BEEKEEPING

IN HADHRAMOUT

Prof. Dr. Mohammed Saeed Khanbash

2021

Al-Omran Institute
for studies and capacity building

معهد العمران
للدراسات وبناء القدرات

إصدار

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Foreword

Historical sources indicate that the importance of beekeeping and honey production has been connected with the socio-economic life in Hadhramout since past ages and up to now. Hadhramout has gained a good reputation for beekeeping and honey production. Data show that beekeeping is developing and honey production is increasing year after year. Export of honey also increased in the last years.

The aim of this book is to document and publish the findings of researches and studies carried out in different areas of beekeeping in Hadhramout.

The book tackles important aspects of beekeeping in Hadhramout.

It includes a historical Background**,** information on Honeybee Colony, local honeybee race *Apis mellifera jemenitica* , bee hives and the honey. It also includes the results of research studies on bee forage plants and the tolerance mechanism of local honeybee to diseases.

I hope that this book will provide helpful invaluable information for those working in the sector of honeybee in Hadhramout.

I would like to express my gratitude to these who gave me invaluable assistance in the preparation of this book. I especially thank Dr. Khaled Awadh bin Makhashin for proofreading the material of this book and everyone who helped me in preparing this book.

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1- CHAPTER
Historical Background

1. Historical Background

Introduction:

All archeological studies have shown that honeybees appeared in earth before human being. Bees started life in mountains and forestry, where they build their hives in caves and hollow trunks of trees. Bee crowds attracted the interest of the first man, who was looking for his food in mountains and forestry; and hence honeybee was known since old times. This was confirmed by drawings, which were found in rocks in Spain which dated back to the 7th M.B.C. These drawings showed how the first man tried to get honey from bees. The Egyptian Inscriptions, which dated back to the 4th M.B.C, showed that old Egyptians were aware of honeybees and presented honey to please their gods (Abdul-Latif et al. 1984).

Beekeeping and honey productions were one of the traditional skills in Hadhramout. History of beekeeping in Hadhramout dated back to the 10th M.B.C. It was related to the prosperous economic life in Hadhramout at that time (Ingrams, 1937). Since that time the people of Hadhramout have been interested in beekeeping over centuries and continued till now.

Hadhramout honey particularly ‘Asal Al-elb' (Sidr) *Ziziphus Spina Christi* produced from Wadi Doan, has gained a very good reputation and commercially it is the most expensive honey in the world (Arrawi,1985; AOAD,1985; Abdul-latif, *et al*.1998) due to some specific characteristics.

Hadhramout beekeepers are competing to provide honey types that meet the consumer's demands in the local markets and foreign markets (Khanbash, *et al*. 1998). Statistics of foreign trade have shown that honey provide a lot of foreign currency and plays an important role in the economy of the country. This study reviewes the history of beekeeping in Hadhramout to highlight the experience of Hadhramout beekeepers gained over centuries and to develop the recent beekeeping practices.

Developmental stages of Hadhramout beekeeping:

Developmental stages of Hadhramout beekeeping have passed mainly through three stages (Khanbash, 2000; 2003):

1. Primitive beekeeping:

in this stage honeybees lived in caves, mountains and logs of trees since God has created them and guided them where to live. Bee colonies built their hives from wax and fed on the pollen grains and nectar of the plants around.

The beekeeper looks for beehives to get honey. He can detect where they live by one of these methods:

1st- Following up the honeybee workers to where theylive.

2nd-Following up the track of bee faeses on land from the places where bees visit plants till they go back home.

3rd- Following up the warwar bird in the area where it guides him to where bees are living.

When the beekeeper discovers where honeybees live, he can extract honey by one of these methods:

1st- burning all the hive which led to the death of a lot of bees, in addition to a number of trees and shrubs being burnt.

2nd- Using heavy smoke to force bees to get out of their hives .

3rd- Closing the entrance of the hive by sticky mud at sunset and after bees come back home. The beekeeper puts a pot of water above the entrance where drops of water fall down on the entrance. The beekeeper opens the entrance after one or two days and all bees are then pushed out in large numbers; they migrate and leave their hives.

These methods aim at getting only honey, the beekeeper is not interested to keep or rear honeybees. These methods have developed later where the beekeeper tried to keep honeybees by burning a band of grass to protect him from the attack of bees and then he cut the combs of honey by a knife. He then sells honeycombs with wax.

This primitive stage of beekeeping is no longer exists in most areas in Hadhramout . However, Khanbash (1996) noticed that this method still exists in Socotra island where honeybees live in a wild stage. He didn’t notice any bee colony living in any type of hives. Families which live around these bee colonies tried to keep them safe, as they consider themselves the sole owners of them, and protect them till honey harvest.

2- Traditional beekeeping

when man first thinks of how to make use of honeybees, he started to make a living place for it similar to its natural habitat. Then he tried to improve it to be more suitable for him to get honey out of it, and at the same time he also can keep it safe.

Hives made of plant debris, stems of plants, clay and hollow logs of trees, were made. They were simple and were made according to the availability of such materials and skills in the area.

3.Modern beekeeping:

Traditional beekeeping is still practiced by a way or another, as beekeepers are not aware of the principles of modern beekeeping in most areas of Hadhramout. The beekeepers of Hadhramout have acquired good ancestral skills that they have learnt from their grandfather over centuries.

Modernization of beekeeping started in the seventies where langstroth beehives and other modern techniques were introduced to some areas in Hadhramout . First trial were not successful in some areas due to the absence of trained personnel (Bahakim, 1987).

Importance of Beekeeping:

Beekeeping and honey production plays an important role in the economy of the country through the past centuries and till present. We will try to review the importance of beekeeping through the following historic periods:

1. B.C period

Ingrams (1937) on his report on the economic, social and political development in Hadhramout, mentioned that beekeeping was concentrated in Hadhramout . At that time the trade of honey ranked the 4th in the economy of Hadhramout State, which was established in the 10th M.B.C. The flourishing of beekeeping was related to the prosperity of economy in Hadhramout at that time.

2.Pre Islamic Period

Hadhramout was almost the richest country at that time due to its fertile land and heavy rains which enhanced good agriculture in Wadis and plateaus. The farmers through their ancestral knowledge developed very good experience in sowing dates, rainfall seasons, quantities expected and crops that suit each seasons and each area in Hadhramout. The Beekeepers also developed experience personal skills over centuries. Hadhramout at that time was famous as a country of good honey (4). Honey trade was famous at that time due to its good reputation.

3. Beginning of Islam Period

People in Hadhramout in this period were interested in beekeeping as it gave them very good returns. The Arab league for Agricultural Development (1988) reported that Ibn Sa,sd had reported that Prophet Mohammed (prayer and peace be upon him) wrote to Rabei,ah bin the Marahb Al-hadrami and his uncles and brothers that their money, honeybees, slaves, wells, trees,. All belong to them …etc (till the end of Al-Hadeith). This shows that prophet Mohamed (prayer and peace be upon him) mentioned honeybees directly after money, which shows how far beekeeping is important at that time, which means that it was one of the important sources of income at that time.

4. Present Period

Beekeeping in Hadhramout at the present time still plays an important role in the economy of the country.

1- Number of hives reached 341657 in 2018 that is 9,4 times what was in 1980. has

2- Total honey production reached more than 1600 ton in 2018, that is, 8,5 times what was in 1980.

3- Exported quantity of honey has been multiplied three times during the last period.

4- The number of beekeepers increased from 665 in 1980 to 8400 beekeepers in 2018. The average numbers of beehives owned by each beekeepers increased in this period three times.

The data show that beekeeping is developing and the contribution of beekeeping in national economy is increasing year after year through:

i. Foreign currency earned after honey export.

ii. The important role that honeybees play in increasing the production of horticultural and field crops.

iii. Increasing new working opportunities.

Factors lead to flourishing of beekeeping:

When we trace the history of beekeeping in Hadhramout , we noted that flourishing of beekeeping is always related to the improvement of the economy of the country. This might be due to several factors, the most important are:

1.Farmer interests :

Through the past centuries, Farmers in Hadhramout were interested in building dams, canals and terraces to make use of water in agriculture. Fertile land, heavy rain and diversity in climate helped in cultivating Wadis, terrace and plateaus. These factors enhanced beekeeping development by indirect way through their effect on pastures and range plants, which are considered good resources for , honeybees and production of honey.

2. Caring for pastures and bee plants:

success of beekeeping depends on other environmental factors such as the prevalence of good plants that are rich in nectar and pollen grains. Due to diversity in flora and climate in Hadhramout , range area for bees are characterized by the following:

i. Multiple bee plants that honeybees can visit at one time (most of them are wild) and collect nectar and pollen grains.

ii. Widespread of these plants in most areas of Hadhramout .

iii. Succession in flowering periods, which almost covers, all the year around, which some dry spells during flowering seasons.

The beekeepeers during the past centuries were taking care of these bee plants and trees, particularly Sidr trees *Ziziphus spina chrisiti*. These trees got a lot of uses such as:

i. Source of very good quality of honey.

ii. Could be used as wind breaks.

iii. Has other economic uses such as wood, paper and their fruits are also eaten.

3.Experience of beekeeper

The beekeepers have earned good ancestral skills, which they developed over years. They used to know their own bees, behavior, know all the beekeeping needs and provide most of them in time. The most important areas of experiences the Yemeni beekeepers have are:

i. The beekeepers has good experience on the appropriate time of bee multiplication and division, honey

ii. production seasons and got very good experience in taking care of his bees all the year around.

iii. The beekeepers knows by heart, the dates of flowering of most important bee plants that are important for his bee. Accordingly moves his hives from one Wadi to another and from one area to anther to catch the flowering period of these plants as good sources for nectar and pollen grains for his bees.

iv. The beekeepers compete to satisfy the consumer interests inside and outside the country . They produce the quality of honey, which is more popular, particularly the Sidr honey that is considered one of the best qualities in the world.

v. The beekeepers developed good experience in how to extract honey by different methods that satisfy the consumer needs which is different from one area to another and from one season to another.

vi. The beekeepers developed experience in how to prepare honey for marketing according to types of honey and market according to types of honey and market needs.

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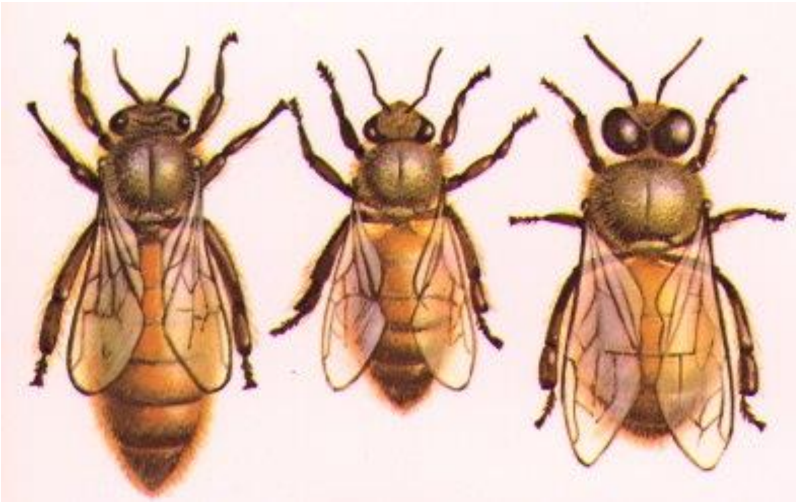
2- CHAPTER
Honeybee Colony

2- Honeybee Colony

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 thousands 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.



Queen Worker Drone

Fig. 2.1 : The Members of Honeybee Colony

THE QUEEN

There is always one queen in a hive. She is half as large again as a worker and longer than a drone. Her wings are much shorter than her body and can not cover the whole of her abdomen. The queen has a sting but, unlike the aggressive workers, does not use it to fight hive intruders. Her sting is only used to fight rival queens. She does not go out to collect pollen, nectar, water or propolis, and therefore, she has no collecting apparatus like pollen baskets, nor long proboscis for drawing nectar or wax glands to secrete wax to build comb cells. As a queen, she usually does not feed herself.

Three days after her last mating flight, the queen starts to lay her eggs, which are produced in herovaries. A good queen lays 1500-2000 eggs per day.

She lives three to five years but after two years she lays fewer eggs

Fig. 2.2 : Honeybee Queen

Each queen produces a queen substance, called a pheromone, by which many activities of a colony are controlled. In the absence of a queen or a pheromone, the workers transform some worker cells containing young larvae into queen cells and start to rear new queens.

Fig. 2.3 : Egg Laying

Laying workers:

When her spermatozoa become exhausted , she also lays unfertilized eggs in worker cells, where drones now develop. Such a queen is called a drone- layer.

When there are no larvae younger than three days in the colony, the bees have no way of rearing new queens. In this case, ovaries of some workers develop, and they start to lay eggs. However, as worker bees cannot be inseminated, they lay only unfertilized eggs. Such workers are called laying workers.

THE DRONE:

The drone is stout and larger than the worker. He has no suitable proboscis for gathering nectar and has no sting to defend himself or the colony. Like the queen, he possesses no baskets for collecting pollen grains and no glands to secrete wax for comb construction. He does no work in the hive but is fed, eating large quantities of food, and moves

about in sunshine and on warm days making loud, frightening noises everywhere he goes. This is why he is considered useless, but he has a very important function to play, which only a few of his kind ever fulfil. This function is to inseminate the queen, and for this he is well prepared.
The compound eyes of the drone are twice as large as those of the queens and workers, and both eyes meet at the top of his head, which is not the case in workers and queens. This enables him to see the queen during the mating flight.
The drones also have the largest wings, which help them to reach the queen during the flight.

Fig. 2.4 : The Drones

THE WORKER :
Workers are the smallest and most numerous of the bees, constituting over 98% of the colony's population. One colony, as has been seen, may have as many as 80,000 workers, but 50,000 is a more common maximum.
They have a longer tongue than the queen and drones, and

thus are well fitted for sucking nectar from flowers. They have large honey stomachs to carry the nectar from the field to the hive; they have pollen baskets on their third pair of legs to transport the pollen to the hive. Glands in their head produce royal jelly as food for the larvae and glands in their thorax sec-rete enzymes necessary for ripening honey. Four sets of wax glands are situated inside the last four ventral segments of the abdomen produceing wax for comb construction.

They have well-developed stings permitting them to defend the colony very efficiently.

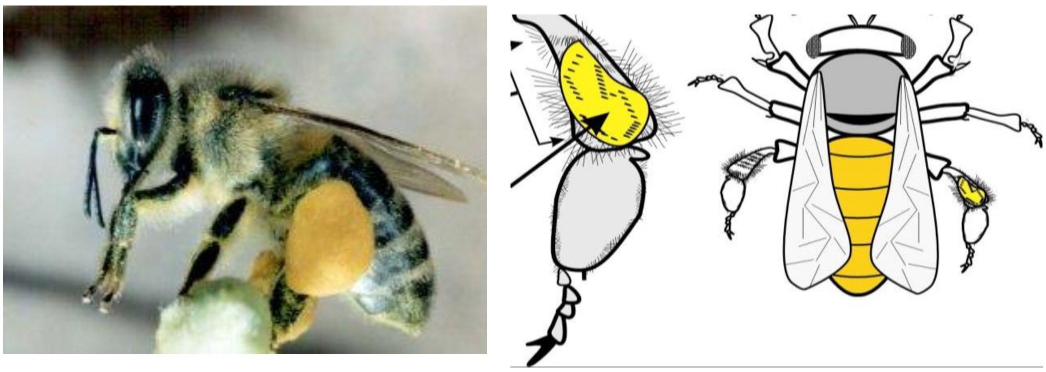


Fig. 2.5 : The third legs of worker (Pollen basket)

Duties of workers:

The kind of work performed by the worker depends largely upon her age. The first three weeks of her adult life, during which she is referred to as a house bee, are devoted to activities within the hive, while the remainder are devoted to field work, so that she is called a field bee .

Duties of the house worker(Fig. 2.6)

1- cleaning the hive and the comb.
2- feeding the brood.
3- caring for the queen.
4- making orientation flights.
5- comb building.
6- ventilating the hive.
7- packing pollen, water, nectar or honey into the combs
8- Executions.
9- guard duty.

1. Feeding the brood
2. Cleaning the hive
3. comb building
4. The Guard of hive
5. Ripening Honey
6. ventilating the hive
7. Hive Heating

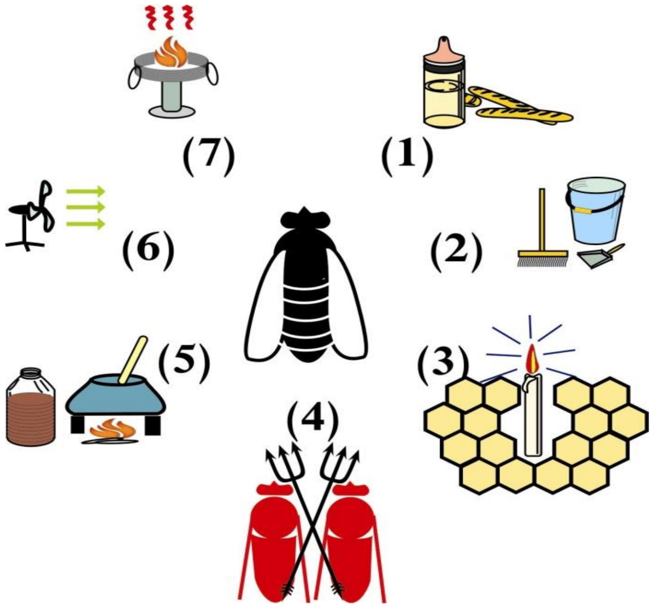


Fig. 2. 6 : Duties of the house worker (Khanbash and Al-Madani,2005**)**

Activities involving flight may start from the third day after emergence From the brood cell, but the young worker begins her actual foraging activity later. Between the 18th and the 21st day, her hypopharyngeal and wax glands have become too week to function, so that she cannot produce royal jelly to feed the queen and the young larvae, nor wax to build comb cells. But by this time she is in perfect condition to fly and knows the geography of the locality.

The field workers:

The workers starts field work, fetching nectar, pollen, propolis, or water, but always concentrating her activity on the immediate needs of colony.

Observations conducted in several places in Hadhramout showed that foragers begin to be active as early as 4:50 - 5:05 a.m. and that by 18:32 - 18:38. almost all have returned to the hive(Khanbash, 1988).

In the latter part of three months, particularly March, April and May, most foragers brought pollen. By 5:00 a.m. the first consignment of pollen had arrived.

More heavy loads of pollen continued to come, and traffic at the entrance was heavy until 6:00 a.m (Khanbash and Bin-ghodel,1994).

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 extra floral 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.

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.

Fig. 2.7 : Pollen Gathering

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 collec 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.

Temperature regulation :

Honeybees, like all other insects, are unable to control their body temperature internal1y according to charges 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 ℃.

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 ℃. 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.

Mating of Honeybee Queens:

The virgin takes a mating flight when about seven days old, though she may make a brief flight before her mating flight. She will mate with several drones possibly an average of 7 to 10 or more and a maximum about 20. If she mated with few drones on this flight she may make another mating flight the same day, or she may make one or more subsequent mating flights the next day, or even later. She begins laying three or four days following mating. Thus, commercial queen breeders expect to harvest laying queens from nuclei 14 or 15 days after the nuclei received queen cells.

All of the sperm produced by a drone are formed before his emergence. When the drone emerges from the ce11, the tubules of the very large testes are filled with sperm, but the drone cannot mate until the sperm move into the seminal vesicles which are a pair of heavily muscled and tracheated epithelial tubes situated between the testes and the ejaculatory duct (Snodgrass 1956). If the young drone is properly fed and remains in the brood nest where the temperature is favorable Jaycox (1961) sperm move into the seminal vesicles where they attach themselves epithelial wall and remain until they are ejaculated at mating (1920). As the sperm migrate to the seminal vesicles where they testes dege until finally they are no more than mere bits of amorphous tissue. Process of sperm migration, or drone maturing, requires 8 to 10 . When drones are mature they tend to move from the active broody to the Side combs.

The drone dies at mating. The eversion of the copulatory brought about by violent contraction of the abdominal muscles and lowed by the contraction of the muscles of the seminal vesicles those of the mucus glands ruptures reproductive tract.

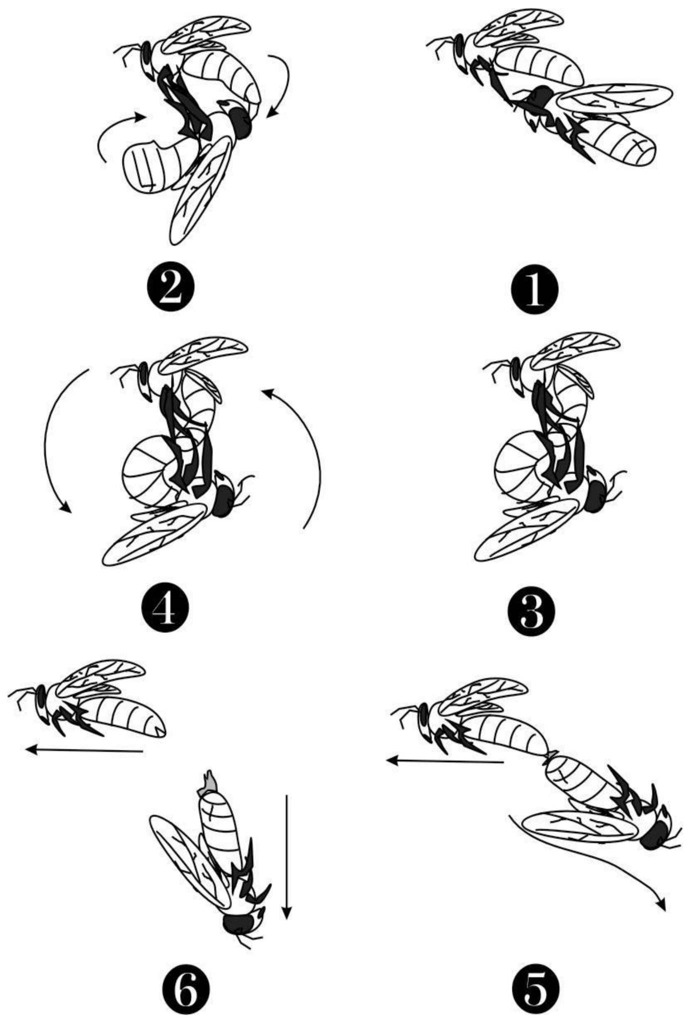


Fig. 2. 8 : Honeybee Queen Mating

Developmental Stages of the Honeybee:

The main stages of honeybee are: egg, larvae, pupa, and imago (Fig.). The Developmental Stages of the Honeybee (table 2.1.):

1- **Egg**: The queen of honeybee laying two types of eggs, fertilized and unfertilized eggs.

2- **Larva**: The larva that hatches from a fertilized egg may become either a queen or a worker. And the larva that hatches from a unfertilized egg become a drone.

The feeding of queen larva is royal jelly only, but the feeding of worker larva in the first three days is royal jelly, and in the 4^{th} ,5^{th} days is bee bread (honey mixed with pollen).

3- **Pre-pupa**: The prepupal period of one day appears to be one of quiet

4- resting. Actually it is a time of great internal activity.

5- **Pupa**: The pupa is at first white and very fragile. For the next five days it remains visably quiet as the adult tissues and organs take form, but color changes become apparent and progress rapidly.

6- Adult stage

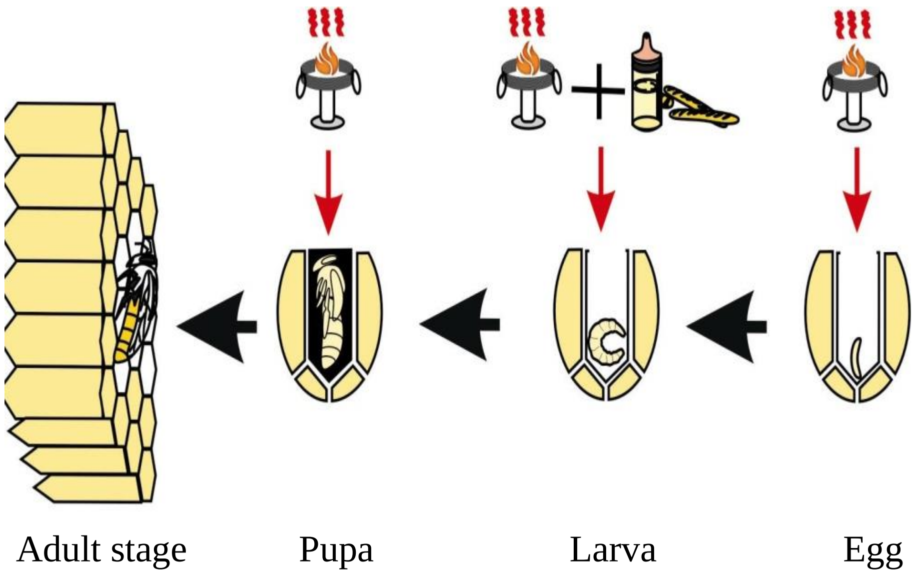


Fig. 2.9 : Developmental stages of the honeybee

Table (2.1) Length of Developmental Stages of the Honeybee Members

Workers		Queens		Drones	
Day	Stages	Day	Stages	Day	Stages
1	Egg	1	Egg	1	Egg
2		2		2	
3		3		3	
4	Larval stage	4	Larval stage	4	Larval stage
5		5		5	
6		6		6	
7		7		7	
8		8		8	
9	Gorging	9	Gorging	9	
10	Pre-pupa	10	Pre-pupa	10	Gorging
11		11	Pupa	11	Pre-pupa
12	Pupa	12		12	
13		13		13	
14		14		14	
15		15		15	Pupa
16		16	Imago	16	
17				17	
18				18	
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3- CHAPTER
Honeybees

3. Honeybees

Introduction:

The species *Apis mellifera* L. has quite a large area of distribution.It extends from southern Scandinavia in the north to the Cape of Good Hope in the south and from Dakar in the west to the Urals and coast of Oman in the east (Ruttner *et al*. 1978). The races of this species have different characteristics; They have been acclimatized according to the prevailing environment.

Ruthenbuhler et.al. (1968) recoded 25 races corresponding to the species of *Apis mellifera*. They are found in some countries in Africa, Middle East, and North –Western Europe. Twelve races of African honeybees have been identified by Ruttner(1975). Four of them were recorded for the first time including *Apis mellifera jemenitica* (Fig. 3.1)

Ruttner *et al*. (1978) measured 404 samples of honeybees from different regions of The world and among them *Apis mellifera jemenitica* was the smallest. The studies of Karpowicz (1989) showed that *Apis mellifera jemenitica* is found in the Northern part of Oman through Dthofar in the South, in the province of Asir in Western Saudi Arabia and in Yemen.

The honeybee *Apis mellifera* is found everywhere in Yemen. In isolated hills and wadis it is still possible to find the indigenous, pure race of *Apis mellifera jemenitica* (Khanbash, 1999).

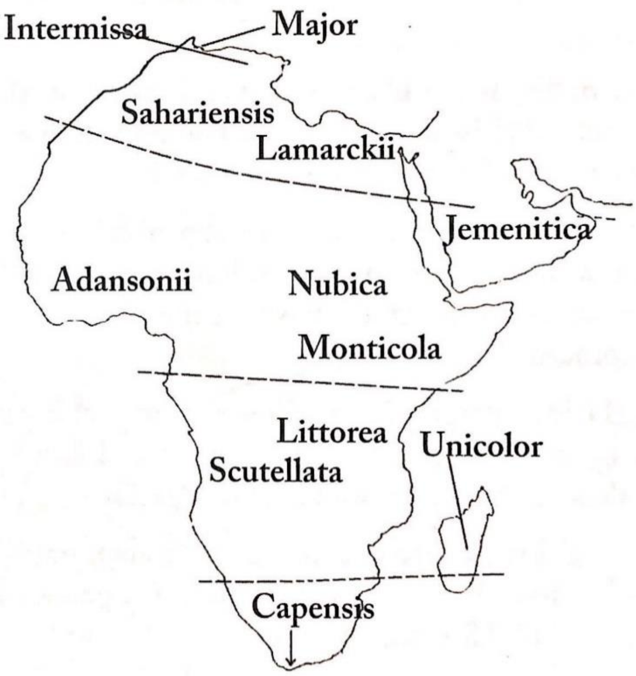

Fig. 3.1 : Distribution of African races of honeybees (Ruttner,1975)

Geographical distribution of *Apis mellifera jemenitica*

Apis mellifera jemenitica is the only race of *A. mellifera* that is reported to occurnaturally in both Africa and Asia. In Africa, A. m. jemenitica is mainly distributed in the Sahel, a dry tropical ecological-climatic zone south of the Sahara and north of the wetter , tropical Africa (Ruttner, 1988; Hepburn and Radloff, 1998). The Asian populations occupy the Arabian Peninsula (Fig. 3.2).

The reported distribution of *A. m. jemenitica* is extremely large, extending 4,500 km from east to west, including Oman (Dutton et al., 1981), Yemen (Ruttner, 1976a, 1976b), Saudi Arabia (Ruttner, 1988), Somalia (Ruttner, 1988), the northern parts of Ethiopia (Radloff and Hepburn, 1997, 1998), eastern and north-eastern parts of Ethiopia (Amssalu *et al.*, 2004), Sudan (Ruttner, 1976a, 1976b; Rashad and El-Sarrag, 1980), Chad (Gadbin *et al.*, 1979), Cameroon (Meixner *et al.*, 1989; Radloff and Hepburn, 1997) and Mali (Hepburn and Radloff, 1998).

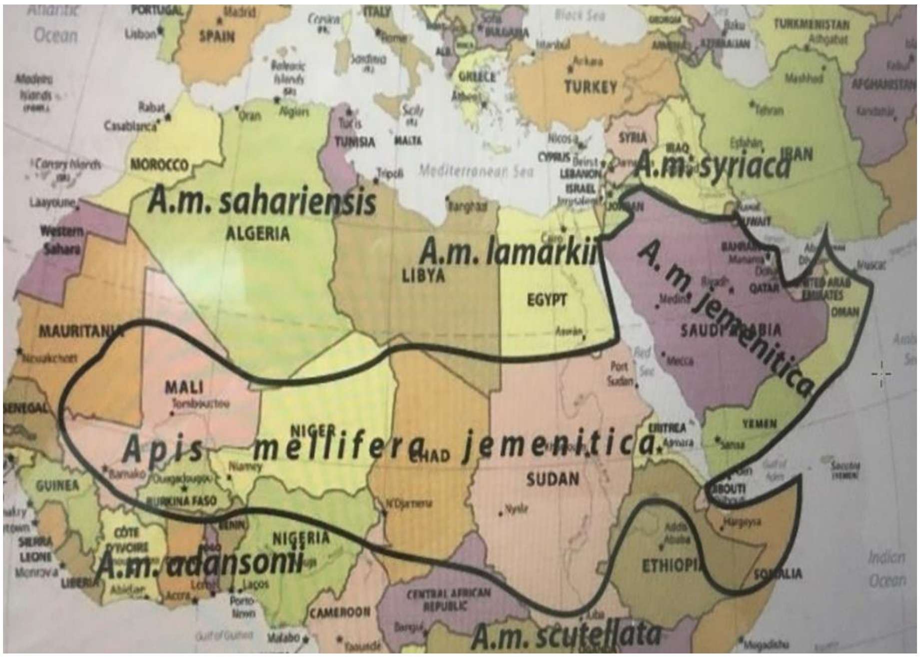

Fig. 3.2 : The distribution of Apis mellifera jemenitica in Africa and Asia (Ruttner. 1988; Hepum&Radloff, 1998)

Radloff and Hepburn (1997) reported the presence of three honey bee races in Ethiopia: A. m. bandasil; A. m. sudanensis and A. m. jemenitica, but later (Hepburn and Radloff, 1998) suggested that the former two subspecies were probably local populations of A. m. jemenitica.

Ruttner (1988) recognized the presence of several different populations of A. m. jemenitica In the region.

Honeybee Morphology:

These populations vary considerably in many characters related to body size, hair length(Table 3.1) and intensity of colour.

Morphometrically, *Apis mellifera jemenitica* is the smallest of all races of A. mellifera both in body size and hair length (Ruttner, 1988)

. Even though all the honey bee populations of the above mentioned geographical areas are considered to be *A. m. jemenitica* Local populations across its wide distribution have distinct morphometric values. Ruttner (1988) recognized five populations of *Apis mellifera jemenitica* (Saudi Arabia, Oman - Yemen, Somalia , Sudan and Cha) with considerable morphometric variation among them (Table 3.1).*A. m.jemenitica* of the Arabian Peninsula (Table 3.1).For example, Amssalu et al. (2004)

reported more intense yellow pigmentation values for A.m. jemenitica population from Ethiopia than from the Arabian Peninsula. Worker honey bees with entirely yellow abdomens without any bands and drones with yellow abdomens were observed in the *A. m. jemenitica* population of Ethiopia (Nuru, 2002). Moreover, Hepburn and Radloff (1998) recognized morphometric variation among the populations of *A. m. jemenitica* of East and West Africa (Table 3.2). In addition, the morphometric values of *A. m. jemenitica* of Ethiopia (Amssalu *et al*., 2004) differ considerably from those reported for *A. m. jamenitica* from West and East Africa, particularly in pigmentation and hair length (Table 3.2).

Aqlan (1999) showed that the morphometric and colour

values of *Apis mellifera jemenitica* from different localities in Yemen (Sana'a, Ibb, Taiz, Mareb, Hajh, and Hhodieda) were variably large: and darker bees were
found at higher altitudes and smaller bees with lighter colour in the coastal areas. Moreover, Khanbash (1990, 2003) reported a high degree of variability, both in body size and pigmentation in Yemeni honeybee populations.

Table 3.1. Morphometric values (mean ± standard deviation) of five population of *Apis mellifera jemenitica* (from Ruttner, 1988)

Characteristics	**Distribution areas**				
	Saudi Arabia	Yemen & Oman	Somalia	Sudan	Chad
Numbers	6	30	9	5	8
Length of Terg.3&4 (mm)	3.748± 0.153	3.937± 0.137	3.981±0.121	3.965±0.180	3.914±0.121
Proboscis Length (mm)	5.277±0.210	5.481±0.132	5.552±0.120	5.450±0.187	5.356±0.187
Fore wing Length (mm)	7.868±0.224	8.135±0.192	8.214±0.179	8.219±0.214	8.136±0.141
Hind leg Length (mm)	6.916±0.259	7.120±0.219	7.207±0.203	7.214±0.245	7.175±0.265
Hair length (m m)	0.172±0.021	0.195 ± 0.020	0.213±0.017	0.193±0.033	0.211±0.019
Cubital vein 1	2.28±0.25	2.20±0.40	2.27±0.36	2.45±0.42	2.39±0.38
AngleJ 16 (degrees)	89.94±2.0	91.09±4.16	99.33±8.03	92.60±3.49	95.90±3.96
Tergite 4 colour	4.60 ±0.99	4.52±1.27	7.75 ±1.03	6.38 ±1.15	5.36 ±1.11

Table 3.2. Morphometric values (mean ± standard deviation) of West African and North East African *Apis mellifera jemenitica* populations

Characteristics	**Distribution areas**		
	West Africa, Hepburn & Radloff (1998)	**North East Africa, Hepburn & Radloff, (1998)**	**Ethiopia (Amssalu et al., 2004)**
Hair	0.20±0.02	0.21±0.02	0.17±0.02
Sternite 3 Length	2.43±0.07	2.48±0.07	2.48±0.06
Wax plates Of Stenite 3 width	1.98±0.06	2.07±0.06	2.05±0.06
Wing angle B4	101.88±4.16	106.45±6.61	104.9±3.33
Wingangle N23	89.11±2.2	89.85±3.32	89.78±2.24
Wing angle O26	38.55±2.49	37.55±2.44	37.07±1.96
Pigment tergite 2	8.72±0.63	8.83 ±0.24	6.88±1.70
Scubellum colour	6.75±0.94	5.87±1.96	4.39±1.93
scutellar plat colour (B,K)	2.97±1.76	2.42±1.19	1.94±1.19

Khanbash (1988) reported that the size of *Apis mellifera jemenitica* workers is small. The data obtained on the biometrical measurements of different structures of the *Apis mellifera jemenitica* workers are given in Table 3.3.

The morphological differences in Yemeni honeybee workers were studied by Khanbash (1990). His result showed that.

The abdominal colour of the Yemeni honeybee workers were classified to in six types as follows:

1- Pure gray.
2- Two yellow points in the second tergite.
3- One yellow streak.
4- Two yellow streaks.
5- Three yellow streaks.
6- Four yellow streaks.

The colour of the abdomen is mostly yellow and 60.8% of the samples were yellow tergites (3, 4, 5, 6 types) and 25.6% contained the pure gray colour (Table 3.4).

Table 3.3. Biometrical measurements (mm) of different structures of *Apis mellifera jemenitica* workers (Khanbash, 1990)

Measurement	$\overline{X} \pm S\overline{x}$	Max.	Min	CV%
Length of proboscis	5.504 ± 0.01	5.70	5.30	1.7
Fore wing - Length	8.424 ± 0.01	8.90	8.00	2.07
- Width	2.765 ± 0.004	2.95	2.50	2.89
- Cubital index	2.22 ± 0.012	2.94	1.80	10.95
Hind wing - Length	5.686 ± .08	6.10	5.30	2.46
- Width	1.640 ± 0.004	1.80	1.40	4.22
- Number of hooks	23.2 ± 0.089	28	17	6.97
Hind leg - Length of femur	2.276 ±0.005	2.60	2.00	3.89

- Length of tibia	2.708±0.006	3.20	2.40	3.90
- Length of metatarsus	2.765 ±0.005	2.10	1.60	5.31
- Width of metatarsus	1.024 ±0.004	1.20	0.85	7.5
Width of 3rd and 4th tergum	3.92 ±0.005	4.40	3.40	4.6

$\overline{X}$ = Mean

S $\bar{x}$ = Standard error

CV% = Coefficient of variation

Table 3.4. The abdomen color of workers (Khanbash, 1990)

Color	Max %	Min %	Mean %
Pure gray	29	21	25.6
Two yellow points	23	9	13.6
One yellow streaks	40	20	32.6
Two yellow streaks	30	17	22.6
Three yellow streaks	9	0	4.4
Four yellow streaks	4	0	1.2

There is no genetic similarity between these colonies and this agrees with what the AOAD has found. However this needs more studies to identify these differences. Ruttner (1975) has mentioned that these complex differences in Yemeni honeybee species may be due to genetic differences in the original mothers or the effect of environment or differences in latitudes and longitudes or altitudes above sea level (Table3.5)

Table 3.5. The deviation in morphological differences in Yemeni honeybee workers

Measurement		Lahj Khanbash 1990	Hadramout AOAD 1988	Different places Ruttner 1975	Different localities Aglan 1999	Socotra Island Khanbash 2003
Length of pooboscis		5.504	4.794	5.452	5.147	5.316
Fore wing	Length	8.424	7.956	8.029	8.094	8.330
	Width	2.765	2.772	2.765	2.732	2.775
	Cabital index	2.22	2.091	2.24	2.253	2.11
Hind wing	Length	5.686	-	-	5.775	5.710
	Width	1.64	-	-	1.556	1.653
	No of hooks	23.2	22.1	-	22.13	22.93
Hind leg	Length of femur	2.276	-	-	2.301	2.326
	Length of tibia	2.708	-	-	2.793	2.671
	Length of metatarsus	1.844	1.959	-	1.768	1.817
	width of metatarsus	1.024	1.013	-	1.020	1.001
Width of 3rd and 4th tergum		3.29	3.173	3.899	3.676	3.834

Brood-rearing and colony growth:

Generally, *Apis mellifisra jemenitica* can quickly increase colony size, an important adaptive feature in a semi-arid habitat where rainfall and flowering periods are very short (Chandler, 1976). Because of their small body size, the average numbers of natural worker cells are relatively high, at 1,025 cells/dm2 (Gadbin et al., 1979; Dutton, *et al*., 1981; Karpowicz, 1989; Woyke 1993). Moreover, Al-Ghamdi

(2005) reported that natural combs built by the A. m. jemenitica population of Saudi Arabia contained an average 25% more ceIIs/dm2 than combs built on embossed European wax foundation sheets. As a result, the number of bees that can be raised per unit area in a given period of time is relatively high compared to European bees. The fast colony growth of A. m. jemenitica could be a positive trait in commercial, and especially migratory beekeeping. Khanbash (1995) reported that during the peak brood-rearing period, queens of the Yemeni population of Apis mellifera jemenitica lay an average of 856 eggs a day and may reach a peak of 1,212 eggs a day and the African race may reach peak rate of 2,500 eggs a day (Fletcher, 1978).

Brood Rearing:

Khanbash (1995) studied the queen bee activity in laying eggs, queen and drone rearing, and the relation between them. The results showed that the queen lay between 538 – 1212 eggs per day. The monthly mean of queen cells in colonies was 5.1. Drone production in colonies extended during the year, reached its maximum in October, November and September. The results showed that a significant correlation existed ($p<0.01$) between drone productions and rearing of queen during the year (Table 3.6).

Since 1975, Beekeepers and Development Programme of Honeybee in Hadhramout imported honeybee colonies (*Apis mellifera carnica*) from some countries (AOAD, 1988).

Table 3.6. Brood rearing (Queen, workers and drones) of honeybee during the year (Khanbash, 1995)

Month	Mean No. of worker brood/day	Mean No. of queen cells/month	Mean No. of drone brood/month
January	550	0	23
February	570	0	18
March	710	0	26
April	940	0	31
May	830	3	38
June	835	7	69
July	770	3	35
August	760	4	43
September	855	8	89
October	1170	16	1195
November	1160	11	420
December	940	3	40

Evaluation of Carniolan Bee in Hadhramout:

Khanbash (1998) evaluated the experience of importation of the carniolan honeybees *Apis mellifera carnica*, studying the behavior of the hybrids, and comparing them with *Apis mellifera jemenitica* honeybees . The results indicated that all good characteristics of the corniolan honeybees deteriorated in Hadhramout. The queen activity in laying eggs and the population of colonies reduced to one third, while the production of honey reduced to less than 10% (Table 3.7).

Table 3.7. Comparison between the activity of carniolan honeybee in Hungary (Country origin) and in Yemen (Khanbash, 1998)

Examined characters	In Hungary	In Hadhramout
Mean No. of eggs laid/day	1200	397
Population of colonies (Mean)	32100	10200
Mean production of honey (Kg)	17.3	1.4

The first hybrid (carnica x jemenitica) was significantly (p<0.01) better in all-biological and behavioral characteristics while the *Apis mellifera jemenitica* honeybee colonies were significantly (p<0.01) higher than the second hybrid in the examined characteristics (Table 3.8).

Based on the obtained results, we recommend stopping import of bee colonies, to conserve the pure local bee race and prepare an improvement programme. We ask the concerned organization to establish queen rearing stations to produce good and healthy colonies, conserve and develop our honeybee wealth.

Table 3.8. The activity of honeybee colonies and some behavioral characters

Race	No. of eggs laid/day	Population of colonies	Stored pollen cm^2	Honey production	Swarming	Agressiveness	Wax moth infestation
A.m.carnica 1. hybrid	1150A	16500	117A	13.2A	Low	Low	High
A.m.carnica 2. hybrid	570C	7950C	430C	2.1C	Medium	High	Medium
A.m.jemenitica	904B	11400B	738B	7.2B	Medium	Low	Low

Means followed by the same letter are not significantly different according to Duncan's Test (P<0.01)

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4 -CHAPTER
Bee Forage Plants

Bee Forage Plants

Introduction:

The total area of Hadhramout is about 161749 Km^2, the greater part of which is desert and mountains. Hadhramout lies in the tropical region where most of its area are in the dry arid and semi-arid lands characterized by hot dry climate with low erratic rains rainfall reached to 100 mm in the Valley and desert. and ranges between 40-60 in coastal area and between 60-150 mm in the mountains (Central Statistical Organization, 2015).

In Hadhramout, climate and soils are largely influenced by topography. The altitudinal range from sea level up to over 6000 meters is largely responsible for differentiation of appreciably different types of climate.

Under the same climatic condition and on the soils and same bedrock will also differ in their development according to their position on steep slopes or in flat basins.

Through the past centuries, farmers were interested in building dams, canals and terraces to make use of water for agriculture. Fertile land, heavy rains and diversity in climate helped in cultivating wadis, terrace and plateaus. These factors enhanced beekeeping development indirectly through their effect on Bee forage plants, which are considered good resources for honeybees and production of honey.

Distribution:

Flora in Hadhramout is species rich. There are an estimated 1000 species, by far the greatest diversity in the Arabian Peninsula. This species diversity is the result of the considerable climatic changes, which have taken place over time.

Plant life depends largely on five interacting factors: temperature, light, moisture, soil and mechanical factors. Success of beekeeping depends on other environmental factors such as the prevalence of good plants that are rich in nectar and pollen.

Due to diversity in flora and climate in Hadhramout, bee forage plants are widely spread in most areas of Hadhramout .

Data in table (4.1) show that the distribution of bee forage plants in some valleys and areas. Table (4.2) shows that the plant density of the main important bee forage plants in Hadhramout. More than 70% of these grow wild. These can be sub – divided into herbs, shrubs and trees that provide nectar and pollen for foraging bees (Fig 4.1).

Table (4.1) Distribution of bee forage plants in Hadhramout

Scientific name of plants	**Distribution**					
	Doan valley (A)	**Amad valley (B)**	**Al-Ain valley (B)**	**Shohouh valley (C)**	**Madar valley (C)**	**Coastal area (D)**
Ziziphus spina-christi	***	***	***	***	***	**
Ziziphus leucodermis		***	***	*	*	**
Acacia tortillis		***	***	***	***	***
Acacia ehrenbergiana		***	***	**	**	
Acacia mellifera	***	***				
Prosopis juliflora	**	***	***	***	***	***
Prosopis farcta				**	*	
Prosopis stephaniana				*		
Zygophyllum gaetulum				*	*	
Zygophyllum coccineum	*			*	**	

Scientific name of plants	Distribution					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Zygophyllum simplex		**		*		***
Zygophyllum decumbens				*		
Fagonia indica	***	***	***	***	***	***
Pulicaria undulate	**	*	**	***	*	
Tephrosia apollinea	***		***	***	**	
Crotalaria persica				**	**	
Tephrosia nubica		***	***	*	**	
Indigofera spinose				*		
Alhagi graecorum				***		
Indigofera oblongifolia	***			*		
Merremia hadramautica				*	**	
Aristida triticoides				*	**	
Cynodon dactylon	*		***	*	*	
Lasiurus scindicus				*	*	
Cenchrus ciliaris				*	*	
Cymbopogon schoenanthus	***			*	*	
Maerua sp	**	***	***	*	*	
Phoenix dactylifera	***	***	***	**	*	***

Scientific name of plants	Distribution					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Citrus aurantifolia		***	***	*	*	
Cleome sp	*			*	**	
Barleria sp	**			*	**	
Cassia italic	***			***	*	
Rhazya stricta	***	***	***	*	**	
Heliotropium spp	*			***	**	
Aerva sp	***			***	***	
Farsetia sp				*	**	
Anticharis linearis	*			*		
Abutilon sp				***	**	
Calotropis procera				***	*	
Solanum sp				*	*	
Citrullus colocynthis	**			*		
Chrozophora sp	***	**	**	**	**	
Capparis sp				*		
Datura innoxia		*	***	*		
Withania sp				*	*	
Amaranthus sp				*		
Leptadenia sp	*			*		
Convolvulus arvensis				*	*	
Flaveria trinervia				*		
Moringa peregrine						
Dipterygium glaucum		***	**			

Scientific name of plants	Distribution					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Pulicaria undulate						
Panicum turgidum						
Pennisetum divisum						
Pithecellobium dulce						
Lwsonia inermis		***	*		*	
Blepharis ciliaris						
Euryops sp			**			
Anisotes trisulcus	***	*	***			**
Blepharis ciliaris			*			
Allium cepa		*	**			
Allium sativum			**			
Coriandrum sativum		**	**			
Foeniculum vulgare		**	**			
Calotropis procera	***	***	***			***
Caralluma hexagona			**			*
Nerium oleander		***	**			**
Pergularia tomentosa			**			
Hyphaene thebaica			*			
Washingtonia filifera			*			

Scientific name of plants	Distribution					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Flaveria trinervia			**			
Iphiona scabra	**	**	**			*
Sonchus oleraceus			**			*
Schouwia thebaica			**			
Commiphora myrrha			**			*
Commiphora gileadensis		**	**			*
Capparis cartilaginea		**	***			***
Cleome droserifolia		***	**			
Conocarpus lancifolius		***	**			***
Convolvulus arvensis		***	**			
Citrullus colocynthis		***	***			***
Phialocarpus glomeruliflorus		*	**			
Cyperus rotundus		***	***			
Jatropha spinose	***		*			
Ricinus communis			*			
Acacia hamulosa		**	**			**
Albizia lebbeck		**	**			**
Indigofera oblongifolia	***	**	***			***

Scientific name of plants	Distribution					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Senna alexandriana	*		*			
Senna italic		**	***			***
Tephrosia purpurea			**			
Vigna unguiculata		***	**			
Ocimum basilicum		***	**			***
Ocimum forskolei		**	**			
Punica granatum		***	**			
Abutilon bidentatum		***	***			***
Abelmoschus esculentus		*	**			
Tamarindus indica		***	**			**
Gossypium barbadense		***	***			*
Carica papaya						**
Mangifera indica						***
Malva parviflora		***	***			**
Ficus salicifolia	***	**	*			
Ficus vasta	*	**	*			
Psidium guajava		***	**			
Boerhavia repens		**	**			**
Boerhavia repens		**	**			**
Sesamum indicum		***	**			
Andropogon cucomus			***			
Cenchrus biflorus		***	***			

Scientific name of plants	Distribution					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Cymbopogon schoenanthus		**	***			
Cynodon dactylon		***	***			***
Dactyloctenium aegyptium			***			
Panicum turgidum		***	***			***
Sorghum bicolor		***	***			
Portulaca oleracea		***	**			**
Nigella sativa			*			
Tamarix aphylla	**	**	**			**
Typha domingensis			***			
Balanites aegyptiaca		**	**			***
Tribulus terrestris		***	***			**
Azadirachta indica		***	**			**
Aerva javanica		***	**		***	***
Salvadora persica	**	***	***	*	*	
Salsola sp				*		

References	
(A)	Khanbash *et al.*, (2008)
(B)	Kanji (2018)
(C)	Bacwud (2017)
(D)	Bawahadi *et al.*, (2019)

Key of distribution	
Distribution	**Key**
Large	***
Medium	**
Limited	*

Table (4.2) Plant Density of Bee Forage Plants in Hadhramout

Scientific name of plants	Mean of plants / ha					
	Doan valley (A)	Amad valley (B)	Al-Ain valley (B)	Shohouh valley (C)	Madar valley (C)	Coastal area (D)
Ziziphus spina-christi	51.7	12.19	8.37	11.33	13	8
Ziziphus leucodermis	2.4	0.35	029	1.67	0.5	3
Acacia tortillis	45	11.4	7.56	33	61.5	36
Acacia ehrenbergiana	11.7	11.12	6.71	4.33	38	
Acacia mellifera	1.2	0.13				
Acacia hamulosa		0.31	0.53			
Prosopis juliflora		1.87	1.01	164	114	235
Phoenix dactylifera		11.46	35.90	21	17	39
Citrus aurantifolia		0.28	0.50	3.67	2	
Sorghum bicolor		10.67	6.91			
Salvadora persica		0.37	023	2	2.5	36
Dipterygium glaucum		0.28	0.28		8.5	
Maerua crassifolia		0.28	0.32	0.67	0.5	
Zygophyllum simplex		0.34				3

Zygophyllum gaetulum				79.33	79	
Zygophyllum coccienum				1.67	37	
Merremia hadramautica				0.67	17	
Tamarindus indica		0.06	0.22			6
Salsola sp				0.67		
Pithecellobium dulce					2.5	
Euphorbia cactus					5	

References	
(A)	Khanbash et al., (2008)
(B)	Kanji (2018)
(C)	Bacwud (2017)
(D)	Bawahadi et al., (2019)

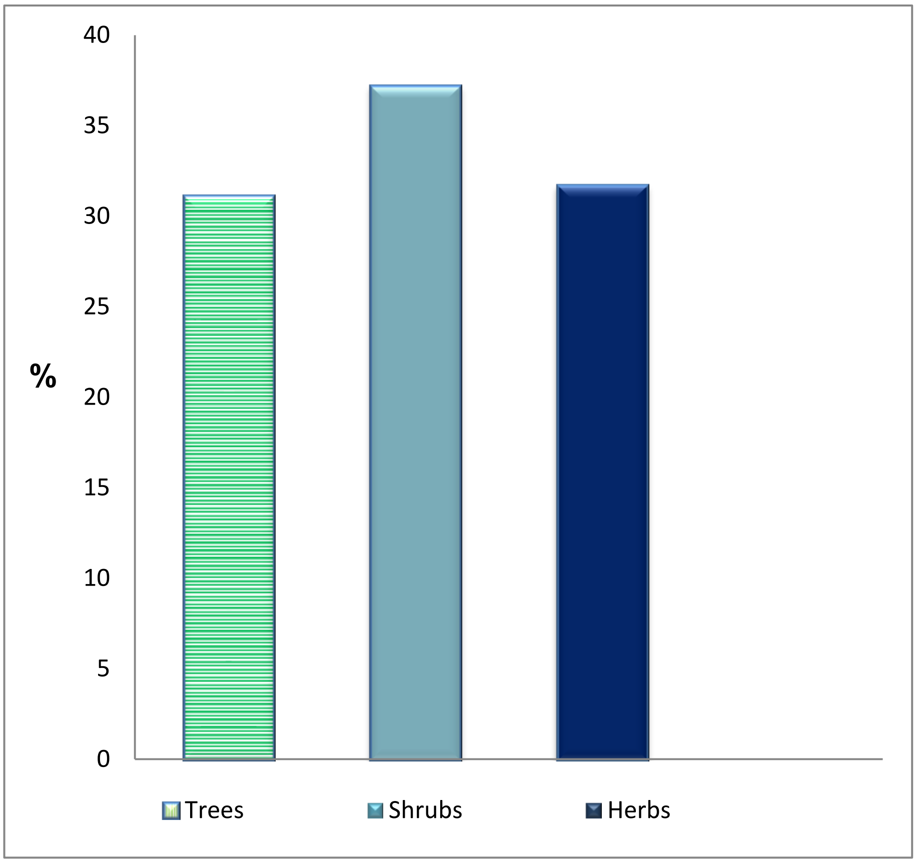

Fig (4.1) Growth Forms of Bee Plants

Nectar and Pollen Plants:

The honeybees visit flowering plants to obtain nectar, which is the source of honey, as well as pollen in order to survive, prosper and be productive. Honeybee colonies, as has already been observed, must have supply of both nectar and pollen in adequate quantities .Not all plant species are equally good for beekeeping. Some supply both nectar and pollen abundantly when in bloom, and these are often called honey plants, because they are best suited for honey

production. Plants producing nectar but little or no pollen are also considered to be honey plants (Table 4.3) .
Other plants, however, yield pollen but little or no nectar. These pollen plants are also important in beekeeping, especially at the time of colony build –up when the bees need large amounts of protein contained in pollen for their brood –rearing .
Khanbash (1998a) found that most bee plants (64.5 %) supply both nectar and pollen while the honeybees visit 22.2 % and 13. % of plants to collect pollen and nectar only, respectively (Fig 4.2).
Figure (4.3) shows that the bee plants are different from the amounts of the nectar and pollen contained in the flowers. These can be sub –divided into rich, medium and poor plants with nectar or pollen (Khanbash, 1998a).
That the optimum activity of honeybee colonies is between March and June, because most of the bee plants are flowering during this period. Also the period between September and November is good period for honeybee activity (Khanbash, 1995, 1998b).

Table (4.3) The amount of nectar and pollen in flower of some important bee forage plants in Hadhramout

No	Scientific name of plants	Amount		Flowering period	
		Pollen	Nectar	Months	No of days
1	*Ziziphus spina-christi*	***	*	October-November	40
2	*Ziziphus leucodermis*	**	**	May	30
3	*Acacia tortillis*	***	*	March-June	40

4	*Acacia ehrenbergiana*	**	*	March-June	40
5	*Prosopis juliflora*	***	**	January-April June-August	40
6	*Zygophyllum gaetulum*	*	**	May	15-40
7	*Zygophyllum coccineum*	**	***	March-June	30-40
8	*Merremia hadramautica*	*	**	March-June	30-40
9	*Maerua sp*	*	**	May	40
10	*Phoenix dactylifera*		***	December-January	30
11	*Citrus aurantifolia*	**	*	March-June	40
12	*Salsola sp*	*	**	May	30
13	*Salvadora persica*	**	*	March-June	30
14	*Capparis sp*	**	**	March-June	30
15	*Pithecellobium dulce*	**	**	May	30
16	*Dipterygium glaucum*		***	Training season	30

Key:

Rich	***
Medium	**
Limited	*

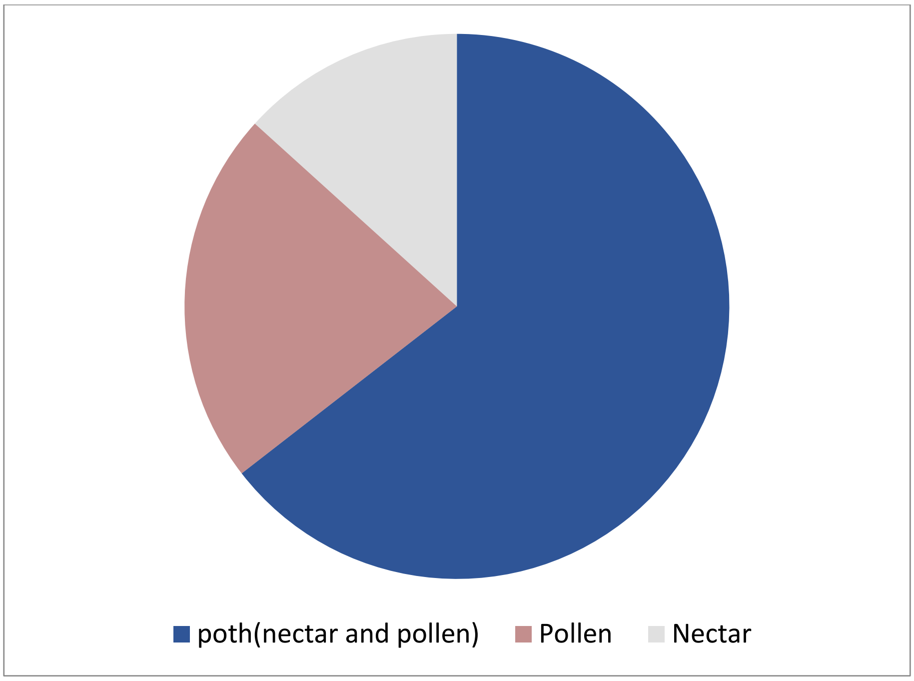

Fig (4.2) Nectar and Pollen Sources in Bee Forage Plants

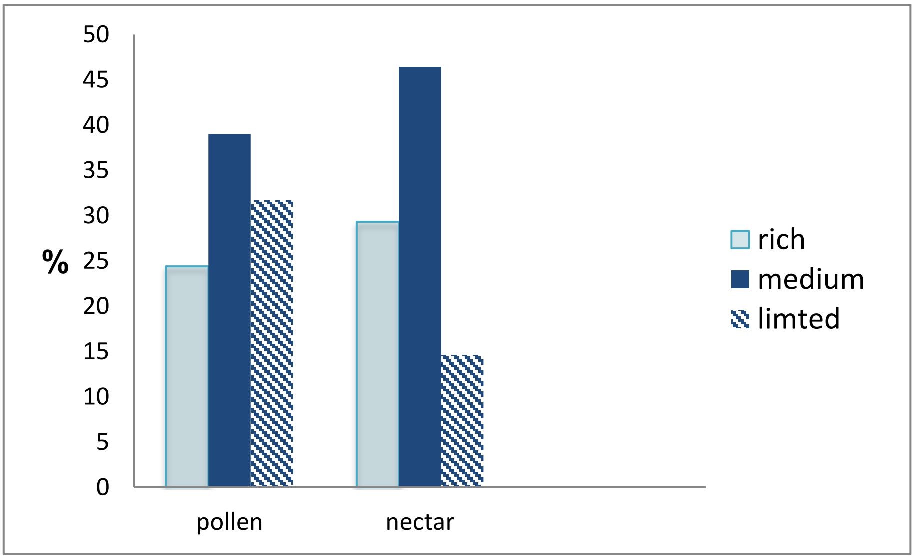

Fig (4.3) The amount of Nectar and Pollen in Flowers of bee Plants

Main Important Honey Plants:

Sidr Trees Ziziphus spina – Christi :

The Sidr tree is the most important plant for honey production in Hadhramout (Fig 4.4). *Ziziphus spina christi* have wide range distribution in Hadhramout (Batheib, 1991).

Sidr tree is evergreen .The height of trees in most areas are between 4 –12 m. (Bataher 1998), while the height of Sidr trees in Sa'ada reached to more than 15 meters (Khanbash, 2001). Bataher (2019 a) found that coppice height was high and fast at first year while mean annual growth in irrigated areas varied between 0.849 – 0.987 m. Also high and fast growth of coppice diameter was found at first year of growth while mean annual diameter growth was 0.735 – 1.149 cm. Studies of the coppices growth in spate irrigated areas showed that the height growth of coppices is fast and high in the first year. The mean growth may mostly reach above 3 m. while the same year stem diameter growth is also fast and high and mean growth may reach more than 1.0 cm. On the other hand current annual growth increment of diameter varied between 0.550 – 0.752 cm. (Bataher, 2019 b)

The main flowering period is different from one area to another .

The concentration of sugar in nectar depends on several factors:

1- The soil type.
2- The time of day.
3- The temperature.
4- Relative humidity (it ranges between 25.3 –51.5 %) .

The beekeepers during the past centuries were taking care of Sidr trees and making a lot of uses out of it such as:

- Source of very good quality of honey.

- Could be used as wind breaks.
- Has other economic uses such as wood, papers and their fruits are also eaten .

***Somor Trees Acacia tortilis* :**

Acacia tortilis has a wide range of distribution in Hadhramout . It attains 5 to 10 meters height (Fig4.5). The flowering period is different from one area to another (February –May). The flowers supply both nectar and pollen. *Acacia tortilis* is a very good tree for bee keeping .The trees provide excellent firewood, have foliage with a high nutritive value and the fruits (pods) are important source of fodder during the dry season.

Acacia mellifera

Acacia mellifera has a medium range of distribution in Hadhramout . The height of trees is between 5 –8 meters (Fig. 4.6). Usually the trees flower after the rainfall from March to June .The flowers produce nectar for 2 –3 weeks.

Acacia ehrenbergiana

Acacia ehrenbergiana has a medium range of distribution in Hadhramout . Small trees the height of trees is between 4 - 5 meters (Fig.4.7). The flowers are yellow .

Acacia senegal

Acacia senegal has a medium range of distribution in Hadhramout . The height of trees is between 5 –10 meters (Fig. 4.8). The flowers are white , supply both nectar and pollen .

Prosopis juliflora

Prosopis juliflora has a wide range of distribution in Hadhramout .The trees is evergreen, it attains 3 to 13 meters height (Fig 4.9). The flowering period are in between January – April and from June to August. The flowers supply both nectar and pollen. *Prosopis juliflora* is a very good tree for beekeeping .

Fig(4.4) ***Ziziphus spina christi***

Fig (4.5) ***Acacia tortilis***

Fig (4.6) ***Acacia mellifera***

Fig (4.7) ***Acacia ehrenbergiana***

Fig. (4.9) ***Prosopis juliflora***

Fig (4.8) *Acacia senegal*

Fig (4.10) Dipterygium glaucam

Fig (4.11-A) ***Zygophyllum simplex***

Fig (4.11-B) ***Zygophylum cocanum***

Fig (4.12) ***Fagonia indica***

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5- CHAPTER
Honeybee hives

Honeybee hives

Development of beehives industry:

All archeological studies have shown that honeybees appeared in earth before human beings. Bees started life in mountains and forests where they built their hives in caves and hollow trunks of trees. Bee crowds attracted the interest of the first man, who was living since old times in the mountains and forests; and hence honeybee was known since old times (Khanbash,2001 b).

When man first thought of how to make use of honeybees, he started to make a living place for them similar to its natural habitat. Then he tried to improve it to be more suitable for him to get honey out of it, and at the same time he also can keep it safe (Khanbash,2003).

Hives were made of plant debris, stems of plants, clay and logs of trees after being hollowed . They were simple and were made according to the availability of such materials and skills in the area (Khanbash,1996 b)

Modernization of beekeeping started in the seventies when langstroth beehives and other modern techniques were introduced in some areas in Yemen. First trial perids were not successful in some areas due to the absence of trained personnel (Khanbash,2001 a) .

Fig. (5.1) Honeybee colony among the rocks

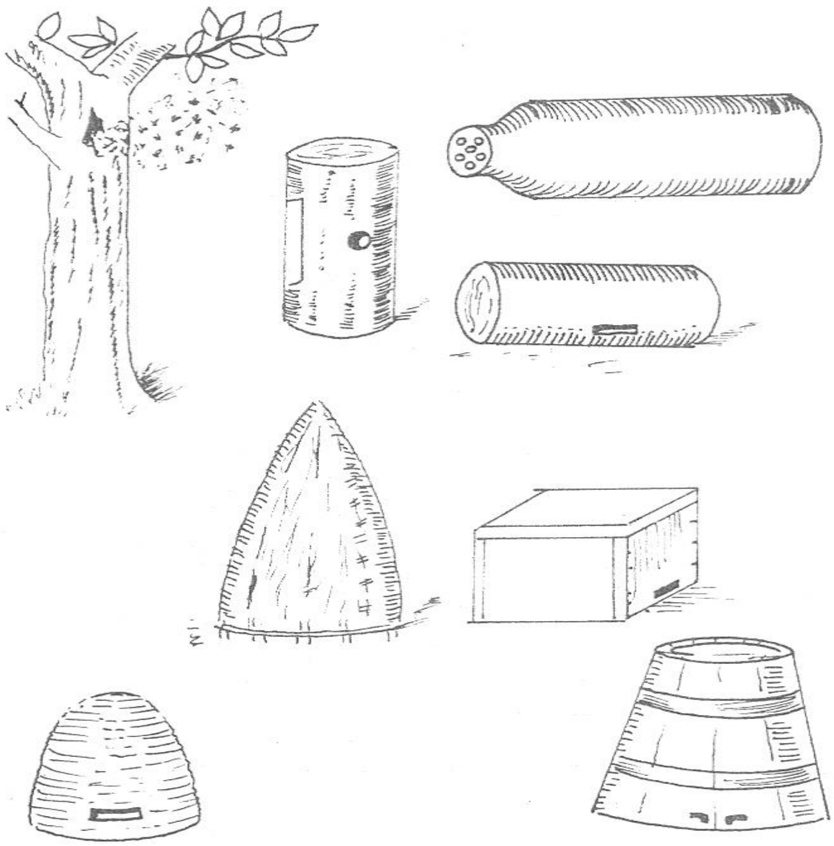

Fig. (5.2) Some types of old hives

Types of hives in Hadhramout

Here are two main types of hives used in Hadhramout **:**

1- **Traditional hives .**
2- **Modern hives.**

1 St. The traditional hives (Khanbash,1996 a)

Traditional beekeeping is more concentrated in wadis Dowan and Am′d, The most characteristics of traditional beekeeping are migration and movement of beekeepers with their hives looking for the suitable sources of food of their bees. Biodiversity of climate and topography plays an important role in diversity of plant cover, which made flora in Hadhramout that has different flowering time in different areas. This made beekeepers move from one wadi to another and from one place to another looking for good food and suitable environment for their bees**.**

1- **Clay hives:**

They are clay pipe hives and considered the famous traditional hives. They are made of a mixture of clay and dung, wetted with water and left for sometime, then they are dried and burnt. The clay hive (Fig.5.3) consists of some pieces starting with the head (front), which is the first piece, of about 50cm long and 22.5cm in diameter. This piece is pointing from the front and constitutes what they call a lip. The head is linked by 4-5 pieces each 22.5cm long and with same diameter like the head piece. These pieces are connected by clay or cloth immersed in clay. The hives are covered from outside to protect them from the heat of the sun. There is a front opening to allow bees to get in and outside the hive . The back opening is closed by hard cardboard,cloth or wood. These hives are usually put separated over iron carriers.

Fig. (5.3) Clay hives

1- **Hives made of logs of trees:**

Logs of trees are cut at 120-125cm long hollowed from inside to make a circle of 20-22cm in diameter. Hives are covered from the front and backside by a net of palm leaves and thick cloth. A small hole is made at the front to allow bees to get in and outside the hive (Fig. 5.4).

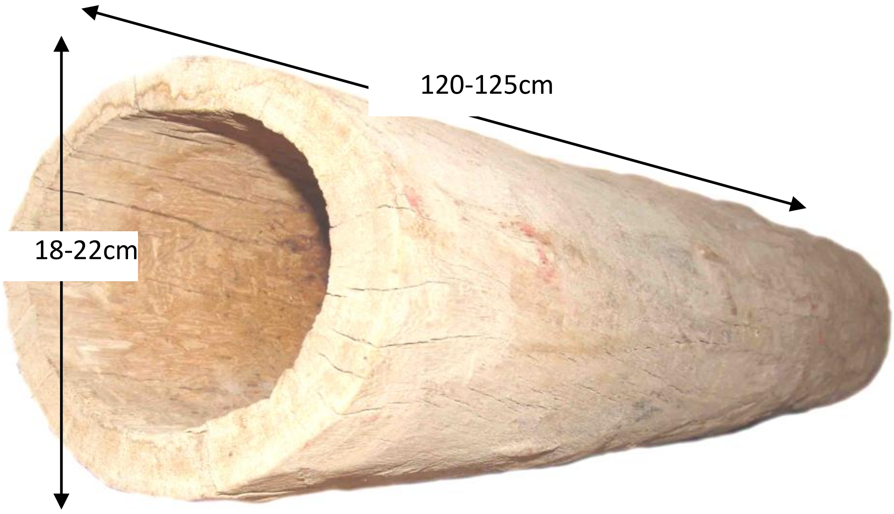

Fig. (5.4) Logs of trees hives

3-Wooden box hives

These hives are spread wide and are made of pressed wood (MDF). It is 90-120cm long, 20cm wide and 16-18 cm high. It is designed in such a way that you can open it form either the front or the back. It has a small opening that allows for the bees to get in and outside the hive. These hives are usually put over iron carriers. A net of date palm leaflets covers them (Fig.5.5).

Fig. (5.5) Wooden box hives

2nd Modern hives.

Langstroth hives

These hives are spread wide in the world . langstroth hive generally contains 10 frames, in Hadhramout the beekeepers used 7,8 and 10 frames (fig.5.6). Normal langstroth box are thus about 51×37×24cm , standard frames are 47×23cm.

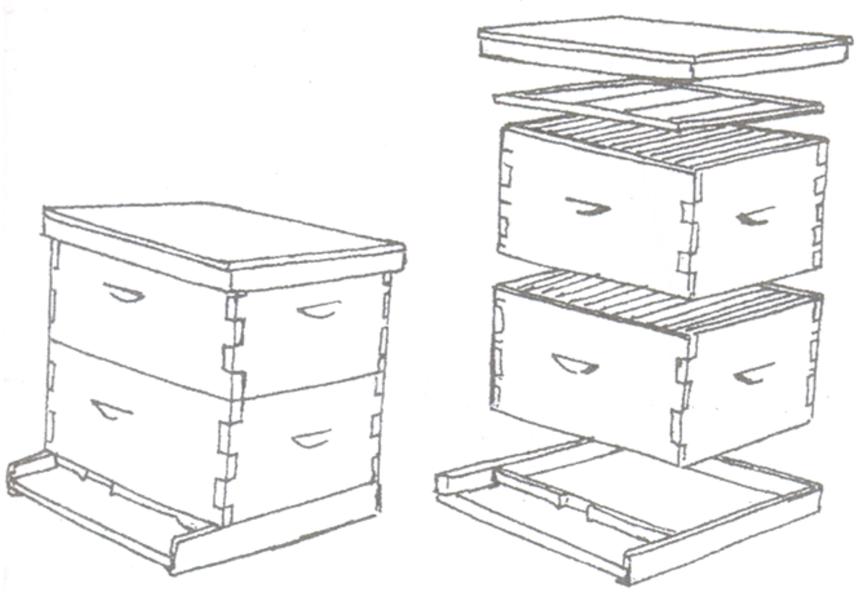

Fig. (5.6) Langstroth hives

Langstroth hives consists of the following parts:

1- Hive stand
2- Bottom board
3- Brood box (hive body)
4- Honey box (honey supers)
5- Inned cover
6- Outer cover

1- Hive stand:

The part where the hive is placed, it has four legs to lift the hive from the ground (Fig. 5.7).

2- Bottom board:

The bottom board is the floor of the hive. It is built to fit the hive body. In order to provide a landing board for the bee, an entrance reducer is generally used at the front of the hive to permit alteration of the size of the hive entrance (Fig. 5.8).

3- Brood box (hive body):

The box containhng brood frames, a box placed above the hive body to accommodate frames (Fig. 5.9).

4- Honey box (honey supers):

The box containhng combs of honey. The depth of honey box 3/4 the depth of brood box (18 cm) or 1/2 the depth of brood box (12 cm).

5- Inned cover:

An inner lid or cover is used in addition to the outer cover. Inner covers are commony mad of boards, plywood or masonite in wooden frame (Fig. 5.10).

6- Outer cover:

The outer cover is essentially the roof of the hive. It should be long- lasting and provide good insulation for the bees (Fig.5.11).

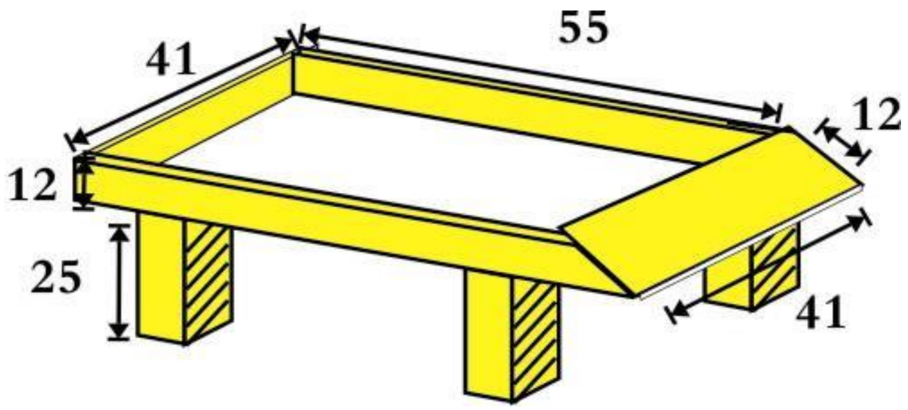

Fig. (5.7) The dimensions of hive stand (cm)

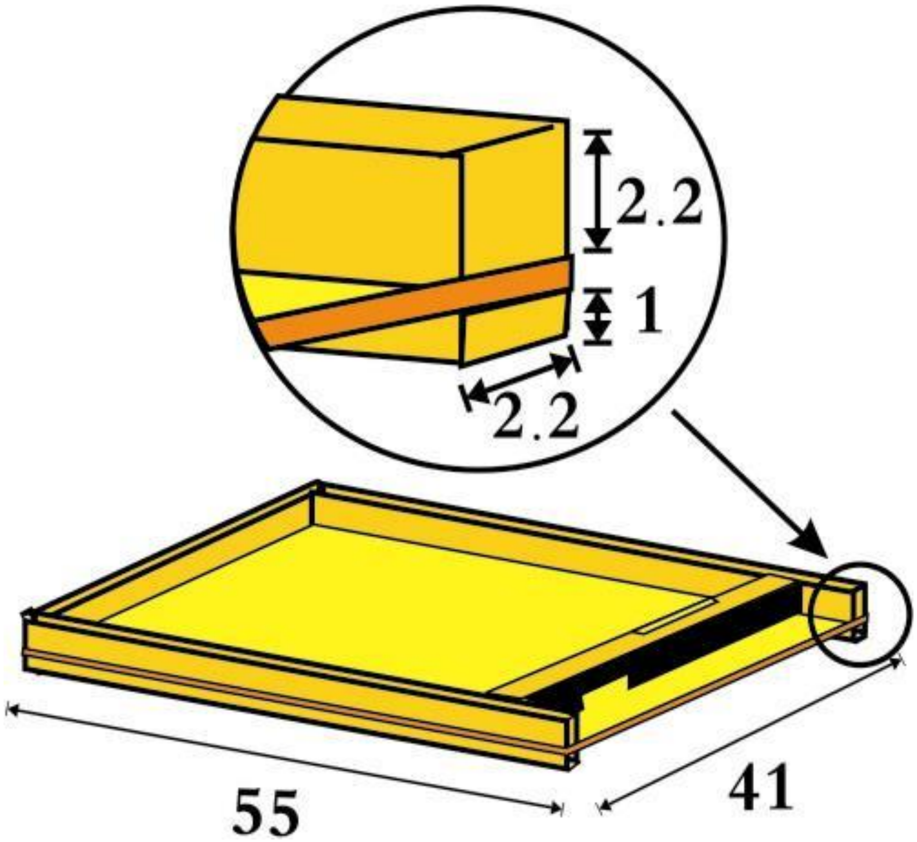

Fig. (5.8) The dimensions of Bottom board (cm)

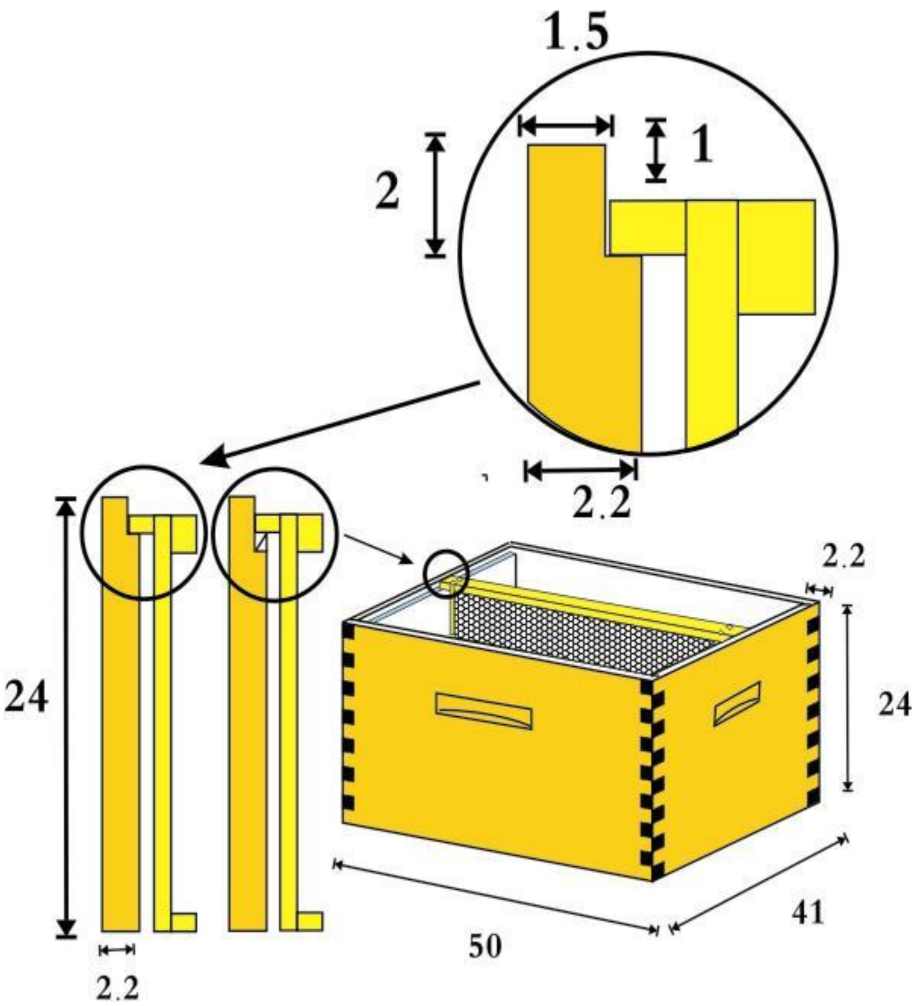

Fig. (5.9) The dimensions of Brood box (hive body) (cm)

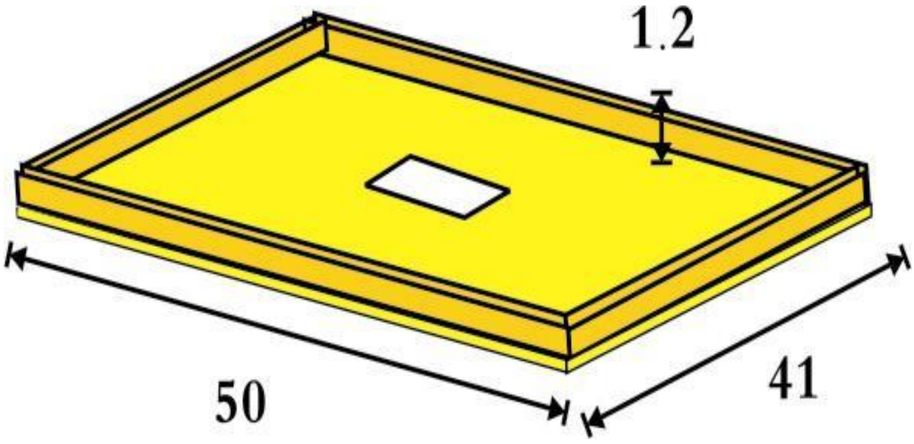

Fig. (5.10) The dimensions of Inned cover: (cm)

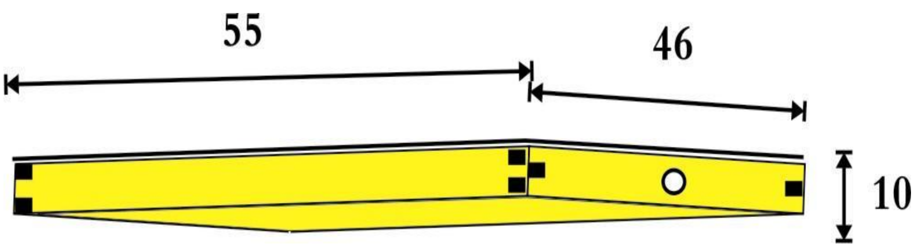

Fig. (5.11) The dimensions of outer cover (cm)

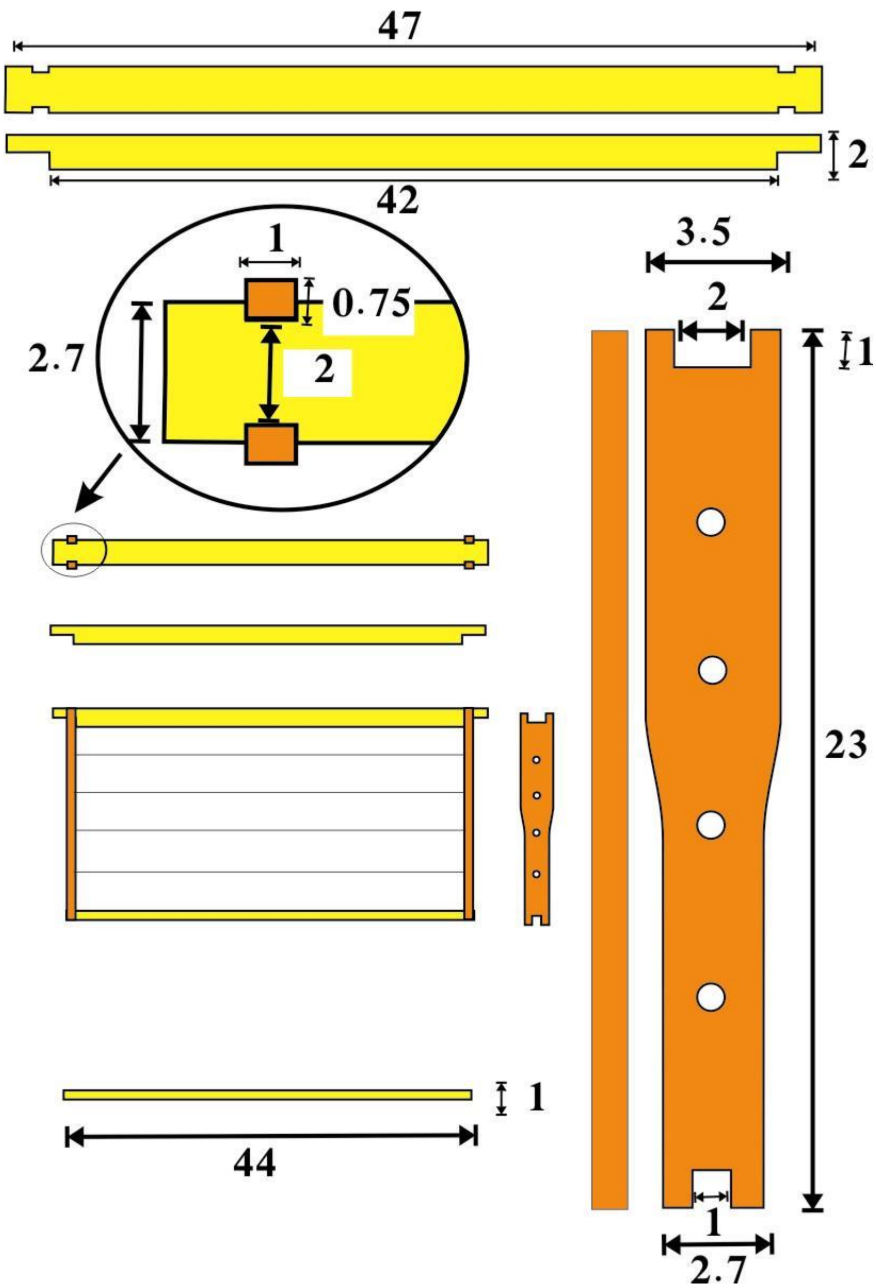

Fig. (5.12) The dimensions of the frame (cm)
Development modern the hives in Hadhramout

Development the modern hives in Hadhramout:

The use of modern hives started in the seventies in a limited scale but in the last years a lot of beekeepers prefer such hives (Table 5.1) During the past year some specialized workshops were conducted in making beekeeping tools (for Langstroth hives) . Data of central statistical Organization (2018) and Ministry of Agricultural and Irrigation (2018) show that the total number of beehives in Hadhramout reached 341567 hives. The wooden hives reached 164294 (48.1%) .Data show that the number of wooden hives has been multiplied 7 times during the last 20 years The number of wooden hives increased from 6380 hives in 2000 to 164294 hives in 2018. The rate increased from 6.8% in 2001 to 48.1% in 2018 .

Table (5.1) Development of number of hives during the period 2000-2018

Year	No. of bee hives	No. of wooden hives	% of wooden hives
1980	36500	392	1.1
1990	68400	2050	3.0
2000	93810	6380	6.8
2010	319700	94630	29.6
2018	341567	164294	48.1

The types of beehives and honey production:

Table (5.2) shows the honey production in different types of bee hives The amount of honey produced from clay and wooden box hives was 9.61kg. 9.7kg. respectivity, while the amount of honey produced from Langstroth hives reached

12.51kg. These results showed that the amount of honey produced from Langstroth hives increased 43% compared with the traditional hives (clay , wooden box) .

Table (5.2) The amount of honey produced from traditional and modern hives(Kg)
Khanbash *et. al.* (2005)

Honey sortes	Traditional hives		Modern hives Langstroth
	clay	wooden box	
Sidr *Ziziphus spina christi*	2.63	3.0	3.75
Somar *Acacia tortilis*	2.38	2.0	2.88
Range *mixed honey*	4.60	4.7	5.88
Total in the year	9.61	9.7	12.51

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6- CHAPTER
The Honey

The Honey

Introduction:

Honey production has always played an important role in the economy of the country from the past centuries to the present. The trade of honey is ranked the 4th in the economy of Hadhramout State, which was established in the 10th M.B.C. The flourishing of beekeeping was related to the prosperity of economy in that time .

Honey of Hadhramout particularly ‘Asal Al-elb' (Sidr) Ziziphus Spina christi, produced from Wadi Doan and has earned a very good reputation and is commercially one of the most expensive in the world (Arrawi , 1985 ; AOAD , 1985 ; Hansen ,1995) due to some specific characteristics. beekeepers are competing to provide honey types that meet the consumer demands inside and outside Yemen (Khanbash etal, 1998).

The beekeepers has developed good expertise in extracting honey by different methods that meet the consumer's needs which is different from one area to another and from one season to another.

Methods of Processing:

Supering for the honey flow:

The beekeepers has good experience in knowing the flowering dates of bee plants which are rich in nectar. He prepares himself before this by doing the following:

i. Feeding the colony with sugar solutions to activate the queen to give more eggs which leads to increase of number of workers and this helps in making full use of the flowering season by collecting and storing good quantities of honey by the workers in the hive.

ii. Collection of honey combs two weeks before the flowering season and this method is useful in :

- Having pure honey and not mixed types
- Production of honey free from any residual of sugar feed
- Encouraging bees to build new white combs for storing nectar and producing good quality honey combs

Bee hives movements:

The beekeeper selects the area where he is going to move his bees. He selects an area where there are dense flowering plants, and few hives available particularly in Sidr flowering season.

The beekeeper moves his hives at the time of dense nectar production, which varies from one area to another. Movement of hives is carried out at night to prevent flying of bees if carried out in the daytime. Beekeepers differ in their preparing for this event. Some of them close the inlets of their hives, while others spray tar material before moving their hives. Some of them leave the inlets of hives open , but when moving their hives they put the inlets facing each other and leaving some space to allow bees to go and return in the early morning to where the beekeeper stops moving in the morning and continue moving at night.

Honey harvesting:

As most of the hives used in Yemen are traditional ones, the beekeepers while harvesting honey open the hives from the back. By using a knife, they cut the combs and put them in a container one after another till they reach the ones that contain the brood .

In wooden hives (Langstrowth), the beekeeper opens them from above and collects the honey combs. If the brood is below, he cuts the parts that contain honey and returns the other parts that contain the brood to the hive by fixing it on the wooden stands by using rubber bands.

Honey extracting:

The beekeepers has developed good experience in selecting the appropriate method of extracting honey according to the consumer demands, which is different from one area to another and from one type to another. We can summarize these methods as follows (Khanbash,1996 a) :

i. The white combs that contain Sidr honey are left as they are without any extraction of honey.

ii. Electric extractor is used where honeycombs, after cutting the wax covers, are put and on extraction, containers receive the honey liquid.

Preparation of honey for marketing:

After harvesting and extracting of honey, the beekeeper prepares his honey for marketing. The following steps are adopted (Khanbash,1996 b)

iii. The un extracted combs are put in metallic or stainless steel containers of 20cm diameter, where two combs are put in one container (Fig. 6.1).

iv. Liquid honey is screened by a transparent piece of cloth and put in containers of 5-20 liters.

Fig (6.1) Honey combs

Honey Sorts:

Honey production is the main purpose of beekeeping in Hadhramout. Beekeepers of Hadhramout have been interested in honey production since old times. The beekeepers compete to satisfy the consumer interests inside the country and outside it . They produce quality honey which is more popular, particularly the Sidr honey that is considered as one of best qualities in the world.

The production of honey depends on the population of honeybee colonies, type of hive, flowering bee plants, environmental factors, and experience of beekeeper. The beekeepers has good experience about the appropriate time of bee multiplication and division, honey production seasons and got very good experience in taking care of his bees all the year around.

The number and time of honey seasons are different from one place to another. Usually there are three seasons. The first from February to May, the second from August to November and the third in summer between the first and second seasons.

Beekeepers in Hadhramout have to move their hives 3-5 times during the year. Often they get honey three times a year.

Physical characteristics of honey:

1- Color

Color in liquid honey varies from clear and colorless (like water) to dark amber or black. The color accepted by the consumer is different from country to another.

2- Taste

The taste is one of important characteristics for accepting honey by the consumer.

3- Viscosity

Viscosity is an important characteristics for accepting honey by the consumer. Freshly extracted honey is viscous liquid. Its viscosity depends on large variety of substances and therefore varies with its composition and particularly with its water content (Table 6.1).

Raising the temperature or honey lowers its viscosity(Table 6.2). Some Honeys, however, show different characteristics in regard to viscosity (FAO, 1996).

Table (6.1) Variation of the viscosity of white clover honey at 25 ℃ according to its water content (Munro, 1943)

Water content (%)	Viscosity (poise)
13.7	420
15.5	138
18.2	48
20.2	20

Table (6.2) Viscosity of sweet clover honey containing 16.1 % water according to temperature (Munro, 1043)

Temperature (℃)	Viscosity (poise)
13.7	600.0
20.6	189.6
29.0	68.4
39.4	21.4
48.1	10.6
71.1	2.6

Physical characteristics of sorts of Hadhrami honey:

Some characteristics of famous sorts of Hadhrami honey were studied (Khanbash, 1997; Khanbash et al, 1998). Data of table 6.3. show:

1- The color of sorts of Hadhrami honey are between light amber (Sidr honey) and light dark amber (Somor honey).

2- The honey taste of Sidr, Somor, and Range is normal. But the taste of Qasas honey is highly acidic.
3- The viscosity of honey sorts Sidr, Somor, Qasas, and Range are: very high, high, medium, and low respectively.

Table 6.3: Some physical characteristics of famous sorts of Hadhrami honey

Honey sorts	Color	Taste	Viscosity
Sidr	Light amber	Normal	Very high
Somor	Light dark amber	Normal	High
Qasas	Amber	Highly acidic	Medium
Range	Amber	Normal	Low

Analysis Requested:

The sugar content in the samples of sidr honey of Hadhramout is shown in table (6.4.). The results of table (6.5) show that the ash content in the three samples of sidr honey of Hadhramout is good (0.4 – 0.5 g / 100 g.). The analyses samples for sidr honey of Hadhramout indicates that the concentration of prolin is between mg / kg. (table 6.6).

Data of table (6.7.) show the commercial analyses:

1- Hydoxymethylfurfural (HMF)
2- Moisture content
3- pH
4- Diastase
5- Free Acid

Table (6.4) Sugars in sidr honey of Hadhramout

Analyses	Unit	Samples (Dar Ibn Khaldoon)		
		1	2	3
Fructose	g /100 g	36.00	36.80	36.80
Glucose	g /100 g	27.00	28.10	27.00
Sucrose	g /100 g	0.70	0.50	1.60
Turanose	g /100 g	3.50	3.70	3.70
Maltose	g /100 g	1.60	1.80	2.10
Trehalose	g /100 g	1.10	1.20	1.10
Isomaltose	g /100 g	1.90	1.80	1.70
Erlose	g /100 g	1.60	1.90	2.40
Melezitose	g /100 g	n.d.	n.d.	n.d.
Maltotriose	g /100 g	n.d.	n.d.	n.d.
Invert sugar (F+G)	g /100 g	63.00	64.90	64.50

Table (6.5) Ash content in sidr honey of Hadhramout

Samples	Unit	Result
1	g/ 100 g	0.50
2	g/ 100 g	0.40
3	g/ 100 g	0.50

Table (6.6) Proline in sidr honey of Hadhramout

Samples	Unit	Result
1	Mg / kg	533
2	Mg / kg	559
3	Mg / kg	541

Table (6.7) Commercial analysis for sidr honey of Hadhramout

Analyses	Unit	Samples (Dar Ibn Khaldoon)		
		1	2	3
HMF	mg / kg	1.1	1.8	1.0
Moisture content	%	14.3	14.8	13.5
pH	pH	5.6	5.0	5.5
Diastase	DZ	10.1	8.9	9.1
Free Acid	Mmol/ kg	9.2	9.8	8.1

Discussion:

Comparing the results of the analysis of Hadhrami sidr samples
(Tables 6: 4,5.6.7)
With the international standard (Table 6.8) we conclude that :

1- The moisture content and free Acidity values are within the accepted limit.

2- The diastase and HMF values indicate that they were not heated during processing.

3- The proline values indicate that the samples were ripe when harvested and show that the mineral (ash) and acid content were within the required range.

4- The sugar profiles show that their (fructose + glucose) and sucrose were within the expected range.

General conclusion:

The quality control parameters analyzed for Hadhrami sidr samples, met honey quality standards as specified in *Codex Alimentarius*, the Draft 96/ 0114 (CNS) of the EU and Proposal for new international standard.

Table (7.8) Honey quality standards according to the draft CL 1998/ 12-S of the *Codex Alimentarius*, the Draft 96/ 0114 (CNS) of the EU and Proposal for new international standard.

Parameters	International Requirements (Quality Standards)
Water content	≤ 21 %
Acid value	≤ 40 meq/Kg
Proline	≥ 180 mg/ Kg
HMF	≤ 40 mg/ Kg
Diastase	≥ 8 Schade units
Sugars (Fru + Glu)	≥ 60 %
Sucrose	≤ 5 %

Marketing Situation:

Marketing channels:

Data of the survey which was carried out by Khanbash and Gardash (2001) show that there are four channels for marketing honey. Direct marketing from beekeeper to shopkeeper. This operation is carried out in the production place during the season of harvesting the honey .

1- Direct marketing from beekeeper to shopkeeper. But the operation is not carried out in the production site and also not during the season of harvesting the honey. The beekeeper here brings his honey to the shopkeeper .

2- The shopkeeper buys the honey from mediators.

3- Direct marketing by the cooperatives of beekeepers.

Honey Prices :

Prices of honey are different from one production place to another and from one sort to another. The price of Sidr honey is between 8-10 times compared with other honeys .

The differences in prices of honey are not only for honey produced from different areas but also even for that produced from the same area. This might be due to several reasons; the most important are (Khanbash,2001):

1- Environmental Factors:

The properties of the honey differ from one area to another due to the prevailing environmental conditions of the area (Temperature, humidity, soil …etc.). Therefore, the price of the same type of honey produced in different areas varies according to its characteristics.

2- Season of Production:

Sidr trees flower twice a year particularly when there is rain. It has been known that honey harvested in autumn (October-November) has better quality than that produced in spring (March) and therefore honey produced in October and November has higher price than that produced in March.

3- Degree of purity:

Pure honey that bees collect from Sidr nectar only is the most expensive and also from nectar of plants that flower at the same time of Sidr trees.

4- Beekeeper experience :

The experienced beekeeper is the one who harvested his honey before moving his hives to Sidr growing areas. He then gets pure Sidr honey, sells it with high price; compared with that beekeeper who doesn't collect his honey before moving his hives to Sidr area and then gets mixed and not pure Sidr honey gets a lower Price.

5- **Degree of trust between the beekeeper and the honey trader**:

The results of a questionnaire distributed to a number of major beekeepers and honey traders showed that the degree of trust between beekeepers and honey traders is very important for determining the price of honey.

6- Demand and Supply movement:

This is also an important factor in changing the prices of honey.

Honey Exportation:

Exportation Methods:

Data on the preparation of honey for exportation , exportation channels and ways , sorts of honey exported, and countries importing honey from Hadhramout covered by the questionnaire are (Khanbash,2001):

Preparation of honey for exportation:

1- Liquid honey in containers (7-28Kg)

2- Combs of honey

Exportation channels :

1- Beekeeper exporter

2- Beekeeper non Yemeni trader

3- Beekeeper trader exporter

Exportation methods:

1- By cars

2- By airplanes

3- By travelers

Sorts of honey exportation:

1- Sidr

2- Somor

3- Range

Countries:

1- Saudi Arabia

2- UAE

3- Kuwait

4- Qatar

5- Jordan

6- Indonesia

Organic honey production:

In most cases honey is organic when it is taken from its natural location, the bee hive. HelpGuide.org points out that in order for a food to be labeled as organic it must be grown in safe soil, have no modifications and must remain separate from conventional products, or products that are not organic. No unnatural pesticides, bioengineered genes or other synthetic products can be used in preparing or storing the honey. When honey is collected using safe practices in a natural bee hive, it is still in an organic state. Honey may contain spores that can cause a deadly infection called botulism. To prevent this, the honey may be pasteurized or heated to temperatures hot enough to kill the bacteria. This process, when done in accordance with USDA standards, has no effect on the organic state of the product. Individuals seeking the most natural and organic form of honey may wish to purchase raw honey.

The honey produced from Hadhramaut can be classified as organic honey ?

What are the factors for successful organic honey production in Hadhramout apiaries ?

To answer this question, we review the following:

The production requirements of organic honey:

1- Location of organic apiary: An organic apiary should be placed on a piece of land that is maintained organically. The nectar or pollen used by the honey bees should come from organic sources.

2- Organic Bee Hives: The bee hives used for organic apiculture should be made of natural timber or metal. Treated timber cannot be used for making the hives.

3- Origin of Honey Bees: The replaced or introduced honey bees can come from organic as well as non organic apiaries. The apiary where new honey bees have been introduced can be included in organic honey production only after a period of about 60 days, after ensuring that the replacement of bees and management of the apiary has been carried out using organic means.

4- Honey Bee Plants: Bee keepers must ensure that organic hives within a radius of five kilometers are kept reserved from any chemical residue and known environmental pollutants.

The steps required to produce organic honey:

1- Transition Period: Like organic milk production, there is a transition period involved when a farmer shifts from conventional honey production to organic honey production. This transition period is about 12 months. Non organic wax should be replaced with organic wax during the transition period.

2- Feed for Organic Honey Bees: In organic apiculture, the honey bee hives should not be placed in or near farms where chemical farming is practiced. Also artificial feeding can be carried out; however, only when it is difficult to provide access to organic foraging to the bees. When non organic feed is used, the apiary should be removed from organic honey production, depending on the duration of artificial feeding.

3- Queen Honey Bees: The queen honey bees can be replaced whenever required. A healthy queen should be selected for replacement to ensure preventive disease management. Sometimes artificial insemination is permitted. Cutting of wings of the queen honey bee is not permitted**.**

4-Organic Honeybee Disease Control: Stress should be laid on using preventive methods of disease control such as selecting healthy queen honey bees and replacement bees. Further, antibiotics cannot be used for treating diseases. Whenever antibiotics are used, the apiary should be isolated and kept out of organic honey production for at least a year.

Honey collection, extraction and packaging techniques:

1- Organic honey harvesting:

- Collecting honey combs while covered with wax.
- Collecting honey combs with out brood.

2- Organic Honey Extraction: Extracting honey must be done in a way that the process is free from any non-organic contamination A live brood cannot be used for extracting honey from a brood comb. The surfaces that come in contact with the honey should be made of food-grade material or should be coated with bee wax.

3- Organic honey should not be heated above 35 degree Celsius. Gravitational settling and filtration should be used for removing extraneous solids.

4- Organic Honey Labeling: The honey stored in an organic honey container to the apiary it has been obtained from.

What are the advantages of honey produced in Hadhramaut?

The results of studies (Arrawi , 1985 ; AOAD , 1985 ; Hansen , 1995 ; Khanbash , 1997 ; Khanbash et.al, 1998; Khanbash, 2008) indicate that Hadrami honey has a number of unique and desired characteristics. These traits are difficult to find combined in any type of honey produced in the world and can be summarized as follows**:**

1**-** A natural product from wild medicinal plants free from chemical pollution of all kinds**.**

2**-** It is a natural product free from toxins and new proteins from genetically modified crops**.**

3**-** It is Free from pesticide residues, which are used to control bee pests**.**

4- It free from foreign odors and which are usually transmitted from old and industrial wax.

5**-** The Honey combs has a high therapeutic value because it contains 100% natural wax**.**

6**-** It has special characteristics desired by the consumer inside and outside the country.

7- It has many unique medicinal uses.

Storage and transportation conditions:

Organic honey is also transported carefully keeping guard against chemicals and toxins so it can be processed. There is even a processing temperature to keep honey on its natural state. Packaging must also be done carefully.

From the results of the application of standards for the production of organic honey to the production of honey from main areas honey production in Hadhramout (Table 6.9) can be divided into three sections:

1st . The areas that meet the all standards for the production of organic honey .

2nd . The areas that meet about 90 % of standards for the production of organic honey .

3rd . The areas that meet more than 50 % of standards for the production of organic honey.

Table (6.9) The application of standards for the production of organic honey to the production of honey from main areas honey production in Hadhramout

No	Standards		Examples of Hadhramout areas		
			1	2	3
1	Location of organic apiary	The chemical farms in the vicinity should be located outside a distance of about 3 km.			
		Must be free from pesticides and other environmental pollutants.			
2	Bee hives	The bee hives should be made of natural timber or metal.			
		Treated timber cannot be used for making the hives			
3	Bee feeding	The artificial feeding can be carried out in organic honey.			
		When non organic feed is used, the apiary should be removed from organic honey production, depending on the duration of artificial feeding.			
4	Source of the Nectar	The honey bee hives should not be placed in or near farms where chemical farming is practiced.			
5	Honeybee Disease Control	Stress should be laid on using preventive methods of disease control.			
		Antibiotics cannot be used for treating diseases.			
		Chemicals cannot be used for treating diseases.			

6	The Honeybee queens	A healthy queen should be selected for replacement to ensure preventive disease management.			
		Artificial insemination is not permitted.			
		Cutting of wings of the queen honey bee is not permitted.			
7	Honey harvesting	Honey combs should be collected while covered with wax.			
		Honey combs should be collected with out brood.			
8	Post-harvest techniques	Honey should not be heated above 35 degree Celsius.			
		Honey should be kept on its normal state.			

Key	
	Available
	Achievable

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7- CHAPTER
Honeybee Pests and Diseases

Honeybee Pests and Diseases

Honeybee Pests and diseases in Hadhramout:

The results of Khanbash (2018) study on the pests and diseases in Hadhramout showed that the infestation of pests and diseases is low. The pests and diseases are:

1- *Varroa destrutor*
2- *Nosema apis*
3- *Galleria mellonella*
4- *Vespa orientalis*
5- *Philanthas sp.*

Varroa destrutor is the important pest in many countries. The Varroa mite was first discovered in Yemen at the autumn of 1990. During the last years the infestation of Varroa has spread rapidly through the whole country. Varroa mite is currently a major concern for beekeepers in Yemen, because of the migratory beekeeping and the traditional hives.

Varroa mites were discovered in 1904 by Jacobson on *Apis cerana*. Oudemans was the first to describe the mite and named it *Varroa jacobsoni* Oudemans (15). Varroa has the ability to spread very rapidly outside Asia because of its parasitism upon *Apis mellifera*, primarily by foraging workers, swarming, robbing, drifting workers and drones (calatayud,1995;konopacka and muszgnka 1987 ; matthesetal ,1991).

The Varroa mite was first discovered in Yemen at the autumn of 1990 (Hoppe,1991). During the last years the infestation of Varroa has spread rapidly through the whole country (Khanbash and Obad 1996). Varroa mite currently causes the most concern for beekeeping in Yemen, because of the migratory beekeeping and the traditional hives (Khanbash,1997).

Population of Varroa mite increase very rapidly in some regions such as Europe but remain at a low level is some tropical countries (De Jong etal.1984), resulting in great differences in damage to beekeeping (Woyka,1987). The buildup of Varroa mite populations can be slow in different climates such as in dry, arid regions or others with long winters and late springs, but it is very rapid in those parts of the world where bees thrive throughout the year (Mobas and Bryn,1993).

Racial differences of brooding patterns of bees affect population dynamics of Varroa mite (Mobas and Bryn,1993). An increase in Varroa population is mainly determined by duration of brood rearing season, and presence of drone brood (Isola,1997). The number of Varroa mites in honeybee colony reached 11000 mites or more. The number of mites on adult worker and drone reached 5; 12 mites, respectively, while reached 12; 20 mites in worker and drone brood cells respectively (Hejazee,1998).

Population Dynamics of *Varroa* Mites on Honeybee Colonies:

Determination of infestation :

The percentage infestation of honeybee brood is different from place to another (Table 7.1), and ranged between 1.4 % - 7.7 %. A high infestation of apiaries was found in Rabat Ba-Ashen, followed by Rehab (6.5%), and Khailah Bugshan

(5.9%). While the low infestation of Varroa mite was in apiaries of Ghar Ben Laswad.

The Varroa infestation of adult bees in all checked places was ranged between 1.6 – 5.9 %. A high infestation of apiaries was found in Rehab, followed by Al- jahy (5.6%), and Khailah Bugshan (5.5 %). While the low infestation of Varroa mite was in apiaries of Al-jazoh.

The ratio of brood / worker infestation was low (0.54 - 1.76) in all checked places in Doan Valley. Woyke (1987) concluded that the ratio of B/W infestation increases when mites remain outside brood cells for a shorter period, if an infested brood cell contains a smaller number of mites (lower reproduction rate) or if the production of brood to worker bees is low.

Table 7.1: Mean percentage infestation of Varroa mite in honeybee colonies in Doan Valley, under survey (banawas,2020)

No.	**Areas**	% infestation		B/W
		Brood (B)	Worker (W)	
1	Al-Mashhad	3.8	5.2	0.73
2	Al-hajreen	2.5	2.9	0.86
3	Ghar Ben Laswed	1.4	1.9	0.74
4	Al-jazoh	1.8	1.6	1.13
5	Gaidon	3.2	4.7	0.68
6	Belad Al-Ma’a	4.2	3.8	1.11
7	Badhah	2.5	4.1	0.61

8	Rehab	6.5	5.9	1.10
9	Al-Kharaibh	5.1	2.9	1.76
10	Ribat Ba-Ashen	7.7	4.9	1.57
11	Dhary	5.1	4.3	1.19
12	Khailah Bugshan	5.9	5.5	1.07
13	Subeekh	3.4	2.9	1.17
14	Al-jahy	3.0	5.6	0.54
Mean		4.01	4.01	1.02

The difference between areas in levels of Varroa infestation, may be due to the migratory beekeeping (Khanbash,1997) and the bee plants that furnish the honeybees with nectar and pollen are different from one place to another. For this reason the sizes of honeybee colonies and brood rearing also are different. The occurrences of the high densities of mites were related to the presence of pollen sources, honey flow and brood cells (chen and shih,1995).

The results showed that the infestation of Varroa mite in some places is high, but the damage was not significant, because the average of mites per cell was not more than 1 mite/cell. This rate is low, also the infestation of adult bees is low (Isola,1987).

Population of Varroa mite in brood cells

The population of Varroa mite per cell was different from one place to another. Figure (7.1) Shows that the number of adult females per worker cell was low (1-3 mites per cell). The high rate (73%) was recorded from worker brood cells included one mite. While 20% of infested worker brood cells included two mites per cell. The rest percentage of infested worker brood cells (7%) included three mites per cell (Khanbash,2002).

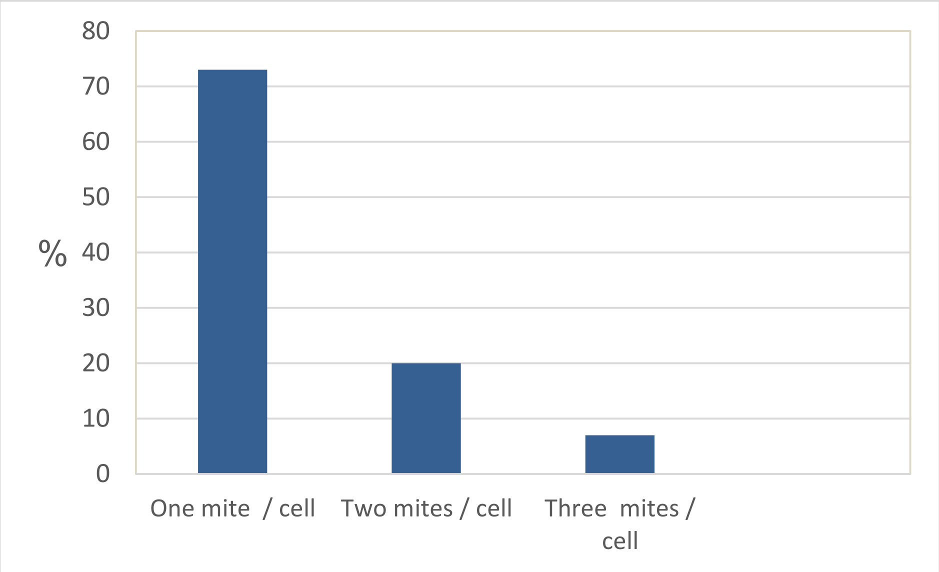

Fig. (7.1): The population of Varroa mite in the infestation worker brood cells in Hadhramout (Khanbash, 2002)

Population dynamics during the year:

As shown in Figure (7.2) the number of Varroa mite in brood cells was very low during the year. It reached to the maximum in February , when the average of closed brood reached also a maximum. While the minimum average of mites was during September, October and November. The closed brood in this period reached it's minimum. Khanbash (2001) results indicated that there is a significant influence of amount of closed brood workers on the population of

Varroa mite in brood cells (r = 0.94). This finding agrees with Isola (1987), which indicated that an increase in Varroa population is mainly determined by duration of brood rearing season.

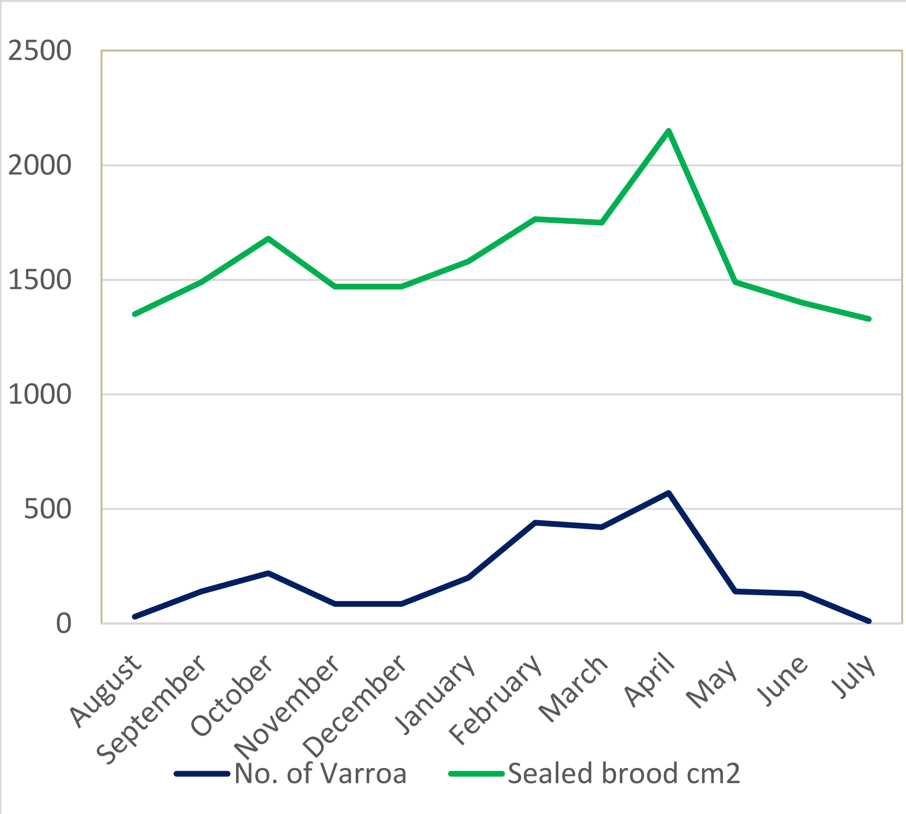

Fig. (7.2) Relation between population of Varroa mite in brood cells and the amount of sealed brood workers (Khanbash,2002)

Figure (7.3) shows that the average of Varroa mite on adult bees reached it's maximum in February (129 mites)). While the minimum average of mite were in October (36 mites). The numbers of fallen mites were between 13.6 –85.2 mites per month. The maximum was in February (85.2 mite /

colony and the minimum was in November and October 13.6 ; 14.0 mite /colony, respectively.

Khanbash, 2002 indicated that the correlation coefficient between the fallen mites and the Varroa on adult bees was low (r = 0.48). A strong correlation was shown between the final mite population and the total number of dead mites (Colatagud and Verdu,1995).

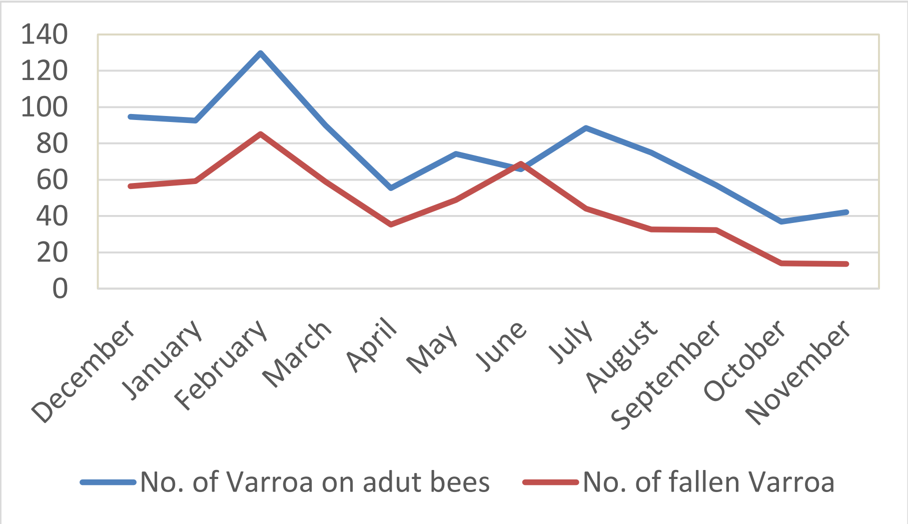

Fig. (7.3) The population of Varroa mite on adult bees and fallen mites through the year in Doan Valley (Banawas, 2020)

Yemeni Honeybee and Diseases:

For the specification of the relationship between Yemeni honeybee *Apis mellifera jemenitica*, Khanbash (2002) Studied three parameters :

1- Grooming behavior .
2- Length of post – capping stage .
3- Hygienic behavior .

Banawas (2020) Studied two parameters :

1- Grooming behavior .

2- Hygienic behavior .

1- Grooming behavior:

To study the grooming behavior Using the following :

- Wire net (3.3*3.3mm) bases were placed under the combs and on the bottom brood (Khanbash,1999). A sticky board was used under the wire net bases to collect mites.
- The fallen mites in the colonies were collected at intervals of three days. The fallen mites were examined with a microscope to detect those with missing legs with dents on their body, etc. The percentage of mites damaged by bees on the colony was determined (Ruttner and Hanel,1992).
- The total number of mites in test colonies was counted at intervals of two weeks. By comparing the number of bees and mites in the sample with the number of bees in the whole colony, (each Langstroth comb was assumed to carry 1500 bees) (1) The number of mites on brood is counted by comparing the number of brood cells and mites in the brood sample with the total quantity of brood in the colony (each 100 square cm of worker brood contains 466.7 cells (Khanbash,1995).

Khanbash (2002) resalts showed that numbers of damaged mites was different from one month to another (Fig.7.4). The percentage of damaged mites reached its maximum during May, April and March (67.5%, 60.5%, and 59% respectively). While the minimum mean of damaged mites was in December (20%). In other months the damaged mites was between 21% - 49%. This finding agrees with several researchers’ findings. Moosbeckhofer (1997) observed low numbers of damaged mites in March (11%), but significantly higher numbers in June (42%) in the same colonies. Buchler (1993) found the average number of damaged mites was between 10% and 64%

The results of table (7.2) showed that the average numbers of damaged mites were between 4.0 – 39.6 per colony. That the average number of damaged mites reached its maximum in February, while the minimum the average number of damaged mites was in October (Banawas, 2020).

The damages was on the legs and the dorsal shield. A damaged mite can be divided into three parts

1- Damaged mite in legs.

2- Damaged mite in dorsal shield.

3-Damaged mite in legs and dorsal shield together.

The maximum percentage of damaged mites was in legs (74.12%), while the percentage of damaged mites in legs and dorsal shield together, and in dorsal shield was 16.20% and 9.56 respectively (Fig. 7.5).

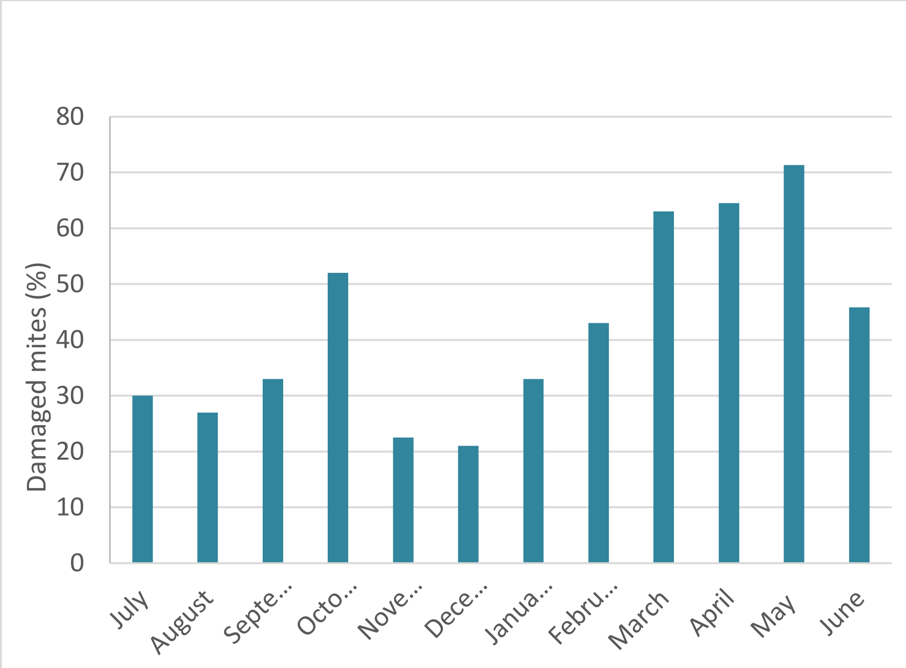

Fig.7.4 : The mean of damaged mites by honeybees on a test colonies through the year (Khanbash, 2002)

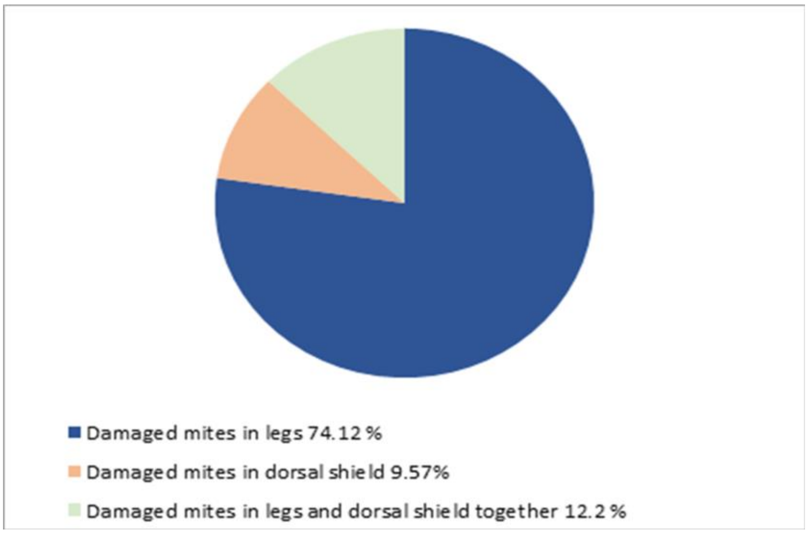

Fig. (7.5) Percentage of damaged mites in legs, dorsal shield, and legs and dorsal shield together (%)

Table (7.2) Average number and percentage of damaged mites in legs, Dorsal shield, and legs and dorsal shield together (Banawas,2020)

Months	Average number of damaged colony /mites	Percentage (%) of damaged mites in		
		Legs	Dorsal shield	legs and dorsal shield together
December 2018	18.6	62.3	12.9	24.7
January 2019	21.2	67.9	15.0	17.0
February 2019	39.6	53.5	23.2	21.7
March 2019	30.8	74.7	6.5	18.2
April 2019	13.4	79.1	6.0	16.4
May 2019	12.4	67.7	4.8	27.4
June 2019	16.8	78.6	8.3	13.0
July 2019	12.8	78.1	10.9	10.9
August 2019	10.0	74.0	10.0	16.0
September 2019	7.2	91.7	2.7	5.5
October 2019	4.0	80.0	10.0	10.0
November 2019	4.4	81.8	4.5	13.6

The percentage of damaged mites reached its maximum in March and February (52.4%, and 46.5% respectively). While the minimum mean of damaged mites was in September (21.7%). In other months the damaged mites was between 24.4 % - 38.1 % (Fig. 7.6).

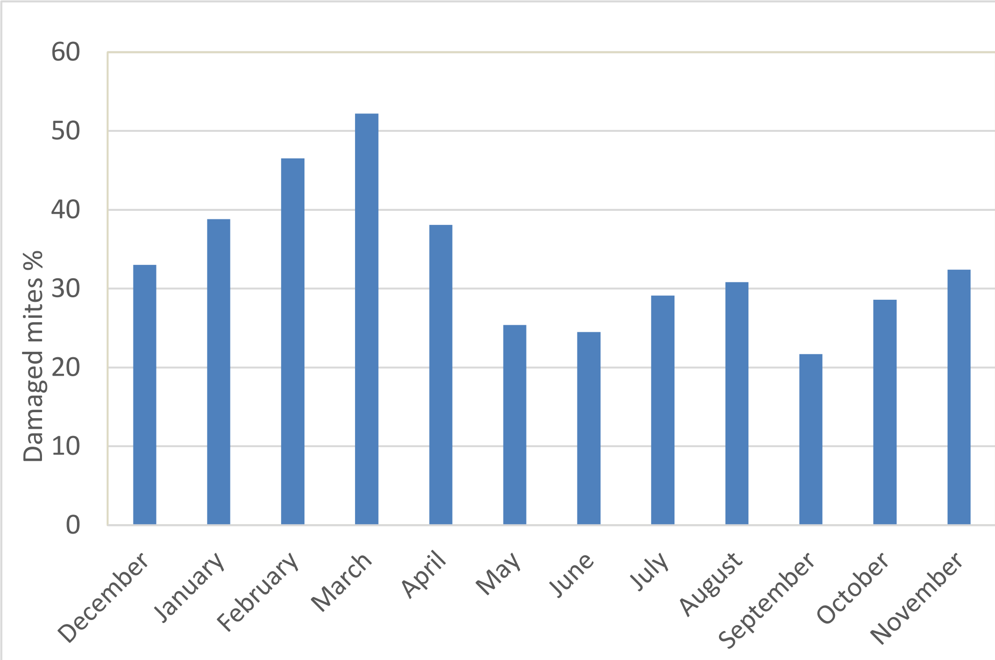

Fig. (7.6) The percentage of damaged mites by honeybees on a test colonies through the year (Banawas, 2020)

A significant negative correlation between the developments of the Varroa infestation in honeybee colonies during the year and the percentage of damaged mites, r = 0.88, has been found. The linear regression ($p < 0.01$) indicates that an increase of damaged mites by 8% results in a 100 mites increase of the final mite infestation (Khanbash, 2002).
Moosbeckhofer (1997) and Büchler (1993) reported a significant negative correlation between the number of damaged mites and the infestation of brood and bee samples and the total infestation.

2. Length of Post-capping stage

The Length of post - capping stage was studied using the following steps (sammatataro,1996;siudaand wilde,1996):

- releasing caged queen
- checking for first sealing after 8 days, and marking a sample of 100-worker cells/ colony in a transparent plastic sheet to locate cells later.
- transposing the tested combs (with sample of cells) after 19 days from releasing the queen.
- measuring the time period starting 265 hours after the first sealing, and at one-hour intervals, and the emerging workers were observed.
- counting the total number of mites in the tested colonies.

Table (7.3.) Presents the length of post capping stage for the different tested Governorates. The period was significantly shorter in the colonies of Lahij and Hadhramout than in the colonies of Ibb. The differences within individual colonies ranged between 15 – 17 hours. A shorter period of post capping was found in colonies of Hadhramout (268h), while the longer period was found in colonies of Ibb (287h.). In colonies of Lahij the length of post capping ranged between 269 – 284 h.

Table (7.3): Duration of Post capping stage (h) in three test Governorates (Khanbash.2002)

Governorates	Range	Mean	SD
Lahij	269 – 284	276.58 a	3.80
Ibb	271 – 287	280.66 b	3.46
Hadramout	268 – 284	277.04 a	3.71

Several researchers studied the duration of the capped stage. In the papers of Moritz and Hanel (1984), Moritz (1985), it has been mentioned that the post- capping period for worker brood of *Apis mellifera* races of African origin is shorter than that of European origin. Sammataro (1996) mentioned that some African bee strain emerge in 11 days and in the European bees emerged in 12 days. Buchler and Drescher (1990) observed differences in the length of the capped stage of up to 9h between different strains and up to 19h between individual colonies. Schousboe (1986) measured maximum differences for the duration of capped stage of worker brood in *Apis mellifera* ligustica colonies up to 1 – 15 days.

A correlation between the duration of the capped period and the infestation level with Varroa mite can be recognized. The average capped period of the test colonies ($n = 15$) is correlated with their final mite infestation with $r = 0.86$ (Fig. 7,7). The linear regression ($p< 0.01$) indicates that a reduction of the post-capping period by 1 hour results in a 19.9% reduction of the final mite infestation. These findings are in agreement with Buchler and Drescher (1986) who indicated the positive correlation between the length of capped stage and the infestation level ($r = 0.48$) indicating that, on average, a reduction of the length of the capped stage by one hour led to an 8.7% reduction in the final mite infestation level.

The results showed that the effect of the few hours' difference in the capped period is surprisingly high underlyning the importance of this parameter for the specific Varroa-Yemeni honeybee relationship.

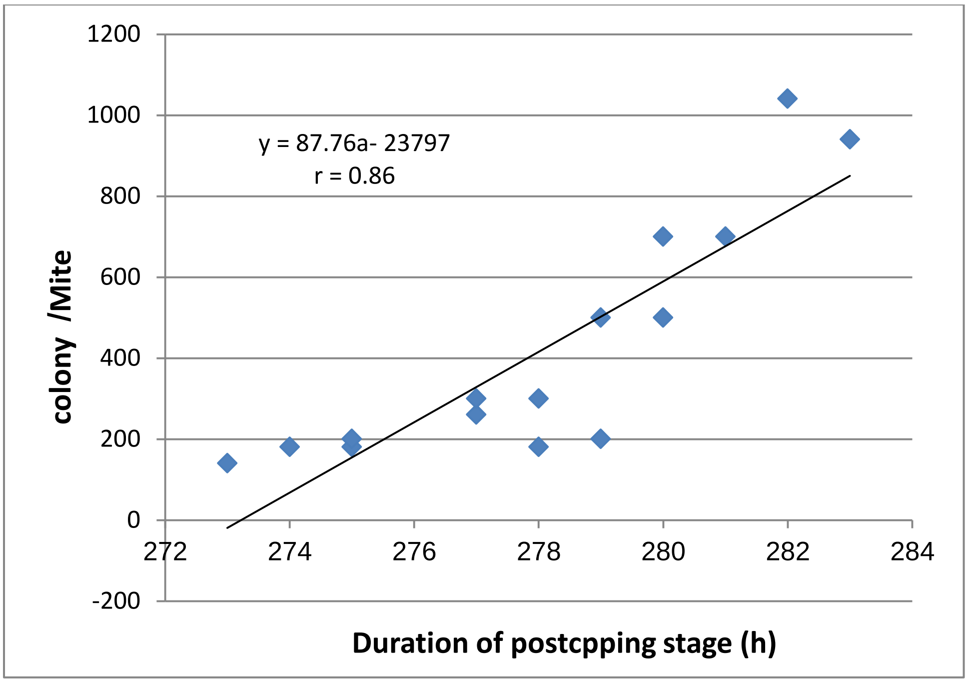

Fig.7.7 : The regression line of the average duration of the capped stage (h) against the final mite infestation of 15 test colonies (Khanbash,2002)

3. Hygienic behavior:

To study the Hygienic behavior Using a thin needle we kill a 2-inch square area of capped brood (100 total cells) from the test colony by inserting the needle through the capping and killing the larvae, then we placed the frame into the test colony. After an interval of 2 hours, we observed how long will it take bees to open the capped brood cells and removed the dead brood (Sammataro,1996).

Khanbash (2002) and Banawas (2020) results show that the experiment colonies in Hadhramout open the capped brood cells and removed the dead brood within 24 hours. The first colony open the capped brood cells and removed the dead brood in short time (14 hours), and the second colony in 18 hours. While the other three colonies open the capped brood cells and removed the dead brood during 20-24 hours (Table 7.4) These results showed that hygienic behavior of the test colonies of Hadhramout are excellent (Sammataro , 1996).

Table (7.4) The percentage of the removal of killed capped brood in experiment colonies (banawas, 2020)

No. of colony	The percentage of the removal of killed capped brood (after hours:)						
	12	14	16	18	20	22	24
1	59.5	74.5	83.0	93.0	97.5	100	
2	71.0	82.5	93.5	100			
3	60.5	68.5	83.5	91.0	95.5	98.0	100
4	99.5	100					
5	68.5	78.5	91.5	98.0	100		

A strong correlation (r = 0.90) was shown between the duration of the removal of killed capped brood and the final Varroa mite infestation (Fig.7.8). The linear regression ($P < 0.01$) indicates a reduction of the removal period by one hour resulting in a 9.2% reduction of the final mite population.

Hygienic behavior may theoretically limit the population growth of *Varroa jacobsoni* in three ways (Fries et al.1994): First, immature mites which have begun to develop in brood cells are killed, decreasing the average number of offspring per mother mite. Second, removal of female mites extends the phoretic period of these mites, which survive the removal process. Third, mite removal increases the mortality of mother mites. Spivak and Reuter (spivak and reuter 1998) demonstrated that colonies bred for hygienic behavior had fewer mites than commercial colonies not selected for behavior after 1 year without mite treatment.

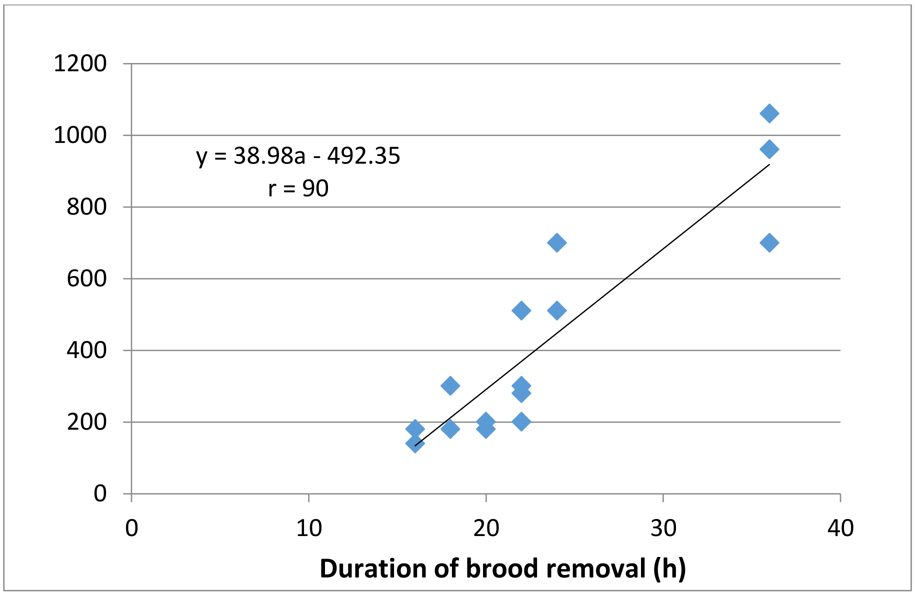

Fig.7.8: The regression line of the duration of killed capped brood (h) against the final mite infestation of 15 test colonies (Kanbash,2002)

SD, Standard Deviation within individual colonies means followed by the same letters are not significantly different according to Danean's test ($P < 0.05$).

Conclusions:

We can conclude from the results of this study that (1) the effect of the difference in damaged mites, capped period and the cleaning period is surprisingly high, undrlyining the importance of these parameters for determining the type of relationship between Varroa and the Yemeni honeybees, (2) the Yemeni honeybees have got high capabilities for Varroa resistance.

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