CHAPTER 2

CHARACTERISTICS OF INDIAN HONEYBEES
There exist four different species of the genus *Apis* all over the world. Out of these only one species *Apis mellifera* is indigenous to Europe which has been subsequently transported to America, Canada, Australia, New Zealand, where no indigenous honeybees existed. The other three species are indigenous to India and adjacent countries. Because of the maximum diversity of honeybee species and their concentration, India and adjacent countries are considered as primary centre of origin of honeybees (Deodikar et al 1959 a, 1959 b).

The present work is based upon honeys and waxes of these Indian species of honeybees. Colonies of these honeybees have been maintained and handled for making observations on them and for collection of unadulterated and representative samples of honeys and waxes.

2.1 Habitats of Honeybees:

1) *Apis mellifera*:

These bees are indigenous to Europe. The natural colonies of this species are found in trunks of trees. Thus these bees work in dark enclosures and build seven to ten parallel combs by secreting wax from their wax glands. The size of an average
comb is 45 x 20 cm. There are about 10 hexagonal cells per linear 50 mm. About 20,000 bees are there in a single bee colony. As these bees are domesticated and maintained in wooden boxes since past one century, techniques of colony multiplication, honey production etc. have been standardized.

ii) *Apis dorsata*:

These bees are also known as giant or rock-bees, because of their big size and habit of building huge combs on tall trees and big buildings or below overhanging rocks. In size, these bees are the biggest among all the *Apis* species of the honeybees. There are ten hexagonal cells per linear 55 mm. These bees are wild and migratory in nature. Each colony builds a huge single comb which is exclusively in open. The colony remains at a place for couple of months so long as some flora is available to them and migrate seasonally to new locations leaving back the empty wax comb. An average comb is semi-circular in shape with a diameter of about 1 meter and thickness of 3 cm. There are about 10 to 15 thousand bees in a single colony (*Plate 2.1*). These bees are very ferocious and all attempts to domesticate them or extract honey from them have so far failed. At the end of the honey flow season these bees are driven off from their natural nests and the honey is obtained by squeezing the combs. On an average a single comb
Natural colonies of the Rock bee or the giant Indian honeybees *Apis dorsata*. Couple of dozens of these colonies are seen on big branches of huge trees.

Natural colony of *Apis cerana indica* in the trunk of a palm tree. The colonies of *A. C. indica* build their combs in dark enclosures. The portion of the trunk of the tree is cut open to transfer the combs and bees to a wooden bee box as in Plate 2.5.
yields 10 to 20 kg of honey and 2 to 3 kg of beeswax. These bees are generally found on plains of India and in hilly regions up to 1500 metres above sea level.

iii) *Apis cerana indica*:

These bees are generally found in hilly and forest regions only. They are also found on the plains which are adjacent to hills. But natural colonies of these bees are absent in the plains of Deccan Plateau or Indo-Gangetic Plains. This is a domesticable species among the Indian honeybees. These bees are smaller than *Apis dorsata* and *A. mellifera* bees and measure from 41 mm to 48 mm per linear 10 cells. The peculiarity of these bees in India is that the size of the bees is the smallest in Kanyakumari District (Tamil Nadu) and the biggest in Kashmir valley. Similar to European *Apis mellifera* bees these bees build their combs in dark enclosures, in the trunks of trees, old logs, crevices of rocks etc. These bees build like European bees 7 to 10 parallel and vertical combs in the dark enclosures. The size of each comb approximately measures 20 cm x 15 cm. There are about 15 to 20 thousand bees in a single colony (Plate 2.2). A single wild colony yields 2 to 5 kg of honey by squeezing method. The wild colonies of this species are captured from their natural abodes and transferred to movable frame bee-box. As honey can be repeatedly extracted from these hived colonies, such
colonies yield 5 to 15 kg of honey per year. In this process of honey extraction no bees are killed.

This Indian species of honeybee resembles in many of its habits and behaviour with the European domesticated counterpart *A. mellifera* bees. A single *A. mellifera* colony yields 20 to 40 kg of honey per annum. This is because of constant selection and improvement of the breed of honey bees as also the improved management methods and technology developed during past over 100 years; Indian beekeeping industry is at its infant stage but there are immense potentialities for improving the breed and performance of Indian species of honeybees by adopting scientific methods.

iv) *Apis florea*:

This is the smallest bee of the *Apis* species. Similar to *A. dorsata*, these bees build a single comb exposed to light. The combs are generally built in bushes about 150 to 240 cm above ground level. A comb measures about 20 cm x 15 cm and the ten linear cells measure about 27 mm. There are about 3 to 5 thousand bees in a single colony (Plate 2.3). A single colony hardly gives 50 to 100 g of honey. These bees, like *A. dorsata* bees, are migratory in nature and cannot be domesticated. These bees, therefore, are not very much important from the honey and wax production point of view.
Natural colony of *Apis florea* bees. These colonies are generally seen in bushes or on branches of small trees. The honey portion with white wax capping is seen at the top, worker brood at the centre and drone brood at the bottom. At the edges of the bottom about a dozen queen cells are seen. This typical comb design is found in all the *Apis* spp. colonies.

Natural colony of *Trigona* bees settled in an old wooden box. Like *A. c. indica*, these bees work in dark enclosures. There is no definite size or shape to the combs of *Trigona* colonies. In the plate the brood is seen at the left, while small honey pots (5 to 8 mm diameter) are seen at the right side.
v) Trigona species:

These are distinct honey bees from the Apis species. The Apis bees possess sting and venom but these bees are stingless. Several kinds of these mosquito-like bees are found all over the world in tropical regions. Many species of these bees are found in Latin America and Africa. The number of species of these bees available in India are not known as these bees are not yet fully studied. These bees build separate cells for brood rearing and separate pots for honey storage. The Indian bee colonies of this species, which the author maintained for honey collection could produce 10 to 25 g of honey. These bees build their combs in old logs, crevices in trees, old house roofs, etc. These bees are generally found in the plains of India (Plate 2.4).

Out of the above kinds of Indian honeybees the first two i.e. A. c. indica and A. dorsata are of economic importance from the honey and wax production point of view. A. dorsata, the giant or rock bees are migratory in nature and supposedly ferocious and many efforts to hive them or harness these colonies for honey and wax production without destroying them are not still completely successful. Hundreds of wild colonies of this species of honeybees can be seen on branches of huge trees, big buildings, towers,
arches, water tanks, etc. in cities and on overhanging rocks, big trees, etc. in forests. The colonies of these species can be seen distinctly and thus fall victim to bee-hunters or honey gatherers. *A. c. indica* colonies have their natural abodes in trunks of trees, crevices of rocks and hence are not easily seen and are less destroyed. The wild colonies of these bees with their wax combs are transferred in wooden boxes (Plate 2.5) and maintained in an apiary for honey and wax production. A photograph of a modern apiary taken by the author can be seen in Plate 2.6.

2.2 Colony Organization and Behaviour of Honeybees:

The majority of the hundreds of species of insects in the world lead solitary or unsocial lives, like flies, grasshoppers, etc. Out of the thirty or so orders of insects recognized by animal taxonomists, only two orders, the Isoptera (white ants) and the Hymenoptera (honeybees and wasps) lead an advanced stage of organised communal life (Butler 1963). Even within these two orders of insects, the highest degree of social and communal life is found in honeybees of *Apis* species. In their colonies there are well marked caste systems in which two female castes, (1) Queen and (2) Worker and (3) one male caste—Drone are present. All these castes in a bee colony differ in many respects,
A modern bee box
Natural colonies of *A. c. indica* are transferred in such boxes. The main parts of the box are (1) Floor board, (2) Brood chamber, (3) Honey chamber and (4) Cover.

A modern apiary
A location where a group of *A. c. indica* colonies are maintained in this fashion is known as 'Apiary' and the honey extracted with centrifugal machines is known as apiary honey.
to be able to carry out well defined and different tasks necessary for the survival of a colony. The lives of its individual worker bees are short from 6 weeks to 6 months. The life of a queen, however, is up to 2 to 3 years and the life of a male bee is for couple of weeks only. The individual caste of a colony may die but the life of a colony as a whole is perennial. This is because of the well defined division of duties between the three castes of bees, as also a well defined division of duties among the worker bees themselves.

The nests of honeybees of Apis species consist of one or more vertical combs containing hexagonal cells, the size of the cells varying from species to species. The hexagonal cells are constructed on both sides of the central base. Each side of the hexagon is shared by one side of the another adjacent hexagons. This design provides (i) maximum utilization of space, (ii) maximum structural strength and (iii) minimum requirement of wax. These cells are used for honey and pollen storage and for rearing broods.

A single colony of Apis species has only one queen, few hundred drones or male bees and thousands of worker bees or sterile females.
Queen: The queen honeybee can be easily distinguished from the worker bees or drones. She is much longer and slender than a worker or drone bees. A young virgin queen of 5 to 7 days old takes a flight and hundreds of drones follow her. During the mating, semen is collected in a special pouch (spermatheca) in the queen's abdomen. In the mating process, the genital portion of the drone gets detached and the drone dies. In this fashion, queen mates with a couple of drones and gets her spermatheca filled completely. Millions of sperms thus collected are stored in spermatheca in viable condition. After 2 or 3 days, the queen starts egg laying using the stored sperms one by one. Once the queen starts egg laying, she does not mate again during her life. A queen lays 500 to 1500 eggs a day depending upon the season. When the queen gets old after 2 years or so, another new queen is reared in a colony and after she is mated and starts egg laying the old queen is killed.

Drone: The drones are blackish in colour and much stouter than either the queen or the worker. The only contribution of the drones to a bee colony is to fertilise the virgin queen. They do not perform any other work in the colony and therefore, become superfluous once the queen is mated. The drones in a colony are, therefore, generally killed by the workers immediately after the mating and commencement of egg laying by
ld or when her spermatheca are again reared in a colony for the colony. Thus seasonally, only during new

sands in number in a colony. 1 the whole colony organization.

The worker bee and the queen zed eggs. Thus from the same the worker bee can be right about by the special e larva which is to be developed female organs.

worker bee is given a coarser but with many other organs tar and pollen, wax glands nding the colony, etc.

a day and after about 21 bee emerges. Hundreds of hundreds of new worker bees of a worker bee varies from on the total labour she puts in.
If a bee is born prior to hectic honey flow season, the life of such bee is about 6 weeks, because of excessive work from dawn to dusk. But if a bee is born in a lean period, her life span increases up to 6 months as there are no flowering plants available in nature and a bee puts in much less labour.

The colony organization of *Apis* bees is very complex, but still is perfectly well organized. There is well defined division of labour among the worker bees. The worker bees perform different duties such as nursing, scavenging, comb building, nectar and pollen collection, etc. During the life span of a worker bee, she has to perform all these duties according to her age group. Bees of about three days old start nursing activity and feeding the queen, larvae, etc. As the age advances, the worker bees take up various duties as building the combs, guarding the colony, etc. and finally nectar and pollen collection. It is very important to note here that bees of different age group though perform different duties in a colony, this division is very flexible and bees of advanced age group are capable of switching on to other duties depending upon the conditions and situation arising inside the colony and outside the colony. The bees instinctly know the important work needed to be done at any particular time for the betterment of a colony and they do it, at times even sacrificing their life. The bee that stings to defend her colony, dies.
Among various tasks performed by the worker bees, the most important are (1) Nectar collection, (2) Pollen collection, (3) Wax secretion, (4) Cross pollination and (5) Defence of colony.

(1) Nectar Collection:

A bee colony consists of about 15 to 20 thousand worker bees. The question arises whether all the foraging bees go out and wander here and there in search of food. If this be so, there ought to be great loss to the colony in terms of time and energy of every worker bee particularly when it is seen that the bee colony though a complex one is still well organised. There ought to be therefore some system whereby least amount of time and energy of the honey gatherers is wasted. It was in 1788, Father Spitzner (Haydak 1966) described certain types of dances which the bees perform on their combs, as a method by means of which bees communicate to the other worker bees the direction of source of honey flow. Further Frisch (1923) carried extensive work on the communication among honeybees and unveiled the mystery of dances and added to one more fascinating behaviour of honeybees.

Within the group of foraging workers, there is a group known as "Scout bees". These scout bees survey the area
within a radius of 1 to 2 km of the colony for the available sources of nectar and pollen. After returning back to the colony these scout bees perform different types of dances on the comb as round dance, sickle dance and wag-tail dance making particular angle with the line of gravity on the comb. This angle indicates the angle made at the hive between the Sun and the source of food. If the source of food and the Sun are in the same direction the dance on the comb is with head of the bee straight upward in the line of gravity. If the source of food and the Sun are in opposite direction the dance on the comb is made with head of the bee straight downward in the line of gravity. Similarly if the source of food is towards left or right of the Sun, the dances are made accordingly to the left or right side of the line of gravity with appropriate angle. The distance between the food and the colony is indicated by the speed of the dance, nearer is the food faster is the dance. The other forager bees sense the meaning of the dances and take a straight flight and reach the sources of food without loss of time and energy (Frisch 1954). Further it has been shown that bees confine their visits to a floral source of single plant species as long as food is available from the source and switch on to another only after the first source has been exhausted. This floral fidelity of bees to plant species (Deodikar 1961) makes it possible to get honey
from a particular plant source as Jambul honey, Til honey, Mustard honey, Litchi honey, Neem honey, etc.

In India there are three different species of honeybees of the genus *Apis* and one more type of bees of *Trigona* sp. In order to exist in the same area closely related species must evolve behavioural and biological differences or else be pushed to extinction by failure to compete successfully. Such differences may be in nesting behaviour, nesting sites, ways of mating, types of flowers visited etc. All these differences and many others have been exploited by honey bees (Kohnieger 1976). Honey extracted on the same day from different species of honeybees show difference in pollen spectrum due to foraging on different plant sources (Phadke 1968).

Bees visit flowers either for nectar collection or pollen collection or for both. India is a vast subcontinent spreading about 3200 km from South to North and 3000 km from West to East and covering tropical, sub-tropical, deciduous, evergreen, sub-temperate and temperate forests, wet and arid zones, etc. Such a diversity in ecological factors leads to a diversity in flowering plant species also, ranging from a typical tropical honey plant as rubber to typical temperate plants as apple, plum, pear, peach, etc. The nectar which is collected by the bees as a raw material for preparing honey is
a flight range of bees,

e general make up or the

is a variation from regions

s chemical composition of

sucrose often associated with

glucose. The nectar also

contains amino acids, organic acids,
s and colouring matters. Since

of the plants, there are minor

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of honey.

ng large number of flowers and
ate 2.7\). A small quantity

o it. The enzyme converts the

ing sugars, glucose and

the colony, the bees

syrup or unripe honey

also few more bees are

sucrose into glucose and

the inverted sugar-syrup,

s of the cases over 50 percent

fermentation. The bees adopt

g this extra moisture as fanning,
Plate 2.7

Laboration of honey by a worker honeybee

The tongue (T) and

Honey-sac (HS).

Plate 2.8

Centrifugal honey extractor

Honey is extracted from the domesticated A. c. indica colonies using centrifugal honey extractor.
passing hot air currents over the combs, exposing the thin film of the honey to the air etc. By these various methods, the water content in the honey is brought down to about 20 percent, and at this stage, the cells filled with honey are sealed with thin wax cappings by the bees. Such sealing of the honey cells is an indication of ripe or mature state of honey. Such ripe or mature honeys do not ferment even after years, if properly stored. In Plate 2.8 is shown centrifugal honey extractor used to get honey from the domesticated A. g. indica colonies.

(2) Pollen Collection:

Bees collect nectar as their energy food. Bees also collect good quantity of pollen which is a sole source of proteins, enzymes, vitamins and minerals. If nectar is not available colony can be fed with sugar-syrup. But there is no substitute for pollen and if pollen is not available queen suspends egg laying, which affects the development of a colony.

The bees set for pollen collection after arriving on the pollen yielding flowers, crawl on them. The body of the bees is hairy and they get, therefore, dusted with pollen. By using the three pairs of legs and by moistening the pollen with some
nectar from the flowers, bees push the pollen downward and backward and finally pack them in a small basket-like structure present in the pair of hind legs (Plate 2.9). A hook-like structure in the pollen-basket of the bees holds the pollen in position and finally two big pellets are seen on the two hind legs of the bees. When the bee is fully loaded with pollen, it returns to the hive, performs some dances with the loads and deposits the pollen loads in a cell. In a peak pollen source as many as 80 to 100 bees with big-pollen loads have been counted by the author entering the hive per minute. More the income of pollen and nectar more is the number of eggs laid by the queen. This makes the colony populous in short period and yields good quantity of honey. Shortage of pollen affects the growth of colony. There are no cent percent substitutes for pollen for filling the natural pollen dearth periods. Preparing a pollen substitute or pollen supplement is of great significance in the beekeeping industry.

During the process of pollen collection, particularly because of the behaviour of bees in collecting pollen, number of pollen grain fall in the nectar of the flower, or the bees while collecting nectar from a particular flower gets dusted with the pollen grains of the same flower. The honey samples, therefore, invariably contain the pollen grains of the flowers
Plate 2.9

A worker honeybee with pollen load
A worker bee loaded with pellet of pollen grains on hind leg, is seen sucking the nectar from the flower. The pollen grains generally get mixed in nectar. The hairy body-parts of the bee get dusted with pollen. This brings about effective cross pollination and also gives clue to know plant sources of honeys.

Plate 2.10

Wax glands of a worker honeybee

The eight wax glands (WG) on the ventral side of the abdomen of the worker bee. The worker bees of 5 to 8 days age group are active wax secretors.
from which the bees have collected nectar and pollen. Microscopical analysis of honey samples thus gives information about the floral source/s of honey. Microscopical analysis of honey besides chemical analysis is, therefore, assuming importance of late (Chapter 5) in judging the quality of honey.

(3) Wax Secretion:

Beeswax is used by the bees to construct new combs and repair old combs. Beeswax is a secretion of four pairs of wax glands (Plate 2.10) possessed by the worker bees under-side of their abdomen and hence is their own product. Worker bees of about 5 to 8 days old are active wax secreters.

The honeybees consume good quantity of honey and clinging together to form a cluster. The temperature of the cluster increases, when the wax glands of the worker bees become active and secrete wax. The liquid wax when secreted solidifies in small flakes, 1-2 mm in diameter. With the three pairs of legs these wax plates are raised to mouth parts. By manipulating these wax flakes with forelegs and mandibles, the bees construct the hexagonal celled combs. A freshly constructed wax comb is semi-transparent and whitish in colour. Later the brood-cells, in which several generations of larval and pupal stages of bees are reared, come in contact with pollen, larval
food, larval excretion, cocoon fragment, etc. and become dark. After the combs become very old and black, bees do not use them for brood rearing. Such old combs are melted over boiling water and filtered to get cakes of beeswax. Beeswax is also obtained from bridge, burr or brace combs in the colony or the cappings of the honey cells.

(4) **Cross Pollination**:

The high degree of development of the sensory capabilities in bees is a result of their exclusive dependence on flowering plants for their food. The flowering plants depend on insects for pollination and the resultant seed and fruit set. Cross pollination and fertilization result in a better seed and fruit set than that by self pollination.

Most of the highly evolved flowering plants show special mechanisms which ensure cross-pollination. The cereals and millets have adopted wind pollination mechanism. These plants produce abundance of pollen which is light and powdery. This pollen is carried by wind to the female part of the flowers in other plants of the same species. Naturally this process involves waste in producing such large amounts of pollen and even then pollination is left to chance, though the probability is very high. In many crop plants like oil seeds, fruits, vegetables, legumes and fodder crops, cross-pollination is
effected by insects. The flowers of these crops may offer nectar or pollen or both and have attractive colours or scents. Attracted by these, the insects visit the flowers and effect cross-pollination. However, most of the insects which visit the flowers may carry the pollen to the flowers of an altogether different species in their next visit. Such pollination cannot result in fertilization and proves wasteful to the plants.

Honeybees with their characteristic foraging behaviour or floral fidelity help in cross pollination of plants in a most efficient way. By their visual, olfactory and guttatory evaluation of available food sources in an area, bees fix up their preference to plant species that provide the best food in large quantities. The information on such food sources is then communicated to the forager bees in the colony. The forager bees then exploit the preferred source as long as it is available. Their successive visits, therefore, remain restricted to the same plant species which is necessary for an effective cross pollination. Honey bees are also known to adopt their foraging behaviour and periods suited to the floral biology of the preferred plant species (Deodikar et al 1976).
Although the role of honeybees in the cross pollination of crop plants has been understood and utilized in many temperate countries, very little work is done on tropical crops. Work on this aspect was initiated during 1958 at the Apicultural Laboratory, Poona and Mahabaleshwar and has since been continued at the Central Bee Research Institute, Poona. The present author has been associated with the programme.

Almost all oilseeds like mustard, niger, safflower, gingelly, sunflower; pulses like tur (arhar), urad, mung; forage legumes like Lucern, berseem, clovers; vegetables like pumpkins, cucumber, snake gourd and fruit crops like melons, apples, pears, oranges, lemon require agents like honeybees for cross-pollination. With indiscriminate use of insecticides, population of many other useful insects is depleting and bees are becoming more and more indispensable insects for controlled cross-pollination and increased crop production.

An assessment of the dependence of a plant species on honeybees for its cross pollination and fruit set is possible by comparing the yield (number of fruits or seeds set per 100 flowers or weight in grammes of fruit or seeds set per 100 flowers) in flowers which are visited by honeybees with that in flowers (i) which are not visited by any insects and (ii) which are visited by the naturally available pollinating insects.
in the locality. For this type of assessment a simple design for experiments on pollination was developed (Deodikar, Thakar and Phadke, 1970). This design proves to be more advantageous compared to the conventional methods used for the same purpose. The method is simple, easy to operate and is inexpensive.

A preliminary assessment of the utility of honeybees in cross-pollination of niger (Guizotia abyssinica), onion (Allium cepa), bringal (Solanum melongena), musambi (Citrus sinensis) and strawberry (Fragaria sp.) was made during 1958-62 at Mahabaleshwar and Poona. Niger is highly self-sterile crop and depends on insects for its seed set. An increase of over 1100 percent in the yield was obtained in bee-pollinated flowers of this crop compared to the yields of the flowers which were enclosed in muslin bags to exclude any insect visit. Similarly in onion 150%, in bringal 90%, in musambi 300% and in strawberry 50% increase due to the pollination was observed over the yield due to self-pollination.

(5) **Defence of Colony**:

To defend the colony against the enemies, the worker bees possess a weapon, the sting. The sting apparatus is situated at the end of the abdomen of a worker and workers use it at the cost of their lives to defend the colony. The sting has
inverted barbs (Plate 2.11) to it. When the worker bee stings, the tip of the sting is thrust into the flesh of the victim. Because of the inverted barbs on the sting, it cannot be taken out of the victim's flesh. The worker bee, in an effort to get released from the body of the victim, turns round and round. In this process the sting with the poison sac gets detached from the honeybee's abdomen, and the bee dies soon. The detached sting apparatus, however, has some movements, whereby the sting goes deeper and deeper in the flesh. The poison sac has a pumping action whereby venom is injected in the body of the victim. Bees when try to sting on a hard substance like glass plate a small drop of venom is ejected from their sting. This observation has been used in developing techniques for collection of venom. The author has attempted to construct such unit (Plate 2.12) after the method of Benton et al (1963) for bee-venom collection for exploratory work.

The observations made on the habits, colony organization and behaviour of the honeybees are described in this Chapter. This information is essential for the study of various bee products, in as much as, the composition and properties of the honeybee products are very much influenced by the species of bees and their behavioural responses to environmental conditions and adaptation to ecological systems.
Plate 2.11

THE STING OF A WORKER BEE

Sting of a worker honeybee.

Plate 2.12

A device to extract venom from the honeybees by giving them weak electric shock.