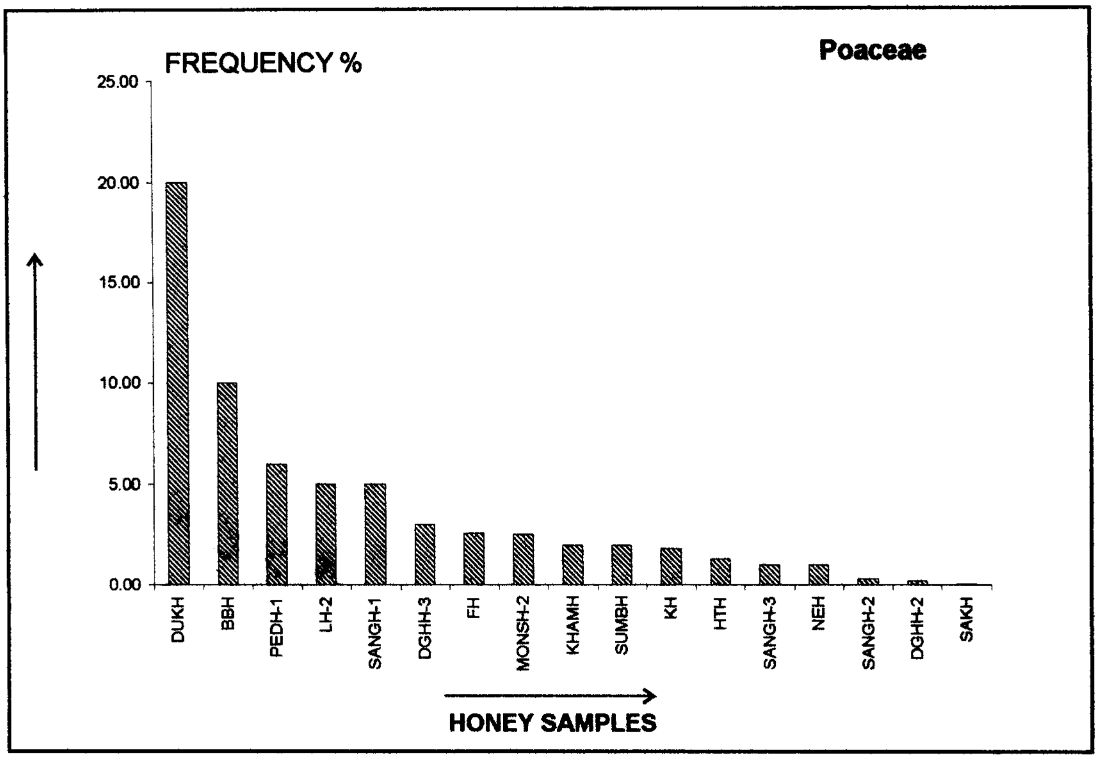
A few pollen types of nectarless or anemophilous taxa namely Poaceae type, *Papaver* spp. etc. were recovered from some honey samples. The bees are supposed to be attracted by the bright petal colour and coloured pollen grains of *P. rhoeas* L. Iwama and Melhem (1979) suggested that the presence of the pollen of anemophilous taxa might be due to contamination made by bees. It was probable that bees visited the members of Poaceae essentially for pollen foraging to feed their brood (Jhansi & Ramanujam, 1990). The presence of amphiphilous pollen types recovered from the honey samples under different catagories like Predominant, Secondary, Important Minor and Minor are shown in the table 3.3.4.1.

Table 3.3.4.1;

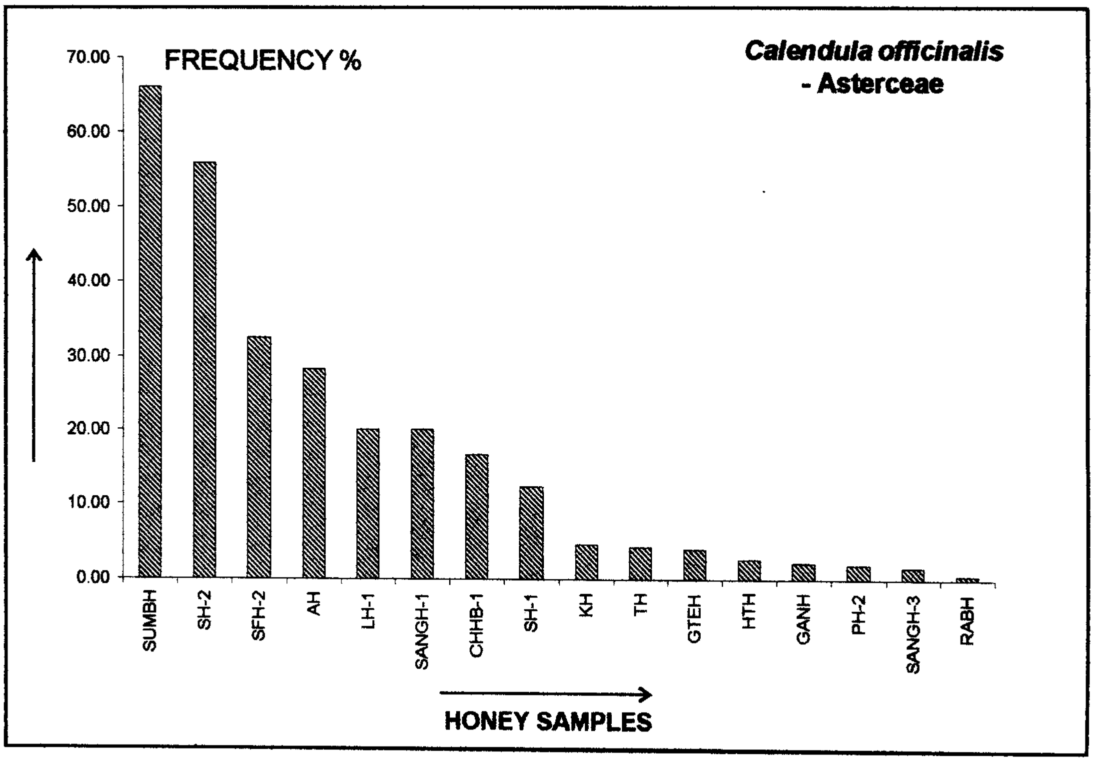
Pollen types recovered from honey samples	Number of honey samples with percentages	Predominant (>45%)	Secondary (16 – 45%)	Important minor (3 – 15%)	Minor (<35%)
Calendula officinalis	16	2	5	4	5
Tithonia diversifolia	5	0	2	3	0
Bidens pilosa	14	0	4	8	2
Erigeron karvinskianus	15	0	0	5	10
Schima wallichii	17	4	3	7	3
Magnolia spp.	16	0	0	5	11
Eupatorium spp.	8	0	1	5	2
Galinsoga parviflora	7	0	0	0	7
Symlocos sp.	7	0	1	0	6
Poaceae	17	0	1	6	10
Papaver sp.	5	0	1	2	2
Camellia spp.	6	0	1	3	2
Papaver spp.	5	0	1	2	2
Michelia spp.	23	1	3	12	6
Centaurea spp.	14	0	2	4	8

Graphical explanations of the above Amphiphilous/Anemophilous pollen taxa have been shown in figure 3.3.4.1 – 3.3.4.15.

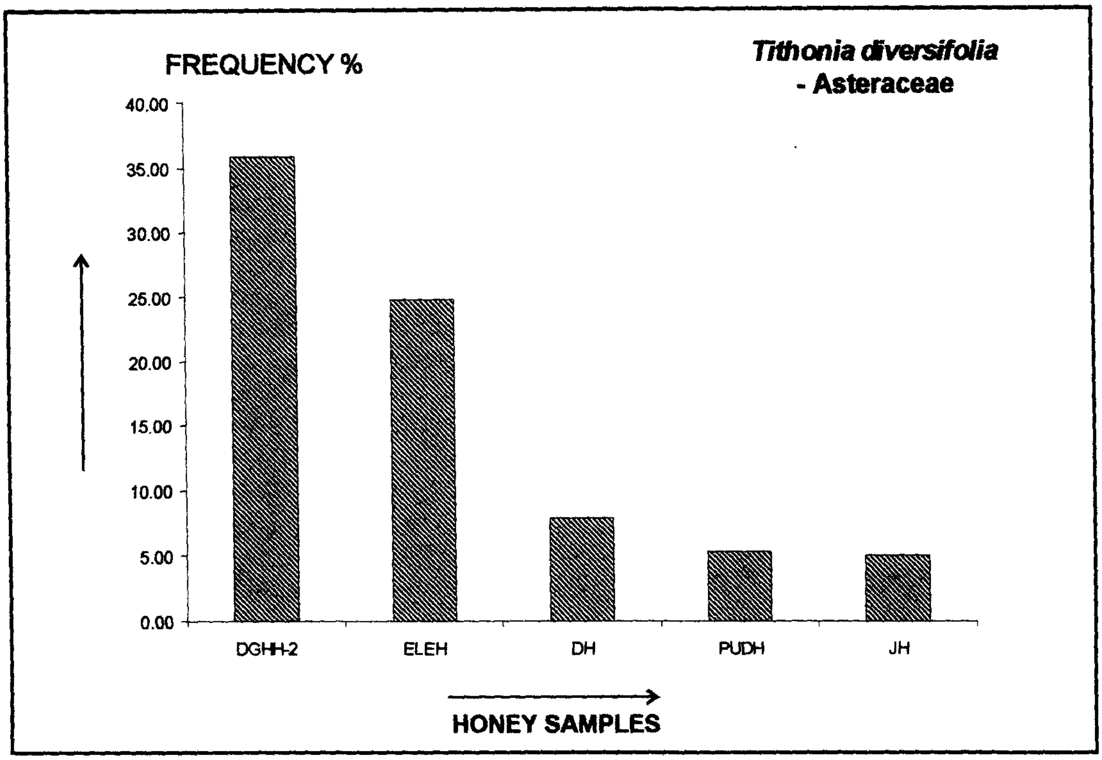
FREQUENCY OF SOME POLLEN GRAINS FROM AMPHIPHILOUS/ANEMOPHILOUS PLANTS IN HONEY SAMPLES



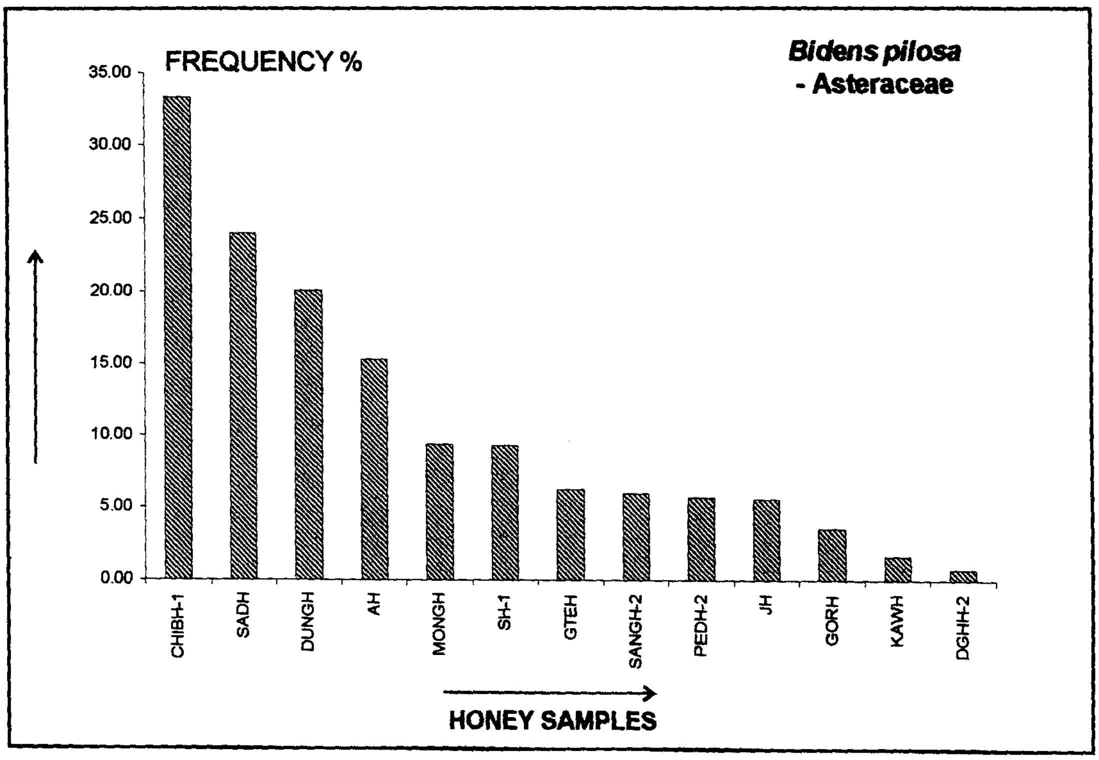
[Fig :- 3.3.4.1]



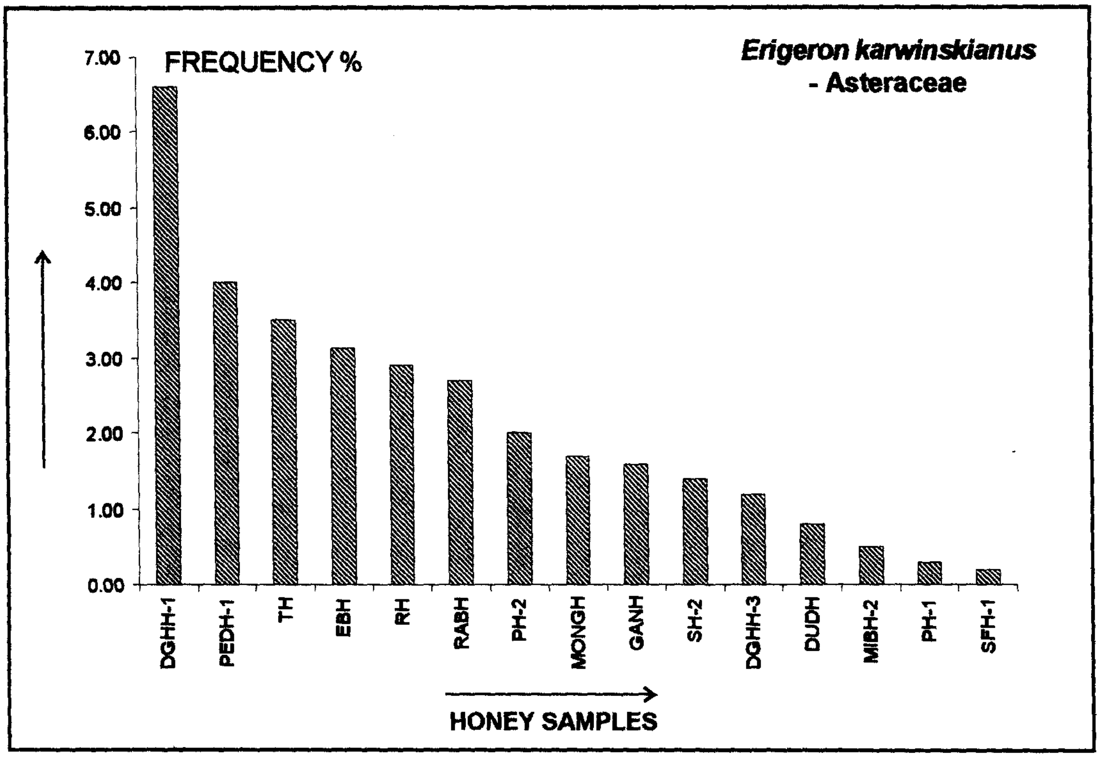
[Fig :- 3.3.4.2]



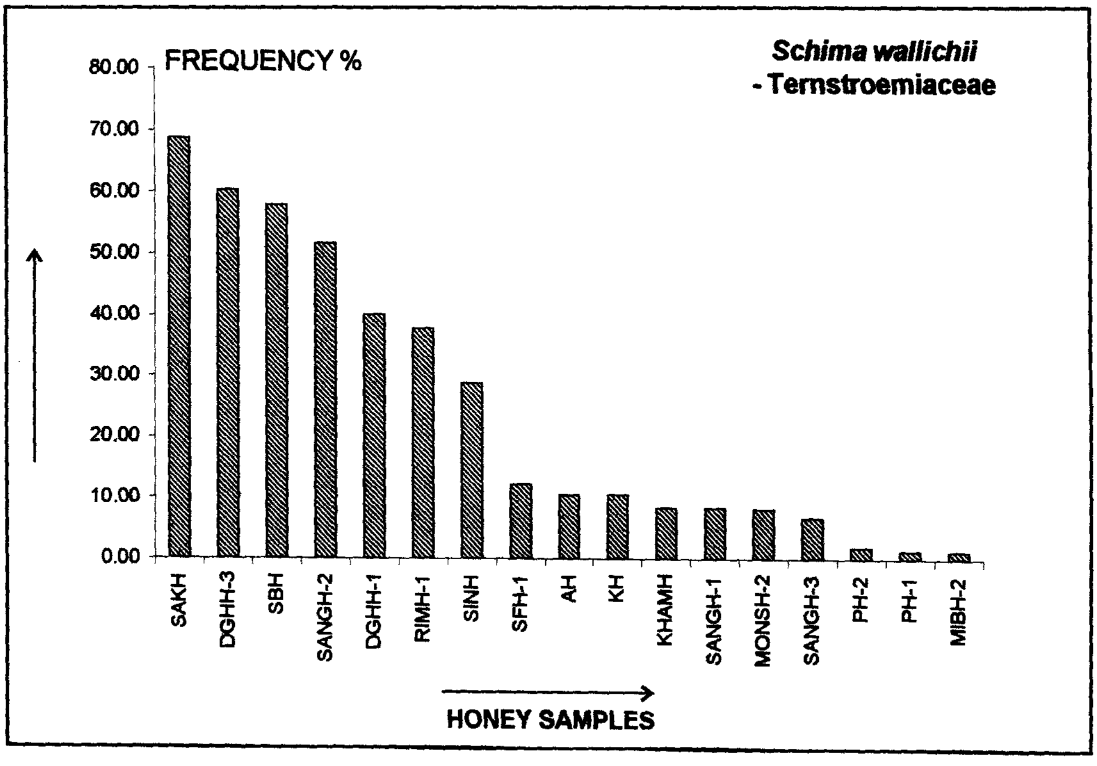
[Fig :- 3.3.4.3]



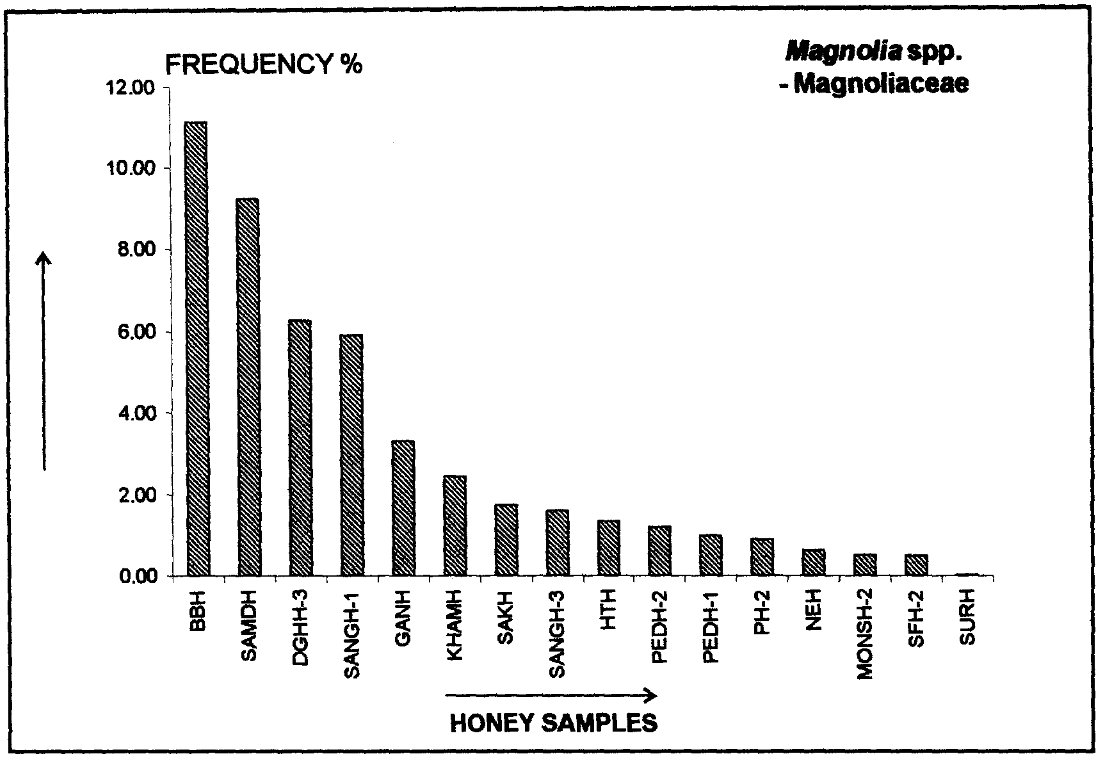
[Fig :- 3.3.4.4]



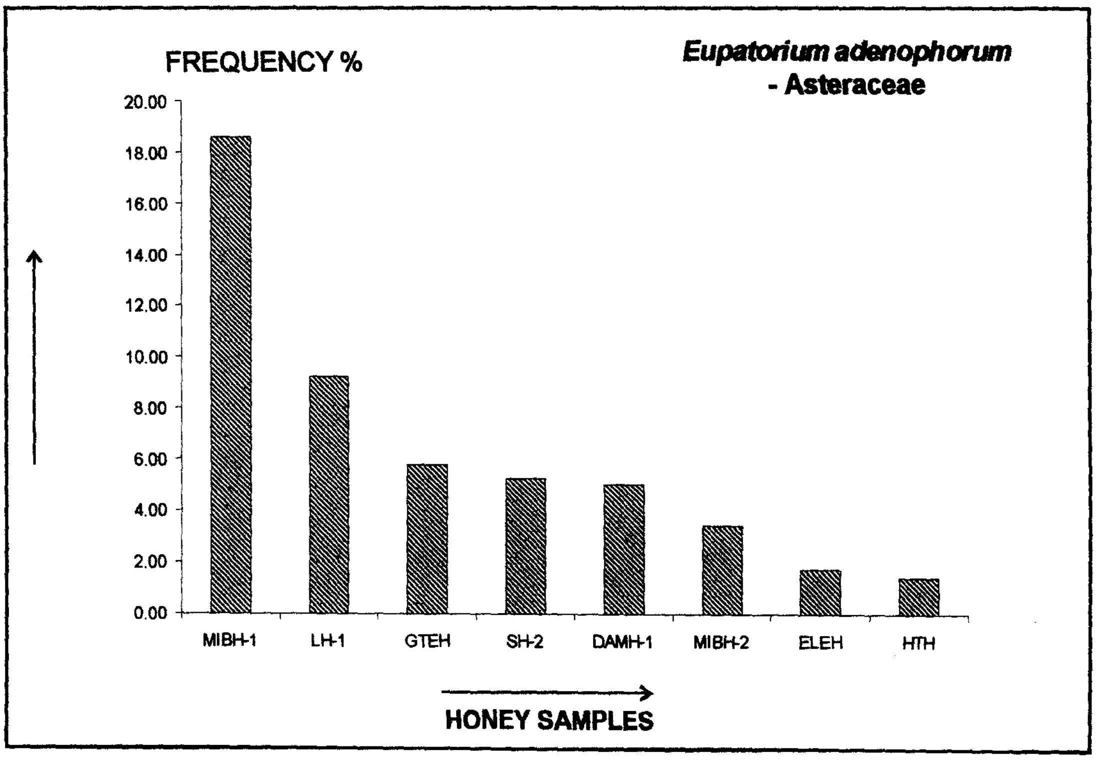
[Fig :- 3.3.4.5]



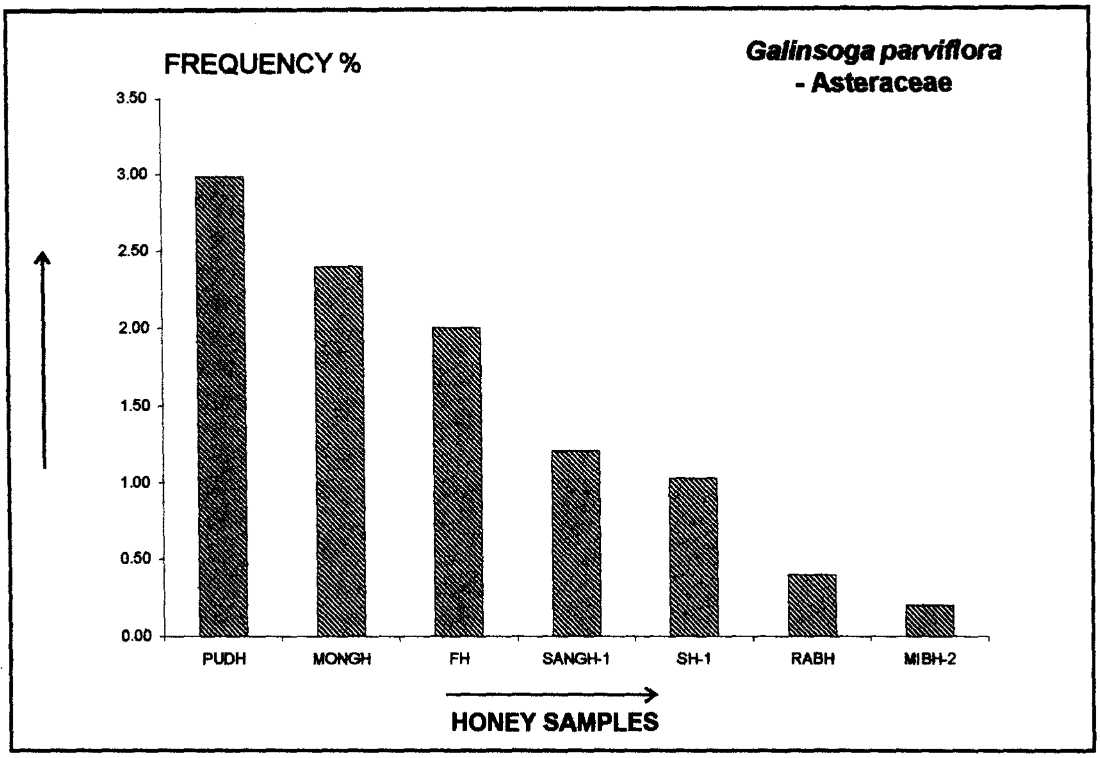
[Fig :- 3.3.4.6]



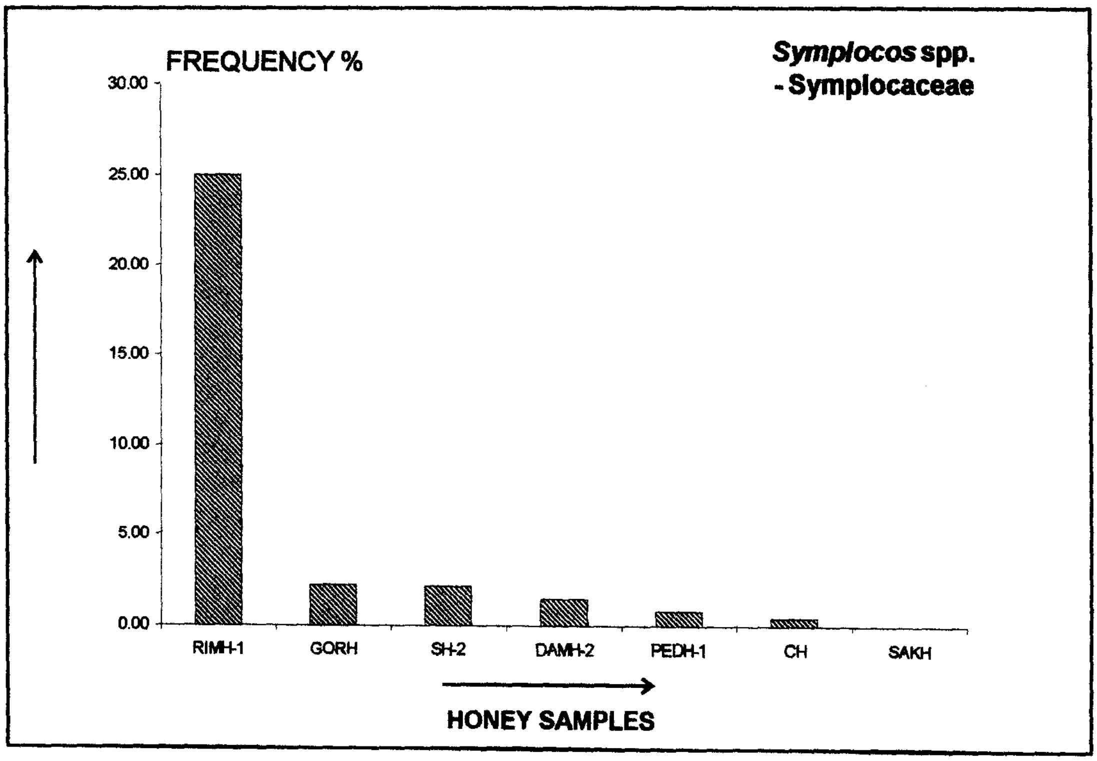
[Fig :- 3.3.4.7]



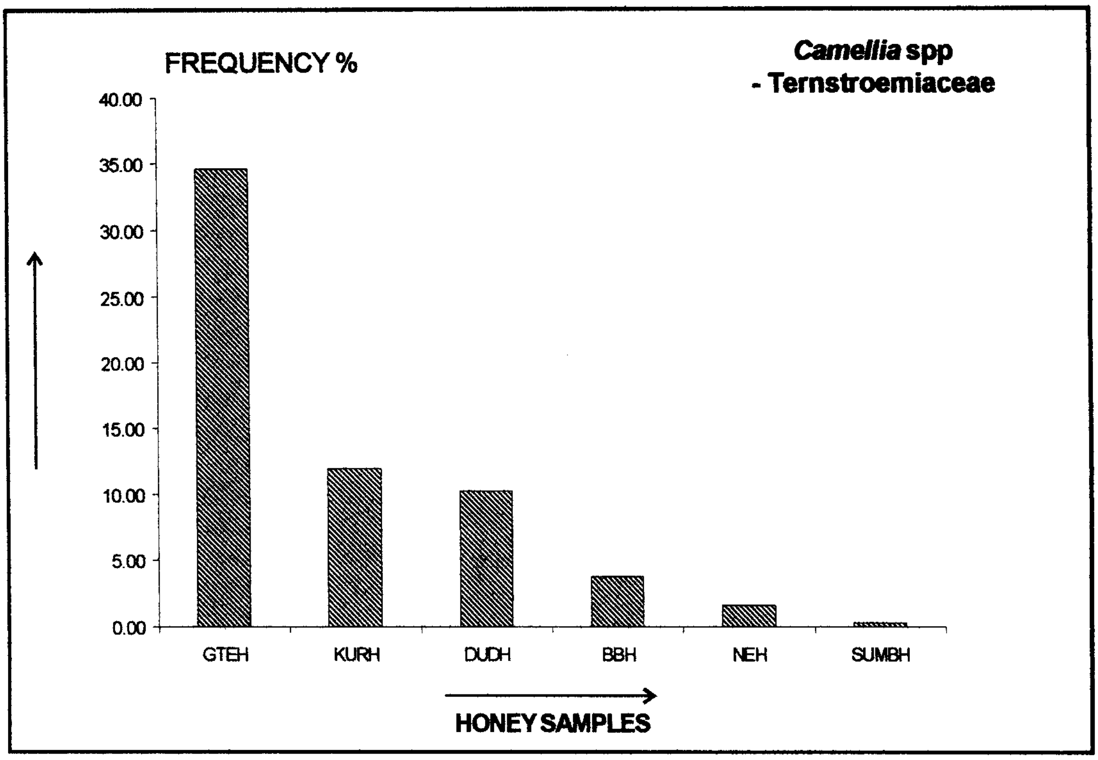
[Fig :- 3.3.4.8]



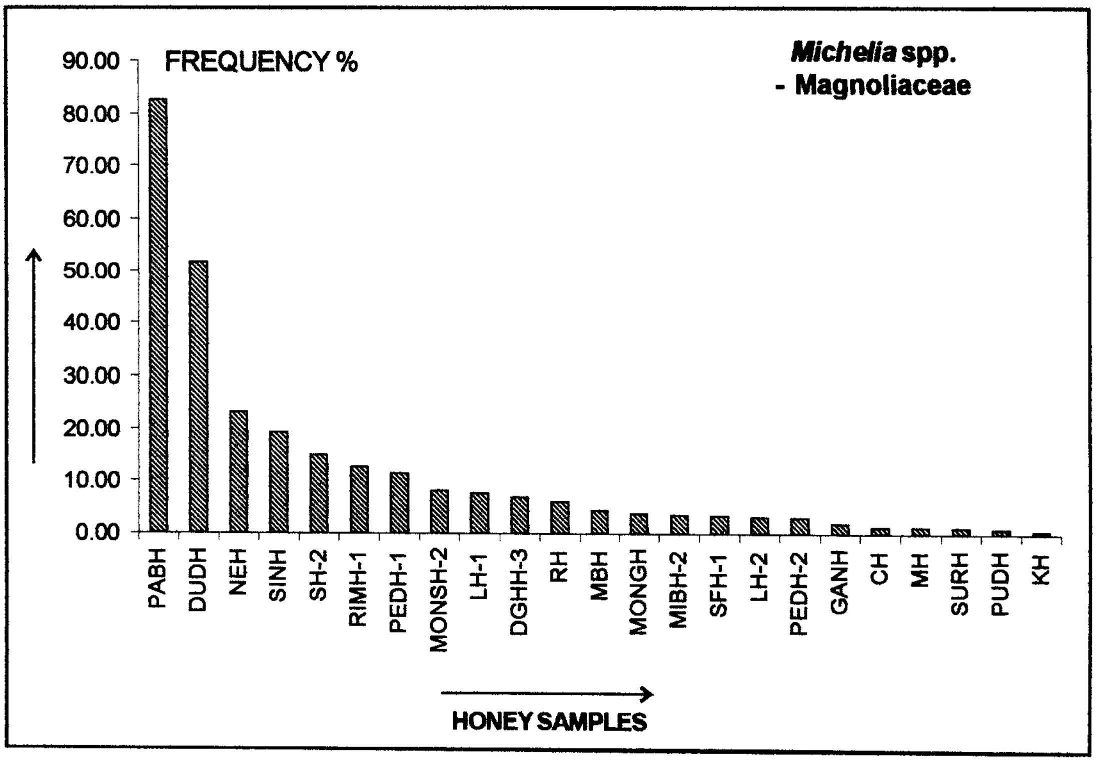
[Fig :- 3.3.4.9]



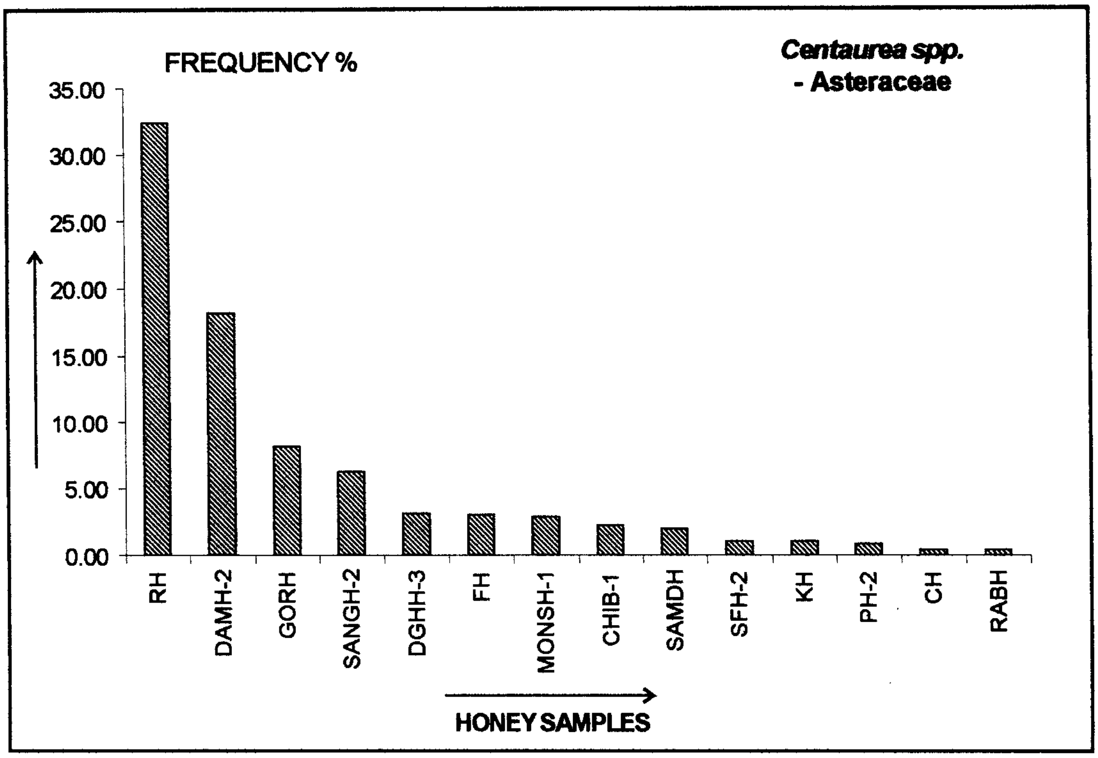
[Fig :- 3.3.4.10]



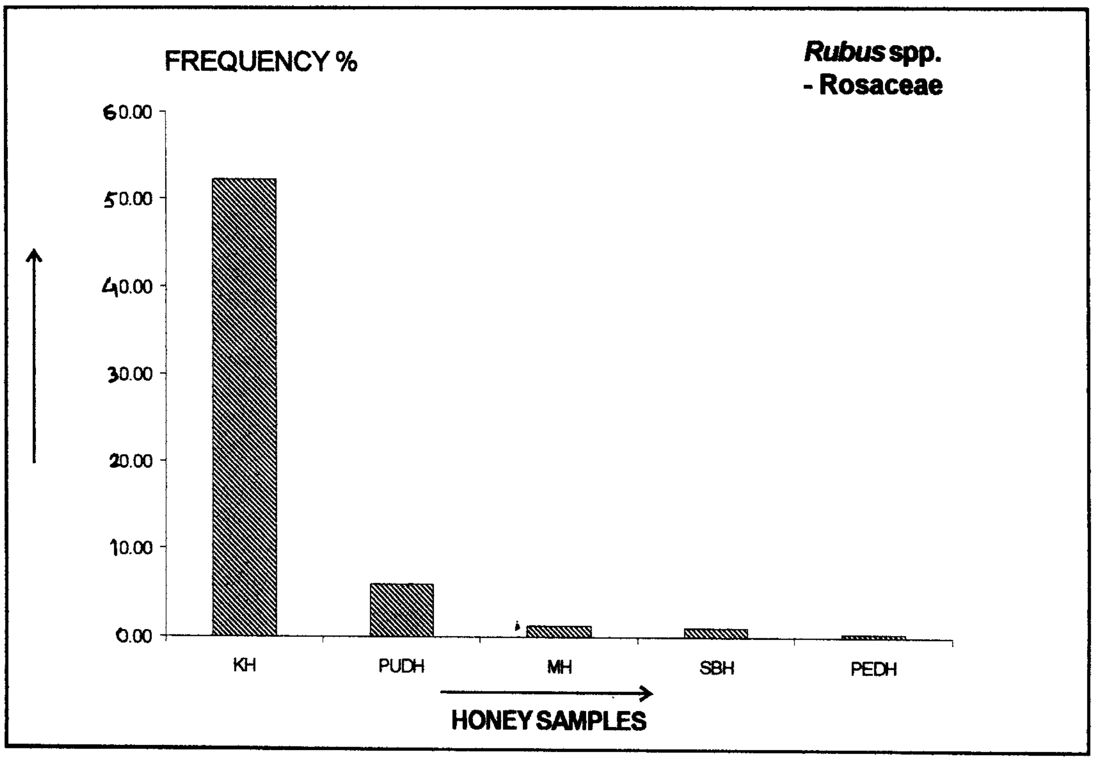
[Fig :- 3.3.4.11]



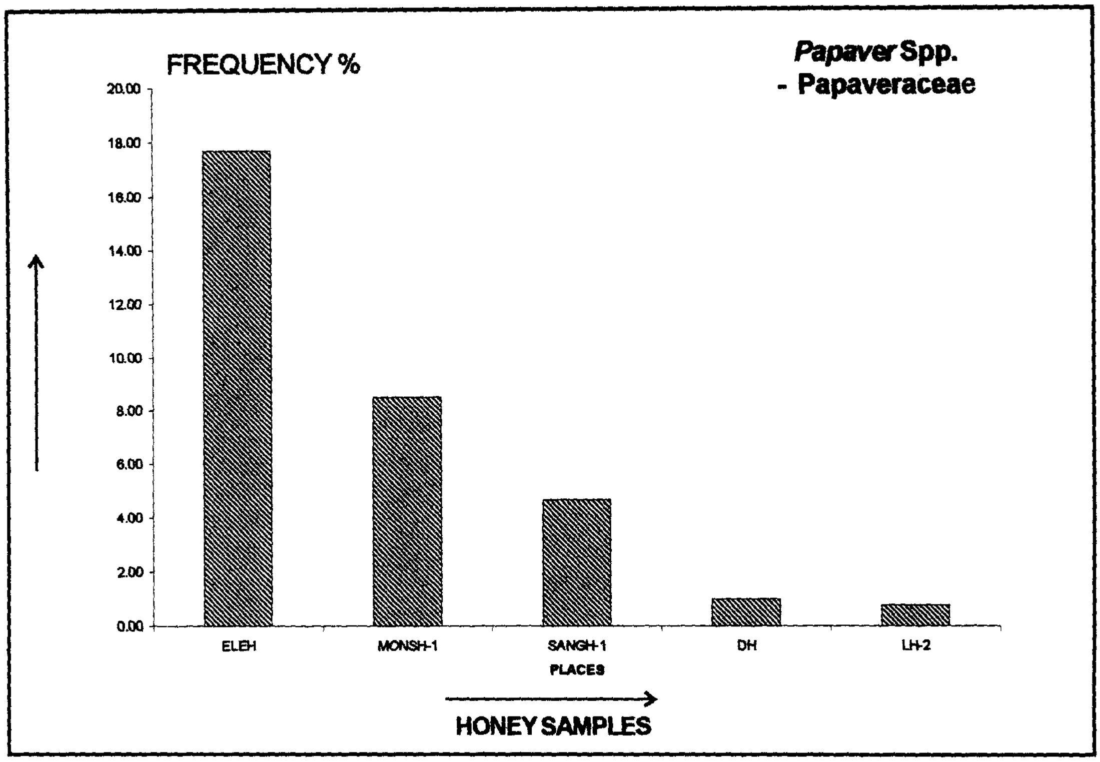
[Fig :- 3.3.4.12]



[Fig :- 3.3.4.13]



[Fig :- 3.3.4.14]


FREQUENCY %
Papaver Spp.
- Papaveraceae
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
ELEH
MONSH-1
SANGH-1
DH
LH-2
PLACES
HONEY SAMPLES

[Fig. : 3.3.4.15]

3.3.5 POLLEN FREQUENCIES OF SOME MULTIFLORAL HONEYS.

The frequencies in terms of percentage of different pollen types as recovered from multifloral honeys are explained as follows:-

The sample AH (August, 1996) showed secondary pollen types as *Calendula offinalis* (28.26 %), *Buddleja asiatica* (19.57 %). *Bidens pilosa* (15.22 %). The important minor pollen types were found *Cestrum* spp. (13.04 %), Schima wallichii (10.37 %), *Tetrastigma obtectum* (4.35 %). The minor pollen types were *Cyphomandra betacea* (2.17 %), *Vitis dubea* (2.17 %), *Rosa* spp. (2.17 %), *Aristolochia* spp. (2.17 %) and unidentified (0.51 %). (Fig. 3.3.5.1 & table 3.3.2A).

The sample HTH (June 1996) showed single secondary pollen type with *Datura* spp. (24.3 %). The important minor pollen types were found as *Nemophila menziensii* (7.6 %), *Sambucus* spp. *(9.4%), Gladiolus* spp. *(7.1%), Prunus* spp. (6.75 %), *Buddleja* spp. (5.4 %), *Michelia doltsopa* (4.0 %), *Petunia* sp. (4.5 %), *Cyphomandra betacea* (3.5 %), *Rubia* sp. (6.4 %). The minor pollen types were *Trapeolum majus* (2.7 %), *Calendula officinalis* (2.7 %), *Dahlia imperialis* (2.7 %), *Pueraria sikkimensis* (2.7 %), *Magnolia* spp. (0.05%), *Plectranthus mollis* (1.35%), *Leucoseptrum cannum* (1.35%), *Eupatorium adenophorum* (1.35%), Poaceae (1.3%), Cactaceae (0.3%), *Eucalyptus* sp. (2.5%), *Hattuynia cordata* (0.5%) and *Salvia* spp. (0.6%) and unidentified 0.35%) (Fig. 3.3.5.2 & table 3.3.2A).

The sample TODH (March 1997) showed two secondary pollen types *Potentilla* spp. (45 %), *Prunus* spp. (39.1 %). Important minor pollen types were *Brassica* spp. (7.14 %), *Spirea* spp. (4.42 %). The minor pollen types were found as *Codonopsis affinis* (2.5 %), *Ligastrum* spp. (0.34 %), *Gynocardia odorata* (0.2 %), *Ammomum subulatum* (1.0 %) and unidentified (0.24 %) (Fig. 3.3.5.3 & table 3.3.2.A).

The sample GORH (September 1996) consisted of secondary pollen *Ageratum conyzoides* (41.8 %), *Dalbergia* spp. (17.06 %). The important minor pollen types were found as *Centaurea* spp. (8.18 %), *Primula* spp.

(7.00 %), *Rosa* spp. (3.48 %), *Woodfordia fruticosa* (5.5 %), *Sterculia* spp. (6.5 %) The minor pollen types were found as *Lantana camara* (2.44 %), *Bidens pilosa* (2.32 %), *Porana* spp. (2.32 %), *Symplocos* sp. (2.2 %)., *Leucus* sp. (1.0 %). *Momordica* sp. (0.5 %), *Cassia* sp. (1.0 %) and unidentified (1.2%) (Fig. 3.3.5.4 & table 3.3.2A).

The sample LH-2 (July'96) showed secondary pollen types as *Passiflora* spp. (17.4 %), *Tropeolum majus* (18.6 %), *Cestrum* spp. (16.2 %).

The important minor pollen types were found as *Spirea* spp. (10.8 %), *Holboelia latifolia* (9.3 %), *Sedum multicaule* (4.3 %), *Saxifraga sarmentosa* (4.65 %), *Streptosolen jamesonii* (4.65 %), *Coronopus didymus* (3.87 %), *Trifolium repens* (3.1 %). The minor pollen types were found as *Tetrastigma obtectum* (1.55 %), *Papaver* spp. (0.77 %), Poaceae (5.0 %) and unidentified 0.77 % (Fig. 3.3.5.5. & table 3.3.2A).

The sample PEDH-1 (June 1996) consisted of two secondary pollens *Buddleja asiatica* (21.07%), *Prunus* spp. (17.76 %). The important minor pollen types were found as *Rosa* spp. (13.2 %), *Trifolium repens* (11.15 %), *Michelia* spp. (5.68 %), *Duranta repens* (6.19 %), *Erigeron karwinskianius* (4.0 %), *Ammomum subulatum* (3.0 %). The minor pollen types were *Raphanus sativus* (2.47 %), *Brassica* spp. (1.06 %), *Citrus* spp. (1.0 %), *Fragaria* spp. (1.23 %), *Abutilon* spp. (1.23%), *Fagopyxum dibotrys* (0.82 %), *Hemerocallis disticha* (0.82 %), *Symplocos* spp. (0.82 %), *Cleome* spp. (0.41 %), *Rubus* spp. (0.41 %), *Leycesteria* spp. (0.3 %), *Magnolia* spp. (1.00%) and unidentified (0.41%) (fig. 3.3.5.6 & table 3.3.2A).

The sample KURH (November, 1996) consisted of two secondary pollen types as *Tropaeolum majus* (25 %), *Nicotiana tabacum* (25 %). The important minor pollen types were *Camellia* spp. (12.0 %), *Streptosolen jamesonii*, (12.5 %), *Mazus surculosus* (11.0 %), *Dahlia imperialis* (12.5 %). The minor pollen types were *Potentilla* spp. (0.5 %) and unidentified 1.5 %. (Fig. 3.3.5.7 & table 3.3.2A).

The sample RIMH-1 (August, 1996) consisted of secondary pollen types as *Schima wallichii* (37.5 %), *Symplocos* spp. (25 %). The important minor pollen types were found as *Trifolium repens* (12.5 %), *Solanum* spp. (12.5 %), *Fragaria vesca* (12.5 %). The minor unidentified pollen type only was found 1.3 % (Fig. 3.3.5.8 & table 3.3.2A).

The sample DAMH-1 (Apr'96) consisted of one secondary pollen type as *Prunus* spp. (31.0 %). The important minor pollen types were found as *Rosa* spp. (15 %), *Clematis* spp. (8 %), *Brassica* spp. (5 %), *Michelia* spp. (6 %), *Eupatorium adenophorum* (5 %), *Syzigium* spp. (4 %), *Ageratum conyzoides* (3 %), *Citrus* spp. (5 %), *Berberis* spp. (3%) and unidentified (3 %). The minor pollen types were found as *Nemophila menziensii* (2%), *Phaseolus* spp. (1 %) (Fig. 3.3.5.9 & table 3.3.2A).

The sample RH (June, 1996) consisted of secondary pollen types *Centaurea* spp. (32.35 %), *Chrysenthemum* sp. (23.52 %). The important minor pollen types were *Prunus* spp. (11.76 %), *Trifolium repens* (5.88 %), *Citrus* sp. (6.5 %). The minor pollen types were *Clerodendrum* sp. (2.94 %), *Pyrus* spp. (1.79 %), *Erigeron karwinskianus* (2.94 %), *Cestrum* spp. (2.94 %), *Gynocardia odorata* (2.94 %), *Leycesteria* spp. (2.94 %), *Buddleja asiatica* (1.2 %) (Fig. 3.3.5.10 & table 3.3.2A).

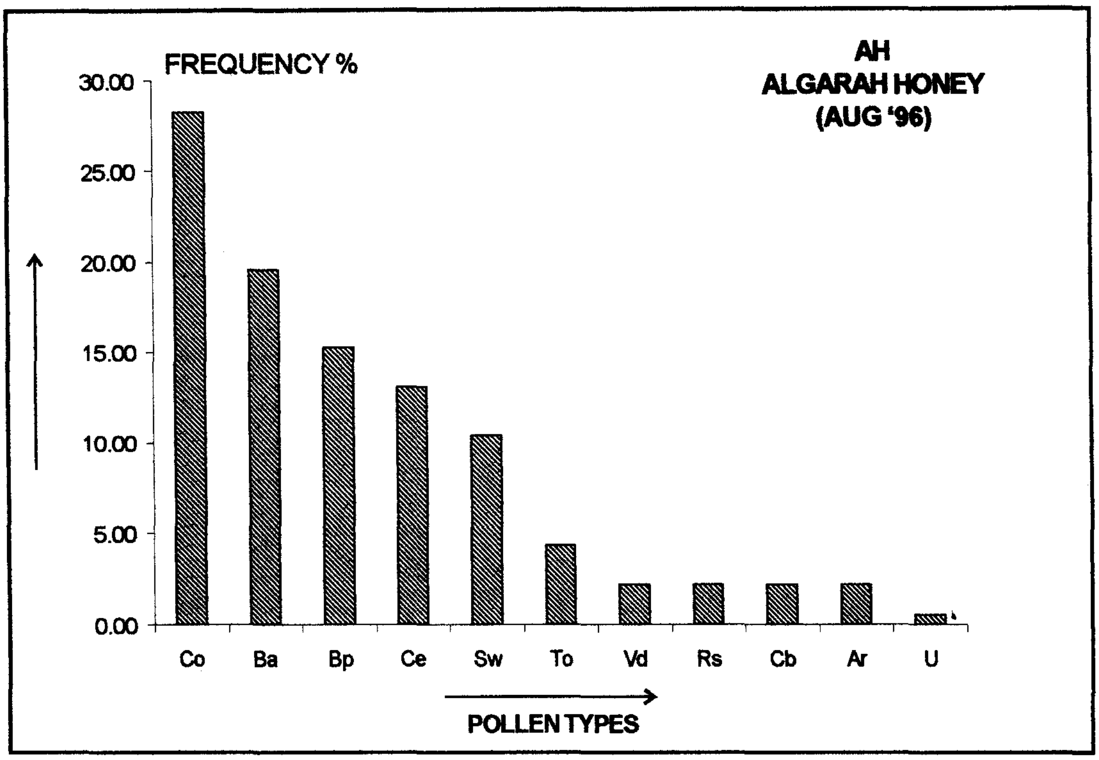
The sample GANH (March 1997) consisted of *Bauhinia* spp. (19.78 %) as the secondary pollen types. The important minor pollen types were found as *Ammomum subulatum* (11.6 %), *Nemophilla menziensii* (10.43 %), *Sambucus* spp. (9.89 %), *Milletia pulchra* (8.79 %), *Rosa* spp. (4.03 %), *Cestrum* spp. (4.39 %), *Asystasia macrocarpa* (3.84 %), *Magnolia* spp. (3.29 %), *Iberis* spp. (3.29 %), *Erigeron karwinskianus* (4.64 %). The minor pollen types were found as *Michelia* spp. (2.19 %), *Calendula officinalis* (2.19 %), *Tropaeolum majus* (1.8 %), *Antirrhinum* sp. (1.09 %), *Trifolium repens* (2.54 %), *Brassica* spp. (1.57 %), *Desmodium* spp. (2.00 %), *Gynocadia odorata* (1.0 %) and unidentified (1.65 %) (Fig. 3.3.5.11 & table 3.3.2A).

The sample MONGH (December 1995) consisted of secondary pollen types *Bellis perennis* (24.5 %), *Rosa* spp. (22.6 %). The important minor pollen types were found as *Bidens pilosa* (9.32 %), *Pimpinella diversifolia* (11.32 %), *Tropaeolum majus* (7.54 %), *Trifolium repens* (3.7 %). The minor pollen types were *Michelia* spp. (2.16 %), *Erigeron karvinskianus* (1.7 %) *Crotolaria* sp. (2.07 %), *Euphorbia* spp. (1.8 %), *Ocimum* spp. (1.8 %), *Datura* spp. (1.8 %), *Brassica* spp. (1.8 %), *Clematis* spp. (1.8 %), *Luffa* spp. (1.8 %), *Galinsoga parviflora* (2.00 %) *Fuchsia dependens* (1.00 %) and unidentified 2.09 % (Fig. 3.3.5.12 & table 3.3..2A).

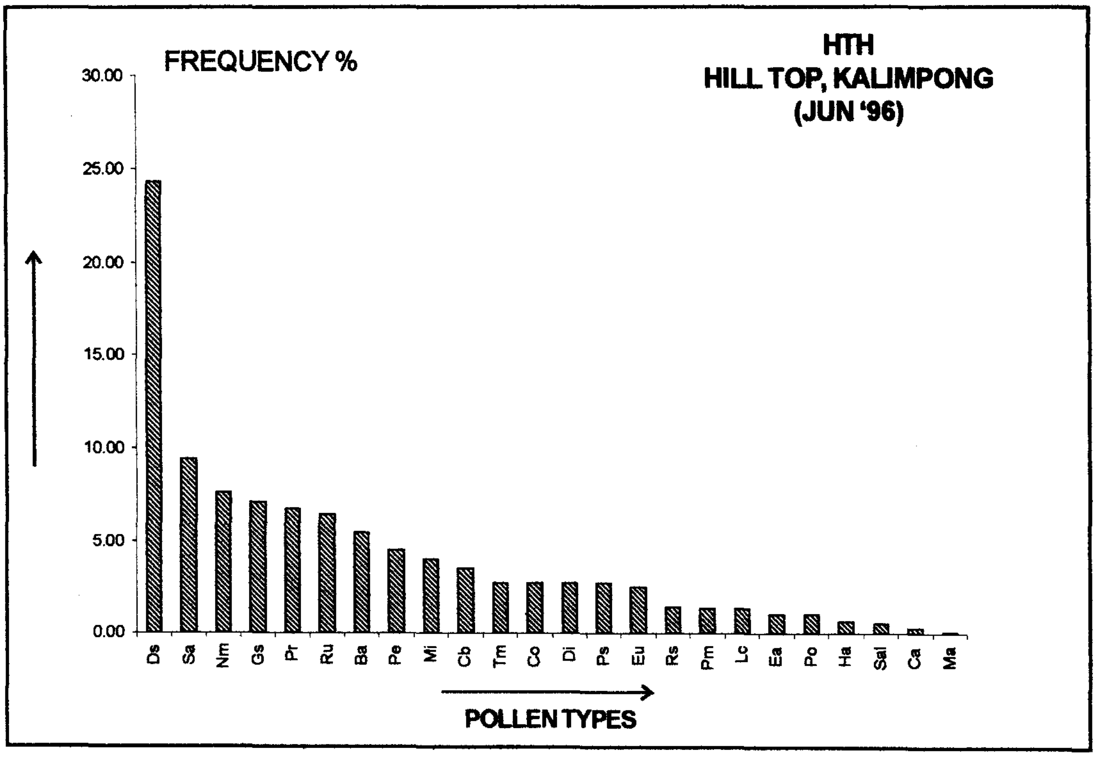
The sample MONSH-! (March 1996) consisted of secondary pollen types *Prunus* spp. (34.2 %), *Pyrus japonica* (25.7 %). The important minor pollen types were found as *Papaver* spp. (8.5 %), *Rosa* spp. (5.7 %), *Michelia* spp. (5.7 %), *Begonia* sp. (5.7 %), *Hypoestes trifora* (5.3 %). The minor pollen types were found as *Centaurea* spp. (2.85 %), *Brassica* spp. (2.85 %), *Tropaeolum majus* (1.65 %), *Digitalis* spp. (1.65 %) and unidentified 0.2 % (Fig. 3.3.5.14 & table 3.3.2A).

The sample GTEH (August 1997) consisted of secondary pollen types as *Camellia* spp. (34.57 %), *Frageria* spp. (20 %). The important minor pollen types were *Bidens pilosa* (6.16 %), *Rosa* spp. (5.68 %), *Eupatorium adenophorum* (5.76 %), *Clematis* spp. (5.0 %), *Calendula officinalis* (4.0 %), *Datura* spp. (3.05 %). The minor pollen types were *Plantago erosa* (0.69 %), *Primula* spp. (1.35 %), *Mazus surculosus* (1.03 %), *Ammomum subulatum* (1.0 %), *Jasminum* sp. (0.68 %), *Edgaria darjeelingensii* (1.0 %) and unidentified 0.05 % (Fig. 3.3.5.13 & table 3.3.2A).

POLLEN FREQUENCIES OF SOME MULTIFLORAL HONEYS



[Fig. : 3.3.5.1]

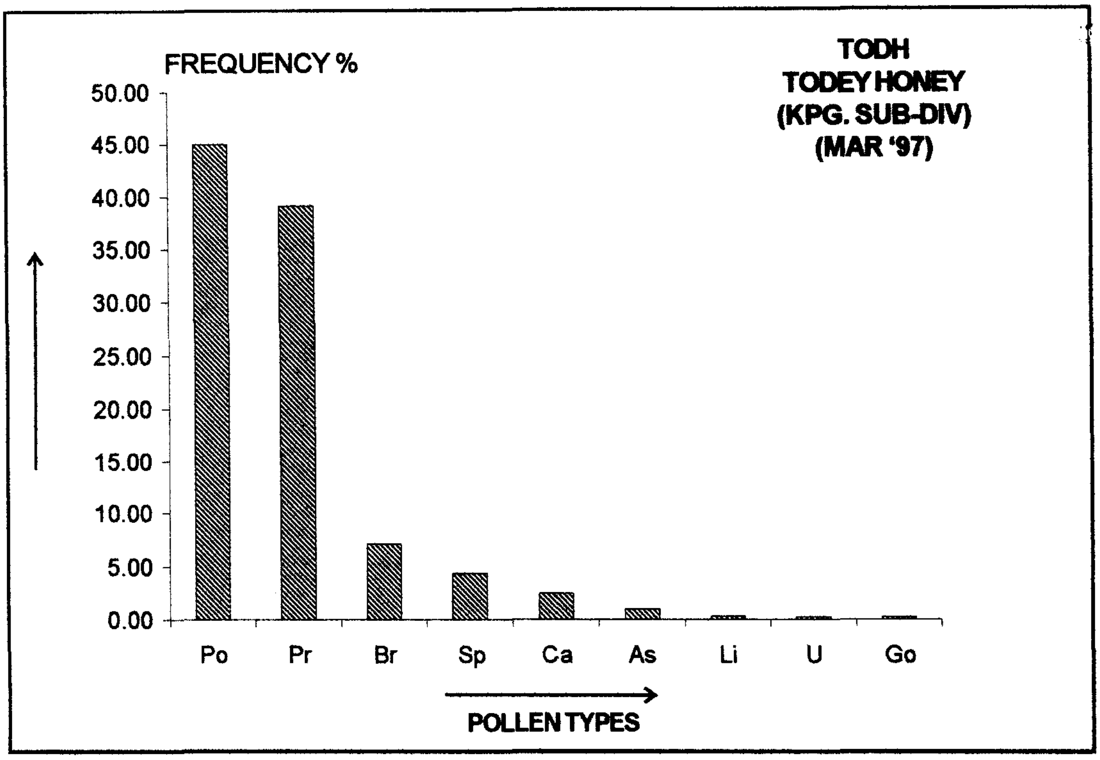


[Fig. : 3.3.5.2]

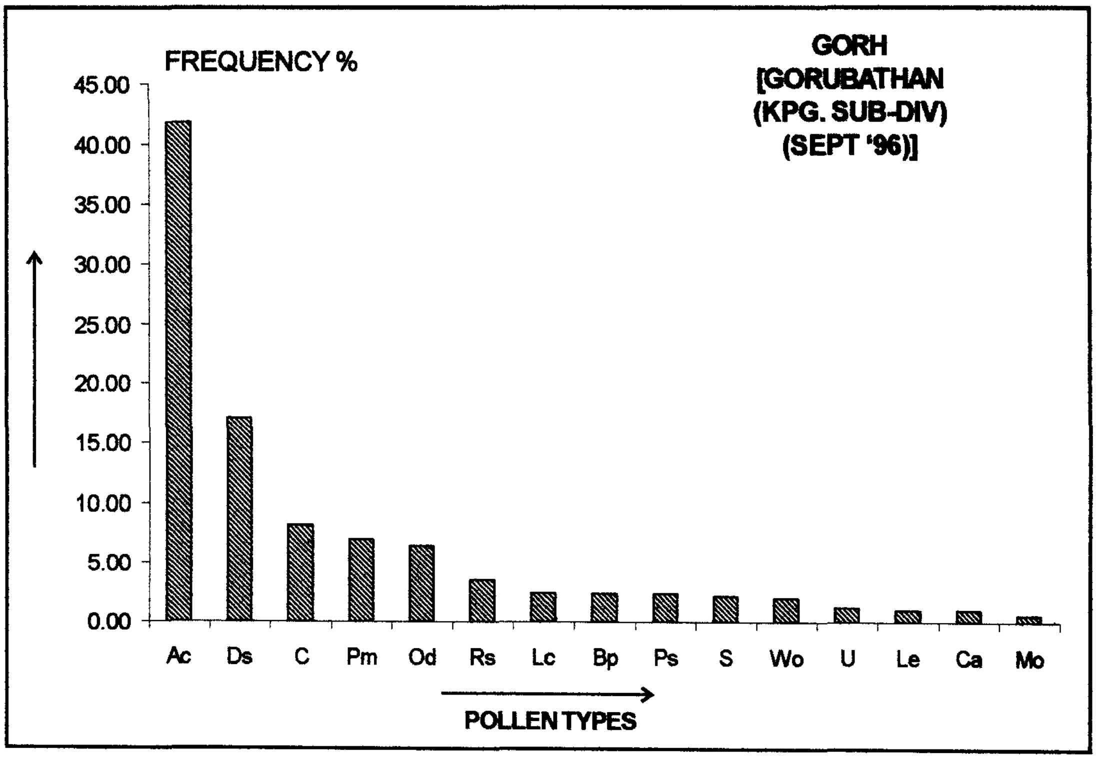
[Abbreviations used :-

Co = *Calendula* officinalis
Ba = *Buddleja asiatica*
Bp = *Bidens pilosa*
Ce = *Cestrum* spp.
To = *Tetrastigma obtectum*
Cb = *Cyphomandra betacea*
U = Unidentified
Vd = *Vietis dubea*
Rs = *Rosa* spp.
Ar = *Aristolochia* spp.
Sw = *Schima wallichii*
Sal = *Salvia* spp.
Ca = Cactaceae
Nm = *Namophilla meziensii*
Tm = *Tropaeolum majus*
Eu = *Eucalyptus* spp.

Ds = *Datura* spp.
Sa = *Sambucus* spp.
Mi = *Michelia* spp.
Rs = *Rosa* spp.
Di = *Dahlia imperialis*
Ps = *Pueraria sikkimensis*
Pm = *Plectranthus mollis*
Lc = *Leucoseptrum cannum*
Ea = *Eupatorium adenophorum*
Ma = *Magnolia* spp.
Po = Poaceae
Ha = *Hattuynia cordata*
Co = *Cyphomandra betacea*
Gs = *Gladiolus* spp.
Pr = *Prunus* spp.
Ru = *Rubia* spp.]



[Fig. : 3.3.5.3]

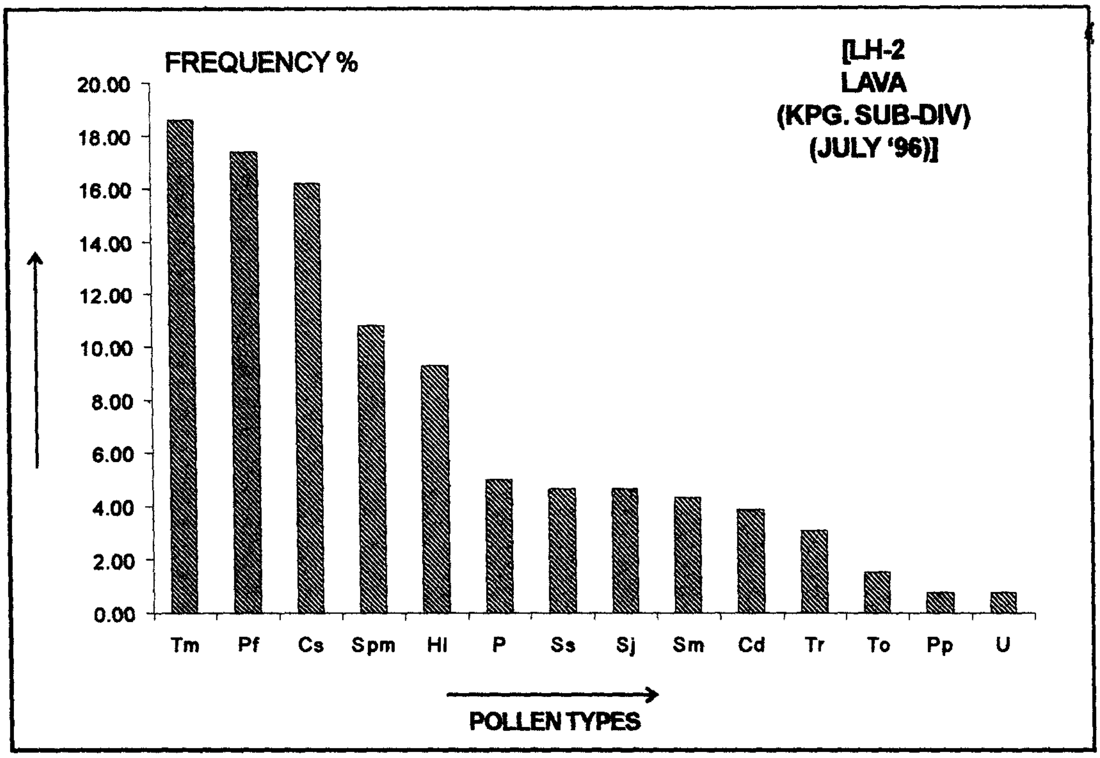


[Fig. : 3.3.5.4]

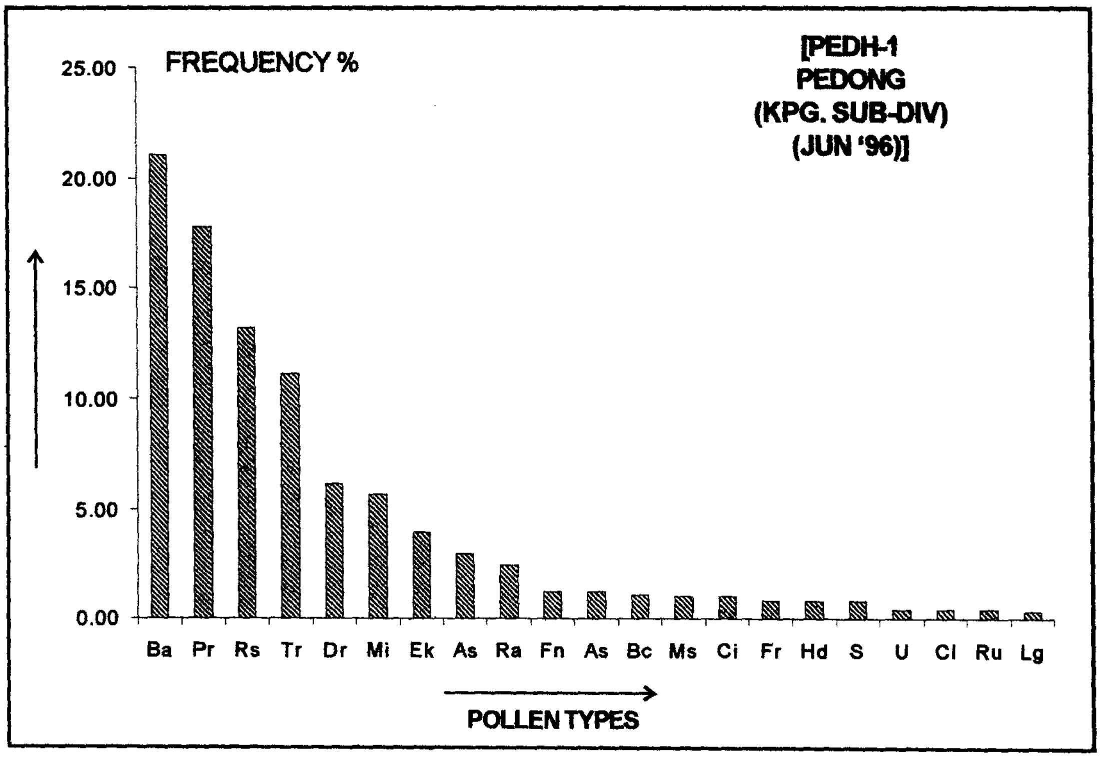
[Abbreviations used :-

Po = *Potentilla* spp.
Pr = *Prunus* spp.
Br = *Brassica* spp.
Sp = *Spirea* spp.
Ca = *Codonopsis affinis*
Li = *Ligastrum* spp.
As = *Ammomum subulatum*
U = Unidentified
Go = *Gynocardia odorata*
Ac = *Ageratum conyzoides*

Ds = *Dalbergia* spp.
C = *Centaurea* spp.
Pm = *Primula* spp.
Lc = *Lantana camara*
Bp = *Bidens pilosa*
Ps = *Porana* spp.
S = *Symplocos* spp.
Wo = *Woodfordia fruticosa*
Lc = *Leucus* spp.
Ca = *Cassia* spp.
Mo = *Momordica* spp.]



[Fig. : 3.3.5.5]

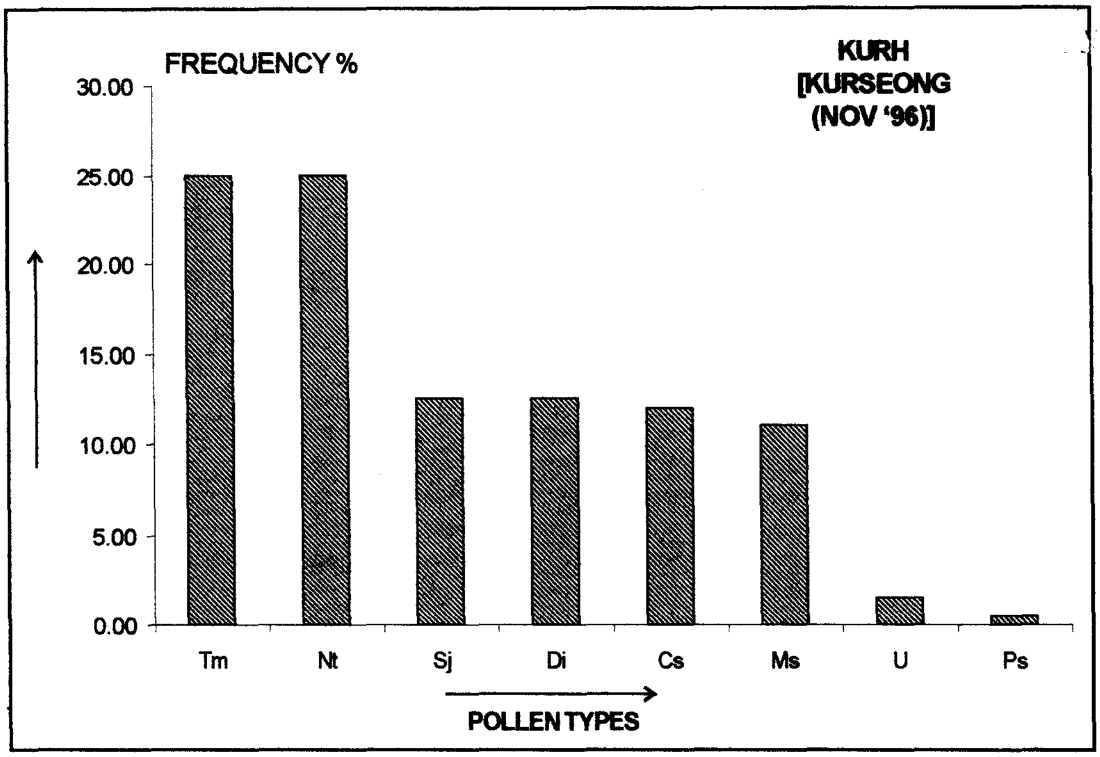


[Fig. : 3.3.5.6]

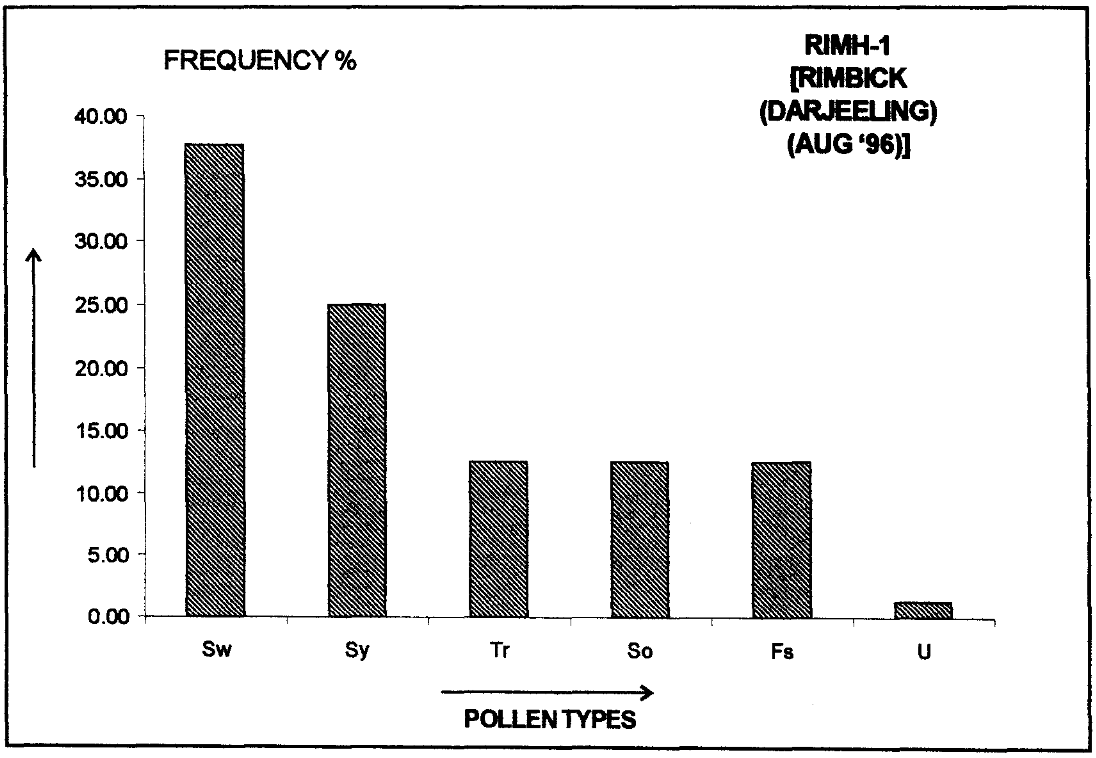
[Abbreviations used :-

Pf = *Passiflora* spp.
Tm = *Tropeolum mejus*
Ces = *Cestrum* spp.
Spm = *Spirea* spp.
Hl = *Holboelia latifolia*
Ss = *Saxifraga sarmentosa*
Sj = *Streptosolen jamesonii*
P = Poaceae
Cd = *Coronopus didymus*
To = *Tetrastigma oblectum*
Pp = *papaver paniculata*
Ba = *Buddleja asiatica.*
Mi = *Michelia* spp.
Pr = *Prunus* spp.
Rs = *Rosa* spp.
Tr = *Trifolium repens*

Ms = *Magnolia* spp.
Dr = *Duranta repens*
Ek = *Erigeron karwinskianus*
Lg = *Leycesteria gracilis*
Ra = *Raphanus sativus*
Bc = *Brassica* spp.
Ci = *Citrus* spp.
Fr = *Fragaria* spp.
As = *Abutilon* spp.
Fd = *Fagopyrum dibotrys*
Hd = *Hemerocallis disticha*
S = *Symplocas* ssp.
U = Unidentified
Cg = *Cleome* spp.
Ru = *Rubus* spp.
As = *Ammomum subulatum*]



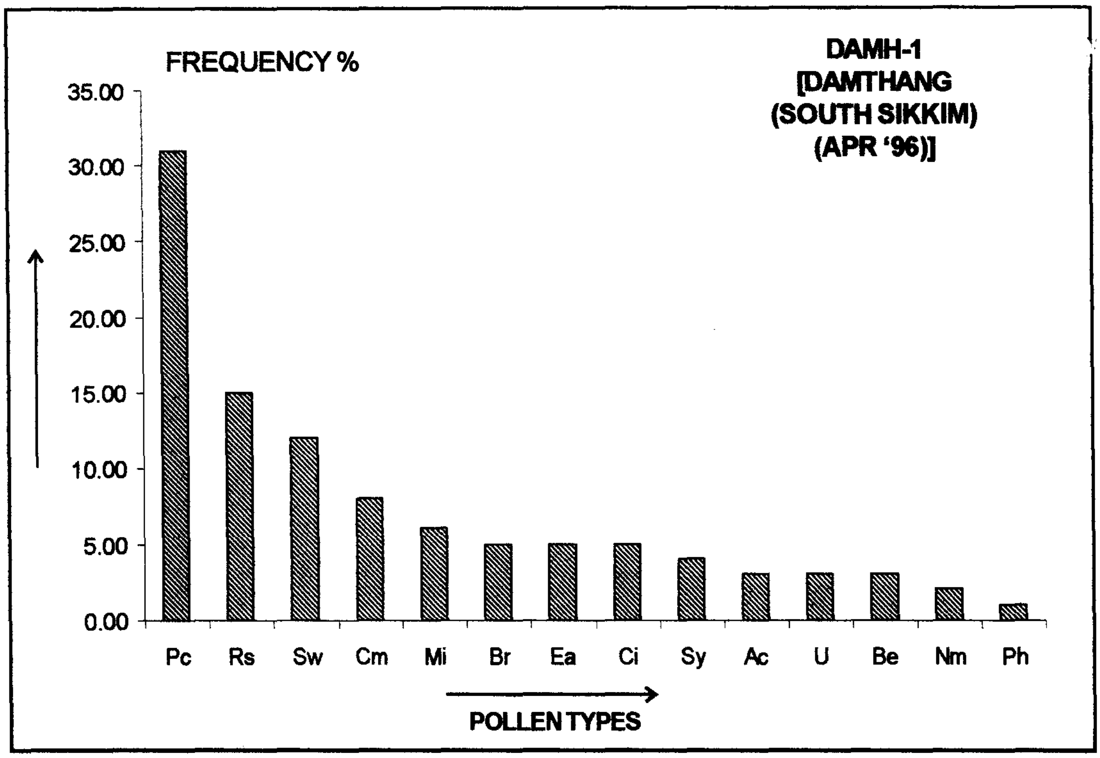
[Fig. : 3.3.5.7]



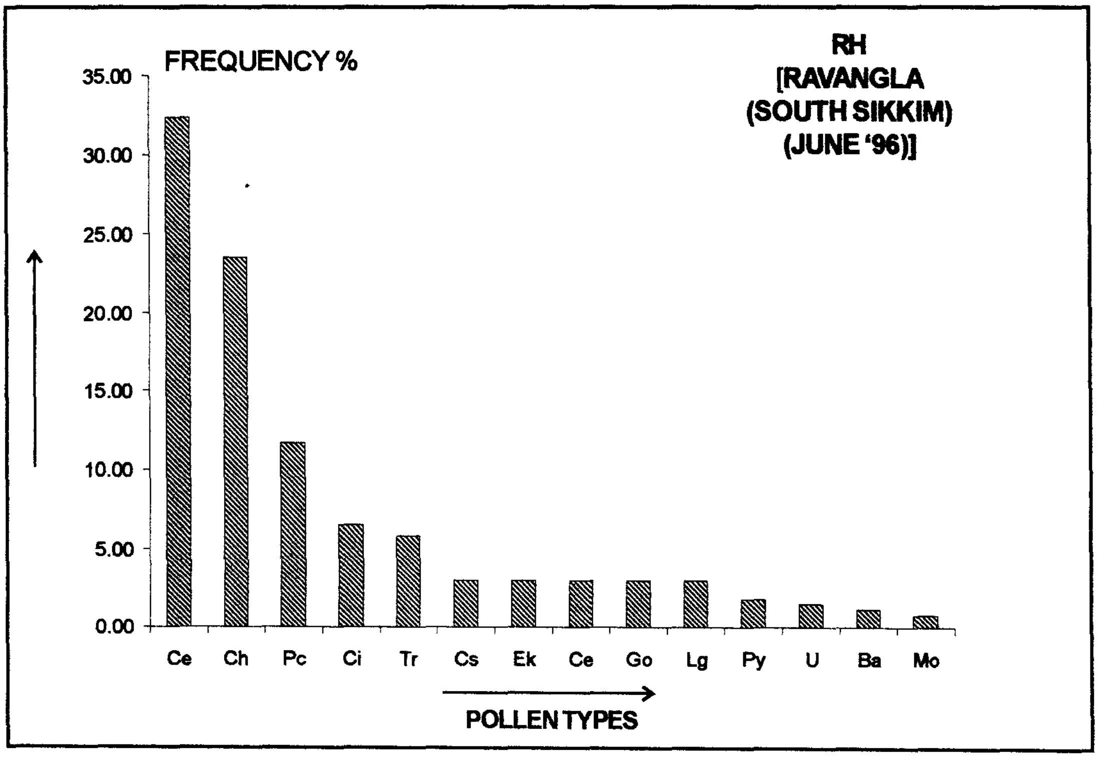
[Fig. : 3.3.5.8]

[Abbreviations used :-

Tm	=	*Tropaeolum majus*	Sw	=	*Schima wallichii*
Nt	=	*Nicotiana tabacum*	Sy	=	*Symplocos*
Ps	=	*Potentilla* spp.	Tr	=	*Trifolium repens*
Sj	=	*Streptosolen jamesonii*	So	=	*Solanum* spp.
Ms	=	*Mazus surculosus*	Fs	=	*Fragaria* spp.
Di	=	*Dahlia imperialis*	U	=	Unidentified]
Cs	=	*Camellia* spp.			



[Fig. : 3.3.5.9]

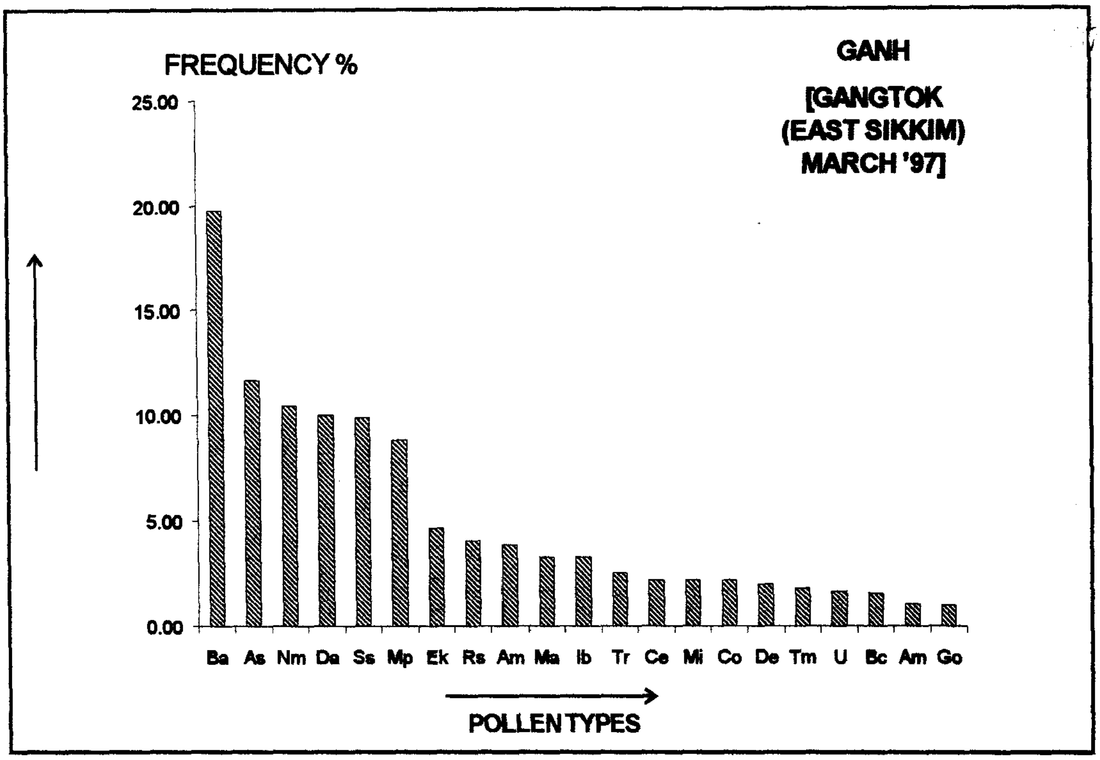


[Fig. : 3.3.5.10]

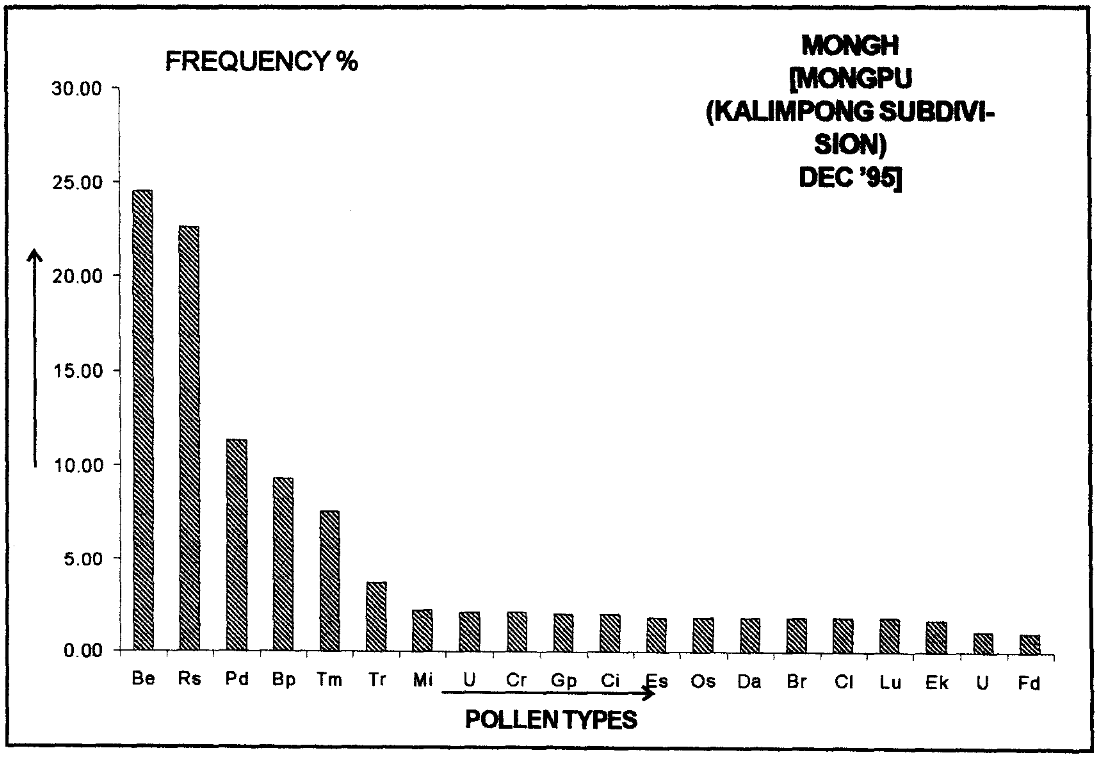
Abbreviations used :-

s = *Prunus* spp.
s = *Rosa* spp.
m = *Clematis montana*
r = *Brassica* spp.
i = *Michelia* spp.
a = *Eupatorium adenophorum*
y = *Syzgium* spp.
e = *Berberis* spp.
i = *Citrus* spp.
c = *Ageratum conyzoides*
m = *Nemophilla menziensii*
h = *Phaseolus* spp.

U = Unidentified
Sw = *Schima wallichii*
Ce = *Centaurea* spp.
Ch = *Chrysenthemum* spp.
Ms = *Myosotis sylvatica*
Tr = *Trifolium repens*
Cs = *Clerodendrum* spp.
py = *Pyrus japonica*
Ek = *Erigeron karwinskianus*
Ce = *Cestrum* spp.
Lg = *Leycesteria gracilis*
Ba = *Buddleja asiatica*
.Go = *Gvnocardia odorata*]



[Fig. : 3.3.5.11]

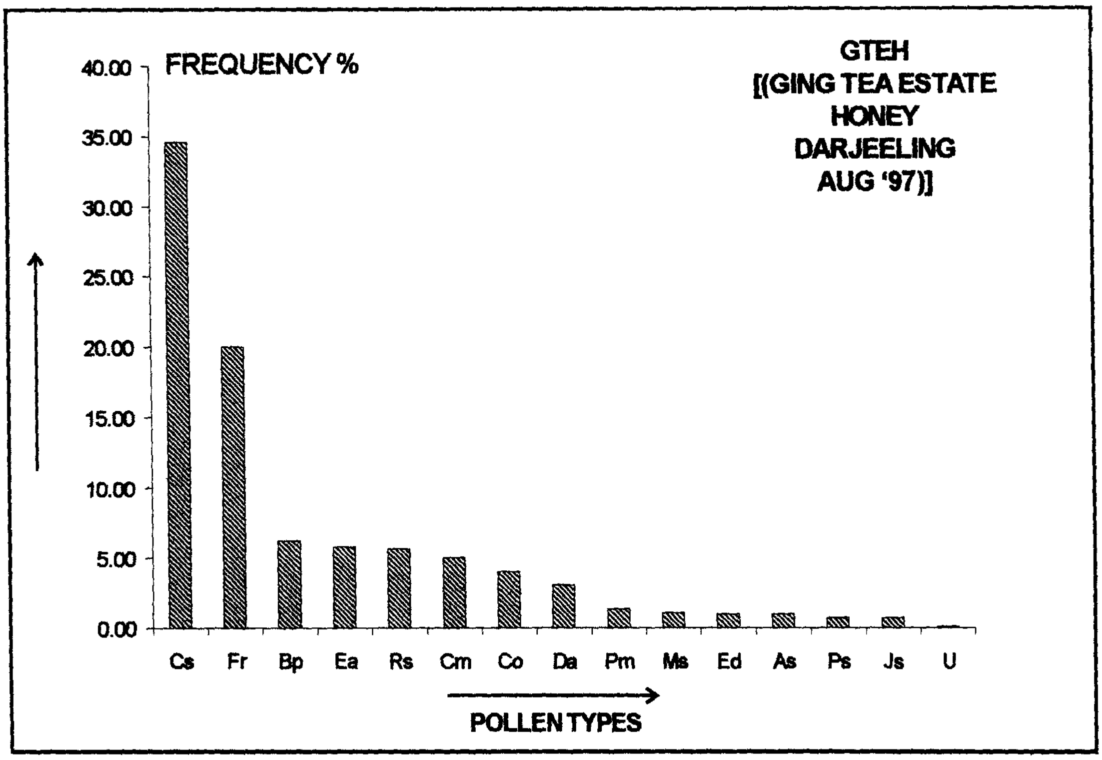


[Fig. : 3.3.5.12]

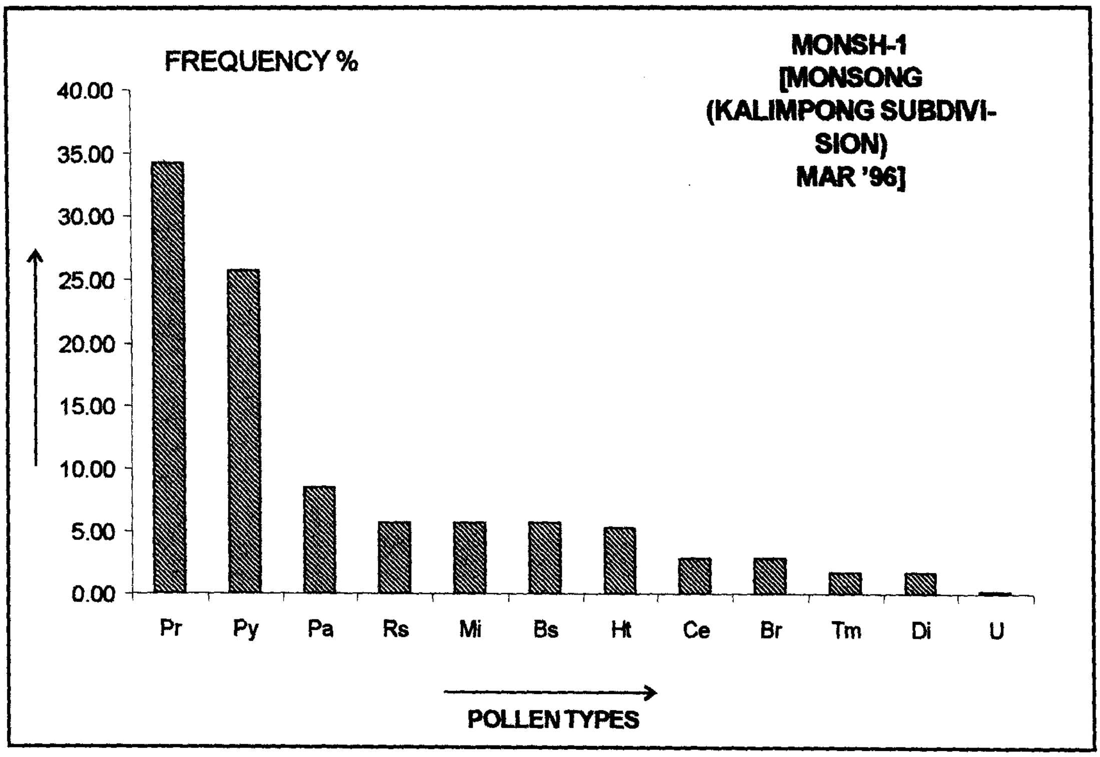
[Abbreviations used :-

Ba = *Bauhinia* spp.
Go = *Gynocardia odorata*
Nm = *Nemophilla menziensii*
Ss = *Sambucus* spp.
Mp = *Milletia pulchra*
Rs = *Rosa* spp.
Ce = *Cestrum* spp.
Am = *Asytasia macrocarpa*
Ma = *Magnolia* spp
Tr = *Trifolium repens.*
As = *Ammomum subulatum*
Ib = *Iberis amara*
Mi = *Michelia* spp.
Co = *Calendula officinalis*
Tm = *Tropaeolum majus*
Ek = *Erigeron karwinskianus*
An = *Antirrhinum* spp.

Br = *Brassica* spp.
U = Unidentified.
Be = *Bellis perennis*
Rs = *Rosa* spp.
Bp = *Bidens pilosa*
Pd = *Pimpirella diversifolia*
Tm = *Tropaeolum majus*
Tr = *Trifolium repens*
Ek = *Erigeron karwinskianus*
Mi = *Michelia* spp.
Cr = *Crotolaria* spp.
Es = *Euphorbia* spp.
Os = *Ocimum* spp.
Cl = *Clematis* spp.
Gp = *Galinsoga parviiflora*
Lu = *Luffa* spp.
Fd = *Fuchsia dependens*]



[Fig. : 3.3.5.13]



[Fig. : 3.3.5.14]

[Abbreviations used :-

Cs = *Camellia* spp.
Fr = *Fragaria* spp.
Rs = *Rosa* spp.
Bp = *Bidens pilosa*
Ea = *Eupatorium adenophorum*
Cl = *Clematis* spp.
Co = *Calendula officinalis*
Da = *Datura* spp.
Pe = *Plantago* spp.
Ps = *Primula* spp.
Ms = *Mazus surculosus*
As = *Ammomum subulantum*
Js = *Jasminum* spp.
U = Unidentified

Ed = *Edgaria darjeelingensis*
Pr = *Prunus* spp
Py = *Pyrus japonica*
Pa = *Papaver* spp.
Rs = *Rosa* spp.
Mi = *Michelia* spp.
Bs = *Begonia* spp.
Ht = *Hypoestes triflora*
Ce = *Centaurea* spp.
Br = *Brassica* spp.
Tm = *Tropaelum majus*
Di = *Digitalis* spp.
U = Unidentified]

3.3.6 POLLEN FREQUENCIES OF SOME UNIFLORAL HONEYS

Pollen frequencies in terms of percentages as recovered from different unifloral honeys are explained as follows.

The sample DGHH-3 (Sept'96) showed *Schima wallichii* as predominant Pollen type with its frequency 60.15%. The important minor types were found as *Trifolium repens* (6.75%), *Buddleja asiatica* (6.25%), *Magnolia* spp. (6.25%), *Centaurea* spp. (3.1%), *Sechium edule* (3.1%), Poaceec (3%), *Luffa* spp. (4.4%), *Ipomoea purpurea* (4.4%), *Dichroa* (2.0%). The mirror Pollen types were found as *Erigeron karwinkianus* (1.2%), *Frageria* spp. (1.2%) and unidentified (1.2%) (Fig. 3.3.6.1, table 3.3.2A).

The sample SUMBH (Mar'97) showed *Calendula officinalis* (66%) as predominant Pollen types. The secondary Pollen type were recovered as *Solidago virga-aurea* (18.2%), the important mirror pollen type were *Ageratm conyzoides* (4.92%), *Ocimum* spp. (3.3%) and minor pollen types were *Mucuna puriens* (0.3%), *Sabia leptaudra* (2.3%), *Porana racemosa* (1.32%), *Camellia* spp. (0.33%) *Aristolochia* spp. (0.33%), *Strobilanthus thomsonii* (0.33%), Poaceac (2%) and unidentified 0.64%. (Fig. 3.3.6.2, table 3.3.2A).

The sample LINH (May'96) showed *Buddleja asiatica* (51.09) as predominant Pollen type, *Raphanus sativus* (39.74%) as secondary pollen type, *Tropaeolum majus* (4.73%) as important minor pollen type. Other minor Pollen types found were *Prunus* spp. (0.32%), *Cestrum spp.* (0.3%), *Rosa spp.* (2.2%), *Citrus* spp. (1.6%), and Unidentified (0.02%). (Fig. 3.3.6.3, table 3.3.2A).

The sample SAMH (Jan'97) showed *Rosa* spp. (78.5%) as predominant Pollen type, *Ageratum conyzoides.* (7.8%) as important mirror Pollen type. The minor Pollen types were found as *Asystasia* *macrocarpa* (2.0%), *Brassica Spp.* (2.45%), *Cleome* spp. (2.4%), *Lindenbergia indica* (2.4%), *Desmodium Sp.* (!%), *Coriandrum Sp* (!%), *Moringa Sp.* (1.0%), *Allium Spp.* (0.8%). (Fig. 3.3.6.4, table 3.3.2A).

The sample JH (Apr'96) showed *Ageratum conyzoides* (50%) as predominant pollen type. The secondary Pollen type was found absent. The important minor Pollen types found were *Potenilla* spp. (11.1%), *Rosa* spp. (11.1%), *Tithonia diersifolia* (11.1%), *Oxalis* spp. (11.1%), *Bidens pilosa* (5.5%) and minor Pollen type were *Allium Spp.* (1%), *Sterculia Sp.* (1%), *Justicia adhatoda* (1.1%), *Thevetia* sp. (1%), *Mangifera indica* (1.1%), *Caesalipinea* sp. (0.9%) and unidentified as 0.1% (Fig. 3.3.6.5, table 3.3.2A).

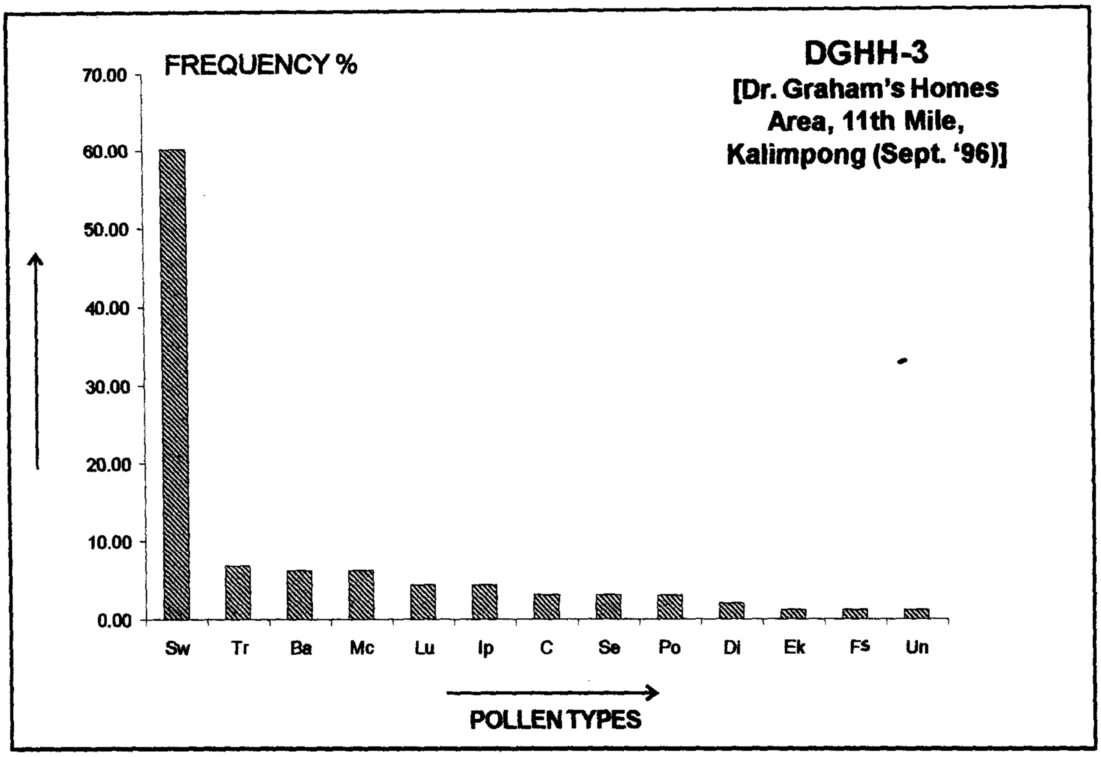
The sample KHAMH (July'97) showed *Michelia doltsopa* (85.36%) as predominant Pollen type. The secondary pollen type found absent. The important minor Pollen type was found *Schima wallichii* (8.13%). The minor Pollen type were found as *Clematis montana* (03%), *Magnolia campbellia* (2.43%), *Sterpotosolen* jasmesonii (0.8%) *Polygonum ampexicaule* (0.8%), *Jakaranda* sp. (0.4%). (Fig. 3.3.6.6, table 3.3.2A).

The sample RABH (July'97) showed *Brassica* spp. (58.29%) as predominant Pollen type, *Ibers amara* (17.84%) as secondary Pollen type. The Important minor Pollen type were found as *Porana grandiflora* (6.72%), *Rosa Spp.* (6.72%0. The minor pollen types were found as *Tropaeolum majus* (2.69%), *Erigeron karwinskianus* (2.69%), *Datura Spp,* (1.34%), *Clarkia pulchella* (0.89%), *Galinsoga parviflora* (0.44%), *Calendula officnalis* (0.44%), *Centaurea* (0.44%) and unidentified 0.5%. (Fig. 3.3.6.7, table 3.3.2A).

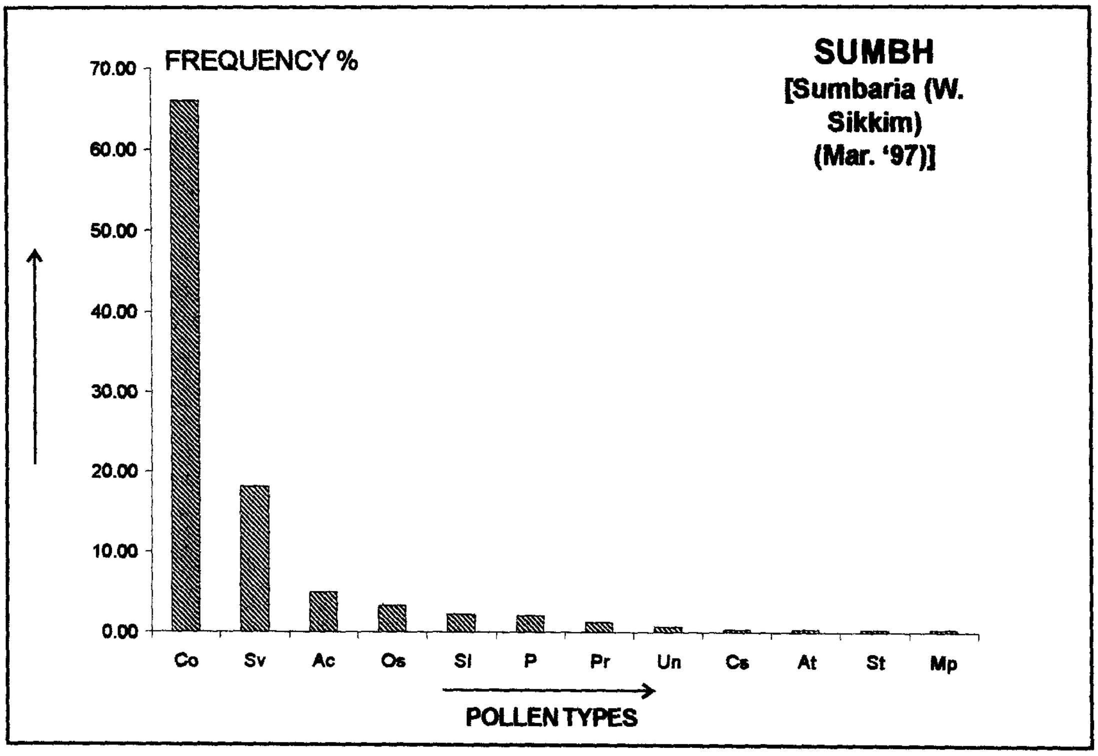
The sample KH (May'96) showed Rubus spp. (52.15%) as predominant Pollen type. The secondary Pollen type was found absent. Important minor Pollen types were *Schima wallichii* (10.27%), *Bellis perennis* (10.0%), *Rosa* spp. (6.9 4%), *Prunus* spp. (5.01%), *Calendula* *officinalis* (4.62%). The minor Pollen types were *Cestrum Spp.* (1%), *Frageria* spp. (1.85%), *Clematis* spp. (1.38%), *Jasminum* spp. (1.38%), *Centaurea* sp. (0.46%), *Trifolium repens* (0.41 %), Poaceese (1.77%) and unidentified (0.26%) (Fig. 3.3.6.8, table 3.3.2A).

Sample SANGH-2 (Aug'96) showed *Schima wallichii* (51.63%) as the predominant Pollen type. The important minor Pollen types were found as *Gynocardia odorata* 10.45%), *Centanurea* sp. (6.2%), *Desmodium* sp. (4.2%), *Cestrum Spp.* (5.55%), *Bidens pilosa* (5.88%). The minor Pollen types were found as *Primula* spp. (2.61%), *Craniotome vesicolor* (6.2%), *Canna edulis* (1.5%), *Aconogonum molle* (1.63%), *Pimpinella diversifolia* (1.3%), *Oenanha thomsonii* (1.5%), *Selinum tenuifolium* (0.98%), *Centaurea* sp. (0.98%), *Rosa Spp.* (0.65%), *Prunus* spp. (0.33%), *Buddleja asiatica* (0.32&), *Asystasia macrocarpa* (0.312%), *Lindenbergia indica* (0.32%) and *Lysimachia japonica* (0.32%), Poaceae ((0.3%), *Berberis* spp. (0.98%) and unidentified (0.88%). (Fig. 3.3.6.9, table 3.3.2A).

Sample DZH (June'96) showed *Citrus* spp. As predominant Pollen type (54.22%). The important minor Pollen type were founds as *Fragaria* spp. (7.69%), *Pyrus japonica.* (7.69%), *Strobililanthus* spp. (4.69%) *Gynocardia odorata* (3.00%), *Spirea* spp. (3.84%), *Prunus* spp. (3.84%), *Rosa Spp.* (3.84%), *Asystasia macrocarpa* (3.8%), the minor pollen type were *Streptosolen Sp.* (2.5%), *Berberis* spp. (2.6%), *Acanthus carduaceous* (1.0%) and unidentified 1.3%. (Fig. 3.3.6.10, table 3.3.2A).



[Fig. : 3.3.6.1]

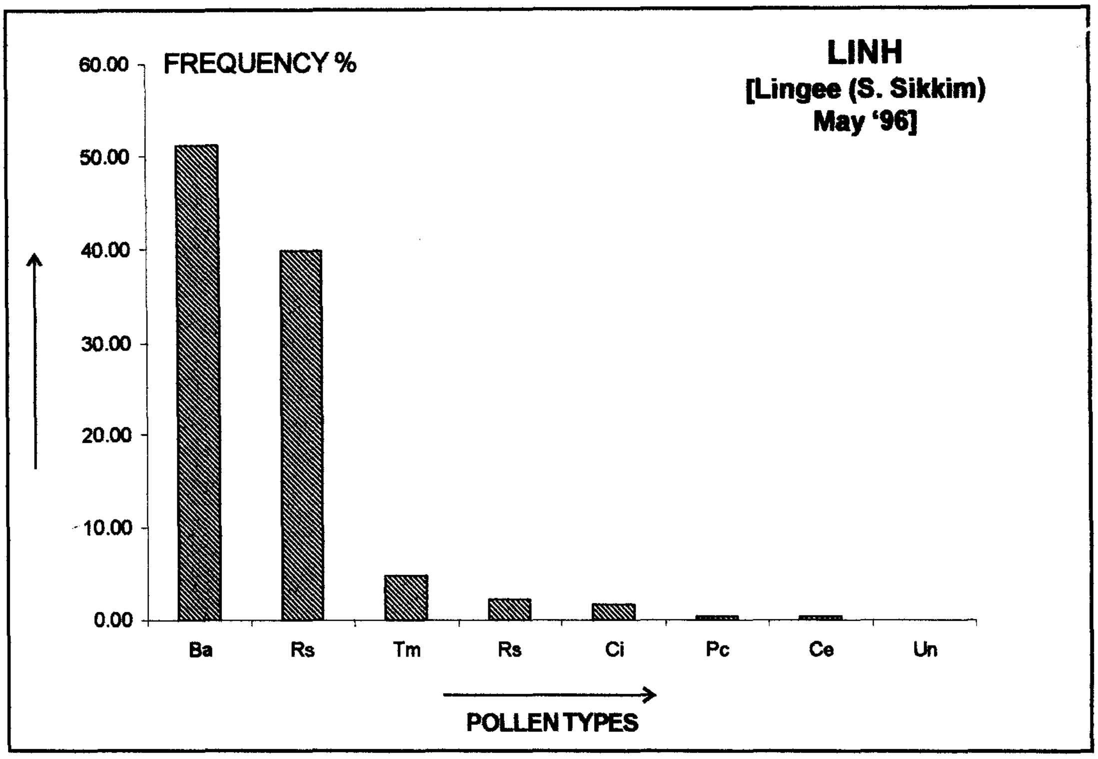


[Fig. : 3.3.6.2]

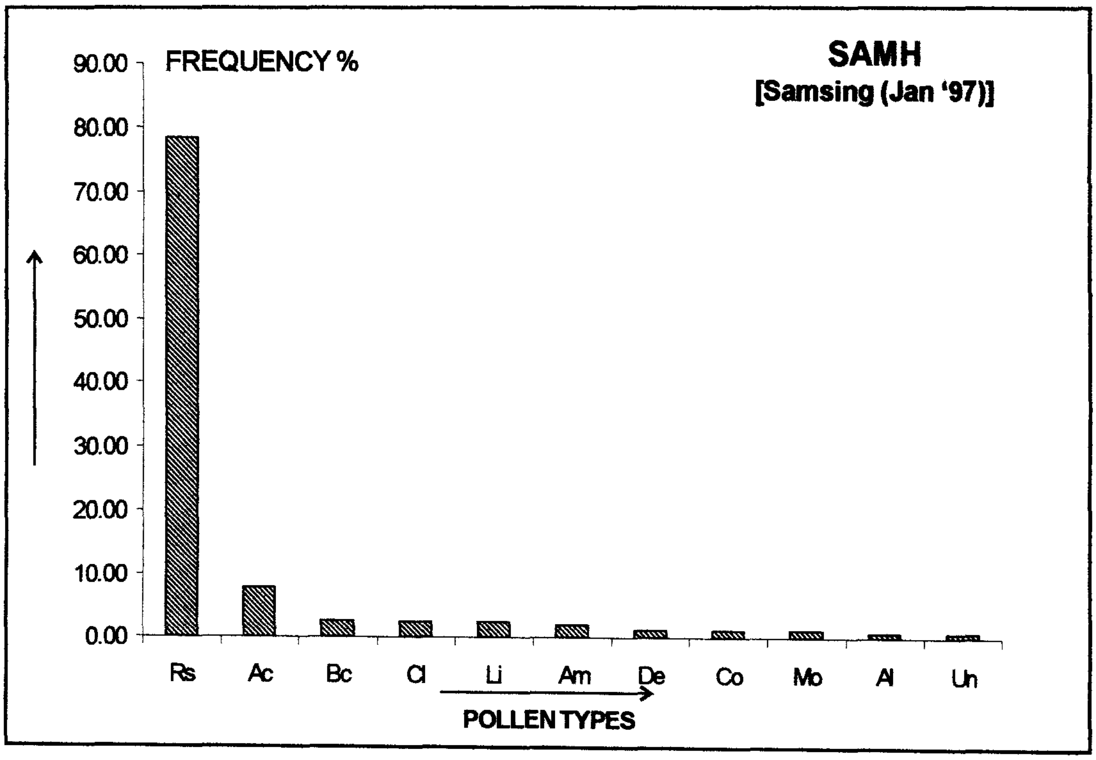
[Abbreviations used :-

Sw = *Schima wallichii*
Pg = *Primula glabra*
Ek = *Erigeron karuinskianus*
Tr = *Trifolium repens*
Ba = *Buddleja asiatica*
Mc = *Magnolia spp.*
C = *Centaurea spp.*
Se = *Sechium edule.*
Fs = *Fragaria spp.*
Po = Poaceae
Lu = *Luffa* spp.
Ip = *Ipomoea* spp.

Di = *Dichroa febrifuga*
Co = *Calendula officinalis*
Su = *Solidago virga-aurea*
Ac = *Ageratum conyzoides*
Os = *Ocimum* spp.
Mp = *Mucuna pruriens*
Sl = *Sabia leptandra*
Pr = *Porana racemosa*
Cs = *Camellia* spp.
At = *Aristolochia* spp.
St = *Strobilanthus thosmsonii*
U = Unidentified.]



[Fig. : 3.3.6.3]

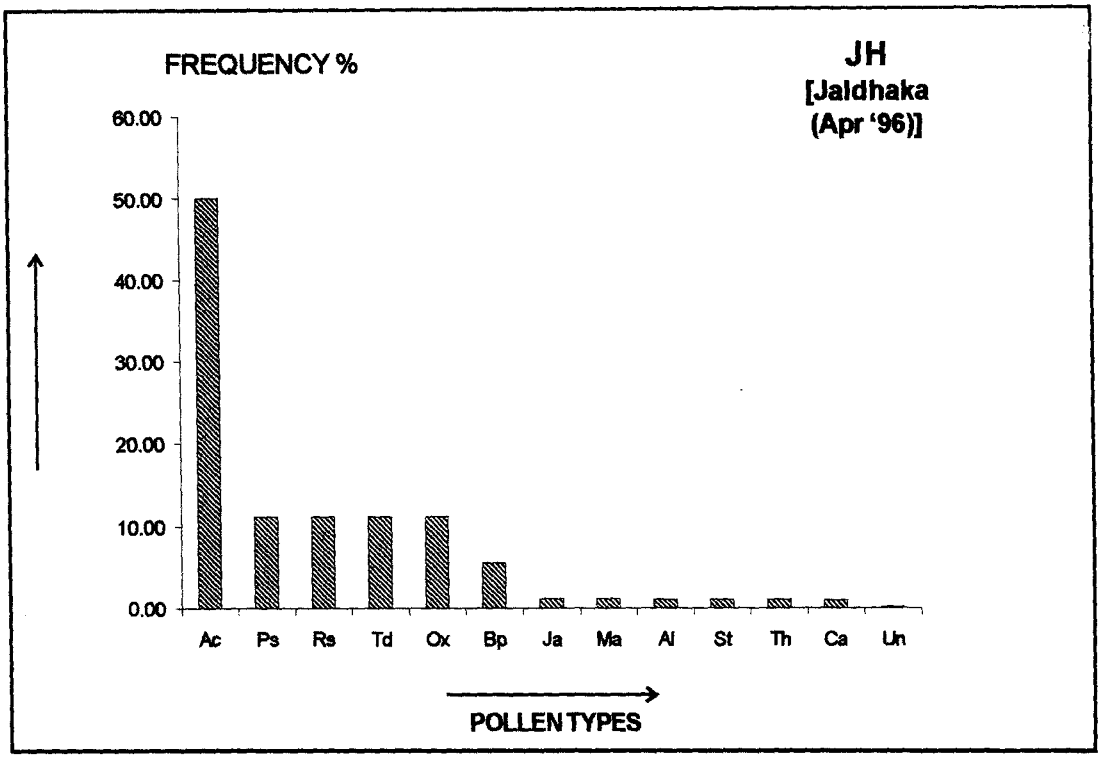


[Fig. : 3.3.6.4]

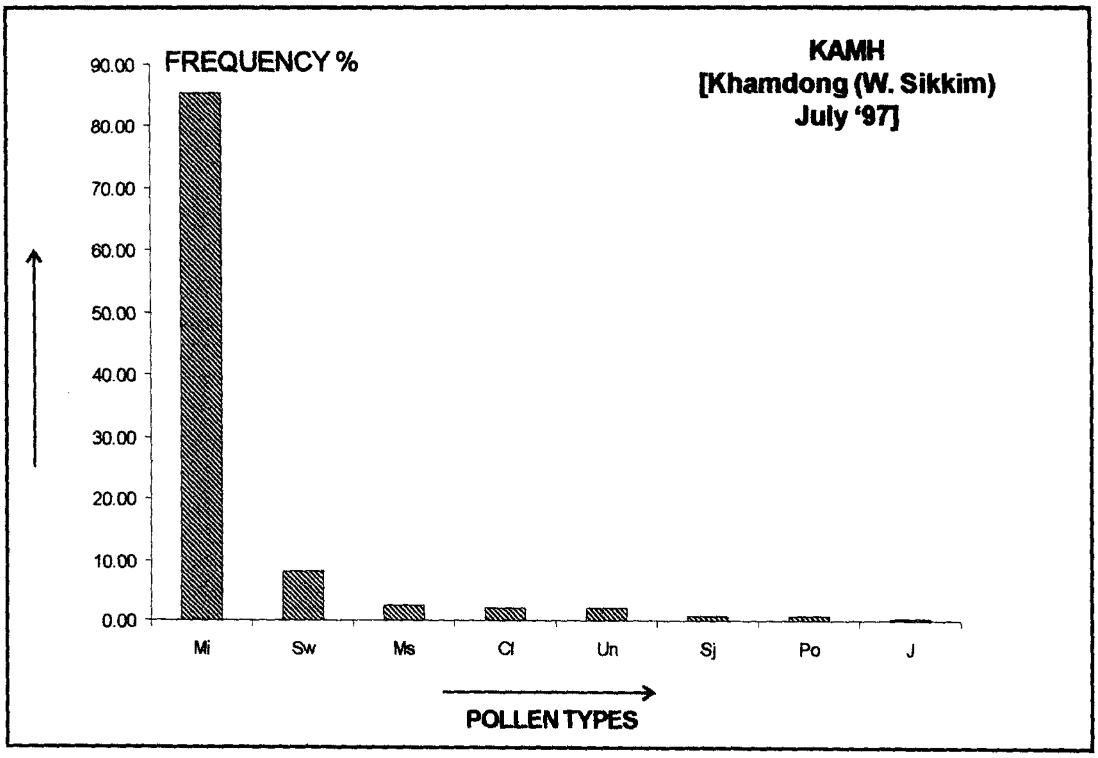
[Abbreviations used :-

Ba = *Buddleja asiatica*
Rs = *Raphanus sativus*
Tm = *Tropeolum majus*
Pc = *Prunus cerasoides.*
Ce = *Cestrum spp.*
Rs = *Rosa* spp
Ci = *Citrus* spp.
Un = Unidentified
Ac = *Ageratum conyzoides*

Am = *Asystasia macrocarpa*
Bc = *Brassica* spp
Cl = *Cleome* spp.
Li = *Lindenbergia indica*
De = Desmodium Sp.
Co = *Coriandrum* spp.
Al = Allium spp.
Mo = *Moringa oleifera*]



[Fig. : 3.3.6.5]

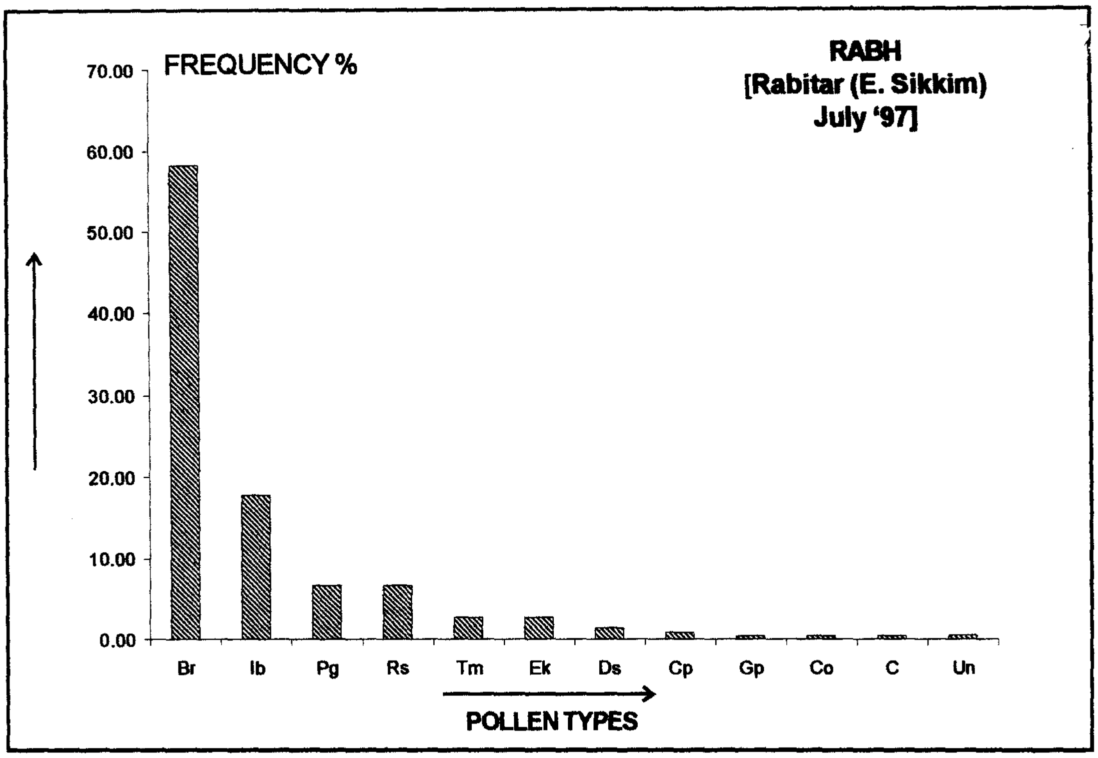


[Fig. : 3.3.6.6]

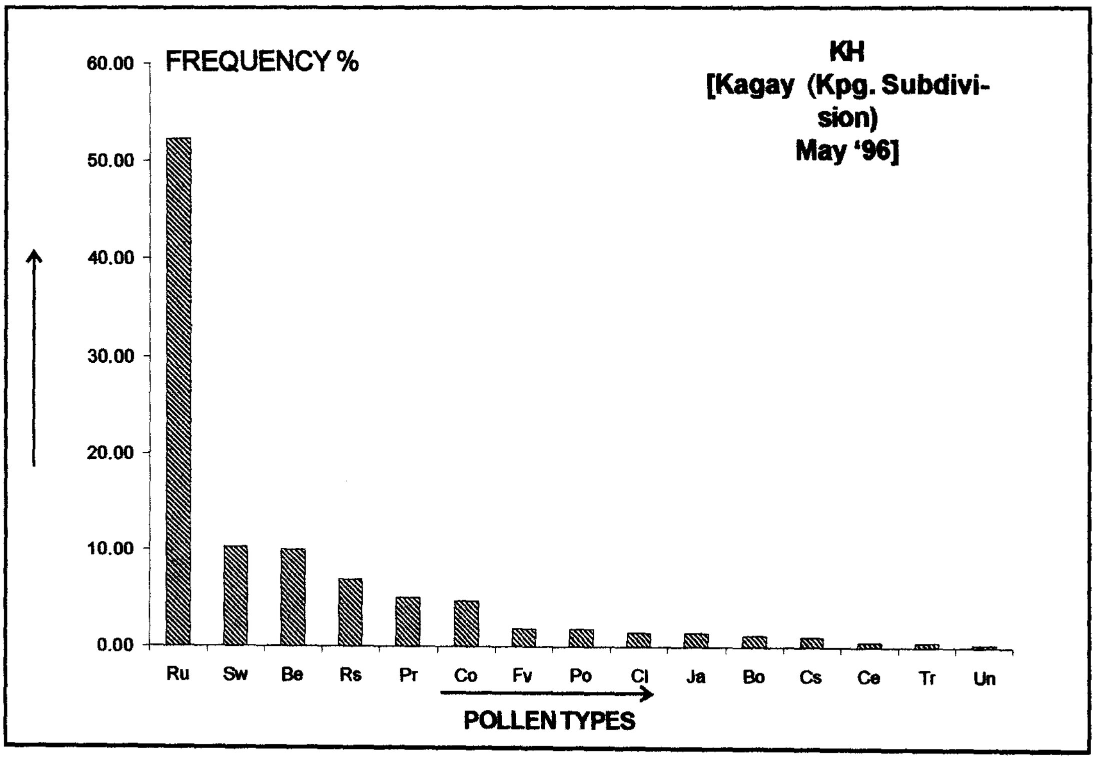
[Abbreviations used :-

Ac = *Ageratum conyzoides*
Ps = *Potentilla* spp.
Rs = *Rosa* spp.
Td = *Tithonia diversifolia*
Ox = *Oxalis* spp.
Bp = *Bidens pilosa.*
Al = *Allium* spp.
St = *Sterculia* spp.
Ja = *Justicia adhatoda*
Th = *Thevetia* spp.
Ma = *Magnifera indica*
Ca = *Caesalpinea* ssp.

Mi = *Michelia* spp.
Cl = *Clematis* spp.
Ms = *Magnolia* spp.
Sj = *Streptosolen jamesonii*
Po = *Polygonum amplexicaule*
J = *Jakaranda* sp.
Sw = *Schima Wallichii*
Un = Unidentified]



[Fig. : 3.3.6.7]

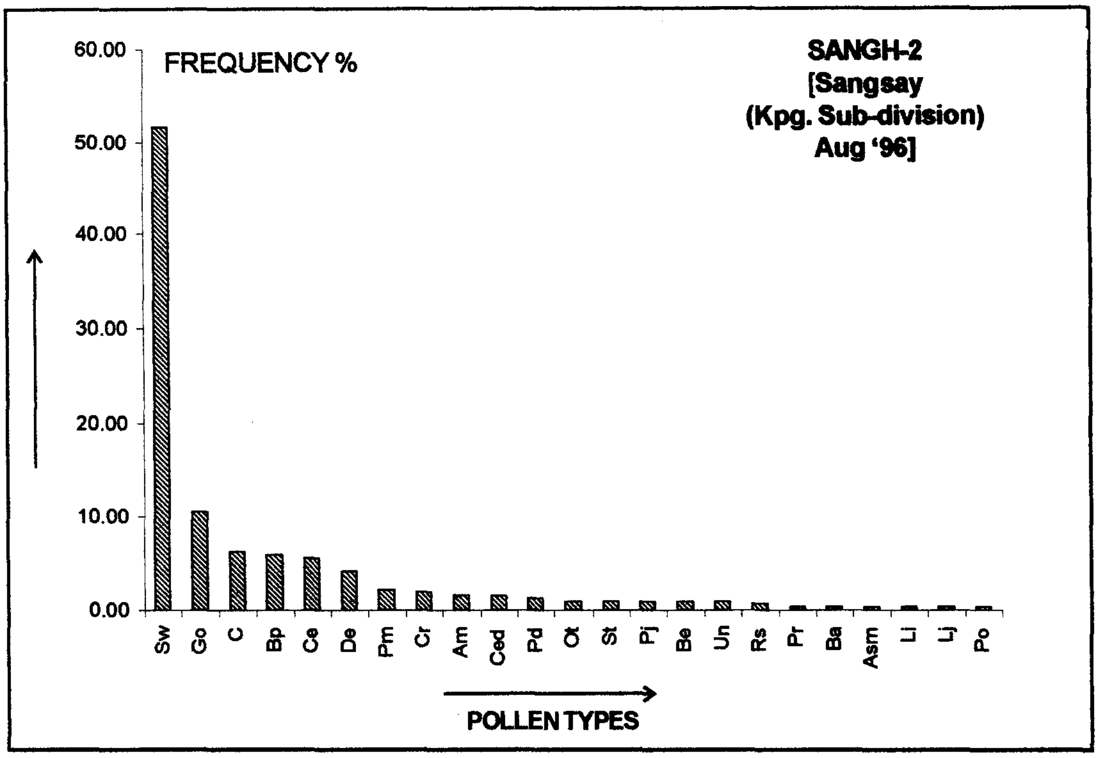


[Fig. : 3.3.6.8]

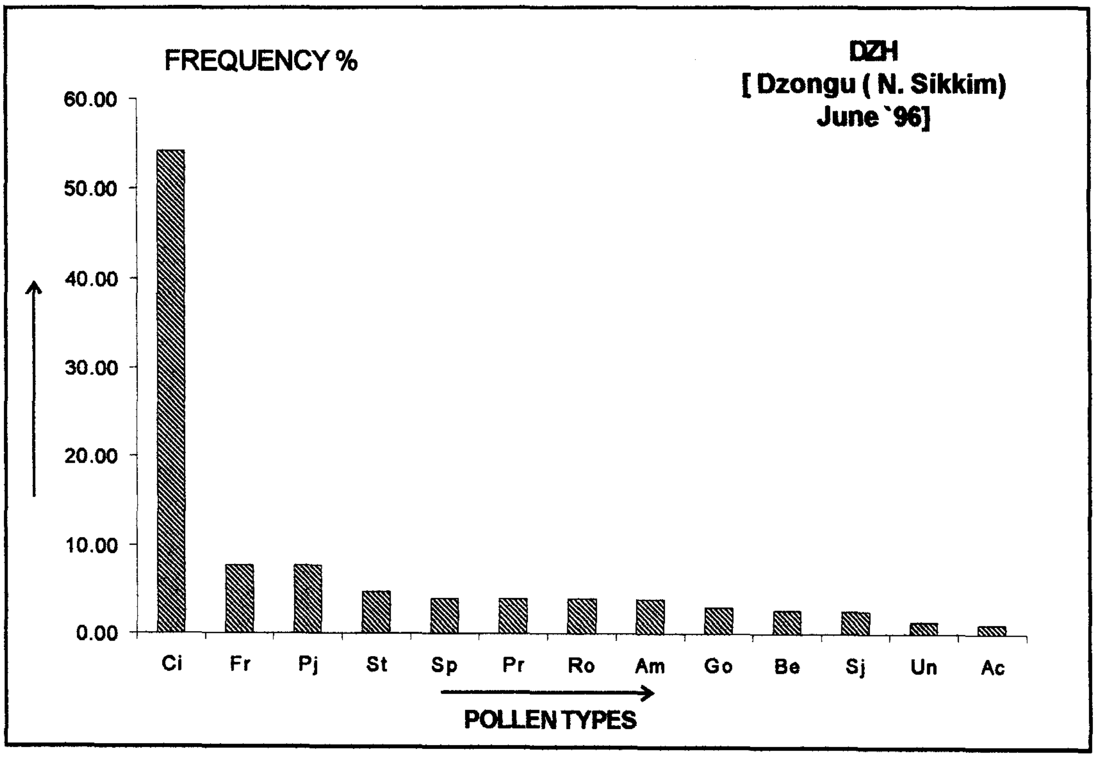
[Abbreviations used :-

Br = *Brassica* spp.
Ib = *Iberis amara*
Pg = *Porana grandiflora*
Rs = *Rosa* spp.
Tm = *Tropeolum majus*
Ek = *Erigeron karwinskianus*
Ds = *Datura* spp.
Cp = *Clarkia pulchella*
Gp = *Galinsoga parviflora.*
Co = *Calendula officinalis.*
Ru = *Rubus* spp.
Be = *Bellis perennis*

Pr = *Prunus* spp.
Co = *Calendula officinalis*
Cs = *Centaurea* spp.
Cl = *Clemetis* spp.
Ja = *Jasminum* spp.
Tr = *Trifolium repens*
Ce = *Cestrum* spp.
Po = Poaceae.
Un = Unidentified.
Sw = *Schima wallichii*
Bo = *Bombax malabaricum*]



[Fig. : 3.3.6.9]



[Fig. : 3.3.6.10]

[Abbreviations used :-

Sw = *Schima wallichii*
Go = *Gynocardia odorata*
Cr = *Craniotome* spp.
C = *Centaurea* spp.
Ce = *Cestrum* spp.
Bp = *Bidens pilosa.*
Pm = *Primula* spp.
Ced = *Canna edulis*
Am = *Aconogonum molle*
Pd = *Pimpinella diversifolia.*
Ot = *Oenanthe thomsonii*
St = *Selinum tenuifolium.*
Rs = *Rosa* spp.
Pr = *Prunus* spp.

Ba = *Buddleja asiatica*
Asm = *Asystasia macrocarpa*
Li = *Lindenbergia* spp.
Lj = *Lysimachia japonica*
Pj = *Pyrus japonica*
Po = Poaceae
Un = Undentified
Be = *Berberis* spp.
Sj = *Streptosolen jamesonii*
Ac = *Acanthus carduaceous*
Fr = *Fragaria* spp.
Sp = *Spirea* spp.
Ci = *Citrus* spp.]

3.3.7 NECTAR CALENDAR OF MAJOR & MINOR BEE-FORAGE PLANTS IN PRESENTLY INVESTIGATED AREA

The nectar calendar of bee-forage plants depends on their flowering seasons in the year. According to Das & Chanda (1987) and Bhujel (1996), there are 4 flowering seasons in this area. The number of dicotyledonous flowering plants in different seasons are as follows –

FLOWERING SEASONS - - - -	DICOTS (app.)
1) December – March (Dry cold winter)- - -	224
2) March – May (Dry hot season) - - -	886
3) June – September (Monsoon) - - -	1305
4) Oct – Dec. (Autumn and beginning of winter)- (species avoiding heavy rain for flowering)	493

In this pattern of observation the maximum of flowering concentration has been observed in monsoon (June-Sept.) while least is recorded in dry and chilled winter (Dec – March). There are a good number of plants flowering in summer (with frequent or irregular rain). A large number of plants especially herbs remain in flowering conditions for more than one season while some of them flower throughout the year. The flowering of such plants have been accounted in all seasons (inclusive).

Nectar calendar of Darjeeling and Sikkim Himalayas highlights month-wise chief and alternate sources of nectar for honey bees as well as the honey flow and crisis periods. While some honey may be seen in the brood chambers, the supers of bee colonies seldom show any surplus honey stored all through the dearth period.

In the present investigation, the nectar calendar has been prepared consideraring 3 honey flow periods throughout the year. Honey flow period-1 (HFP-1) refers to (winter honeys) belong to the months from November to

February. Honey yield is minimum during this period for to least number of nectar sources and also for excessive coldness particularly in the month of January & February. Honey flow period-II (HFP-II) is the summer or spring honeys belong to the months from March to June. Honey yield is maximum during this period due to availability of sufficiently good number of flowering plants as the nectar sources for the honey bees. Honey flow period – III (HFP-III) is the monsson/autumn honeys belong to the months from July to October. Honey yield is low to moderate. Although maximum number of flowering concentration is observed but heavy rain particularly during the months of July and

August greatly affects the foraging activities of the honey bees/ But honey yield improves sufficiently in the months of September, October and November i.e. during autumn or beginning of winter.

In the nectar calendar (Fig. 3.3.7.1) all such taxa constituting predominant pollen types in the unifloral honeys were considered as chief sources of nectar and those represented by at least 10 % of the pollen spectra of each honey sample as alternate sources of nectar.

The chief nectar sources during the honey flow period – 1 (i.e. Nov. – Feb.) were found as *Prunus* spp., *Rubus* spp., *Aristolochia* sp., *Buddleja asiatica*, *Brassica* spp., and *Calendula officinalis.*

The alternate nectar sources diring the same period were *Datura* sp., *Tithonia* sp., *Cestrum* sp., *Eupatorium* sp., *Solidago* sp., *Aconogonum* sp., *Strobilanths* sp., *Raphanus* sp., *Euphorbia* sp., *Strptosolen* sp., *Trifolium* sp., etc.

The chief nectar sources during the honey flow period – II (i.e. Mar – June) were enumerated as *Michelia* spp., *Magnolia* sp., *Buddleja asiatica, Brassica* spp., *Calendula officinalis, Fragaria* spp., *Schima wallichii*, *Rosa* spp., *Citrus* spp., *Ageratum conyzoides, Potentilla* sp., *Primula* sp. and *Trifolium* spp.

The alternate nectar sources were *Camellia* spp., *Bidens pilosa, Cardamine* spp., *Asystasia* sp., *Streptosolen jamesonii*, *Erigeron* *karwinskianus, Syzygium* spp., *Centaurea* spp., *Nemophilla* sp., *Embelia* sp., *Phaseolus* sp., Poaceae, *Sambucus* sp., *Ammomum subulatum, Tropaeolum* sp., *Plectranthus* spp., *Datura* spp., etc.

The chief nectar sources during the honey flow period – III (i.e. July – Oct.) were *Potentilla* spp., *Rosa* spp., *Sedum multicaule, Prunus* spp., *Schima wallichii, Ageratum conyzoides, Michelia* sp. and *Trifolium* spp.

The alternate nectar sources were *Citrus* spp., *Ammomum subulatum, Datura* spp., *Sambucus* spp., *Cestrum* spp., *Streptosolen jasmesonii, Erigeron karwinskianus, Clematis* spp., *Tropaeolum majus, Passiflora* spp., *Sechium edule, Symplocos* spp., *Nicotiana* sp., *Primula* sp., *Solanum* sp., *Chrysanthemum* sp., *Spirea* sp., *Eupatorium* sp., *Cyphomandra beateaceae, Aristolochia* spp. etc.

The months from July to October constituting essentially the monsoon period not only furnishes inadequate and poor sources of nectar but also not conducive to promoting uninterrupted foraging activity of the bees and it represents the dearth period.

NECTAR CALENDAR FOR HONEY BEES

▨ Chief Nectar Source (> 45%)

☐ Alternate Nectar Source (10 - 45%)

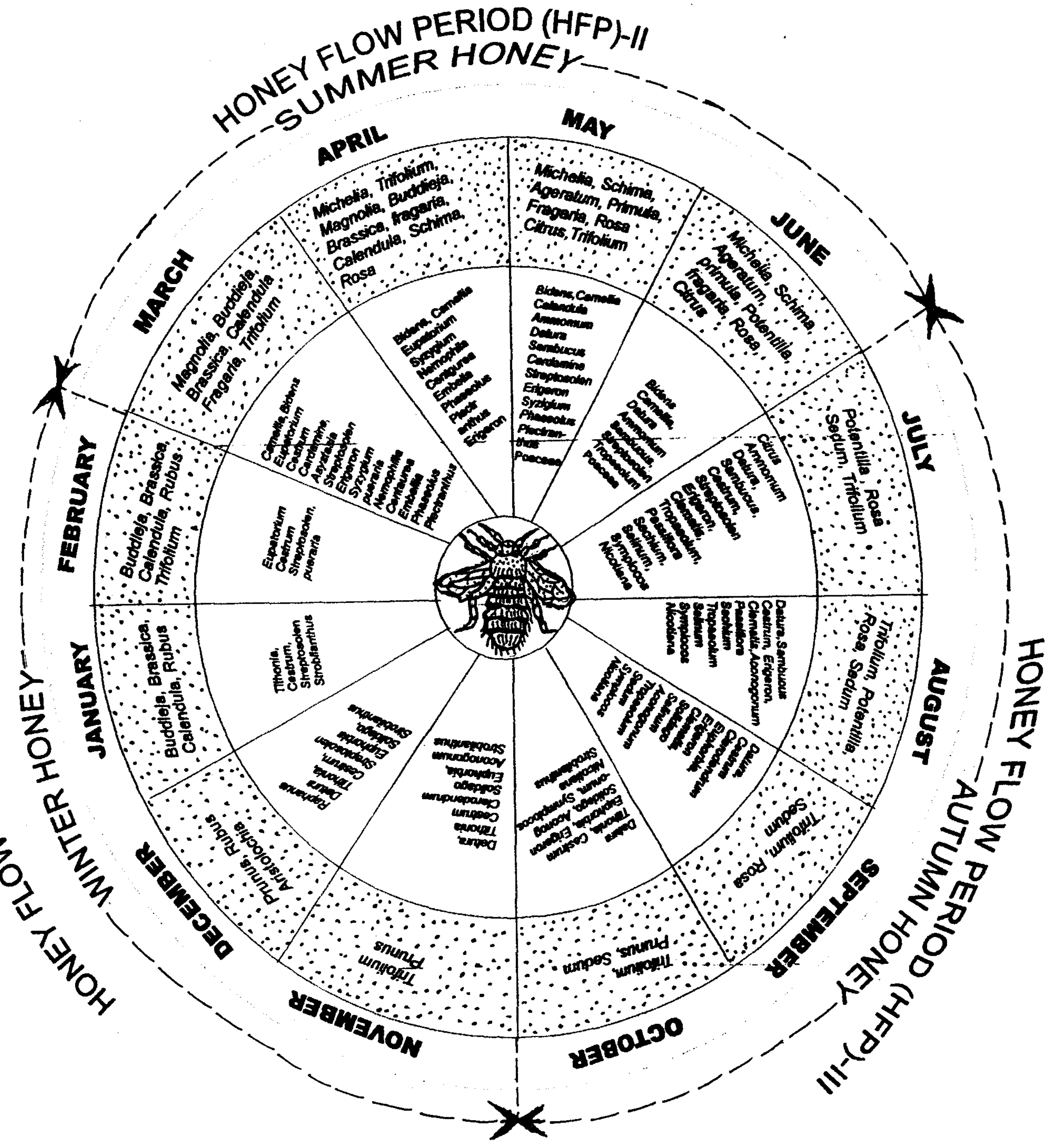


Fig : 3.3.7.1

3.4 PHYSICO-CHEMICAL ANALYSES OF SOME HONEY SAMPLES

A. *Apis cerana indica* F.

Physico-chemical analyses of twenty five honey samples *Apis cerana indica* F. had been made taking 2 samples each from Chalsa (CH) and Mitiali (MH) of the foot hills region (upto 300m Altitude), 4 samples from the high hills region (altitude 600m and above) *viz.* Dzongu (DZH) , Lava (LH), Rimbick (RIMH-1 & 2) and the rest 19 samples from the midhills region (alt. 300 – 1600m).

A different degree of pigmentation had been observed in all the present honey samples . It ranged from creamish white (eg. PH – 1, SANG-2) to dark amber (eg. FH, DGHH – 3) in colour (Table 3.4.1).

According to Paine *et al.,* (1934) amino acids present in honey play an important role in the formation of colour of honeys. Melanoins, the dark brown compounds formed due to reaction of amino acids and sugars in honey are responsible for darkening of honey.

The total amino acids present in the honey samples ranged from 3.5 mg/gm (DGHH – 1) to 14.0 mg /gm (RIMH-2, Rimbick) . Table 3.4.1. The data Dr. Graham's Homes area data is correlable with the view of Paine *et al.,* (1934) although a few exceptions were also observed. Payong honey (PH – 1) having creamish white in colour showed high amino acid content (10.5 mg / gm). Similarly Lava honey (LH – 1) with its light colour showed high amino acid content (13.5 mg / gm) in comparison to other samples.

The ash content in the honey samples varied from 0.115 % (SANGH – 2, Sangsay) to 0.483 % (DGHH – 3, Dr. Graham's Homes area, Kalimpong) (Table 3.4.1).

The results also showed a close relationship with the colour intensity of the honey samples. The sample SANGH-2 with creamish white in colour showed the lowest ash content and the sample DGHH-3 with dark amber colour showed the highest ash content. All the intermediate results of ash content showed a correlation with the colour intensity of the samples with two exceptions only. Suruk honey (SURH) and Mitiali honey (MH) with their yellow colours showed high ash percentage values 0.420 and 0.413 respectively.

Schuett and Remy in 1932 studied a close relationship between the mineral content and the colour intensity of honey. The above results of the ash content also corroborate with the observations of the previous workers. But in Dzongu sample (DZH) some exceptions had been observed. This sample with its amber colour did not match properly with its minimum ash content (0.217%) although matches properly with its high amino acid content (13.5mg/gm) (Paine *et al.,* 1934).

The moisture content in all the honey samples varied from 17.5 % (eg. DUDH, MONGH, MONSH-1) to 30.0 % (eg. SANGH – 2, DAMH – 1). (Table 3.4.1). Honeys having moisture content more than 22 % (Agmark specification, 1959) can be considered as unripe and are liable to ferment. The results indicate that a number of honey samples (eg. DAMH –1, DGHH-1, 3, RIMH –1 etc.) fall above this Agmark specification which may be due to high relative humidity and low temperature values of the climatic conditions of the hilly regions (Weather table 1.6.7 & 1.6.10) at the time of collection of the honey samples.

In all the honey samples the specific gravity was found more than the minimum value of 1.4 prescribed by the Agmark specification with one exception of Damthang honey (DAMH – 1) . The sample showed the value of specific gravity 1.390 which may be due to its higher wax content believed to be mixed at the time of extraction of the honey. (Table 3.4.1).

The pH values of the honey samples ranged from 4.09 (Khamdong honey, KHAMH) to 7.71 (Damthang honey, DAMH – 1) . All the honey samples showed acidic nature in their pH value except the latter (Damthang honey) which showed basic nature (> 7) due to its high wax content. This pH value correlates with its low specific gravity (1.390) also (Table 3.4.1).

The total sugar content in all the honeys showed a wide range of variation from 102 mg / gm (Sangsay honey) to 762.5 mg / gm (Seed farm honey, Kalimpong) . These are within the prescribed range of 'Agmark' specification for special and Grade A honeys although a few exceptions have been observed eg. KHAMH (130 mg / g,), SANGH – 2 (102 mg / gm) etc. (Table 3.4.1).

The protein content in these honey samples also showed a wide range of variation from lowest 12.9 mg / gm in SANGH – 2 to highest 102.5 mg / gm in DAMH – 2 in sample. (Table 3.4.1).

A high protein content in honey is a probable cause of its thixotropic property (Pryce-Jones, 1936). But this does not tally always with the above results . The Monsong honey (MONSH –1) with its low protein content (26.05 mg / gm) showed thixotropic property, on the contrary Damthang honey (DAMH – 2) with its high protein content (102.5 mg / gm) showed no thixotropic property. The probable reason for the ethixotropic property of honey might be due to high dextrin and non-reducing sugar content in it. (Phadke, 1962). (Table 3.4.1).

The phenol content in the honey smples ranged from 0.69 mg / gm in Rimbick honey (RIMH – 2) to 2.8 mg / gm in Damthang honey (DAMH – 1) . In the latter higher amount of phenol might be contributed from the pollen grains of *Schima wallichii,* (Theaceae; De and Bera 1995). This is also common with Seed Farm, Kalimpong (SFH – 1) honey which contains 2.51 mg / gm of phenol. The frequency of pollens of *Schima wallichii* in the above two samples DAMH – 1 and SFH –1 ranged from 12.0 % and 11.96 % respectively. (Table 3.4.1).

The undetermined factors in the honey samples ranged from 0.09 5 in Seed Farm honey (SFH – 2) to 3.00 % in Damthang honey (DAMH – 1).

The medicinal property and food value of honey are significantly subject to the presence of these undetermined factors in honey (Phadke. 1962).

Table 3.4.1; **PHYSICO-CHEMICAL COMPOSITION OF SOME HONEY SAMPLES**

A. *Apis cerana indica* F.

Honey Sample Code	Area of Collection	Altitude (m)	Time of Collection	Average Temp. of the Place (°C)	Average Relative Humidity of the Place (%)	Moisture Content of Honey (%)	Specific Gravity	Ash (%)	pH
CH	Chalsa, Jalpaiguri dist.	200	May '96	14.25	81.50	19.5	1.42	0.312	4.12
DAMH-1	Damthang, Sikkim	1500	Mar'96	12.60	80.7	30.0	1.39	0.313	7.71
DAMH-2	Do	1500	May'97	20.7	92.5	22.5	1.43	0.421	4.93
DGHH-1	Dr. Graham's Homes	1220	June'96	20.0	84.9	25.0	1.42	0.310	4.55
DGHH-3	Do	1220	Sep'96	24.0	90.0	25.0	1.41	0.483	4.39
DUDH	Dudhia Tea estate, Kurseong	1405	Apr'98	18.2	92.5	17.5	1.43	0.358	4.56
DZH	Dzongu, Sikkim	2300	June'96	NA	NA	20.0	1.41	0.217	4.59
FH	5th Mile, Kalimpong	1160	June'96	23.8	85.5	17.5	1.42	0.421	4.91
GANH	Gangtok, Sikkim	1547	Mar'97	13.0	77.5	20.0	1.42	0.440	5.20
KHAMH	Khamdong Sikkim	720	Jul'97	19.2	92.5	30.0	1.43	0.375	4.09
LH-1	Lava, Kalimpong	2050	May'96	10.5	80.0	22.4	1.41	0.131	4.71

Contd….

Honey Sample Code	Area of Collection	Altitude (m)	Time of Collection	Average Temp. of the Place (°C)	Average Relative Humidity of the Place (%)	Moisture Content of Honey (%)	Specific Gravity	Ash (%)	pH
MH	Mitiali, Jalpaiguri	275	June'96	-	-	24.0	1.49	0.413	5.13
MONGH	Mongpu	1300	Dec'95	9.8	86.5	17.5	1.41	0.221	6.25
MONSH-1	Monsong	1280	Mar'96	13.6	80.2	17.5	1.42	0.205	4.19
PH-1	Payong, Sikkim	1445	June'96	18.5	93.5	22.4	1.41	0.121	5.09
PEDH-1	Pedong. Kalimpong	1000	June'96	20.2	87.4	25.0	1.42	0.312	4.35
RIMH-1	Rimbick, Darjeeling	2400	Aug'96	NA	NA	25.0	1.44	0.272	5.76
RIMH-2	Do	2400	Oct'97	NA	NA	20.0	1.42	0.392	4.62
SBH	Solak Kalimpong	480	Apr'97	21.4	57.6	24.5	1.43	0.310	5.02
SANGH-1	Sangsay, Kalimpong	1192	Jul'96	24.0	90.15	22.5	1.42	0.202	4.43
SANGH-2	Do	1192	Sep'96	23.2	89.26	30.0	1.41	0.115	4.16
SANGH-3	Do	1192	Jun'97	23.8	85.2	20.0	1.43	0.254	4.20
SFH-1	Seed farm, Kalimpong	1160	Apr'96	21.5	71.5	22.5	1.42	0.382	4.36
SFH-2	Do	1160	Jan'97	13.0	61.5	20.0	1.43	0.211	6.42
SURH	Suruk, Kalimpong	490	Nov'96	20.8	82.42	20.0	1.42	0.420	4.58

NA; Not Available

Table 3.4.1; **PHYSICO-CHEMICAL COMPOSITION OF SOME HONEY SAMPLES**

A. *Apis cerana indica* F.

Honey Sample Code	Area of Collection	Sugar (mg /gm)	Protein (mg /gm)	Amino acid (mg /gm)	Phenol (mg /gm)	Colour	Undetermined factors (%)	Absolute pollen content (APC)	Group	Nature of honey
CH	Chalsa, Jalpaiguri dist.	602.5	63.5	8.75	1.6	Pale yellow	0.93	27369	GII	M
DAMH-1	Damthang Sikkim	500.0	23.5	8.0	2.8	do	3.00	40200	GII	M
DAMH-2	Do	550.0	102.5	4.5	1.6	Do	0.65	50700	GII	U
DGHH-1	Dr. Graham's Homes	402.5	29.0	3.5	0.8	Do	0.30	188	GI	M
DGHH-3	Do	362.5	53.5	8.4	1.68	Dark amber	1.20	1052	GI	U
DUDH	Dudhia tea estate, Kurseong	525.0	39.5	4.5	0.81	Light yellow	0.14	38054	GI	M
DZH	Dzongu, Sikkim	372.5	88.5	13.5	1.17	Do	1.30	11765	GI	U
FH	5th Mile, Kalimpong	427.5	79.0	8.8	1.15	Dark amber	0.70	9475	GI	M
GANH	Gangtok, Sikkim	604.0	53.5	8.75	1.2	Amber	1.65	5556	GII	M
KHAMH	Khamdong Sikkim	130.0	25.6	14.0	1.59	Pale yellow	2.02	2550	GI	U
LH-1	Lava, Kalimpong	377.5	86.0	13.5	1.29	Creamish white	0.83	1795	GI	M
MH	Mitiali,	727.5	88.75	8.7	1.9	Yellow	0.99	3059	GI	U

Contd...

Table 3.4.1; **PHYSICO-CHEMICAL COMPOSITION OF SOME HONEY SAMPLES**

A. *Apis cerana indica* F.

Honey Sample Code	Area of Collection	Sugar (mg /gm)	Protein (mg /gm)	Amino acid (mg /gm)	Phenol (mg /gm)	Colour	Undetermined factors (%)	Absolute pollen content (APC)	Group	Nature of honey
MONGH	Mongpu, Monsong	437.0	49.5	9.0	1.0	Light yellow	2.09	926	GI	M
MONSH-1	Payong, Sikkim	300.0	26.05	4.0	2.7	Do	0.20	1022	GI	M
PH-1	Pedong. Kalimpong	525.0	39.0	10.5	0.9	Creamish white	2.40	11351	GI	M
PEDH-1	Rimbick, Darjeeling	350.0	39.25	8.5	1.1	Pale yellow	0.41	4172	GI	M
RIMH-1	Do	337.5	26.0	8.7	0.8	Light yellow	1.30	4938	GI	M
RIMH-2	Solak	422.5	40.0	14.0	0.69	Dark amber	1.20	13158	GII	U
SBH	Busty, Kalimpong	525.0	50.0	7.5	0.88	Yellow	1.86	54000	GI	U
SANGH-1	Sangsay, Kalimpong	552.5	39.5	9.0	0.7	Light yellow	1.38	1548	GI	M
SANGH-2	Do	102.5	12.9	8.5	1.86	Creamish white	0.88	7895	GI	U
SANGH-3	Do	622.5	90.5	4.5	1.7	Light yellow	0.52	26400	GII	M
SFH-1	Seed farm, Kalimpong	762.5	77.5	8.5	2.51	Pale yellow	2.64	350609	GIII	U
SFH-2	Do	607.5	92.0	6.0	1.3	Light yellow	0.09	3382	GI	M
SURH	Suruk, Kalimpong	377.5	72.0	9.2	0.89	yellow	1.8	2386	GI	M

[Nature of honey; M=multifloral,U=unifloral]

GRADATION- GROUP I<20000, GRII 20000 – 100000, GR III 100000 – 500000, GR IV 500000 – 1000000, GR V >1000000 (Louveaux *et al.*, 1978)

B. *Apis florea* F.

Two honey samples both from *Apis florea* F. collected from the mid hills region, one of Pabong busty (Kalimpong Sub-Division, altitude 490 m) and another from Lathpancher (Kurseong Sub-Division, altitude 550 m) were analysed physico-chemically in the similar manner as has been done in case of *A. cerana indica* F. honey.

The amber colour of Lathpancher honey (LPH) rightly matched with the high amino acid content (14.2 mg/gm) in it which correlated with Paine's view 1934. The Pabong honey (PABH) with amino acid content 13.6 mg/gm and yellow colour is no exception of the above view (table 3.4.2).

The ash content in the honey samples 0.245 % in LPH and 0.310 % in PABH (table 3.4.2) also shows a correlation with the colour intensity of the honey samples. This result also supported the view of Schutt and Remy (1932).

The moisture content of honey samples 20.6 % in LPH and 21.5 % in PABH (table 3.4.2) showed their ripe nature being below the level of 22 % (Agmark specification, 1959).

The specific gravity of the honey samples 1.410 in LPH and 1.418 in PABH (table 3.4.2) also matched with the Agmark specification being above the minimum value 1.4.

The pH values 3.42 in LPH and 3.73 in PABH (table 3.4.2) indicated high acidic nature of honey samples in comparison with pH values of honey samples of *A. cerana indica* F.

The total sugar content of the honey samples 344.5 mg/gm in LPH and 280.5 mg/gm in PABH (table 3.4.2) also fell within the prescribed range of Agmark specification for Special and Grade A honeys.

The high protein content in honey samples 93.5 mg/gm in LPH and 96.8 mg/gm in PABH (table 3.4.2) did not match rightly the low thixotropic property of the same. This deviated the view of Pryce-Jones (1936).

The phenol content in the two samples 1.12 mg/gm in LPH and 1.53 mg/gm in PABH (table 3.4.2) showed a moderate limit in comparison with the phenol content of honey samples of *A. cerana india* F.

The undetermined factors in honey samples 2.01% in LPH and 2.02 in PABH showed significantly high amount in comparison to those of *A. cerana indica* F. honeys. High medicinal property and food values of this *A. florea* F. honeys are probably due to presence of these high undetermined factors (Phadke, 1962).

Table 3.4.2

B, *Apis florea* F.

Honey sample code	Area of collection	Altitude (m)	Time of collection	Average temp. of the place °C	Average relative humidity (%)	Moisture content of honey (%)	Specific gravity	Ash (%)	PH
LPH	Latpancher, Kurseong Sub-Division	550	April'96	20.5	87	20.6	1.410	0.245	3.42
PABH	Pabong, Kalimpong Sub-division	490	Mar'98	23.2	67.5	21.5	1.418	0.310	3.73

B, *Apis florea* F.

Honey sample code	Area of collection	Sugar (mg /gm)	Protein (mg /gm)	Amino acids (mg /gm)	Phenol (mg /gm)	colour	Undetermined factors %	Absolute pollen count	Group	Nature of honey
LPH	Lathancher, Kurseong Sub-Division	344.5	93.5	14.2	1.12	amber	2.02	25862	GRII	M
PABH	Pabong, Kalimpong Sub-division	280.5	96.8	13.6	1.53	yellow	2.20	463767	GRIII	U

3.5 HEAVY METAL CONTENT IN HONEY SAMPLES FROM THREE DIFFERENT ALTITUDES OF THE STUDY AREA

Representative honey samples from different altitudes were selected for Atomic Absorption Spectrometry to trace the presence of heavy metals in them.

Random use of pesticides at different crop field areas to kill insects, fungal pathogens, weeds etc. has created a serious problem to the bee-keepers now-a –days. Pesticidal poisoning wherever has occurred resulted in large scale destruction of honey bee colonies. According to McGregor (1978) number of honey bee colonies declined from 116000 to 60000 due to insecticidal poisoning in Arizona (U.S.A.).The study of Pimental in 1980 also reveals such data in California and Washington where the number of honey bee colonies killed were 70000 and 33000 respectively due to the extensive use of insecticides. This resulted in an annual loss of $ 135 million due to honeybee poisoning and reduced pollination.

Keeping this above view in mind that honey bees are the environmental pollution indicator three honey samples had been selected for the determination of some heavy metals from three different altitudes at the vicinity of crop fields, tea gardens and research fields where the chances of pesticidal poisoning are more common. These honey samples include:

1) Mitiali honey (MH) from foot hills region (Altitude 275m)
2) Dudhia tea estate honey (DUDH) from the midhills region (altitude 1405m) and
3) Seed Farm honey (SFH-1) nearby the crop research beds at Kalimpong (altitude 1160m).

The heavy metals selected were Cu, Zn, Mn, Cd, and Pb as the probabilities of their presence in the pesticides which are commonly used are greater.

On Atomic Absorption Spectrophotometry of the above three honey samples after proper nitric acid digestion it was found that copper was present in comparatively high amount in Dudhia Tea Estate sample (0.17 mg/100 gm) whereas in other two samples it was found 0.14 mg/ 100 gm in Mitiali honey (MH) and 0.15 mg/ 100 gm in Seed Farm honey sample (SFH-1).

The amount of Zn in DUDH (1.13 mg/ 100 gm) was also found to be higher in comparison to MH (0.54 mg/ 100 gm) and SFH-1 (0.36 mg/ 100 gm).

Similar was the case with Mn also. Its content in DUDH was found to be 0.76 mg/ 100 gm as compared to 0.35 mg/ 100 gm MH and 0.15 mg/ 100 gm in SFH-1 sample. The amount of Cd and Pb were found to be nil (Table 3.5.1).

Table 3.5.1; **Heavy metal content in honeys from three different altitude of the study area**

Honey samples	Heavy metals				
	Copper (Cu) (mg/100 gm)	Zinc (Zn) (mg/100 gm)	Manganese (Mn) (mg/100gm)	Cadmium (Cd) (mg/100gm)	Lead (Pb) (mg/100gm)
MH	0.14	0.54	0.35	Nil	Nil
DUDH	0.17	1.13	0.76	Nil	Nil
SFH-1	0.15	0.36	0.15	Nil	Nil

3.6 ETHNIC USE OF HONEY

Ethnobotanical studies in the region was thoroughly made by Bennet in 1983,1985. From edible point of view, wild plants of the region have been thoroughly studied by Bhujel *et al.,* in 1984. From medicinal point of view, a study has been made by Yonzone *et al.,* (1985), Bhujel (1995) and Rai *et al.,* (1998) on local plants of the area. However, according to the latest survey of the lattter (Rai *et al.,* 1998) Darjeeling and Sikkim Himalayas inhabitated by different ethnic groups (table 3.6.2 & 3.6.3) like Lepcha, Sherpa, Bhutia, Limboo, Rai and Nepali provide a sustainable rich flora on which they particularly the ethnic groups of the far-flung remote villages, are solely dependent on maintaining their economy and science in respect of food, cloth, medicine or articles for religious rights. The Lepcha system of medicine from the ethnic angle is still not organised one and lacks well defined method of preparation and administration in comparison with "Nepali Jaributti System" and "Bhutia System" as they observed. Use of honey as an admixture with the edible parts of the plants (also acting as medicine) or honey itself occupies a special status.

In the present investigation, a little attempt has been made on the use of honey by the ethnic groups of the area as an allied study considering the enormous impact of the former on the latter (ethnic groups) from consumable, ritual and other points of view, which can not be ignored. The overall tribal picture of Darjeeling district in respect of total population has been shown in the table no. 3.6.1 (Roy, 1995) and that of Sikkim has been shown in table 1.6.1 (Shresta, 1991).

These tribal people use honey in many ways. The use of this nutritious liquid particularly in medical field needs special mention. The local 'Gunin' or 'Jhankri' (medicine man) find its utmost utility in the preparation of their hand made ayurvedic pills, pastes or liquid mixtures from different plant drugs. These are prescribed for different ailments to the local patients. The speciality is that the poor patients particularly of the remote areas depend solely on these 'Gunins' for their treatment as sometimes it becomes impossible for them to reach upto the nearby health centre in the urban areas owing to non-availability of proper vehicle/carriages on the hilly slopes. The use of honey as medicinal ingredients has been mentioned in the table 3.6.4. According to the local 'Gunins', the honey extracted by squeezing method has proved medicinally more valuable than extracted by mechanical method. This is probably due to mixing up of different bee-hive products containing antimicrobial principles like inhibing (Wahdan, 1998) or antifungal matters with honey while squeezing out of honey from comb cells.

Some of the plant drugs as used along with honey in curing or ameliorating different ailments need further research e.g. use of *Basella* leaf (Basallaceae) in Insomnia, use of root bark of *Ficus religiosa* (Moraceae) in impotence, the use of *Astilbe rivularis* (Saxifragaceae) and *Bergenia ligulata* (Saxifragaceae) and *Viscum articulatum* (Lauranthaceae) in bone fracture, the use of *Eclipta alba* (Asteraceae) and *Tagetes patula* (Asteraceae) in diabetes, etc. The 'Putka' honey *i.e.,* honey obtained from *Apis florea* F. has got enormous medicinal value particularly in treating tubercular patients and snake bite cases as experienced by the tribal Ayurvedic Prescribers or 'Gunins'. Even local Tibetan doctors use honey as an important ingredient in their medicines.

The use of honey directly or indirectly as a source of nutrition by the local tribal people needs no mention. Even when a child is born, the first liquid put into its mouth is honey. This is exercised by the local tribal people also.

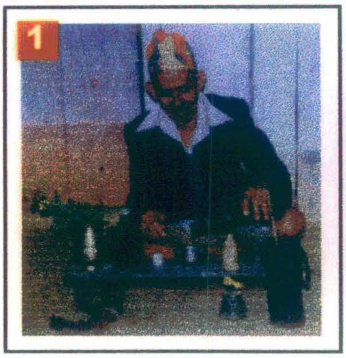
During marriage ceremony, honey is needed along with other accessory materials while chanting 'Mantras' (Spiritual Scriptures) by the local Brahmins.

The local Buddhist Lamas while daily worshiping the God chant 'Domang' (Buddhist religious scriptures) and pour honey in 'Gumba'

(Photoplate IX, fig. 9). [Holy place or special Buddhists' architecture where image of Lord Buddha is worshiped.]

An attempt has been made to show tribal use of honey in this zone in different occasions through a few photographs as explained in photoplate IX.

PLATE IX

1


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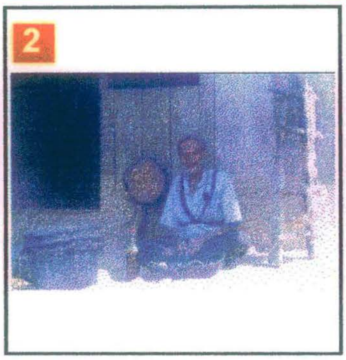

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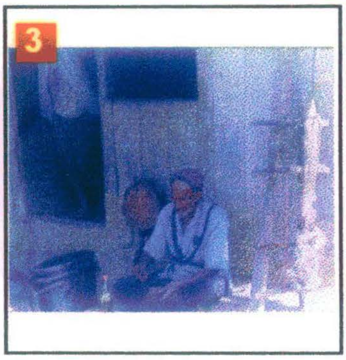

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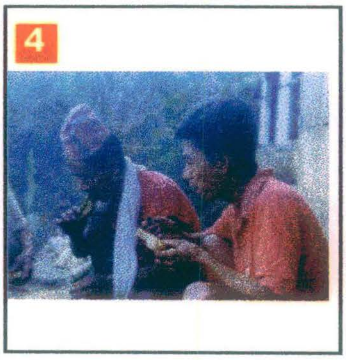

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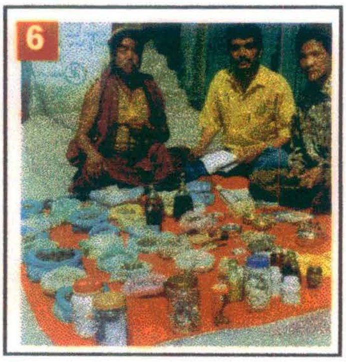

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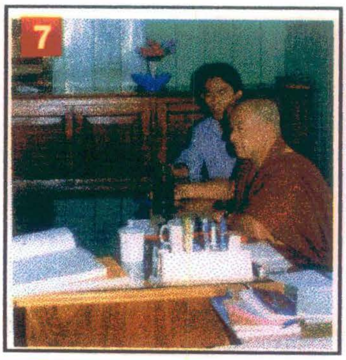

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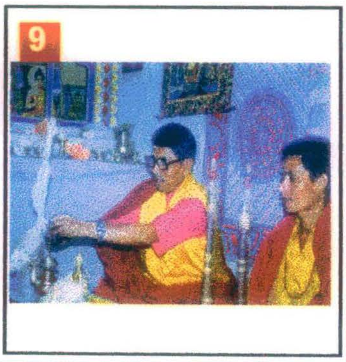


Fig. 1 : 'Jhankri', a local herbalist preparing medicine, mixing honey as an ingradient

Fig. 2 : 'Jhankri', sitting in the middle of all the utilities related to his own environment along with honey also.

Fig. 3 : The same person in full attention in preparing herbal medicine with bottle of honey in front of him.

Fig. 4 : 'Chaka', the honey comb as a source of food of the local tribal people.

Fig. 5 : The mobile medicine - shop on display along the roadside with bottles of honey also in the stock as an ingradient of medicines or food.

Fig. 6 : The same view with a Buddhist Lama who also claims to be a herbalist.

Fig. 7 : Honey on display by a Lama doctor (Buddhist) in his chamber of a local Tibetan medicine centre, Relli Road, Kalimpong, claiming the importance of honey in the preparation of herbal drugs which they use.

Fig. 8 : The same in their medicine counter.

Fig. 9 : Honey being poured while chanting 'Domang' (Buddhist religious words) by local Lama in Buddhist 'Goomba' (The holy place where Lord Buddha is worshiped)

Table 3.6.1; **TRIBAL PICTURE OF DARJEELING DISTRICT**

Sub-Division, C.D. Blocks, Municipalities notified areas	Total population	Scheduled caste			Scheduled tribes		
		Male	Female	Total	Male	Female	Total
Darjeeling Sub-Division	347912	11861	11785	23646	15964	15192	31156
Darjeeling Phulbazar	117196	2893	2779	5672	4763	4365	9128
Rangli-Rangliot	65342	1901	1897	3798	3065	2898	5963
Jorebunglow-Sukhiapokhri	92312	2900	3069	5969	3057	2985	6042
Darjeeling Municipality	73062	4167	4040	8207	5079	4944	10023
Kalimpong Sub-Division	190266	7862	7441	15303	16756	16139	32895
Kalimpong I	53641	2051	2017	4068	4684	4789	9473
Kalimpong II	51411	1063	981	2041	6371	5889	12260
Gorubathan	46382	1533	1401	2934	2945	2718	5663
Kalimpong Municipality	38832	3218	3042	6260	2756	2743	5499
Siliguri Sub-Division	615101	83139	75104	158243	53886	51248	105134
Siliguri Naxalbari	194094	30522	27808	58330	20568	19764	40332
Kharibari-Phasidewa	204057	40660	36946	77606	32697	30996	63693
Siliguri Municipality	216950	11957	10350	22307	621	488	1109
Kurseong Sub-Division	146640	6625	6059	12684	5170	4798	9968
Mirik	34001	1102	828	1930	580	459	1039
Kurseong	78859	3522	3421	6949	3455	3221	6676
Kurseong Municipality	26758	1635	1476	3111	950	982	1932
Mirik (Notified area)	7022	366	334	700	185	136	321
Rural	-	85262	78725	163987	81394	77324	158718
Urban	-	24225	21664	45888	10382	10053	20435
Total	1299919	109487	100389	209876	91776	87777	179153

Source; Census of India, 1991 (Roy, 1991)

Table 3.6.2; **NAMES OF DIFFERENT COMMUNITIES AND THEIR SUB-CASTE/TITLE UNDER SCHEDULE CASTE (HILL AREAS)**

DAMAI (Tailors)	KAMI (Blacksmith)	SARKI (Leather workers)
Name of the sub-caste/title	Name of the sub-caste/title	Name of the sub-caste/title
Pariyar, Berdewa, Karkidea, Nawloag, Bhusal, Sundas, Tikhatri, Darnal, Thatal, Bagdas, Mothey, Mohra, Sunam, Das, Labar, Hingmang, Bhitrikotay, Panchakoti, Karal, Sewa, Suji, Chahar, Ranapahali, Magar, Siral, Powral, Ramadamu, Ghalay.	Bishwakarma, Shankar, Khati, Gazmair,Sinchuri, Ghimiray, Gahatraj, Rasaily, Baraily, Shashankar, Sunar, Lohagun, Lamgaday, Darnal, Ghatany, Singh, Dhamala, Siral, Lohar, Tirwa, Diyali, Kalikotay, Portel, Dural, Lakandri, Sapkota, Dutraj, Setisural, Thapalia, Sinha, Lamichanay, Rahapal, Ramudamu, Pourel, Gadailee, Ghamghotley, Jaankami, Mizar.	Ramtel, magrati, Pukkuti, Bailkuti, Roka, Bishnukhey, Lamjel, Mizar, Tolangi, Khilingay, Piyungba, Kukurti.

[OBC; Tanang: (Sub-caste)- Yonzone, Ghising, Moktan, etc.
Limbu: (Sub-caste)- Nembang
Rai : (Sub-caste)- Bungchhen, Sampang]

[Source; Backward Classes Welfare Office, Kalimp[ong]

Table 3.6.3; **NAME OF DIFFERENT COMMUNITIES AND THEIR SUB-CASTE/TITLE UNDER SCHEDULE TRIBE (HILL AREAS)**

Lepcha	Sherpa	Bhutia/ Tibetan	Dukpa	Kagatay	Yolmo
Name of the Sub-caste/title	Sub-caste /title	Sub-caste /title			
Tingbomu, Molommu, Simikmu, Karthakmu, Fudongmu, Namchu, Kalikasmu, Sanguthmu, Borfongmu, Brimu, Golokmu, Sadamu, Adenmu, Tanitangalmu, Sithingmu, Youngmu, Kabomu, Foningmu, Rongongmu, Kunchudangmu, Panlookmu, Samlingmu, Tashomu, Gaulanmu, Phiponmu, Sampumu, Sambermu, Sumburmu, Yoksomu, Tamsangmu, Chongmu, Kahomu, Sandangmu, Luksommu, Myanmu, Manchongmu, Patkatomu, Takchungthamu, Rosongmu, Kashuyommu, Ragenmu, Gyanzomu, Kathookmu, Phatungmu, Arangmu, Seripuchomu, Dingrongmu.	Salakha, Lama, Pandiyongdi, Pankermu, Gorju, Takto, Pinasha, Payami, Khabajon, Chyba, Ricktomo, Halluri, Nawami.	Shopep, Gayrong, Khamba, Nalongpa, Haaf, Musep, Denzongpa, Amdo, Thangthapa, Phenpupa.	No Sub-caste	No Sub-caste	No Sub-caste

[Source; Backward Classes Welfare Office, kalimpong]

Table 3.6.4; ETHNIC USE OF HONEY AS INGRADIENT FOR MEDICINAL SUBSTANCES

Name of the ailment	User	Process of use	Dosage
Blood dysentery	Kami, Lepcha, Rai & Sherpa	The bark of the stem of *Holarrhena antidysenterica* (Apocynaceae Nepali name; 'Khirra') is boiled with water to get the extract. The extract is again boiled to make a thick sediment. This sediment is mixed with honey and consumed by licking.	Adult; 2 tea spoonful amount thrice daily. Child/minors; ½-1 tea spoonful thrice daily.
Boiles problem	Lepcha and Sherpa	The leaves of *Cyanodon dactylon* (Gramineae) are boiled with water to get a thick sediment (extract) which is mixed with honey and consumed.	-do-
Bone fracture	All tribal people	Powder of the following plants are mixed with honey and consumed for quick calcification and healing of the fractured bones. 1) *Bergenia ligulata* (Saxifragaceae, Nepali name; 'Pakhanbet', all plant parts) 2) *Viscum nepaulense* (Loranthaceae, Nepali name; 'Harchur', stem parts only) Decoction of stem administered orally along with milk and honey. Paste applied topically on fracture along with honey. 3) *Astilbe rivularis* (Saxifragaceae, Nepali name; 'Buraokhati', root parts only)	Adult; Two teaspoonful thrice daily Minors; one teaspoonful thrice daily

Contd...

Name of the ailment	User	Process of use	Dosage 300
Blood purification	Damai and Kami	1) The stem-bark of *Ficus religiosa* (Moraceae) is boiled with water to make thick extract which is consumed with honey 2) *Centella asiatica* (Umbelliferae) leaf extract with honey	Adult; two spoonful thrice daily Minor; one teaspoonful thrice daily
Constipat-ion	Kawai, Damai, Lepcha	The extract of the *Andrographis paniculata* (Acanthaceae) is mixed with honey and consumed	One teaspoonful once daily early in the morning
Common cold and cough problem	All tribal people	1) The leaf extract of *Ocimum* spp. (Labiatae) is mixed with honey and consumed 2) The leaf powder of *Cyperus* spp. (Poaceae) is mixed with honey and prescribed for consumption 3) The leaf extract of *Bacopa monrieri* (Scrophulariaceae, 'Brahmi') is mixed with honey and consumed 4) Aril of *Taxus buccata* (Taxaceae), local name 'Dhengre Salla' is crushed and consumed with honey 5) Fruits of *Terminalia chubula* (Combretaceae) local name 'Harra' are sucked with honey	-do- -do- -do- -do- -do-

Contd...

Name of the ailment	User	Process of use	Dosage
Colic pain	All tribal people	Seeds of *Holarrhena antidysenterica* (Apocynaceae, 'Khirra') are powdered and mixed with honey and consumed	One teaspoonful every three hours interval
Debility	-do-	Powdered or crushed rhizome of *Panax pseudo-ginseng* (Araliaceae, local name 'Panch Patay') is mixed with honey and consumed	Adults; 2 teaspoonful thrice daily Minors- one tablespoonful twice daily
Diabetes	Lepcha	The extract of the leaves of *Tagetes patula* and *Eclipta alba* (both Compositae) are mixed with honey and consumed	One teaspoonful twice daily
Dizziness and Nausea	Lepcha and Bhutia	The wax and the bee polish from the beehive are usually smelt during carriage-riding to check dizziness and nausea by the tribal people. The 'nosal or Tuti' of 'Putka' honey bee (*Apis florea* F.) is most effective for this purpose according to them.	-
Diarrhoea and Dysentery	Lepcha	Leaf powder of *Cannabis sativa* (Cannabinaceae) is mixed with honey and consumed. Root decoction of *Bergenia cilita* (Saxifragaceae, local name 'Pakhan Bet') administered orally along with honey	One teaspoonful every 3 hours interval

Contd....

Name of the ailment	User	Process of use	Dosage
Fever and Lungs trouble	All tribal people	Root decoction of *Bergenia cilata* (Saxifragaceae, local name 'Pakhan Bet' is mixed with honey and taken orally	Adult; 2 table spoonful every 3 hours interval and Minors; one tea spoonful during the same time interval
Gonorrh-oea	Kami, Damai, and Lepcha	1, Powder of inflorescence of *Ocimum* spp (Lamiaceae) is mixed with honey and consumed to relieve pain 2, Arial root extract of *Tinospora cordifolia* (Menispermaceae, local name 'Gurip') is applied with honey (Rai *et al.,* 1998)	One teaspoonful every 3 hour interval
Itching and urticaria	All tribal people	Plant extract of *Swertia chirayita* (Gentianaceae, local name 'Chireto') is mixed with honey and consumed	One teaspoonful once daily early in the morning
Insomnia (Sleepless-ness)	Lepcha	The leaf extract of *Basella* sp is mixed with honey and consumed	One teaspoonful thrice daily
Impotance	-do-	The root bark and newly formed buds of *Ficus religiosa* are powdered are mixed with honey and prescribed for consumption	2 teaspoonful twice daily

Contd....

Name of the ailment	User	Process of use	Dosage
Lactation problems of mothers	Lepcha and Tibetians	The leaf extract of *Eclipta alba* (Asteraceae) is mixed with honey and consumed	One-two teaspoonful twice daily
Menstruation troubles in female	Kami and Sarki	The tips of the prop-roots of *Ficus benghalensis* (Moraceae) are ground with the extract of *Tagetis patula* (Compositae) mixed with honey and prescribed for consumption	Two teaspoonful twice daily
Mumps	All tribal people	Roots of *Thysanolaena maxima* (Poaceae, local name 'Amliso') are crushed and mixed with honey. Than the paste is applied tropically	-
Nausea	Kami, Damai and Lepcha	1) The powder of the dried fruit with seed of *Terminalia chebula* (Combretaceae) is mixed with honey and prescribed for consumption 2) The extract of fresh *Cyanodon dactylon* (Poaceae) leaves is mixed with honey and consumed	One teaspoonful twice daily -do-
Piles	Lepcha	Same as mentioned in blood dysentery	-
Rheumatism and gout	Kami, Damai And Lepcha	1, The milky latex of *Salmalia malabaricum* (Bombacaceae) is mixed with its root bark extract and honey and consumed 2, Decoction of lower part of the stem and root of *Achyranthes bidentata* (Amaranthaceae, local name 'Ankhla Jhar') mixed with black pepper and honey and taken orally	One-two teaspoonful thrice daily

Contd...

Name of the ailment	User	Process of use	Dosage
		3, Arial root extract of *Tinospora cordifolia* (Menispermaceae, local name 'Gurip') applied with honey (Rai *et al.*, 1998)	-
Snakebite	Lepcha Yolmo	'Putka' honey or honey from *Apis florea* F. is directly used for internal consumption and external application	One-two teaspoonful every one hour interval
Skin troubles	Kami, Damai, Sarki, and lepcha	1, 50 gm of curd, 50 gm of soyabean paste and 15 gm of honey are mixed together to make a paste. This is prescribed for external application only to make the skin softer and brighter. The external application should be washed after 15 minutes with mild hot water. 2, Oil extracted from the seeds of *Gynocardia odorata* (Flacourtiaceae, local name 'Gantay') mixed with honey and applied externally for skin diseases and also for leprosy	-
Tuberculosis	Lepcha, Kami	The powder of the stem-bark of *Terminalia arjuna* (Combretaceae) is soaked in the extract of the leaves of *Justicia adhatoda* (Acanthaceae) and sun-dried. This alternate process of soaking and sun-drying is repeated seven times. The material is mixed with honey and prescribed for consumption.	One-two teaspoonful thrice daily

Contd…

Name of the ailment	User	Process of use	Dosage
Throat infection	Lepcha, Bhutia	Leaves or ripe fruits of *Hemiphragma heterophylla* (Scrophulariaceae, local name 'Malajhar') crushed and strained through cloth and is taken orally mixed with honey	Adult; 2 table spoonful twice daily Minor; 1 tea spoonful twice daily
Tonic for post natal woman	Lepcha, Bhutia	Decoction and powder of root tuber of *Astilbe rivularis* (Saxifragaceae, local name 'Buro-okhati') mixed with honey and consumed (Rai *et al.,* 1998)	-do-
Urine trouble	Lepcha, Bhutia and Yolmo	The powder of stem-bark of *Holarrhena antidysenterica* (Apocyanaceae) is mixed with honey and prescribed for consumption.	-do-
Vomiting	Sarki, Lepcha	Extract from the leaves of *Mangifera indica* and *Mentha* sp is mixed with honey and consumed	One-two teaspoonful one hour interval
Worm trouble	All tribal people	The leaf-extract of *Andrographis paniculata* (Acanthaceae) is mixed with honey and consumed	Adult; 2 tablespoonful once daily Child; ½ teaspoonful once daily

Chapter Four

Discussion

The importance of a taxon as geographical or regional indicator is a function of the frequency of its occurrence in the total contingent of honey samples (Ramanujam and Kalpana, 1995). In other words the importance of a taxon as a chief nectar source for the honeybees can be assessed by taking into consideration the frequency representation of its pollen in the pollen spectrum of individual honey.

In this study a total of 25 unifloral honeys (36.9 %) were recognised with the following taxa as predominant pollen types in different seasons of honey flow periods:

SUMMER SEASON:-

Citrus spp., *Rosa* spp., *Rubus ellipticus, Buddleja asiatica, Prunus* spp., *Calendula* sp., *Primula* spp., *Schima wallichii, Fragaria* spp., *Potentilla* sp., *Trifolium repens.*

WINTER SEASON:-

Aristolochia sp., *Rosa* spp.

AUTUMN SEASON:

Ageratum sp., *Schima wallichii, Michelia* spp., *Brassica* spp., *Sedum* sp. *Prunus* spp.

Of these the majority (4samples) were derived from the nectar of *Schima wallichii* during autumn (3) and summer (1). *While Schima wallichii* flollowed by *Calendula, Prunus* spp., *Citrus* spp., *Buddleja* sp., *Rosa* spp., and *Ageratum* spp. and *Trifolium* as the chief nectar sources during summer and autumn *Schima – Prunus – Rosa – Calendula-Trifolium* complex based upon frequency of occurrence, can be considered as regional indicators of summer honeys of Sikkim and sub-Himalayan area.

The other plants which provide the major sources of nectar in different seasons for the honey bees constituting the secondary pollen types in the honeys of the area include as follows-

SUMMER HONEYS:-

Tithonia diversifolia, Bidens pilosa, Chrysenthemum sp., *Centaurea* sp., *Solidago* sp., *Aconogonum molle, Jasminum* sp., *Cardamine* spp., *Raphanus sativus, Strobilanthus* sp., *Fragaria* sp., *Clerodendrum* sp., *Strptosolen jamesonii, Milletia* sp.

AUTUMN HONEYS:

Camelia spp., *dalbergia sisoo, Ammomum subulatum, Symplocos* spp., *Selinum* sp., *Drymaria villosa, Brassica* spp.,

WINTER HONEYS:

Tropaeolum sp., *Nicotiana* sp., *Bellis perennis, Porana* spp., *Clematis* sp., *Dahlia* sp., *Bauhinia* spp.

Other plants representing the noteworthy suppliers of nectar and pollen in different seasons include as follows:-

SUMMER HONEYS:

Asystasia macrocarpa, Embelia sp., *Nemophilla* sp., *Petunia* sp., *Michelia* spp., *Saxifraga* sp., *Poaceae, Tropaeolum* sp., *Phaseolus* sp., *Syzygium* sp., *Gladiolus* sp., *Pimpinella* sp., *Erigeron karwinskinanus, Euphorbia pulcherrima, Coccinea grandis, Begonia* sp.

AUTUMN HONEYS:-

Papaver spp., *Passiflora foetida, Spirea micrantha, Trifolium repens, Lindenbergia* spp., *Iberis* sp., *Solanum* spp., *Cestrum* spp., *Linaria* spp., *Saxifraga* spp., *Duranta* sp., *Eupatorium* sp., *Rubus* spp., *Holboelia* sp., *Schium eduli, Cyphomandra* spp.

WINTER HONEYS:

Datura spp., *Euphorbia* sp., *Cleome* sp., *Plectranthus* spp., *Spergula* sp., *Veronica* sp., *Galinsoga* sp., *Magnolia* sp.

Pollen analytical studies of honeys coupled with critical field observations help in providing data regarding the bee plants of an area and also the favourable period of honey production on commercial basis (Ramajunam and Kalpana, 1995).

The nectar or pollen calendar (Fig. 3.3.7.1) furnishes information on month – wise chief and alternate sources of nectar of pollen for the honey bees as well as honey flow periods. Sometimes pollen of previous seasons are stored in the honeycombs. So in microscopical study of such honey samples sometimes pollen out of seasons were also encountered.

Foraging bees are specialists either in nectar or pollen collection, although they do change over from one to other depending upon the need of the hive and the availability of the grub (Suryanarayana, 1986). The honeybees are polytropic and therefore collect food even from anemophilous flowers such as those of *Poaceae, Papaver* sp., *Castanopsis* sp., *Fagopyrum* sp., *Hattuynia* sp. Some times diverses of flowers particularly 4-5 parted to 5 pointed star shaped flowers and different colours specially yellow, violet, orange, blue, pink play important role in changing the behavioural pattern of both the species of *Apis* (table 3.1.1).

Unifloral honeys of Sikkim and Sub-Himalayan West Bengal merit critical palynological studies to facilitate recognition of all such key plants which constitute the chief source of nectar and pollen to the honeybees.

Once such type of honey and the regions producing them are recognised, attempts should be made to assess their market potential and the apiary keepers may accordingly be advised to undertake their production on a commercial scale.

A total number of 1052 species of angiospermic plants were recorded form Drjeeling Himalyas and adjoining areas (Das and Chandra, 1987). Of these 388 secies are entomophilous, 58 species Amphiphilous 61 species. Anemophilous and the flowering period of 51 species remained unrecorded. A total of 505 species of plants are found to flower throughout the year.

A total number of ±310 'Bee-forage-plants' have been recognised so far from the present investigation in the study area, out of these ±262 plant species are of entomophilous taxa, ±41 plant species are of amphiphilous taxa whereas 9 plant species are of anemophilous taxa (Table 2.2.1).

During summer, plants belonging to 142 genera were found to be foraged by *Apis cerana indica* F. and *Apis florea* F.

Similarly during autumn plants of 91 genera and during winter 60 genera were found to be foraged by these species of bees.

On analysis of 67 honey samples a total of 166 pollen types referable to 77 families have been recognised.

Most of the bee-forage-plants represented in the honey samples had other economic uses too in addition to being good honey plants. A few had ethnomedicinal uses in the region of present study. Some such examples are as follows:-

The entire plant of *Rubia cordifolia* is used to cure stomach ache and that of *R.. manzith* is used for paralysis and jaundice. *Cardamine hirsuta* is used against heart diseases, low blood pressure and gout (Yonzone *et al.*, 1985). *Drymaria villosa* is used in curing nasal infection and cold.

The young shoots of *Artemisia vulgaris* are used for headache, nose – bleeding and eye- infections. The similar parts of *Eupatorium adenophorum* is used to heal cuts and to check haemorrhages as an antiseptic and blood coagulating agent.

Ageratum conyzoides (leaves) is used for fever, *Brassica juncea* (leaves) is used for earache, *Cannabis sativa* (leaves) is used for indigestion, acidosis and food poisoning, *Eupatorium odoratum* (leaves) is used for cuts and abrasions, *Lantana camara* (leaves) for skin itches, *Prunus persica* (leaves) is used for vermifuge. The stem of the *P. cerasoides* is used for bone- fracture and toothache. (Yonzone *et al.,* 1985 and Bhujel, 1995). *Camellia sinessis* (root) is used for mumps, *Clerodendrum viscosum* (root) for dysentery, *Dahlia pinnata* (root) for mumps, *Dichroa febrifuga* (root) for fever and malaria. *Plantago major* (root) for toothache, *Rubus ellipticus* (root) for fever, *Rhododendron arboreum* (flowers) is used for dysentery and throat infection, *Woodfordia fruticosa* (flowers) for dysentery, *Coriandrum sativum* (fruits) for difficulty in passing urine, *Datura metel* (fruits) for hydrophoebia insanity, convulsions. *Fragaria indica* (fruits) for mouth and tongue sores, *Luffa cylindrica* (friuts) for diarrhoea in cattle, *Momordica charantia* (fruits) for diabetes, *Zanthoxylym hamiltonianum* (fruits) for flatulence, digestive disorders. *Clematis montana* is used as decongestant in the treatment of cough and cold, *Tropaeolum majus* for colites and inflammation of kidney (publication and information directorate, CSIR, 1986) *Torenia peduncularis, Centauria cyanus, Cineraria grandiflora*, *Calendula officinalis, Papaver rhoeas* are used as common ornamental in the study area. Some more informations may be added in this respect.

Bauhinia spp. (roots) is used as carminative. Bark of the same is used for tonic purpose and anthelmintic, flowers laxative. Roots of *Buddleja asiatica* are used in the preparation of fermented liquor. The flowers of *Bassia butyracea* are used in the preparation of distilled liquors and vinegars. Flowers of *Citrus* spp. yield an essential oil, Nerdi oil. Leaves *of Cleome icosandra* are used as rubefacient.

Leaves and flowering tops *of Datura stramonium* constitute the drug Stramonium which is used as narcotic, antispasmodic. Leaves of *Digitalis purpurea* are used for cardiac stimulant. The barks and leaves of Jacaranda are used for syphilis and mennorrhagia. The flowers of *Jasminum* are the important source of fragrant *Jasminum* oil. Bark *of Holarrhena antidysenterica* is astringent, anthelmintic and stomachic, antipyretic. Flowers of *Lantana camara* yield and essential oil, the entire plant is credited with carminative and antispasmodic properties. Leaves of *Leuncaena glauca* are a good source of protein and carotene and can be employed as supplement to alfa alfa leaf used in poultry rations.

The bark of *Magnolia grandiflora* is stimulant, diaphoretic and tonic used for malaria and rheumatism. Roots of *Mucuna prurita* are used as tonic, stimulent, diuretic, purgative and emmenagogue. The fruits *of Prunus* *communis* are crushed to produce juice to produce beverages and wines. Bark of *Symplocos racemosa* is used as astringent and also used for dysentery, liver complaints, dropsy, opthalmia and conjunctivities. Its docoction is employed to stop bleeding of gums. *Solidago virga-aurea* is diuretic, carminative and is mixed for whooping cough, dropsy, chronic eczema.

Leaves of *Strobilanthes* are astringent, diuretic. The alcoholic extract of *Solanum khasianum* affect the contraction of isolated ileum of guinea pig and also influence central nervous system. *Solanum nigrum* is antiseptic and antidysenteric, fruits of S. torvum is antiseptic useful in liver as well as spleen problems and their decoction is used for cough (Biswas and Chopra, 1940).

From the overall chemical analysis of 25 samples *of Apis cerana indica* F. honeys it was found that among the high hills honeys Rimbick honey (RIMH – 2) collected in the month of October 1997 contained highest amount of amino acids (14.0 mg/gm). The significant amount, *ie,* 0.392 % does not tally properly with its dark amber colour. This honey is unifloral in nature (Table 3.4.1a) with its predominant pollen type *Sedum multicaule* (Crassulaceae) (50.0 %). Moreover slight bitter taste of the honey sample might be due to the presence of some unidentified factors (1.20 %) or nature of pollen chemicals which needs further investigation.

Lava honey (LH-1) is although matched with its minimum ash content (0,131 %) it did not corroborate with the idea of Paine *et al.,* (1934) as mentioned earlier having high amount of amino acids (13.5 mg/gm). The honey is multifloral in nature (Table 3.4.1a).

Dzongu honey sample with its amber colour did not correlate with its minimum ash value (0.217 %) (Schuett and Remy, 1932) but on the contrary, the sample having high amount of amino acids (13.5 mg/gm) in it matched properly with its colour (Paine *et al.,* 1934).

Among the mid-hills honey samples Damthang honey collected in May 1997 (DAMH-2) highest protein content (102.5 mg/gm) which did not corroborate with Pryce-Jone's finding in 1936 by not having thixotropic property in the sample as mentioned earlier. Its pale yellow colour also rarely matched with its high ash content (0.421 %) in it. The sample with its APC 50700 is graded as Gr II (Louveaux *et al.,* 1978).

The seed farm honey from Kalimpong (SFH-1) collected in the month of April 1996 showed highest amount of sugars (762.5 mg/gm) in it. The high percentage of undetermined factor (2.64 %) in this sample is responsible for nutritive and medicinal value for honey (Phadke, 1962). Moreover, the highest APC (absolute pollen content) of 350609 (Table 2.3.1A) in the sample place the honey in Group III category (Louveaux *etal.,* 1978).

KHAMH, the honey sample from Khamdong (West Sikkim) collected in July 1997 showed minimum content of sugars (130.0 mg'gm) but highest amino acid content 14.0 mg/gm. The honey is unifloral one with its predominant pollen type *Michelia* sp. (85.36 %) (Table 3.2A). The undetermined factor present in significant level (2.02 %) and APC (25500, Gr II) need special mention from nutritional and medicinal point of view.

The Fifth Mile honey sample of Kalimpong (FH) collected in June 1996 with its dark amber colour well suited with the high ash content (0.421 %) in it. Same is the case with the Gangtok honey sample (GANH) (collected in March 1997) with its amber colour correlating with the high ash content (0.440 %) (Paine *et al.,* 1934). Both the samples were multifloral in nature and graded as Gr. II with APC 9475 and 5556 respectively per 10 gms of the samples.

The foot-hills honey samples from Chalsa (CH, May 1996) and Mitiali (MH, June 1996) showed high amount of total sugars 602.5 mg/gm and 727.5 mg/gm respectively which fulfil the prescribed range of 'Agmark' specification for sample with considerable high amount of protein content (88.75 mg/gm) showed its high thixotropic property. This corroborated with the research findings of Pryce-Jones in 1936. Moreover, the same honey sample with yellow colour, high ash content (0.413 %) and undetermined factors present (0.99 % in amount) place the honey in medium nutritional status. The honey is unifloral one with its predominant pollen type Gr. I with

APC 3059/10 gm of honey. On the contrary Chalsa honey is multifloral one with Gr. II having APC 27369/10 gm of honey.

Overall physio-chemical analysis of the selected honey samples revealed that honeys of higher hills contained high amount of amino acids although the same is tru for some mid hills honeys also e.g. Khamdong sample (14.0 mg/gm), Payong sample (10.5 mg/gm) Mungpoo sample (9.0 mg/gm),Sansay sample - 2 of July 1996 (9.0 mg/gm) etc. (table 3.4.1).

The higher amino acid content associated with higher undetermined factors and ash content as observed in the cases of Rimbik sample of October 1997, Lava sample of May 1996, Dzongu sample of North Sikkim (June 1996), exception as content minimum (0.217 %). Damthang samples of South Sikkim (March 1996 and May 1997) Seed Farm sample of Kalimpong (April 1996) Khamdong sample of West Sikkim (July 1997), Gangtok sample of March 1997, Fifth Mile sample of Kalimpong (June 1996) place them in nutritionally and medicinally higher status in comparison to other samples. However, the higher moisture content above the Agmark specification, 1959 (22 %) in cases of Khamdong, Damthang – 1 & 2, Seed Farm and lava samples with their corresponding values 30.0 %, 30.0 %, 22.5 %, 22.4 % respectively indicate that the samples might be unripe and are liable to get fermented. Another probable cause is that due to low temperature and humid climate condition at the time of collection of the honey samples the moisture content in the latter became high.

Chemical analysis of the samples of *Apis florea* F. honeys revealed the more acidic nature of the same in comparison to the *Apis cerana indica* F. samples. High amino acid content (14.2 mg/gm in LPH and 13.6 mg/gm in PABH) and relatively moderate sugar content in the former (*Apis florea* F. honey) place them in nutritionally higher status in comparison to *the Apis cerana indica* F. samples.

There was some deviation from Pryce-Jone's view (1936) having low thixotropic property in these two honeys although the percentage of protein content was found to be higher. The same observation had been made in

Damthang honey (DAMH-2), one of the *Apis cerena indica* F. samples which showed no thixotropic property although protein content was found to be relatively high (102.5 mg/gm) as mentioned earlier (Table 3.4.1).

The high APC value of PABH sample (463767/10 gm) and its corresponding Gr III. status with significant amount of undetermined factors (2.20 %) need special mention from nutritional and medicinal point of view (Phadke,1962).

The ripe nature of the samples as indicated by moisture content level being below level of Agmark specification (22 %) revealed that these are less liable to ferment.

From the study of heavy metal content in the three honey samples from three target zones with a view to observe the impact of random use of pesticides in the crop fields, tea gardens, orchards, research fields of the study area it was found that Zinc (Zn) was present in significantly in high amount (1.13 mg/100gm) in Dudhia Tea Estate sample DUDH). This exceeded the average quantity of Zinc content (0.2 – 0.5 mg/ 100 gm) in honey (Crane, 1975). Similar was the case with copper (Cu) also in all the three samples. The average amount of Cu as found by Crane in 1975 range from 0.01 mg to 0.1 mg per 100 gm of honey. But in the present investigation the quantity of Cu (0.14 mg/ 100 gm in MH, 0.17 mg/ 100gm in DUDH and 0.15 mg/ 100 gm in SFH-1) exceeded the said level.

The amount of cadmium (cd) and lead (Pb) was found to be negative though Manganese (Mn) was present in trace amount. But its quantity in Dudhia Tea Estate sample (DUDH) was found to be comparatively higher (0.76 mg/ 100 gm) than those in the other two samples (0.15 mg/ 100 gm in MH and 0.36 mg/ 100 gm in SFH-1). These findings indicated that amount of Manganese in Dudhia Tea Estate sample and Mitiali sample exceeded the normal value of Mn in honey (0.02-0.15 mg/ 100 gm of honey). Studies on some trace element content in Polish – made food products (in some bee honey grades) were already made by Bulinski *et al.,* 1995 by Flame Atomic Absorption Spectrometry. In their studies lead was determined 0.004 mg/kg

– 0.118 mg/kg, Cadmium from 0.004 mg/kg – 0.016 mg/kg, Nickel from 0.042 mg/kg – 0.500 mg/kg, copper from 0.14 mg/kg – 1.37 mg/kg, Zinc from 2.69 mg/kg to 19.37 mg/kg, Iron from 2.30 mg/kg – 9.46 mg/kg, Manganese from 0.51 mg/kg – 10.43 mg/kg and chromium from 0.017 mg/kg - .053 mg/kg. The amount of Zinc, Copper and Manganese fell within the above range as studied by Bullinski *et al.,* 1995. But the amount of Cadmium and Lead was found to be negative.

The comparative study of the above metals in respect to normal and experimental values has been represented in figures 4.1a, b, c.

On local survey and proper investigation it was found that the local farmers are using the pesticides in the crop fields, tea garden areas, orange orchard areas to kill the weeds, insects and fungal pathogens. The name of some of the pesticides with their corresponding chemical contents and groups are mentioned in the table 4.1.

It is most probable that random use of above mentioned pesticides in the crop fields, tea garden areas, orange-orchard areas etc. during their flowering seasons has a very negative impact on the production of honey either from qualitative or from quantitative point of view.

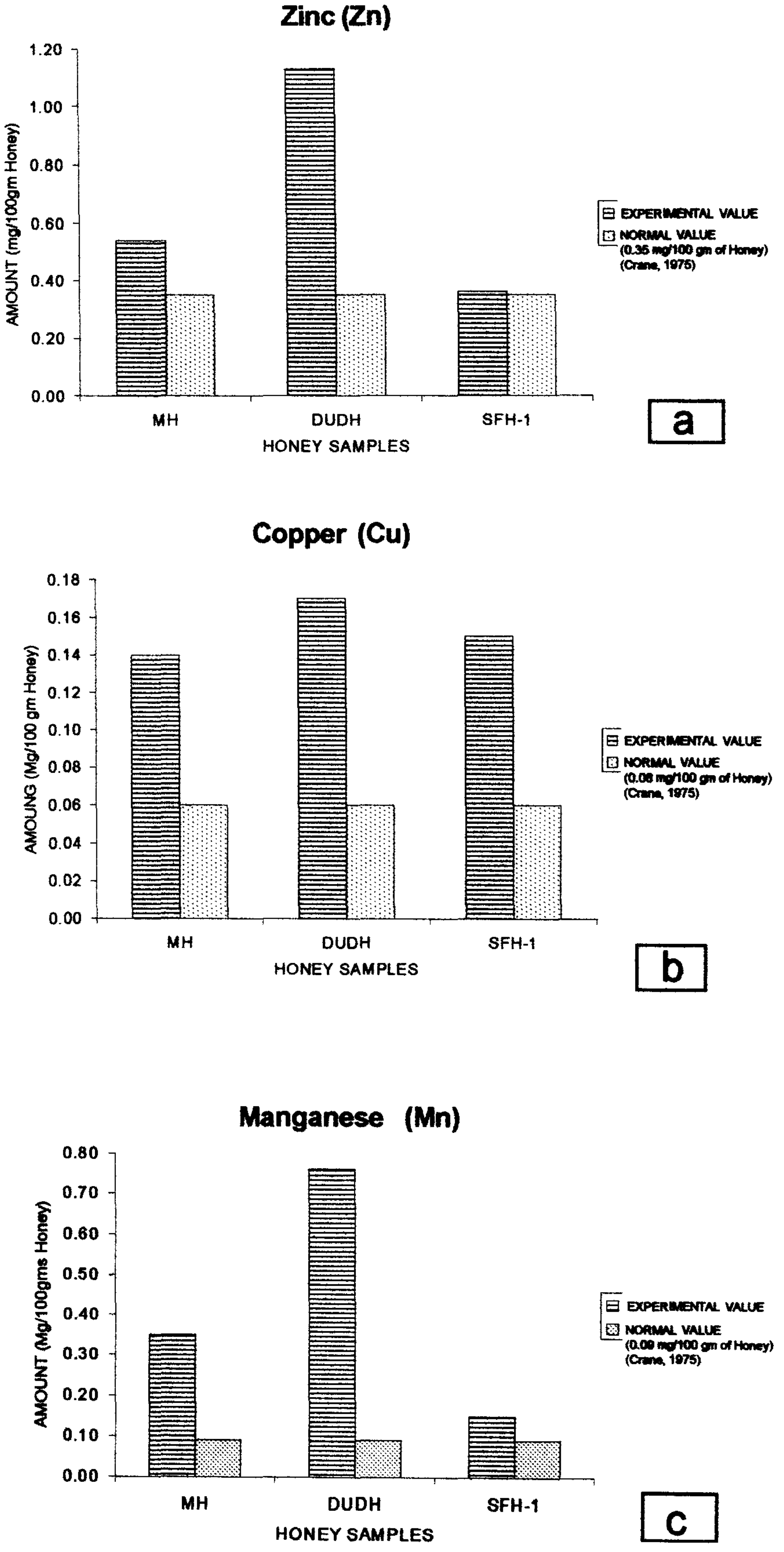
The chemical ingredients like Zn-ion and Mn-ethylene bisdithiocarbamate, Cu-oxychloride within the fungicides like Indofil M-45, Dithane M-45, Blitox-50 W etc. sprayed over the flowers might have reached through the nectar collected by the bees and ultimately stored in the honey combs of bee-hives. Consequently there might be greater chances of increasing the level of toxicity of honey or honey-poisoning. This phenomenon degrades the quality of honey on one hand whereas large scale destruction of honey bee colonies due to pesticidal poisoning causes low quantity of honey production on the other (Singh *et al.,* 1974).

Now-a-days several countries like France, Sweden, U.K., New Zealand etc. have come forward to adopt legislation to protect the honey bees and other pollinating insects from pesticides. (Abrol, 1997). In India a similar approach is made by section 11 of "Code for conservation and

Tab.4.1 LIST OF PESTICIDES WITH THEIR CORRESPONDING INGRADIENTS, GROUP AND SITES OF USE

Sl. No.	Name of pesticide	Chemical ingredients	Group	Site of use
1	Blitox-50W	Copper-oxychloride	Fungicide	Crop fields of paddy, zea, wheat, tomato, chillies, orange orchads, tea belt, tobacco fields, etc.
2	Indofil M-45 (Mancozeb 75% WP)	75 % of co-ordination product of Zn-ion and Mn-ethylene bisdithiocarbamate	-do-	-do-
3	Dithane M-45 (Mancozeb 75% WP)	-do-	-do-	-do-
4	Glycel 41% SL	Isopropylamine salt of Glyphosphate	Weedicide	Tea belts
5	Rogor 30E (Dimethoate 30% EC)	0,0 – di-methyl S-(N-Methylcarbamoyl methyl) – phosphorodithionate	Insecticide	Tea, chillies, orange, vegetables, tobacco growing areas
6	Roundup	Glyphosphate	Herbicide	-do-
7	Leader	Isoproturon (IPU)	Weedicide	-do-

COMPARATIVE STUDY OF HEAVY METAL CONTENT IN 3 HONEY SAMPLES THROUGH ATOMIC ABSORPTION SPECTROMETRY IN RESPECT OF NORMAL AND EXPERIMENTAL VALUES



[Fig. : 4.1]

[HONEY SAMPLES : MH = Mitiali Honey (Jalpaiguri District)
DUDH = Dudhia Tea Estate Honey (Kurseong)
SFH - 1 = Seed Farm Honey (Kalimpong]

maintenance of honeybees" (India, Indian Standards Institution, 1973). Indian Standard No:IS6695, 28 pages. This appoach stresses that beekeepers and farmers should enter into voluntary agreement so as to maximise crop yields and minimize bee damage in context of their own conditions. In 1968, Indian Government set up a registration committee for Registration of Pesticides and importers and manufactures were required to test toxicity to human being, animals, fish, birds and also to honey bees.

It is the high time that strict legislation be enforced to save the honeybees which will not only produce honey, bees-wax, improve crop-productivity, provide employment but also help in the maintenance of stable ecological system.

INTOXICATING HONEY-

During the local survey and present investigation in the study area it has been observed that some taxa add intoxicating properties to the honeys. The nectar and pollen sources of such types include *Gynocardia odorata* (local name "Gantay": Fl. Period Apr.-June) of family Flacourtiaceae, *Bassia butyracea* (local name: 'Chewri'Fl. Period Feb.-Apr.) of family Sapotaceae, *Bauhinia vahlii* (local name 'Varala') of family Caesalpinaceae, Fl. Period May-June, *Leucosceptrum canum* (local name 'Ghurpis' Fl. Per. Dec-March) of family Lamiaceae etc.

The intoxicating property within such honeys is more prominent, if the honey is of unifloral type (i.e. for predominant of >45% pollen) for these taxa especially. The local people give the name for these honeys collected during the flowering seasons of the above plants according to their local names eg. 'Guntay honey', 'Chewri honey', 'Ghurpis honey', 'Varala honey', etc.

Although in the present study of the honey samples predominant nature of such pollen taxa had not been found still some of these had been recovered as secondary (i.e. 16-45%) important minor (i.e. 3-15%) and minor (i.e. below 3%0 pollen types. *Gynocardia* had been found in 12 samples ranging from 0.01% (in SURH) to 28.81% (in SANG-3). Similarly *Bassia* had been found in 3 samples (0.86% in SBH, 3.4% in MIBH- and 4.8% in FH), *Bauhinia* in 3 samples (3.4% in SORBH, 9.78% in GANH and 10.5% in SURH) and *Leucosceptrum* in only one sample (1.35% in HTH).

It is most probable that the nature of the sugar present within the nectar of such taxa add to the intoxicating property of the honey and this needs further investigation in respect of fermentation of sugars in the nectar into some alcoholic compounds.

TOXIC HONEY-

Mention has already been made regarding the toxicity of honey due to toxic nectar and pollen sources and different authors' views in this respect in the introduction chapter. Florido-Lopez *et al.,* studied in Spain in 1995 on allergy to natural honeys and camomile tea. On their studies, pollen studies showed high level of sunflower pollen (23.6 %) in the honey from Andujar. The allergological test and the inhibition studies suggested that the pollen Compositeae may be responsible for allergic reactions to such an natural foods and that the reactions are mediated by an IgE-related mechanism. Similar study on food allergy to honey was made by Bauer *et al* in 1996 in Vienna, Austria.

Immunoblot analysis of the patients showing alergic symptoms after injection of honey or honey containing products revealed IgE bindings to protein at the molecular mass of 54 kd, 60 kd or to a 30 kd/33kd double band or to both in sunflower honey extracts. The three bands corresponding to higher molecular mass protein could also be detected in three other kinds of honey (locust tree, European chestnut and forest honey). Both proteins derived from secretion of pharyngeal and salivary glands of honey bee head and pollen protein content in honey cause allergic reactions to honey.

In the present investigation four such pollen taxa which have been recognised as having toxic properties had been recovered from different honey samples. *Papavar* had been recovered from five honey samples ranging from 0.77 % in Lava honey (LH-2) to 17.7 % in eleventh mile honey in (ELEH) The other three samples having *Papavar* pollen were Monsng honey (MONSH-1) having 8.5 %, Deolo hills honey (DH) having (DH) 1 %. Sangsay honey (SANGH-1) having 4.7 % *Rhododendron* had been recovered from two samples as minor pollen type *i.e.* 1.00% each in both Damthang (DAMH-2) and Payong (PH-1) honeys. Aesculus had been recovered in single sample as minor pollen type i.e. 0.5% in Monsong honey (MONSH-2) only. Croton had been recovered as minor pollen type in Mitialu honey (MH) of the quantity of 1%.

It might be that the floral gap periods at different seasons compelled the bees to forage on such poisonous plants (Chauhal and Deodikar, 1965).

According to study of Abrol in 1997 *Rhododendron arboreum* and *Aesculus californica* in honey pose a serious problem in USA.

In the present investigation it was found that Damthang sample (DAMH-2) had the highest amount of protein (102.5 mg/gm). It contains *Rhododendron* of 1 %. There are several species of *Rhododendron* whose nectar and pollen may not be toxic to the bees. Still it is doubtful for human consumption from safety point of view. Similar is the case in Monsong honey (MONSH-2) with *Aesculus* pollen. Toxic honeys collected during the blooming period of such poisonous plants should be avoided.

"PUTKA" HONEY

Honey is so named by the local people not because of its floral sources but for the name of honey causing agent, *Apis florea* F. (local name ("Putka"). This honey is 10 times costlier than the *Apis cerana indica* F. honeys in the local areas because of the poor availability ad high medicinal value of the former as per the information obtained from the local bee keepers.

In the present investigation of two such honey samples it was found that Pabong honey (PABH) was of unifloral nature with *Trifolium repens* as the predominant pollen type (82.7 %), whereas Lathpancher honey (LPH) was of multifloral nature with *Spirea* (43.28 %), *Buddleja* (20.10 %), *Primula* (18.03 %) and *Desmodium* (14.02 %) as secondary pollen types.

On chemical analysis of the two samples it was found that both the samples were of more acidic nature in comparison with the *Apis cerana indica* F. samples having high amino acid content (14.2 mg/gm in LPH and 13.6 mg/gm in PABH) and protein content (93.5 mg / gm in LPH and 96.8 mg/gm in PABH) as mentioned earlier. The ripe nature of the honeys (moisture level below the Agmark specific level, 22 %) high APC value 463767/10 gm in PABH and 25862/10 gm in LPH and considerable quantities of unidentified factors (2.20 % in PABH and 2.01 % in LPH) also add some more incentives in favour of their higher nutritional and medicinal status and this needs more attention of future researchers in this field.

Chapter Five

Conclusion

Melissopalynological study besides enabling to infer the botanical source of a given honey sample also serves to indicate its geographical source on the basis of the characteristic associations of component species. (Chaubal and Deodikar, 1965).

Sikkim and Sub-Himalayan West Bengal with varied and rich floristic complex have the natural potentialities for organized apiary industry and production of commercial quantities of honey. Single sources of honeys (for unifloral honeys) like *Schima, Citrus, Buddleja, Prunus, Ageratum Rubus, Rosa, Calendula, Fragaria, Michelia, Brassica, Potentilla, Aristolochia, Sedum* and *Trifolium* along with varied multiple sources (for multifloral honeys) from different pollen taxa place this study area in significantly high status from 'bee-keeping' point of view. There are greater chances of economic gains from higher honey yield with better qualities if the information gathered in the present study from melissological point of view are used judiciously by the local bee-keepers.

Other than the finding of botanical sources of a honey sample the present study also enables to detect artificial mixtures of different unifloral and multifloral honeys by way of deliberate adulteration or misrepresentation. Some of the unifloral honeys are specially preferred for their taste, flavour, nutritive value or medicinal properties. In such cases the pollen analysis provides a reliable assurance for the consumer (Chaubal and Deodikar, 1965).

The bee forage plants of this zone can be categorised into three groups : 1) Crop plants 2) Herbaceous weeds and 3) Arborescent taxa.

The establishment of large scale apiary colonies in the vicinity of all such areas would result in assured supply of good quantities of honey. Further, it would also result in increased crop-production because of higher percentage of pollination in flowers. Hill and Webster in 1995 in their study on apiculture and forestry (bee and trees) opined that purposeful planting of trees as in agro-forestry systems, could designed to favour bee forage or hive protection. Tree growing and bee keeping can easily be combined for several reasons. Both are sustainable on land that is hilly or otherwise less desirable for other agricultural purpose. Combining forestry and bee keeping provides annual honey bee products (eg. Honey, bee waxes) to supplement income from a landowner's long term forest managements.

For the improvement of the socio-economic set-up of the local people in the region following suggestions in this line may be made.

1. Local farmers should be encouraged to grow more bee forage which are the crude sources of honey production at the same time deforestation need to be checked by rendering them proper environmental education
2. Plants supplying poisonous and allergic pollens like *Rhododendron, Aesculus, Papaver* etc., as mentioned earlier should be avoided during their flowering season for safeguarding the consumers' interest.
3. Local people should be educated properly for discouraging the random use of pesticides to save the honey bees which produce not only honey but also improve the crop production and thus helping in the maintenance of ecological balanced.
4. Some of the major factors should be considered while educating the local people before making pesticidal applications like (a) Extent of toxic effect on bees from the chemicals used in making pesticides. (b) Estimated loss in honey production from hives within 3 km radius of the crop, if treatment would necessitate their temporary removal of the hives, (c) Estimated loss of pollination if hives are removed.
5. Large scale bee-keeping industry and some ancillary industries based on honey and its by products like pharmaceuticals, baking, confectionery, cosmetics, veterinary, boot & floor polishes, wax models, insulting tapes, dentistry casting, lithography etc. along with bee nurseries, bee equipment and hives may be developed in this

zone. This will give enormous opportunities to the local people in providing employment directly or indirectly particularly in this era of unemployment.

6. Productive efficacy of the apicultural industry depends upon improvements in : (a) bee breed, (b) bee management and (c) bee forage. Of these three bee forage involves adequate attention to bee forage plants in local flora. Some such plants which deserve consideration at different seasons are as follows-

SUMMER/SPRING –

Ammommum sp., *Citrus* spp., *Schima wallichii, Prunus* spp., *Buddleja asiatica, Rubus* spp., *Primula* spp., *Calendula officinale, Fragaria* spp., *Potentilla* spp., *Rosa* spp., *Clematis* spp., *Trifolium repens, Torenia peduncularis, Tropaeolum majus, Erigeron karwinskianus*, *Cineraria grandiflora*, *Milletia* spp., *Brassica* spp., *Bassia butyracea, Centaurea* spp. etc.

WINTER –

Aristolochia spp., *Rosa* spp., *Ageratum conyzoides, Tithonia diversifolia, Calendula officinalis, Thumbergia* sp., *Erigeron karwinskianus, Brassica* spp., *Cardamine hirsuta, Magnolia* sp., *Oxalis* sp., *Spirea* sp., *Datura* spp., *Solanum* spp., *Cestrum* spp., *Cyphomandra betaceae, Rubia* spp., etc.

AUTUMN –

Michelia spp., *Brassica* spp., *Sedum multicaule, Ageratum conyzoides, Citrus* spp., *Begonis* spp., *Berberis* spp., *Linaria* spp., *Trifolium repens, Desmodium* spp., *Gynocardia odorata, Dichroa febrifuga, Holboelia latifolia, Michelia* sp., *Magnolia* spp., *Passiflora* spp., *Primula* spp., *Rosa* spp., *Prunus* spp., *Rubus* spp., etc.

So the present work signifies the importance of apiculture in this floristically rich region. Manifold benefits like getting both pleasure and profit, food and nutrition at the same time maintenance of ecological balance will be achieved through this goal.

Chapter Six

Summary

The present study incorporates a qualitative and quantitative pollen analysis with biochemical investigation of 67 natural (squeezed and extracted) honey samples from the forests nearby agricultural areas of Sikkim and Sub-Himalayan West Bengal during the period of 1995 to 1998. Of the 67 samples, 65 included honeys of *Apis cerana indica* F. and rest 2 were of *Apis florea* F. The investigation was undertaken in order to identify the chief bee foraging plants, to recognise types of honey *viz.* unifloral or multifloral, quality of honey and to identify areas suitable for bee keeping industry where most of the economically backward tribal people like Lepcha, Tamang, Sherpa and others live. The study may also serve to indicate the geographical source of the honey samples collected widely from different areas with rich and characteristic flora.

The quantification of the pollen types and categorisation of the honeys were carried out according to the methodology recommended by the International Commission for Bee Botany (Louveaux *et al.*, 1978). Four frequency classes were recognised by the commission *viz.* predominant pollen types (> 45 %), secondary pollen types (16 - 45 %), important minor pollen types (3 - 15 %). and minor pollen types (< 3 %). The honey dew elements were studied from unacetolysed honey samples. The absolute pollen count of the honey samples were determined following the method adopted by Suryanarayana *et al.* (1981).

Of the 65 *Apis cerana indica* F. samples 7 were of Winter honeys (Honey Flow Period I during the months from November to February), 40 were of Summer honeys (Honey Flow Period II during the months from March to June) and the rest 18 were of Autumn/Monsoon honeys (Honey Flow Period III during the months from July to October). Rest two samples (No. 66 & 67) of *Apis florea* F. were of Summer honeys.

Of the 40 summer honeys of *Apis cerana indica* F. 15 were found to be unifloral and rest 25 were found to be multifloral. The dominant pollen taxa representing the unifloral honeys during summer were *Citrus* spp. (54.22 % in Dzongu honey), *Rosa* spp. (66.66 % in Damthang honey), *Ageratum conyzoides* (50 % in Jaldhaka honey*), Rubus* spp. (52.15 % in Kagay honey), *Buddleja asiatica* (51.09 % in Lingee honey), *Prunus* spp. (56.79 % in Mitiali honey and 88.8 % in Tendrabong), *Milletia* spp. (70.73 % in Makum Busty honey), *Primula* spp. (51.21 % in Soreng Busty honey), *Calendula officinalis* (55.94 % in Sumbuk honey and 66 % in Sumbaria honey), *Schima wallichii* (57.7 % in Solak Busty honey), *Trifolium repens* (51.5 % in Dudhia Tea Estate honey), Fragaria spp. (54.91 % in Seed Farm honey) and *Potentilla* spp. (45.06 % in Todey honey). Pollen taxa in unifloral honeys during winter were *Aristolochia* spp. (52 % in Ecchey Busty honey) and *Rosa* spp. (78.5 % in Samsing honey). Unifloral samples during autumn consisted of the pollen taxa like *Michelia* spp. (85.36 % in Khamdong honey), *Brassica* spp. (58.29 % in Rabitar honey), *Sedum multicaule* (50 % in Rimbick honey), *Schima wallichii* (51.63 % in Sangsay honey, 65 % in Sakyone honey and 60.15 % in Dr. Graham's Homes area honey*), Prunus* spp. (50.22 % in Payong honey) and *Ageratum conyzoides* (55 % in Chibo busty honey).

Of the two summer honey samples of *Apis florea* F., one was unifloral with *Trifolium repens* as the dominant pollen source (82.7 % in Pabong honey) and another was multifloral in nature.

A total of 166 pollen types referable to 78 families were recovered from the honey samples of which 142 pollen types, represented the summer honeys, 60 the winter honeys and 91 the autumn honeys.

On the whole 310 (approx.) bee forage plants were recognised of which ±262 were entomophilous, ±44 were amphiphilous (pollinated by both insect and air) and ±7 were anemophilous in nature.

Of the 65 honey samples of *Apis cerana indica* F. 51 samples were graded as Group I (APC, < 20000/10 gm honey), 13 samples as Group II (APC,20000 – 100000/10 gm honey) and rest one sample of seed farm area of Kalimpong as Group III (APC, 100000 – 500000/10 gm honey).

Of the two *Apis florea* F. honey samples the Pabong sample (PABH) was graded as Group III (APC, 463767/10 gm) and the other from Lathpancher (LPH) as Group II (APC, 25862/10 gm honey) honey.

Physicochemical characterisation of 25 honey samples of *Apis cerana indica* F. and 2 honey samples of *Apis florea* F. were made adopting standard analytical methods. Samogyi, 1945) and were estimated. Specific gravity and pH of the honey samples were measured using hydrometer and pH meter (digital) respectively. Of the 25 samples of *Apis cerana indica* F. total sugar (both levulose and dextrose) was found to be highest in the seed farm honey sample of Kalimpong (762.5 mg/gm) and lowest in the Khamdong sample (130.0 mg/gm). Total amino acid was found to be highest in Rimbick sample (14.0 mg/gm), total proteins was found to be highest in Damthang honey (102.5 mg/gm). Both the honey samples of *Apis florea* F. showed highly acidic in nature having low pH (3.42 – 3.73) value and high amount of total amino acids 14.2 mg/gm in Lathpanchar honey and 13.6 mg/gm in Pabong honey).

The total water soluble protein and unidentified matters in both the samples were also found to be higher in comparison to those of *Apis cerana indica* F.

Intoxicating nature of a few honey samples was recognised due to presence of some intoxicating pollens like *Gynocardia odorata* (eg. 28.81 % in Sangsay honey, 5.19 & 12.8 % in two Pedong honeys etc.), *Bassia butyracea* (eg. 4.8 % in Fifth Mile honey, 3.4 % in Middle Bong busty honey etc.),, *Bauhinia* spp. (eg. 10.5 % in Suruk honey, 9.78 % in Gangtok honey etc.) and *Leucosceptrum canum* (eg. 1.35 % in Hill top honey)

A few honeys were found to have probable toxic effect due to the presence of certain percentages of toxic pollen like *Rhododendron spp.* (eg. 1.0 % each in Damthang and Payong honeys), *Papaver* spp. (eg. 17.7 % in Eleventh Mile honey, 8.5% in Monsong honey etc.), *Aesculus indica* (eg. 0.5 % in Monsong honey and *Croton* spp. (eg. 1 % in Mitiali honey).

Atomic absorption spectrometry was carried out taking three honey samples from three different target zones from pesticidal poisoning of honey point of view. Presence of traces of heavy metals were tested following nitric acid digestion technique and using the model varian AA 575 ABQ. Zinc, Copper, and Manganese were found to be higher than the normal quantity of the same in honey as denoted by Crane in 1975.

Ethnic use of honey was also investigated from qualitative, medicinal and ritual points of view. It was found that local herbalists, ('Jhankri'/'Gunin') give the 'Putka honey' of *Apis florea* F. more importance medicinally than the honey of *Apis cerana indica* F.

So, the present melissopalynological investigation of the honey samples and overall survey regarding the uses of honey and its importance near the local people favour the possibility of utilizing the rich flora of Sikkim and Sub-Himalayan West Bengal in developing apiary industry for good quality of honey and some honey based ancillary industries. This will create not only employment opportunities for the economically backward classes of this zone but also will help to maintain ecological balance through planting more and more bee plants which will also enhance the crop production through cross pollination by bees.

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