Survey of the pests and diseases of honeybees in Sudan

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Dedication

To my beloved family

and to all who work in beekeeping
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Discussion
Abstract

A survey of the honeybee pests and diseases in Sudan were curried out. About 117 colonies were inspected in addition to 344 packages of imported honeybee colonies and 20 colonies of Apis florea. All inspected colonies in all locations were found to be free of American foul brood, European foulbrood, Chalkbrood, Sackbrood and Stonebrood. The only brood disease found was Serratia marcescens, in Khartoum State 7 out of 117 (6.82%). Dysentery was the only adult disease found during this survey in Kordofan State and its percent infestation was 2 out of 117 (1.70%).

The parasitic mite Varroa jacobsoni was discovered in Sudan in this study for the first time. All Khartoum apiaries were infested with this mite and 50% of the inspected colonies had positive infestation. High incidence was found in Shambat apiary 100% followed by E-l kadaro apiary 70% and El-faki Hashim apiary 50%. Among bees the mean incident percent in Khartoum was 10.92%, high infestation was found in Shambat 1.476% followed by E-l kadaro 1.246% and El-faki Hashim 0.594%. In addition to that 37.24% of wild colonies were infested with mites, incidence of 2.033%.

The mean percentage of infested colonies by Greater wax moth (Galleria mellonella), Ants (different spp), Small hive beetle (Aethina tumida), large hive beetle (Hyplostoma fuligineus) and Hawk moth
Acherontia atropos was, 86.320%, 77.292%, 2.389%, 2.194% and 0.043% respectively. The Small hive beetle (Aethina tumida), the large hive beetle (Hyplostoma fuligineus) and the Bee wolf (Palarus latifrons) were recorded for the first time in Sudan.

Some insects such as Earwigs, Silverfish, Cockroaches, Praying Mantids, Dragonflies, Termites, Locust, Dwarf bee (Apis florea) and the sting less bees were also reported as a pest of honeybees.

The major mammalian pests that found in Sudan were Man (honey hunters), Livestock (Cattle and Camels), Squirrel and Honeybadger (Mellivora capensis). The last one was reported as a pest of honeybee colonies in Sudan in this study for the first time.

The bee-eaters birds of honeybee colonies were: Merops apiaster, M.nubicus, M.albiculus, M.orientalis and M.pusilus. The honey guide Indicator indicator and the ground hornbill Bucorvus abyssinicus were recorded as a pest of honeybee colonies for the first time in Sudan.

It was found that Sudanese honeybees were hygienic colonies resist pests and diseases. It was found that 80% of the preventive methods were the main control measure of the bee pests and diseases in Sudan and only 7% used chemical methods.
الخلاصة
خلال السودان في النحل ألمراض والآفات لحصرين مدنيين. إجراء التم (2002/3002) (فحص التم 711 حيث إلى الموالي ببالإضافة إلى النحل طاففة 423 وخرطوم بمتار مزودة النحل طاففة 52 طاففة النحل من السوداني النحل خلود دراسة أوضحت عليها الجمالة من الأوربي الجحضية تعلمت النحل وامريكي الجحضية تعلمت النحل مثل بولاية السيراليون النحل تتشخيص تم أنه إذا النحل تجرع النحل وامريكي الجحضية تكالب ببلغت حيث النحل خرطوم النحل النشبة 2 نسبة 3653.

الجماحة من البالغ النحل كأحد الدستارة كردفان النحل وولاة في معدي الغيرة.

الفارو من طفيلة اكتشاف تم (Varroa jacobsoni) في السودانة النحل على النحل الأول ببلغت قد وطفيلة بذلها مصابة الخرطوم منحل كل أنس وجد حيث النحل وولاة النشبة 57 نسبة % النحل وولاة في الفحصية الخلية جمالية من 0.01ل نسبة الكدور منحل 5700 وولاة في الجماعة الخرطومية النحل،

هذه نسبة البالغ النحل على النشبة النشبة نسبة 68.52% بينما 74.59% النحل والشمعة الدوارة للحشرات الغيرة (Galleria mellonella) النحل الصغير النحل طاففة خنفسة النمل، (Aethina tumida) النحل الكبير النحل طاففة خنفسة، (Hyplostoma fuligineus) النحل السرم الفراشة، (Acherontia atropos)

(1990)
**Palarus latifrons** may be found in the first occasion in Sudan. Some of the above-noted species, such as *Merops apiaster* (Western swallow-tailed), *M. orientalis* (Eastern swallow-tailed), and *M. nubicus* (White-throated), may be observed in the Sudan. The swallow-tailed may be found in *Bucorvus abyssinicus* (and it may also be found in *Indicator indicator*).
Honeybee like most animals suffer from diseases and pests which causes the most injury and mortality of honey bee colony, reduce the honeybee production such as honey, bees wax, royal jelly, propolis and pollen grains. Moreover, the yield of crops and vegetables may decrease as a result of inadequate pollination.

Although great interest has been given during recent years to the Sudanese honeybee, much more information is needed in that field, very little is known or has been published about the pests and diseases of the Sudanese honeybee, which is recommended to be studied (El-Sarrag, 1977).

The manner of bees in living in crowded hives makes it almost inevitable that any contagious discover will spread rapidly within the hive or to other colonies unless it is dedicated and the appropriate treatment is given. Honeybees are hosts to almost 37 known pathogens, all of which debilitate colonies, as well as many predators and parasites. A summary of the diseases, pests and parasites infecting bees is given below:

Viruses: Paralysis virus, chronic bee paralysis virus, sacbrood virus, black queen cell virus, filamentous, bee virus Y, bee virus X, cloudy wing virus, acute bee paralysis virus, slow paralysis virus, Kashmir bee virus.

Bacteria: American foulbrood, European foulbrood, secondary bacteria (*Bacillus alvei*) and others.

Fungi: Chalkbrood, Stonebrood, Yeasts and others.

Protozoans: *Nosema apis, Malphighamoeba mellificase,*

Insects and nematodes: Hymenopterous, (such as Wasps, and Ants) Dipterous (such as *Braula coeca*), Coleopterous (such as the small hive
beetle and large hive beetle) Lepidopterous (such as *Galleria mellonella*), nematodes (such as *Mermis nigriscens* and *Agamormes spp.*).

Mites: Tracheal Mite, *Varroa jacobsoni*, *Tropilaelaps clareae*.

Birds: Such as Bee-eaters (*Merops spp*), Honey guide (*Indicator spp*).

Mammals: Such as Man, Honeybadger, Squirrel and livestock.

Some factors such as importation of diseased or suspected diseased honeybee colonies from different parts of the world, importation of contaminated bee products and migratory practices of beekeeping, assist in distribution and spreading of bee diseases and pests. The first recorded importation of honeybees in Sudan was made in April ٨٢٩١ by King, who introduced two nuclei of Cyprian honeybees from the Apiary of the Egyptian Ministry of Agricultural. Italian, Carniolan as well as F, Carnio-Egyptian honeybees were also imported from Egypt (Anonymous ٩٦٩١). The Langstroth standard hive was introduced by Khalifa In ١٦٩١ to the Department of Entomology, Faculty of Agriculture, University of Khartoum for educational purposes. This hive, which is getting to be popular today, has been successful (Anonymous ١٥٧١).

Recently thousands of honeybee colonies were imported for commercial purposes so the threat of spreading exotic diseases and pests is one of the main justifications of this study.

Honeybee colonies in Sudan were found in different nesting sites and different type of hives. Wild honeybees *Apis mellifera* (L.) are widely spread in forests. They establish their nests in holes in trees and fallen logs, holes of white ant mounds, rocks roofs and similar places (El-Sarrag ٧٧٩١). Domesticated honeybees inhabit either Langstroth hive or traditional hive. The majority of the traditional hives are of elongated wicker or hollowed log type. These hives are fastened to the
branches of trees at the swarming seasons. There is at least two subspecies of Honeybees in Sudan: ayelow banded group *Apis mellifera sudanensis* nov subsp and mixed group *Apis mellifera nubica* Ruttner. *Apis mellifera sudanensis* is a little honeybee distributed all over the Sudan between latitudes 3°N and 6°N while *Apis mellifera nubica* distributed along the international boundaries of Sudan, Ethiopia and Uganda (El-Sarrag et al. 1994). The three clusters of the Sudanese bees were classified to three sub-clusters; the smallest bee of sudan *Apis mellifera yemenitica*, Ruttner, The medium bee *Apis mellifera sudanensis*, Rashad and the largest bee *Apis mellifera bandasii* (Mogga 1988). The smallest honeybee *Apis florea* was introduced to Sudan in 1985 (Lord and Nagi 1987 & Mogga and Ruttner 1988).

There were about 0.002 honeybee hives in Sudan the total numbers of beekeepers were 0.006. About 99% of these beekeepers were traditional and 1% of them using modern beekeeping technology (El-Sarrag et al. 1988).

Honeybees in tropics suffer more injury and mortality from pests than from diseases caused by invisible organism Crane, (1974). Therefore vigorous and healthy honeybee colonies are necessary to ensure adequate and sufficient pollination of agricultural and horticultural crops, wild plants and maximum exploitation of forage for potential honey yield. Consequently, such healthy colonies help in increasing the quantity and improving the quality of fruits and seed products.

The activity of the honeybee and their enemies are greatly affected by the environmental factors such as climate and vegetation. It is worth giving a short description of these factors in Sudan since this study is dealing with the honeybee in a tropical country.
Sudan is the largest country in Africa, roughly extending from about 9° N to 22° N and from 22° E to 9° E with total of 5.2 million m². It covers all kinds of habitat ranging from desert to tropical rainforest. Even though the country is mainly flat with average altitude of 0.5 m, there are some important mountain ranges such as Jebel Marra, Didinga Mountains in the southern Sudan along Uganda international border. About 4,000 km of shoreline along the Red Sea and the River system of the Nile River form the major aquatic habitats in Sudan. The Nile Sudd is one of the most important wetlands in Africa.

Even though large part of the country especially in Sahil belt, are intensively used for agriculture, such as the Rahad and Gezira schemes, there do nomadic cattle owning people mainly use still large areas with natural habitats.

The Sudan has generally only one rainy season from April/May to September becoming shorter towards desert in the north. The rainy season differs only along the southe. The temperature is usually high throughout the year. However, in the northern parts of the country the temperature drops particularly at night. The mountainous areas, such as Jebel Marra in the west, the Red Sea Hills in the east and the Imatong, Dongotona and Didinga mountains in the south are naturally cooler than the low-lying plains, which surround them.

The country is characterized by unstable atmospheric pressure, resulting in the creation of two types of winds, namely:

1. The Inter-Tropical Continental Winds (zone) ITCZ, which is an active wind blowing southerly or west southerly. ITCZ is wet as it crosses the Atlantic Ocean, causing much rain in southern Sudan, loosing its moisture as it blows northwards. This wind blows throughout the year; it is more active in summer. As a result two rainfall belts may be differentiated in the central and southern Sudan; the northern belt where
the rainfall amounts to ٠٠٢-٠٠٨ mm per annum (between June and October), and the southern belt where rainfall reaches ١٤٠٠-١٦٠٠ mm in the extreme south and the rain lasts from March to November.

٢. The Trade Wind; which is either northeast or southeast. Although this wind is dry and blows throughout the year, it is more active during the winter causing winter rainfall along the Red Sea coast.

Accordingly, the vegetation of the Sudan varies, and can be divided into five main types extending from north to south, namely: Semi-desert, poor-savannah rich savannah and forests (attached map) appendix (١)

The desert region about one third of entire country the rainfall is very light and irregular (٠-٠٥ mm per annum). The vegetation is therefore negligible except in desert valleys. Adjacent to the River Nile plants are more abundant, especially various species of Acacia spp, and date palms (Hyphaene thebaica).

South of the desert is semi-desert region, much smaller than the desert and richer in vegetation due to the higher rainfall ranging (١-٣ mm per year). Numerous shrubs and small trees grow in this area, most of them acacia plants. Various species of short grasses are also common. Along the Red Sea Hills, the vegetation differs somewhat due to the influence of topography.

The most important agricultural areas of this region are the Tokar Delta in east, and the northern parts of the Gezira, Khartoum and Shandi in the center.

The poor-savannah region forms a comparatively narrow belt south of the semi-desert region. The rainfall amounts ٣-٥ mm per year and the dry season lasts ٤-٦ months. (April – July). Acacia trees are still dominant, sometimes forming open woodland. Acacia mellifera (Kitr) is a rather typical tree in the eastern part and A. Senegal (Hashab) is predominant in western parts of this region. Moreover, the Managil
extension, Gash delta and Kashm Algerba scheme are situated. Malvaceos plants as well as wild *Sorghum spp.* are naturally abundant.

The rich-savannah region includes Bahr Elarab, Jebel Marra, Nuba Mountains, Ingessana Hills and White Nile tributaries. The annual rainfall reaches between \(0.5-1\) mm. *Acacia seyal* (Talh) and *A. mellifera* are predominant, broad-leaved trees of the genera *Terminalia*, *Combretum*, *Streculia* and Tebeldi tree *Adansonia digitata* are found. The Dom balm is characteristic for riverian areas and stretches around isolated mountains. The flora of the Nuba Mountains includes number of species, which belong to the more southern region. In Jebel Marra area, whose higher altitudes resemble certain areas in the Mediterranean, the Olive tree *Olea chrysophylla* and *Acacia albida* are very common.

The forest region forms the most southernly vegetation belt in the Sudan. The annual rainfall as high as \(1-1.5\) mm resulting in very thick vegetation. The forests lie mainly in the southwestern parts of the region and are the link to the forests of the neighboring Congo and Uganda. The broad-leaved Mahagony; *Khaya grandifolia*, *Chlorophora excelsa*, *Cola cordifolia* and kapok tree *Ceiba pentandra* are the typical tall trees. The Papyrus (*cyperus papyrus* var. *antiquorum*) is the most characteristic plant distributing in vast areas of the forest regions.

Table in appendix (2) shows the annual climatological means form normals of the period \(1791-2002\) for 8 states concerned in the present study; the Blue Nile, Khartoum, Kordofan, South Darfour, Kassala, White Nile, River Nile and Gezira.

Because Sudan is an agricultural country and due to the recent progressing in beekeeping and horticultural development in the country and also due to the high demand for honey the present study was planned to aim at establishing abundance of the diseases, predators and pests that effect, or even destroy large numbers of honeybee colonies in Sudan. This study also aims at showing the distribution of these disease, pests and predators in
Sudan. An attempt to study the hygienic behaviour of Sudanese honeybee colonies, were also made.
Chapter 7
Review of literature

7.1. Bacterial Diseases

The most important diseases of honeybees are (A.F.B.) American foul brood and (E.F.B.) European foul brood both of bacterial origin (Shimanuki 1981). Philip is the first one who used the terms "European" and "American" foul brood diseases to differentiate the two conditions. However, he cleared that the designations did not refer to the geographical distribution of the diseases (Shimanuki 1981).

7.1.1. American Foul Brood Disease

American foul brood is the most widespread and most destructive of the brood disease. It caused by microscopic spore forming organism known as Bacillus larvae white (Smith 1963; Bailey 1967 and Anonymous, 1991). Recently Bacillus Larvae White reclassified to Beanibacillus larvae sub sp. larvae (Ash et al. 1993).

Spreads

Robbing and drifting bees spread the American foul brood disease from colony to colony. In addition, beekeepers can spread AFB by feeding honey from diseased colonies or into changing brood combs between diseased and healthy colonies (Bailey 1990 and Shimanuki 1981). The AFB can also spread by swarms or package bees from one locality to another (Anonymous, 1981).

Distribution

Shimanuki (1981) reported that AFB is found almost worldwide. Beekeepers on every continent have reported the disease but it appears that not every country in each continent has American foul brood disease.

Symptoms

The symptoms are sunken and perforated capping of sealed brood. The larvae die after the cells have been capped and then turn a chocolate-brown colour at a later stage the larvae remains become a ropy mass in
the cell. Finally the remains dry into a hard scale fixed to cell walls. The disease produces a foul smell in the hive, (Smith 1960 and Bailey 1967).

**Treatment**

Shake treatment:

The earliest treatment of AFB disease was the 'Shake treatment' where in the adult and queen from a diseased colony were shaken to clean combs (Morse 1985).

Burning treatment:

A colony in which AFB is found to be present should be destroyed by fire as soon as possible. All the contents of the hive-bees, combs, frames, quilts and honey should be burned and the live part disinfected before they are used again (Bailey 1969, Anonymous 1969 and Morse and Hooper 1985).

Antibiotic:

Bailey (1969) and Morse and Hooper (1985) listed some of Antibiotics to prevent and control AFB; Sulfathiazol, Tetramycin (Oxytetracyclin), Extender pathes, ethaline ovid. More recently the antibiotic tylosin was found to be effective in controlling Oxytetracycline resistant American foul brood in honeybee (Elzen, et al., 2002).

Genetic control

Recently different mechanisms of resistance of diseases were discovered among them was hygienic behavior, Palacio et al. (2002) stated that the hygienic colonies had a lower frequency of brood diseases when compared to no hygienic colonies.

European Foul Brood

European foul brood is less common, but where it does occur infection often spread unseen through the apiary (Shimanuki 1987). The causal agent of this disease is *Bacillus pluton* white and at later stages
other bacterial forms known as *Bacillus curydice*, *B. alvei* and *Streptococcus apis* appear as associates Smith (1961). Bailey (1962) considered that the more accurate designation of this organism is *streptococcus pluton* rather than *Bacillus pluton* and suggested that *Bacillus pluton* be renamed *Streptococcus pluton* white. More recently *Streptococcus pluton* was reclassified to new genus *Melissococcus pluton* (Bailey and Collins 1984).

**Spread**

The factors already considered in connection with spread of AFB usually apply also to the spread of EFB (Anonymous, 1975).

**Distribution**

According to ANONYMOUS (1965) the EFB is found in Arab countries; Syrian, Jordan, Iraq, Palestine, Saudi Arabia, Libya, Tunisia and Morocco but no part of it in Sudan, Egypt, Yemen, Algeria and Oman.

**Symptoms**

Symptoms of EFB are dead larvae in cells in unnatural positions, yellowish to brown in colour of foul or merely sour, smell a few sunken or perforated cappings may be seen the cappings of the dead larvae are usual dark (Smith 1973; Shimanuki 1978 and Bailey, 1993).

**Treatment**

Colonies with high proportion of diseased brood should be destroyed, as with AFB (Bailey, 1963; Smith 1961). Success has been obtained in curing EFB with Streptomycin and tetramycin fed to colonies in sugar syrup (Smith, 1974).
١١٣. Serratia marcescens

El-Sanousi, et al., (٧٨٩١) reported a bacterial larval brood disease in honeybee colonies in Shambat apiary and identified the causal organism as Serratia marcescens. They related the source of the disease to carniolan honeybee colonies imported to Shambat apiary from Egypt in ٦٨٩١. They suggested that the infection took place when the bacteria have been picked up by the adult bees when passing over the infected area and then introduced by them to the larvae in food. The biochemical properties of the isolates were also studied. Abdalla (٨٨٩١) stated that Serratia marcescens reduced the strength of the infected colonies by about ١٦٪ and increased their superseding by two and ٣ folds as compared to healthy colonies.

١١٤. Septicemia

Septicemia is caused by a bacterium-Bacillus apiscepticus (Burnside) in the blood of bees and is spread through contaminated water getting into the breathing organs. The losses infected by this disease were minor Smith (٩٩١). Shimanuki and Knox (٠٠٠٢) stated that pseudomonas aeruginosa (= pseudomonas opistica) is the bacterium that causes septicemia in adult honeybees. This disease results in the destruction of connective tissues of the thorax, legs, wings and antennae. Dead bees may have a putrid odor. Septicemia can also be caused by Serratia marcescens (El-borony and Hejazi ٩٩٤).

١١٥. Fungal Diseases

١١٦. Chalkbrood
This fungal disease caused by *Pericystis apis* Maasen, which reclassified to *Ascosphaera apis* (Bailey, Shimanuki and Knox). This fungus attack the larvae and converts them into chalk-white masses of mycelium, it infects larvae only. It is not considered as a serious disease. However, endemic infection can be very persistent and the damage may well equal that by EFB (Bailey).

**Distribution**

According to Bailey (*Ascosphaera apis* occurs in Europe, including British Isles, but not in north America. There are no reports of its occurrence elsewhere. However, The ANONYMOUS listed, five Arab countries as infected countries with Chalkbrood disease, among them are: Syrian, Jordan, Palestine, Egypt and Tunisia.

**Stonebrood**

This disease is caused by *Aspergillus flavus* linkey and *A-fumigatus* Fres (Bailey).

**Symptoms**

Larvae turn into hard stone-like objects lying in open cells (Smith, Bailey and Morse). These fungi can also infect and kill other insects and some-time cause respiratory diseases in animals particularly man and birds (Bailey, Shimanuki and Knox).

**Treatment**

Combs and equipment can be disinfected by exposure to formaldehyde gas (Smith).

**Protozoan Disease**
Nozema Disease

The protozoan *Nozema apis* Zander causes Nozema disease in adult honey bees (Smith, 1961; Bailey, 1963). *Nozema apis* spores are large, oval bodies, 4-6 μM long x 4.2 μM wide. The spore develops excessively within the epithelial cells of the ventricular of the adult honeybee.

The queen bee may be infected with Nozema, in this case the ovaries soon degenerate, and the result may be either queenless colony or superseding. Nozema can infect drones but they are not an important factor in the cause of the disease or its effects upon the colony (Anonymous, 1971).

Symptoms

Smith (1961) reported that the symptoms of Nozema are dysentery within the hive during winter, dwindling or failure to build up as rapidly as other colonies, dead bees on the ground in front of the hive, bees standing or lying about outside the hive with trembling legs or wings.

Distribution

Bailey (1963) stated that *Nozema* infection among bees seems universal: it was well known in Europe Asia, Africa, Australasian and North America.

Viral Diseases

Sac brood:

The larvae die after becoming fully grown and the cells sealed. They becoming sack like with tough skin filled with a watery granules fluid, later they dry into loose scales. It is rarely dangerous and usually passes away without treatment (Smith, 1961, Bailey, 1963, Morse, 1978).
**Distribution**

Bailey (1979) mentioned different countries from where Sac brood has been reported; Swizerland, Germany, New Zealand, Australia, British, Hawaii, Italy and Romania, in addition to other countries under diagnosis.

**1.4.1. Chronic Bee Paralysis**

Shimanuki and Knox (2002) reported that adult bees affected by chronic bee paralysis are usually found on the top bars of the combs. They appeared to tremble uncontrollably and were unable to fly. In several cases, large numbers of bees were found crawling out of the hive entrance. Individual bees were black, hairless, and shiny.

**1.4.2. Acute paralysis bee virus and Kashmir virus:**

Acute paralysis bee virus (APBV) and Kashmir bee virus (KBV) are two sertogially related viruses, and the antiserum produced from one virus will cross-react with the other virus/ (Hung et al., 1991). These viruses commonly occur in apparently healthy adult bees. No specific gross symptoms have been attributed to either virus. Whereas APBV was a disease of adult, KBV was reported to cause mortality in brood and adult honeybees (Shimanuki and Knox 2002).

**1.5. Noninfectious Diseases:**

If foul brood and sacbrood were ruled out by the absence of bacteria or typical signs, then Neglected brood, chilled brood, starved brood, overheating, genetic lethality or poisoning might be suspected Bailey (1979).

In neglected brood the larvae may suffer and die of chilling overheating, or starvation, as a result of shortage of nurse bees, which feel and protect the brood. Chilled brood usually occurs in early spring when brood nest expand rapidly, there is shortage of adult bees to cover all the brood from the cold Tucker (1971). Chilled
larvae are often yellowish, tinged with block on segmental margins. They might also be brownish or black crumbly, pasty, or watery. In extreme cases, brood cells were punctured and uncapped, and pupae were decapitated by the adult bees or wax moth (Shimanuki and Knox, 2002).

Starved brood occurred normally when there is shortage of food and shortage of adult bees to feed the larvae. The most striking feature of starved brood was larvae crawling out of the brood cells in search of food. Emerging adult bees might starve if they were stressed as pupae by chilling or overheating or absence of nurse bees to feed them soon after they have cleared through their cappings. In those cases emerging bees died with only their heads out of the cells and their tongues extend.

The overheating of brood develops when there was a sudden loss of worker bees to cool the colony during hot weather. Larvae died from overheating became brownish or black and watery; pupae have a black greasy appearance. Newly emerged adult bees might be wingless. Cappings of brood cells can appear melted, sunken, and punctured. Worker bees can overheat if they were confined in their hives during hot weather without proper ventilation or access to water. Adult bees dying from overheating crawl out rapidly while fanning their wings. They were after wet, and their wings appeared hazy.

Bees can also died from genetic lethality during all stages. Drone brood from laying workers and drone laying-queen often die with symptoms resembling EFB (Bailey, 1977, Shimanuki and Knox, 2002).

The effects of plant poisoning are usually more gradual and last longer than the effects of pesticide poisoning. Plant poisoning occurs in the same geographical area at the same time each year, whereas pesticide poisoning is indiscriminate. The most
apparent indication of serious pesticide poisoning is the sudden loss of adult bees. This loss is characterized by the appearance of many dead and dying adult bees and some time pupae at the colony entrances. Bees may lose in the field before returning to the colony. If poisoned bees return back, the nurse bees, will die from feeding on contaminated honey or pollen. The symptoms of poisoned honeybees often depend on class of pesticide involved (Shimanuki and Knox, 2002).

In California Solanum magram L. Aesculus californica Nutt, Zygadenus uenesosus (S. wats), Cuscuta spp., Cyrilla vacemifora L., Kolamia Latifolia L., Veratrum californicum Durand and Gelsemium semperuirens Ait are suspected to be poisonous plant to bees (Smith 1969). Barker (1969) listed Nicotinana tabacum as a poisoning plant. He stated that Nicotiana tabacum contains insecticides nicotine, nomicotine, and anabasine.

\[\text{Parasitic Mites of honeybees}\]

\[\text{Varroa jacobsoni}\]

According to Koeniger, (1994) the honey bee species were found to be associated with six mites; Apis mellifera is prasitized by Acarapis woodi (Rennie) mite, Apis cerana is natural host to Varroa jacobsoni (Oudemans ) mite, Apis dorsata and Apis dorsata labrosia are both hosts to Tropilaelaps clereae and Tropilaelaps koerigenum mites, Apis florae is a host to Euvarroa sinhai mite and Varroa under woodi is associated with both Apis cerana and Apis koschevnikovi.

The mite Varroa jacobsoni can be found on adult bees, on the brood, and hive debris. The female mite is oval and flat about 1.1 mm long x 1.5 mm wide and pale to reddish brown; it can easily be seen with unaided eye because the mites attach to the adult bee between the abdominal segments or between body regions (head, Thorax and abdomen). Male
mites are considerably smaller, and pale to light tan (Delefindo Baker 1984).

De long et al. (1984) reported that in the heavy infestation with Varroa jacobsoni, pupae may not develop into adult bees, emerging bee may have shortened abdomens, misshapen wings, and deformed legs and may weight less than healthy bees. The external parasitic mites (Varroa) of honeybees were a major plague of honeybees. Colonies die within a few months of infestation unless beekeepers vigilantly apply costly acaricide treatment (Thomas 1998).

**Distribution**

Varroa jacobsoni was discovered in 1941 in the eastern honeybee Apis Cerana, is now one of the most destructive pests of extensive colony mortality due to Varroa in Europe, the new East and South America (Ramirez, and Otis 1987).

The first record of Varroa in western honey bee was in China 1980. Flowed by U.S 1984, Japan 1985, and then spread to all Asian countries. Introduced to Argentina from Japan in 1981, and from Argentine spread to all South America countries. In 1987 it was discovered in U.S.A (Abuzid, 1990). All Arabic countries were infested with Varroa except Sudan (Anonymous 1990). The investigation curried by Mogga (1990) showed that no parasitic mites were found in both Apis mellifera and Apis florea in Sudan.

**The life cycle of Varroa jacobsoni**

The life cycle of Varroa jacobsoni was divided into five phases; phase I: postmating; feeding on adult bees (drone or workers). Phase II: searching for brood cell of the correct stage: penetration into larval food and in activation (Duration from days 7-9 of immature bee development). Phase III: reactivation and feeding on bee larvae, prepupae, and/or pupae, vitellogenesis and laying of the first two eggs. (Duration: from 9-10 hours
after engorging of larva and cell capping). Phase IV; feeding on pupae; vitellogenesis and laying of the other eggs. (Duration: from ⁹·₀ hours after cell capping until emergence of adult bee). Phase V: Maturations and mating (Duration from ⁹·₀ – ⁷·₄ hours after cell capping to emergence of adult worker bee) (Ramirez and Otis ¹⁹⁸¹).

۷، ۷. Acarapis woodi

Morse (¹⁹⁸¹) stated that the cause of acarine disease was described as Tarsonemus woodi Rennie in ¹⁹⁴¹ and the generic designation was changed by Hirrst to Acarapis in ¹⁹⁸¹. Bailey (¹⁹⁸¹) stated that Acarapis woodi (Rennie) completed its life cycle within the prothoracic tracheae of honeybee. All stages, eggs, larvae, nymphs, and adults of Acarapis woodi may found in tracheae at one time; apparently the mites breed through the year (Rennie et al ¹⁹⁸¹).

Shimanuki and Knox (²⁰⁰²) stated that three Acarapis species were associated with adult honeybees: Acarapis woodi, A. externus, and A. dorsali. Only Acarapis woodi was known to be harmful. The other Acarapis are external Acarin mite and they are wide spread and exist everywhere Apis mellifera kept, and they do not appear to pose any serious threat to bees (Morse ¹⁹⁸¹).

۷، ۷، ۷. Euvarroa sinhai and Tropilaelaps clereae

Morse (¹⁹⁸¹) reported that Euvarroa sinhai Delfinado- Baker was first described in samples collected from India ¹⁹⁹⁴. Akratanakul (¹⁹⁹⁵) found that the life cycle of Varroa jacobsoni Oudemans and Euvarroa sinhai Delfinado-Baker were "bionomically similar". Tropilaelaps clereae Delfinado-Baker was first described in ¹⁹⁸¹ from specimen taken in the Philippines (Morse ¹⁹⁸¹).

۷، ۷. Hygienic behaviour
The best-known example of disease resistance in honeybees was the hygienic behaviour. Apparently, there were two independent behaviour all activities: uncapping cells and removing diseased larvae from uncapping cells. Hygienic behaviour has also been shown to be an effective behavioural mechanism against Chalkbrood disease and infestation of Varroa. Over the next 10 years, they successfully selected resistant stock. The percentage of AFB inoculated colonies that become diseased dropped from 90% to 10% at the end of 5 years and to 7% to the end of 10 years (George 2002).

Bees demonstrate "hygienic behavior if they characterized by the following: nest cleaning activities include cleaning cells in preparation for egg deposition and keeping the nest free from debris and disease, as well as removing dead brood and even healthy brood when there was a dearth of nectar or when the colony can no longer take care of the brood, and coating interior hive parts and the entrance with propolis (George 2002). Floures et al. (2001) found that a positive correlation was found in hygienic behaviour towards cells artificially infested with 1 or 2 mites, Labb and Martin (1997) reported that a strong correlation was found between the number of fallen mites (V. jacobsoni) and the emergence of worker and drone honey bees from sealed brood, about 90% of the dead fallen mites had died within the sealed cells and the other died shortly after bee emergence. Shanng et al. (2002) reported that V. jacobsoni mite hive-population has positive relation with the hygienic behaviour of bees. Boeking et al. (2002) and Spirak and Downley (1998) demonstrated that honeybee (Apis mellifera) hygienic behaviour was a mechanism of disease resistance and mode of defense against the parasitic mite Varroa jacobsoni.

Palacio et al. (2002) stated that colonies that removed >9.5 of dead brood after 72 h were selected for queen and drone production and new
colonies were evaluated for hygienic behaviour and they found that the hygienic colonies had a lower frequency of brood diseases when compared to non hygienic colonies. However, colonies, which consistently uncapped, and removal freeze killed brood with \( h \) were demonstrated as hygienic colonies (Spivak and Downely 1991). In comparative study between hygienic colonies and non hygienic colonies, Spivak and Reuter, (1991) found that the hygienic colonies removed significantly more freeze-killed brood than commercial colonies, moreover has significantly less Chalkbrood, had no AFB, and produced significantly more honey than the commercial colonies, and had fewer mites and adult bees than the commercial colonies.

\section*{Insects}
\subsection*{Moths}

Among the moths there are two classes of pests, the robbers and the breeders. Most notable among the robber is death's hawk moth, \textit{Acherontia atropos} common in Africa, \textit{Acherontia styx} in India, and \textit{Acherontia} sp. in Indochina Smith (1943). The wax moths, \textit{Galleria mellonella} (L.), the greater wax moth, and \textit{Achroia grisella} (Fabr.), the lesser wax moth, and the Mediterranean flour moth, \textit{Anagusta kvehniella} are belong to the breeders and caused serious damage to honey combs (Smith 1984; Shimanuki and Knox 2000).

\textbf{Death head hawk moth:}

Smith (1943) stated that the hawk moth might be found on unguarded comb in week colonies, strong colonies threw them out in small pieces. The adult of hawk moth feed mainly on sap from tree wounds, they may resort to robbing nectar from the hives of honeybees (Brugger, 1943) In Sudan the hawk moth was listed as pest of honey bees
in South Sudan (Marshall 1955), Two species of *Acherontia* were exist in Sudan; *Acherontia styx* and *Acherontia atropos* (Ahmed 2002). Singh (1964) reported that several caterpillars of other moths were noticed in comb, but their damage was occasional and rarely occur in India, among them were; *Ephistia Kuhruella* (zell.); *E. cutella* (walk); the Indian meal moth, *pladia interpunctela* (Hbn.) the dried fruit moths, *Vitula serratilineella* (Rag.) and moth from bumble bee nests, *Aphomia sociella* (L.)

**Greater wax moth**

The greater wax moth, *Galleria mellonella* Lis the most serious pest of honeycombs. It is an especially serious problem in tropical and sub tropical climates, where worm temperature favors their rapid development. The larvae are the destructive stage. They obtain nutrients from honey, cast of pupal skins, pollen, and other impurities found in bees wax, but not from the bee wax itself. Older combs are more likely to be damaged than new comb or foundation (Shimanuki and Knox 2002).

Losses of wax moth in three main beekeeping stats in South America average nearly $1,000 per colony in California, $1,500 per colony in Texas, and $3,000 per colony in Florida. Losses due to wax moth damage equal or exceeded the losses of American foul brood (five million dollar or more) in USA (Williams 1974).

**Lesser wax moth**

The lesser wax moth *Achroia grisella* is less frequently reported but it was reported in central and South Africa, India, South America, the west India and Hawaii (Smith, 1966). Hassaein *et al.* (1992) reported that summer weather was favourable season for growth and reproduction of lesser wax moth in Egypt and winter was least; however, reproduction continued through out the year.
Control measures for wax moths

Various insecticidal fumigants, paradichlorobenzen (PDB) ethylene dibromide, carbon dioxide have been used in different countries to protect honeybee products, especially combs, from wax moth. Only carbon dioxide treatment was recommended to be used for honeycombs intended for human consumption (Morse and Shimanuki 1978).

*Galleria spp* are the natural host for certain bacteria, viruses, protozoa, nematodes, and insects. Ali *et al.* (1993a) stated that the third, fifth and seventh instars of *Galleria mellonella* were found susceptible to *Bacillus thuringiensis*. Adult honey bees were not affected by the dosage with satisfactory controlled *G. mellonella* larvae that thricide was effective at low concentrations (\(7^\circ\times10^\circ\) viable spores wax comb). *Bacillus thuringiensis* also protected combs, and remained viable for 18 months (Ali *et al.* 1993b).

Singh (1984) reported that the greater wax moth larvae and other larvae of wax moth are parasitised by braconid, *Apanteles galleria*.

Ebadi *et al.* (1994) reported that the greater wax moth females were not able to reproduce through parthenogenesis there was no significant difference between the chemical and mal-sterile methods for the control of this pest. He also showed that the best dosage to sterilized male pupa of the greater wax moth was 360 grays of gamma radiation. The best release ratio was four sterile male, one normal male, for each normal female (4:1).

Heat can be used to kill all stages of wax moth. At 85°C (185°F) an exposure time of 83 minutes was sufficient; but when this was increased to 85°C Celsius (185°F Fahrenheit), only 8 minutes of exposure was required. On the other hand low temperatures also been used to kill wax moth on combs containing honey and pollen.
At \(27^\circ\) Celsius (\(80^\circ\) Fahrenheit), 4 and half hours were required to kill all stages (Morse and Shimanuki, 1981).

According to Williams (1981) the only means of reducing wax moth losses are the management procedures below:

1. Maintain vigorous colonies with adequate food stores.
2. Control diseases and pest that might substantially weaken colonies.
3. Remove wax and debris from the bottom board of the hive at least once a year.
4. Replace stock if it is unusually susceptible to wax moth attack.
5. Avoid pesticide poisoning of colonies where possible.

**Wasps**

The yellow banded brown wasp *Vespa orientalis* (L.); yellow-banded wasp *V. cineto* (F.); golden wasp *V. urarian* (Smith), *V. duealis* (Smith); and large black wasp-*V. magnifica* (Smith) and *V. bosalis* (Smith), were reported by Singh (1981) as pests of honey bees in India. *Palarus orientalis* was reported in South Indica (Smith 1961).

**Palarus latifrons**

According to Smith (1961) *Palarus latifrons* wasp is very common in central Africa and also known in South Africa. If numerous, this wasp can demoralize a colony to extent of causing the bees to cease foraging stinging them and carrying them off to their nests as food for their larvae.

**Philanthus triangulum**

*Philanthus* spp. was also reported in Sudan (Mohamed 1981 and Abdalla 1981). The *Philanthus* spp. belongs to tribe of digger wasp, which in German is called a Bienen-wolf or bee wolf because of their veracious appetite for bees. It inserts their sting into their victim’s throat;
or alternatively into the soft joint between the prothorax and meso thorax. The female wasp claps that part of the bee’s abdomen, which contains the honey-bag, squeezes out the nectar it contains through its moth part, and consumes it. Then carrying the bee to a hole in the sand soil from where a sloping shaft leads into abroad chamber prepared earlier for this purpose. The chamber may contain 3-4 bees, the wasp deposit one single egg on the body of one of the bees. As soon as the larva has hatched from its egg, it starts devouring, one by one, all the bees that has been put, after growing to its full size It pupates in side the brooding chamber, to emerge from it in the flowing summer A survey in burrows made within an area of 150 by 100 yards nearly two million bees had fallen victim to the Philanthus wasps in single year, that is to say the equivalent of entire population of about fifty colonies of bees (Frisch 1954).

*Vespa orientalis*

Abu Lila, (1966) stated that *Vespa orientalis* was a serious pest of honeybees in Egypt. It hindered the spread of beekeeping in Egypt (Wafa, 1966).

**Control of wasp**

Singh, (1966) reported that best method to control wasps was to kill the fecundated females early in the spring. An earnest should also be used to kill them at hive entrances or destroy their nests by burning them with kerosene torches, fumigation with calcium cyanide, by spraying 5 percent benzene hexachlorid or by blowing 1 percent DDT dust. Bait made from poisoning meat, fish or fermented sugar or honey put in specific wooden or metal trap was used to control *Vespa orientalis* in Egypt (Abu Lila 1966).

§, 8, §. **Beetles**
Many beetles have been described as pests of honeybees. Most are not serious pests, however, and many inhabit only weak hives, the debris area of hives, or combs in storage (Caron 1981). Smith (1961) listed hive beetles found in Africa: *Hyplostoma fuligineus*, *Diplognatha gagates*, *Coenochilus bicolor* and *Rhizoplatys trituberculatus*, *Plotyholium alivearium*, *Dermestes vulpinus* and *Aethina tumida*. The large hive beetle *Hyplostoma fuligineus* and the small hive beetle *Aethina tumida* were nuisance, particularly in weak colonies. Ibrahim (1927) reported that eight species of beetle identified in pollen grain traps, the most common were *Tribolium castanium* and *Tribolium confusum*.

1. The small hive beetle (SHB) *Aethina tumida*

   The small hive beetle was first identified in 1981; Lundie first reported its biology in South Africa in 1981. It was called the small hive beetle to distinguish it from the larger one *Hyplostoma fuligineus*, which was also found frequently in bee colonies in South Africa (Mostafa 1992).

   It is believed that the small hive beetle have originated in South Africa (Brown *et al.* 2004 and Headings and Colon 2000). Since the discovery of the SHB it spreaded and it is now believed to range through the African continent. Headings and Colon (2000) stated that the newest threat to the beekeeping industry in the western Hemisphere in Florida USA was the small hive beetle, *Aethina tumida* (family Nitidulidae, commonly known as sap beetles). It was estimated that this beetle destroyed thousands of colonies in USA (Mostafa and Williams 2001). It was found to be a pest of European honeybee in Uganda Roberts (1991). Recently it was also reported in Ethiopia, Kenya, Zimbabwe and Egypt, Appendix (2004) (Mostafa and Williams 2004).
The small hive beetle (SHB) may spread through package bees, migratory beekeeping, empty beekeeping equipment, fruit, importation of soil and vegetables, and queen’s importation (Brown, et al. 2002).

Adults are broad, flattened beetles about 0.75 mm (¼ inch) long, 2.3 mm wide and dark brown to nearly black in color. Adults are red just after pupation and soon thereafter become blackish. They move rapidly across comb and are difficult to pick up. The larvae are elongate, whitish grubs with rows of small spines along the back. Larvae look superficially like wax moth larvae, but the legs of beetle larvae are larger, more pronounced, and restricted to near the head. Beetle larvae do not spin webs or cocoons in the bee hive but rather pupate in the soil outside the hive. Pupae are whitish brown (Delaplane 2002). Adult female beetles were significantly longer than males. Overall means did not differ from width between sexes. Due to small variation in width between sexes, width may be an important factor when designing exclusion or trapping devices for SHB. Overall female beetles weighed significantly more than males. There tended to be more females than males at each location (Ellis et al. 2002). Brown et al. (2002) identified the same species in both Africa and America continents.

According to Brown et al (2002) the life cycle of small live beetle can be summarized as follow: the females lay eggs in empty cells and in small cracks and carves. The larvae hatch in 1 – 5 days, with most hatching in 2 – 3 days, and feed on sealed and unsealed brood, pollen and honey. Mature larval mass in the corner of the frames and on the hive floor-brood, after 10 – 15 days they move out of the hive and pupate in the soil for 3 – 4 weeks. Newly emerged adults were mate and invade hives. The adult females reaching maturity about one week after emergence. Five generations can be produced per year.
In Africa the main problems associated with beetles one in destruction of stored comb, and beekeeping extract honey within 1–3 days before returning the combs to the colonies. In the cape, only severely weakened colonies affected by *Aethina tumida*. The beetle became a problem when moved to European honeybee, *Apis mellifera*, which showed fewer defenses against the beetle (Elzen *et al.* 2002). The adult beetle itself had little impaction the colony as it is the larvae that do the damage weakened and stressed colonies succumb within two weeks (Wenning 2002). Moreover the SHB have been implicated not only in colony mortality but increased absconding rate (Hood 2002, and Shimanuki and Knox, 2002), damaged honey and causing it to drip from comb, and discolored and fermented it (Shimanuki and Knox 2002).

According to Mostafa and Williams (2002) three major techniques for controlling the small hive beetle were used in its place of origin, South Africa, where it is considered as a secondary or moderate pest, and in its new habitat in the USA where it is causing considerable damage. These techniques are: fumigate wax frames, combs and supers in storage to kill any hidden stage of the beetle. Treatment of soil under and around hives with some type of chemical soil drench to kill the larvae, pre-pupae, pupae or newly emerged adults. Using of some safe and slow released pesticides (specially in a formula of plastic strips) to control adults and larvae in colonies.

### 4.8.2. Ants

Various species of black ants visit bee colonies and take away honey, brood, pollen, dead bodies and other debris (Singh 1962). Smith (1962) reported that the most dangerous ants in Africa are safari or driver ants, which can overwhelm any colony by sheer weigh of numbers. The following species of ants were reported as a pests of honey bee colonies; *pheidole megacephola* in Hawai, *Iridomyrmen humilis* in
Hawai, America and Africa. *Componotus comperssus* and *Doylus orientalis* in India and *Monomorium pharaonis, Oecophylla Smargina, Grematogaster dohrui, Prenolepis virdula* and *Dicamma vugosum* in south east Asia (Smith ٠٦٩١)

De Jong (٨٧٩١) stated that ant predation of honey bee colonies can be a serious problem, especially from the ants belonging to Dorylinae and Ecitoninae which include Army ant that found in tropical and worm temperate climate. The Argentine ant, *Iridannagrex humilis* Moyr, was a serious pest of honeybees, whenever was found; the ants were capable of destroying strong colonies. The wood ant (*Formica vufa* L.) attacked and destroyed some colonies placed near its nest. The species of *componatus* (Carpenter ant) attacked beehives occasionally, they damaged the wood of hive, week hives and super emptied by a bee scape were subject to robbing by *componotus*, and stored comb honey were also be damaged.

Ant can be controlled by different methods; spreading of fresh wood ash round the hives it was very effective in discouraging ants, legs stood in tin of oil, stick banding grease round the leg, preventing weeds and grass from growing under the hives and blowlamp was very effective in controlling safari ant (Smith ٦٩٦٧). Moreover, fumigating ants nest by carbon disulphide (٢٤ table spoons) or pouring ٠٥٫٢ gallons of ٪٢٫٠ BHC suspension or ٪١٫٠ Aldrin emulsion and sealing them with mud were very effective methods (Singh ٦٩٦٧).

٦٩٦٧. *Other insect*

**Dragonfly**

Morse (٨٩٦٧) listed dragonflies as one of the problems hinder queen breeding in Florida. He stated that dragonfly often feed while flying and usually consume part of the thorax only, allowing other part to fall on the ground. Caron (٨٩٦٧) stated that the best solution to protect bees or queen from dragon fly predation was to move the bee colonies to
avoid queen or worker loss, strength of colonies were able to tolerate loss of some workers, and good management by beekeeper.

**Fly (Braula spp)**

Morse (1991) listed a small wingless fly (*Braula spp*) as a pest of queen. He stated that the flies did not feed on the queen but it might hinder the queen' movement and egg laying when they were present in large numbers. The larvae burrow in the capping of the honeycomb and can make comb honey unmarketable (Smith 1991).

**Stingless bees**

Stingless bees were reported as a pest of honeybees in Bolivia (Shideler 1991). Kempff Mercado (1991) reported that two cases of robbing and destruction on *Apis mellifera* colonies were done by meliponins (stingless bees) (*Melipona floripenis*, and other).

**Apis (Honey bees)**

Interspecific aggression (Robbing) occurs “among” *Apis*, presumably among all species; this type of aggression may result in the spread of certain diseases. In Sudan *A. florea*, which was introduced in 1985 (Mogga 1988; Lord and Nagi 1987), had been seen successfully entering *A. mellifera* colonies. There was also a lot of body or floral contacts between the forager of these bee species to facilitate interspecific organism exchanges (Mogga 1992).

**Earwig, Mantis, Silverfish, and Cockroach**

Caron (1998) stated that earwig, mantis, silverfish, and cockroaches were listed as pests of honeybees by some authors.

**White ants (Termites)**

Adomson (1993) listed three termite species as pests for beekeeping industry on the Caribbean Island of Trinidad: *Heterotermes tenuis* (Hagen), *Nasutitermes costalis* (Emerson), and *Microcerotermes arboeus* (Hplmgren). He also stated that they attacked the wooden hives.
stands and he recommended placing colonies on metal stands or poisoning the termites with one of the arsenicals insecticides. Singh (2691) suggested that soaking all wooden boxes and bottoms with pentachlorophenol, coating the termite galleries with coal tar or spraying an insecticide on their mounds could control the termite.

**4. Birds**

Ambrose (9791) stated that the role of birds as predators of honeybees and pests to beekeepers had a long and varied history.

**4.1. Meropidae (Bee-eaters)**

Frey (9691) stated that all 11 African species of Merops were studied. Honeybees formed \( \frac{4}{9} \) of the prey of at least six species. In Iran Bee-eater considered one of the problems for Beekeeping. A flock of birds could kill every foraging honeybee, and colony activity was reduced when predators were near the hive (Esmaili 9794). Ambrose (9791) stated that, since bee eaters were migratory species they might prey on bees in an apiary for a period of time and then move on to another locality. Jenn (9793) reported that *Merops apiaster* was a serious pest of honeybees in Algeria.

Gossma (9991), Nagi (9991) and Abdalla (9991) reported bee-eaters as a pest of honeybees in Sudan. Mohamed, (9991) reported that the bee-eater was found all year in Sudan. However Abdalla (9995) stated that bee-eater was found in the Sudan from May to November. Nagi, (9941) listed bee-eater one of the factors that influence queen rearing in Sudan. Al-Gamdi, (9991) listed *Merops Apiaster* and *Merops Orientalis* as dangerous pests of honeybee colonies in Saudia Arabia. According to ANONYMOUS (9995) birds were appeared as a pest of honeybees in all Arab countries. In Egypt two species of bee-eater were existed, European bee-eater and Iraq bee-eater. The European bee-eater was the dangerous one; it was abundant during March, April and August,
September and it was found causing a big damage to bee colonies Abu Lila (١٩٩٧). Abdalla (١٩٨٨) reported that the European bee-eater *Merops spp* appeared in large flocks in the Sudan particularly during May – July and attacked the bee even during routine manipulation of honeybee colonies.

٢٫٣. **Distribution and identification of bee-eater in Sudan**

**European bee-eater *Merops apiaster* (Linnaeus)**

The European Bee-eater *Merops apiaster* was about ١١ in, ٧٨ cm, long. It had yellowish- chestnut upper parts, darker on the crown; forehead; white; throat yellow bordered black; breast and belly greenish-blue (Williams and Arlott, ١٩٨٩).

This bee-eater is common in open bush savanna, woodland, cultivations, land form large numbers on autumn and spring migration especially in north (Nikolaus ١٩٨٧).

**Carmine bee-eater *Merops nubicus* (Gmelin)**

It was about ٦٣ – ٧٨ cm. long. It’s central tail feathers very elongated, head and throat dark greenish-blue and wings and tail deep carmine red. This bee-eater was found gregarious in large flocks, especially at roosts and also breeding in large colonies (Williams And Arlott, ١٩٨٩).

It was common, locally very common bush and grassland, open woodland, most birds moving to the north during the rainy season, brooding in large colonies mostly near rivers, present throughout the year, local migrant and also African migrant (Nikolaus ١٩٨٧).

**Little bee-eater *Merops pusillus* (Muller)**

It was about ٧٥ cm. long. It’s central tail feather not elongated, and tail square. This bee-eater was very small green with yellow throat, blue-black neck patch and a conspicuous black eye stripe (Williams and Arlott ١٩٨٩).
All the *Merops pusillus* sub species inhabiting open bushed-grass land (Nikolaus 1989).

**Little green bee-eater *Merops orientalis* (Lathan)**

It was about 32 cm, long. It had golden-green with greatly elongated central tail feathers; black stripe (William and Arlott, 1989).

It was common in the north and fairly common in the south inhabiting open country with tress and bushes on sandy soil, resident (present throughout the year) local migrant (Nikolaus 1989).

**White-throated bee-eater *Merops albicollis* (Vieillot)**

It was about 82 cm. long. Its central tail feathers extremely long and slender, projecting four in, 5 cm, beyond others. Upper parts pale green, merging to blue on rump; crown blackish, forehead and eye-streak white; below, chin white, followed by abroad black band across throat; breast and flanks pale green to white on abdomen. In flight wings appear pale cinnamon. Its very lone central feather, black throat band and cinnamon wings are good field characters (William and Arlott, 1989).

It was very common in north frequenting open *Acacia*, savanna, fairly woodland and forest edges and moving north to breed during the rainy season (Nikolaus 1989).

**Red-throated bee-eater *Merops bulocki* (Vieillot)**

It was about 91 cm. and had Square-tailed bee-eater with a deep chestnut back; crown and nap ultramarine blue merging to cobalt blue and white on forehead; chin with bright scarlet streaks lower throat blue-black to deep blue on rest of underpants and tail (Williams and Arlott, 1989).

It was fairly common inhabiting broad-leaved tree savanna breeding in hive banks (Nikolaus, 1989).

**Blue-cheeked bee-eater *Merops persicus* (Palls)**

It was about 7 cm. it was bright green with long central tail feather; top of head green with a bullish wash; forehead and checks, a
above and below black eye streak, blue, chin yellow to chestnut on throat (Williams and Arlott 1989). The subspecies *M. p. persicus* was common on passage any bush and wood land, in the north only on passage wintering in south while the subspecies *M. p. chrysocercus* breeding at Dongola and at Old Dongola (Nicilaus 1989).

**Cinnamon chested bee-eater Merops oreobates (Sharpe)**

It had deep cinnamon chest and belly (Williams and Arlott 1989) inhabiting forest edges, clearing and cultivations above 1000 m, (Nikolaus 1989).

**Swallow-tailed bee-eater Merops hirundineus (Lichtenstein)**

It’s tail deeply forked; throat yellow (Williams and Arlott 1989). It was locally fairly common inhabiting better-wooded tall grassland (Nikolaus 1989).

**Madagascar bee-eater Merops superciliosus (Linnaeus)**

It had long central tail feather and white throat (Williams and Arlott 1989). It was uncommon to rare. Inhabiting dry *Acacia* bush land it was recorded only from south of Juba (Nikolaus 1989).

**Blue – breasted bee – eater Merops variegatus (Vieillot)**

It had deep cinnamon chest and belly (Williams and Arlott 1989) fairly common inhabiting humid grassy savanna. It only reared from Boma. The subspecies loring might occur in the Diding amounts (Nikolaus 1989).

**Ground hornbill Bucorvus abyssinicus**

The Ground hornbill *Bucorvus abyssinicus* was about 170 cm. It distinguished by its curious casque, which is truncated and open in front. Bare skin of face and neck mainly blue grey or red and grey. A local species found in southern Sudan, Ethiopia, northern Somalia, northern Kenya and northern Uganda (Williams and Arlott 1989).

**Indicatoridae (Honey guides)**
Friedmann (1964) reported that nine of eleven species of honey guide were reported in central and south Africa. The greater honey guide was among them. Of the eleven species of honey guide only two have actually been observed exhibiting the guiding behaviour, indicator and indicator variegates (Ambrose 1981). The name of this bird family is based on the symbiotic relationship that two of the species have developed with certain mammals (man; ratels or honey badgers, Mellivora capensis, and possibly baboons, Papio spcies), which involves leading the mammalian symbiotic to the nest of bees. This guiding "habit" is the basis of the common name, of the family, honey guides, and the technical name Indicatoridae, (Friedmann 1964 and Ambrose 1981). Seven species of honey guides were encountered in Sudan (Nikolaus 1987).

\textbf{7.4.5. Other birds}

Ambrose (1981) listed four families of birds in addition to the previous families as a pest of honeybees: Bicidae (wood peekers), laniidae (shrikes), Apdidae (swifits), tyrannidae (Tyrant-fly catchers).

\textbf{7.1.1. Mammals}

\textbf{Man}

Caron (1981) reported that human was one mammal pest of honeybee, which seems to be becoming more and more of a problem. Botha (1974) listed human as first animal pests of bees in South Africa.

\textbf{Honey badger}

Several member of the weasel family, Mustelidae were occasional honeybee pests. Honey badger was the well-known honeybee pest. It was native to tropical Asia and Africa and was once common in India and much of Africa Caron (1981). The other names of honey badger were in French Ratel, in English Honey badger, in Germany Honigdachs, in Swah, Nyegere, (Kingdon 1974) and in Arabic Therban (Ahmed 1981).
Ahmed (١٠٠٢) and Kingdom (١٠٠٢) reported that the honey badgers were short-legged and have a short tail and powerful front claws. They were whitish above and black below. They were nocturnal, resting during the day in burrows that they dig with front claws, they were able to locate the bee' nests by smell and were well-known follow honey guide birds. They were opportunistic omnivores, specializing in the excavation of social insect, mice, trapdoor spider, They also caught surplus food including honey combs and their thick skin and stink gland help to protect them from stings.

Smith (٣٥٩١) and Botha (١٩٩١) called the ratel a fierce animal. And they stated that its behavior was devastating to wild nests and to both native and langstroth frame hive. Beekeeper encounters with it in the bee yard could be dangerous as the animal would attack with its powerful front claws the ratel could push heavy hives from their stands and will even smash lumber up to two centimeters thick. It usually carries combs away from the hive before consuming them to escape the wrath of stinging bees.

Smith (١٩٩٢) found that beekeepers in Africa hanging their hives in trees to protect against pests such as the honey badger (and baboons). Caron (١٩٧٨) said that other beekeeper surrounding their apiaries with a fence of wire netting buried٠٣ centimeters deep and any led outward and the other African beekeepers keep bee colonies in the European style by placing them in strongly built bee houses.

**Squirrels**

Smith (١٩٩٢) listed squirrels as occasional pests in the tropics and Park (١٩٣٠) listed them as a pest in North America.

**Baboon (Papio ursinus)**

Caron (١٩٧٨) mentioned that three primates, monkeys baboon and chimpanzees, had been referenced as pests of honeybees. Botha (١٩٩٢)
stated that baboons would usually not tamper with well-constructed hives because of the stings they receive. However, they did raid and break up boxes sited out for trapping bee swarms. Baboons might tip colonies over repeatedly until the combs and frames came apart, and they frequently carried the frames away from the bee yard to consume the honey.

**Large livestock**

Stanger *et al.* (1991) stated that livestock caused damage to bee colonies by toppling hives. Some animal would scratch to remove flies or pests or became skittish around buzzing insects and as a result may upset bee colonies. They stated that to protect against these possibilities, colonies should be maintained outside areas of large livestock or the apiary site should be fenced.

**Chapter 3**

**Materials and Methods**

**3.1. Sampling techniques**

Numbers of about eight locations were surveyed for the pests and diseases of honeybees in Sudan (table 3.1). They were chosen according to their potentiality of beekeeping, involved different types of beekeeping industry and different hives (traditional hive, langstroth hive, wild nest). Cluster sampling was used as sampling design. At least four honeybee colonies’ were chosen randomly each apiary for pest and disease inspection and suitable sampling techniques were used for each diagnosis. Wild nests were inspected wherever it possible. Table (3.1) shows the number of inspected colonies (samples), which were chosen from every State.

**3.2. Diseases diagnosis**
Symptoms

Different bee colonies, kept in modern apiaries, traditional apiaries, and even wild colonies were inspected in different locations in Sudan. Symptoms of brood diseases (foulbrood, Stonebrood, Chalk brood and Sac brood) were observed. The suspected combs were removed from the hive, wrapped with newspaper and transferred to laboratory for further investigate.

Culture technique:

Capped and uncapped brood contained dead larvae were removed. Suitable media was used to isolate the organism. Biochemical tests were carried to identify the causal organisms of the disease according to techniques described by U.S.D.A. (1980), El-Sanousi et al. (1987) and Cowan and Steel’s (1993).

Table (T-1) Number of inspected colonies (samples), which were chosen from every State

<table>
<thead>
<tr>
<th>States</th>
<th>No. of apiaries</th>
<th>No .of wild colonies</th>
<th>No. of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum</td>
<td>3</td>
<td>11+45#</td>
<td>23+249*</td>
</tr>
<tr>
<td>Lat.41°-16°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log.31°-34°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kordofan</td>
<td>3</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Lat.9°-16°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long.27°-34°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darfur</td>
<td>6</td>
<td>1</td>
<td>39</td>
</tr>
<tr>
<td>Lat.9°-20°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long.21°-28°</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Blue Nile</td>
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<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Lat.9°-12°</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Long.33°-40°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kassala</td>
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<td></td>
<td>6</td>
</tr>
<tr>
<td>Lat.41°-17°</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lat.</td>
<td>Long.</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>---------------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Gezira</td>
<td>21° 00′ 15″ 50′</td>
<td>13° 00′ 45″ 30′</td>
<td>4</td>
</tr>
<tr>
<td>White Nile</td>
<td>21° 00′ 50″ 50′</td>
<td>31° 00′ 33″ 30′</td>
<td>4</td>
</tr>
<tr>
<td>River Nile</td>
<td>21° 00′ 22″ 00′</td>
<td>31° 00′ 30″ 30′</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>1° 26″ 117</td>
<td>6° 36″</td>
<td></td>
</tr>
</tbody>
</table>

# 20 colonies of *Apis florea*

- 344 (7 patches) colonies of Carnio- Egyptian honeybees imported from Egypt (Khartoum Air Port) + 62 colonies Carnio- Egyptian honeybees from River Nile State.

**Microscopic examination:**

This technique was used to diagnose bacterial, protozoan as well as acarin diseases.

1. **Bacterial diseases**

2. **Foul brood**

The dead larval remains on the suspected combs were subjected to the following:

a) **The rop test**

A matchstick was inserted into dead larval cells and slowly withdrawn, the remains were drawn out, and the consistency of dead brood were recorded, soft, becoming sticky to ropy is positive result of AFB and negative result of EFB.

b) **Microscopic examination**
The smear was dried and fixed under a heat lamp, or the smear was first air-dried and the head-fixed by passing it, smear side up, several times over a Bunsen burner flame. The fixed smear was stained with a suitable spore stain (Carbol fuchsin) for 15 seconds. Enough stain was placed on the slide to cover the entire smear. The excess stain was then washed off with distilled water. The smear was then allowed to dry in air. A drop of immersion oil was placed directly on the smear. No cover glass was used. The slide was examined by using oil immersion.

c) Detection of Paenibacillus larvae spores in hive products

Beeswax samples taken from imported nucleus of honeybee were melted in boiling water, Beeswax cake was removed after cooling, and water was centrifuged at 1000 G for 15 minutes. The sediment was then examined microscopically for the presence of spores. (U.S.D.A.

2.1. Identification of Serratia marcescens

2.1.1. Methods for bacterial isolation and Identification

Cappings containing dead brood were removed, placed in sterile containers and immediately transferred to the laboratory, where they were surface sterilized by dipping them in 70% (v/v) ethanol, allowed to dry and crushed between sterile slides. Larval contents were streaked on several freshly prepared 1% (v/v) sheep blood agar (2% w/v, nutrient agar, Difco) plates, which were incubated at 37 °C aerobically and examined at 48 h intervals for 7 days before being discarded as negatives. Direct smear prepared from dead larvae and from the growth obtained on blood agar were fixed and stained with Gram’s stain. Isolated organisms were subjected to biochemical tests at the Department of Microbiology, Faculty of Veterinary Science, Khartoum
University according to El-Sanousi et al. (1989) and Cowan and Steel’s (1993).

1. Biochemical test

Oxidase test

Using oxidase paper one colony was spreaded on it with platinum loop. Change of colour to violet within 10 seconds indicates positive reaction (Barrow and Feltham, 1993).

Catalase test

An isolated colony was emulsified in one drop of hydrogen peroxide on a slide. Positive reaction was indicated by gas bubbles (Barrow and Feltham, 1993).

Oxidation fermentation test

An isolated colony was inoculated in two containing O.F media using straight wire. One was tube cover with a layer of sterile paraffin oil. Two tubes were incubated at 37°C for 5 days. Change in colour in the two tubes indicates fermentation while change just in the open tube indicates oxidation (Barrow and Feltham, 1993).

Urease activity test

An isolated colony was inoculated in urea test media and incubated at 37°C for 5 days. Positive reaction was indicated by change in colour of medium to a pink (Barrow and Feltham, 1993).

Methyl red (MR)

The isolated bacteria were inoculated in tube of glucose phosphate media and incubated at 37°C for two days. One drop of
methyl red was added to tube for MR test. Positive reaction for MR test was indicated by change in colour (Barrow and Feltham, 1993).

**Citrate utilization test**

Simmon’s Citrate medium was inoculated by the organism and incubated at 37°C and examined daily up to 7 days. Change in color to blue indicates positive reactions (Barrow and Feltham, 1993).

**Indole production test**

The organism was inoculated in peptone water incubated for 48 hours 37°C. then 1 ml of Kovac’s reagent was added. A pink ring, layer within a minute, indicates Positive reaction.

**Motility test**

Tubes of motility medium were inoculated by stabbing to a depth of about 5 mm and incubated for 7 days at 37°C. motile organism migrate through medium which become turbid. Growth of non-motile organism would be confined to the stab inoculum.

**Antibiotic sensitivity test**

Sensitivity of isolates to a number of antibiotics was determined by the standard diffusion method (Buxton and Fraser, 1977). Plates of (DSTA) medium were dried in the incubator for 5 minutes. A plate was used for each isolate to test eight different antibiotics. Each isolate was incubated in test tube containing 1 ml nutrient broth, shaken thoroughly to obtain a homogenous suspension containing approximately \( \times 10^5 \) C.F.U./ml. Excess fluid was aspirated and the plate was again dried for 5 minutes. The plasmatic Lab. Products ltd disk contained the following antibiotics.

- Ampicillin (AMP) \( \times 1 \) ug
Chloramphenicol (CHL) 1 ug
Cloxaillin (CXC) ∈ ug
Erythromycin (ERY) ∈ ug
Gentamicin (GEN) 1 ug
Penicillin (PEN) 1 i.u
Streptomycin (STR) 1 ug
Tetracycline (TET) 1 ug

**3.4. Protozoan disease (Diagnose of Nosema Disease)**

For quick, routine examinations, the abdomens from 1 or more bees were removed, placed in a dish with ∈ ml water per bee abdomen, and ground with a pestle or rounded end of a clean test tube. A cleaner preparation was obtained by grinding digestive tracts removed from the abdomens.

A wet mount was prepared from the resulting suspension and examined under the high dry objective of a compound microscope. (U.S.D.A. 2002).

**3.5. Mites**

**3.5.1. Inspection of parasitic mites (Washing of adult bees)**

Adult *A. mellifera* bees were captured on the combs of colonies kept in Langstroth hives at the apiaries and traditional hives while those of *A. florea* and wild *A. mellifera* were captured from nests of mature *A. florea* and wild *A. mellifera* colonies wherever possible.

Each sample was shaken into polythene bag where the bees were allowed to die by suffocation these respective bee samples were treated
by placing them in plastic washing cup. Seventy percent alcohol (ethyl) was added to the cup (U.S.D.A).

The container was then shaken by hand continuously for one minute, then the cup was poured with the bees through wire mesh (screen \(3\times3\) mm) into another large cup. The solution left in the larger cup was poured through a white sheet of cloth. The cup was replaced and the bees rinsed twice, every time the solution was poured through same sheet of cloth, which was then left to dry.

The debris in this sheet of cloth was subsequently inspected for mite presence with the aid of a \(\times5.3\) magnifying lens. Before discarding, the bees so washed for each sample were counted. Any bee sample, which could not be treated immediately, was kept in freezer until the day of treatment. Values of mite infestation among adult bees are expressed as mean percentage, number of mites/bees \%; colonies infestation Value are given in number of infested colonies/number of inspected colonies\%.

**4.4. Inspection of capped brood cells of both *A. florea* and *A. mellifera***

Capped broad combs were removed from *A. florea* nests and *A. mellifera*. These brood combs were carefully uncapped at random (about \(100\) larvae and pupae from each drone and worker cells) and they were removed by dissecting pin. Then the walls, larvae and pupae were thoroughly examined for any mite presence using \(\times5.3\) magnifying lens. The cell walls were illuminated by small hand torch for clear inspection. The incidences of *Varroa* among adult, worker brood, and drone brood were recorded. Computer program Spss version \(9.0\) is used to analyze data of *Varroa* infestation among adults, workers brood and drone brood of honeybees as One-way ANOVA and LSD.
٣.٣.٣. Tobacco smoke detection technique

This technique described by Morse and hooper (٣٨٩١). We used it to detect mites only in imported honeybees. It was also the main technique used by Sudanese Plant Quarantine for detecting mites.

Ten percent of rehived honeybee colonies from every patch of imported honeybees were chosen randomly for mites’ inspection.

A flat sheet of light color paper was cut and inserted to cover the floor area of inspected colonies under the frames in brood chamber. Thin layer of grease was applied along the sides of the paper to prevent any mite from crawling back. The opened spots of the hive were closed by paste stripe. Three grams of tobacco were added to the smoker, the smoker was burnt until tobacco smoke was produced from the smoker nozzle. The hive was then fumigated by inserting smoker nozzle in hive entrance. At the end of every ٤٢ hours the inserted paper was removed from the hive. Once insert were removed the debris that fell on to the paper were inspected for mites’ presence with aid of magnifying lens (٥٩٥).

٣.٣.٤. Inspection of tracheal mite (Acarapis woodi)

Ten worker bees of each sample were inspected for tracheal mite (Acarapis woodi). The bee was first put on it’s back and then it was grasped with forceps then ahead and a first pair of legs were removed by bushing them off with a scalper in downward and forward motion, then a thin transverse section from anterior face of the thorax was cutted with razorblade to obtain a disk, which was placed on a microscope’s slide. A few drops of lactic acid were added after the dissecting microscope was used to separate the muscle and examined trachea, then suspicious
trachea placed on glass slide, and covered with a cover glass and examined at \(4 \times\) to \(100 \times\) on a compound microscope (U.S.D.A. 1992).

### 3.4. Insects

Different bee colonies, kept in modern apiaries, traditional apiaries, and even wild colonies, were inspected for the presence of insect pests of honeybee. The detected insects were counted, collected by hand or test tube and preserved in 70 percent alcohol for identification.

The hive entrance and foraging honeybee were observed several times in different location. The insects that observed preying on honeybee were trapped either by sweeping net, or by bait trap.

The collected insects were identified at the Insect Collection, Agricultural Research Corporation, Medani.

### 3.5. Mammals

Mammals were surveyed either by questionnaire or by direct observations in the field. Mammals were identified according to Kingdon (1982), Wild life Research Center and Khartoum Natural History Museum.

### 3.6. Birds

Birds attacking honeybee colonies were observed in different locations in Sudan. An area of about 1 km in diameter a round bee yard was determined to indicate the presence or absence of birds (modification of Nikolaus, 1984). A small optical and a field guide to Bird in Central and East Africa (Williams and Arlott, 1992) were used to help in birds’ identification in the field. Wild life Research Center and Sudan Institute for Natural Science were used to authenticate the identification.
Further observations were carried out about Bee-eaters in Khartoum State.

\textbf{7.3. Questionnaire}

An interview with some modern beekeepers, traditional beekeepers and honey hunters according to questionnaire was carried out whenever possible to find out: (i) any abnormality in the colony development that may have been noticed by the beekeeper during the previous seasons, (ii) all control measures carried out by beekeepers, (iii) insects, mammals and birds pest of honeybee colonies and (iv) the symptoms and estimated damage. Computer program Spss version 9.0 is used to analyze data obtained from questionnaire as Frequency and Chi Square.

\textbf{7.4. Testing for Hygienic Behaviour in Sudanese Honeybees}

Testing for hygienic behaviour by freezing a patch of pupated sealed brood with liquid nitrogen was carried out. Liquid nitrogen is poured onto frames, to freeze and kill brood. The amount of brood removed in 84-hour period was recorded. The liquid nitrogen was confined to a specific spot on the brood using a tin soup can opened on both ends [9.3" diameter \& 8.5" tall]. The can was driven through the brood into the mid-rib of the frame. The rim of the can was sawed off and filed to provide a good seal between the frame and the can. A good seal was made to prevent the leakage of liquid nitrogen from the selected area. The patches of brood selected for the test contained less than 0.012 empty cells. Approximately 9.0-9.0ml (3-1.0 ounces) of liquid nitrogen was poured on the brood. The can was kept approximately 5 minutes to thaw before it was removed and the frame replaced to the colony.
Liquid nitrogen, which was stored in specific tank (Plate 7-1), has a boiling point of almost -196°C. Careful precautions were taken to prevent frostbite. Protective clothing including heavy gloves, boots and safety glasses were worn.

1. Nitrogen comes in specially built thermos bottle.

2. Protective clothing and common sense must be used when handling liquid nitrogen.

3. Modified Campbell's soup being used to isolate a patch of brood for freezing with liquid nitrogen.

4. Two patches of frozen brood 84 hours after freezing
   a. Non-hygienic
   b. Hygienic.

Freezing tests were repeated and only colonies removing 90% of frozen brood for two consecutive tests regarded as hygienic colony and should be bred from (Melathopouloua 2001)
Plate (٣-١) liquid nitrogen container

Chapter ٤

Results

٤٫١ Diseases diagnosis

Total number of ٧١١ colonies was inspected for diseases. Table (٤-١) shows that all inspected colonies in all locations were found to be free of American foul brood, European foulbrood, Chackbrood, Sac brood and Stonebrood. The only brood disease found was Serratia marcescens, in Khartoum location and its incidence was ٪٣٦٥٫٢ (٣ out of ٧١١).
Dysentery was the only adult disease found during this survey in Kordofan location at \( \% 90.7 \text{ (2 out of 711).} \)

\[ \frac{1}{1.1} \]

Identification of *Serratia marcescens*

**Symptoms**

An unpleasant odour was noticed, examination revealed dead larvae in capped cells that were yellowish to light brown in colour. They were soft in consistency and mucous when punctured. Most of the affected larvae were in the prepupal stage. The cappings of the cells containing dead brood were punctured and sunken in appearance. Only (1-2) combs had dead larvae in every infected colony.

**Culture technique**

Plate (1-2) shows the culture of isolates organism from dead honeybee larvae. The organism was isolated in pure culture. Growth on blood agar consisted solely of small white colonies 1-2 mm in diameter, slightly raised with convex surfaces.

**The properties of the isolates**

The properties of the isolate were shown in table (1-2). It was gram-negative rod, motile. Produce acid and gas from glucose, utilized sucrose as carbon sources. None of the isolates produced oxidase, or utilized malonate or lactose. None produced HVS, aerobic and
### Table (4-1) Percent infestation of diseased honeybee colonies in different States of Sudan
(Number of infested colonies/number of inspected colonies)

<table>
<thead>
<tr>
<th>Diseases</th>
<th>States</th>
<th>Khartoum</th>
<th>Kordofan</th>
<th>Darfur</th>
<th>Blue Nile</th>
<th>Kassala</th>
<th>Gezira</th>
<th>White Nile</th>
<th>River Nile</th>
<th>Over all percentage</th>
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<tbody>
<tr>
<td>American foul brood</td>
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<td></td>
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<td>European foul brood</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Serratia brood 13.043%</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
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<td>Sacbrood</td>
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<td>Stonebrood</td>
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<td></td>
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<tr>
<td>Dysentery 18.181%</td>
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<td>1.79%</td>
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</table>

(+) Present
(-) Absent
Plate (4-1) Spores of *Serratia marcescens* from hive infected by *Serratia* disease

Plate (4-2) Pure culture of *Serratia* Bacteria isolated from dead larvae of honeybee
Plate ( ٤-٥٩ ) Anti biotic sensivity test

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
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<tbody>
<tr>
<td>Gram</td>
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</tr>
<tr>
<td>KCN</td>
<td>Positive</td>
</tr>
<tr>
<td>Simmons’ citrate</td>
<td>Positive</td>
</tr>
<tr>
<td>Glucose (gas)</td>
<td>Positive</td>
</tr>
<tr>
<td>Indole</td>
<td>Negative</td>
</tr>
<tr>
<td>Urease</td>
<td>Negative</td>
</tr>
<tr>
<td>Sucrose</td>
<td>Positive</td>
</tr>
<tr>
<td>Malonate</td>
<td>Negative</td>
</tr>
<tr>
<td>MR</td>
<td>Negative</td>
</tr>
<tr>
<td>H₂S</td>
<td>Negative</td>
</tr>
<tr>
<td>S.F</td>
<td>Positive</td>
</tr>
<tr>
<td>MacConkey growth</td>
<td>Negative</td>
</tr>
<tr>
<td>Oxidase</td>
<td>Negative</td>
</tr>
<tr>
<td>Catalase</td>
<td>Positive</td>
</tr>
</tbody>
</table>

Table (٤) the tests of Serratia marcescens isolated from dead honeybee larvae.
facultatively anaerobic, Catalase, citrate, and KCN positive. The organism was thus diagnosed as *Serratia marcescens* which came in line with (El-Sanousi et al. 1981) and Cowan (1991).

**Preparations for Microscopic Examination**

Direct smears from dead larvae revealed minute gram-negative rods arranged singly and in groups Plate (4-7). No morphological difference was observed between the slide taken from the pure culture and that taken from smears.

**Antibiotics sensitivity test**

Plate (4-7) shows the sensitivity test by using the plasmatic Lap. Products ltd disk. In the disk assay the *Serratia marcescens* was found to be susceptible to streptomycin, ampicillin, chloramphenicol and tetracycline, but resistant to cloxaillin, penicillin, gentamicin, and erythromycin.

Detection of *Paenibacillus larvae* spores in hive products

Four samples from imported beeswax were examined microscopically for the presence of *Paenibacillus larvae* spores. No spores similar to *Paenibacillus larvae* spores were found in the sediment.

Investigations of mites

Washing of adult *Apis mellifera* bees

Mite investigations on the adult *A. mellifera* bees were carried out. A total of 7 washings of adult bees collected were done. Samples from Khartoum that were collected during February – August.
while samples from other locations were collected during September 2002-March 2003. Samples were taken during brood rearing.

All the samples were washed separately in \( \frac{1}{2} \) Ethanol. Mite investigations on the adult *A. mellifera* bees were shown in table (3-4). On inspection of the debris washed from the bees, *Varroa jacobsoni*
Table (4-7) Percent infestation of parasitic mites of honeybee in different States in Sudan (Number of infested colonies/number of inspected colonies)

<table>
<thead>
<tr>
<th>Mites</th>
<th>States</th>
<th>Khartoum</th>
<th>Kordofan</th>
<th>Darfur</th>
<th>Blue Nile</th>
<th>Kassala</th>
<th>Gezira</th>
<th>White Nile</th>
<th>River Nile</th>
<th>Over all percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varroa jacobsoni</td>
<td></td>
<td>٥٦٫١٧٣</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>٦٥٢٫٠١</td>
</tr>
<tr>
<td>Acarapis woodi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>١٠٫٢٥٪</td>
</tr>
<tr>
<td>Tropilaelaps clareae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>٠٫٠٪</td>
</tr>
<tr>
<td>Euvarroa sinhai</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>٠٫٠٪</td>
</tr>
</tbody>
</table>

(-) Not inspected
Plate (4-4) Dorsal view of an adult female of *Varroa jacobsoni*
Plate (4-4) was found in \(100.246\%\) of the inspected colonies. No mites were found out of Khartoum State (33.172%). Population levels of parasitic mite *Varroa jacobsoni* in Shambat apiary are shown in figure (4-1). High population levels were found in October while low population levels were found in June.

Incident of *Varroa jacobsoni* in Khartoum State was shown in table (4-4). It was found that all inspected Khartoum apiaries were infested with *V. jacobsoni* and \(5.0\%\) of the inspected colonies had positive infestation. High incidence (number of positive colonies/number of inspected colonies \%) was found in Shambat apiary \(100\%\) followed by El-kadaro apiary \(5.0\%\) and El-faki Hashim apiary \(5.0\%\). Among bees the incident percent in Khartoum apiaries (number of mite/number of bee\%) was \(20.901\%\). High infestation was found in Shambat \(65.741\%\) followed by El-kadaro \(40.417\%\) and El-faki Hashim \(40.941\%\). In addition to that \(72.72\%\) of wild colonies were infested with mites, their mean percent was \(35.520\%\) (Table 4-5)

**Use of tobacco smoke in imported *Apis mellifera* colonies**

Three imported patches (each contained 801 packages of honeybees) were treated with tobacco smoke. Inspection of the debris on the inserted paper showed no mites after one hour and after \(42\) hours. Generally some pollen particles, bee feaces were found. However washing technique proved to be better than tobacco smoke. It resulted in high incidence of Varroa mite in \(5.0\%\) of the inspected colonies.

**Washing of adult *Apis florea* bees**

Twenty-five samples of *Apis florea* adult bees were collected between February and August\(2002\). The whole colony (workers and drones) was washed in \(70\%\) Ethanol and the debris inspected for mites. No mites were found in any of the 25 samples.
Fig. (4-1) Population levels of the parasitic mite *Varroa jacobsoni* on adult honeybees at Shambat apiary during October 2002 to June 2003
### Table (4-4) Incidence of *Varroa jacobsoni* in Khartoum State apiaries

<table>
<thead>
<tr>
<th>Apiary</th>
<th>Mites/ bees%</th>
<th>No. of infected colonies/No. of all inspected colonies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Shambat apiary</td>
<td>0,8777-1,8450</td>
<td>1,4766%</td>
</tr>
<tr>
<td>El-kadaro apiary</td>
<td>0,1516-2,7713</td>
<td>1,2046%</td>
</tr>
<tr>
<td>El-faki Hashim apiary</td>
<td>0,9677-1,3937</td>
<td>0,5904%</td>
</tr>
<tr>
<td>Mean</td>
<td>1,0904%</td>
<td>75%</td>
</tr>
</tbody>
</table>

### Table (4-5) Incidence of *Varroa jacobsoni* in Khartoum State wild colonies

<table>
<thead>
<tr>
<th>Colony Type</th>
<th>Range</th>
<th>Mean</th>
<th>No. of infected colonies/No. of all inspected colonies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild colonies</td>
<td>0,367-1,945</td>
<td>0,4953%</td>
<td>77,777%</td>
</tr>
</tbody>
</table>
**Table (4-7) Incidence of *Varroa jacobsoni* infestation in Sudanese honeybee colonies**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>( F )</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within Groups</td>
<td>2960.259</td>
<td>15</td>
<td>197.377</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6763.428</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table (4-7) Multiple Comparisons between the incidences of *Varroa jacobsoni* to Sudanese honeybee colonies**

<table>
<thead>
<tr>
<th></th>
<th>Mean Difference</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drone brood</td>
<td>Adult*</td>
<td>33.737</td>
<td>.001</td>
</tr>
<tr>
<td>Worker brood</td>
<td>Drone brood*</td>
<td>-23.456</td>
<td>.002</td>
</tr>
<tr>
<td>Worker brood</td>
<td>Adult</td>
<td>1.216</td>
<td>.876</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.
Inspection of capped *Apis mellifera* brood cells

A total of 711 brood comb pieces were obtained. Between 3 to 410 capped worker and brood cells were opened at random (depending on the overall number of brood available). The larvae or pupae were removed and inspected for mite presence. The walls of the cells from which the immature bees got removed were inspected as well. It was found that the parasitic mite *Varroa jacobsoni* was only found in the brood of infested colonies plate (4-5). In tables (4-6) statistical analysis of data revealed that there was significant difference in the mean incidence of *Varroa* between drone brood, worker brood, and adult at 0.05 level while there was no significant difference in the mean incidence of *Varroa* between worker brood and adult.

Inspection of capped *Apis florea* drone brood cells

A total of 52 A. florea brood combs were obtained. Between 3 to 410 capped drone brood cells were opened at random (depending on the overall number of drone brood available). The larvae or pupae were removed and inspected for mite presence. The walls of the cells from which the immature bees got removed were inspected as well. In all these no mites were encountered.

Inspection of tracheal mite (*Acarapis woodi*)

*Acarapis woodi* was not found in any inspected location (apiaries or wild colonies) of Sudanese honeybees inspected. The imported Carnio-Egyptian (F1) honeybees were also found to be free of *Acarapis woodi*; the presence or absence of acarine could not be confirmed in Darfur State.

4, 5 Insects

The important insect pests of honeybees in Sudan were shown in table (4-7). The mean percentage of infested colonies by Greater wax moth, Ants (different spp), Small hive beetle, large hive beetle, Hawk
Plate (♀-♂) Adult female of *Varroa jacobsoni* on drone pupa of honeybee
Table (4-8) Percent infestation of insect pests of honeybees in different States of Sudan

(Number of infested colonies/number of inspected colonies)

<table>
<thead>
<tr>
<th>Insects</th>
<th>States</th>
<th>Khartoum</th>
<th>Kordofan</th>
<th>Darfur</th>
<th>Blue Nile</th>
<th>Kassala</th>
<th>Gezira</th>
<th>White Nile</th>
<th>River Nile</th>
<th>Mean percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater wax moth</td>
<td></td>
<td>100%</td>
<td>100%</td>
<td>24%</td>
<td>26.6%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>82.325</td>
</tr>
<tr>
<td>Ants (different spp)</td>
<td></td>
<td>32%</td>
<td>36.66%</td>
<td>100%</td>
<td>100%</td>
<td>0.1%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>77.290</td>
</tr>
<tr>
<td>Small hive beetle</td>
<td></td>
<td>•</td>
<td>•</td>
<td>8%</td>
<td>11.11%</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>7.389</td>
</tr>
<tr>
<td>Large hive beetle</td>
<td></td>
<td>•</td>
<td>•</td>
<td>12%</td>
<td>3.33%</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>2.194</td>
</tr>
<tr>
<td>Hawk moth</td>
<td></td>
<td>2.34%</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>1.543</td>
</tr>
<tr>
<td>Bee wolves</td>
<td></td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Palarus</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

(+) Present
(-) Absent
moth (Plate ٤-٦) was, ٨٦٠٢٣٪, ٧٧٠٢٣٪, ٢٣٨٩٪, ٢١٤٥٪ and ٠٣٤٪ respectively. All the wax moth specimens were identified as Greater wax moth Galleria mellonella and it was found in all locations. The Small hive beetle (Aethina tumida) and the large hive beetle (Hyplostoma fuligineus) were recorded for the first time in Sudan. The first observation of Aethina tumida was made in November ٢٠٠٢ in a traditional apiary near Kabom, South Darfur State (Plate ٤-٧). The second observation was made in March ٢٠٠٣ in wild colony near Abu Gomi, Blue Nile State. Adult beetles which were collected from both States, were found on the surface of wax combs while inspecting of colonies. The specimens were identified as Small hive beetle by the author and supervisor. The large black beetle found to be well known by the honey hunters and traditional beekeepers. However, adult beetles were found dead and covered with propolis in one of the traditional apiary near Kabom, South Darfur and it was also found in Blue Nile State.

Bee wolves and Palarus spp were also found to be dangerous pests. Palarus latifrons found to be dangerous wasp in Kordofan State however it was found in most States. Adult wasp (Plate ٤-٨) was trapped while it was preying on bees at the front of the hive. While adult wasp of Philanthus triangulum (Plate ٤-٩) was trapped while it was preying on foraging bees and was found only in Kordofan State. The Philanthus wasp was observed claps the honey-sac, squeezed the nectar it contained through its mouth parts, and consumed it then it left the victim fall in the ground. This observation was made in last winter (٢٠٠٣). The specimens of the two wasps were identified at Insect Collection, Agricultural Research Corporation, Medani.
Plate (4-6) Dorsal view of *Acherontia atropos*

Plate (4-7) Adult of small hive beetle, *Aethina tumida*
Plate (4-9) Dorsal view of *Palarus latifrons*

Plate (4-9) A. Ventral view of *Philanthus trinangulum*  
B. Dorsal view of *Philanthus trinangulum*
Different species of ants were observed; the big black one was found in Darfur inhabiting trees by making gallerias in tree stem. It has painful bite and it causes absconding to bee colonies. Local citizens calling it ‘El nehsha’ it probably be carpenter ant. The small red ant was also fond in Darfur inhabiting trees it was regarded as a pest for honeybee colonies and honey sellers it probably be pharaoh ant. The small black ant local name ‘El der’ of wide spread and it was a serious problem to bee colonies especially in drought season.

Table (٤-١١) shows that some insects such as Earwigs, Silverfish, Cockroaches, Locusts, Praying Mantids, Dragonflies and Robber fly were observed inside and out side the hive, but they were not seen preying or hurting honeybee colonies. Termites were observed damaging wood part of hive (Plate ٤-١١). The sting less bees and Apis florea were observed competing and robbing weak honeybee colonies. The stingless bees were observed only in Darfur and Blue Nile States, while Apis florea has been observed in most locations except Darfur and Kordofan States.

٤.٤. Mammals

The mammal pests of honeybee colonies were shown in table (٤-٥) and their damage was shown in table (٤-١٠). The major mammalian pests that found in Sudan were Man (honey-hunters), Livestock (Horse, Cattle and Camels), Squirrel and Honey badger Mellivora capensis (Plate ٤-١١). The last one was found in Darfur, Kordofan and Blue Nile States, the last two were associated with wild and traditional beekeeping industry.

٤.٥. Birds

The Bird pests of honeybee colonies were shown in table (٤-١١) and their damage was shown in table (٤-١٠). The following bee eaters were observed in different locations; Merops apiaster (Plate ٤-١٢), M.nubicus,
<table>
<thead>
<tr>
<th>Vernacular names</th>
<th>Arabic common name</th>
<th>Order</th>
<th>Species</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palarus</td>
<td>Daeb El nahel</td>
<td>Hymenoptera</td>
<td><em>Palarus latifrons</em></td>
<td>Found in most locations</td>
</tr>
<tr>
<td>Bee wolves</td>
<td>Daeb El nahel</td>
<td>Hymenoptera</td>
<td><em>Philanthus</em></td>
<td></td>
</tr>
<tr>
<td>Hornet#</td>
<td>Daboure El ballah</td>
<td>Hymenoptera</td>
<td><em>Vespa orientalis</em></td>
<td>Khartoum East Sudan</td>
</tr>
<tr>
<td>Ants</td>
<td>Nameel</td>
<td>Hymenoptera</td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td>Death’sHead Moths</td>
<td>Farashat El simsim</td>
<td>Lepidoptera</td>
<td><em>Acherontia atropos</em></td>
<td>Found in most locations</td>
</tr>
<tr>
<td>Greater Wax moth</td>
<td>Dodat El shama</td>
<td>Lepidoptera</td>
<td><em>Galleria mellonella</em></td>
<td>Found in most locations</td>
</tr>
<tr>
<td>Small Hive Beetel</td>
<td>Khanfoos</td>
<td>Coleoptera</td>
<td><em>Aethina tumida</em></td>
<td>Darfur and Blue Nile</td>
</tr>
<tr>
<td>Large hive Beetle</td>
<td>Khanfoos</td>
<td>Coleoptera</td>
<td><em>Hyplostoma</em></td>
<td>Darfur and Blue Nile</td>
</tr>
<tr>
<td>Termites</td>
<td>Arda</td>
<td>Isoptera</td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td>Braula*</td>
<td>Gamol Elnhel</td>
<td>Diptera</td>
<td><em>Braula sp</em></td>
<td>Kordofan</td>
</tr>
<tr>
<td>Robber fly</td>
<td>Elzubah Elsarig</td>
<td>Diptera</td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td>Ear wigs</td>
<td>Ebrat Elagos</td>
<td>Dermaptera</td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td>Silverfish</td>
<td>Elsemik elfidi</td>
<td>Thysanura</td>
<td>Khartoum</td>
<td></td>
</tr>
<tr>
<td>Cockroaches</td>
<td>Sersar</td>
<td>Dictiptera</td>
<td>Khartoum</td>
<td></td>
</tr>
<tr>
<td>Locusts*</td>
<td>El Grad</td>
<td>Orthoptera</td>
<td>Darfur</td>
<td></td>
</tr>
<tr>
<td>Praying Mantis</td>
<td>Faras El Naby</td>
<td>Dictiptera</td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td>Dragonfle</td>
<td>Elrashat</td>
<td>Odonata</td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td>Arachnids</td>
<td>Anakeb</td>
<td></td>
<td>Found in most locations</td>
<td></td>
</tr>
<tr>
<td><strong>Reptiles</strong></td>
<td>Zwahif</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lizards</td>
<td>Shali</td>
<td>squamata</td>
<td><em>Mohaia striata</em></td>
<td>Khartoum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Chalcides ocellatus</em></td>
<td>Khartoum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Agamma spp</em></td>
<td>Darfur</td>
</tr>
<tr>
<td><strong>Birds</strong></td>
<td>Tuor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bee-eaters</td>
<td>War war</td>
<td>Coraciiformes</td>
<td><em>Merops apiaster</em></td>
<td>Found in half locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coraciiformes</td>
<td><em>M.nubicus</em></td>
<td>BlueNile,Gezira,WhiteNile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coraciiformes</td>
<td><em>M.albicola</em></td>
<td>Khartoum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coraciiformes</td>
<td><em>M.orientalis</em></td>
<td>Found in half locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coraciiformes</td>
<td><em>M.pusillus</em></td>
<td>Found in most locations</td>
</tr>
<tr>
<td>Honey guide*</td>
<td>Morshed Elas(Eklema)</td>
<td>Indicator</td>
<td><em>Indicator indicator</em></td>
<td>Darfur and Blue Nile</td>
</tr>
<tr>
<td>Ground Hornbill</td>
<td>Abu ondolok</td>
<td>Coraciiformes</td>
<td><em>Bucorva abyssinicus</em></td>
<td>Kordofan, Darfur &amp;Blue Nile</td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honeybadger*</td>
<td>Therban</td>
<td>Carnivora</td>
<td><em>Mell ivora capensis</em></td>
<td>Kordofan, Darfur &amp;Blue Nile</td>
</tr>
<tr>
<td>Squirrel</td>
<td>Sengab</td>
<td>Rodentia</td>
<td>Darfur</td>
<td></td>
</tr>
</tbody>
</table>

*Indicated that this pest is documented by questionnaire
# Indicated that this pest is documented by literature
Table (4.1) The percent damage caused by mammals and birds to honey bee colonies in traditional hives during season ٢٠٠٢-٣٠٠٢ (data obtained by questionnaire).

<table>
<thead>
<tr>
<th>Mammals &amp; Birds</th>
<th>Number of traditional hives</th>
<th>Damaged hives</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honey badger (<em>Mellivora capensis</em>)</td>
<td>٢٩٠٣</td>
<td>٢٣</td>
<td>١٩٣٤٪</td>
</tr>
<tr>
<td>Rodent (squirrels)</td>
<td>٢٩٠٣</td>
<td>١٣٢</td>
<td>١٧٤٧٪</td>
</tr>
<tr>
<td>Hornbill (<em>Bucorvus abyssinicus</em>)</td>
<td>٢٩٠٣</td>
<td>٥٦٥</td>
<td>٢٧٢٨١٪</td>
</tr>
<tr>
<td>Mean</td>
<td>٢٩٠٣</td>
<td>٦٧٢</td>
<td>٦٢٩٨٪</td>
</tr>
</tbody>
</table>
Plate (4-1) Symptoms of damage caused by termites
Plate (4-11) Leather of honey badger
Plate (4-11) Bee-eater *Merops apiaster*

Plate (12-13) Ground hornbill *Bucorvus abyssinicus*
*M. albicolus, M. orientalis* and *M. pusilus*. The first two are dangerous bee-eaters in apiary, while the others have less importance to beekeepers and they were not seen preying on bees. In addition, the ground horn bill *Bucorvus abyssinicus* Plate (4-31) was appear to be a pest of traditional hives (open & damage hive) of honeybee colonies specially in Darfur State (Kaboum) Plate (4-14). Honey guide, *Indicator indicator* was observed only in Darfur.

Table (4-17) shows the distribution of bee-eaters in Sudan. It was found that high Species percent of the bee-eaters were observed in Khartoum and Gezeira States followed by Blue Nile and River Nile, in Darfur and White Nile and in Kordofan and Kassala States. *M. pusilus* was observed in of the surveyed area followed by, *M. orientalis* and *Merops apiaster*.

**Observation on Merops apiaster**

The *Merops apiaster* invade the apiary in early morning about 7 o'clock, preying on bees until 11 o clock, then it disappeared in the afternoon and attack colonies again at 1 o’clock in the evening and continued until sun set. During season the bird migrated to Khartoum State in May and nested until June then it migrated to another area and returned again to Khartoum State in autumn season and still there until 15 November after that it migrated to unknown area. While in season it arrived at early April and still there until 17 July then it migrated to another area and did not returned again.

**5.9. Lizards**

Table (4-11) shows that three species of lizards were found; *Mabuya striata, Chalcides ocellatus* and *Agamma spp* the last one was found in Darfur while the other two were found in all locations but they were only observed under and inside Langstroth hives in Khartoum State.
Plate (4-14) A. Intact traditional hive of honeybee

B. Symptoms of damage on traditional hive of honeybee caused by ground hornbill bird
Table (٤-١٩) Distribution of bee-eater species in different States of Sudan

<table>
<thead>
<tr>
<th>Bee-eater species</th>
<th>Khartoum</th>
<th>Kordofan</th>
<th>Darfur</th>
<th>Blue Nile</th>
<th>Kassal</th>
<th>Gezira</th>
<th>White Nile</th>
<th>River Nile</th>
<th>Distribution percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merops apiaster</td>
<td>++ +</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+ + +</td>
<td>+ + +</td>
<td>-</td>
<td>+</td>
<td>80.0%</td>
</tr>
<tr>
<td>M.nubicus</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+ + +</td>
<td>-</td>
<td>++ +</td>
<td>+</td>
<td>-</td>
<td>37.2%</td>
</tr>
<tr>
<td>M.albicolas</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>14.2%</td>
</tr>
<tr>
<td>M.pusilus</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>84.8%</td>
</tr>
<tr>
<td>M.orientalis</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>64%</td>
</tr>
<tr>
<td>Species percentage</td>
<td>80.0%</td>
<td>37.2%</td>
<td>14.2%</td>
<td>84.8%</td>
<td>64%</td>
<td>80.0%</td>
<td>84.8%</td>
<td>64%</td>
<td></td>
</tr>
</tbody>
</table>

(+) Less than five birds (+ +) more than five (+ + +) flock
(-) Absent
4.1. Questionnaire

Diseases of honeybees in Sudan

Table (4-12) shows that 94.1% of the respondents mentioned that there was no diseases of honeybee in Sudan while 6.4% percentage of the respondents mentioned the opposite. Table (4-14) shows that there was significant relation between the importation of honeybee and disease (p<0.0).

Insects’ pests of honeybees in Sudan

Table (4-15) shows that 24.0%, 90.7%, 22.6%, 7.5%, 59.1%, 18.6% and 2.1% of the respondents mentioned Wax moth, Ants, Wasps, Hawk moth, Beetle, Termites and Spiders as pests of honeybees in Sudan respectively. Wax moth, Ants and Beetle appeared to be well known pests to respondents.

The control measures of pests and diseases of honeybees in Sudan

The control measures of the pests and diseases of honeybee colonies in Sudan were summarized in Table (4-9) and Table (4-11). It was found that 86.7% of the respondents used preventive methods such as maintaining high population colonies using metal hive stands locate hive in high place, securing guard and apiary fence, place colonies out side live stock areas and so on, while 3.6% used chemical control such as Kaftrtodox, Sevin and other chemicals.

Damage of mammals and Birds in traditional hives

Table (4-10) shows the damage of both mammals and birds. Personal communication of traditional beekeepers showed that 18.2%, 7.4% and 1.3% of the native hives were damaged by ground hornbill Bucorvus abyssinicus, Squirrel and Honeybadger Mellivora capensis respectively during season 2002-2003.
### Table (١٣) Distribution of respondent according to honeybee disease, which found in Sudan

<table>
<thead>
<tr>
<th>Disease</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>٥</td>
<td>٨٨</td>
<td>٩٣</td>
</tr>
<tr>
<td>Percent</td>
<td>٥,٤٪</td>
<td>٩٤,٦٪</td>
<td>١٠٠,٠٪</td>
</tr>
<tr>
<td>Dead larvae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>٣</td>
<td>٢</td>
<td>٥</td>
</tr>
<tr>
<td>Percent</td>
<td>٦٠,٠٪</td>
<td>٤٠,٠٪</td>
<td>١٠٠,٠٪</td>
</tr>
</tbody>
</table>

### Table (١٤) Relation between importation of honeybees and disease

<table>
<thead>
<tr>
<th>Introduce of honeybees</th>
<th>Disease</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>Coun</td>
<td>٥</td>
</tr>
<tr>
<td>% of</td>
<td>٥,٤٪</td>
<td>٧٣,٧٪</td>
</tr>
<tr>
<td>No</td>
<td>Coun</td>
<td>٦٦</td>
</tr>
<tr>
<td>% of</td>
<td>٧١,٠٪</td>
<td>٧١,٠٪</td>
</tr>
<tr>
<td>Total</td>
<td>Coun</td>
<td>٦٦</td>
</tr>
<tr>
<td>% of</td>
<td>٦٠,٠٪</td>
<td>٩٤,٦٪</td>
</tr>
</tbody>
</table>

### Chi-Square tests

<table>
<thead>
<tr>
<th>Value</th>
<th>Df</th>
<th>sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearsin Chi-Square</td>
<td>١٣,٩١٧</td>
<td>١</td>
</tr>
</tbody>
</table>
Table (4-5) Control measurers of the pests and diseases of honey bee colonies in Sudan as indicated by observation and questionnaire.

<table>
<thead>
<tr>
<th>Pests</th>
<th>Common name</th>
<th>Control measures</th>
<th>Numbers of beekeepers saying they adapting the treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Chemical</td>
<td>Preventive</td>
</tr>
<tr>
<td><strong>Insects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moths</td>
<td>Kafrotrex, (Fumigation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beetles</td>
<td>None needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wasps</td>
<td>Tererate Trap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ants</td>
<td>Sevin, Rambo (Powder)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Termites</td>
<td>Metal hive stand</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primates</td>
<td>Man, Monkey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carnivores</td>
<td>Honey badger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rodent</td>
<td>Squirrel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ungulates</td>
<td>Horse cattle camels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birds</td>
<td>Bee-eaters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Honey-guide</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Horn bill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases</td>
<td><strong>Serratia</strong> Disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dysentery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td><strong>Varroa</strong> mite</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Table (۱۵) Distribution of respondent according to insect pest of honeybee, which found in Sudan.

<table>
<thead>
<tr>
<th>Insect Pest</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax moth</td>
<td>۶۰</td>
<td>۳۳</td>
<td>۹۳</td>
</tr>
<tr>
<td>Percent</td>
<td>۶۴.۰٪</td>
<td>۳۰.۰٪</td>
<td>۱۰۴.۰٪</td>
</tr>
<tr>
<td>Ants</td>
<td>۸۹</td>
<td>۴</td>
<td>۹۳</td>
</tr>
<tr>
<td>Percent</td>
<td>۹۰.۸٪</td>
<td>۱۳.۳٪</td>
<td>۱۰۴.۱٪</td>
</tr>
<tr>
<td>Wasps</td>
<td>۲۱</td>
<td>۷۲</td>
<td>۹۳</td>
</tr>
<tr>
<td>Percent</td>
<td>۲۲.۶٪</td>
<td>۷۷.۴٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Hawk moth</td>
<td>۷</td>
<td>۸۲</td>
<td>۹۳</td>
</tr>
<tr>
<td>Percent</td>
<td>۷.۵٪</td>
<td>۸۲.۵٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Beetle</td>
<td>۰۶</td>
<td>۸۶</td>
<td>۹۲</td>
</tr>
<tr>
<td>Percent</td>
<td>۶۹.۱٪</td>
<td>۳۰.۹٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Fly</td>
<td>۹۳</td>
<td>۹۳</td>
<td>۱۸۶</td>
</tr>
<tr>
<td>Percent</td>
<td>۱۰۰.۰٪</td>
<td>۱۰۰.۰٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Termite</td>
<td>۸</td>
<td>۸۵</td>
<td>۹۳</td>
</tr>
<tr>
<td>Percent</td>
<td>۸.۹٪</td>
<td>۹۱.۱٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Spider</td>
<td>۷</td>
<td>۹۱</td>
<td>۹۸</td>
</tr>
<tr>
<td>Percent</td>
<td>۷.۲٪</td>
<td>۹۲.۷٪</td>
<td>۱۰۰.۰٪</td>
</tr>
</tbody>
</table>

Table (۱۶) Distribution of respondent according to control measures of honeybee pests and diseases, which found in Sudan.

<table>
<thead>
<tr>
<th>Control</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>۴۰</td>
<td>۹</td>
<td>۴۹</td>
</tr>
<tr>
<td>Percent</td>
<td>۸۰.۰٪</td>
<td>۲۰.۰٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Koverdox</td>
<td>۷</td>
<td>۳</td>
<td>۱۰</td>
</tr>
<tr>
<td>Percent</td>
<td>۷۰.۰٪</td>
<td>۳۰.۰٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Sevin</td>
<td>۷</td>
<td>۷</td>
<td>۱۴</td>
</tr>
<tr>
<td>Percent</td>
<td>۵۰.۰٪</td>
<td>۵۰.۰٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>۱۰</td>
<td>۱</td>
<td>۱۱</td>
</tr>
<tr>
<td>Percent</td>
<td>۱۰۰.۰٪</td>
<td>۱۰۰.۰٪</td>
<td>۱۰۰.۰٪</td>
</tr>
<tr>
<td>Other</td>
<td>۷</td>
<td>۸۶</td>
<td>۹۳</td>
</tr>
<tr>
<td>Percent</td>
<td>۷.۰٪</td>
<td>۹۲.۰٪</td>
<td>۱۰۰.۰٪</td>
</tr>
</tbody>
</table>
Birds’ pests of honeybees in Sudan

Table (4-17) shows the bird’s pest of honeybee colonies in Sudan. About 3.0% of the respondents recorded ground hornbill *Bucorvus abyssinicus* as a pest of honeybee colonies followed by bee-eaters 1.1% and finally honey guide 0.5%.

Mammal’s pests of honeybees in Sudan

Table (4-18) shows Mammal’s pests of honeybees in Sudan. It was found that 7.8% of the respondents regarded the honey badge *Mellivora capensis* as a pest of honeybee colonies in Sudan followed by squirrels 2.1% while 5.6% of the respondents mentioned other pests such as man (honey robbers), livestock (camels cattle) and monkeys.

About 7.3% of the respondents mentioned lizards as pests of honeybee colonies in Sudan.

4.5. Testing for Bygienic Behaviour in Sudanese Honeybee

Two Sudanese honeybee colonies (A& B) kept in Shambat apiary were chosen randomly for testing hygienic behaviour in Sudan. The number of the removed freeze- killed brood was recorded after 42 & 84 hours and replicated twice (Melathopoulosa 100) colony (A) showed Hygienic behaviour after 84 hours (100%) Table (4-19), while (B) colony showed Hygienic Behaviour after 42 hours Table (4-20).

4.6. Distribution of honeybee pests and diseases in surveyed areas

Table (4-21) lists all the pests and diseases of honeybees in surveyed areas, which were diagnosed or documented by Questionnaire with respect to their geographical distribution. The distribution of the pests and diseases of honeybees were also illustrated in Figures from (4-22) to (4-31).
Table (17) Distribution of respondent according to bird pest of honeybee, which found in Sudan

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horn bill</strong></td>
<td>44</td>
<td>29</td>
<td>73</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>60.3%</td>
<td>39.7%</td>
<td></td>
</tr>
<tr>
<td><strong>Bee eater</strong></td>
<td>30</td>
<td>43</td>
<td>73</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>41.1%</td>
<td>58.9%</td>
<td></td>
</tr>
<tr>
<td><strong>Honey guide</strong></td>
<td>4</td>
<td>69</td>
<td>73</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>5.5%</td>
<td>94.5%</td>
<td></td>
</tr>
</tbody>
</table>

Table (18) Distribution of respondent according to animal pests of honeybee, which found in Sudan

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birds</strong></td>
<td>77</td>
<td>16</td>
<td>93</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>82.8%</td>
<td>17.2%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Squirrels</strong></td>
<td>29</td>
<td>64</td>
<td>93</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>31.2%</td>
<td>68.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Rats</strong></td>
<td>93</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Honey badger</strong></td>
<td>36</td>
<td>57</td>
<td>93</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>38.7%</td>
<td>61.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Lizards</strong></td>
<td>22</td>
<td>71</td>
<td>93</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>23.7%</td>
<td>76.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Other things</strong></td>
<td>6</td>
<td>87</td>
<td>93</td>
</tr>
<tr>
<td>Count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>6.0%</td>
<td>93.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Table (19) The removed freeze-killed brood by Sudanese honey bee colonies after 48 hours

<table>
<thead>
<tr>
<th>Colony</th>
<th>Number of removed brood</th>
<th>Mean</th>
<th>Percentage of removed brood</th>
<th>Colony strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R(^1)</td>
<td>R(^2)</td>
<td>١٥٤</td>
<td>١٥٤</td>
</tr>
<tr>
<td>A</td>
<td>١٥٤</td>
<td>١٥٤</td>
<td>١٥٤</td>
<td>١٠٠٪</td>
</tr>
<tr>
<td>B</td>
<td>١٥٤</td>
<td>١٥٤</td>
<td>١٥٤</td>
<td>١٠٠٪</td>
</tr>
</tbody>
</table>
Table (٢٠) The removed freeze-killed brood by Sudanese honey bee colonies after ٤١hours

<table>
<thead>
<tr>
<th>Colony</th>
<th>Number of removed brood</th>
<th>Mean</th>
<th>Percentage of removed brood</th>
<th>Colony strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R١٠</td>
<td>R٢٠</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>١٣٤</td>
<td>١٣٧</td>
<td>١٣٥,٥ ٨٧,٩٩٪</td>
<td>٠ comb</td>
</tr>
<tr>
<td>B</td>
<td>١٥٠</td>
<td>١٤٩</td>
<td>١٤٩,٥ ٩٧,٠٨٪</td>
<td>١٠ comb</td>
</tr>
</tbody>
</table>
Figures (4-2) to (4-11) shows the distribution of the pests and diseases of honeybees in Sudan.

- Indicates that the pest is present
- Indicates that the pest is not present
- Indicates that the pest is suspected to be present
- Indicates that the survey is not made (therefore insecurity or there are no domesticated colonies)
Fig. [4.2] Distribution of Serratia disease in Sudan
Fig.(4-3) Distribution of Varroa jacobsoni in Sudan
Fig.(4.4)Distribution of ants (different species) in Sudan
Fig.(4-5) Distribution of wax moth *Galleria mellonella* in Sudan
Fig.(4-8) Distribution of bee wolf wasps Falarus latifrons and Philanthus triangulum in Sudan
Fig. (4.9) Distribution of honeybadger *Mellivora capensis* in Sudan
Fig. (4-9) Distribution of honeybadger *Mellivora capensis* in Sudan.
Fig. (4.11). Distribution of bee-eaters (different species) in Sudan
Discussion

1.5. Disease diagnosis

Foul brood

The absence of AFB agreed with the findings of (Anonymous, 1990). AFB was found in Syria, Jordan, Palestine, Saudi Arabia, Libya, Tunis, Algeria, and Morocco. However, Sudan, Egypt, Yemen, Iraq, and Oman are free from this disease. The absence of AFB disease could be attributed to plant quarantine justifications, which prevent importation of honeybee colonies in honeybee nuclei.

The absence of EFB disease could be attributed to it’s rare occurrence in Africa. Smith (1961) reported that EFB had not been found in the Tropics but in Europe and North America there were occasional outbreaks. Recently we expect it to spread in Africa as a result of importation of honeybee colonies in nuclei.

Detection of Paenibacillus larvae spores in hive products:

Paenibacillus larvae spores were not detected because hive products (bees wax) that inspected was imported from Egypt, which is free of American Foul Brood (Anonymous, 1990) also it is difficult to be identified due to the inhibition of P. larvae spores. American Foul Brood is transmitted by the spores of Paenibacillus larvae. There are some successes in recovering spores, which are morphologically similar to those of P.larvae in bees wax. However positive identification of the spores is not possible because the recovery technique render the spores nonviable (Shimanuki and Knox 2002)
Identification of *Serratia marcescens*

**Biochemical test**

The biochemical properties of *Serratia marcescens* were gram-negative rod, motile, produce acid and gas from glucose and utilized sucrose as carbon sources. None of them produced oxidase, or utilized malonate or lactose. None produced \(H_2S\), aerobic and facultatively anaerobic, catalase, citrate, and KCN positively. This result agreed with the findings of El-Sanousi, *et al.* (1989). Although *Serratia* disease was noticeable in Shambat apiary it was the first time to discover out of it. This discovery was made in hives kept in Khartoum forest. Data obtained in table (14) showed that disease was associated with the importation of honeybees so that *Serratia* disease could be attributed to importation of honeybees. We suggested that *Serratia* disease could be spread among the wax moth. El-borony and Hejazi (1991) listed the wax moth *Galleria mellonella* as a host of *Serratia marcescens*. *Serratia marcescens* was not well known pathogen to honeybees however new record confirmed that. Al-kazzaz and Al-kazzaz, (2002) reported that the bacterium *Serratia marcescens* was identified in dead and diseased larvae, which were examined in Iraq in 2002.

**Antibiotic sensitivity test**

El-Sanousi, *et al.* (1989) showed that all the strains were susceptible to carbenicillin, kanmycin, streptomycin, ampicillin, gentamicin, nalidixicacid and chloramphenicol put resistant to oxacillin, clindamycin, polymxin B, penicillin, erythromycin, norobiocin and sulphamethizo. And this result is similar to which we found.

**Chalk brood disease**

According to Bailey (1983) *Ascosphaera apis* occurs in Europe, including British Isles, but not in north America. There are no reports of its occurrence elsewhere. However, The Anonymous (1990) listed, five
Arab countries as an infected countries with Chalkbrood disease, these are Syria, Jordan, Palestine, Egypt and Tunis. The absence of Chalkbrood disease in Sudan could be attributed to the fact that our beekeepers do not import pollen grain to feed their bees. El-ghamdi (٠٩٩١) attributed the infestation of Ascosphaera apis in Saudi Arabia to the importation of large quantities of pollen by beekeepers.

**Viruses**

Viral disease symptoms were not observed and more investigations on Viral diseases must be done because adult honeybees may fall prey to many kinds of viruses, which they are not easily detected because they need sophisticated technique, and often ignored by bee inspectors and beekeepers. Sanford (٨٩٩١) reported that the most recognized was chronic bee paralysis. Some bee stock was highly susceptible to that virus which caused the workers to become hairless and develop a uniform black color. Other viruses found to affect honey bees include "Arkansas bee virus," "S-shaped virus," and "slow bee paralysis virus"

**Diagnose of Nosema Disease:**

Nosema disease was not found; this might be attributed to the hot weather in Sudan, there was no dealing of package bees and no bees used for pollination in green houses. Bailey (٣٦٩١) suggested that development of the Nozema parasite is inhabited during the summer by temperature, later he attributed that to the bees being freely in summer to defecate away from the colony so that combs become cleaner and the chances of bees contacting spores decrease. So infection declines. The disease usually manifests itself in bees that are confined, so the heartiest infections are found in winter bees, package bees and bees from hive used for pollination in green houses (Shimanuki and Knox ٠٠٠٢). In-spite of all more investigations must be done because symptoms of the disease are not clear-cut and sometimes, even at high levels of infestation, are difficult to detect (Sanford ٨٩٨٧).
**Dysentery**

Dysentery was found at Kordofan and it was attributed to the fermented honey that consumed by the infected colonies. The term ‘dysentery’, as used by beekeepers, refers not to any infectious disease but to the involuntary discharge of excreta by the adult bees within and near the hive in late winter. Dysentery is caused by the consumption of unsuitable food during the winter acid-inverted invert sugar for example, or honey which is too watery (Anonymous ١٩٨٩).

**Insects**

**Greater wax moth**

Greater wax moth was found to be dangerous pest, wide spread and well known to the beekeepers. This result supported by different researchers in Sudan; Marshall (١٩٩٠) reported that complete damage was caused by Greater wax moth *Galleria mellonella* in a hive in South Sudan, Abdalla (١٩٨٨) listed the greater wax moth first of the major pests of Sudanese honey bees, Mohammed (١٩٨٨) studied the life cycle of *Galleria* under Shambat condition, Nagi, (١٩٨٤) stated that wax moth is one of the factors influence queen rearing in the Sudan. However, Gassma (١٩٨٤) reported that the Sudanese honeybees were found to be resistant to the attack by the greater wax moth in comparative to Carnio-Egyptian honeybee. The importance of the greater wax moth in Sudan might be due to tropical climate, which provide it with suitable temperature for reproduction and growing. Singh (١٩٨٤) reported in India, larval *Galleria* population of density became so serious damaged colonies during dearth periods or monsoon; the infested honeybee colonies absconded. The development of *Galleria* caterpillars even in worm localities slowed down in winter and it became active from March to October. The emergence of adult started in March and April, this pest attacked all colonies; strong ones were able to resist it . Although Singh
(٣١١) reported *Galleria mellonella* as a pest of all colonies of *Apis cerana*, *Apis dorsata*, and *Apis florea* in India, all the inspected colonies of *Apis florea* were found to be free of wax moth, this could be attributed to that *Apis florea* build their nest in open areas.

In tropical countries wax moths destroyed and weaken colonies (Bailey ٣٦٩١). They also caused Gallerasi which result in preventing emerging workers and drones to leave the cells of combs, and this is because the bees remain trapped in their cells by silken threads that *Galleria* have spun at cell bases (Williams ٨٧٩١).

**Lesser wax moth**

The lesser wax moth *Achroia* was not found during this survey and this result agree with Anonymous(٥٩٩١), which found that lesser wax moth was not found neither in Egypt nor in Sudan. The absence of *Achroia* may be due to high competitions of *G. mellonella*. Williams (٨٧٩١) stated that larvae of the lesser and greater wax moths frequently infested beekeeping materials simultaneously, but *Achroia* are unable to compete if the *Galleria* larvae become numerous.

**Hawk moth**

The hawk moth *Acherontia atropos* was found in week colonies or in unwell closed hives in Khartoum State and documented by beekeepers on the other States. Smith (٠٦٩١) stated that the hawk moth might be found on unguarded comb in weak colonies, strong colonies threw them out in small pieces. Marshall (٢٠٠٢) listed the hawk moth as pest of honeybees in South Sudan. (Ahmed ٢٠٠٢) reported that two species of *Acherontia* were existed in Sudan; *Acherontia styx* and *Acherontia atropos*.

**Bee wolf *Palarus latifrons***

In this study *Palarus latifrons* was recorded as a pest of honeybees for the first time. It was found preying on honeybees in Khartoum,
Kordofan, Gezeira, White Nile and River Nile. It was numerous in Kordofan that decrease honey production during autumn. This may be due to Kordofan sand soil, which is preferred to the wasp. This finding came in line with Smith (1961) who reported that *Palarus latifrons* wasp was very common in central Africa and also known in South Africa. If numerous, this wasp could demoralize a colony to extent of causing the bees to cease foraging. It has been recently collected by the author and identified at the Insect Taxonomy Department, Agriculture Research Corporation; Sudan. It was also reported in four areas as a new fauna that cause problem for bees in Saudi Arabia El-ghamdi (1991).

**Bee wolf Philanthus triangulum**

*Philanthus triangulum* has been found in Kordofan only, may be due to the fact that thy are ground nesters and that the soil in this state is sandy soil. Being ground nesters, they easily built their nests in such soils. El-Borollsly *et al.* (1970) reported that the bee wolf *Philanthus triangulum* is the pest of apiaries in Egypt, especially on sand soils. *Philanthus* spp. was also reported in Sudan (Mohamed, 1984, Abdalla, 1988), Saudi Arabia El-ghamdi (1990). Since *Philanthus triangulum* and *Palarus latifrons* have similar behaviour it is difficult to differentiate between them so that the *Philanthus* spp, which was reported by Mohamed (1984) and Abdalla, (1988) might be *Palarus latifrons* because *P. triangulum* do not found preying on honeybees around hives. It has its own particular type of prey, she pounces down the bee when it is about to visit a flower Frisch (1924) while *Palarus* waits around hive during the head of the day, and pounces on passing foragers, stinging them and carrying them off to their nests as food for their larvae Smith (1976). And this was similar to which we found.

**Horn wasp Vespa orientalis:**
Abu Lila (١٩٩١) stated that *Vespa orientalis* is a serious pest of honeybees. It was hindering the spread of beekeeping in Egypt (Wafa, ١٩٠٦). It was widely distributed in Saudi Arabia especially where date palm trees grow El-ghamdi (١٩٩١). Although it was also reported as a pest of honeybees in Sudan (Mohamed ١٩٨٨, Abdalla ١٩٨٨) and El-Sarrag (١٩٩٣) listed it as one of the pollinators of certain crops, it was not observed during this survey and also it was not cough by bait trap, moreover it was not documented by any beekeepers. This could be attributed to that all the surveyed area was not growth with date palm trees. It was really exist according to the Department of Insects Taxonomy, Agriculture Research Corporation but we think that it is not cause any problem to the Sudanese honeybees in surveyed area.

**Ants**

Ants were found to be the most serious, wide spread and well-known pests. Roberts (١٩٧١) stated that in Uganda ants were serious and wide spread enemies of honeybee. Abdalla (١٩٨٨) listed ant as one of the major pests of honey colonies in Sudan. It was found that ants’ species were abundant in drought season. Lindsey and Skinner (١٩٧١) reported that great abundance and diversity of ants were recorded in summer than in winter in South Africa. *Componotus compressus*, *Monomorium indicum*, *Doryhus labiatus* and *Monmorium destrecter* were reported as pests of honeybees in India (Singh, ١٩٨٧). Since India and Sudan are tropical countries ants’ species in Sudan were probably similar to Indian species.

**Termites**

White ants were observed damaging wooden components of hives and other apiary equipments. This finding agreed with Singh (١٩٧٧)
who reported that white ants or *Termites obesus* (Rab.) were seen damage wooden components of hives and other apiary appliances.

**Small hive beetle & Large hive beetle**

This was the first record of Small hive beetle in Sudan, however similar beetle was described in south Sudan by Marshall (1959) who stated that two species of beetle were observed in hives in South Sudan. One of these beetles was small and dark, and it was suggested to be belonging to family Tenebrionidae, the other was big and dark. The Adult of small beetle, which we found in this study are broad, flattened beetles about $\frac{7}{8}$ mm ($\frac{1}{4}$ inch) long, $\frac{3}{4}$ mm wide and dark brown to nearly black in color. Adults are red just after pupation and soon thereafter become blackish. They move rapidly across comb and are difficult to pick up and belong to family Nitidulidae. Large hive beetle might be the big one that described by Marshall and it was well known to traditional beekeepers and honey hunters.

**Mites**

*Varroa jacobsoni*

*Varroa jacobsoni* was found only in Khartoum State and this is the first report of this mite in Sudan. The importation of honeybee colonies is the main reason of introducing this dangerous mite in Sudan and it is expected to be dispersed in other places that imported honeybees. It was observed that this mite prefered drone brood to worker brood and this result agreed with Rilter and Ruttner (1989) who stated that the most sever parasitism occurs on older bee larvae and pupae, with the mite preferring drone brood to worker brood and Nazzi (2002) reported that *Varroa destructor* showed strong response to the larval food collected from drone cells before capping. Male mites weren’t observed during this survey in accordance to DelefindoBaker (2004) who reported that male mites are rarely encountered. Mite population levels were found to be high during winter months and quite low in summer months
this could be attributed to the high temperature in summer and this result is similar to Webster and Callaway (1991) who reported that mite levels in mid-summer (June and July) were generally quite low, making detection was difficult. The proportion of fallen mites increases during very hot weather (Webster et al. 2002). Reference the life cycle of Varroa it seemed likely that those genetic stocks of bee with shorter worker developmental rates will be less severely affected by Varroa because few or no mites can mature to the infective stage before the bees leave their cells as adults (Ramires and Otis, 1987).

As Sudanese honeybees belong to African honeybee races (Ruttner 1979), the total developmental period from egg oviposition to emergence of the Sudanese honeybee worker was found to be 19.6 days (Gassma 1989) so our native honeybees might be resistant to the parasitic mite Varroa jacobsoni.

**Tropilaelaps clereae**

*Tropilaelaps clereae* was not found in Sudan. However, there was no substantiated record of it in Africa and it might be died in imported honeybee colonies. Wilde (2002) stated that it's impossible to introduce *Tropilaelaps clereae* together with imported honeybee queen to Europe since most mites died during the first 21h, and non-survived more than 47h.

**Inspection of tracheal mite (Acarapis woodi)**

*Acarapis woodi* was not found in Sudan however it was reported in the neighbor countries. *Acarapis woodi* was first found in England but now its known throughout most of Europe except Scandinavian countries (Morse 1979). It was also reported in Morocco, El green, Libya, Egypt, Palestine, Iraq, Jordan and Syrian (Anonymous 1990).

**Euvarroa sinhai**
E. sinhai was not found in Sudan in neither A. mellifera colonies drone brood nor the drone brood of A. florea this result is agree with Mogga (1991) and Koeniger et al. (1989) who reported that the number of mites found in infested A. florea colonies was very small. Moreover the possibility of spreading of this mite is very low because there was only one A. florea colony introduced in Sudan. Lord and Nagi (1981) stated that they discovered a single Apis florea colony in suburbs of Khartoum, Sudan in 1985.

**Tobacco smoke detection technique**

Inspection of mites by using tobacco smoke detection technique showed that there were no mites on the imported honeybee. However, washing Technique had positive result. This result did not mean tobacco is not efficient but this technique needs especial quarantine procedures and limited security justification. Therefore the importers of the honeybees can easily change the result. Treatment of package honeybees may also be the cause of this result.

**Mammals**

**Baboons**

Baboons were reported as a pest of honeybee colonies only at south Blue Nile State. Honey hunters said that baboons open wild bee nests and avoiding bee sting by covering it’s face by it’s hand taking the honey comb far from bee nest this is similar to the report of Friendmann (1960) who stated that related tale of baboons opened wild bee nests, after they had been guided to the nesting sites by honey guide, *Indicator indicator*.

**Squirrels**

Squirrels were observed inhabiting traditional hives. The majority of traditional beekeepers said that it chew the traditional hive to enter
inside it and cause absconding of bee colonies, this result came in line with Caron (1984) who stated that squirrels chewed and destroyed combs to obtain honey and pollen for food. Supers and bee equipment should be stored in rodent proof areas to avoid the destruction by squirrels.

**Man (honey-hunters)**

Man was recorded as a pest of honeybees. Several honeybee colonies were destroyed by honey hunters especially in south Blue Nile State where honey hunting is the main activity of most of the native, on the other hand some traditional beekeepers complained from honey thieves, who kill bees and steal honey in honey production season. This result came in line with Ntenga and Mugongo (1994) who mentioned that man was the first of the several hazards to beekeeping industry in Babti district, Tanzania and Mogga (1993) who reported that honey hunters in Sudan apply much fire and smoke to drive out defender bees when the whole colony is destroyed or much of bee population is killed and Sanford (1984) who reported that the greatest predator or pest of honey bees might be man. Bees can be vandalized, stolen and/or burned. In addition, reductions of bee forage by large-scale agriculture and urbanization was deleterious to bee populations. A major threat was the proclamation of ordinances. Every beekeeper should, therefore, strive to become the best of neighbors

**Honey badger**

Honey badger was recorded as a pest of honeybee colonies in Sudan for the first time and this finding agreed with Ntenga and Mugongo (1994) who listed honey badger as one of the several hazards to beekeeping in Babti district in Tanzania.

**Livestock**
It is well known that Livestock provoke honeybee colonies. Different traditional beekeepers complain from camels that camels odour causing absconding of honeybee colonies. Caron (٨٧١) reported that colonies should not be located in the areas close to the area where large livestock are located.

٤٤ ٥ Birds

**Merops apiaster**

*M. apiaster* is a migratory species, which prey on bees in an apiary for a period of time and then moves on to another locality. Bee-eaters are dangerous because they attack bees in large flocks. In year (٣٠٠٢) *M. apiaster* was not observed during rainy season and winter season and this could be attributed to that there was high rate of rains in that year which provided the bird by different alternative food.

**Merops nubicus**

*M.nubicus* is a local migratory species. The birds are dangerous because they attack honeybees colonies in large flocks. *M.nubicus* harm is less than *M. apiaster* because it has other alternative hosts i.e. locust. Numbers of this bird were observed concentrated around grass fires and this behaviour could be attributed to that this bird have learned that bees were abundant when honey hunters apply much fire and smoke to avoid bee stings and others insects were abundant when farmers burned grasses with fire.

**Merops orientalis**

*M.orientalis* was observed in the following Stats; Khartoum, Darfur, River Nile and Blue Nile. It is harmless to beekeeping industry because it was not observed preying on bees in flocks.

**Merops pusillus**
Although this bird has wide distribution it has less importance to beekeeping because it was not found preying on bees in flocks and also it has alternatives hosts.

**Honey guide**

This bird is well known to honey hunters that guide them to bee nests. It was observed only in forests in Darfur State and this is agreed with Friedmann (1961a) who reported that the guiding behaviour is less common in populated areas, where the number of ratels and baboon are reduced, than in less populated areas. Only the adult birds eat the comb for the wax, which they can digest; they also eat adult bees (Friedmann 1961b).

**Ground hornbill *Bucorvus abyssinicus***

This is the first record of this bird as a pest of traditional hive of honeybees in Sudan. The majority of traditional beekeepers in Darfur State said that this bird damaged their traditional hive entrances. We thought that this bird can not cause this high damage alone. Others factors may share in this damage such as environmental factors (rain, wind) or others animals.

**6.5 Bee poisoning**

It was observed that wild honeybee colonies were reduced in cultivated areas (Gezeir, Elrhed, Khartoum) this may be due to the intensive use of insecticides in these areas. To reduce bee-poisoning hazards the safety measures of using pesticides are recommended (Johnsen 1977).

**6.7 Testing for Hygienic Behaviour in Sudanese Honey Bee**

Although the expression of this characteristic by any given hive of bees varies somewhat with time and circumstances, there is a standard quantitative test, which is now routinely used to determine whether a
specific hive of bees is deemed 'hygienic' or not according to Melathopoulos (2002) our honeybee stock were regarded as hygienic.

Questionnaire

It was found that all the results obtained by questionnaire similar to those obtained by field survey in general. However questionnaire added new information about estimated damage, control measures and mammal pests. Data obtained by questionnaire came agreed with out details (wasps ants beetle).
References


Abu Lila, (٦٩٩١). *The pests of honeybees. Training Course on the Diagnosis of the pests and diseases of honeybees*. Arab Organization For Agricultural Development P.O.Box: ٤٧٤ Khartoum, Sudan.


Ahmed, D. (٢٠٠٢). *Biodiversity in Sudan* (in Arabic) Sudanese Association for Environment Conservation


Anonymous (1999). Questionnaire of Arab Organization For Agricultural Development on the present and constrains of Beekeping. Arab Organization For Agricultural Development P.O.Box: 47 Khartoum, Sudan.


Delaplane, K. S. (2003). The Small Hive Beetle, Aethina tumida a new beekeeping pest. bugwood@arches.uga.edu


Geroge, (.StartsWithYear). Hygienic behaviour. WWW.mainbee.com


Jenn, R.AY. (StartsWithYear) Ravages of bee-eater Am. Bee J. 113 (1): 71.


Koeniger, N. (StartsWithYear). The parasite host relationships of Varroa jacobsoni and Apis species. 11th. Nter. Congr. IUSSI, India

Koeniger, N. (StartsWithYear) Overwintering and Varroa mortality. Bierie. 120: 37, 21-227.


Melanthopoulos, A. (1994). Testing for hygienic behaviour in honeybees. melanthopoulosa@em.agr.ca


*Mostafa, A.M. and Williams, R.N. (1994). new record of the small hive beetle Aethina tumida in Egypt and notes on its distribution and control,* Bee World 1-3 pages


Webster, T.C. and Callaway, D.J. (1947). Bee Science 7, 30-138


Appendix (1)
The vegetation belts of Sudan
### Appendix (٧)

**Annual means from normal of the period (١٩٩١-٢٠٠٢)***

<table>
<thead>
<tr>
<th>Element</th>
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<th>Annual mean min. temp.°C</th>
<th>Annual mean Relative Humidity%</th>
<th>Annual mean Rainfall (mm)</th>
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<td>٨٢</td>
<td>٦٢,٤</td>
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</tr>
<tr>
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<td>٨١,٩</td>
<td>٦٠</td>
<td>٦٩,٨</td>
<td>٦٩,٨</td>
</tr>
<tr>
<td>Wad medani</td>
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<td>٦١</td>
<td>٦٨,٧</td>
<td>٦٨,٧</td>
</tr>
<tr>
<td>Obied</td>
<td>٦٧٧,٧</td>
<td>٦٠,٠</td>
<td>٦٦</td>
<td>٦٨,٧</td>
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<td>٦٤,٦</td>
</tr>
</tbody>
</table>

(Source Meterological Corporation)
Appendix (3)

Illustration of recent status of small hive beetle in Africa and USA

Illustration of recent status of small hive beetle in Africa (A) and USA (B). Darker areas signify infested countries or states. The numbers on the Africa map refer to countries as follows: (1), Egypt; (2), Eritrea; (3), Ethiopia; (4), Kenya; (5), Uganda; (6), Nigeria; (7), Zimbabwe; (8), Botswana; (9), Namibia; (10), South Africa.

(Source Mostafa and Williams 2002)