SCIENCE EDUCATION SERIES

No. 20

HONEY PRODUCTION IN SRI LANKA

By

E.F.W. Fernando

NATURAL RESOURCES ENERGY & SCIENCE AUTHORITY
47/5 MAITLAND PLACE
COLOMBO 7

1986

HONEY PRODUCTION IN SRI LANKA

BY

E.F.W. FERNANDO
Senior Lecturer, Department of Zoology,
University of Kelaniya, Kelaniya, Sri Lanka.

November 1986

CONTENTS

FOREWORD TO THE SERIES

The dissemination of scientific information is one of the main functions of the Natural Resources, Energy and Science Authority. The Journal of the National Science Council published by this Authority provides a medium for the publication of scientific research papers, and "Vidurava", the quarterly science bulletin contains scientific articles of a general nature which are of interest to the public.

There is still a wide gap in the availability of reading material on scientific subjects of local interest. One result of this is that science students confine their reading only to their school notes and to the few available text books which are mostly published abroad. In an attempt to improve this situation, the Working Committee on Science Education Research of the Natural Resources, Energy and Science Authority decided to publish a series of booklets on scientific topics of local interest as supplementary reading material for students and the general public. The authors who have been selected by the Committee to prepare these booklets are experts in their respective fields. The manuscripts that were submitted by the authors were examined by referees before being accepted for publication. The views expressed in these publications are those of the authors and are not necessarily those of the Natural Resources, Energy and Science Authority.

I must thank the Working Committee on Science Education Research of the Natural Resources, Energy and Science Authority, and in particular Prof. V. Basnayake who is the Hony. Director of the Working Committee for the work they have done to make this project a success.

R.P. Jayewardene
Director General

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Beekeeping for honey production is an ancient art with honey forming an important part of early man's diet. The developing larvae of honey bees or "broad" was often eaten along with honey stores by bee hunters who raided natural colonies in the forests. Such broad and pollen stores found below the honey stores provided a good source of protein. This practice is followed even today among villagers living in some of the tropical countries of the world who have the practice of hunting in the forest for food.

The honeybee is an insect which depends on the pollen and nectar of flowers for its existence. This mutual interdependence between honeybees and flowering plants could have developed only after the origin of angiosperms sometime around Cretaceous to Tertiary Periods.

The best known genus which is important in relation to the production of honey is Apis. This genus contains only social bees living in closed communities or "colonies" as they are called. This genus of Indo-Malayan origin where both the primitive diploid species Apis florea and Apis dorsata, and the advanced tetraploid species Apis cerana (indica) first appeared. It is also thought that A. cerana may have originated sometime during the Pleistocene Period. During its northward migration by various land routes across the Himalayan barrier, A.cerana seems to have gradually differentiated into a new species Apis mellifera and subsequently into a number of its European African and Sino-Japanese races. During the course of time many of these races have accumulated sufficient genetic differentiation and isolation mechanisms governing sex and behaviour, so as to deserve recognition of new sub-species or even new species among this tetraploid group of bees. During this very long interval from Tertiary to the present period, the process of evolution and consequent differentiation, both in the honeybees as well as in the flowers they pollinate, has exerted several mutual influences reciprocally.

All species of the genus Apis have three distinct castes in their colony, a Queen bee (fertile female), worker bees (sterile females) and drones (males).

SPECIES OF HONEY BEES IN SRI LANKA

Three species of honey bees exist in Sri Lanka. They are :

Apis florea Fab. (the dwarf bee; S = Danduwelimessa)
Apis dorsata Fab. (the rock bee; S = Bambara)
Apis cerana Fab. (the eastern honey bee; S = Meemessa)

Apis florea Fab. is the smallest of the three species and is highly migratory. Their nesting sites are arboreal, building nests on lower sides of horizontal branches of trees or bushes affording much protection and shade. Their nests are never built in high and inaccessible positions as in the case of *Apis dorsata*. The nest always consist of a single comb and is exposed to the outside environment.

Apis dorsata is the largest of the three species of honey bees in Sri Lanka. The nesting sites are also arboreal and exposed as in *A. florea*, but they are built in high, inaccessible positions. Here, too, the nest consists of a single comb, but several indepenmdent colonies of bees may be seen in very close proximity to each other.

Apis cerana Fab. is the popular honey bee, and in size, this species is intermediate between the two above mentioned species. This honey bee is not migratory and the nest very often consists of several combs built parallel to each other inside spacious crevices and deep hollows of large tree trunks and other secluded spaces. It is this feature of living in more or less closed spaces that has contributed to the domestication of this species of bee in man-made bee hives.

GENERAL FEATURES OF APIS CERANA

The honey bee is a social insect living in a nest or hive comprising waxen combs drawn out on each side into hexagonal cells. This whole structure contains a colony or community of individuals comprising different forms or castes in different stages of development. The bee colony consists typically of a single, large, fertile, egg-laying Queen bee, a very large number of sterile but highly efficient Worker bees and a few male bees or Drones whose only function is to fertilize new queen bees. The queen a few days after emergence from her special pupal cell, leaves the colony on her nuptial flight and mates with a drone in the air. After mating is accomplished she returns back to her colony and starts laying eggs in the combs. A single egg is laid in each cell, the fertilized eggs giving rise to worker bees while unfertilized eggs giving rise to drones.

The eggs of *Apis cerana* hatch out in three days and the immature stages last 19-21 days for a worker bee, 22-24 days for a drone and 12 - 15 days for a queen bee. The duration of post emergence or adult life is about six weeks for the workers, 2 months for drones and 2 - 3 years for a queen. The egg-laying power of the queen usually declines after the second year of her life.

The larva is curved, white in colour and maggot like in form with a small head, three thoracic and nine abdominal segments. It is apodous, very sluggish and moves but little and shows a degeneration of the organs of special sense.

These features are associated with the fact they live in darkness and are supplied with an abundance of nutriment in their immediate vicinity, there being no necessity to seek for it.

The larvae are at first nourished on a rich nutriment containing 40-43 per cent protein secreted by the hypopharyngeal glands of worker bees. The larvae which give rise to queen bees are fed upon this diet throughout life until pupation, while those destined to produce worker bees and drones (males) are nourished upon honey and pollen from the fourth day onwards (Richards & Danes, 1977).

The subject of sex-determination is a highly complex one and it has been established that drones are produced from unfertilized eggs and from eggs laid by virgin queens, while workers and queens are produced from fertilized eggs.

In A. cerana the worker bee has a yellow, striped, tapering abdomen on a reddish brown background while the drone is larger and stouter than the worker, has larger eyes, a rounded abdominal end and is of a grey-black colour. The queen bee is similar in appearance to the worker bee but somewhat larger and has a longer abdomen extending some distance behind the closed pair of wings. She performs none of the functions carried out by worker bees like comb building, brood care or food gathering and the organs specialized or adapted for such purposes in the worker honey bee are not specially developed.
The general structure of the honey bee follow the basic pattern of a typical insect, consisting of a head bearing mouth parts, a pair of antennae and a pair of compound eyes, a

3-segmented thorax with two pairs of wings and three pairs of legs, and an abdomen, but with several modifications adapted to its highly specialized mode of social life.

Some important anatomical modifications seen in the honey bee are as follows:

1. <u>Mouthparts:</u> The mouthparts are specially adapted for sucking up of its liquid food, nectar, and water. It is formed by the elongation and union of the glossae of the upper lip or labium, to form a slender protrusible tongue working in a food channel formed by the fitting together of the alongated maxillary galeae and labial palpi. This food channel is continuous with the pre-oral cavity which has been modified into a sucking pump or cubarium situated in the head. In feeding on nectar the mouthparts are brought together to form a functional proboscis, the base or proximal end of which is held firmly between the pair of mandibles while its apex or distal end is inserted into the nectary of flowers. The nectar is drawn into the proboscies by the rapid back and forth action of the tongue after which it gets sucked up by the muscular action of the cibarium. When not in use the mouthpatts are separated and remain folded back behindd the ventral region of the head .

The small pair of mandibles is used only for the manipulation of pollen and wax.

2. <u>Legs:</u> The legs are adapted, in worker bees other than for walking on the combs, for collecting and carrying pollen loads from flowers into the hive. The first tarsal joint of all the legs are provided with stiff hairs and function as pollen brushes for the collection of pollen grains from the anthers

of flowers as well as those adhering to its body during foraging. The hind tibiae of the third pair of legs of the worker bee are provided with long, stiff hairs or setae to form pollen baskets which can hold large pellets of pollen formed by the aggregation of the pollen grains collected by the wide, flat pollen brush situated in the 1st tarsal joint of the hind leg and then transferred to the tibiae of the opposite leg to be carried back into the hive.

3. <u>Wax secreting glands:</u> The ventral or sternal plates of the fourth, fifth, sixth and seventh abdominal segments are formed in an overlapping manner to form pockets in which specialized wax-secreting glands are situated. The fat cells and cenocytes (certain large cells dispersed among the fat cells) situated within the body of the worker bee which play a major role in the synthesis of beeswax. Certain biochemical substances produced in these tissues pass to the wax glands and are subsequently secreted as beeswax. Beeswax has been found to contain approximately 13 percent of free long-chain fatty acids, 12 percent paraffins and 72 percent esters.

4. <u>Nassanoff's gland:</u> This is a specialized odoriferous gland found in the worker bees and situated beneath the intersegmental membrane between the tergites (dorsal plates) of the sixth and seventh abdominal segments. It is usually concealed beneath this tergum, and when it is to be exposed the segments of the abdomen behind the sixth segment is depressed downwards. The scent from the gland is dispersed by the simultaneous vibration of the wings, thus sending current of air over the gland. The scent produces an odour specific to the colony. This dispersion is done at the entrance to the hive, usually by foraging worker bees indicating a floral source or by scout bees during recruitment to a new colony site.

5. <u>Sting:</u> The sting is the modified female genitalia or ovipositor of the honey bee. It consists of basal movable plates connected with a pair of curved rami to a tapering shaft made up of a dorsal stylet and two ventral lancets. Enclosed between them is a poison canal leading from a posion gland situated in a cavity in the bulb of the sting. The lancets of the sting are barbed at the distal ends and are provided with pouch like valves at their base which serve to conduct the poison from the bulb into the channel of the shaft when the lancets are pushed into the victim during the process of stinging.

When a honey bee stings, it injects about one microlitre of a 30 percent protein solution just below the skin and causes, in most people, a small area of painful irritable inflmmation. The honey bee venom has only five major constituents, three basic peptides (melittin, apamine and mast-cell degranulating peptide) and two enzymes (phospholipase A_2 and hyaluronidase).

When the poison from the sting enters the tissues of the skin, the mast-cell degranulating peptide provokes the release of histamine from the mast-cell granules storing it present in the skin. At the same time, melittin, which constitutes half the dry weight of bee venom, also liberates histamine by a complex reaction involving phospholipase enzyme. It is the release of this histamine which causes inflammation of the tissue after one gets sting by a bee. Histamine also causes anaphylactic shock in the victim. The enzyme hyaluronidase presenting bee venom depolarizes the hyaluronic acid or mucin found in the tissues and this process hastens the spread of liquids along with the toxin in the body fluids of the stung victim (Kreil, 1978).

Since bee venom acts mainly by the release of histamine into the tissues of the victim, anti-histamines can be used to counteract the effects of bee stings.

6. Hypopharyngeal glands: These are highly specialized, paired glands present in the head cavity of the worker honey bee, but vestigeal in the queen bee and absent from the male. The glands consists of large numbers of solid lobules attached to a coiled tube appearing like a bunch of grapes when fully developed. They open into the mouth cavity by a duct at the base of the hypopharynx.

These glands secret a protein-rich nutriment which is referred to as "brood food" or "Royal Jelly" and is the food given to developing queen bee larvae throughout their larval development period and to worker and drone larvae only in the initial stages of larval development.

The hypopharyngeal glands undergo changes in development which are associated with changes in the behaviour of the worker bees. The newly emerged adult worker bee has poorly developed glands, but when they commence to feed on pollen, their only source of protein, after the second or third day after emergence from the pupal cell, these glands become highly enlarged due to the formation of the larval food material within its tissues. During this period of development of the glands, the young worker bee takes on the function of a nurse bee, feeding the young larvae. Subsequently, when the worker bee starts, functioning as a field bee foraging for pollen and nectar, they cease to feed on pollen thereby causing the glands to retrogress giving them a wrinkled appearance. (Richards & Davies, 1977).

7. <u>Mandibular glands:</u> These are a pair of sac-like glands situated in the head and attached to the mandibles. A duct from the gland on each side opens into a depression at the base of each mandible. The mandibular glands are well developed in the queen bee where they produce the all important phrtpmonrd concerned with colony control. They are vestigeal in the drones while in the worker bees these glands produce a salivary secretion which serve to soften the pupal cocoons at the time of emergence.

Pheromones are glandular secretions discharged externally which stimulate a reaction in another individual of the same species which results in a modification of the behaviour or the physiology of this individual. In honey bees Pheromones serve the important function of controlling sexual and social behaviour in a way beneficial to the progressive development of the colony.

The pheromones released by the mandibular glands of the queen bee function as:

1. a sexual attraction for drones towards queen bees for mating.
2. an attractant which induces clustering among worker bees within the colony and in swarming.
3. an inhibitor of queen-ceel construction.

8. <u>Sense organs:</u> The sense organs of the honey bee, particularly in workers, are composed of individual or groups of sensory cells or sensillae highly specialized to perform specific functions.

The sense organs governing taste and odour are distinguished by special sensillae distributed chiefly on the antennae and legs. Those organs responsible for vision, the visual sensillae, are grouped to form special visual organs, the compound eyes and ocelli. The compound eyes of bees produce a mosaic image which is sensitive to form but blurs with distance. It is very sensitive to movement in the field of vision and is also sensitive to colour (except red), ultra-violet and polarised light.

9. Alimentary canal: The alimentary or food canal has special modifications, as follows: (Richards & Davies, 1977)

(a) specialization of the pharynx to form with the cibarium, a sucking pump.
(b) the expansion of the crop to serve as a honey stomach for receiving, transporting and holding nectar until converted into honey.
(c) a well specialized proventriculus for sifting out pollen grains from the nectar injested.
(d) head anbd thoracic salivary or labial glands whose secretion contain an enzyme, invertase, essential for the conversion of nectar into honey.

Reproductive system: The reproductive system is very well developed in the drone and the queen honey bee, but vestigeal in the sterile worker honey bees.

Table : 1. Life-cycle stages (in days) of the three castes in the honey bee, *Apis cerana* F.

Stage	Worker bee	Drone	Queen bee
Incubation period	3	3	3
Larval period	5	6-7	7
Pupal period	11-13	13-15	7-8
Total period	19-21	22-25	12-16

DIVISION OF LABOUR IN A HONEY BEE COLONY

As is well known, bees are social insects and the highest degree of such a social development and specialization amongst them is shown by honey bees of the genus Apis, in which a very distinct caste system and a division of labour is found. They live in a community or colony with only a single impregnated reproductive female or "queen".

In nature, the nest consists of a few combs fixed to the roof and sides of a cavity or hollow of a tree trunk in which the colony lives, and suspended vertically downwards. The dimensions of these combs are adapted to the size of the cavity. Each side of the comb is made of hexagonal worker brood cells, which are of the correct size for rearing their larvae or "brood", with patches of slightly larger drone cells among them during the swarming season.

The centre and the lower centre of the nest is mainly filled with larvae or brood in various stages of development, eggs stuck to the bottom of the cells, one in each cell, very young larvae resting on a white mass of brood food with older larvae tightly curled up in their cells, and pupae sealed under their brown cappings.

The upper parts of the centre combs are often stored with pollen and honey, while the outer combs are partly filled with patches of pollen and honey beside the brood.

There is very strong and abundant evidence in support of the belief that a very efficient, automatic division of labour exists among the worker honey bees of a colony. This division of labour is based mainly upon the age of the worker bees and their physiological state.

After the emergence of the worker bees, under normal conditions, the first two to three weeks of adult life are occupied with duties within the hive, and the remaining three to four weeks foraging for pollen and nectar. Very often a resinous substance called propolis is also collected by these worker bees and used for sealing up small spaces or cracks that may occur within the hive.

The activities of the young worker bee when she is occupied with duties in the hive can be distinguished into different phases.

1. During the first three days of adult life the young worker solicits food from the older worker solicits food from the older worker bees (but never helps herself to food stored within the hive) and cleans out empty brood cells making them suitable for the queen bee to lay her eggs, one egg per cell. When not occupied with such duties these young worker bees rest on the surface of the combs. This phase of resting has been considered to be an important function as it is believed to incubate the brood.

At the end of the cell-cleaning period of her life the young worker bee commences to feed on pollen and honey stored in the combs. The consumption of large amounts of pollen causes the enlargement of the hypopharyngeal gland in the young bee which in turn produces a highly nitrogenous secretion forming the food of the developing larvae or brood. This stage generally commences about the fifth to sixth day of adult life and continue until the worker bee is about fourteen days old.

Once the nursing period is over the hypopharyngeal glands become very much reduced in size and simultaneously, the wax glands situated on the under side of the sixth, seventh and eight abdominal segments become activated and commence to secrete wax for the purpose of building combs. This activity usually takes place until the workers are about nineteen days old.

After this period, they commence to fly out of their hive, and the first few flights are referred to as orientation flights. During this period the worker bees learn to orientate themselves and when they are about three to four weeks old, they know the position of their hive in relation to other objects around it.

Thereafter, she becomes a field worker bee and devotes the rest of her life of about another three weeks, to foraging in the field for pollen, nectar and water. In addition to these functions, they also help in the deposition of pollen and nectar in the cells of the comb, and even guarding the entrance of the hive against intruders.

Thus it is clearly seen that both within the hive and outside in the field, every worker has her own specific duty to perform in the intext of her colony. The nature of the duty which she performs of any particular time is largely determined by that state of physiological development which she has attained at that time.

Drones do not work or attend to any of the hive duties and are usually fed by worker bees from food stores in the hive.

The queen bee is continuously fed and attended by workers. The queen, apart from laying eggs, also secretes certain specialized pheromones, referred to as "queen-substance" from her mandibular glands. These pheromones are responsible for the unity or cohesion of the bee colony. (Clark, 1951; Butler, 1952)

HONEY BEE FLORA

The life of the honey bee is affected to a great extent by the availability of forage (pollen and nectar) and also by climate. A study of the availability of honey bee forage in different climatic regions and within various forest communities in the country is of utmost importance in determining the suitability of a particular region for apicultural practices.

For the purpose of honey production, Sri Lanka could be broadly divided into the following ecological regions:

1. Low country dry zone - comprising of the north-western, north-central, eastern and south-eastern regions of the country.
2. Hill country dry zone - comprising of the Uva province eg. Bandarawela, Diyatalawa, Badulla and Welimada district.
3. Low country wet zone - comprising of the Sabaragamuwa, Western and Southern regions of the country.
4. Mid country wet zone - comprising the central regions, including Kegalla, Gampola, Peradeniya, Kandy, Pussellawa, Teldeniya districts.
5. Up-country Wet zone - comprising of the Nuwara Eliya, Talawakella, Ragala districts.

The availability of pollen, the only source of protein available for the worker bees for feeding the brood, and the amount of honey produced in the hive will depend on the pollen and nectar producing flowers available to the bees within a limited foraging range of approximately half a mile of the hive. Therefore, as a primary requirement for successful maintenance of honey·bee colonies, it is necessary to acquire a good knowledge about the surrounding flora, its component species and their value to bees, their flowering seasons and the duration of flowering of these various species. With these data, a floral calendar showing a detailed record of the flowering sequence of such species important to bees throughout the year in a specified locality could be maintained. The identification of pollen samples collected weekly from the pollen baskets of the legs from foraging worker bees from representative locations would also help to ascertain accurately the relative abundance duration and the importance of the different species.

Temperature, climate and rainfall exercise a considerable influence on bee keeping, both by the direct effects on the activities of honey bee as well as indirectly through the effects on flowering and consequently on the availability of pollen and nectar for the bees.

The flowering season varies with different plant species, some flowering early and others late, and an many cases with a very marked intensity and periodicity. Many localities of mixed vegetation thus have a continuous succession of different flowering periods, the later blossoms being very often the most profuse in nectar secretion. Such a condition is just what is necessary for the progressive build-up of a honey bee colony leading to an increasing honey reserve towards the end of the productive season. In areas where nectar secretion is over in a limited period or such nectar producing flowers are available only for a short period, this disadvantage could be overcome by shifting the bee colonies to other areas as these come into blossom.

Another feature of importance is a good rainfall distribution followed by an alternate rhythm of warm days and cool nights as often occurs in the hill country. Such conditions act as stimulative factors for copious secretion of nectar by flowers, thereby enabling the beed to gather in their honey harvest in quick succession within a minimum period of time.

The forests and natural vegetation of Sri Lanka are by far the most important part of the honey bee flora in the country and they support very large numbers of wild bee colonies of both Apis cerana and Apis dorsata. Apart from the natural vegetation, distinctive types of homogeneous agricultural crops in Sri Lanka are found like those planted with the major plantation crops of tea, rubber and coconut and reserves of man-made forests maintained for timber.

The only potentially for nectar secretion in tea plantations are the shade trees of Albizzia spp., and Grevillea spp. and Eucalyptus spp. maintained for obtaining fire wood.
The importance of rubber plantations is in the availability of nectar secreted from the extra floral glandular nectaries situated at the base of the young leaves. This secretion takes place only when the leaves are young and usually occurs from the latter part of February to April, depending on the bud break consequent to satisfactory weather conditions.

Coconut yields much pollen but only a small amount of nectar in Wet Zone districts not in sufficient quantity to allow a collection of significant surplus honey bee colonies. However, large numbers of honey bees visit male inflorescences of coconut that have been tapped to collect the sugary exudate for the preparation of toddy. This exudate is said to contain as much as 75-80 percent sucrose (Pulle, 1975).

With regard to natural vegetation, the rich forest flora, particularly in the dry zone, sustains many natural colonies of all three species of honey bees in Sri Lanka. During the main honey flow season, which usually extends from May to September, those wild honey bee colonies, especially those of A. cerana, are exploited for honey by village honey hunters. Some of the more predominant honey yielding flora in the dry zone are Drypetes sepiaria ("Weera"), Manilkara hexandra ("Palu"), Euphoria longana ("Mora"), Syzygium . spp. ("Domba"("Dan"), Derris spp. ("Kala-wel").

The number of colonies per acre, which can be maintained without any supplementary feeding of sugar syrup, on a plantation depends on the seasonal availability of pollen and nectar around the site. Flowering in coconut is more lr less continuous throughout the year and this is of advantage in off season maintenance of honey bee colonies. During a good honey flow season two to three dozen colonies may safely be accommodated per acre of rubber in the South-Western wet zone or eucalyptus in the hill country, but not more than ten colonies per acre of coconut. In the hill country areas, about 6 lbs of honey may be obtained on average per six framed hive per year during an average honey flow. However, in extensive bee colonies throughout the year to each type of bee floral ecosystem as the "honey flow" commences. Such a procedure of migratory bee farming may be necessary for the production of adequate quantities of honey for profitable honey production.

In addition to the main types of vegetation suitable for bee farming mentioned above, there are various miscellaneous horticultural crops and other species of plants capable of yielding nectar and pollen. These species are useful for bee forage in the absence of large continuous areas of plantation crops. (Baptist, 1976, 1979; Fernando, 1979).

The nectar bearing plants in Sri Lanka may be classidied into three categories:

1. Major honey plants: These are very abundant groups of plants often comprising only of a few species with long periods of flowering and producing abundant nectar secretions.

2. Secondary honey plants: Those which may be copious secretions of nectar individually, but indufficiently plentiful. They are more important on account of the earliness of their flowering than for the quantity of nectar they yield. This light, early honey flow is very valuable in giving the honey bee colonies stimulation of breeding activities for the season.

3. Minor honey plants: These form many species visited by bees which, though individually negligible, yet when taken together have some value as nectar secretors.

As mentioned earlier, a compilation of a floral calender will be very useful to the bee farmer. The objective is to provide the usual flowering periods of the more important honey bee flora in particular parts of the country. A close relationship exists between the weather, the time of floweering of these plants, and the development of honey bee colonies. In the event of any deviations from the average, other ecological or site conditions may be significant. Such a calender may, however, be misleading if it encourages the expectation of a rigid pattern.

Floral relationships could best be studied by analysis of the pollen loads of returning foraging worker components of pollen identified by reference to standard pollen slides for each species of plant maintained in a reference collection. The relative proportion of component pollens are statistically analysed for their spectrum at regular intervals during the season. The pollen spectrum reflects particular association of important honey bee forage flowering synchronously in a specified area. A quantitative analysis may also indicate relative preferences by honey bees for particular species of plants.

Similarly, the analysis of honey samples for its pollen spectrum during the same period can enable one to identify the floral sources of particular honeys.

TABLE 2: Flowering phenology of some major honey bee flora in Sri Lanka (as observed by the author during 1977 and 1978) Contd....

Botanical Name	Local Name	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Feronia limonia (l) Swingle (Rutaceae)	Divul			------	------								
Hevea brasiliensis Muell (Euphorbiaceae)	Rubber			------	------								
Madhuca longifolia (L) J.F. Macbr. (Sapotaceae)	Mee						------	------					
Manilkara hexandra (Roxb.) Dubard (Sapotaceae)	Palu					------	------	------					
Mallotus albus (Roxb.) Muell Arg. (Euphorbiaceae)	Bukenda				------	------							
Musa paradisiaca L. (Musaceae)	Kehel				All the year round								
M. sapientum L. (Musaceae)	Kehel				All the year round								
Neolitsea cassia (L) Kostermann (Lauraceae)	Davul kurundu				------	------							
Pleurostvlia opposita (Well) Alston (Celestraceae)	Panakka						------	------					

TABLE 2: Flowering phenology of some major honey bee flora in Sri Lanka (as observed by the author during 1977 and 1978).

Botanical Name	Local Name	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Azadirachta indica A. Juss (Meliaceae)	Kohomba -					----	----						
Chloroxylon swietenia DC (Rutaceae)	Burutha					----	----						
Cocos nucifera L. (Palmae)	Pol			All the year round									
Drypetes sepiaria (Wright & Arn.) Pax & Hoffm. (Euphorbiaceae)	Weera				----	----							
Eucalyptus camaldulensis Deheh. (Myrtaceae)	Karpantine				----	----							
E. citriodora Hook (Myrataceae)	Karpantine							----	----	----			
E. grandis Hill ex Maiden (Mycrataceae)	Karpantine							----	----	----			
E. microcorys. F. Muell (Mycrataceae)	Karpantine							----	----	----	----		
Euphoria longana Lam. (Sapindaceae)	Mora					----	----	----	----				

TABLE 2: Flowering phenology of some major honey bee flora in Sri Lanka (as observed by the author during 1977 and 1978) Contd....

Botanical Name	Local Name	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sapindus emarginatus vahl. (Sapindaceae)	Penela		----	----									
Schleichera oleosa (Lour.) Oken (Sapindaceae)	Kon					----	----	----	----				
Syzygium assimile Thw. (Myrtaceae)	Damba					----	----						
S. cordifolium (Wright) Walp. (Myrtaceae)						----	----						
S. cumini (L.) skeels (Myrtaceae)	Ma dan							----	----				
Tectona grandis L.f. (verbenaceae)	Tekka	----	----									----	----
Terminalia arjuna (Roxb.) Wright & Arn. (combretaceae)	Kumbuk					----	----						
Zyziphus mauritiana Lam. (Rhamnaceae)	Debera					----	----	----	----				

THE DOMESTICATED BEE HIVE

For several hundred years there have been people interested in rearing honey bees under domesticated conditions, and hives of various materials like straw, wood, glass, etc. which could be opened were used. Most of these hives were referred to as skeps. But to remove a honey comb it had to be cut out which partly damaged the comb and even the brood. However, towards the end of the eighteenth century a Swiss naturalist by the name of Huber designed a hive which gave him reasonable access to both sides of every comb and was referred to as a "leaf hive".

Through the first half of the nineteenth century many types of hives were tried in which honey bees built their combs suspended from bars which could be lifted from the hive, but the combs had still to be cut from the sides, which again damaged the combs.

In 1851 an American by the name of Langstroth discovered that honey bees fill all spaces between two combs with wax and propolis but keep clear excessive space between and around the combs with wax or propolis keeping only sufficient space for easy passage between and around the combs for the movement of the bees on adjacent surfaces. Consequently, he introduced a movable frame hive where the frames are hung in such a way that they allow the bees to preserve the correct bee space between and around the combs so as to allow only sufficient space for natural movement. By this bee combs will not be stuck to the hive or to each other, and consequently they can be quickly removed, examined or even interchanged with one another. (Clark, 1951)

This discovery and invention gave a start to modern beekeeping. Since Langstroth's invention there has been no substantial new ideas in the basic pattern or construction of domesticated bee hives, and this pattern with minor modifications where necessary is still being used in various parts of the world.

The bee hive in use in Sri Lanka today is a modified movable frame Newton type hive so named after the designer a Jesuit priest, and which has been in South India. The recommendation of this modification was by Dr. Butler in 1953. It incorporates all the advantages of the Newton type, but restricts the brood box to six frames instead of seven and with the super, half the depth of the brood box, and is referred to as Sri Lanka Standard Hive.

This domestic bee hive consists essentially of the following sections comprising:

1. a lower Brood Box with six removable frames, and resting on a Floor Board, with provision for a restricted Entrance Exit.

2. one or more Super Boxes or "Supers" half the depth of the brood box, also with six removable frames placed directly over the brood box.

3. surmounting the super is a Crown-Board.

4. a Roof placed over the crown board giving protection to all components.

The brood frames measure 11 inches in length and 6 inches in depth while the super frames measure 11 inches in length and 2 3/* inches in depth. The space between two adjacent combs is referred to as the "bee space" and should be 5/16 inches or 9.4 mm. It is essential that this space is correctly ensured for otherwise additional cells may be constructed along this space which will prevent the free removal of the frames for inspection or extraction of honey.

In order to facilitate comb building and to provide additional strength to the drawn out combs, a comb-foundation sheet should be fixed on to the brood and honey frames. Strengthening of honey combs in this manner will be very useful as it would prevent them from breaking away from the frames during the extraction of honey.

The Sri Lanka standard hive has several advantages.

1. It was so designed to provide successive, small but quick crops of honey during the honey flow season.

2. The small size of brood box ensured the covering of all the combs by worker bees in the brood nest, thus maintaining developing brood at the required temperature and also enabling the workers to defend the comb against the deadly wax moth and other unwelcome intruders.

3. The freely removable small sized combs allows greater flexibility for inspection of brood and extraction of honey without causing damage to them.

4. The small sized brooa pox also discourages absconding of colonies after the honey flow season which is often a common occurrence in Sri Lanka.

The dimensions of all components comprising the standard bee hive as adopted in Sri Lanka is given in Figs. 1. to 7.

Special Appliances:-

Some basic appliances which are necessary to facilitate handling and management of honey bee colonies are as follows:

1. Smoker: This is used for generating smoke (using coconut husk, cardboard, cloth, etc.) to subdue bees when a colony is to be opened or manipulated (Fig. 15).
2. Bee Veils and gloves: Many experienced beekeepers do not use a neil or gloves, but they are useful for beginners. Use of such material protects the face and hands from bee stings which could otherwise hinder the operations.
3. Entrance guard: This is a perforated sheet of metal, the perforations being 1/8 inch wide and 3/4 inch long, which allows worker bees but not the queen bee to pass through, especially while the new colony is not yet established (Fig. 10).
4. Queen Excluder: This is a perforated metal contraption fitted to the crown board to allow passage of workers but not the queen to the super chamber, to prevent the queen from laying in the super combs.
5. Comb decapping Knife: (Fig. 11)
6. Porter Bee Escape: This is a metal device fitted at the centre of the crown board in which worker bees could pass in through a round opening on the outer side into a traingular space on each side, bounded by two flexible metal strips which almost meet at their distal ends but can be pushed apart by the bee from inside only allowing an outward passage of the bee but preventing an inward one. This strip should be kept clean and the points at

the two ends adjusted to about one sixteenth of an inch apart. The bottom part of the device could be slided away from the upper part to reach the springs. (Fig. 13).

7. Queen Cages: Small cages made of metal or wood for securing and the gradual introduction of queen bees into colonies (Fig. 14).

8. Feeders: For providing week honey bee colonies with sugar syrup to tide over unfavourable conditions or until honey stores are built up.

9. Honey Extractor: A metal mechanical extractor to enable honey to be extracted from super combs by centrifugal force without causing any damage to the combs. (Fig. 16).

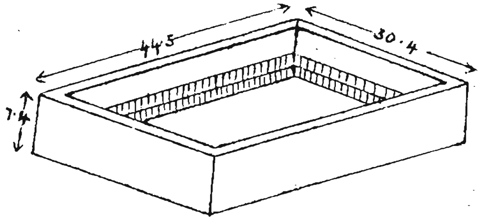

Fig. 1: Roof (with top cover removed)

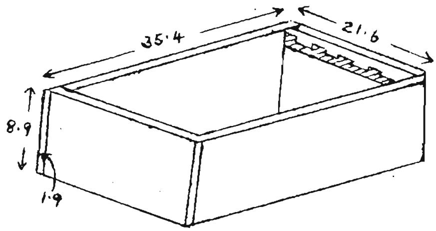

Fig. 2: Super Box

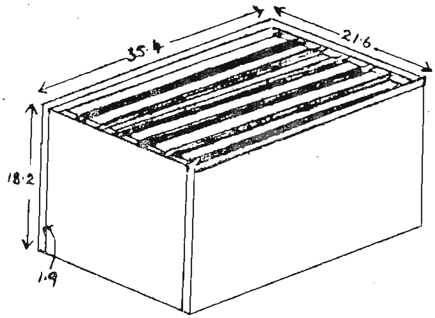

Fig. 3: Brood Box (containing six frames)

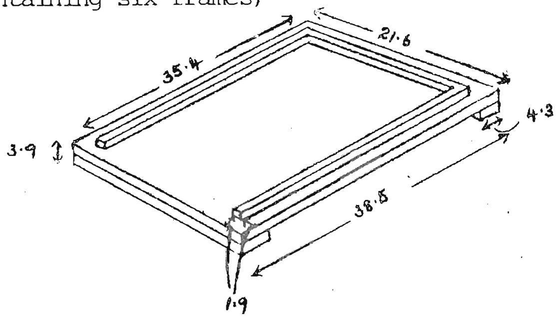

Fig. 4: Floor Board

(All measurements are indicated in centimeters)

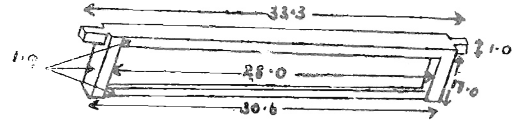

Fig. 5: Super frames.

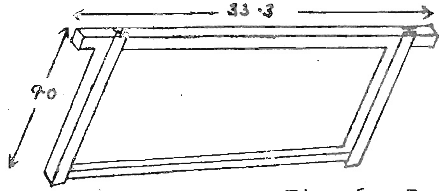

Fig. 6: Brood Frames

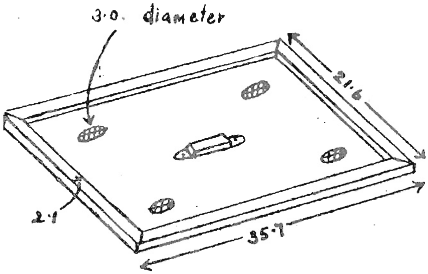

Fig. 7: Crown Board

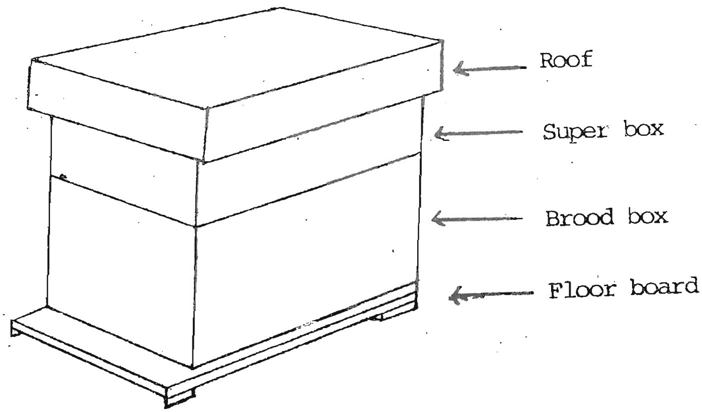

Fig. 8: Complete Domesticated Bee hive

(All measurements are indicated in centimeters)

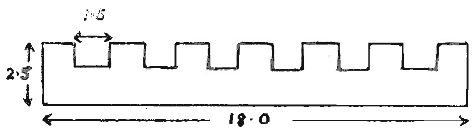

Fig. 9: Frame Spacer

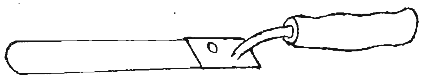

Fig. 11: Decapping knife

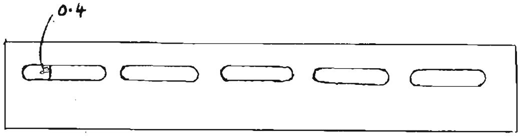

Fig. 10: Entrance guard

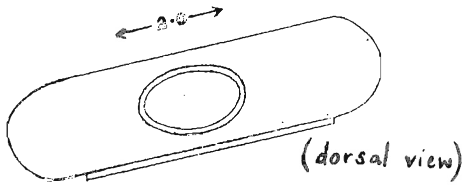

Fig. 12: Porter bee escape

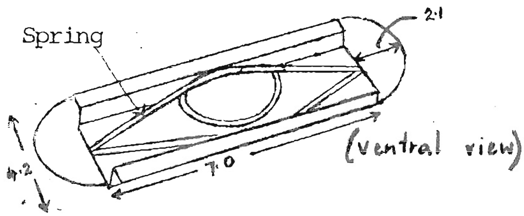

Fig. 13: Porter bee escape

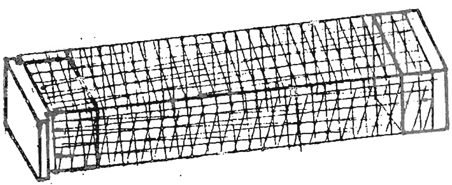

Fig. 14: Queen bee introducer/transporter (natural size)

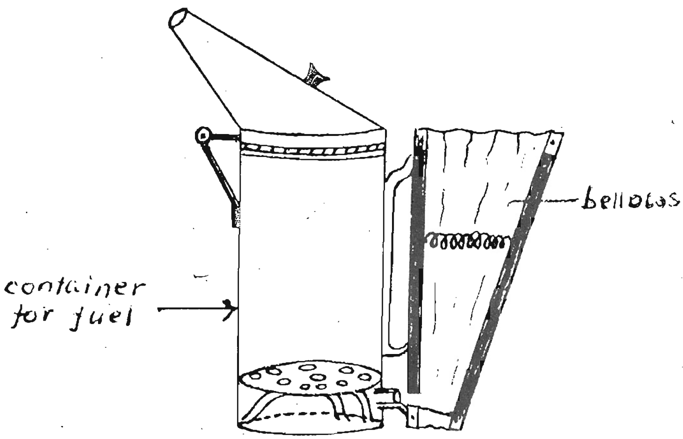

Fig. 15: Smoker

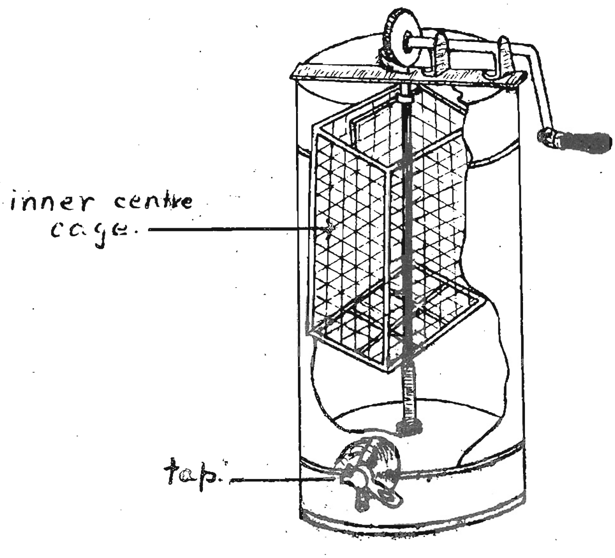

Fig. 16: Honey Extractor (showing internal arrangement)

GENERAL MANAGEMENT OF HONEY BEE COLONIES

1. Every site where a hive is to be kept should be cleaned of ground vegetation and other debris within a radius of approximately three feet of the hive stand.
2. The hive stand should be firmly implanted on the ground so as to allow no movement when the hive is placed on the stage.
3. The stage should be at a height of about 2 1/2 to 3 feet above ground level so as to allow free removal of frames for inspection, transfer, or honey extraction, without causing any undue strain.
4. The hive stand should be treated with persistent insecticide in order to prevent ants or other insects from crawling over to enter the hive. Care should be taken not to allow the insecticide to come in contact with the hive as this will be very detrimental to the honey bees.
5. The hive stand should be so placed under shelter so that the hive is protected from direct sunlight from at least 9.00 a.m. to 3.00 p.m. Where no natural shelter is available, artificial shelter should be provided.
6. The hive must be firmly secured to the hive stand preferably with the entrance facing either South-East or North-West.
7. The hive should have at least one super box.
8. An outer wooden cover should be provided for both brood and super boxes, especially during poor weather conditions like rainly seasons.
9. The roof should be covered with waterproofing material and should sit on the crown board along its entire edge so that no opening is left between the crown board and roof spare.

10. Routine examination of the hive should be carried out every four to six weeks in order to clean the floor board, remove uncovered old board combs, destroy other intruding insects, and ensure that the bees have adequate space for their activities in the brood chamber and super box.

11. In the case of acute congestion of the brood chamber, especially during brighter weather periods, division of the colony may be done if drones are present. In doing this the old queen is removed to a new site with not more than two brood frames, one of which should contain mostly sealed brood and the other a reasonable amount of honey and pollen. It is also advisable to feed the colony with dilute cane sugar solution after it has been moved to the new site.

12. The hive should be checked for requeening within three to four weeks after division, and if not requeened the parent colony joined back to it.

13. The replacement of the queen in any colony with unsuitable tendencies to swarm or abscond or showing poor brood raising ability, should be carried out just before the commencement of the "honey flow".

14. When there are two super chambers, extraction of sealed honey from the supers is done by removing only one super at a time, learning the second with unsealed honey behind.

15. Extra supers not filled with honey should be removed at the end of the "honey flow", taking care to see that bees have some stock of stored honey to tide over unfavourable periods of heavy rain and shortage of food sources. Otherwise the feeding of honey bee colonies with sugar syrup in time of food scarcity may be necessary under exceptionally adverse conditions.

SWARMING

Nature is primarily concerned with the maintenance, multiplication and spread of a species under natural conditions. Man, however, by meeting some of these conditions artificially can eliminate or modify these needs. In bee farming, due to man's control of honey bee activity and the ability to get his stocks to multiply as he requires, the natural characters favouring multiplication and dispersal instead of being useful could often be disadvantageous to him. His real aim of multiplication of the honey bee colonies is to produce a constant maximum honey yield within a minimum period of time and with least financial expenditure.

In honey bee colonies, dispersal or spread under natural conditions is accomplished by a process known as "Swarming". Swarming is the departure of a group of worker bees from a honey bee colony along with its queen bee to another new nesting site, after having made provision in the original colony for the formation of another new queen. The frequency of swarming varies widely between colonies, some sending out several swarms therby making the mother colony to remain in a weak condition, while others send out only a single swarm in a season, and continue to function efficiently, storing relatively large reserves of honey in the old colony.

A good stock of honey bees with an efficient queen does not usually prepare to swarm unless there is a large surplus of worker bees over and above those that are required to maintain the brood-nest. This population increase is not a cause of swarming but only a condition which has to exist before swarming is to take place. Two of the main factors which would cause swarming are:

1. a condition brought about by an imbalance to the decline of the queen bee relative to colony demands, like the inadequacy of the secretion of the "queen substance". It is known that a colony hardly swarms if it has a queen raised during the current season.
2. an inborn tendency to swarm in a particular strain of honey bees, and its reaction to certain extrinsic factors operating. Some of these important extrinsic factors are the availability of ample sources of pollen, nectar, prolonged good weather conditions and inadequacy of the hive of site in relation to colony condition. (Clark, 1951).

Supersedure Swarming: The bees often have a better way of replacing an old queen bee than waiting for her to fail in her duties. They rear one or more queen cells without any ot the usual preparations for swarming. This virgin green emerges and after mating returns back to the colony and starts to lay her eggs amicably in the same brood nest in the presence of the old mother queen. However, after a few days the mother queen disappears from the colony. Such a phenomenon is referred to as a supersedure. This supersedure of the old queen commonly occurs during the latter part of the honey flow season when the normal impulse to swarm has s=dwindled away. But if the colony stock of bees is strong, supersedure during the peak season is likely to cause a swarm, the one-cell queen being followed by a few other cells, the old queen bee flying off with a swarm, and superseded later on.

If the queen is old or inefficient, this supersedure impulse may change to the swarming impulse at any stage and then there may be a very small swarm leaving the colony that is not really fit to swarm at all.

Swarm control and Reuniting a honey bee colony:

1. In order to ensure the life of the colony, the old queen bee must be replaced every one or two years. This would occur naturally by swarming, in which case, the natural swarm with the existing queen can be captured when the swarm temporarily suspends itself on a branch of a nearby tree soon after leaving the parent hive. This captured swarm could then be placed in a hive with brood frames.

2. An artificial swarm with one or two brood frames containing a good population of worker bees is removed with the existing queen when queen cell construction occurs in the hive.

3. A swarm, natural or artificial, which is later deprived of its queen and when reunited with the parent stock usually makes a first rate honey bee colony. A nucleus colony is prepared from the existing stock of bees as soon as it is strong enough, and a queen-cell is provided to the necleus. When the young queen commences laying, a fair proportion of worker bees along with brood are gradually transferred from the old stock to the nucleus colony. Just before the onset of the main honey flow, the old queen is removed and they are reunited.

4. The tendency for secondary swarms to emerge from a well established honey bee colony can be prevented by destruction of excessive queen-cells.

5. The prior clipping of thw wings of the original queen bee normally ensures the return of the primary swarm. However, prompt action must then be taken to prevent a swarm escaping with one of the new queens.

It should be borne in mind that requeening of colonies with stock from high yielding productive strains should be done only in the honey-flow season which would create large, strong colonies during the major honey-flows, and also minimise swarming during such periods.

In requeening, the old queen bee must be removed with one or two frames of worker bees and brood together with a frame containing pollen and honey stores to an empty brood chamber. This fragmented brood chamber should be taken away to a fair distance from the original site of the colony. It should be supplied with adequate drawn out brood combs and the colony fed with sugar syrup to offset any temporary absence of foraging worker bees. A queen guard should be placed at the entrance to the hive for at least two weeks or until the risk of desertion is eliminated.

The most suitable time for requeening is within three weeks of the appearance of drone cells on the brood combs. These drone cells are groups of large, capped cells projecting a little out of the comb in contrant to the surrounding smaller brood cells. With the absence of the old queen bee the worker bees will commence building queen cells in the lower region of the brood combs. These queen cells have a characteristic appearance, being much larger than worker or drone brood cells and are shaped like a thimble attached to the surface of the brood comb.

If, however, due to some reason or another requeening does not take place within four to five weeks, the contents of this colony should be rejoined with the fragmented brood chamber.

<u>Absconding or Desertion</u>: A common problem among bee farmers in Sri Lanka is the absconding or desertion of honey bee colonies from their hives. This phenomenon should not be confused with reproductive swarming mentioned above. During desertion all bees in the colony leave the hive except those few that are too young to fly. Absconding occurs especially during the onset of rainy periods and when the honey-flow season has come to an end.

Some of the main factors responsible for desertion are:

1. Lack of food stores (honey and pollen) in the brood nest to tide over unfavourable periods.
2. Unfavourable environmental factors, especially rain.
3. Unsatisfactory position of the hive in relation to the surrounding environment.
4. Frequent disturbances to the colony.
5. Offensive odours around the site in which the honey bee colony is situated.
6. Invasion of the colony by pests or intruders like the wax moth, ants, wasps, cockroaches, geckos, etc.
7. Undue congestion in the colony.

Some measures to prevent such absconding involve the ensurance of a good colony capable of effectively protecting itself against inclement weather and the above-mentioned unwelcome guests, providing adequate accommodation for increase in size of the bee colony without undue congestion, and also providing the colony with sugar syrup if there is insufficient food storage, especially during unfavourable weather conditions.

NECTAR

The food of both the larval and adult honey bee consists of pollen, which supplies the main protein component fats, and nectar or honey, supplying all the carbohydrates and mineral requirements.

Pollen is obtained from dehisced anthers of flowers while honey is transformed or elaborated from nectar, which is a sugary liquid produced by nectaries consisting of groups of glandular secretory cells occuring in many flowers. These nectaries are usually situated within the flowers at the bases of petals or corolla tubes. But in certain plants such nectaries, referred to as extra-floral nectaries, are found on the calyx of flowers or on certain parts of leaves.

Nectar, whatever may be its source, consists essentially of three important sugars, Sucrose (a disaccharide), Glucose and fructose (monosaccharides) in various proportions. In addition to these sugars there are various other substances like enzymes, essential oils, organic acids, minerals, etc.

Most nectars collected by honey bees usually contain around 30-40 percent sugar and 60 percent water and it has been found that they seldom collect nectar having a sugar concentration less than 18 percent (Butler, 1952). The concentration of the sugar content in the flowers, however, is most important to the bee in deciding which crop to forage and von Frisch has shown that honey bees dance more vigorously when carrying more concentrated nectar (Burch, 1963).

The range of nectar concentration in the flowers of any one species of plant could vary from one district to another, and concentration in flowers from any particular district could also vary not only from day to day but also from hour to hour. In most instances these variations are due to changes in temperature and atmospheric humidity. Each plant has its own optimum temperature or nectar secretion and it is believed that this is related to the availability of water to the plant. High temperature may increase the sugar concentration in the nectar by increasing evaporation. It has also been found that more nectar is secreted in the cooler and more humid hours of the day though its sugar concentration is less (Burch, 1963). As a general rule the greatest number of foraging bees will be found at any given time working upon these plants where flowers possess the most highly concentrated nectar.

Butler (1952) has reached the conclusion that

1. the concentration of nectar determines which species of plant will be visited in preference to others flowering simultaneously in any given locality and
2. the abundance of nectar within this area determines the proportion of the foraging population of a honey bee colony which will collect from the flowers in question.

HONEY

Honey have been valued since earliest times, and in many parts of the world it is among important commodities mentioned in the earliest written records. Several countries in the tropics and sub-tropics have a long tradition of honey harvesting from wild honey bee colonies and also in the domestication of honey bees.

Honey was an important part of early man's diet and the brood or honey bee larvae was also often eaten with it and provided a food source of protein. Obtaining honey from wild honey bee colonies living under natural conditions was a regular practice among the veddha communities and many villagers living in settlements around the vicinity of forests of Sri Lanka. Apart from honey being valued as a food, it also forms an important component in certain indigenous medicines.

Honey is defined as "the sweet substance produced by honey bees from the nectar of blossoms or from secretions of or on living parts of plants, which they collect, tramsform and combine with specific substances, and store in honey combs". (Codex Alimentarius Commission of the Joint FAO/WHO Food Standards Programme, 1969).

Honey is prepared by honey bees from nectar or secretions of living parts of plants by the inversion of the greater part of the sucrose contained therein into approximately equal proportions of glucose and fructose together with the elimination of much of the water. This inversion is affected by the enzyme invertase contained within the honey appratus in the fore-gut of the honey bee. It should be borne in mind that whereas nectar contains approximately 60 percent water, honey contains only about 18-20 percent.

Nectar is gathered by the field worker bees and on her return to the hive this nectar is passed on to one or more bees, after which she flies out to the field again for further collections. After receiving the nectar, the house bee commences ripening of the honey by a procedure of manipulations by regurgitating and swallowing back the nectar. This process goes on for several minutes and this load of partially ripened or "green honey" is deposited inside a cell. During this process of ripening a relatively large surface area of the nectar is exposed to the atmosphere of the hive and a rapid evaporation of water, too, takes place from it. It is often observed during this process some other house bees ventilate the comb by "fanning" with their wings, thereby hastening the process of ripening of the honey. In this manner nectar droplets brougnt in by several foraging worker bees are deposited into a single cell in the comb. This process takes place until both sides of the honey comb is stored with honey.

Finally, when the honey is fully ripe the stored cells are sealed over with wax coverings or caps.

REMOVAL OF HONEY FROM COMBS

1. Clearing:-

The first thing to be done before combs are removed from the super box for the extraction of its honey is to remove all the worker bees from them. This process is referred to as "clearing"supers". Clearing can be accomplished either by a. Shaking and brushing or b. Using escape or clearer boards.

a. Shaking and brushing:- The entire colony of bees is smoked using the smoker in the usual way, and the roof and crown board is then removed. Each super frame is now removed and gently shaken or tapped to get most of the bees off and the remaining bees gently brushed away using a bruch fitted with soft bristles. Each honey comb, now free of bees, is then placed in an empty super box made available before the operation commenced. After all the honey frames had been freed of bees the new super box is covered over with a cloth or a board and removed away from the main colony so that the worker bees cannot get back into it. The now empty super box which has been cleared of its honey frames is removed to take the combs from the next colony to the cleared, and so on. By adopting the same procedure, all super boxes containing sealed honey combs are brought in from the apiary to a central place for extraction.

b. Use of bee escape or clearer boards:- This is also a common method used by bee farmers for removing bees from the supers. This is based on the use of a board fitted with a Porter bee-escape at its centre and placed between a super box and the brood chamber. This bee escape allows the worker bees to travel down from the supers to the brood chamber below, but preventing return traffic of bees. The board is placed in position usually in the evening. During the night the worker bees will move away from the honey chamber into the brood chamber but they cannot return back. The following morning the honey chamber will be ready to be removed away for extraction. If any bees happen to linger on some of the honey combs, they could be wiped away.

Having cleaned all the bees from the honey combs and then removed away from the site, they should either be extracted in a room devoid of any bees. If they are to be stocked the supers should be kept tightly covered, for if any bees happen to enter the room accidentally, several hundreds of them will turn up and help themselves of the honey, which would result in the loss of a good honey harvest. Further, such carelessness would even cause a disturbance or danger both to oneself, one's neighbours, or even to any colonies in the immediate neighbourhood.

2. DECAPPING:-

The wax seals or caps covering the cells containing mature honey in combs prevent it from dripping out. Therefore, the wax cappings have to be removed from the combs of honey which can then be put into the honey extractor for extraction. Each honey comb is gently lifted out of the super chamber and the cappings are cut off with a knife, preferably a decapping knife sold for the purpose, or a sharp, fluted small kitchen knife. The fluting on the knife blade helps to prevent it being held by the viscosity of the honey. It is also advisable to heat the knife blade as this will facilitate its movement across the wax during decapping.

During decapping a wide mouth bowl or container is taken across which is placed a strip of wood. The frame containing the comb to be decapped is then placed on this wooden strip vertically with the shorter side of the frame overhanging the bottom on the side being cut. By having it in this position the pieces of capping fall away from the face of the comb into the container below without adhering on to the honey covered cut surface. It has been found that the movement of the knife from below upwards across the comb gives a better control of the cutting movement and also causes very little damage to the comb as well.

It would be preferable if the container for collecting cappings is large enough so as to hold all the cappings from one spell of extraction. The dripping contained in the vessel could be strained later and collected in a jar.

A stand of some sort is necessary to place the decapped honey combs on, and a drip tray to collect the dribbles of honey which will run from the combs.

3. EXTRACTING:

Honey combs which have been decapped are placed in a honey-extractor of the tangential type which operates by using centrifugal force, to throw honey out of the comb (Fig. 16).

The tangential honey extractor is constructed out of stinless metal and consists basically of an outer cylindrical barrel and an inner centre cage revolving on a central axis. The lower end is fitted with a set of tooth-wheels and a handle. The whole device is covered with a lid.

To use this extractor two or, four decapped super combs are placed inside the inner centre-cage, resting against the cage which supports the comb and prevents it from falling away when the cage is revolved. The cage is gradually revolved by the handle until the honey from one side of the comb has come out. The movement should then be stopped and the combs taken out, turned around, and replaced so that the other non-extracted face is outwards. The cage is revolved once again until all the honey on this face of the comb is extracted. If necessary, this process could be repeated once more in order to ensure complete extraction of the honey from all the combs. All the empty combs after extraction is complete should be replaced in their super chambers.

One should remember that, theoretically, the honey frames should be removed from the super chamber for extraction only when all the cells in the comb are sealed. But, however, in practice this is not always possible, as there will often be several unsealed cells distributed in the comb containing unripe honey. It is simply honey which has not yet had the surplus water removed from it by the worker bees. Unripe honey in fair quantities in extracted honey will cause fermentation by osmophilic yeasts present in them. Therefore, this could be avoided by not extracting honey combs unless they are at least ninety-five percent sealed over, since the bees do not seal honey cells until it is fully ripe or mature.

Frames containing unsealed honey at the end of the honey-flow season should not be extracted until about a week after the end of the flow. However, they should not be left in the hive for too long after the season in over, since several of these unsealed honey cells will have been emptied by the worker bees and the honey stored in the brood-chamber for their own consumption.

4. STRAINING:

The extracted honey is run out of the extractor barrel through its tap into another clean, collecting container over which is placed a cotton or nylon cloth strainer which will remove away pieces of wax, bee parts and other debris contained in the honey. The straining cloth should preferably be about 54 to 60 meshes to the inch.

If the honey happens to be too thick for straining, it may be warmed quickly to about 35°C (95°F) and then strained.

5. STORING HONEY

Honey after extraction from its combs should be stored in clean, preferably wide-mouth jars for easy handling.

As a precaution against fermentation, it is best to heat the honey in a large, closed container to 140°F for 10 min. before it is poured into storage jars.

CHARACTERISTICS OF HONEY

Honey is a conglomeration of several organic and inorganic chemical substances, variation in the relative proportions of which can provide the combinations which makes each lot of honey collected from one colony of honey bees markedly or even slightly different in its colour, aroma, flavour and texture, from the next.

It is a viscous fluid, its viscosity being dependent on the proportions of solids dissolved in it. The lower the water content the greater will be its viscosity. It is also increased by the amount of colloidal material and proteins present in the honey.

Origin of honeys:

Honeys are classified according to the source from which they have originated

1. Blossom honey: a honey that has been elaborated from the secretions of nectaries of flowers. These may be of two types:

   (a) Monofloral honey: a honey that has one predominant botanical source. This could be ascertained by examing the pollen contents of the honey. The pollen count should contain about eighty percent of one particular species of plant. e.g. Eucalyptus honey (from Uva region).

   (b) Polyforal honey: a honey that has several botanical sources, of which none is predominant.

2. Extrafloral honey: a honey that has been elaborated from the sugary secretions of certain specialized glands

situated on various parts of plants other than flowers. e.g. Rubber honey (from rubber plantations in the wet zone).

Chemical composition:

The composition of honey, however, varies from one sample to another. The approximate composition of mature honey of *Apis cerana* F. is as follows:

Water	18-20 percent
Dextrose (Glucose)	20-25 percent
Laevulose (Fructose)	35-40 percent
Sucrose and other sugars	4-5 percent
Other components	3 percent

The three percent other components present in honey consists of about fifteen organic acids, seven proteins and seventeen free amino acids.

An important factor with regard to honey is its water content. This is because of its effect upon keeping quality during storage. Distinct variations in water content do occur in honeys, and may be primarily attributed to the degree of maturity or "ripeness" of the honey. Further, being hygroscopic, it has the ability to absorb moisture from the atmosphere. Thus, honey which has been allowed to remain exposed too long to the surrounding atmosphere or not carefully bottled or stored in air tight containers may absorb considerable moisture, thereby increasing its moisture level.

Maintaining the moisture content of honey below twenty percent level is also important as it would prevent fermentation.

The main constituents of honeys of *Apis dorsata* and *A. florea* are also similar to that of *A. cerana* but differs basically in their relative proportions.

Only about fifteen percent of the honey available in the market in Sri Lanka are those collected from apiaries, the rest being forest honeys, and among them the majority are those of *A. dorsata.* Honey collected from combs of *A. florea* are usually not available in the market, because very small quantities could be extracted from their combs. They are mainly used in the preparation of ayurvedic medicines.

Honey has also antibacterial substances mainly based upon the production of peroxide by an enzyme which is incorporated by the worker bees.

The physico-chemical characteristics of some honeys of *A. cerana* in Sri Lanka is given in Table 3.

The colour, flavour and aroma varies from one honey to another and they depend on the floral sources from which it has been collected. The colours can range from a light honey to a dark honey and in the International market liquid honey colours have been graded as follows:

Extra white
White
Extra light amber
Light amber

Amber
Dark amber
Dark

These colours are determined using an apparatus known as the Pfund Honey Grader.

Ageing and heating of honey accelerates a number of natural processes which occur all the time during storage. Two such important compounds are:

1. Hydroxymethyl furfuraldehyde (HMF) content: This is a chemical produced by the degradation of sugars in the presence of acids. The presence of this compound is believed to be responsible to a great extent for the darkening of honey with time.

2. Diastase: It is an enzyme responsible for the digestion of starch. Since it is a protein it is degraded by heat and other natural breakdown processes, thereby reducing the quantity present in normal honey. Its activity is measured and expressed as a Diastase Number. (Crane, 1975).

Analysis for both these compounds is rather complex and should be done in a reasonably equipped laboratory.

<u>Granulation of honey:</u>

Because they are highly supersaturated liquids most honeys crystallize fairly readily and this process is referred to as granulation or crystallization of honey.

TABLE 3: Physico-chemical characteristics of some honeys of *Apis cerana* from Sri Lanka.

	Blossom (Floral) Honey			Extrafloral Honey
	Monofloral		Polyfloral	
Type of Colony	Apiary	Apiary	Feral	Apiary
Floral Source	*Eucalyptus* spp.	Mixed flora	Mixed flora	Rubber
Colour	Amber-Dark amber	Amber-Dark amber	Amber-Dark	Light amber
Appearance	Transluscent	Transluscent	Transluscent to Turbid	Transluscent
Specific Gravity	1.3-1.4	1.4-1.45	1.4-1.45	1.3-1.4
Moisture (%)	18-20	18-21	20-24	19-24
Sucrose (%)	2.8-4.5	2.5-5.0	3.0-7.5	2.5-5.5
Total Reducing Sucrose (%)	67-74	64-73	63-70	67-70

After a period of time the dextrose, being much less soluble in water than the other major component, laevulose, tend to crystallise out in most mature or ripe honeys, but the laevulose remains permanently in solution. The precise factors which afect the rate of granulation are not fully understood, but the ratio of laevulose to dextrose (L/D ratio) and the moisture and colloid contents in the honey appear to have considerable influence. Different types of honey behave differently so far as crystallization is concerned, some sources of nectar giving a honey that crystallize rapidly while others allow bees to elaborate honey types that may remain in the liquid state for a long period, even upto several years. (Crane, 1975).

A honey which crystallizes within a few weeks of storage contains fine small sized crystals giving it a creamy texture, often referred to as "creamed honey". On the other hand, a honey having a low water and a high colloid content may take several months or even years to granulate. In such a honey the texture is coarse and is due to the presence of large crystals.

Where it is intended to produce creamed crystallised honey, it is best to promote crystallization artificially by adding a small quantity of creamed honey into the liquid honey. This process is known "seeding the honey". After the addition of "seed" the honey should be well stirred, avoiding formation of air bubbles, and then allowed to stand undisturbed. The proportion of "seed" to liquid honey is not very critical but a ratio of 1:12 appears satisfactory with good apiary honeys.

It should be noted that crystallization of honey also takes place fairly rapidly at low temperatures provided, of course the L/D ratio is suitable. However, crystallized honeys usually liquify at warm temperatures.

Many people are of the opinion that creamed honey is a product of adulteration with sucrose. This is a wrong inference.

Marketing of Honey:

Honey may be marketed in four different forms:

1. Apiary honey - where the honey has been extracted from uncrushed honey combs from domesticated honey bee colonies in a mechanical extractor.
2. Forest honey - where the honey has been extracted by crushing honey combs collected from honey bee colonies in forests.
3. Chunk honey - the honey comb is cut into square or rectangular pieces and immersed in a vessel containing liquid honey. When packed in glass jars they increase the attractiveness of its appearence.
4. Granulated honey - as described above.

The standards for Sri Lankan honeys and the methods of analysis are given in detail in a booklet entitled "Specification for Bees Honey" published by the Sri Lanka Standards Institution.

ACKNOWLEDGEMENTS

I wish to thank Miss Ruwandi Abeyratne for helping me with the diagrams and Miss Suchithra Manawadu for typing the manuscript. I also thank the Natural Resources Energy and Science Authority of Sri Lanka for affording me the opportunity of presenting this publication.

REFERENCES

Anon (1979) Specification for Bees Honey. Bureau of Ceylon Standards. SLS. 464, pp. 25

Baptist, B.A (1979) Beekeeping development programme in Sri Sri Lanka. in "Beekeeping in Rural Development". Commonwealth Secretariat London. pp. 109-114.

Baptist, B.A. (1976) Beekeeping Development Programmes in Sri Lanka in "Apiculture in Tropical Climates". International Bee Research Association, London, pp. 135-142.

Baptist, B.A. (1966). Beekeeping with special reference to its development in Ceylon. Prov. Ceylon Assoc. Advmt. Sci. 12: 99-118.

Burch, D.V. (1963) Nectar. Publ. Central Association of Beekeepers, Essex. pp. 8

Butler, C.G. (1952). The Honey bee. An introduction to her sense physiology and behaviour. 2nd Editor. Clarendon Press, Oxford. pp. 139.

Clark, K.K. (1951). Beekeeping. Penguin Books, Middlesex, pp. 222.

Crane, E. (1975). Honey: a comprehensive survey. Heinemann, London.

Dayaratne, K.H. (1968). A seasons performance of an Apis colony at Erabedda. Vidyodaya J. Arts. Sci. Lett. 1(2): 221-223.

Drieberg, C. (1923). Beekeeping for Beginners. Bulletin no. 63. Dept. of Agriculture, Ceylon.

Fernando, E.F.W. (1979) The ecology of honey production in Sri Lanka in "Beekeeping in Rural Development". Commonwealth Secretariat, London. pp. 115-125.

Fernando, E.F.W. (1979). Some biometrical features of Apis cerana F. from Sri Lanka. Indian Bee Jour. 41(1): 5-8.

Fernando, E.F.W. (1978). Studies on apiculture in Sri Lanka. 1. Characteristics of some honeys. _Joun. apic. Res._ 16(1): 44-46.

Kannangara, A.W. (1939). Beekeeping. _Trop. Agric._ 92: 94-99.

Kreil, G. (1978). _Biochemical surprise of a bee sting._ New Scientist. 79: 618-620.

Perera, L.A.S. (1960). Beekeeping for honey production. A study of factors involved. _Trop. Agric._ 116: 31-45.

Pulle, M (1975). Quality characteristics of sugar substitutes. _Proc. Sri Lanka Ass. Advmt. Sci._ _31_

Richards, O.W. 7 Davies, R.G. (1977). _Imms' general Textbook of Entomology._ Vol. 2. Classification and Biology. Chapman and Hall, London.

Townsend, G.F 91961). Preparation of honey for market. _Publ. Ont. Dept. Agric._ No. 544, pp. 36.

Wickramasinghe, R.H. (1983). Beekeeping and its management on coconut, rubber, cashew, citrus, gingelly, fruit, timber and other plantations. _J. National Inst. Plantation Management._ 2: 94-104.