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Syllabus For Mid Term Examination

THE IMPORTANCE OF BEES IN NATURE

BEES AS PART OF ECOSYSTEMS

Pollinators strongly influence ecological relationships, ecosystem conservation and stability, genetic variation in the plant community, floral diversity, specialization and evolution. Bees play an important, but little recognized role in most terrestrial ecosystems where there is green vegetation cover for at least 3 to 4 months each year. In tropical forests, savannah woodlands, mangrove, and in temperate deciduous forests, many species of plants and animals would not survive if bees were missing. This is because the production of seeds, nuts, berries and fruits are highly dependent on insect pollination, and among the pollinating insects, bees are the major pollinators. In rain forests, especially in high mountain forests where it is too cold for most bees, other pollinators like bats and birds play a greater role in plant pollination. In farmed areas, bees are needed for the pollination of many cultivated crops (see Chapter 7), and for maintaining biodiversity in ‘islands’ of non-cultivated areas. The main role of bees in the different ecosystems is their pollination work. Other animal species are connected with bees: either because they eat the brood or honey, pollen or wax, because they are parasitic to the bees, or simply because they live within the bees nest.

WHAT IS POLLINATION?

Pollination is transfer of pollen from the anther (the male part of the flower) to the stigma (the female part of the flower). Some plants can pollinate themselves: in this case, the pollen passes from the anther to the stigma inside the same flower, and this is called *self-pollination*. Other plants need pollen to be transferred between different flowers or different individuals of the plant. This is *cross-pollination*. Many plants can be pollinated both ways. Plants can be pollinated by wind or animals.

Some plants have only one method for pollination, others use a combination. The knowledge of pollination by animal pollination (*Zoophily*) in the tropics is still little known, and much work and research have to be done in this area. Some general rules can be used to detect whether a plant is pollinated by bees, flies, beetles, wasps, butterflies, moths, thrips, birds, bats, marsupials, slugs or rodents. Flowers pollinated by bees most often bloom in daytime, they can have different colours, but seldom red. The scent of daytime bee pollinated flowers tends to be less strong than that of night-pollinated flowers, often pollinated by bats or moths. Honeybee pollinated flowers have nectar tubes not more than 2 cm long. They have nectar guides (patterns to direct the bee towards the nectary) and often a landing place for bees. Bees are especially attracted to white, blue and yellow flowers. Plants pollinated by insects are called “entomophilous”, and insects are generally the most important pollinators.

THE POLLINATION WORK OF BEES

If we look at the many colourful and different looking flowers, we should not forget that they have developed as an adaptation for the bees and other pollinators, and not to please humans! Bees and most flowering plants have developed a complex interdependence during millions of years. An estimated 80 percent of flowering plants are entomophilous i.e. depending more or less on insect pollination to be able to reproduce, and it is estimated that half of the pollinators of tropical plants are bees.

The efficiency of honeybees is due to their great numbers, their physique and their behaviour of foraging on only one plant species at one time. The bees have to find their food in flowers. The food can be nectar or pollen. Nectar is produced to attract the bees. Pollen is also attracting the bees, but it has another function too: it is produced to ensure the next generation of plants. Bee pollinated flowers have evolved in such a way that a visiting bee has to brush against the flower's anthers bearing pollen, or there may be a special mechanism to release the anthers to spring up or down to cover the bee with pollen. Compared with other insects, bees are extremely hairy. Each hair has a branched structure that makes it highly effective at catching pollen.

While flying to the next flower, the honeybee will brush herself and move many of the pollen grains, to arrange them in the pollen baskets made of stiff hairs on her hind legs. Some pollen grains are so dry that they cannot be formed into a clump. To prevent the pollen falling off during flight, the bee will regurgitate some nectar and mix it with the pollen. This gives the sweet taste when eating pollen balls collected by bees. It also makes the pollen a little darker so that it can be difficult to see from which plants it comes. Some bees do not have pollen baskets – they transport the pollen in the hair on their abdomen (e.g. *Osmia* bees and leaf cutter bees). When the honeybee with pollen is landing in the next flower, there will be pollen enough left on the bees' body hairs to pollinate the new flower, by delivering some grains to the flower's stigma. Now pollination has taken place. To create a seed, the pollen grain has to grow a small tube inside the stigma to the ovary of the flower. Then a male gamete can travel through the tube, fertilize the egg cell and start development of the fertile seed. Now the fertilization has taken place.

Some plants need several successful visits from bees to ensure that all the flower's eggs are fertilized. For example, some varieties of strawberry need about 20 pollen grains – requiring visits by several bees, an apple flower may need four or five bee visits to receive enough pollen grains for complete fertilisation. If the fertilization is inadequate because of lack of bees, not all seeds will develop, and the shape of the fruit will be poor and small. Fertilization is the beginning of a new seed, which perhaps will grow and develop into a new plant. The new plant will bloom, provide the bees with food, be pollinated, and be fertilized, and in this way, the story continues.

The forager bee returns to the honeybee colony with her pollen loads, which are placed in the nest in areas of comb close to the brood.

Bees have to learn where in a flower the nectar is to be found. To guide the bees, many plants have *bee-tracks*, which are lines of colour leading the bee towards the nectar. These can sometimes be seen by humans, but some are in the ultra-violet part of the spectrum and visible to bees, but not humans. In this way, the plant also guides the visiting bee to pass the anthers or stigma in the right way. Bees have no problems in finding the nectar in flat, open flowers, but in flowers that are more complex, they have to learn it by trial and error. After some visits in the same type of flower, the bee has learned where the nectar is, and learns this for the next visit. Pollen is the protein food for bees. Without pollen, the young nurse bees cannot produce bee milk or royal jelly to feed the queen and brood. If no pollen is available to the colony, egg laying by the queen will stop.

Usually a honeybee can visit between 50-1000 flowers in one trip, which takes between 30 minutes to four hours. In Europe, a bee can make between seven and 14 trips a day. A colony with 25,000 forager bees, each making 10 trips a day, is able to pollinate 250 million flowers.

The ability of the honeybee to communicate to other bees in the colony where to go for collecting more pollen and nectar is very important for their efficiency as pollinators. When a scout bee has found a good nectar or pollen source, she will return to the colony and communicate to other bees where they can find the same food. This is done with a special dance indicating the distance, quality, and direction from the nest.

Flowers closer than around 200 metres are just announced with the waggle dance without indicating any direction. Chapter 6 describes how these stingless bees are guided to the flowers.

When bees begin foraging for pollen and/or nectar, they will visit the same species of flowers and work there as long as plenty of nectar or pollen can be found. For example, if a honeybee starts collecting in an *Acacia* tree, she will fly from *Acacia* flower to *Acacia* flower, and not behave as many other insects do, visiting different species of plants within the same trip without any great pollination effect. This behaviour of bees is called *foraging constancy*.

Some flowers are open and with nectar all day and night, but others are open only for a few hours in the morning, afternoon or night. The single worker bee learns and remembers what time the different flowers are worth visiting. One bee can remember the opening time for up to seven different types of flowers. The honeybees are pollinating a great number of different plant species, and they do it effectively. Some solitary bee species are much more specialized for pollinating specific plant species.

SPECIALIZED POLLINATION

Some species of plants and bees have developed a close interdependence in connection with pollination. Such a mutual adaptation and interdependence between a plant and pollinator is a result of a long and intimate co-evolutionary relationship. The pollinating bees of the Brazil nut tree *Bertholletia excelsa* is an illustrative example of such a relationship and its economic importance.

The Brazil nut tree grows wild in the Amazon Forest. Brazil nuts are one of the economically most important wild products growing trees in the area, with more than 50 000 tonnes of the nuts exported from Brazil every year. The Brazil nut trees cannot be grown in plantations, because they need to be pollinated by one special bee species, the small shining *Euglossa* bee. This bee is dependent on the presence of an orchid species that is found only in the rain forest. They are also the only pollinators for a number of orchids in the forest. In some species of *Euglossa*, the male bee collects some scented material from the flower, which they distribute to attract other males – who do the same and multiply the effect with a scented cloud, in the end so strong, that it attracts female bees so that mating can take place. During the collection of the scented material, male bees transfer pollen from orchid to orchid and pollination takes place. The female *Euglossa* bees live from nectar from the Brazil nut tree and pollinate it. This means that without the orchids, there would be no *Euglossa* bees and no Brazil nut trees, and none of the many other plants, insects and animals associated with that tree – including the people whose livelihoods include collection and sale of the Brazil nuts.

Studies in the Amazon forest have shown that many *Euglossa* bees do not cross open areas. That means that great parts of forest lose its pollinators when the forest is cut, and open parcels of land are created between remaining forest islands.

This example is only one of many important specialized interrelations between bees and trees. In spite of this, the bees perhaps play a minor role as pollinators in the rain forest compared to their role in temperate forests, monsoon forests and savannah woodland. In tropical rain forests, many trees are pollinated by birds, bats and insects other than bees. Animal pollination is of greatest importance, because there is no wind between the trees and because the distance between trees of the same species may often be great. In that way, it is most convenient for the trees to use animals as pollination vectors. In tropical forest, there may be rather few flowering plants on the ground because of the trees' shade.

In European deciduous forests, the forest floor can be totally covered by flowering plants in springtime, before the trees produce their leaves. These plants often need fast pollination from a great number of honeybees. Not many other insects are present in high numbers in early spring.

In Denmark, it is seen by forestry people that the presence of bees in forest areas helps to protect the newly planted trees from being eaten or spoiled from gnawing by roe deer, compared to other plantations with no bees. The reason is because bees secure a better pollination and seed production of so many other plants, which the roe dear can forage on instead of the tree seedlings. By pollinating trees, bushes and herbaceous plants, the bees are important for the food production of all the other animals and birds in the forest ecosystem dependent on it for food berries, seeds and fruits.

BEES ARE GOOD FOR TREES AND TREES ARE GOOD FOR BEES

Bees and trees belong together. The honeybees and stingless bees have originally developed in forest biotopes. Given the choice, wild honeybees chose nesting places in trees rather than in an open landscape. Most often the honeybees prefer to build their combs or nests high in trees instead of close to the ground, but bees nests can be found everywhere in a tree. In savannah areas with bushfires in the dry season, a high nesting place is an advantage. When beekeeping is present in a forest, the beekeepers will be interested in protection of the forests and especially the tall trees preferred by the bees. When enough bees are present in a forest, they provide a better pollination that leads to improved regeneration of trees and conservation of the forest'sbiodiversity.

BEES AND BIODIVERSITY

Without bees there would be no flowering plants, and without flowering plants there would be no bees. Without bees biodiversity would not be so great. Biodiversity is measured as the number of different plant and animal species found in a certain unit area. Biodiversity is highest in tropical forest areas and lowest in the Arctic. High biodiversity is related to the high age of the ecosystem, and a stable environment. A stable environment creates the possibility of development of specialization and use of narrow ecological niches. The explanation of the high biodiversity in tropical forests can be as the species' efforts to avoid attack by diseases and pests. Both can be much more serious in a tropical forest biome with a constant supply of water, and a hot and stable temperature. The high diversity with its high specialization in pollination relationships can also be a danger for the forest. The specialist pollinator must have access to food all year round. Many of the smaller trees flower all year round or nearly all year, but the larger trees have blooming seasons. Some flower every year, others every third or fifth year, where all trees from the same species bloom at the same period and maybe even at the same hours. If the specialized bees loose their stable resources by tree cutting, they will not be there when the bigger trees require their pollination service.

The reproduction of plants is simplest as vegetative reproduction – a new tree could just come from a root shoot. The new tree would then be genetically identical with the mother tree. Vegetative reproduction alone would be no problem if the environment were stable, but most environments are not stable over time, they change. It can be climatic changes, new diseases or pests. To be able to adapt to environmental changes there need to be genetically different plants. In that way there will always be some plants, which are better adapted than others because of special genetic constitutions. The only way to constantly mix the genes for the plants is by cross-pollination, where pollen from one plant is transported by bees to another so that the offspring become genetically different. In that way, there is a greater chance for at least some of the offspring to survive in the competition of life. In this we find the bees as one of the most important factors.

KEY FACTS AND FIGURES

Three out of four crops across the globe producing fruits or seeds for human use as food depend, at least in part, on pollinators.

Improving pollinator density and diversity boosts crop yields – pollinators affect 35 percent of global agricultural land, supporting the production of 87 of the leading food crops worldwide.

Pollinator-dependent food products contribute to healthy diets and nutrition.

Pollinators are under threat – sustainable agriculture can reduce risk to pollinators by helping to diversify the agricultural landscape and making use of ecological processes as part of food production.

Safeguarding bees safeguards biodiversity: the vast majority of pollinators are wild, including over 20 000 species of bees.

FAO plays a leading role in facilitating and coordinating the International Pollinators Initiative 2.0

POLLINATION:

INVISIB TO THE EYE BUT YIELDIG GREAT RETURS IN AGRICUL TURE

Pollination is the highest agricultural contributor to yields worldwide, contributing far beyond any other agricultural management practice. Thus, bees and other pollinators make important contributions to agriculture. Pollinators affect 35 percent of global agricultural land, supporting the production of 87 of the leading food crops worldwide. Plus, pollination-dependent crops are five times more valuable than those that do not need pollination. The price tag of global crops directly relying on pollinators is estimated to be between US$235 and US$577 billion a year. And their quantity is on the rise. The volume of agricultural production dependent on pollinators has increased by 300 percent in the last 50 years. These figures reflect the importance that pollinators have in sustaining livelihoods across the planet. Several of the crops produced with pollination, cocoa and coffee, to name two examples, provide income for farmers, in particular smallholder farmers and family farms, especially in developing countries.

Bees can, in a sense, be considered as livestock. With the increasing commercial value of honey, bees are becoming a growing generator of income, livelihood strategy and means of food security for many small-scale producers and forest dwellers in many developing countries.

Clearly, the benefits that bees and other small pollinators bring us go beyond human food. Thanks to these pollinators, farm animals have diverse forage sources and hence more flexibility to adapt to an increasingly changing climate. And we also have certain medicines, biofuels, fibres and construction materials. Some species also provide materials such as beeswax for candles and musical instruments. So embedded in our lives, bees and other pollinators have long inspired art, music and even sacred passages.

Some facts about bee pollination:

- In India 50 million hectares of land is under bee dependent.
- More than 50 per cent of the existing species of plants propagated by seeds are dependent upon insects for adequate pollination and only 15 per cent of the 100 crops that fed the world are pollinated by domestic honey bees while 80 per cent are pollinated by wild bees and other wild life.
- Value of additional yield obtained due to bee pollination alone is 15-20 times more than the value of all the hive products put together. The total value of pollination services rendered by all insects globally comes in excess of 100 billion annually.
- It has been estimated that bees are gainfully tapping only about 1/4th of the available floral resources of the country. Of the 90 per cent of flowers which are cross pollinated, 85 per cent depend upon insects for pollination.
- Being a mega diversity country there are about 1000 species of bee forage plants offering rich food to all the four important species of honey bees.
- The estimated losses in India due to complete absence of bee pollination has been measured to be somewhere between Rs.10,000 to Rs.55,000 per hectare in some crops.

Advantages of bee pollination : Honey bees are the most efficient pollinators of several agricultural, horticultural, silvicultural, fodder and wild plants because of their following characteristics:

- Body parts are specially modified to pick up many pollen grains
- Flower fidelity and constancy
- Potential for long hours
- Maintainability of high populations as and when needed
- Adaptability to different climates and niches
- Through micromanipulation of flowers.

Bee Benefits to Agriculture

One mouthful in three of the foods you eat directly or indirectly depends on pollination by honey bees. The value of honey bee pollination to U.S. agriculture is more than $14 billion annually, according to a Cornell University study. Crops from nuts to vegetables and as diverse as alfalfa, apple, cantaloupe, cranberry, pumpkin, and sunflower all require pollinating by honey bees.

For fruit and nut crops, pollination can be a grower’s only real chance to increase yield. The extent of pollination dictates the maximum number of fruits. Post-pollination inputs, whether growth regulators, pesticides, water, or fertilizer, are actually designed to prevent losses and preserve quality rather than in-crease yield. When pollination is this important, farmers can’t depend on feral honey bees that happen to nest near crop fields. That’s why farmers contract with migratory beekeepers, who move millions of bee hives to fields each year just as crops flower. Pollinating California’s 420,000 acres of almond trees alone takes between 900,000 and 1 million honey bee colonies.

But the bees’ importance goes far beyond agriculture. They also pollinate more than 16 percent of the flowering plant species, ensuring that we’ll have blooms in our gardens. Of course, there is also the honey. More than $130 million worth of raw honey was produced in 2002 in the United States. Not bad for an insect that is not even native to the New World. But then again, most of our crops and many of our gar-den plants aren’t natives either. These evolved in areas where honey bees are native, and both crops and insects were brought here to become essential parts of our agricultural system. Because all our common honey bees are introduced rather than native, colonies not managed by beekeepers are considered feral rather than wild. We have lost much of our managed and feral honey bee populations in recent years. New invasive pests like *Varroa* and tracheal mites and the small hive beetle have appeared in the last 15 to 20 years. Diseases like American foul brood and chalk brood are also taking a heavy toll. Beekeepers are battling these problems and not always winning.

With these kinds of pressures on such an important agricultural and environmental resource, it should not be surprising that ARS maintains a strong honey bee research program to improve disease and pest treatments, breed stronger honey bees, and enhance management methods. While all these problems are well known to beekeepers, the honey bee problem the public is most familiar with is the invasion of the Africanized honey bee (AHB), for which Hollywood has created a fearsome reputation as a “killer bee.” Since the bees first arrived here in 1990, ARS has been the primary USDA agency for tracking their spread in the United States and for figuring out how we will live with them. There is currently no way to eradicate AHBs, because anything that will kill them will also kill our essential honey bees.

AHBs are problems for beekeepers mainly because of two characteristics. They have a strong tendency to abscond—leave the home hive for new venues which makes it hard for bee-keepers to keep them. The other trait is defensiveness. All honey bees defend their nest by stinging, and their behavior ranges from mild to intense. But AHBs sting in greater numbers on less provocation. That makes them hard for beekeepers to work with, because they don’t want to get stung nor do they want to have to wear complete bee suits just to work their bees.

It is this defensive behavior that Hollywood has raised to mythic proportions. But in the past 14 years, fewer than 15 deaths have been attributed to AHBs in the United States. The average person can survive 1,000 to 1,500 stings (about 10 to 15 stings per pound of body weight), especially if they get medical attention. Fortunately, such massive stinging is rare. To put this in some perspective, in 2000 alone, 50 people in the United States died from being struck by lightning.

If a person is allergic to bee venom, however, a single sting from either a European or Africanized honey bee could be equal-ly dangerous, as their venom is virtually identical. Vibrations from heavy machinery like lawnmowers can up-set all bees. If you live in an area with AHBs or if you are allergic to bees, it is a good idea to inspect your property for signs of a bee nest before operating machinery. Sealing cracks and openings in buildings that could attract a swarm looking for a nest cavity is also a good idea whether you live in an area that has AHBs or not.

But public fear and concern about AHBs has cost beekeepers many of the locations they once rented to maintain bee-hives, often in areas thousands of miles from the nearest AHB. ARS continues to be a center for research on how AHBs affect our honey bees, managed and feral. Beekeepers in the five U.S. states and two territories that already have AHBs—Arizona, California, Nevada, New Mexico, Texas, Puerto Rico, and the U.S. Virgin Islands—must be able to deal with them. And the public needs the best advice on how to live with AHBs.

In the 14 years we have had AHBs in this country, ARS has developed some important answers about living with them. Like most good research, many answers have given rise to additional questions, but we believe we are well on our way to contain-ing this and other bee problems.

Kevin J. Hackett
ARS National Program Leader
Biological Control
Beltsville, Maryland

Chapter 1 Honeybees of the Genus *Apis*

Bees are insects of the Order Hymenoptera which feed on pollen and nectar. They constitute a group of about 20 000 species throughout the world, known taxonomically as the Superfamily Apoidea. Honeybees of the genus Apis belong to the family Apidae, a sub-group of this superfamily. Although the question of how many honeybee species exist is still debated among taxonomists, at least four species are commonly recognized: the dwarf, or midget, bee Apis florea, the giant, or rock, bee Apis dorsata, the oriental (Indian, Chinese, Japanese, etc.) bee Apis cerana, and the common (European, African, etc.) honeybee Apis mellifera. The existence of another giant tree, Apis laboriosa, has recently been confirmed from Nepal, but little is known about its biology.

All honeybee species are eusocial insects, that is to say that they engage in favourable social activity. A colony of honeybees consists of a queen, several thousand workers, and at certain seasons of the year - a few hundred drones. Among the members of the colony there is division of labour and specialization in the performance of biological functions.

The architectural design of the comb of all honeybee species is essentially similar: it consists of adjoining hexagonal cells made of wax secreted by the workers' wax glands. The bees use these cells to rear their brood and to store their food. The general utilization of comb space is also similar among the species: honey is stored in the upper part of the comb, with, beneath it, rows of pollen-storage cells, worker-brood cells, and drone-brood cells, in that order. The groundnut-shaped queen cells are normally built at the lower edge of the comb.

As an inherited behaviour characteristic, all honeybee colonies tend to store a certain amount of honey and pollen as their food reserve. The quantity of food stored depends upon several factors, including the seasonal availability of forage, the worker population of the colony and its rate of reproduction, the capacity of the nest, etc. Another important inherited behaviour characteristic lies in the colony's natural site of comb construction: whereas some Apis species build singlecomb nests in the open, others build multiple-comb nests in dark cavities.

A. The dwarf honeybee Apis florea

The distribution area of A. florea is generally confined to warm climates. In the west, the species is present in the warmer parts of Oman, Iran and Pakistan, through the Indian sub-continent and Sri Lanka. It is found as far east as Indonesia, but its primary distribution centre is southeast Asia. Rarely found at altitudes above 1500 m, the bee is absent north of the Himalayas. It is frequently found in tropical forests, in woods and even in farming areas. In southeast Asia it is not rare to find a nest of A. florea in a village.

As its name implies, the dwarf honeybee is the smallest species of honeybee, troth In the body size of its workers and in the size of its nest. A nest of A. florea consists of a single comb, whose upper part expands to form a crest that surrounds the branch or other object from which the comb is suspended. Dwarf honeybees nest in the open, but not without camouflage: most nests are hung from slender branches of trees or shrubs covered with relatively dense foliage, usually from 1 to 8 metres above the ground. In Oman, where A. florea nests are frequently found in caves, such combs are without crests.

Combs of the dwarf honeybee are well covered with layers of workers clinging to each other' often three or four deep. About three quarters of the colony's worker population are employed in forming this living protective curtain of bees. When disturbed, this curtain shows a "shimmering" movement, the individual trees shaking their abdomens from side to side in a synchronous manner; at the same time, a hissing sound is released. If the colony is further disturbed, the worker trees raise their abdomens and take off from the curtain to attack the intruder.

The section of comb surrounding the support (in Fig. 1/1, a small tree branch) consists of adjoining honey-storage cells that form a crest, from whose inroad curved surface the trees take off and on which they land. The communication dance by scouts, announcing the discovery of a food source, also takes place on this platform. Adjacent to the rows of honey-storage cells is the section of comb which the workers use for storing pollen. Beneath this band of pollen-storage cells is the area where the worker brood is reared. Prior to the swarming season, drone-brood cells are added, adjoining the lower rows of the worker-brood cells. When a colony loses its queen, emergency queen-cells are built from normal cells containing young worker larvae.

To ward off ant attacks, the workers coat both ends of the nest support with sticky strips of propolis, or "plant gum", from 2.5 to 4 cm wide. A. florea is the only honeybee that uses this defensive technique.

During the season when there is an ample supply of nectar and honey, populous colonies of the dwarf honeybee send out multiple reproductive swarms. In addition, colonies of this tree have a high degree of mobility. Disturbance by natural enemies, exposure to inclement weather and scarcity of forage are among the major causes of colonies absconding.

In comparison with other honeybee species, the amount of honey that A. florea workers will store in their nests is small, usually not exceeding several hundred grams per colony. In some parts of Asla, the rural people have devised a scheme for harvesting this honey. First, nests or the bees are transferred from their natural sites to the village, and then, using twine and two short twigs, the nest is clamped and attached to a small branch of a tree. The upper part of the comb, containing the honey, is cut out, and the honey is squeezed out from it. A period of about six to eight weeks is allowed for the

bees to repair the comb and replenish it with honey, and then it is harvested again. This method is not always reliable, however, because most colonies will abscond either shortly after their transfer to the new site or after the first or second harvest has taken place.

Where nests of A. florea are abundant, several rural families can subsist on the income generated from beehunting alone. Although the practice appears ecologically destructive, particularly insofar as it reduces a valuable population of natural pollinators, it does not always destroy the colony being hunted. Workers and laying queens of the dwarf honeybee are able to respond to nest predation quickly. The entire colony, accompanied by a laying queen, can fly several meters away to regroup, and later abscond. Some absconding colonies are able to survive to build their new combs in a nearby area.

B. The giant honeybee Apis dorsata

The distribution area of the giant honeybee is similar to that of the dwarf honeybee: it occurs from Pakistan (and, perhaps, parts of southern Afghanistan) in the west, through the Indian subcontinent and Sri Lanka to Indonesia and parts of the Philippines in the east. Its north-south distribution ranges from the southern part of China to Indonesia; it is found neither in New Guinea nor in Australia.

The giant honeybees of Nepal and the Himalayas have recently been reclassified as belonging to another species of Apis, A. laboriosa. It is not yet c]ear whether the giant honeybees of Sikkim and Assam in northern India, western Yunan Province in China, and northern Burma should he classified as A. dorsata or as A. laboriosa, but in the present state of our knowledge, it is safe to consider that all the giant trees constitute a single taxonomic identity. Although minor variations in anatomical, physiological and behavioral characteristics exist among the different geographical races of the giant honeybees, they are essentially similar in all their major biological attributes.

The giant honeybees are found predominantly in or near forests, although at times nests may be observed in towns near forest areas. The bee shares the openair, single-comb nesting habits of Apis florea, suspending its nest from the under surface of its support, such as a tree limb or cliff. In general, A. dorsata tends to nest high in the air, usually from 3 to 25 meters above the gound. In tropical forests in Thailand, many nests are suspended in Dipterocarpus trees from 12 to 25 meters high: this tree is probably preferred as a relatively safe nesting site because its smooth bark and its trunk rising for 4 to 5 meters before branching out make it very difficult of access to terrestrial predators. Nonetheless, about three-quarters of the worker population of a colony of giant honeybees is engaged in colony defence, forming a protective curtain three to four trees thick in the same way as Apis florea. While birds are common predators of A. dorsata, the workers' large body size protects them reasonably well against ant invasion, so that the sticky bands of propolis characterizing the nests of the dwarf honeybee are not found surrounding the nests of A. dorsata, nor are the nests hidden by dense foliage. Nests of A. dorsata may occur singly or in groups; it is not uncommon to find 10-20 nests in a single tall tree, known locally as a "bee tree". In India and Thailand, tree trees harbouring more than 100 nests are occasionally seen in or near the tropical forest.

The single-comb nest, which does not have the crest of honey-storage cells typical of A. florea nests, may at times be as much as one meter in width. The organization of the comb is similar to that in the other honeybee species: honey storage at the top, followed by pollen storage, worker brood and drone brood. At the lower part of the nest is the colony's active area, known as the "mouth", where workers take off and land, and where communication dances by scouts, announcing the discovery of food sources, take place. This dance takes place on the vertical surface of the comb, and during its progress, the bees must have a clear view of the sky to observe the exact location of the sun. Workers of A. dorsata are however able to fly at night, when the light of the moon is adequate.

In many places, the arrival of A. dorsata colonies is an annual event, occurring at the end of the rainy season or at the beginning of the dry season, when several species of nectaryielding plants are in bloom. This phenomenon leads to speculation that A. dorsata has a fixed pattern in its annual migratory route. Most professional bee-hunters know when and where the trees are to arrive, but they wait patiently until the end of the honey-flow period before taking down the nests. Observations in northern Thailand indicate that if the nests are left undisturbed, the colonies will eventually abscond or migrate when their food reserves have been depleted, usually at the end of the summer months. By the beginning of the rainy season, A. dorsata colonies are found deep in the lush jungles.

A. dorsata is well known for its viciousness when its nest is disturbed: the mass of defending workers can pursue attackers over long distances, sometimes more than 100 meters. Notwithstanding its ferocity, however, this tree's honey is highly prized locally, in some places commanding the best prices in local markets,

Nests of the giant honeybee have been hunted by man since antiquity, and today, organized bee hunting exists in many parts of Asia. In Thailand, bee-hunters must pay fees for permits to hunt the bee in state forests, and landowners possessing bee trees sell annual or biennial rights to hunt nests from such trees.

Some professional bee-hunters prefer to work at night. Smoke is used to pacify the bees, which are then scraped from the comb. The nest is cut and placed in a cloth bag, which is lowered to an assistant on the ground. This method does not result in all colonies being killed: about a fourth of the colonies in a bee tree that has been worked over are able to reconstruct their nests.

The recent intensification of bee hunting has caused an alarm in several Asian countries. There is general concern that the total number of A. dorsata nests all over Asia may be on the verge of declining, partly due to shrinking forest areas, the use of toxic pesticides in foraging farm lands, and bee hunting.

C. The oriental honeybee Apis cerana

For ages, colonies of the oriental honeybee Apis cerana have provided mankind with honey and beeswax, as well as furnishing invaluable service in the pollination of agricultural crops. This bee's range of distribution is far greater than those of A. florea and A. dorsata: it is found throughout the tropical, sub-tropical and temperate zones of Asia, occurring in the Indian sub-continent and Sri Lanka in the west, through southeast Asia, to Indonesia and the Philippines in the east. Further north, it is found in the southern USSR and China, through the Korean peninsula, to Japan. This wide range has led to important variations among the bee's geographical races: particularly between the tropical and temperate races, there are wide differences in workers' body size, nest size, colony population and swarming and absconding behaviour, The temperate and sub-tropical races appear to store greater quantities of food than the tropical races, which in turn are more mobile than the former, tending to swarm, abscond and migrate quite frequently.

In the wild, the oriental honeybees construct their multiple-comb nests in dark enclosures such as caves, rock cavities and hollow tree trunks. The normal nesting site is, in general, close to the ground, not more than 4-5 meters high. The bees' habit of nesting in the dark enables man to keep them in specially constructed vessels, and for thousands of years Apis cerana has been kept in various kinds of hives, i.e. clay pots, logs, boxes, wall openings, etc. Despite the relatively recent introduction of movable-frame hives, colonies of Apis cerana kept in traditional hives are still a common sight in the villages of most Asian countries. As a result, the feral nests of the oriental honeybee in tropical Asia sustain fewer casualities in being hunted by man than those of the dwarf and giant honeybees.

The several combs of an A. cerana colony are built parallel to each other, and a uniform distance known as the "bee space" is respected between them. The body size of the workers of this tree is much smaller than that of the A. dorsata workers, and its brood comb consists of cells of two sizes: smaller for the worker brood and larger for the drone brood. The queen cells are built on the lower edge of the comb. As in the other Apis species, honey is stored in the upper part of the combs, but also in the outer combs, adjacent to the hive walls.

Following the invention of the movable-frame hive for the European honeybee about a century ago, traditional beekeeping with A. cerana has been partially replaced by this modern method in several Asian countries, and at the same time attempts have been made - with varying degrees of success - to improve hiving techniques and colony management.

D. The common, or european, honeybee *Apis mellifera*

There are many geographical races of the common honeybee Apis mellifera, distributed widely throughout Europe, Africa, and parts of western Asia, as well as in the Americas. All these races display similarities in their basic biological attributes, e.g. the construction of multiple-comb nests in dark cavities, colony social organization and division of labour, etc,

In the wild, the natural nesting sites of A. mellifera are similar to those of A. cerana: caves, rock cavities and hollow trees. The nests are composed of multiple combs, parallel to each other, with a relatively uniform bee space. The nest usually has a single entrance. The temperate races prefer nest cavities of about 45 Litres in volume and avoid those smaller than 10, or larger than 100, litres. Colonies of the European races are composed of relatively large populations, usually between 15 000 and 60 000.

Many feral nests of A. mellifera in the northeastern forests of the United States have been reported to store 25 to 30 kg of honey per colony, and even more, during the nectar-flow spring season, and properly managed, commercially operated, colonies yield much more.

Anthropomorphically speaking, this behaviour of the temperate races is obviously an evolutionary advantage: without it, the colony faces starvation during the cold winter months, when food is not naturally available and the temperature is too low to permit flight activity. The shortage of natural forage and the cold temperatures prevailing from late autumn until early spring appear to play an important role in exercising rigid natural-selection pressures on the colonies. As a result, both feral and hived colonies of temperate-zone A. mellifera are less likely to abscond than the tropical races.

The past three centuries have seen the introduction of the common honeybee to all the habitable continents. Outside Asia, beekeeping with A. mellifera constitutes an integral part of modern agricultural systems, furnishing crop pollination services as well as honey and beeswax. Although this bee is one of the most studied animals, many aspects of its biology being fully known, efforts over the past few decades to introduce A. mellifera into Asia have encountered a number of problems, such as the inter-species transmission of bee pests and diseases.

But successes have been reported from several Asian countries as regards the commercial viability and the likelihood of a profitable economic return of beekeeping with A. mellifera. It appears that the adaptability of the bees, appropriate beekeeping technology, better understanding of forage ecology and socio-economic suitability are among the most important factors underlying the further development of beekeeping with the common honeybee in Asia.

E. Honeybee species kept by man

Among the four commonly-recognized species of Apis, only A. cerana and A. mellifera are kept commercially by man. Behavioural limitations of the dwarf and giant honeybees, particularly their practice of open-air nesting, prevents their being kept in man-made hives for reasonably long periods, while hiving colonies in specially-constructed containers is essential in that it enables the colonies to be manipulated.

In many parts of the world, including several countries in Asia, commercial beekeeping depends on moving the honeybee colonies to places where forage is abundant at certain periods of the year. Such migratory beekeeping often calls for the colonies to be moved several times a year, over distances which may range from a few kilometres to several hundred kilometres from the home base. This approach is practicable only when the colonies are in movable-frame hives, which can he transported without danger to the hives or the colonies. From the practical standpoint, therefore, beekeeping can he A dependable agricultural occupation only when the beekeeper can determine and control the number of hives he owns.

Generally speaking, there are two possible approaches to the development of commercial beekeeping in Asia: the introduction of modern beekeeping with A. mellifera or the improvement of existing techniques for using A. cerana. Notwithstanding the difficulties involved in establishing new apiaries of the introduced colonies and in developing colony management techniques suitable to local conditions, A. mellifera colonies are generally more productive than those of A. cerana where forage is abundant, and the development of beekeeping with A. mellifera in Japan, the Republic of Korea, China and northern Thailand is based on this finding.

On the other hand, where forage is available only marginally, colonies of A. cerana survive better and can produce with lower management inputs than colonies of A. mellifera. It is the absconding behaviour of most, if not all, tropical races of A. cerana that creates a major obstacle to the development of beekeeping with this bee in rural areas in southern Asia. Since this behaviour is apparently triggered, at least to some extent, by an unfavourable hive environment, proper colony management may be able to provide at least a partial solution to this problem.

Thus, only through systematic research and development activities carried out locally is it possible to judge which of the two approaches to apicultural development should be adopted to suit the socio-economic situation, the vegetation pattern and the climatic conditions of each locality.

Chapter 2 Honeybee biology

A thorough understanding of basic honeybee biology is one of the most important requisites for success in beekeeping. Notwithstanding the fact that they have been kept by man for thousands of years, A. cerana and A. mellifera still retain all their natural biological characteristics. As compared with the other farm animals, they have not been truly domesticated, in that their life history, social organization, behaviour, physio-ecological characteristics and genetic composition have not been significantly altered by man. The honeybees of today are very much like their predecessors of millions of years ago. They live in a tightly-knit social organization in which each individual member of each caste and sex plays a specific role in the survival of the colony and thus improves the chances of continuity of the species. An individual honeybee cannot long survive when it is separated from its colony.

Anthropomorphically, honeybees may appear to possess social intelligence and a reasoning mind, and such misconceptions often lead to colony mismanagement. The fascinating social behaviour of honeybees is uniquely the result of millions of years of evolution through natural selection. It is not an exhibition of a high level of cleverness. Bees behave, or react to environmental stimuli, in a fairly predictable manner. Most of what they do and how they do it is in essence genetically programmed, and only through proper techniques of manipulation can beekeepers put the colonies to work.

A. Colony members

Every honeybee colony is a family, consisting of a single fertile female, the queen, which is the mother of the colony; a large number (ranging from several thousand to tens of thousands) of infertile females, the workers; and, at certain times of the year, several hundred male drones. Taken together, these three categories are referred to as castes.

(1) The Queen

Being the sole member of the female reproductive caste, the queen is indispensable for the survival of the colony. A mated queen serves the colony in two essential functions: laying fertilized and unfertilized eggs, and secreting substances known as pheromones, required for the stability of the colony's social order.

Within a few days of having mated in mid-air with about ten drones, the queen begins to lay eggs, and continues to do so until she is physiologically exhausted. The larvae of female bees (queens and workers) will hatch from the fertilized eggs, while the unfertilized eggs yield drone larvae. Factors determining whether fertilized or unfertilized eggs are to be laid include the size of the cells in the comb and the mechanism underlying the functioning of the queen's reproductive organs. During the mating process, the queen stores sperm from the drones in a storage organ, the spermatheca, within her abdomen. By controlling the opening and closing of the spermatheca, the queen can allow sperm cells to fertilize her eggs or prevent them from doing so. The fertilized eggs are deposited in small worker cells, while the unfertilized eggs are laid in the larger drone cells: the queen can determine cell size and cleanliness by passing her head into the cell and using her front legs to measure its internal width.

Healthy, sufficiently mated A. mellifera queens can lay as many as 1500 to 2000 eggs a day, provided that the colony is strong, that the queen is sufficiently fed and that there is sufficient empty comb space to accommodate the eggs. The workers partially control the queen's egg-laying by regulating the amount of food fed to the queen and by their preparation of empty cells; they also cannibalize the eggs when a food shortage occurs.

Worker bees recognize their queen not by her physical structure but by her scent, given off by the pheromones she secretes. These pheromones, which consist of about 30 organic compounds, have both direct and indirect effects on the colony's social behaviour. During the nuptial flight, they serve as sex attractants, drawing the drones to the queen. Inside the hive, they assist in stabilizing the colony: the workers are aware of the queen's whereabouts by the presence or absence of pheromones. In A. mellifera colonies, some workers act as "messengers" in distributing the pheromones they obtain from direct contact with the queen to other workers within the hive. Under certain circumstances, the presence within the hive of pheromones will inhibit the untimely construction of queen cells: they also inhibit the development of the workers' ovaries, and during swarming they exercise a direct influence on swarm stabilization.

Pheromone communications within the colony constitute one of the most important components of the social life of all honeybee species. Since older queens secrete less pheromones as well as laying less well - than queens in their prime age, and although a queen can live for several years before being superseded by a younger one, professional beekeepers often requeen their colonies every one or two years, in order always to have queens at their maximum biological efficiency.

(2) The Drones

The drones are the male members of the honeybee society reared by the colony shortly before the swarming season begins. As already stated, several hundred drones may be reared by the colony, emerging from unfertilized eggs the queen lays in larger brood cells. In queenless colonies, workers whose ovaries have developed as a result of the lack of inhibiting action by the queen's pheromones can also lay eggs which, being unfertilized because the worker is unmated, also yield drones.

Drones possess no food-gathering apparatus: their sole biological function is to mate with queens. During the mating season, they are well fed by the workers before taking flight. A drone may make from 4 to 6 flights a day, but a smaller number is not uncommon. Drones from neighbouring colonies all fly to a place known as the "drone congregation area", where mating takes place. To ensure successful mating, several thousands of drones must be in the area, although the queen will mate with only about ten. The drone dies shortly after copulation.

When the mating season is nearing its end, the colony reduces its drone-rearing, and when the season is over, the rearing of drones ceases completely. The drones remaining in the hive gradually die of old age, negligence by the worker bees or starvation, or they may simply be expelled from the hive.

(3) The Workers

The workers are an infertile caste of female bees, developed from fertilized eggs. They are suited by their physiological and anatomical features to perform virtually all kinds of chores except reproduction, to increase the chances of the colony's survival. Factors determining the type of task to be executed by a worker include its physiological and anatomical state of readiness, and environmental stimuli, as well as the requirements of the colony to have a particular job done at a particular time.

Soon after emerging from its cell, a young worker receives food, in the form of either nectar or honey, from mature workers, and also helps herself to honey and pollen she finds in the colony's storage cells. In the first few days after she emerges, she is too weak to do anything except inspect and clean empty cells in preparation for food storage by the colony or egg-laying by the queen. During this period she consumes relatively large amounts of honey and pollen, and this directly affects the development of her hypopharyngeal and wax glands.

The secretion from this "nurse bee"'s hypopharyngeal glands, rich in fat and protein, is fed to the larvae, those of all ages in queen cells receiving large quantities; for this reason it is referred to as "royal jelly". Larvae in worker and drone cells receive this special diet only during the first days after hatching; during their later larval life they are fed on a mixture of honey and pollen.

At about the same time as the hypopharyngeal glands of the nurse bee develop, or shortly afterward, four pairs of wax glands, located below her abdominal segments also develop, under the stimulation of consumption of large amounts of honey. From these glands she secretes flakes of whitish wax, which are manipulated by worker bees, using their mandibles, in the process of comb construction and repair and in capping cells.

Under normal conditions, a worker bee is physiologically exhausted from the tasks of secreting royal jelly and wax when she reaches the age of about 14 to 18 days. A few days after this period are spent packing pollen in storage cells, the mouth-to-mouth retrieval of nectar from returning foragers, and occasionally guarding the hive entrance. When she is about three weeks old she ceases to be a "house bee" and becomes a "field bee". At this stage her flight muscles are sufficiently developed, and after orientation flights which enable her to locate the hive in relation to surrounding landmarks, she collects nectar, pollen, water and propolis and carries them back to the hive until she dies.

As already stated, physiological readiness is not the only factor exerting a direct influence on a worker to perform any specific task: environmental stimuli, the condition of the hive, and the colony's immediate requirements are among other factors regulating the type of work to be carried out and the number of bees to be involved in each task. When a colony is running out of space to accommodate brood and food stores, for example, or when combs have been damaged or destroyed, many workers will undertake the task of comb construction and repair; older workers who have already passed beyond the wax-secretion stage can, by consuming large quantities of honey or sugar syrup, reactivate their wax glands and participate in the construction work. Again, when a colony requires a relatively large population of nurse bees to tend the growing number of brood, the duration of royal jelly secretion by the existing nurse bees can be prolonged, provided that the colony has an ample supply of honey and pollen for them to consume. On the other hand, during a heavy honeyflow season younger workers can easily be recruited for foraging as field bees to increase the colony's food-gathering capacity.

B. Development of the honeybee

The first stage in the development of a worker bee occurs when the queen deposits a single fertilized egg at the bottom of a worker cell. After three days, the egg hatches to become a tiny first-instar larva, lying at the bottom of the cell and fed regularly by nurse bees. After successive stages of growth and moults, the larva completely covers the floor of the cell, and it then changes position, stretching out along the depth of the cell. When the larva is fully grown and no longer needs to be fed, house bees cap its cell with a thin layer of wax; unlike the flat cap of a honey-storage cell, the cap of a brood cell shows a slight protuberance.

At this stage the larva, henceforth called "sealed brood", spins a cocoon around itself and begins to pupate, i.e. to shed its last larval integument and differentiate into a pupa. The pupa has all the adult bee's distinct body parts, but they all adhere tightly to the bee's body, and some appendages are not yet fully expanded. Before emerging, the pupa grows gradually darker in colour. Finally, transformed into an adult, it slowly chews its way out of the cell. The complete metamorphosis from newly-laid egg to emerging adult worker requires a total of 21 days: three as an egg, six as a larva, and 12 as a pupa.

For a drone, life begins when the queen deposits an unfertilized egg in a larger drone-brood cell at the bottom of the comb. Like the eggs of worker brood, drone-brood eggs require three days to hatch, and as for worker larvae, nurse bees feed drone larvae, which uncurl along the depth of the cell when their bodies fill the cell floors. When the larvae are fully grown, the nurse bees cease feeding them, their cells are capped, they spin their cocoons, and pupation takes place. It requires 24 days - three days longer than for worker bees - for a drone to develop, from newly-laid egg to emerging adult. Emerging drones are fed on honey and royal jelly until they are about a week old. Their flight activity begins when they are from 6 to 8 days old, but they are sexually mature only when aged from 12 to 14 days.

A honeybee colony will rear a new queen or queens under two circumstances: in the colony reproduction process known as swarming or in an attempt to replace an old queen with a younger one (supersedure) or to create a new queen in an emergency, when the old one is accidentally lost.

Whereas worker and drone brood are, as will be recalled, reared in hexagonal cells, queen development takes place in cells shaped somewhat like a groundnut. Queen cells are of three types: swarm cells, supersedure cells and emergency cells. Swarm queen cells are built along the lower edge of the comb, often in large numbers: as many as 20 cells of various ages may be seen in a colony. Supersedure queen cells, fewer in number, are generally about the same age and built perpendicular to the comb surface; they are usually formed from old, darker wax than swarm queen cells which, built at times of high food availability, usually consist of whiter, newly-secreted wax. The distinctive feature of emergency queen cells is that they are expanded from ordinary worker cells already containing young larvae, and appear to protrude directly from worker-brood cells on the surface of the comb.

The development period of a queen is significantly more rapid than those of workers and drones: 16 days from egg to adult. The queen larva is well provided by nurse bees with royal jelly for her entire stage of development: it is deposited very frequently in the cell, and the queen larva simply lies on a bed of its food; the remains of uneaten royal jelly is often seen in the cell after the young queen emerges. Although larvae destined to become queens and workers are genetically similar in that both are hatched from fertilized eggs, qualitative and quantitative differences in the diet they receive, particularly in the early stages of their larval lives, determine major differences in their anatomical and physiological development.

C. Colony growth cycle; swarming

If a honeybee colony is relatively safe from damage or destruction by its natural enemies, if it has an ample supply of forage, and if the queen and the workers have been performing their duties in an optimum manner, it will eventually outgrow its hive space. When this occurs, the colony is ready to reproduce itself by swarming.

In temperate regions, natural food is available to honeybee colonies only in spring and summer, when warm ambient temperatures permit flights and active foraging. The colony is most busily engaged in brood-rearing during this period, until hive overcrowding and congestion signal the colony to swarm. During the cold autumn and winter months, however, colonies raise only a small amount of brood, depending for their survival on their stored food.

Such a clearly-defined annual cycle does not exist to the same extent in tropical regions, where colonies of indigenous _Apis cerana_ and introduced temperate races of _A. mellifera_ rear brood whenever their food supply is plentiful. Overcrowding of the hive can thus occur at almost any time, and swarming under tropical conditions occurs not annually, but when the seasonal availability of forage permits. Thus, under normal conditions a temperate-zone colony of A. mellifera casts out a single swarm yearly, while tropical races of A. cerana may cast out several successive swarms, each of such secondary and tertiary swarms being accompanied by an unmated queen.

In preparation for swarming, a colony builds new queen cells and rears young queens. At the same time the old queen receives less food and loses weight, acquiring the capacity to fly. Before the new queens emerge, from 30% to 70% of the colony's worker population fill their stomachs with honey as a food reserve and leave the parent hive in search of a new home site.

Upon leaving the hive, usually accompanied by the old queen, the swarm settles near the parent hive until scout bees have located a new site. If the queen is lost at this stage, the swarm will return to the parent hive, since it cannot function without a queen.

D. Colony defence

Colony defence is a duty of the workers. Bees over two weeks old are frequently involved in guarding the hive, most of them having been relieved from their tasks of brood-rearing and comb construction and repair. Their hypopharyngeal glands no longer function at full efficiency, but their poison glands are in the prime stage of development.

Guard bees recognize members of their own colony by a hive odour specific to each colony. Having the same odour, returning foragers have no difficulty in passing through the hive entrance, but most foreign intruders, including worker bees from other colonies with a different odour, are repelled by the defending guards.

The stings of workers of all species of Apis are anatomically similar, being composed of three shafts and barbed at the tip. When a worker bee stings her enemy, the sting, along with its poison sac and part of the gut adjoining the base of the bee's last abdominal segment, is torn from her body and remains in the enemy's flesh when she pulls away. If the sting is left untouched, the muscles controlling the pumping movement of the poison sac continue to function, injecting the bee's venom into the enemy's body. Her last abdominal segment torn away, the worker soon dies, however, from the loss of blood and body fluid through the open wound.

At the same time as she stings her enemy, the worker releases an alarm pheromone from glands near the base of the sting, to alert other workers and indicate the whereabouts of the enemy. The alarm pheromone, which smells to man like synthetic banana oil, is isopentyl acetate. Easily diffused through the air, it brings a rapid response from the workers in the hive.

E. Foraging

Under normal conditions, worker bees begin to forage when they are about 2 to 3 weeks old. Foraging is the last chore in the life of a worker. Once she has begun foraging, she continues in this activity for the rest of her life. Foragers are sometimes called "field bees".

Part of the colony's stored honey is invested in foraging activity: before taking off on a flight a field bee consumes a certain amount of honey to ensure that she will have a sufficient energy supply for her round-trip journey. To obtain a full load of nectar and/or pollen in a single trip, she may have to visit several hundred flowers. The amount of energy she expends, related to the amount of food she collects, is determined largely by such factors as the species of forage, floral density per unit area, the distance from the hive, and weather conditions. Despite opinions to the contrary, flight productivity does not necessarily depend on the capability of the worker bee or of her race.

In the collection of nectar and pollen there is no specialization or division of labour among foragers. There are, however, both qualitative and quantitative differences among flowering plant species as regards nectar and pollen production: not all plant species possess nectaries (glands secreting nectar), and for a forager to collect nectar, the nectaries must be attainable by the bee's proboscis or tongue. Nectaries may be located on many parts of the blossom: base of the stamen and stigma, petals and sepals. Moreover, some plant species have extrafloral nectaries that may be visited by bees.

A forager may appear to prefer the nectar of one flower species over another. This is because it is to her advantage to visit flowers producing greater quantities of nectar with a higher sugar concentration. Further, the sugar concentration in the nectar of a given plant species may vary from one place to another, or from one time of day to another, or even from one plant to another in the same species. If high-quality nectar is available, a forager of Apis mellifera can carry as much as 70 to 80 mg of nectar per load.

Workers of all honeybee species carry nectar internally, part of their alimentary canal being modified to form a "honey sac" or "honey stomach" to accommodate their nectar load. On returning to the hive, the forager regurgitates the nectar to one or more house bees, by which it will be converted into honey. They add to the nectar the enzyme invertase, through whose action the sucrose sugar in the nectar is split into fructose and glucose, the sugars predominant in honey. Using their proboscises, the house bees expose the nectar as a thin film, thus increasing its surface area and ensuring the more rapid evaporation of the water it contains.

The entire body of a worker bee, particularly her thorax, is densely covered with fine, branched hairs, on which pollen grains are caught when the bee works on a flower. She sometimes uses her mandibles to chew off the anthers, or deliberately rolls over the anthers to acquire the pollen. The tibiae of the bee's hind legs are equipped with rows of short setae, which she uses to scrape the pollen from her body and to form it into pellets, sometimes regurgitating a slight quantity of nectar to provide moisture and adhesiveness for this purpose.

The pellets, attached to "pollen baskets" on the bee's rear tibiae, are carried back to the hive, where the load is deposited by itself in a pollen-storage cell. Whereas cells containing ripe honey are capped, pollen-storage cells are not: the bees tightly pack pollen to about two thirds of the capacity of the cell and coat the top surface of the pollen in each cell with honey, This protects the pollen against spoiling.

In addition to collecting nectar and pollen as the colony's food, field bees collect plant gum (propolis) and also water. Propolis, which is exuded by certain plants, often to protect wounds on their surface, is rich in tannin and displays antibiotic activity. It is an adhesive material, which the bees use in comb construction, to coat the interior of the hive, and to seal cracks. In collecting propolis, a field bee uses her mandibles to bite the substance from the plant surface and carries it back on her rear legs to the hive, where the house bees, in their turn, use their mandibles to remove it from the forager.

The honeybee colony needs water for two purposes only: to cool the hive and to dilute the honey fed to the larvae. Like nectar, water is collected by the field bee through her proboscis and is carried back to the hive in her honey stomach, being regurgitated to the house bees on arrival. During the heat of the day, some foragers may switch from nectar to water collection, or they may prefer to collect nectars with a low sugar concentration, whose water concentration is correspondingly higher.

F. Temperature regulation

Honeybees, like all other insects, are unable to control their body temperature internally according to changes in the ambient temperature; for this reason they are referred to as "cold-blooded animals". However, although the individual bee cannot control its body temperature, a populous honeybee colony can regulate the interior temperature of the hive, particularly within the area surrounding the developing brood. In normal colonies, the brood-nest temperature is maintained at a remarkably constant 32-36 C.

By fanning their wings, evaporating the water film at the proboscises of the workers, and dispersing drops of water in empty cells, a honeybee colony can reduce its temperature markedly. When water is available, a colony of Apis mellifera can withstand an external heat of 70° C.

When the external temperature is low, on the contrary, the bees reduce heat losses by clustering together, and the lower the temperature, the more compact the cluster. In addition, in order to generate more body heat, the worker bees will consume more food, especially honey: more heat is released as a result of the increased rate of food metabolism.

The survival ability of honeybee colonies during severe winter months depends on whether the colony has enough workers, adequately provisioned with food. Insulating the hive wall and decreasing the volume of the hive can also improve the effectiveness of the colony's thermal regulation. In the temperate regions,, colonies of A. mellifera survive by forming clusters around the brood nest, the bees at the surface of the cluster and those within it changing their respective positions at intervals. In this manner, A. mellifera colonies can survive temperatures as low as -40° C.

The regulation of brood-nest temperature is not confined to the European races of A. mellifera which further do not lose this behaviour characteristic on being transferred to tropical regions. Tropical honeybee species and races can also regulate their brood-nest temperature to a certain extent, but they are able to survive only mildly cold temperatures, generally not below 0° C.

G. Communication and recruitment to crops

Communication among its members is one of the most important biological attributes of the honeybee colony. All species employ two principal modes of social communication: pheromones and dance "language".

Pheromone communication among the members of a colony plays an essential role in regulating its social life. Apart from the queen pheromones and the alarm pheromone mentioned above, scent-gland pheromones, known as Nasomov pheromones, are used by workers of A. mellifera to mark the site of a food that has little or no scent, in order to assist other foragers in locating the site. The same pheromones are also used extensively by workers in indicating the hive location, and during the process of swarming.

In addition to chemical communication through pheromones, workers of all honeybee species are able to attract their nest-mates to a crop by dancing, scouts announcing the discovery of a new home site or, more often, food source in this manner. The distance from the hive and the direction of the food source are conveyed through a dance "language", which has two important basic forms: the round dance and the tail-wagging dance. The round dance indicates that food is near the hive, and therefore does not give a direction, but the tail-wagging dance gives more details. The distance is indicated by the speed with which the dancer completes her dance cycle, while the direction is shown by the angle of deflection from the vertical made by the bee's abdomen while in movement, which is equal to the angle formed by the lines between the food source, the hive entrance and the sun. If the line of movement is upward, it signifies that the foragers should fly toward the sun, and vice versa. Further, if the dance indicates the presence of nectar, the scout will pause and give a small quantity of the nectar to her fellow-workers, while if the source consists of pollen, she will allow the others to inspect or perceive the odour of the pollen. Finally, the intensity of the dance indicates the richness of the food source: a vigorous dance, indicating a rich source, will attract numerous recruits, while a slower dance, indicating a poorer source, will on the contrary attract fewer recruits.

Products of Bees

Honey

Honey bees collect nectar from flowers. Nectar is a sugary water that differs in composition per plant species. The forager bees bring the nectar in their honey stomachs to the hive and give it to the house bees. They process the nectar, thicken it, and fill the cells of the comb with it, where it ripens further into honey and then is sealed in with a wax capping.

Properties and composition

Honey originating from a single flower species is called monofloral honey, such as kapok honey, banana honey or coffee honey. If the nec-tar of more than one species is collected, then it is called multifloral or polyfloral honey.
Nectar contains a minimal amount of pollen, which can also be detected in the honey. Pollen is present on the anthers of all plants from which bees collect nectar. Only small traces of pollen are found in 'modern' honey. By observing pollen under a microscope, it is possible to identify its plant family, genus and species.

Bees also gather honeydew. These are droplets that hang on the flower in the morning, or extrafloral nectar from other plant parts such as the calyx, stalk or leaf. Honey made of honeydew and leaf honey contains substances found in the petals, plant stalk or leaves and a high concentration of yeasts and dust particles. This honey therefore crystallises sooner. It is also often cloudy and sour and does not keep as long.

Ripe honey is a strong supersaturated sugar solution that usually contains less than 20% water and more than 80% sugars. These sugars eventually crystallise and the product takes on a more solid form. The sugars are mostly monosaccharides such as glucose and fructose. A relative high concentration of glucose compared to fructose will make the honey crystallise sooner.

Honey

See chapter 13: Quality and regulations.

Some honey crystallises in the comb already before it is harvested. However, due to the higher temperature, it takes longer for the honey to crystallise in the hive than after harvesting. During harvesting, dust particles are introduced that function as extra crystallisation kernels (figure 11).

Figure 11: Crushed honey combs

The unprocessed product

Honey in the comb contains small amounts of pollen, wax, propolis and possibly also bee venom. The amount of these substances depends on how long the honey is left in the comb. If the honey comes from combs previously used for brood, it will contain propolis from the membranes of cocoons. However, only minimal amounts of pollen are contained in this honey. Other particles that the flying bees have caught while in the air and combed off with the pollen are also present in minimal amounts in the honey.
Honey contains enzymes, i.e. biologically active substances from the bees' saliva and stomach fluid, as well as short proteins or oligopeptides. Pure honey -has very little minerals, spore elements and vitamins.

The derived product

Honey that has been centrifuged is almost the same as honey in the comb. However, crushed or pressed honey can contain a large amount of pollen. If there is a lot of bee bread in the comb, this honey is actually a combination of honey and pollen. This 'enriched' honey contains, in addition to the nutrients in the pollen, a much higher amount of vitamins, minerals and biologically active substances.

If brood is also pressed along with the honey, the honey will have an even higher protein, vitamin, mineral and moisture content. Three or four products have then actually been combined: honey, bee bread, bee milk and brood. This is why pressed honey harvested from traditional hives is often of lesser quality and does not keep as long, but is much richer in nutrients.

It is possible, however, to harvest ‘modern’ honey and other products separately from simple and traditional hives. See the section below on production and processing.

Health value

Properties

Honey can be a lifesaver for people and animals in critical health. The simple sugars and especially the fructose content play an important role. Honey is absorbed very quickly into the tissues. It contains small amounts of other bee products such as pollen, bee milk, propolis and bee venom. These products together have a healing effect on the throat, the gastrointestinal tract, the skin and body tissues.

Glucose-oxydase is an enzyme that begins to produce hydrogen peroxide (H_2O_2) when the honey is diluted with water, saliva or fluid from a wound. This substance has a disinfecting effect. It is released slowly and is therefore more effective and does not bite as much as a 3% solution of hydrogen peroxide from a pharmacy. When honey is warmed the enzyme becomes denatured (see also 13.5), so fresh, raw honey is the most effective.

The honey from stingless bees (*Meliponini*) found in the tropics is more effective than the honey from true honey bees. This honey also has a higher moisture content (>24%) and is thinner, but it does not ferment quicker. It also has a higher content of antibiotic short proteins and enzymes, the latter of which inhibit fermentation.

Uses

Honey has traditionally been used to relieve the symptoms of asthma, hangovers and for diabetic comas. It is known to help induce sleep and to improve physical performance. Fructose is quickly absorbed by the tissues, without the intervention of the hormone insulin. Of course, this does not mean that honey can be added without caution to a diabetic's diet.

Honey is thinned for use as a cough syrup or it is added to improve the syrup's effectiveness. This is the most important use of honey in the food and pharmaceutical industries. The short proteins and propolis play an important role in the honey's effectiveness.

Honey is also used for burns and other wounds because of its osmotic cleansing effect and its healing properties. The hydrogen peroxide released when honey is thinned disinfects wounds and stings a bit. To reduce this discomfort, the honey is mixed with an equal amount of oil, butter or fat. As the wound heals, the percentage of fat is reduced. Because of the minimal amount of pollen contained in honey, it is eaten to build up a resistance to hay fever or a pollen allergy. Honey from one's own region is particularly good for this purpose. Honey also contains other particles from the air because as the bees fly these particles stick to their hairs and they are eventually combed off with the pollen. See also chapter 5.

The honey of stingless bees is used for the same ailments as the honey from honey bees. In South America it is also used in pure form as eye drops to treat cataracts.

Traditional uses of honey are surprisingly similar in all parts of the world, but there are some regional differences. Beekeepers can play an important role in gathering together this type of information, which for the most part has not yet been documented.

Harvesting and extraction

Honey is best harvested after the peak of the bee season. The quality of honey changes during its production in the hive, so the selection of which combs to harvest determines in part the quality of the honey. All extraction is best done right after harvesting when the honey is still fluid. When removing combs from the hive, application of too much smoke should be avoided. Honey in freshly built combs can be packed and sold right away as cut comb honey, without extraction or process-ing.

It is important to separate combs before extraction, and harvesting of full combs is preferred. It is better not to harvest combs that contain unripe honey, bee bread and brood if pure honey with a low moisture content is desired. Separating combs with different honey colours and extracting the honey separately will enable a beekeeper to diversify his or her production. Honey in freshly built combs is often lighter in taste and colour.

Crushed honey (figure 12) is made by crushing and mixing the honeycombs. This is a traditional processing method. Crushed honey resembles creamed honey.

Figure 12: Retail sale of crushed honey

Extraction methods

Honey can be separated from the comb in various ways: through floating or dripping, pressing, or centrifugal extraction. The floating and dripping methods make use of differences in density. In the floating method the wax floats to the surface and in the dripping method the honey drips from the comb. Dripping, floating and hand pressing honeycombs are considered to be traditional beekeeping methods, but if practised well they can be very effective and give good honey. Dripping and floating will often lead to a higher moisture content, especially in the rainy season. Before pressing, combs are wrapped with mesh material to retain the wax particles. The honey extracted in this way is less clear than with dripping or centrifuging. Plastic screening material and stainless steel sieves are better than cloth as they are more hygienic and leave no (cloth) particles behind that may serve as kernels for crystallisation. Agrodok 32 describes some methods for pressing manually and with pressing aids.

Centrifugal extraction using a centrifugal honey extractor (figure 13) is a good method for movable combs from chambered hives or top-bar hives. Agrodok 32 describes the centrifugal extractor in more detail and how to operate it optimally. Broken comb pieces can be put in a basket or a sack and be centrifuged as well.

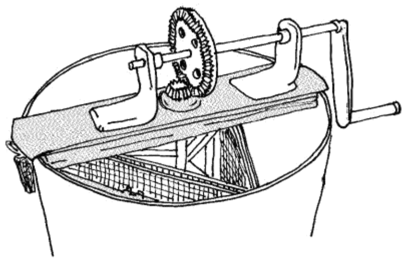

Figure 13: Centrifugal honey extractor

The capping with honey stuck to it should be kept separate, as it may contain smoke particles. The capping can be consumed as it is, or it can be saved for use as feed for the colonies. With centrifugal extraction more than 70-80 % of the honey can be extracted if it is fluid and has not crystallised in the comb.

Storage

The most important factors to consider in transporting, storing and processing honey are air humidity and temperature.

Conditioned environment

For the storage and processing of honey, it is best to have a honey house in which all the necessary conditions (cleanliness and dry air) can be created. All honey treatment must be done under dry air conditions. During transport and storage comb honey, even if it has been sealed, may absorb moisture from humid air. The time of exposure to humid air must be kept to a minimum. Honey containers should not be left open in humid air and combs must be covered.

Inside the honey house, air conditioning, fans for ventilation or other means to reduce humidity in the air can be installed and applied. Warming the processing room will help reduce relative air humidity and also make the honey less viscous, which will simplify processing. Hygrometers and thermometers should be present in every room of the honey house. A refractometer (see figure 28) to monitor moisture content of the honey at different stages is also useful.

Drying of honey

If honey has a high moisture content, this is usually caused by inadequate production, but it can also be a result of handling and transport after harvesting. Forced drying of honey after harvesting is a poor method. Water extraction or dehydration after processing will lead to evaporation of volatile substances, thus severely deteriorating the quality and taste of the honey. The best way to dry honey is to store the full honeycombs for several days in a dry room. The dry air will absorb water from the honey even through the capping.

Processing and packaging

Honey can be packaged raw. Fresh honey has the aroma of the flowers the nectar was collected from. The content of biologically active substances such as enzymes is highest in fresh and unheated honey.

Sooner or later honey will crystallise and become solid. The colour then becomes lighter. The honey can be creamed by_first heating it slightly and then stirring it. Creamed honey made of fine crystallised honey tastes the best.

Within a few days after extraction, pour the honey into an airtight storage jar or containers. To fill small pots and jars easily, use a container with a valve (figure 14). Store honey in glass jars or plastic buckets with well-sealing lids or in metal containers that have been coated on the inside with liquid paraffin or plastic, or that have been treated with food-safe varnish.

Large honey companies warm the honey to keep or make it fluid and to prevent fermentation if the moisture content is too high. After heating, the honey is filtered and poured into glass jars. This process is also called refining. Through the heating process, however, the honey loses some of its quality. Its fresh character is gone but it does stay clear longer. This is an advantage if the honey is to be sold in stores.

The honey can start fermenting during storage if the water content is above 19%. Fermentation can be prevented by heating the honey to a temperature of 55 to 60 °C over a period of 8 hours, followed by rapid cooling. However, heating honey for much longer will diminish its taste, smell, enzyme content and health value.

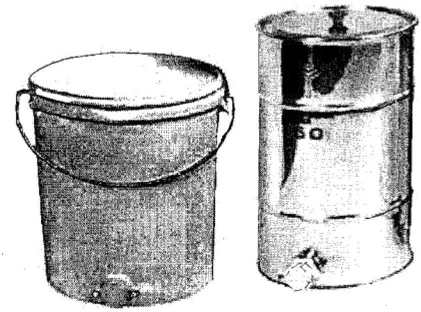

Figure 14: Metal and plastic honey bottling tanks with valves

Pollen

Honey bees collect pollen from the stamens of flowers. The pollen sticks to the bee’s hairs while the bee is sucking nectar. The bee removes the pollen from its hairs using a comb on its forelegs and adds some saliva to help roll it into a ball. The bee flies with these loads in the pollen baskets on its hind legs to the beehive. House bees push these loads with their heads into the honeycomb cells, together with a small amount of honey and saliva. The bees then process this mixture and it ripens into bee bread.

Properties and composition

Pollen grains have a tough outer wall: the exine. This sometimes has barbs that allow it to stick well to the bee's hairs. This outer wall is covered in a layer of wax, which makes the pollen very difficult to digest and is also the reason pollen can become fossilised and remain intact in the soil for millions of years. Despite this hard outer wall bees make it slowly more digestible and eventually after several weeks make bee milk or royal jelly out of it for the young larvae.

Each pollen load comes from one plant species. The amino acid pattern of the proteins in pollen determines its biological value for the bees. Bees in a colony visit various plant species, so the multi-coloured mixture of pollen loads usually has a good composition as long as it is not dominated by a deficient type, such as the pollen of corn. When the forager bees return to the hive, the beekeeper can usually recognise the origin of the pollen by the colour of the loads. The composition and health value of the pollen vary per plant species. By looking at the pollen under a microscope it is possible to identify its plant family, genus and species (see also section 13.6). This is called melissopalynology.

Pollen contains lipids, essential oils, vitamin E (tocopherol), carbohydrates, peptides, short proteins or oligopeptides, amino acids, pantothenic acid, anthocyanins, carotenoids, flavonoids, ferulic acids and enzymes as well as many minerals such as iron, manganese, zinc and spore elements. See also table 3.

Table 3: Composition of several bee products

	Components and weight in %				
Product	Water	Protein	Fat	Carbohy-drates	Ash
Honey	17-21	0.4	0	79-83	0.1
Pollen	25 => 11	22	5	31	3
Bee bread	20 => 14	20	3	24-35	3
Royal jelly	67	11	6	9	1
	' => ' refers to the moisture content after drying				

Health uses

The biologically active substances, such as anthocyanins, carotenoids and flavenoids, in pollen help cleanse the blood by scavenging free radicals. Pollen improves people's strength and well-being, supports mental exertion and enhances the blood flow to the brains. It is a supplemental source of vitamins B_2, B_6 and B_{12}.

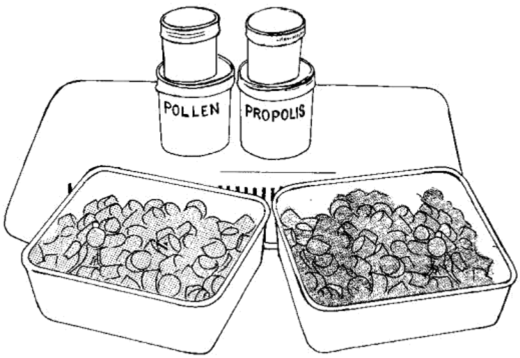

Figure 15: Pollen and propolis capsules

Pollen is used for improving fertility, relieving the discomforts of old-age, and combating the symptoms of menopause, an enlarged prostate, listlessness and stress. Due to the high amounts of micronutrients contained in pollen it is used by athletes to optimise their diet. Dry pollen loads or pollen in the form of capsules or pills (figure 15) are also taken as a remedy for hay fever, asthma, soar throats and colds.

Because it is so difficult to digest, pollen is a good remedy for intestinal problems.

Extraction and storage

Production of pollen is only possible in the early part of a season, in an area with good vegetation made up of pollen-rich plants and with a strong colony. Harvesting pollen is not good for the development of the colony because the colony may not have enough pollen left to make bee bread and bee milk, which are needed to feed to the young bee larvae. Some pollen has to therefore be left behind, for example by not harvesting every day and by rotating the production colonies.

Harvesting

Pollen is harvested with the help of a pollen trap (see figure 16).

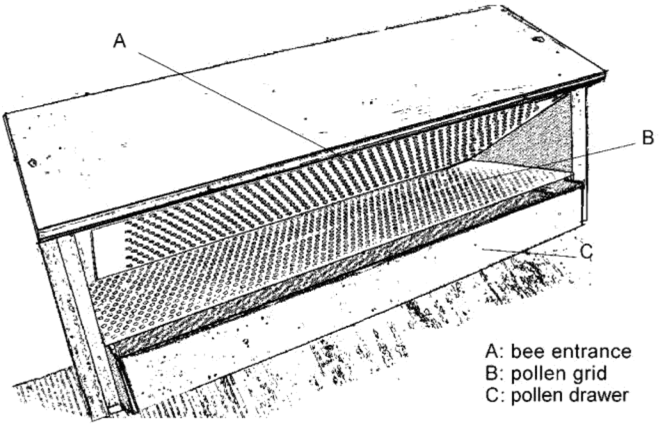

Figure 16: Pollen trap

This includes a grid that the bees have to pass through when they return to the hive. The entrance holes, which can be round or lobed, are so small that the loads are scraped off of the bees and fall through a grid. The bees cannot get through the grid to pick them up again. The various colours of pollen loads are all mixed together in the collection drawer.

Wild races, such as the African and Africanised bees, can become very agitated by this process. They do not accept the theft of their collec-tion. It is therefore much easier to harvest pollen once it is made into bee bread (see chapter 6).

Storage

Pollen spoils quickly and can therefore be left in front or under the hive for no longer than a day. The loads have to be dried immediately after harvesting to prevent mouldiness and_extend their shelf-life. The moisture content decreases during drying from about 25% (fresh) to an average of 11%. Fresh pollen becomes mouldy after just one day, and these moulds can produce unhealthy aflatoxins. To keep it longer, fresh pollen can also be added to honey, but the concentration has to be no more than 10%.

Pollen has to be stored in a dry, dark place to retain its good proper-ties. Brown glass jars are better for this purpose than clear glass jars.

Bee bread

Bees make bee bread out of the pollen that they have collected. In the previous chapter we described how house bees push these loads with their heads into the honeycomb cells, and press them into pellets with a small amount of honey and saliva. This undergoes biochemical processes caused by enzymes added through the bees' saliva and stomach fluids. Thanks to the work of micro-organisms and the influence of moisture and temperature in the beehive (35-36 ºC), the mixture ripens in two weeks into bee bread.

Properties and composition

Bee bread is a source of proteins, fats, micro-elements and vitamins for the bees. It is the raw material for production of bee milk and royal jelly, which the young nurse bees make with the help of secretions from glands in their heads (see also chapter 7). Bee bread has a different composition than pollen (see table 3 in chapter 5).

Bee bread contains fewer proteins than the original pollen, but they are easier to absorb. The moisture content decreases considerably to 13 or 14% through drying after the harvest. Bee bread also contains the following substances:

? proteins with essential amino acids
? vitamins C, B_1, B_2, E, H (biotin), K, P (rutin), nicotonic acid, folic acid and pantothenic acid
? pigments, carotenoids and anthocyanins
? the enzymes saccharase, amylase and phosphatase
? flavonoids
? more than 25 different minerals and spore elements such as iron, calcium, magnesium, phosphorus, potassium, copper, zinc and selenium.

Since the amount of lactic acid in bee bread is about six times greater than in pollen, it has a higher acidity and thus a lower pH value. This acidity of bee bread makes it self-preserving: it inhibits the growth of moulds and other micro-organisms so bee bread does not become mouldy as quickly as pollen.

Health value

Properties

The combination of various biologically active substances in bee bread makes it effective for the prevention and treatment of various diseases. Its high B-vitamin content improves the metabolism and the functioning of the nervous system and it stimulates the production of red blood cells and the haemoglobin count of children as well as adults.

Both bee bread and pollen have a positive effect on the immune and anti-oxidant systems of healthy people. It can improve the physical performance of athletes by providing extra energy.

Bee bread also has antibiotic properties: it inhibits the development of bacteria and viruses and helps reduce fever. It also stimulates tissue growth and recovery and it cleanses the blood. Bee bread has a pleasant calming effect and it slows down the aging process. It helps increase a person's appetite, gives added strength to the elderly and speeds recovery.

Uses

In apitherapy bee bread is used quite successfully in combination with other methods to treat the elderly and children. The use of bee bread is recommended for anaemia, hepatitis, diabetes and gastrointestinal problems such as colitis, constipation and diarrhoea that is resistant to treatment with antibiotics. Bee bread reduces cholesterol, improves the lipid pattern and cleanses the blood; it also improves gallbladder and liver functions and reduces blood pressure. Bee bread, like honey, is recommended for the prevention of prostate problems.

Bee bread can also help strengthen someone who is generally worn down or who is recovering from an operation. It is also helpful in combating depression and memory or concentration loss, which makes it a good product for people who are active ‘thinkers’.

Production, harvesting and storage

Bee bread is more easily digested than pollen loads and is also easier for the beekeeper to produce. If a good harvesting method is used, stress for the colony can be kept to a minimum.

The natural production of bee bread by house bees was explained above. Bee bread can be produced in larger quantities by making part of the colony ‘queenless’. A surplus of bee bread develops in that part of the colony because there is no brood and no bee milk is made from the bee bread. The combs with ripe bee bread can thus be harvested. Less damage is done to the colony in this way than when pollen loads are harvested.

Bee bread can be peeled from the comb. A special instrument is available for this purpose, called a bee bread punch. In drying the bee bread its moisture content can be decreased from 20% to 14%. Due to the changed composition, bee bread can be stored longer than pollen loads. But it too will eventually become mouldy.

Fresh bee bread can be kept in the freezer, pressed together with honey or dried. The concentration of bee bread in honey cannot be more than 15%. Dried bee bread can be eaten in pure chunks or columns in the shape of the cell, or it can be added to foods. Bee bread is tastier and easier to digest than pollen loads.

7 Royal jelly

The young bees add secretions from glands on their heads to the ingested bee bread to make bee milk or royal jelly. They put this bee milk in cells that contain young larvae. The larvae of worker bees, drones and the egg-laying female (the queen) eat these products, which make them grow. The bee milk is made up of two components: a clear and a milky white fluid. Royal jelly consists of approximately equal parts of these two, whereas the bee milk for the drones and workers is made up mostly of the clear component. The bees produce the most bee milk when they are a week old; after three weeks the secretions stop and they go outside to collect nectar and pollen. For the production of royal jelly it is therefore important to have many young bees in the colony.

Properties and composition

The bee milk for the queen is the most nutrient rich and is therefore called royal jelly. The queen also gets much more than the workers. This is partly why the queen becomes much bigger and stronger than the workers. She can live for a few years, and thus much longer than the 4 weeks to 6 months, depending on the season, that the worker bees live.

The composition of bee milk depends partly on the bee bread and thus the pollen (see also table 3 in chapter 5). It is rich in vitamins B_1, B_2, B_6, folic acid, inositol, pantothenic acid, vitamin C and vitamin E (tocopherol). Royal jelly also contains peptides, lipids, sterols, aromatic oils, carbohydrates, enzymes, anthocyanins, carotenoids, flavenoids, ferulic acids, as well as minerals and spore elements from the bee bread.

The gland secretions needed to digest the bee bread give bee milk a lot more free amino acids and short proteins (oligopeptides) than the bee bread. These form in combination with the fatty acids an acidic fraction, royalisin. Royal jelly is therefore acidic and tastes somewhat rancid, even if it is fresh. It stays good for only a limited time (5 days) without refrigeration or freezing, but it can be kept longer by mixing it with honey.

Health value

Properties

The acidic fraction royalisin makes royal jelly effective in combating a broad spectrum of bacteria, but not fungi. Royalisin contains gamma globulins, which are important amino acids in the immune system. This fraction also contains 16% asparagin, which is needed for tissue growth. About half of the fat fraction is made up of 10-hydroxy-2-decanoic acid (10-HDA), which plays a role in growth, the hormonal system and the immune system. Fresh royal jelly contains 2-15% 10-HDA, which determines its quality (>5% is preferred).

Uses

Royal jelly is recommended for stomach, liver and digestion problems, high blood pressure, loss of appetite, weight loss, fatigue, listlessness, insomnia, pregnancy, menopause, old-age problems, convalescence and athletics. Royal jelly can be viewed as a tonic to make you feel stronger, healthier and less tired. It can be eaten pure or mixed with honey. It is also often sold in glass tubes or capsules mixed with sorbitol or another sweetener. In many countries it is also added to energy drinks. Capsules with dried royal jelly are commonly used in apitherapy.

For external use, royal jelly is added to creams and salves, because it enhances or preserves the beauty of the skin. It stimulates the formation of healthy tissue and hair growth.

Production and processing

For the production of royal jelly there have to be many young bees in the hive; this is naturally the case at the beginning of a bee season. The beekeeper can increase the number of young bees in various

ways. He or she can add closed worker brood from another hive a few days before they hatch. Or he can shake bees off comb from another colony. The young bees that cannot fly yet stay behind on the combs, and the flying bees return to the hive they came from.
This makes it possible to have a production colony and one or more supporting colonies that will supply more young bees, honeycombs and bee bread. Enough bee bread, the main ingredient of royal jelly, and honey have to be available in the production colony to feed the young bees. Royal jelly production is most successful in a colony that has a queen, but the part of the hive where the production takes place has to be queenless.

Method 1: Cutting off the comb

Without the use of specialised materials, it is possible to have the bees make many new cups, in which they make royal jelly, by cutting a ragged edge on the underside of a comb that contains eggs in the queenless section. The bees will then make emergency queen cells on the cut edge where the eggs are located. The number of added cups varies between 10 to 50 depending on the strength of the colony, the number of young bees, the season and the surrounding vegetation.

Method 2: Artificial cups

The beekeeper can also use artificial cups made of PVC or beeswax. The latter can be made by inserting a stick of the right shape and diameter in the wax. These artificial cups are then glued or otherwise attached (see figure 17) to the underside of a frame (about 15 per frame) and the beekeeper inserts an egg or one-day old larva into each of them. This is called grafting and is done using a pen or other instrument. This has to be done carefully in order to not da-

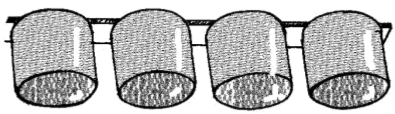

Figure 17: Grafting cups

mage the larvae. An egg or larva that was lying down has to be placed in the same position in the new cell to prevent it from drowning in the bee milk.

The final result is illustrated in figure 18: the bees then build queen cells for royal jelly.

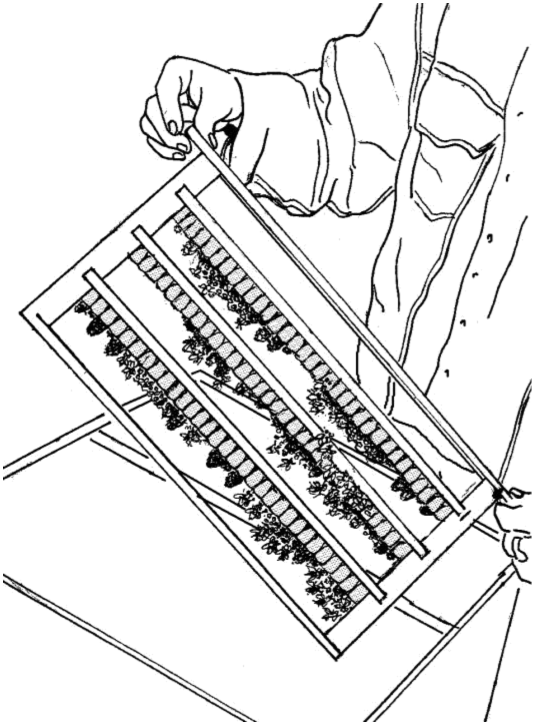

Figure 18: Bees put royal jelly into grafted cups

Method 3: The introduction cage

With a similar system using PVC cups it is possible to have the queen lay the eggs herself. Exactly 100 cups are placed in a square box, such as the Nicot-brand *cupularva*. The queen is confined inside this box. The worker bees can come in and out through a grate, i.e. queen excluder, to feed the queen. In a good colony it will take one to four days for all of the cups to be filled. These are then placed in corresponding holders that are already attached to the frame in the hive. This method ensures that the eggs will not be damaged.

Harvesting

If any of the methods described above are followed, it will take three days for the maximum amount of royal jelly (between 0.25 and 0.30

grams per cup) to be produced, and it can then be harvested with a pipette or a spoon (see figure 19). A special instrument with a suction pump is also available for this purpose.

Figure 19: Extraction of royal jelly with a plastic pipette

Fresh royal jelly can be kept at room temperature for only a few days. Of course it can be kept longer in the freezer or by adding it to honey, but the con-centration must not be more than 3-5% to prevent fermenta-tion. After being freeze-dried, or lyophilised, it can be kept in powder form at room tempera-ture.

Since the production of royal jelly is very labour-intensive for the beekeeper and the yield is very small this product is very expensive. The active in-volvement of the beekeeper makes it important to work with calm colonies.

Brood

Bee brood is made up of eggs, larvae and pupae in the comb (figure 20).

Figure 20: Brood comb with larvae

The larvae and pupae are especially suited for consumption. Harvesting brood is bad for the development of the colony, so the larvae and pupae of drones are usually used because the colony is less dependent on them. Brood is also sometimes a by-product of the honey harvest, especially with wild colonies (figure 21).

The composition of bee brood, especially in the larva-stage, is in part that of the bee milk. In the pupa stage many of the substances provided for growth become body proteins and fats.

Figure 21: Harvesting brood comb from traditional hive

Health uses

Bee bread is eaten in some countries as a traditional dish, either with the comb or separated as just larvae and pupae. In Africa the larvae and pupae are removed from the comb and used as an ingredient in various dishes. In Indonesia the sealed brood comb of *Apis cerana*, the indigenous honey bee, is sold at markets. The cocoons and brown membranes of the pupae plus added spices give the dish a traditional, strong flavour. In Eastern Europe beekeepers eat drone larvae because of their hormone-like strengthening properties. They are used to treat old- age ailments and to enhance convalescence. They also supply extra energy, for athletic competitions for example. Apitherapy products made of drone brood are found in Asia as well.

Production, harvesting and storage

The production of worker brood naturally takes place in the early part of a season. If there are already some combs with worker brood present and the supply of nectar and pollen continues to increase drone brood will also be made. This is normally no more than 10% of the total brood. After this, queen cells are made.

Since removing brood is bad for the colony's development and for its subsequent production of honey, it is best to harvest only drone brood and only a small amount. Drones mate with the young queens and have a function in the colony during the nectar- and pollen-collection period. Drones are not limited to one colony so drones from other colonies may also enter the hive. Drone brood can be harvested with a special unsealing tool, with which a whole piece of drone brood can be removed from the comb at one time.

Traditional beekeepers often harvest brood together with the honey. Most of the sealed honey is pressed out. The remaining honey is then used to make honey beer or wine.

The fresh, unprocessed brood can only be kept for one day. It can be added to honey, but the concentration may not exceed 5% for larvae and 10% for pupae. The larvae from harvested royal jelly are also processed by drying and then grinding them into powder.

Beeswax

Bees need wax to build their honeycomb nest. The building material and supply of energy for this activity is honey.

9.1 Production by the bee

The bees sweat wax out of four pairs of glands on the underside of their abdomens. The development of the wax glands depends on the pollen eaten by the young bees after they emerge from the cells. Rich pollen feed in this early phase ensures that the bees will later have an optimal capacity to build. Bees that are about ten days old sweat the most wax.

While producing and building with wax, the bees eat and digest a lot of honey. Their high metabolism leads to a high body and surrounding temperature, which is necessary to keep the wax fluid. The wax drips like a curtain out of the gland's narrow opening and hardens as it comes in contact with the air. It thus becomes transparent, white, ellipse-shaped scales. The bees then hold these scales with their forelegs and chew them into the right form to build a comb. If a bee swarm remains for some time in the same place the bees will start to produce these scales and build a comb. Fallen wax scales can then be found under the colony.
A swarm, i.e. a travelling colony that does not have a nest, will naturally build a piece of comb in or on the new nesting place. Sweating wax is an energy-consuming biochemical process. The required material and energy comes from honey the bee has brought along in its honey stomach or, if a bee nest is present – that is stored in the comb.

Properties and composition

The information provided below refers mostly to the honey bee *Apis mellifera*. Other *Apis* species produce wax that has a somewhat different composition. Stingless bees sweat very little wax but they collect from nature gums, glues and resins to mix with. This makes the wax from these bees tougher and stronger.

Beeswax is a natural product that consists of a number of insoluble fractions. This gives wax a melting trajectory rather than a melting point. The melting trajectory lies between 62 and 65 ˚C and a relatively high level of energy is required to melt it. The melting trajectory offers a number of advantages. It makes the wax pliable: it already becomes soft at 35 ˚C. Beeswax can be extracted from the comb using the heat from the sun, steam or hot water.

Beeswax is chemically inert. It can therefore be used to protect materials from chemical substances and also from honey by covering them with a thin layer of beeswax. Wax is also suitable for uses in which the active ingredient has to be released slowly. Beeswax does not dissolve in water; this makes it suitable for waterproofing materials and cloths and for resist techniques. Beeswax does dissolve in organic solvents such as benzene, ether or chloroform, as well as in fats and oils through heating.

The colour of beeswax is determined by the pollen that the bees collect during the building process. New wax is usually white, but it can also be yellow to reddish-orange. With use, the combs become darker, even brownish-black after they have contained brood. Beeswax bleaches in the sun.

Cold beeswax is a brittle mass that crumbles apart easily. It has a density of about 0.95 kg/litre and it floats in water. Its density increases at lower temperatures, which makes it shrink. This is useful for processing in moulds because as the wax cools off after being melted it shrinks and comes loose automatically from the mould.

Uses

Beeswax has a wide variety of uses.

Wax in beekeeping and honey production

The most important use of beeswax is in beekeeping itself, namely for the production of artificial combs. Artificial comb foundation is made of moulded or pressed wax sheets with cells imprinted on them that the bees very quickly and economically (using very little honey) build into comb. A surplus of beeswax can be found mainly in countries where artificial comb foundation is not used.

New wax is much cleaner than old, melted combs. Beeswax, both from new and old comb, is edible but not digestible. If you eat comb honey you ingest a very small amount of wax, less than 2 to 3% of the honey's weight. Comb honey is therefore produced only in new comb. Honey from older combs or from built-up artificial combs does not taste as good.

In countries where traditional beekeeping is practised, people often eat honey in and from all types of comb. This gives the honey a strong membrane taste.

Traditional and industrial uses

Makers of musical instruments use beeswax because of its shaping, gliding and tanning properties on wood and leather. It is also used in the production of coloured crayons and paint. It is applied in woodworking, metal casting, printing presses, for carbon paper, waterproofing of textiles and in the electro-technical industry. It is also an important ingredient in polishing and furniture wax, shoe polish, car wax and lubricants and metal polish (together with calcium powder) as well as in resist techniques such as etching and batik. Beeswax has been used for centuries in engraving and batik techniques as well as in the casting of bronze hollow statues with the ‘lost wax’ or ‘*cire perdue*’ method.

Thin straight candles are made by repeatedly dipping the wick in wax. In Europe, candle makers used pure beeswax to make candles for the church up until the mid-19th century. This is still practised in Ethiopia, among other countries, although paraffin candles that are died yellow are becoming more common. Beeswax was seen as a symbol of virginity because of the worker bees that produced it.

In the food industry, beeswax is used as a polish and anti-adhesive for candy, such as liquorice and chewing gum. Liquorice pieces are coated with a thin layer of beeswax so that they don't stick to each other. Beeswax is used as an air-tight seal to preserve jams and fruits, and to cover honey that is separated from the comb through heating and then poured into a jar.

Beeswax also has applications in the sport world, such as in archery, and in horticulture, such as in the grafting of trees.

Cosmetic applications

The cosmetic industry uses beeswax as an emulsifier and binding agent in oils and fats because of the high amount of energy required to melt it and its melting trajectory. This makes these cosmetics hard when cold, and prevents them from melting too quickly in the sun like solid fats. Moreover, they react perfectly to human skin. Beeswax is therefore frequently added to creams, salves and lotions. Lipstick and mascara, which normally contain more than 30% beeswax, are both quantitatively and qualitatively important uses.

Beeswax is also used to remove hair by first pouring it over the skin in liquid form and then pulling it off once it has become solid.

Health uses

Beeswax does not contain any proteins, digestible fats or carbohydrates and is thus not really a foodstuff. But it can be an ingredient in foods. If you eat beeswax, for example as an ingredient in comb honey or candy, it is not digested but acts as a filler. As such it helps the food pass through the gastro-intestinal tract, but the beeswax itself is eventually excreted undigested.

The hardness and slow melting trajectory of beeswax make it an important addition to suppositories. Wax often has a lubricating and emulsifying effect. In pills and suppositories it functions as a carrier that slowly gives off the active substances. Other uses for beeswax are as coatings for pills and as dentistry aids. Beeswax is thus more often a carrier or binding agent for other medicines than a remedy itself. At the pharmacy and in pharmaceutical literature it is called *cera flava* (yellow purified wax) or *cera alba* (white, bleached wax).

Beeswax is used for rheumatic ailments, which require the transfer and retention of heat. In physical therapy and massage treatments pure beeswax is used as a compress on muscles and joints. It has a heat-regulating or balming effect, for example as a treatment for heel cracks.

Ear candles, which have no wick, are made of beeswax and are used in natural medicine. They are said to stimulate the blood and lymph circulation in the ears, throat, nose and sinuses and regulate the pressure in these areas. They also may stimulate the coordination of the brain hemispheres. Candles are also used as aids in rituals and in meditation.

Throughout history beeswax has also been used together with honey and propolis for embalming dead bodies.

Melting wax

Beeswax is extracted from various sources. The honeycomb in feral colonies can provide a lot of wax, approximately 1 kg per large bee nest. Old used honeycomb can also supply wax. Small pieces of comb can be collected and saved until the total amount is worth melting: these can be bits of comb from hives, frames and wax cappings that are removed before the honey is extracted from the comb. Wax from wax cappings is easy to extract and is often of high quality.

To get pure wax from the comb you have to separate the wax from various impurities. This can be done first of all by melting the wax out of the comb with the help of solar energy, hot water or steam. The wax is then cleaned. We will discuss below only a few techniques used in these processes. With the hot-water method, the residue after melting still contains 30% beeswax. For this reason it is more efficient to melt and press this residue a second time.

Sun

Wax can be melted by the sun through a slanted rectangular box covered with a (preferably double-paned) piece of glass or transparent plastic. A heat absorbing plate is placed on the bottom of the box (see figure 22).

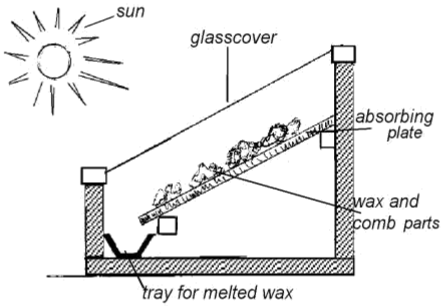

Figure 22: Solar wax melter

Sunrays penetrate the glass and are absorbed by the plate. This plate transforms the sunrays into heat, which increases the temperature in the box. The wax, which is located on a grate in the box, melts and drips down the plate into a catch tray. This solar wax melter is very suitable for wax cappings and empty comb.

It is important that the sun shine as directly as possible onto the box to prevent the light from being reflected back by the glass. Place the box on a slant that corresponds to the position of the sun. The glass plate can be made of either single or double-paned glass or it can be made of transparent plastic. The heat-absorbing plate can be made of black stone or black-painted zinc. The catch tray is made of thin metal so that it is flexible enough for the hardened wax to be removed easily.

Hot water

In using hot water to melt wax, pieces of comb and wax cappings are bundled in a cotton or jute bag. The bag is submerged in a cooking pot filled with water and held under water with a press weight. The water is heated (see figure 23). When the temperature rises above 65 °C the wax begins to melt, filters throught the bag and floats to the surface. When no more wax floats to the surface, a little bit more wax can be extracted by pressing the bag with more weight. This method has to be repeated once or twice to remove the remaining wax, which can be as much as one third as much as was extracted in the first attempt.

The hot water wax melter is suitable for empty comb. Wax cappings can be melted directly in hot water without being bundled or pressed. Any honey still sticking to the cappings will be left behind in the water, which can be used later as a basis for feed.

The wax hardens in the water and can be removed in chunks to be processed further. It is important that the water not be allowed to boil. The bag cannot rest on the bottom of the pot, directly above the fire, because the temperature is too high there. The bag should therefore be placed on a wooden rack or bar.

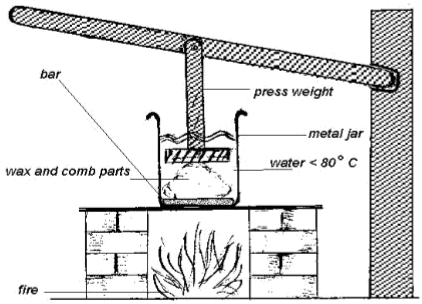

Figure 23: Hot water wax melter with press weight

Steam

Figure 24 shows a steam wax melter. This device produces steam from a separate boiling pot. The steam is guided with a valve to a perforated sieve or bag, that is attached in the wax melting chamber. The wax thus drips to the bottom and is tapped with a valve.

The steam master can process large amounts of comb efficiently and it is suitable for all sources of wax. But it is difficult to fabricate such a wax steamer on your own; which can be done with the sun and hot water wax melters.

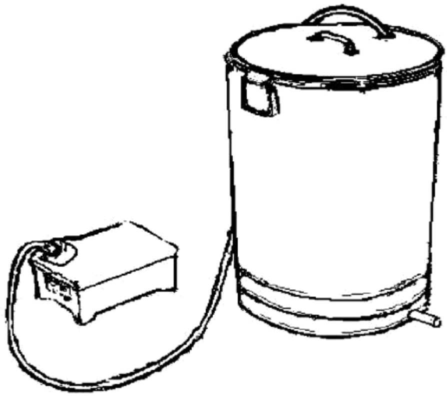

Figure 24: Steam wax melter connected to melting pot with valve

Another type of steam wax melter is heated from below e.g. by fire. Steam ascends from boiling water in a lower part, underneath a perforated holder full of comb or wax cappings. The wax in the upper part melts out of the comb and drips into a catch basin that can be taken out separately. The wax parts can be scraped from the bottom part once they have cooled.

Double-walled steam wax melters heat wax in a central body through a double wall that is surrounded by steam.

Processing and marketing

After melting, the wax still contains impurities, especially on the undersides of the wax sheets. These can be easily scraped off. The wax is then cleaned again in hot water or steam and poured into one or many smaller forms. These can be made of metal or even plastic, since the wax is not hotter than 70-80 °C. It is best to allow the form, with a warm closure, to cool off slowly in a draft-free area. Allow it to cool for at least one day. The wax will now generally be free of organic impurities. The underside can be scraped again up to the pure wax.

For some uses the wax may have to be bleached, which can be done naturally or with chemicals. For beekeepers, only a natural method is recommended, preferably exposure to the sun. Grate the wax into fine pieces and spread them thinly over a mat, or make thin sheets by dipping a wet board in fluid wax and then scraping it off once the wax hardens.

If large amounts can be collected and processed, beeswax can be an attractive product for beekeepers in the tropics to trade and even export. Wax produced for the export market has to be cleaned as well as possible. After the cleaning process is completed, the wax can be poured into manageable blocks weighing 20 to 25 kg. To collect enough for a whole shipment, the wax production of many beekeepers can be combined. This can be done, for example, by a beekeepers' organisation or group.

Do not mix the wax with wax substitutes such as paraffin or oil residues. This diminishes its value and the buyer’s trust in the product.

Propolis

Propolis is made by bees out of tree gums, glues, waxes and resins. These can be found around the flower buds and are excreted as drops from the tree's bark if it is cut or cracked. The bees bring them on their hind legs, just like pollen, to the hive. They mix them with their own wax and saliva. This produces propolis.

Properties and composition

Propolis has its own specific properties: it is sticky, brown and fragrant. The bees use it to fill undesired holes or cracks in the walls of the hive and they polish their cells as protection for the future brood. Bees also use propolis to adjust the size of the opening into the hive. In a severe winter they will make it smaller. They also smear it on the inside of their hive and use it to stick loose parts of the hive together. This can be an advantage if the hive is moved. They use it to embalm undesired invaders, such as dead mice. Bees also mix a small amount of propolis with the wax used to cap the brood cells.

All honey bees produce propolis, but the substance is used differently by the Asian honey bee species and stingless bees. One colony will collect much more of the necessary ingredients than another, and the seasons can also play an important role. One can expect a production of 50 to 100 grams of propolis per colony per year.

The potent components of propolis are flavonoids, ferulic acid, resins, aromatic oils and carotenoids. Other ingredients include botanical waxes and beeswax (about 30%) and various other crude particles. The gums, resins and botanical waxes collected by the bees are always from a mixture of tree species, each of which has its own type of flavonoids. Propolis therefore varies with the vegetation and its geographic origin. The flavonoids from various origins all have a similar, but not identical, chemical formula. They are therefore used scientifically to identify the geographic and botanical source of the honey.

Propolis in moderate regions contains more than 50% active ingredients. In tropical regions propolis is dryer, harder, less sticky and less fragrant; it has less than 10% active ingredients. This is the case for the propolis of *Apis mellifera*. The propolis of stingless bee species is mixed with more beeswax and is therefore also called cerumen.

Propolis is not water soluble and does not allow air to get through. It is hard at low temperatures but flows out at temperatures above 35°C. The colour of propolis can vary from dark brown to reddish or yellow.

Health value

Characteristics

Propolis contains no proteins, carbohydrates or fats and therefore has no energy value. Since propolis is a mix of many substances, its effectiveness covers a broad spectrum. Due to its therapeutic qualities, it is used as a dietary supplement.

If a germ of a bacteria, mould, virus or yeast is encapsulated by propolis it will no longer be able to breath or take up water. The germ therefore shrinks and dies. This is an antibiotic effect and the reason propolis is often called a natural antibiotic. Human skin and bones can also be strengthened by propolis. Propolis enters the tissues through the skin and thus enhances the healing of broken bones and muscle ailments, such as a bursa infection. It is soothing to the skin and has a healing effect. When taken internally, propolis cleanses the blood, that is, it actively scavenges free radicals. Propolis also relieves pain when applied externally.

Some beekeepers are allergic to propolis; they can develop rashes in which the skin becomes red and scaly. If this occurs, avoid contact by wearing gloves.

Uses

Propolis is used for healing wounds, as a ‘natural antibiotic’ taken in addition to antibiotics and as a way to strengthen one’s health and immune system. For external use, propolis is processed in nose drops, cough syrup, toothpaste, lotions, salves, creams, skin oils, shampoo and skin soap. Health care products that contain propolis are used for wounds, scars, infections, muscle ailments, eczema, psoriasis, warts, moulds and nail cuticles (fungi).

For internal use, propolis powder is often mixed with honey. To make tablets and capsules (figure 15), propolis has to first be purified because the botanical waxes and beeswax normally present make it difficult to absorb the propolis in the digestive system. For homeopathic uses, raw propolis is extracted with alcohol, or ethanol (see chapter 11), to make the so-called mother tincture. This is processed in nutrient supplements and health care products or diluted further for use as a tincture. Tincture does not dissolve in water, so the best way to take it is to drip it onto a crust of bread, a sugar cube or tablet. Drops of light tincture (10%) can be added to a glass of water. Chewing gum, capsules, tablets, cough syrup, and mouthwash are also available.

Further uses

In beekeeping

Beekeepers use propolis, sometimes mixed with wax, to make hives more attractive to swarms. Bees detect the smell of propolis from a great distance. A propolis wood stain can be made with ammonia or other alkaline solvent.

Traditional uses

Propolis has many different traditional uses. It can be used as an agent in a cast for splinting a broken leg and as a glue (with or without added wax), for example to repair broken earthenware. Propolis was once used as an ingredient in paints, but this method is not practised anymore and the old recipes are lost.

Propolis improves the quality of wood and thus used to be used primarily for polishing wooden musical instruments. Not only does it prevent moulding and rotting, but when mixed with beeswax it also tans or enhances wood and leather. It improves the sound of musical instruments, such as that made by the skin of a drum. African musicians press with their fingers onto a pellet of propolis mixed with beeswax on the skin of their drums to improve their tone.

Harvesting and processing

Various systems have been devised to collect propolis. One way to collect propolis is by using a net or a special propolis plate made of PVC, with variegated holes or slits 2 to 3 mm wide. The propolis plate is hung at the top of the hive on the frames or in the form of a frame hung between the other frames. Using propolis, the bees try to close them as quickly as possible to prevent draught. This is important for the thermoregulation of the brood nest.

After harvesting, the propolis trap is put in a cool place, or it can also be put in the freezer or in cold water. Once everything has become cold, the beekeeper can break the propolis off the plate in small chunks and if desired reuse the plate or net.

An easier and more common method is to scrape the propolis from old frames that have been removed from the hive. The propolis is found mostly on the top and the upper parts of the side slats. In top-bar hives, the propolis is scraped from the sides of the top slats. In the tropics it is also possible to hang calabashes or pots with a large bee entrance in the hive. The bees close the entire opening with propolis.

Processing

The propolis has to be cleaned. Bits of wax, paint chips, nails and other impurities have to be taken out. The concentration of pure propolis in the mixture in moderate regions has to be higher than 50%. Propolis can be ground, such as with an old coffee mill. The propolis should be as cold as possible, straight from a freezer for example, because it is then hard and not sticky. The best results are achieved by first putting the freezing cold propolis through a circular grater until it becomes a rough mixture and then grinding it.

The collected propolis can be stored in plastic buckets but not in cans. As propolis becomes warm, it flows out and eventually forms a hard block. It is then very difficult to get it out of a can. Adding a small amount (10%) of a different powder prevents it from coagulating. For this purpose you can use pollen, sugar, cassava or other type of flour, dextrin-maltose or magnesium stearate.

Bees

Origin and composition

On the outside bees have a chitin skin, legs and wings (figure 25). Their internal structure is made up of tissues and organs, such as glands and organs for endocrine (hormone) production. Bees' blood has a high concentration of short proteins. These are thus also found in their gland secretions.

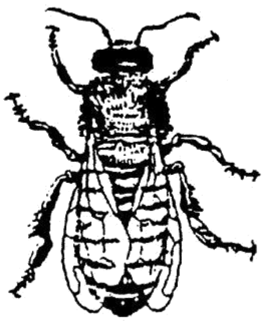

Figure 25: Worker honeybee

Health value and production

The health value of bees is recognised primarily in traditional medicine and homeopathy. The proteins in gland secretions have an antibiotic character and contain enzymes. An important gland is the venom gland, which contains the bee's venom. The digestive tract contains components of honey and pollen. All of these substances contribute to the therapeutic value of bee products.

Bees or parts of them are extracted with alcohol in natural medicine to make mother tincture. Homeopathic dilutions are made from this at a ratio of 1 part tincture to 9 parts alcohol (D_1), and again as 1 part to 9 (as D_2), etc. Diluted tincture is dripped onto a sugar cube and used for people who react strongly to a bee sting. Mother tincture and its dilutions are sold in the pharmacy as *Apis mellifica*.

Bee stingers are collected by cutting them off from the back of worker bees. They are then dried and ground, and mixed with sugar or a powder in the same ratio as noted above. This product, called *Apisinum*, is stronger than *Apis mellifica* and of course contains more bee venom.

Bee venom

Female bees, namely the worker bees or the queen, have a stinger on the end of their abdomen that they can extend. The queen usually only uses this to lays eggs, but she can also sting with it. Worker bees do not lay eggs usually, but only sting with it. A drop of fluid, the bee venom, hangs on the extended stinger. The stinger is also covered in barbs.

The bee venom is made in the venom gland and is stored in a venom sac at the base of the stinger. Young bees have little venom. Their venom sac is not filled until their 15th to 20th day, when it contains about 0.3 mg of liquid venom. The spring bees that are raised with a lot of pollen have the most and most effective venom.

Bee venom dissolves in water but not in oil. Alcohol is harmful to bee venom.

Composition

The effect of a bee sting

When a bee stings, it pumps liquid venom through its stinger and injects it into its victim. If a bee stings another bee or wasp, a lizard or a snake, it can retract its stinger. However, due to its barbs the stinger stays in the skin of a person or other mammal. The stinger continues to pump venom for 10 to 20 minutes, whereby only one third of the venom from the venom sac is released. Most of the venom is released from the venom sac in the first minute. A bee or other insect can die from one sting and a chicken, horse or donkey from a few stings, but a person can tolerate many more. This differs of course per person and depends on how often a person has been stung before.

Someone who is attacked by a colony can have hundreds of stingers in his or her skin. These can be counted in a hospital in order to get a better idea of how many stings it takes to make different people lose consciousness or die. On the skin of a person, a white ring about 1 cm in diameter will develop around the spot that was stung and then a larger red spot will develop leading to swelling. The first sting a person receives can cause a number of unpleasant symptoms, such as a headache, a large swelling and itch. Most people build up resistance, but some become allergic after a number of stings.

Bee venom is poisonous in very small amounts and some people can be allergic to it, particularly when it is injected through stinging. Within an hour of being stung, an allergic person’s blood pressure may drop so severely that renal shock causes the person to die. Blood flows to the tissues, resulting in a shortage of fluid in the organs, especially the kidneys. Vomiting and drinking water can help to reverse this, since the blood is then pulled to the digestive system and other organs. Caution and precautionary measures are therefore extremely important when dealing with bees and extracting and processing bee venom.

Potency

The composition of the venom varies somewhat between the individual colonies or races of one bee species, and it varies considerably between various species of honey bees. Components of bee venom include, among many other substances, mellitin (40-60%), phospholipase A (10-12%), apamine (2-3%), MCD-peptide (2%), histamine (1%). The effectiveness of *Apis cerana* venom is twice as high as that of *Apis mellifera*, and the venom of *Apis dorsata* is about the same strength as that of *Apis mellifera*. The venom of *Apis florea* is less potent. Stingless bees do not have a stinger nor venom, but some species can bite and release irritating substances into the victim’s skin.

The active ingredients in the venom are dissolved in the fluid in the venom gland. The venom contains five components from the bees' blood fluid, such as proteins. Someone who is allergic to bee stings, is not only overly sensitive to the venom, but also to this blood fluid.

The equivalent of one bee sting contains about 0.1 mg of dry material. For use in medicines, nutrient supplements and health care products, the liquid venom is dried and purified. It is then concentrated by more than three times.

The LD_{50}, or lethal dose, is equivalent to the amount it would take for 50% of people to die (calculated based on animal tests and conversion of the results to the average body weight of humans). The LD_{50} of pure bee venom is 2.8 mg per kg of body weight. For someone who is 70 kg, this would amount to 0.2 grams or about 2,000 bee stings. The effect of the venom can be intensified, however, by panic and fear when a person is attacked by bees.

A beekeeper who is stung often has an increased amount of immunoglobin-E in his or her blood. This is an antibody in the blood proteins. He or she would be able to tolerate being stung 40 to 100 times, but this would lead to problems for anyone else. An allergic person can die from just one bee sting, but this extreme reaction, or anaphylaxis, can only occur the second time an allergic person is stung.

Health value

Properties

In non-allergic people, bee venom stimulates the blood supply to the tissues and the permeability of the cell membranes. Blood vessels are widened and the blood pressure drops. Bee venom also relaxes muscles and can reduce muscle pain by dissolving the lactic acid in the tissues. A small amount of bee venom is invigorating, but too much can cause heart palpitations and sleeplessness, comparable to the effect of too much coffee. The production of more or less urine can also result.

According to available statistics, beekeepers are less likely to contract a number of diseases because they are continuously injected with bee venom. These include rheumatic ailments, such as arthritis, and cancer.

There are many documented cases of disabled multiple sclerosis patients who were able to walk again after receiving many bee stings. Bee venom induces production of cortisone, a hormone of the adrenal cortex. This affects the nervous system, namely the conduction in the myelin sheath of nerves. Bee venom is said to have a healing effect on damage to this area.

Uses

In traditional medicine in Africa finely ground bees were used as a salve or tea to combat various diseases including rheumatism. People also had themselves stung on specific places on their body.

Bee venom is used in various ways: it is inhaled, eaten in the form of bee venom honey, injected in the form of injection fluid or applied on the skin as a salve. It is also applied by being stung, either on its own or in combination with electrotherapy, acupuncture or acupressure. This is very painful and it can be dangerous. In China and Japan only the removed stinger is used as a needle on acupuncture points. This is felt by the patient, but it is not painful.

A minimal amount of bee venom is naturally present in honey. It is of course also present in the mother tincture *Apis*, which is used in homeopathy and natural medicine.

Production and preparation

Bee venom is a poison and it can kill both humans and animals! For its collection, harvesting and processing special precautions are needed like gloves, a mouth-cap, etc. Do not inhale or consume bee venom in any way without carefully following prescriptions and calculations regarding the dosage!

Production

Bee venom is harvested using a bee venom collector. This is a glass plate over which metal wires are strung that are electrified with one large battery or a number of small batteries. When the bees touch the wire they empty their venom sacs. After a number of bees have re-leased their venom, the colony as a whole attacks the collector plate so that thousands of bees empty their venom sacs onto it.

The venom dries up on the glass plate and the jelly-like powder can then be scraped off. Protect your hands with gloves to ensure that you do not come in contact with the venom and cover your face with a mask to keep from inhaling it. The bee venom collector is placed in the hive for an hour and is then taken away. During and after use of the collector the hive and other colonies in the area can become very agitated. It is therefore best to do this in an isolated area.

Venom from one hive can only be harvested a few times per year, oth-erwise it would weaken the colony too much. Harvesting bee venom can also reduce the production of honey. A strong colony can supply approximately one gram of bee venom each time.

The venom can be added in raw form to products or it can first be pu-rified. Strict rules apply to this process, which have to be adhered to. Beekeepers can, however, supply the raw venom to recognised and certified laboratories.

Preparation

To ensure exact concentrations, bee venom is added to honey in stages. For example, 0.1 gram of bee venom is added to 1 kg of honey and then 100 grams of this mixture is again added to 1 kg of honey. This gives a concentration of 0.01 mg of bee venom per gram of honey.

To give a good idea of how much venom is involved and to prevent an overdose, the added amount is given as a sting equivalent (0.1 mg) per tablespoon (10 grams) of honey. In salve, the added amount is given as a sting equivalent (0.1 mg) per gram. The dosage is never more than 2 sting equivalents (0.2 mg) per gram.