15. CONSTRAINTS TO DEVELOPMENT

THE NATURE OF CONSTRAINTS FACING BEEKEEPERS IN DEVELOPING COUNTRIES

Beekeepers worldwide face increasing constraints, and the extra challenge for beekeepers in developing countries is how to address them with fewer resources to do so. Constraints facing the sector may be broadly categorised as biological, technical, trade and institutional.

BIOLOGICAL CONSTRAINTS

Biological constraints include the introduction of exotic species and races of honeybees, honeybee diseases, predators and parasites, the loss of indigenous species and habitat diversity, and problems arising because of pesticides use. Some of these aspects are also discussed in Chapters 2, 4 and 8.

The legislation of industrialized countries to prevent the introduction of undesirable honeybee pests and predators, and to protect species and races of honeybees is increasingly sophisticated, yet as we have seen, it has proved inadequate to prevent the spread of honeybee diseases and parasites throughout the developed world. For example, developing countries of sub-Saharan Africa contain the last populations of *Apis mellifera* (the honeybee species most widely used in beekeeping industries world-wide) that are as yet relatively uncontaminated by introduced diseases and parasites, or introduced exotic bee species or races, yet few of these countries have legislation in place to protect their indigenous bee populations. These indigenous bees deserve preservation, not only for biodiversity reasons, but also because they represent the last stocks of uncontaminated *Apis mellifera* bees, and are resources that may in the future be needed by, and be valuable to, the world beekeeping industry, for example in the provision of virus-free stock.

The pathology of diseases and parasites affecting non-European species and races of honeybees are poorly understood. Populations of these less-known bee species may be threatened because of over-exploitation, or because of competition from introduced races and species of honeybees. The trend has been for these diseases and predators to remain little known or researched until they have been introduced to *Apis mellifera* stocks (for example, *Varroa* spp., *Tropilaelaps* spp., and most recently, small hive beetle). Of course, it is the absence of understanding by beekeepers, combined with lack of regulations and enforcement that has enabled the increasingly rapid spread of pathogens during the past thirty years. The main pests and predators affecting beekeeping world-wide are summarised below.

TABLE 27
Honeybee pests, predators and diseases

HONEYBEE PREDATORS	HONEYBEE DISEASES	OTHER PROBLEMS
Mammals Humans Rodents Honey badgers Bears **Insects** Moths Ants Small hive beetle **Mites** *Acarapis woodi* *Tropilaelaps clareae* *Varroa destructor* **Spiders and pseudo scorpions** **Birds**	**Viruses** Sacbrood Thai sacbrood Chinese sacbrood Chronic paralysis virus Kashmir bee virus Deformed wing virus **Fungi** Chalkbrood Bacteria American foulbrood European foulbrood Protozoa Nosema Amoeba	Dysentery Chilled brood Laying workers Drone-laying queens Pollen shortage Honey shortage Pesticide poisoning

Not all of the above are significant everywhere in the world; for example, honey badger is a major predator of honeybee colonies in east Africa, but not in West Africa. In recent years, the main problems for the beekeeping industry have been the spread of *Varroa destructor,* and most recently, the small hive beetle. These are both predators that have been spread outside their natural distribution, and that can have fatal effect upon the new host races or species of bees. As these predatory species have been spread rapidly around the world, the world's apiculture researchers endeavour to learn about them and find effective and sustainable methods to control them. Few beekeeping textbooks are completely up to date with current methods of control, and for many beekeepers gain their main knowledge from attending beekeeping meetings and conferences, and from the internet. Please see Chapter 16 for such sources of further information. The following sections introduce the main pathogens, pests and predator problems faced currently by beekeepers. In industrialized countries, legislation controls the way that beekeepers are permitted to manage some of these problems. Only few developing countries have legislation concerning beekeeping methods, and lack of regulation means that in many poor countries honeybee diseases are treated often with chemicals that would be illegal elsewhere. The presence of residues of these chemicals in honey is dangerous for human health and if detected, will lead to loss of trade, as outlined in Chapter 14.

Parasitic mites

Several parasitic mites are important pests of *Apis mellifera*: *Acarapis woodi, Varroa destructor* and *Tropilaelaps clareae*. The natural host species of *Varroa destructor* is one race of *Apis cerana, and t*he natural honeybee host species of *Tropilaelaps clareae* is *Apis dorsata.* In Asia, indigenous honeybees have evolved in the presence of *Varroa* and *Tropilaelaps* mites and have natural host-predator relationships where neither the host species (the bee) nor the predator (the mite) is wiped out completely. By contrast, *Apis mellifera* has not evolved in the presence of these mites and has no natural resistance. *Apis cerana* has a range of methods including grooming of its body, to rid itself of *Varroa* spp. Beekeepers have increased the distribution of these mites outside their natural range, by moving bee stocks throughout the world.

Varroa destructor

During the past twenty years, this ecto-parasitic mite has had a significant effect upon beekeeping industries in many countries. It is now present throughout most of Europe, North, South and Central America. In Africa, it is present in all countries bordering the Mediterranean and is present in South Africa. Recently it has been spreading north of South Africa and was identified in Zimbabwe in April 2003 and in Botswana later the same year[38]. The female mite is red coloured with four pairs of legs whilst the male is much smaller and white. In one batch of eggs, the (single) male hatches before the females and mates with the females before the females emerge from the cell. Only females are long-lived and feed on the haemolymph of adult bees by squeezing under the tergites of the abdominal segments.

Symptoms

This mite feeds on brood and adults: when the larvae in the brood are attacked young bees emerging from the cells are deformed (the extent depending upon how many mites were in the cell). If too many, the bee will fail to live to emergence.

Life cycle

The mated female mite enters the brood cell before it is capped, and lays eggs on the young bee larvae on day 10 of the bee life cycle. Male mites hatch first and mate with females. As the bee pupa develops, the mites develop. When the worker emerges, she is already infested with mites. The worker bee takes 21 days to develop whilst the drone takes 25 days. Consequently, drone brood usually contains more mites. The mites are able to select drone brood, and therefore one method of control is to selectively remove drone cells. The *Varroa* mite can survive on adult bees, but the parasitic effect of the mite on an adult bee is not so important – the mite is sucking haemolymph, but the bee is able to survive this as long as there are not more than three mites per bee. Most dangerous for the colony is the number of mites parasitising on brood. If there are two mites per larva, the larvae will die in brood cells. With one mite present on a bee at its pupal stage, these are the resultant changes in behaviour:

[38] *Bees for Development Journal* 72, 2004.

- the adult bee changes abnormally quickly from a nest bee to a foraging bee (this is influenced by damaged food glands);
- lower resistance to pesticides (because the bee's fat body is not so well developed);
- orientation ability is reduced;
- cleansing instinct is lowered;
- brood care is less; and
- guarding service is reduced.

It is not just the effect of the mite itself that kills *Apis mellifera* colonies – the mite carries viruses, and it is these that kill the colony. Pesticide is more dangerous for bees if *Varroa destructor* is present and the symptoms of chalkbrood and sacbrood become more obvious. Bees are very easily robbed, and when the colony is collapsing, the bees fly with the robber-bees back to their hive. In colonies that have died out because of *Varroa*, the beekeeper will often find an empty hive. This is because the bees, and the mites they are carrying, have moved to a healthy colony, which now has more bees and many mites. Even when beekeepers are treating colonies properly, after one month, 5,000 'new' mites can have arrived on bees arriving from collapsing colonies. Therefore, it is helpful if beekeepers can work together in controlling *Varroa* populations.

Many different medicines have been developed to treat *Varroa*. None of these is of any use unless they are connected to management. Mites quickly develop resistance to any chemical used to control them, and beekeepers need to use integrated methods of control. There is no single 'magic bullet' way to control *Varroa*.

Tropilaelaps clareae

This is also a mite predator of bee brood, but it can easily be controlled by removing brood cells. In countries or areas with cold winters and therefore a natural break in the colony's brood rearing, the mite population is naturally controlled in this way. However, for beekeepers in tropical countries this mite could be a problem when the mite population becomes large. A break in the brood cycle of three days is necessary to prevent *Tropilaelaps clareae* surviving.

Nest symbionts

Braula coeca is the bee louse, which is often mistakenly identified as one of the bee mite species. It is a wingless fly that lives in bee nests, and it is not a problem for the bees.

Observation of mite populations

Collect a sample of bees, and using plastic sheeting, make a funnel to pour the bees into a jar containing petrol or paraffin. The mites float on the surface of the liquid. Filter the liquid and identify the mites.

BACTERIAL DISEASES

American foulbrood

The causative agent of American foulbrood (AFB) is *Paenibacillus larvae larvae.* As far as is known, this disease only affects colonies of *Apis mellifera,* and it is one of the most dangerous diseases for honeybee colonies, being difficult to eliminate since the bacterial spores survive for at least 50 years. Spores of AFB can be found in honey samples, even though the colonies from which these samples are collected may not yet be showing symptoms of the disease. There is no cure for AFB, and quarantine measures are difficult to implement. Once the symptoms are identified in a colony, the only answer, which has been recommended for many years to prevent this disease spreading to other *Apis mellifera* colonies, is to burn all infected colonies and boxes. In addition, it has been recommended that all clothes and tools should be destroyed. In recent years, the Danish researchers Hansen and Brodsgaard have been advocating 'The shaking method' to control AFB (Hansen and Brodsgaard, 2005). In this method, a colony is shaken from its hive into a screened box, left in a cool place for three-four days, and then re-housed in a new hive with completely new frames and equipment. In this way the pathogen is reduced to a level at which it does not provoke clinical symptoms of the disease.

Symptoms

The disease is present in brood comb only. Larvae affected by the bacteria die after the cell is sealed. There is a bad, unhealthy smell, and the brood comb looks like a destroyed mass with broken cappings, sunken cappings, and holes in sunken capping or "pepper pot" brood with many empty cells. The disease affects larvae soon after hatching but the larvae continue to develop and die as pupae. The resulting dead pupae dry out as a dark scale that becomes stuck to the side of the bottom of the cell and is very difficult to dislodge. If a pupae dies and is held vertically in the cell, very often the labrum (the bee's "tongue") sticks out. Prior to these well-developed terminal symptoms being seen, if a match stick is inserted into an infected cell, on withdrawing it slowly, about an inch of ropey brown foul-smelling liquid is withdrawn attached to the matchstick.

Beekeepers do well to form local associations in order to obtain and share information and to produce their own wax foundation material. Imported wax foundation is a potential source of infection. Unnecessary import of inputs should be avoided. A good beekeeper detects AFB and treats colonies for it, and the real source may be never identified. Spores of AFB are very widely spread: they can be present in a colony that does not yet show symptoms of AFB.

European foulbrood

The causative agent of *European foulbrood (EFB)* is *Melissococcus pluton*. This disease is quite different from American Foulbrood, and is less dangerous since it is less contagious, and colonies with EFB can be treated and cured of the disease. The smell of EFB is distinct from that of American Foulbrood. EFB affects mainly unsealed brood.

Symptoms

A normal, healthy honeybee larva is curved and lies relatively still, whereas a diseased larva is straight and writhes about. The larva dies before the cell is capped, and consequently it is possible to see dead larvae in cells. Unlike American foulbrood, there is no sunken or punctured capping, and no drawn out ropes of liquid when a matchstick is inserted and then withdrawn from infected cells. The dead larva turns black in the bottom of the cell, but does not adhere to the side of the cell and is easy to remove with a toothpick.

Interventions

Some beekeepers burn and destroy the colony and the hive. However, worker bees remove diseased larvae outside the hive and a colony with EFB can sometimes survive without intervention from the beekeeper. Strong colonies are more resistant to this disease. The disease will be more common in small colonies that are stressed, for example, colonies belonging to migratory beekeepers, and those that are short of water. Some beekeepers treat bees with antibiotics such as *Terramycin* (tetracycline), which merely suppress the bacteria population – the antibiotic is mixed with sugar and spread on to the colony or diluted with syrup and sprayed on to the colony with a six-week post-application interval prior to harvesting the honey.

If bees are continuously fed antibiotics, the symptoms of the disease will never show. The use of antibiotics in this way is not an environmentally sound procedure and is banned by law in many countries. Excess use of antibiotics allows them to enter the food chain and risks selecting resistant disease-causing organisms within the human population, thus making these compounds useless in controlling important human diseases.

BOX 16
Viral diseases

There is no cure for viral diseases.

SACBROOD VIRUS AND THAI SACBROOD VIRUS
Symptoms
Sacbrood virus affects the sealed brood of *Apis mellifera*, while Thai sacbrood affects the sealed brood of *Apis cerana.* When diseased larvae are removed from the cell with tweezers, the larva looks like a wet bag of white sap. The cappings of the cell are perforated.

Interventions
Strong colonies survive best. Small, stressed colonies are susceptible to viral diseases. If the colony is requeened and transferred to a new, clean box, the colony may overcome the attack.

OTHER VIRAL DISEASES
There are many diseases of bees that have recently been recognised as of viral origin. Many of these change the behaviour of bees, for example, the bees crawl on the ground and do not attempt to fly. Parasitic mites such as *Varroa destructor* serve as vectors for these viruses.

- Bee paralysis virus
- Chronic bee virus
- Black queen cell virus and many others still being identified.

PROTOZOAN DISEASES
Nosema disease - diarrhoea: the causative agent is *Nosema apis.*

Symptoms
Brown faecal spots are seen at the entrance to the hive. This often occurs when artificial feeding is taking place.

Cure
Keep the bee colony strong, and stop feeding the bees.

FUNGAL DISEASES
Chalkbrood
This is a fungal disease affecting sealed brood, caused by a fungal organism: *Ascosphaera apis*. The cell cappings are perforated, and the larvae become solid and white – 'mummified' and chalk coloured. Nurse worker bees remove affected larvae from the hive and the disease is not a problem in strong colonies. Severely affected colonies should be requeened.

PESTS OF BEES AND BEE NESTS

Moths

Several moth species feed upon the products of honeybee colonies: honey, pollen and beeswax. Most well known to beekeepers are the wax moths, and more rarely, death's head hawk moths, *Acherontia* spp.

Wax moths

The greater wax moth, *Galleria mellonella*, can be found in association with *Apis mellifera* and the Asian honeybee species. It seems to be a more severe pest in the warm climates of the tropics and subtropics. The lesser wax moth, *Achroia grisella,* is more commonly found in temperate zones. The greater wax moth may be to three centimetres long – the lesser wax moth is around one centimetre long. Larvae of these moths (and several other species) feed on wax. They are adapted to the life cycle of bees, and in nature, feed on empty, and abandoned outer combs during the winter or non-flowering period when the colony size contracts and the bees occupy only the central combs in the nest. Wild bees thus build fresh combs each year, and wax-feeding moth larvae perhaps fulfil a valuable role in nature by removing old and diseased comb in wild nests: they do not in general feed on occupied comb. Wax moths can be a problem for weak colonies in hives, and in unoccupied comb or foundation stored in hives during the non-flowering period. The moth can be repelled from empty supers and boxes of wax comb or foundation by the use of naphthalene or paradichlorbenzene sprinkled on sheets of newspaper placed between the supers when stored one on top of another vertically. The stack should be placed on newspaper. If paradichlorbenzene has been used, before reusing the boxes and supers with bees, they must be aired so that there is no trace of the smell of the chemical, since it will also flavour and ruin any future honey produced in boxes stored in this way. Mechanical control of the larvae can be made of infested comb, and badly infested comb burnt. If neglected, bad infestations of the larvae will also attack and damage the boxes.

Small hive beetle

The small hive beetle *Aethina tumida* is not considered a very serious pest of honeybee colonies in Africa: *Apis mellifera* African honeybees rarely allow the beetles to multiply to an extent where they are harmful to the colony. Beekeepers are accustomed to seeing a few of the beetles (as well as the large hive beetle) in colonies, but numbers remain low. In 1998, small hive beetle was reported from Florida in the US. This was the first recoding outside Africa. The introduced European races of *Apis mellifera* are not accustomed to these beetles, which are able to multiply greatly within the colonies. The beetles spoil the honey in combs, cause it to ferment, and damage the combs. The colony is weakened, eventually dying out or absconding.

Predatory birds

It is said that so-called Bee-eater birds (*Merops* spp.) and others prey on bees. However, certainly in the case of the Bee-eater it has been shown that it is in fact a beneficial species for bees, preferring hornets to bees: hornets are in some areas harmful predators of honeybees and regularly take bees from the entrance of hives.

TECHNICAL CONSTRAINTS

Technical constraints facing beekeepers in developing countries concern lack of knowledge of appropriate methods for managing tropical bee races and species, lack of appropriately skilled trainers, materials and training possibilities, and lack of dissemination of new research information, especially as described above, relating to disease control. Few developing countries have laboratories with resources to identify honeybee pathogens, or to identify the residues as described below. There are only a handful of laboratories world-wide with the necessary skills and resources to identify honeybee viruses.

TRADE CONSTRAINTS

Constraints faced by producer groups in developing countries often include problems arising because of the remoteness of producers from suppliers, traders and technical advisers, the often-small volumes of products, and difficulties of obtaining pre-finance for honey purchase, packaging and marketing. A major constraint is the increasing requirement for bee-products to meet international standards. As described in Chapter 14, the world market demands increasingly that honey be certified free from chemical, antibiotic and other residues. These residues are likely to be present in honey due to the use of medicines to treat honeybee diseases, introduced during some form of honeybee management, or from environmental pollution. This demand for residue-free honey opens opportunities for honey producer organizations in the poorest countries. It is often the most poor and most remote people of these countries, with few other livelihood options, who practise beekeeping. These people can harvest honey and beeswax that are of excellent quality, and especially now, because these products are residue-free, they can achieve good prices on world markets, if they are able to gain access. World market access depends upon honey meeting the import criteria of the world markets, and this is where producer organizations' problems begin.

Currently only five African nations[39] are able to conform with EC import requirements relating to antibiotic and other residues. These are Kenya, South Africa, Tanzania, Uganda and Zambia. Only four Asian countries (China, India, Taiwan and Vietnam) meet EC import requirements.

Therefore this legislation denies access to EC markets for most African countries, even though chemical residues are not a problem in African honey. Beekeepers in rural areas of Africa still harvest from stocks of

[39] Last amendment of Commission Decision 2004/432/EC of 29 April 2004 on the provisional approval of residue plans of third countries according to Council Directive 96/23/EC (Last amendment = Decision 2005/233/EC).

wild honeybees, uncontaminated by the diseases and exotic predators that now afflict bees in most other world regions. For this reason, African beekeepers do not apply medicines to their bees and are able to harvest the residue-free honey that is currently in short supply on the world market.

At present honey with any detectable level of any antibiotic, including streptomycin, cannot be imported into the EC because no Maximum Residue Limit (MRL) has been set, even though streptomycin is permitted in other animal products and does not represent a public health issue. Bees *for* Development[40] has undertaken research funded by the UK Department for International development (DFID) towards proving that streptomycin can occur naturally at low levels in honey, and is not necessarily a contaminant.

Honey regulations are effective at different levels: see Table 28 below:

TABLE 28
Honey criteria and legislation

Level of influence	Organization
Global	Codex Alimentarius
Regional	e.g. European Community (EC) Regulations Directives
National	Honey laws Beekeepers' Associations Supermarket chains Honey exporters Honey importers Honey packers Consumers

Globally, Codex Alimentarius sets a definition and gives chemical standards for honey, and this definition is widely used and accepted. The EC criteria for honey are regional, but at the national level, honey regulations may be more or less strict, and supermarket chains in industrialized countries set their own criteria that may well be more prescriptive than other honey standards. Honey coming into the EC from third countries has to meet EC honey criteria – but of course as honey is a natural product – honey arising (for example) from tropical areas is likely to be very different from honey created from European flora. Where these differences are proved to be due to natural reasons, then EC honey standards are modified accordingly.

One area where there is a significant difference is in the EC definition of honey, which, unlike the Codex Alimentarius, states that honey is the product of *Apis mellifera* honeybees. This means that honey produced by other honey-producing bees such as the Asian honeybee species, or by stingless bees, would not qualify as honey for the EC.

INSTITUTIONAL CONSTRAINTS

These include the weakness of producer organizations, and lack of resources (personnel, laboratories) to support the industry: to analyse products, certify for export, identify bees and their diseases and parasites. As mentioned above, there is a lack of policies that protect the industry and prevent the introduction of bees diseases and parasites. Infrastructure to monitor, certify and enable trade in honey and beeswax is also lacking in the majority of developing countries. This has implications for the apiculture industry as so much honey and beeswax tend to be traded informally and never reach official trade statistics.

Beekeepers in developing countries need regulatory and organizational services and support to create market links and meet trade criteria, and ultimately to maintain their precious stocks of healthy, indigenous bees[41].

[40] Bees *for* Development Journal 72, 2004, 3.
[41] For more references: ARC Plant Protection Research Institute Honey Bee Research, Stellenbosch, South Africa, www.arc.za/institutes/ppri/main/divisions/beekeeping/honeybeeresearch.htm