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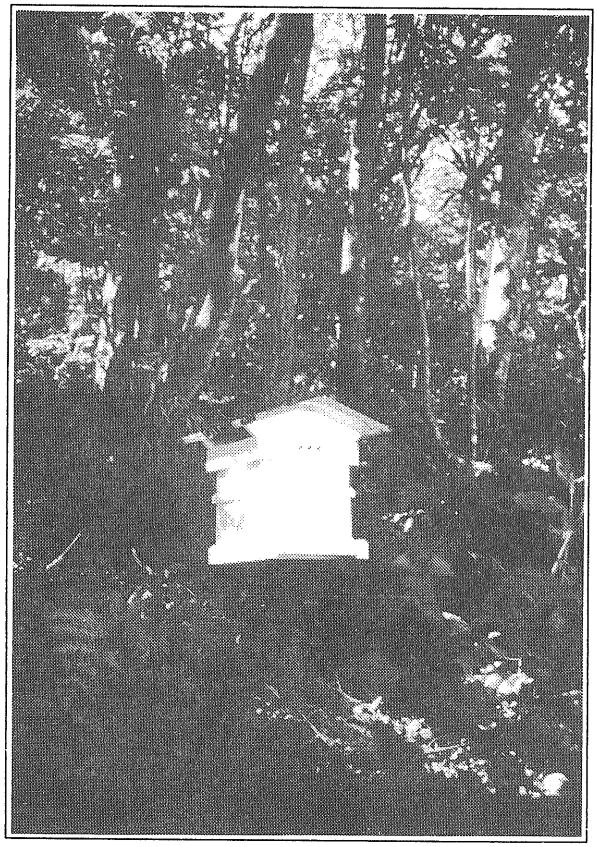
Bees and trees

Börje Svensson



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BEES AND TREES

PREFACE

It's not just that Bees and Trees rhyme well! Bees and trees are interdependent, and have been perfecting their relationship over the last 50 million years or so, literally millions of years before man appeared on the scene.

A wonderful and complex interdependency has evolved whereby flowering plants depend upon bees to bring about pollination and thereby the production of viable seeds. The bees in turn depend upon the plants for their food. Trees do not need bees simply for their own reproduction (although for many species bees are vital), but for maintenance and regeneration of the whole system within which the trees exist. The more species of fruits and seeds generating within a system, the greater its diversity, and the richer its life-carrying capacity. Trees and bees represent truly harmonious symbiosis. It is essential that this symbiosis is protected.

Rural people can also generate income from this symbiosis, while at the same time helping to safeguard natural habitats by encouraging it. The sustainable use of tree resources is now widely promoted but the tremendous scope for sustainable use of bee resources is as yet poorly appreciated.

This document explains how to encourage and protect the important relationship between bees and trees, and the benefits of doing so.

The information is not intended just for beekeepers! It is presented here for the attention of people in all sectors of forestry who make decisions concerning future resources for bees and beekeepers. The document will have achieved success when it is read and used by people who had not considered previously the ecological importance of bees and the economic value of beekeeping.

Nicola Bradbear
International Bee Research Association

Cover photo: A royal bee-hive in the royal forest sanctuary of Gokarna, Nepal

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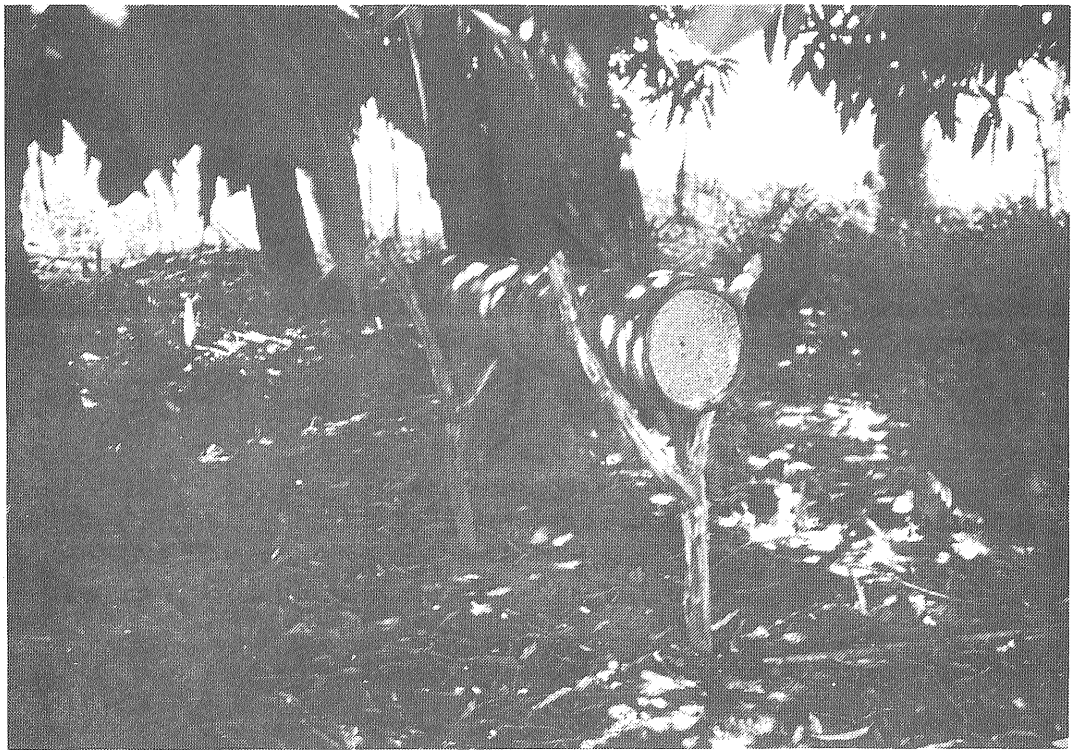
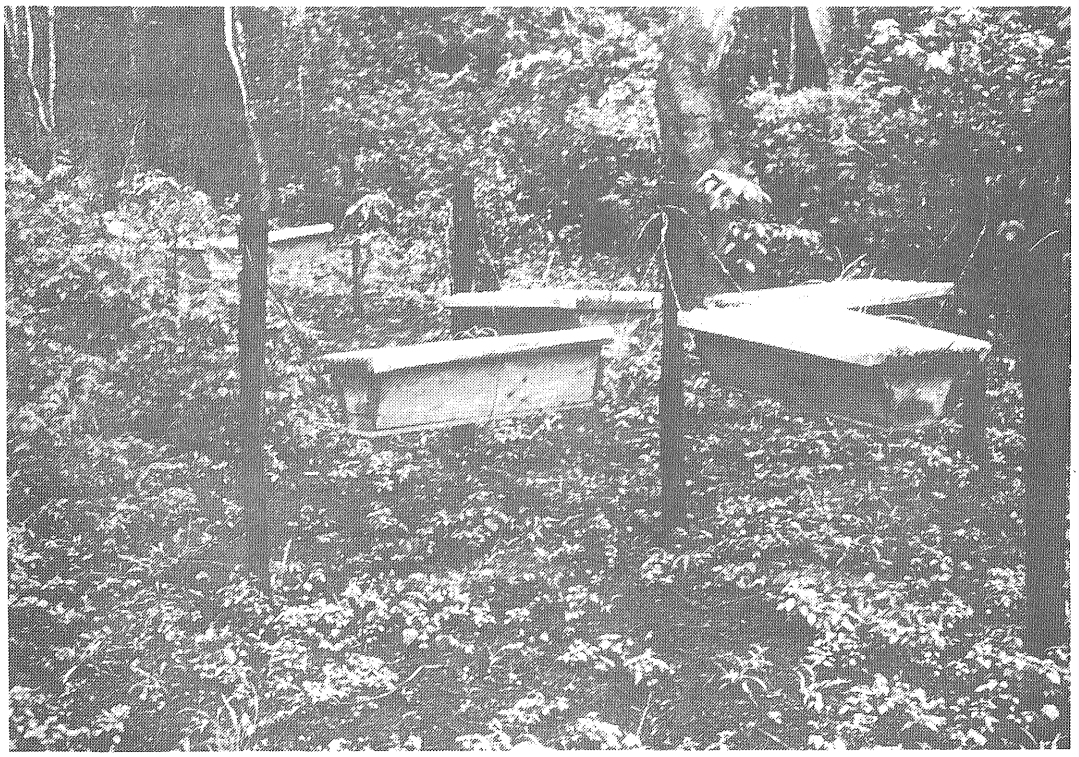


"Get yourself a fruit garden and a hive of bees"
(Cachungo, Guiné-Bissau)



..... just five bee colonies was sufficient to pay the school fees for six children at secondary school!
(Nairobi, Kenya)

INTRODUCTION

'Do you want to be happy for the rest of your life? Get yourself a fruit garden and a hive of bees' Chinese proverb

'The one who planted a tree did not live in vain!' Harry Lindkvist

In many cultures proverbs dealing with bees and trees are common. Trees are often connected with life, reserve capital or the relationship between generations.

This affects the daily life of farmers; for instance, a farmer in Vietnam will plant Melia azadirachta trees for his newborn son which will eventually provide timber for a house when the son marries. Similarly, a father in India will plant Casuarina trees as future 'dowries' for his daughters, and a farmer in Kenya may plant Eucalyptus, Cupressus or Pinus trees at the birth of a child to provide income for school fees. (Chambers, 1988, Corlin et al., 1989)

Many societies associate bees with savings for future needs, wealth, prosperity, fertility and long life. (Crane, 1983)

Regina Matiro, a beekeeper from Kibwesi in Kenya, provided newspaper readers in Africa with a good example of the value of bees: the two harvests of honey she gained from just five bee colonies was sufficient to pay the school fees for her six children at secondary school! (The Herald, Harare 17 June 1989).

The value of bees and trees is easily appreciated if we study their importance to societies before forests were over-exploited. People then used a small portion of the total forest production of fruits, wildlife, fodder, fuelwood, timber and honey. In ancient times trees were abundant and variations in crop production could always be endured because of the presence of reserve resources within forests. Honey-hunting in forests was one such activity that did not over-exploit the trees but provided a highly valued food.

During the last 50 years a great change has taken place. The over-exploitation of trees and forests now threatens the existence of man. One consequence of forest degradation is a decreasing number of bee colonies in many parts of the world, thus depriving people of both food and income. The information on Tiro-Botar Becho in Ethiopia (fact box 1) is a sad example of an area where bees have disappeared after tree felling in recent years.

One of today's greatest challenges is to save existing forests, to regenerate and develop others and find sustainable management systems which provide both income and food for future generations. Community forestry activities support the use of multipurpose trees to benefit everyone in a rural community.

Many multipurpose trees are good nectar or pollen producers and/or provide shelter for wild bees' nests or beehives. Beekeeping must therefore be supported by community forestry activities. Careful comparison may reveal that beekeeping is one of the most remunerative activities in community forestry, with economic returns commencing soon after the start of the project.

This report attempts to produce a multi-disciplinary contribution to the discussion of community forestry and trees, people and bees. It is the authors' wish that development workers in both beekeeping and community forestry will find arguments for further interest and research into suitable planting practices and appropriate beekeeping technology. Beekeeping is well established in some developing countries, but great scope remains for forest-based small-scale enterprises to run in conjunction with community forestry projects.

The arguments for beekeeping development presented in this report will be valuable to extension workers, forestry officers and project planners willing to face the challenge of finding food and income for our growing human population.

Women carrying traditional beehives to the local market at Modula, Ethiopia (Photo: Anders Öhlund)

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Women carrying traditional beehives to the local market at Modula, Ethiopia (Photo: Anders Öhlund)

FACT BOX 1

Forests and beekeeping in Ethiopia

Beekeeping held great importance in the traditional Ethiopian society, but is today threatened as an income-generating activity by devastating forest degradation. At the beginning of this century forests covered an estimated 40% of Ethiopia: today not more than 4% is covered.

The national policy to counteract degradation contains three programmes:

1. Protection of remaining forests
2. Fuelwood production around the cities (mainly Eucalyptus)
3. Community forestry activities near small villages

The Tiro-Botar Becho forestry project south-west of Addis Ababa has realised the former importance of beekeeping in rural society. The project area includes about 20 000 ha of natural forest which is still one of the largest forests in the central highlands of Ethiopia. However, Björklund and Ståhl (1988) describe the drastic decline of beekeeping among the population. Farmers claim that honey used to be their main cash income and many families had 30-50 beehives, some of them up to 100 hives. Honey-hunting was also important.

When logging activities started in 1952, bees began to disappear. At first wild nests in large trees disappeared but later on colonies kept in hives also diminished in number. Today almost no honey is being produced in the area. The reasons for this are:

1. A reduction in the number of large flowering trees
2. Prohibition of honey-hunting
3. A change of climate, resulting in severe droughts
4. Traditional methods are no longer viable when wild swarms are scarce
5. Hive damage by monkeys
6. The younger generation is not interested in beekeeping. One farmer concludes: 'We do not care about it as we did before; the young ones do not want to be taught either.'

This sad experience from Botar Becho is a story common in many parts of the developing world.

SUMMARY

This report presents arguments for the establishment of beekeeping as a valuable forest-based, small-scale, income-generating activity that can be usefully incorporated into rural development.

Chapters 1 through 5 present facts about bees, trees, and their inter-relationship.

1. Bees are important to people because:

   * bees pollinate cultivated and wild crops

   * bees provide valuable food

   * bees are important for culture and social life

   * beekeeping is a very suitable income generating activity for poor people in rural areas

   * beekeeping creates a need for co-operation and enhances self reliance

   * beekeeping is good for the environment and helps to protect the ecological balance

2. Bees are important to trees because:

   - beekeeping is a good way of exploiting the forest resource without destroying it

   - beekeepers are encouraged to protect trees

   - bees pollinate tree flowers and thus help the regeneration of the forest resource

   - involvement of beekeepers in community forestry projects helps to improve people's participation

3. Trees are important to bees because:

   - trees are essential for the survival and production of bees

   - trees can help to protect beehives and provide materials for beehives, supports and various aids used in the process of managing bees

   - the floral diversity in a forest provides a base for a sustainable beekeeping sector

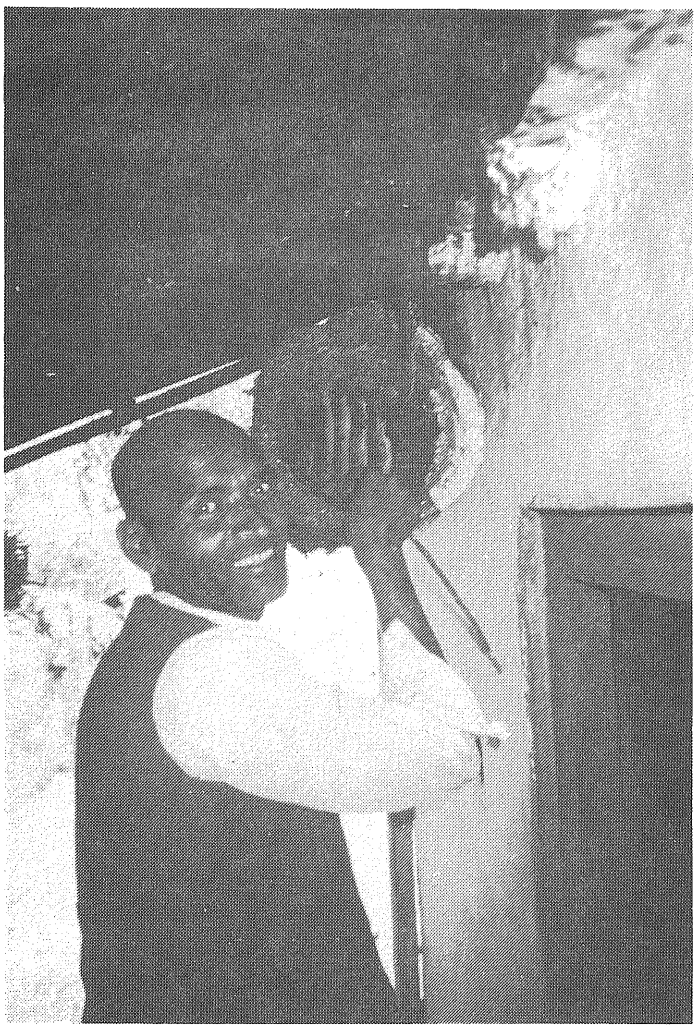
4. In most cases beekeepers are already using materials and methods which are sound from an environmental point of view. In some places, however, beekeepers are being accused of causing tree felling or forest fires. If such accusations are true, honeyhunters or beekeepers must be taught new methods of managing bees that are not harmful to the environment.

5. Chapter 5 is a mixture of general facts concerning the flowering biology of trees, the risks of introducing exotic tree species and the consequences for bees of various forestry management techniques.

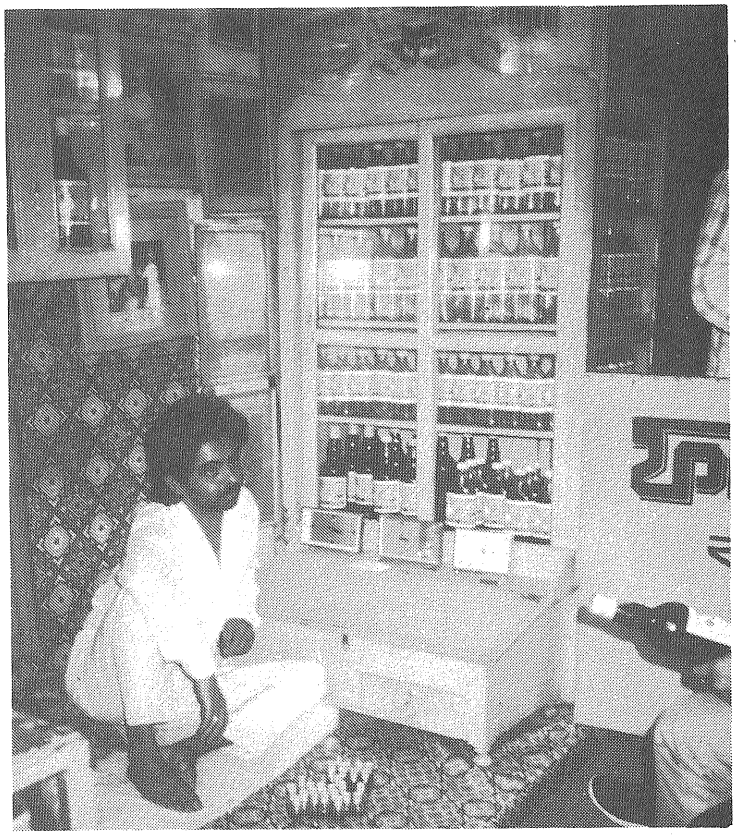
   Finally, the need for improved co-operation between foresters and beekeepers is also stressed.

Chapters 6 through 9 include data-lists and other relevant information for development workers in the beekeeping and community forestry sectors.

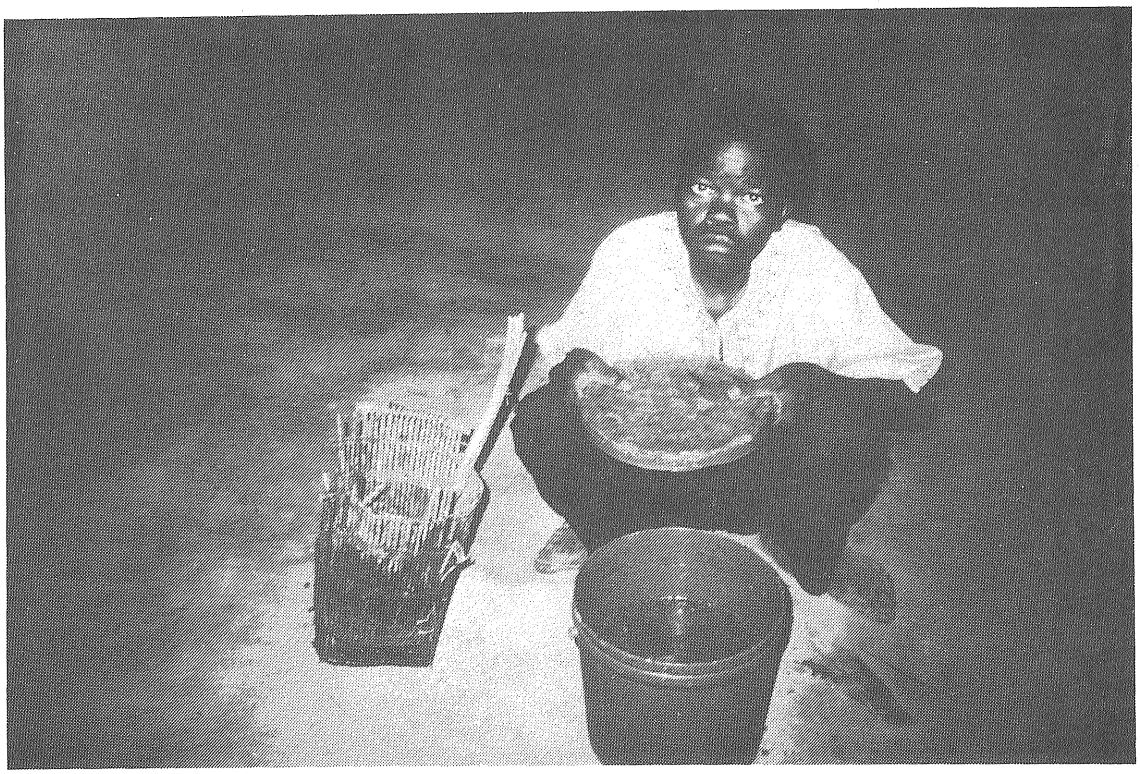
This report aims to serve both as a source of facts about bees and trees, and as a petition to stimulate discussion amongst all concerned development workers.



..... beekeeping ..... enhances self reliance .....
(loghive beekeeper in Laleng, Nepal)



..... a regular honey intake may be vital, although the total quantity of honey consumed is not large. Honey shop in Dhaka, Bangladesh



Beeswax is a very valuable bee-product (Ikoko, Zaire)

1. How do bees benefit people?

1.1 Pollination

The pollinating activities of bees gathering nectar and pollen from cultivated crop plants is important for achieving optimum quality and quantity of the crops. (See also 6.2.) (McGregor, 1976)

As bees fly from one flower to another in search of food, their hairy bodies transfer pollen grains between flowers and thus ensure pollination and the subsequent development of seeds and fruits. The seeds and fruit may be eaten by man or other animals or used to grow another crop of fodder for animals.

Honeybees are considered outstanding pollinating agents for the following reasons:

- flower constancy (on each foraging trip, a honeybee visits flowers of only one species)

- large colony size (one colony contains 30-50 000 insects)

- potential for high colony concentration (50-100 colonies can be kept within a limited area).

Honeybees are especially important in tropical and subtropical regions where a majority of cultivated and tree crops require insect pollination. (Baumer, 1985)

1.2 Honey and pollen

A honeybee colony must build up stores of pollen and nectar for its survival and development. Nectar is transformed into honey by the bees. Honey may be harvested from the hive by man and eaten with or without further processing.

Honey is a concentrated food source which also contains small quantities of enzymes and minerals. Honey can be a vital food for the rural poor of developing countries because:

a) In a diet limited in protein or mineral content, a regular honey intake may be vital, although the total quantity of honey consumed is not large. This is because in areas with limited technology honey is often harvested by pressing of whole combs. The result is a mixture of honey, pollen and bee-brood, which has a high protein content. Traditional beekeepers or honeyhunters often consider pollen stores and bee-brood as a delicacy. This has recently been filmed among the Gurungs of Nepal and the Baka tribe of Cameroon.

   Sometimes bee-brood is grilled and eaten, and separated from the wax combs. In Southeast Asia and Japan, grilled bees are considered a delicate snack. Commercialisation of these products would be difficult in developing countries because special preservation techniques are required.

b) Honey is a useful dietary component, particularly for children and old people, because it tastes sweet, yet has antibacterial properties, a valuable micro-nutrient content, and is believed to stimulate appetite. It also improves water absorption in children with diarrhoea.

c) Seasonally it can provide a useful addition to the diet, as it is often gathered or harvested when other food is limited or monotonous. It also keeps well, and can therefore be stored for use in times of food shortage.

The tradition of using honey to make beer, especially in Africa, must not be neglected in this dietary discussion.

Compared with industrialised countries, honey consumption is generally low in developing countries (Crane, 1990). This is because honey is not a daily food item but is a highly regarded food to be consumed on special occasions. This is particularly true for poor people in urban areas, who cannot produce their own honey. On the other hand some rural groups consume large quantities of honey. For example in Shaba, Zaire, Parent (1978) estimated a yearly consumption of 22 kg honey per adult (September-January). Ichikawa (1981) also studied the importance of honey in the diet among the Mbuti hunters in Zaire (see fact box 2) who collect and eat about 15 kg per capita during a honey season of just a few months.

As mentioned in the introduction, bees and honey are important culturally and socially for many different world groups. The uplift and stimulation that honey gives to the diet of people in traditional societies explains its important role in ceremonies, traditional medicine and as labour remuneration. This use of honey is rarely appreciated by visiting socio-economists or development workers. Honey is indeed 'an important lubricant in social life'!

FACT BOX 2

Foodstuff consumed by Mbuti hunters in a honey camp in Zaire, June 1975 (Ichikawa, 1981)

Food item	Average consumption per person during 12 days of honey season		
	kg	Cal	% of total
Honey	10.0	22.402	81.9
Wild animals (monkeys, rats, antelopes, birds)	2.0	1.839	6.7
Cultivated produce (cassava, beans, peanuts maize)	2.2	3.000	11.0
Wild produce (roots, nuts, mushrooms)	0.3	0.125	0.5
Total		27.366	100

Average consumption: 2.280 Cal per person per day
Daily collection time: 6-7 hours

Less effort is spent on food collection during the honey season than during the hunting season. Life is therefore relatively comfortable for Mbutis during the honey season!

1.3 Beekeeping and income generation

Beekeeping is a traditional, income-generating activity among poor people almost everywhere. In some parts such as the miombo woodlands of southern and eastern Africa, in Ethiopia and in the rain forests of Africa, south Asia and Central and South America, beekeeping has been the most important income generator for many families. In some cases, production has decreased in recent times due to environmental changes but beekeeping remains potentially an important income-generating activity for rural households in developing countries. (Fact box 3)

Family-level beekeeping among poor people can be very profitable. On the other hand large operations with employees, modern equipment and sophisticated management methods will not necessarily be profitable and may even collapse

unless subsidized. Many projects have shown that it is difficult for poor people to adopt a technology that is unsuitable for local conditions, local bees and the educational level of the beekeeper. Modern technology will rarely be profitable for the beekeeper unless s/he is supported by project finance and/or regular extension help.

FACT BOX 3

Comparisons between beekeeping income and average annual incomes.

Country	Net annual income per honeybee colony	Income from a honeybee colony as % of average annual worker's income
Bangladesh -		
appropriate technology	US$19	12
advanced technology	US$38	18
Jamaica	-	4
Kenya/Rift Valley		
traditional hive	200-600 KSh	
top-bar hive	290 KSh	
Nicaragua	-	17
Pakistan -		
low cost hive	US$29	-
modern frame hive	US$32	-
Sri Lanka	-	max 10
Tanzania -		
traditional hive	-	1.9
Zaire	US$25	12-17

Ethiopia: One kg of honey equals 2-3 days of salaried work.

Exceptions exist in countries like Argentina, China, India, Israel, Mexico, Morocco, Nicaragua, Tunisia, and Vietnam where investments in large scale, modern, private or co-operative operations have succeeded.

Beekeeping is an activity which requires few resources when practised at family level. No land resources are necessary as hives may be sited on waste land or in back yards. Hives can be produced in traditional ways using whatever cheap materials are available locally. Recently experiments have shown that it is possible to develop intermediate technologies using low cost, local materials such as bamboo, grass, clay

or waste materials. Bee management and honey extraction can be handled without sophisticated equipment, using instead the materials and containers normally available in rural households.

Beekeeping does not compete with other agricultural activities. Bees and flowers are usually freely available and will not be otherwise exploited. Furthermore, successful beekeepers often achieve a raised social status. (Drescher & Crane, 1982)

Beekeeping at family level tends to be mostly a seasonal activity requiring little labour. The time necessary for keeping bees will therefore not compete with other work or income-generating activities in the rural life. Beehive management is also a flexible job that can be carried out as time allows. Consequently, revenue from honey and wax sales will add to other income. Normally, good markets exist for honey and beeswax both in rural areas and on the international scene.

An expanding beekeeping sector in any society will also mean secondary effects for suppliers of wood, containers and other equipment, and within the transport and trade sectors.

1.4 Beekeeping and human development

Beekeeping is an interesting and stimulating activity. Beekeepers often become so fascinated that they devote increasing interest to their activity. In this way they learn more about bees and the environment and also about their own abilities as producers and entrepreneurs. Thus we can conclude that beekeeping generates self-reliance.

The last point is especially true of female beekeepers. Women have become very successful beekeepers. In Kibwezi, Kenya, beekeeping was until recently solely a male occupation as traditional beekeepers used to harvest honey in the forests at night time, and in the nude. The development of intermediate technology and protective clothing has made beekeeping in Kibwezi accessible to women. A side-effect is that the women often use their beekeeping income for the nutrition, clothes and school fees for children; male beekeepers tend to spend a large portion of their income on luxury items and beer.

In Bangladesh women are often less afraid than men are of bees and have a gentler way of managing bee colonies. However, the possibility for women to practise beekeeping has often been restricted due to traditional taboos. For instance, in Muslim countries women are not allowed to climb trees for collection of bee swarms and in other cultures women are not allowed to handle honey during their menstrual periods.

FACT BOX 4

The Proshika process for Human Development in Bangladesh

Proshika Kendra is a non-governmental organization that organizes poor landless people in over 2000 rural villages of central Bangladesh. So far 140 000 people have been organized in 9000 development groups.

The members receive help to improve the social and economic conditions of their families in several ways:

a) Human development training
b) Practical skills training
c) Rural credit
d) Support to get started with income generating activities (equipment, material, advice).

The Proshika philosophy builds on the basic concept that human development is a necessary condition for social and economic development. The 'human development training' uses music and theatre to improve group strength and individual self-confidence and awareness. Practical results are already visible; for example in the form of action against criminal landowners or moneylenders. The skills training, credit, and support for income generation are channelled through the human development group and many activities such as making ponds, installing water pumps or silk production are co-operative efforts. For other individual activities such as raising chickens, digging wells, making kitchen stoves, planting fruit trees or beekeeping the Proshika group is still the natural meeting place for training, advice, equipment or credit and for delivery of products such as honey.

Beekeeping has been promoted by Proshika since 1984 and today over 300 members are active beekeepers. However, several technical problems triggered discussion of appropriate technology for the poor landless of Bangladesh. Therefore the beekeeping programme has been reinforced with external assistance since 1988. After two years, simple hives and management advice appropriate to the rural poor are being devised and distributed.

It is clear that Proshika beekeepers have gained confidence and become more self-reliant and independent from landlords or money-lenders since they joined the programme. Many Proshika beekeepers are female, and it is hoped that the new technology will be appropriate and profitable for them. (Jensen, 1990)

A confident Proshika member showing his bees (Bangladesh)

Another advantage of beekeeping development is that it favours co-operation between family members and stimulates social contact between different groups or castes within society. Traditional beekeeping in many parts of Africa and in the jungles of south-east Asia has often been a co-operative group activity. For instance, in the Babati district of Tanzania an elaborate system of collective beekeepers' camps during honey harvest has been described in the FTPP. (Mugongo, Ntenga, 1989)

Co-operatives are a useful way of developing beekeeping; for instance for honey filtering, bottling or marketing purposes. Groups provide an effective access to extension services and limited resources for training. The self-reliance gained from being a beekeeper can also be very valuable to school leavers and young persons, giving them an alternative to migration to urban areas.

1.5 Bees and ecological balance

It is difficult to evaluate the value of a single species of animal or plant in the earth's ecological balance. Bees are involved with maintenance of the ecological balance wherever they exist naturally, but it is difficult to quantify this in economic terms.

Many plants depend entirely, or partly, on bees for pollination. (See also 1.1) Bees are important for the continued existence of a multiplicity of species all over the world from desert to polar climates. The diversity of natural ecosystems renders them less vulnerable to human influence and environmental change. Some plant

species would become extinct if bees were no longer available. These plants are in turn valuable to other species for food, protection or nutrition. Honeybee nests are also hosts for, or provide food for, a number of animals and insects.

It is impossible to specify the full importance of bees for our environment. But we can conclude that bees should always be regarded as a natural component in local ecosystems, and this component can be exploited by man without harm to the rest of the environment. Beekeeping is an income generating activity that creates productive resources while being environmentally sound.

FACT BOX 5

Bees are of many species: over 20 000 species have been identified, and all of these will be important within their ecosystems as described in section 1.5.

An extremely small minority of these 20 000 species is deliberately exploited by man, either for their products, or for pollinatory purposes. Honey and other products are obtained mainly, but not exclusively, from species belonging to the genus Apis, the honeybees. The honeybee species with the widest distribution is Apis mellifera, which is native to Africa, Europe and the Middle East. During the last 400 or so years this species has been taken by man to much of the rest of the world. At least five other Apis species exist in Asia and are exploited by man in various ways.

Only a few bee species can be kept in hives, and in many parts of the world honey crops are obtained from bees nesting in the wild, i.e. honeyhunting.

2. How do bees benefit trees?

2.1 Beekeeping enhances the perceived value of trees and forests

Forests and trees are vital for the survival of mankind, and it is important that people are persuaded of their value.

Because their value is not fully appreciated, trees are often disregarded during the expansion of other agriculture. If we consider forests only as a resource for pulp or timber without other value, we will cause large scale destruction without environmental considerations.

"Every minute of every day tropical forest of an area equivalent to two football pitches is cleared. These forests are of priceless ecological value: they prevent soil erosion by wind and rain, control flooding, affect rainfall, store and recycle nutrients, and provide habitats for vast numbers of plant and animal species. In addition they provide energy (half of the world's population depends on fuelwood), food, fodder, pharmaceuticals and other products. And of course, beekeeping is an important forest-based activity in many tropical countries."

(Nicola Bradbear, IBRA Newsletter, No. 14, May 1989)

It is very important to understand this multipurpose value of trees and forests if we are to argue for conservation of forests and development of new community forestry activities.

The keeping of bees is one way of exploiting forests without destroying them. Together with other resources such as fuelwood, and food and fodder production, beekeeping allows forest exploitation without destructive tree felling. The higher the economic value of tree resources, the more likely are local people to protect them.

Of course, the financial outcome of forest beekeeping depends on factors such as the botanical composition, climatic conditions, and the traditions and skills of beekeepers. But we can still generalize, saying that the value of trees and forests increases considerably if we consider the current value and the potential future development of beekeeping in forests.

Beekeeping as an important income-generating activity must not be ignored by community forestry projects (see also 1.3).

2.2 Beekeepers are encouraged to protect trees

In the Rift Valley, Kenya, the value of honey from one hive can equal the value of two goats. Similarly, honey-hunters and beekeepers everywhere know the value of bees and are ready to protect them, especially if they are scarce. In Africa and Asia trees holding wild swarms or bees' nests are considered very valuable. This is

particularly true in places where traditional honey-hunting or beekeeping with simple methods are being practised.

For instance, in Bangladesh the owner of a bee tree will not accept the bees being touched if this involves branches being cut. Trees containing bee swarms are considered valuable and are protected carefully. However, a modern hive with bees does not have the same status; although the cost of frame hives is relatively high, they are often left unprotected.

The owner of a bee tree will ask a honey-hunter, sometimes living far away, to come and harvest the honey and wax. A common agreement in Bangladesh is that the honey-hunter receives 50% of the crop as payment for the service.

In new community forestry plantations of multipurpose trees, bees will produce honey and beeswax yields within three or four years. It may be another 10-50 years of tree growth before timber or paper pulp yield a financial return.

In central Africa a bee-owner will often mark his bee tree by clearing surrounding ground and hanging up an old piece of cloth or tying a knot of grass beside the tree. By doing this 'good spirits' will protect the tree and the bees, and prevent others from touching the tree or stealing the honey. Ownership of individual trees may have derived from the tending of bee trees in ancient times, when land was not owned privately. Traditional beekeepers in East Africa who sometimes hang many hives in a single tree will place thorny bushes around the base of the tree. This will protect the bee colonies both from man and from visits by climbing honey badgers Mellivora capensis.

Some honey-hunters and beekeepers are also well aware of plants which have particular value to pollen and nectar collecting bees, and must be protected. They often recall hearing the buzzing of bees in certain trees or having observed many bees in a particular flower. Sometimes they claim that the special taste of their honey is derived from a particular flower or that one tree gives honey of bad taste. However, scientists sometimes find that such opinions do not correspond with reality. Important nectar-producing trees may have been missed and the value of others overestimated. Beekeepers' opinions may be biased by what others say, and beliefs often have social or religious explanations. The fact still remains that beekeepers are anxious to protect certain trees because of a believed value to their bees.

2.3 Ensured pollination leads to improved regeneration of trees

When given a choice for planting in a forestry programme, farmers often request fruit trees or trees from which they can obtain a harvest within a short time, such as fodder trees or fast growing Eucalyptus for poles and building purposes.

Community forestry projects in many countries have accepted this demand and supply farmers with fruit trees and seedlings. Many of the tropical and sub-tropical fruit tree species depend on bees and other pollinating insects for a good fruit set. Well-pollinated trees give both a high production and first quality fruit. Many of these trees are also important nectar and pollen producers for bees (see 3.1). In

rural areas of Bangladesh and Malaysia as many as 200 tree species important to bees may be available in village surroundings.

Pollinating bees are even more essential for economic yields in large scale fruit plantations, where the natural spectrum of wild insects is limited because of loss of habitat and use of pesticides. Individual fruit trees may be ignored by bees if more attractive nectar producers are available nearby. Some varieties may yield no fruit if there is no suitable pollen-donating variety within the flight distance of the bees.

The importance of pollination for fruit set has only been studied in detail for a small number of highly commercialised tropical fruit species such as avocado, carambola, cashew nut, coconut, coffee, kiwi, litchi, and macadamia nut. This does not mean that less important tropical crops do not similarly benefit from insect pollination. Evidence from detailed research on temperate zone fruit trees indicates that with very few exceptions bees are always important for optimum crop yield. (Mcgregor, S E, 1976 and Free, J B, 1970).

Forest people know and utilise a great number of edible fruits and seeds as well as gums, fibres and spices. These species are often poorly known to science and their flowering biology and pollination requirements are unknown. Nevertheless, such species are valuable for the forest, for man and for birds and animals that feed on them.

The Indigenous Food Plants Programme in Nairobi, Kenya, is studying the ethno-botanical and ecological relationships of such unusual food plants. Many belong to the great number of species threatened due to clearance of tropical forests.

It must also be remembered that well pollinated seeds of valuable forest trees will produce healthy and vital offspring both in the wild and in plant nurseries.

2.4 Community Forestry Projects are strengthened by the involvement of beekeepers

People's Participation and Forest-based Small-scale Enterprises are two crucial topics in the development of sustainable, community-based forestry activities. The Forest, Trees and People Programme (FTPP) run by FAO and SUAS is emphasising the relationship between these two topics.

"The benefits from forest-based small-scale enterprises and non-timber forestry products play a major role in increasing local interest in sustainable management of forest resources." (*FTPP Newsletter No. 7, November 1989*)

Beekeeping is an excellent example of such a forest-based enterprise. Some FTPP projects already have baseline studies on beekeeping (Burkino Faso, Kenya, Tanzania and Thailand). The study from Babati, Tanzania, particularly exemplifies the importance of beekeeping (Ntenga, G M and Mugongo, B T, 1989). The report details the skills and habits of traditional beekeepers and their lives in forest camps during honey harvest time. It reveals that beekeepers are experienced craftsmen with much knowledge and interest in what the forest can produce.

In Babati beekeepers are already organized in traditional groups and it should not be too difficult to approach them with a discussion of beekeeping and forestry development. They are automatically interested in such a communication as long as they are not contacted by the old-fashioned armed and uniformed forest rangers. They already understand the economic value of bees and trees and are motivated for further discussion of environmental protection issues.

However a single group of producers within a large society is unlikely to be able to protect or develop the forest. All social and age groups have to be mobilised and all possible reasons for participation have to be gathered to achieve the sustainable management of forests.

Traditional beekeepers tend to be important persons in a society, often old men with lots of 'secrets' to divulge. Their products, honey, beer and wax, are often important lubricants in social life carrying prestige for the producers. News about forest activities among a group of beekeepers will circulate easily among community members, and arguments for forest conservation and tree planting will often receive respect if presented by beekeepers.

Beekeepers may have a high status in the society for religious reasons because honey and wax are traditionally important in both Islam, Hinduism and Christianity, as well as in animistic religions.

Among Mbuti hunters in the forests of Zaire, beekeeping, honey and beekeepers have a central position in everyday life. The honey-hunting season is important for social relations within the group, in these ways:

- Honey is always exchanged between producers and shared with non-producers (income distribution). This is a form of labour exchange. First quality honey is bartered for other products with neighbouring tribes.

- Honey-hunting is impossible in large groups, and therefore the society is split into smaller groups during the honey season. This helps to resolve conflicts and strengthen family ties.

- Honey harvesting creates a mutual dependence between the hunting units and within families and the tribe, and honey is therefore important for tribe unity.

  (*Turnbull, C, 1961 and Ichikawa, M, 1981*)

Motivating people to participate in the defence and development of forest resources is not easy, comparing the reality of daily problems of finding food and fuel with the intangible prospect of seeing a flowering forest in the future. Therefore no single group of producers, or any income opportunity from the forest, is too small to be neglected.

In cases where traditional beekeeping does not exist it may be worthwhile to develop beekeeping solely to create another group of participating forest dependents.

3. How do trees benefit bees?

3.1 Nectar sources

The annual honey yield from one colony depends on factors including soil condition, climate, agricultural practices, flora, bees and beehive management. The number and quality of flowering plants within flight range of a bee colony is crucial for profitability in beekeeping. Fact box 6 illustrates honey yields under varying conditions.

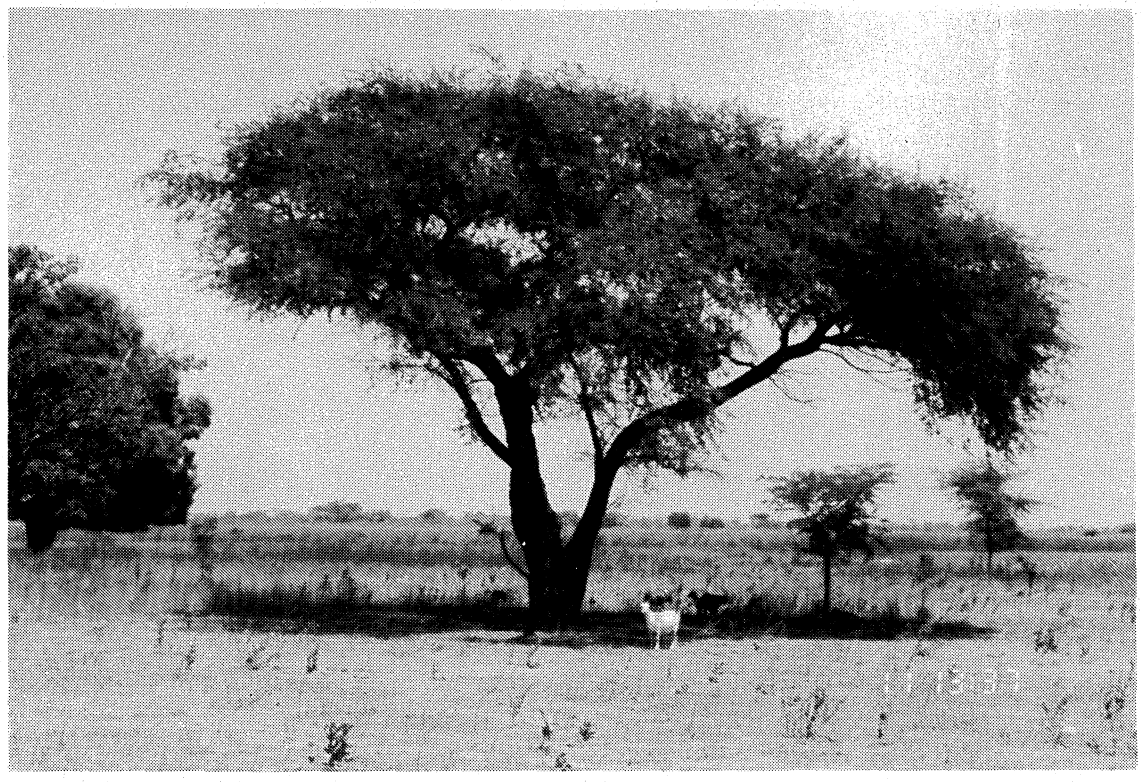
Under extreme conditions a honeybee colony can survive for 6-8 months without access to nectar or pollen. A colony can store enough food in the wax combs and adjust colony activity and metabolism to survive such dearth periods. Tropical bees can also survive by the whole colony moving to another area with better conditions for survival. This ability, known as absconding, is regarded by beekeepers as a negative trait, because hives often remain empty for parts of the season. However honey yield can still be satisfactory: beekeepers must learn to accept this absconding behaviour of the bees and adjust their practices accordingly. (See also 3.3 Swarm attractants.)

A good colony of Apis cerana bees left the hive and absconded away. (Kathmandu, Nepal)

FACT BOX 6

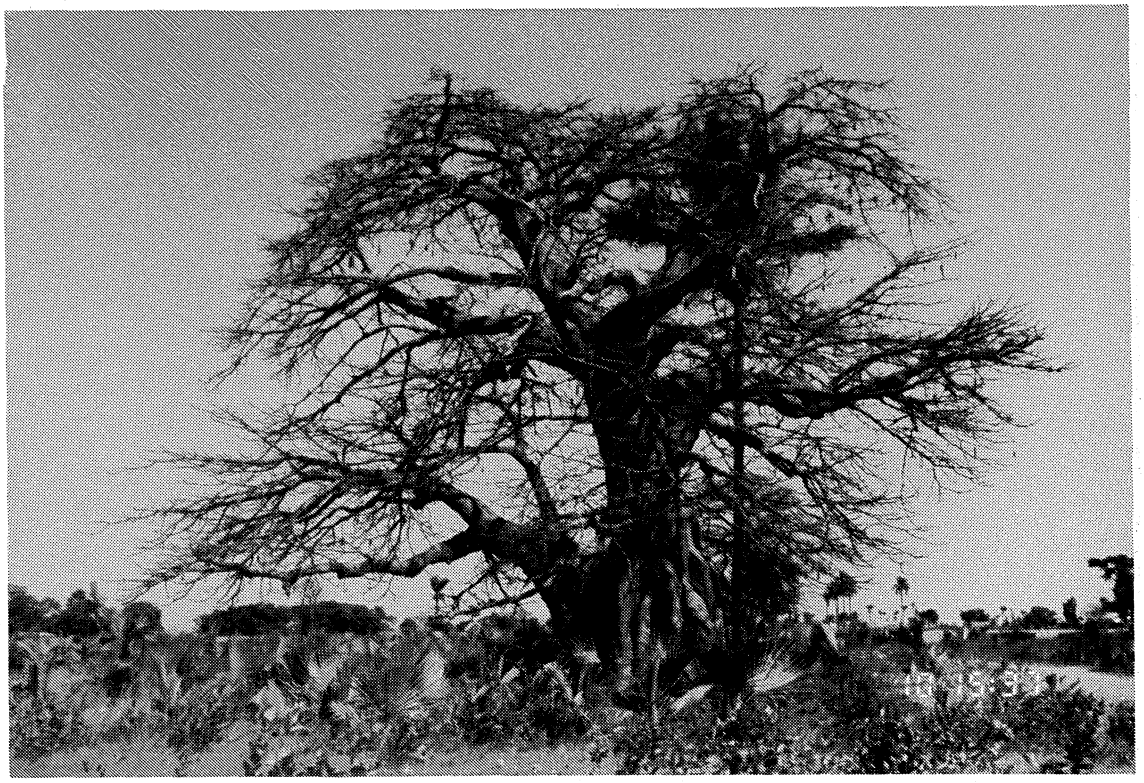
Country/region:	Examples of annual honey yields. Annual honey crop: kg/colony
Bangladesh	2 - 10
Belize	23 - 44
Botswana	10 - 30
Burkino Faso	3.5
Brazil - commercial beekeeping	120
Congo-Brazzaville	10 - 20
El Salvador	6
The Guianas	7 - 28
Guinea Bissau	11 - 28
Kenya/Kitui - Log hives	1.95
" " - Top-bar hives	4.84
" Rift Valley	25 - 75
Nicaragua	26 - 36
Niue Island	42
Pakistan - low cost hives	14
" - frame hives	18
Papua New Guinea	25
Rwanda - traditional hives	1 - 5
" - Top-bar hives	7
" - Frame hives	10
Sri Lanka	4
Vietnam	7 - 35
Zambia - Bark hives	2.2 - 8.5
" - Frame hives	10.0 - 21.6

Dearth periods are caused by cold weather, drought, monsoon rains and floods, or devastating bush fires. Flowering trees allow bees to build up sufficient stores for survival during such extreme conditions. In the Sahel zone of Africa some tree species (for example Acacia albida) flower at the end of the rainy season providing welcome resources for honeybee colonies which have recently been harvested for honey. In dry parts of southern Africa, Acacia mellifera and Acacia hebeclada have similar importance. Many bee colonies would starve or abscond if such trees were not available. Trees are often major sources of pollen and nectar during critical periods and may support bees throughout the year when the rains are short. Several Eucalyptus species are also vital for the survival of bees during dearth periods. In dryland areas of Chile, Mexico, North Africa, the Middle East, India and China a few tree species are important not only for survival of bees but also for the main honey flow and therefore the profitability of beekeeping (see 6.6.).



In the Sahel zone of Africa some tree species (for example Acacia albida) flower at the end of the rainy season providing welcome resources for honeybee colonies which have recently been harvested for honey (Yundum, Gambia)

The physiological explanation for the importance of these off-season flowering trees or drought tolerant trees is their deep root system which permits them to lift underground water and nutrients to the nectar producing flowers. Some Acacia species may even lift fossil water sources to the flowers. Other families of plants such as the Euphorbiaceae and Cactaceae are enabled to flower under very dry conditions by their water storage mechanisms. Some trees are important to bees because of their ability to survive salinity in soil or water, for example palms Phoenix spp. and mangrove species Avicennia, Nyssa and Serenoa. In areas with higher rainfall, trees are often the main nectar producers for the honey crop. Forest tree species may produce a variety of nectars throughout different hours of the day and throughout the seasons, providing bees with a plentiful, and relatively constant supply of nectar. Wild herbaceous plants and monocultural crops often have concentrated flowering periods, often more sensitive to climatic constraints (see 3.4.).



Trees with a deep root system may lift underground water and nutrients to the nectar producing flowers. (Baobab tree, Adansonia digitata in Gambia)

Trees are also major nectar sources because they produce a large number of flowers from a small land surface area. Examples of nectar secretion by trees mentioned by Crane, E (1975):

The aborigines of Australia found that species of Grevillea, Cassia and Hakea had so much nectar that it could be eaten directly or shaken out of the flowers.

The sugar concentration of nectar is also important. The nectar of Grevillea robusta is reported to consist of 79% sugar.

Other trees with high nectar-sugar values have mainly been studied in temperate climates, but are worth mentioning (mg sugar per flower per 24 hours): Eucalyptus spp. 18.8, Hakea laurina 5.3, Tilia spp. 7.7, Rubus idaeus 8.1, Robinia pseudoacacia 2.3, and Aesculus hippocastaneum 2.1.

The Tournefortia argentea on Hawaii can support a number of bee colonies and give 100 kg/colony on a small island of only 8 km2 (the Wahe atoll).

Eucalyptus plantations in Brazil are reported to be able to support 80 - 100 colonies of bees in a single location.

Trees are also important to bees because of the honeydew (plant sap) produced directly from extrafloral nectaries, or indirectly through the action of plant-sucking insects (Coccidae, Lachnidae, Aphididae etc.). Although the chemical composition of honeydew honey differs in enzyme and sugar content from floral honey it still has the same nutritional value. Important honeydew trees include rubber Hevea brasiliensis in Southeast Asia, mango, Mangifera indica in Bangladesh, oak Quercus spp. and pinetrees Pinus halepensis in North Africa. The value of honeydew for bees has been studied in Europe, Pakistan and New Zealand, and is believed to be important elsewhere, especially in the equatorial rain forests where many tree species secrete saps and gums.

Some trees are not so valuable to commercial beekeeping because their corresponding honeys are considered to be less palatable on the export markets. Sugar cane, Saccarum officinarum, should also be included in the following list because the honey made from its sap is regarded as a falsification:

Elaeis guineensis, Agave sisalana, Manihot glaziovii, Ricinus communis and Melaleuca leucadendron.

It is also necessary to note that not all nectar producers in forests are good for bees. Some nectars contain substances toxic to bees or other honey consumers. Naturally toxic nectars can derive from:

Andromeda spp., Arbutus unedo, Datura spp., Euphorbia spp., Gelsemium sempervirens, Kalmia latifolia, Rhododendron anthopogon and R. ponticum, Senecio jacobaea and Tilia spp.

3.2 Pollen and propolis sources

Pollen production by trees is mainly important as a source of protein for developing larvae (brood).

If insufficient pollen is available to bee colonies they suffer from lack of protein, the brood level is decreased and colony strength declines. A few trees of different species nearby may produce enough pollen for bees to survive a dearth period. Although many trees produce both nectar and pollen, some produce only pollen and these may nevertheless be important for bees during particular periods. A mixture of pollens from different tree species will always be of better nutritional value for bees than pollen from a monocultural plantation.

The value of pollen as human food or in a mixture with honey or bee brood is discussed in section 1.2. Pollen can also be commercially harvested by placing a special trap in front of, or under the beehive. Commercial bee pollen production is important in countries including Chile, China, Israel, Mexico, Taiwan and Vietnam, and pollen is an international trade commodity.

Propolis is another bee product derived from trees. It is a red-brown, sticky substance collected from certain trees by bees, and used by them to impregnate or seal their nest or hive. Propolis is used by man for its pharmaceutical properties and its harvesting is of economic value in many Latin American countries. Kawa (1989)

mentioned that African propolis may find a future market as a cure for malaria fever. Propolis is not widely valued in Asia as it is not collected by Asian honeybee species.

The origin and composition of propolis in tropical countries is little known.

3.3 Other forest materials

Traditional honey-hunters and beekeepers use whatever materials are available locally for their forest activities. They have good knowledge of the wild and cultivated plant species around them and they are skilled at crafts. They also develop new tools or find new materials if old practices cannot be continued for some reason. They will even practise traditional beekeeping with modern waste materials if they cannot find the usual resources, for instance wine barrels in Guinea Bissau, clay-pots in Sudan, plastic sheets in Papua New Guinea or cardboard boxes in Botswana.

By contrast, beekeepers using modern frame hive equipment are often inflexible, adhering to a uniform and standardised system. They feel handicapped when they run out of prefabricated or imported tools and materials.

Listing all the trees and forest products that beekeepers use in their craft would be a considerable task. To illustrate their importance just a few examples of the diversity of species and their uses are listed here:

Beehives

In North Yemen four tree species are considered good for making log hives - Cordia abyssinica, Ficus vasta, Tamarindus indica and Terminalia brownii.

In Ghana three special species are sought for log hive production - Terminalia ivorensis, Chlorophora excelsea and Piptadeniastrum africanum.

Species suitable for bark hives in African miombo woodland are mentioned later (chapter 4.4).

In Guinea Bissau log hives are produced from palm stems (Borassus flabellifera), cylindrical hives from bamboo and grass straw, and box-shaped hives are made from tara palm leaves (Raphia spp.). Similarly the doum palm leaves (Hyphaene thebaica) are used for hive making in Sudan, and Papyrus spp. are used in Egypt and Rwanda. Cordia alliodora in Latin America provides modern frame hives that last for 40 years or more.

Hive supports

Multipurpose trees such as Ficus natalensis and Erythrina abyssinica are reported to work well as living hive stands in Uganda. These same species are widely used in agroforestry.

The population in West Pokot, Kenya, protect certain 'holy' tree species Ficus natalensis and Ficus sycamorus that are also suitable for housing beehives or attracting bee-swarms. Their word for honey-beer is 'phet' meaning 'of the tree'. For people in West Pokot honey is very valuable for several reasons:

- It is an important food reserve during times of food scarcity.
- It is often given as a remedy to old people and convalescents.
- It is the 'oil of social life' and is used during rituals such as initiation and marriage.
- It is produced as a gift to elders in order to receive their blessings. (Östberg, 1988)

A similar social importance of honey is reported from West Africa and Saudi Arabia (Svensson, B, 1984).

In Gambia and Guinea Bissau some tree-owners protect particular trees holding bee swarms or nests as very precious property. They will even peg pieces of iron into the tree stem or cover up the nest hole with mud or cement after harvest, as a way of tending wild colonies. Many different kinds of hives are also supported high in trees all over Africa south of the Sahara. The Tamarindus indica tree is considered to be a good home for bees in East Africa and holy Banyan trees (Ficus bengalensis) in India and Bangladesh also provide good protection for many bee colonies. Similarly Ziziphus trees in Saudi Arabia are well protected by landowners as they provide shade for beehives and flowers rich in nectar.

A claypot with bees in Kounday, Chad

Production of Mulderry hives from local materials in Norail, Bangladesh (Photo: Mogens Jensen)

Swarm attractants

For traditional beekeepers in the tropics it is important to have a large percentage of hives populated with bees each season. Sometimes hive occupancy rate is measured as an indicator of success in beekeeping, for instance in Mali, Kenya, Zambia and Bangladesh. This is the correct approach to the measurement of beekeeping profitability and sharply contrasts with many beekeeping development projects that judge success by the number of hives or equipment distributed, even if the hives are unoccupied or the equipment unusable.

Traditional beekeepers are aware of the problem of low hive occupancy and many different methods to overcome this problem have been reported, although inventions by beekeepers are sometimes based on beliefs or religious cults rather than practical observation.

Citrus juice, a pot of fresh water, fresh cow dung or perfume are reported to attract bees to empty hives. Old hives containing scraps of beeswax or propolis also attract swarms very well and smoke from these is reported to attract swarms in Rwanda.

Ocimum suave is reported as a good beehive bait in Kenya, and fever grass works well in Jamaica.

Hanging hives in Ficus trees or painting the hive entrance with white clay (kaolin) is reported to be effective in Rwanda. Similarly, manioc powder is used in Chad. In Rwanda beekeepers claim to attract flying bees with the help of a spear dipped in butter, a plate with beer or dough of millet or sweet potatoes. Similar beliefs also exist in Ghana.

Bee tranquillisers or repellents

Many different materials such as corn stalks, cow dung, bark, rice straw or jute cloth are used as smoker materials to pacify bees. Beekeepers always know useful materials available within their vicinity.

Other less common tranquillisers and soporifics include:

Green leaves from manioc Manihot esculenta in Zaire and Zimbabwe, and leaves from Vitex payos and Voandzeria subterraneum in Zimbabwe.

Research is being carried out on Adenia spp. in Ghana and Amomum aculeatum in the Andaman Islands, India.

Puffballs Langermannia vahlbergii are used during honey harvest in Tanzania but will often kill brood and adult bees because of the hydrogen sulphide gas produced.

The Orophaea katschallica plant from the Andaman Islands caused a scientific sensation when it was reported that the honey-hunters could use it as a repellent against attacks from Apis dorsata (the giant honeybee) when smeared on their bodies.

Similar effects are reported in Rwanda from smearing the body with plants such as Phytolacia dodecandra, Cassia ditymobotriya and Momordia faetida. Caloncoba wabewesii is reported to have the same effect in Central Zaire.

Shorea floribunda bark is used as a honeybee repellent in date palm sugar production in Malaysia.

Further investigation would reveal more traditional knowledge of the different uses of forest products among traditional honey-hunters and beekeepers.

*** Other related materials ***

Wax moths are major pests in tropical beekeeping. Burning feathers or smearing the hive entrance with Citrus spp. or banana Musa spp. is reported to stop wax moths from entering beehives in Rwanda. Burning incense from the 'Ishangi tree' or a mixture with Phytolacia dodecandra is reported to even kill wax moths.

Incense and torches are also mentioned in connection with bees and wax from plants such as Spirostachys africana and Boswelia sp. Traditional beekeepers also know which fibres or twigs are suitable for baskets, ropes and smokers used at honey-harvest.

Many trees and plants are mentioned in connection with food and honey. For instance, Amaranth seeds are popped and mixed with honey in Mexico, Algeria and India; barley mixed with honey has been a very common food in Ethiopia, and in Zaire, honey is often mixed with palm-oil. Fruit of the sausage tree Kigelia pinnata is used as an additive to honey beer in Kenya. Many other plants are associated with the comsumption of honey and honeybeer.

As a final example of the elaborate skills of traditional beekeepers I would like to mention the knowledge of tying the queen to prevent her from egglaying and thus forcing bees to concentrate on honey storage rather than brood rearing. Traditional beekeepers in Thailand knew how to do this, placing a small piece of thread around the queen's thorax. The same skill is also recorded in Rwanda, together with the technique of placing a trap door inside the hive to limit the brood space (and thereby increase the honey storage area).

Trees and forests must also be regarded as a great potential for the future, as a source of biological remedies against diseases and pests in beehives. The maintenance of species diversity provides multiple options for the future.

3.4 Environmental protection

As seen in 3.1, many individual tree species are important for honey production and the survival of bees. Some species such as orange, chestnut, rubber and palms provide crops of export-quality monofloral honeys.

Generally it is the great species diversity within forests and the ability of bees to adjust to this diversity that provides security for the survival of bees and guarantees pollination of wild and cultivated plants. Forests and other tree-dominated ecotypes therefore have considerable environmental importance from both global and local points of view.

On the global level we are now realising the risk of climatic changes leading to unreliable weather: storms, floods, severe drought and decreased ground water tables. Scientists are already discussing whether the uncontrolled exploitation of tropical forests is one of the main causes of climatic changes and catastrophes in Bangladesh, Philippines, Equatorial Africa, the Sahel and Central America.

In extreme cases conditions may improve for beekeeping but on the whole it means a challenge for the survival of bees. Here are a few current examples:

A forestry report from Nicaragua mentions 'severe ecological threats from logging and fuel-wood cutting and shifting cultivation'. The native forest consists of many hundreds of species of which only 15-20% yield timber suitable for industrial use. Yet forest degradation has reached the stage where beekeeping is no longer profitable in some areas (Goppers et al., 1987).

A 100.000 ha forestry project in Cameroon aims to exploit all 340 tree species for wood pulp. 50% of the total forest area will be used and replanting is planned with monocultures of Eucalyptus and Pinus. Will the bees survive? In 1960 65% of Thailand was covered by forest. By the 1980s forest cover had

decreased to 30%. (Skogen, 1982) The problems in the Tiro-Botar Becho project were already mentioned in the report introduction (page 3)

In Brazil 145.000 ha of tropical forest is being killed chemically to make way for the Tucuri water power dam project. What will happen to the bees?

Floral diversity within the flight range of a honeybee colony is of utmost importance for the output from beekeeping. Other conditions such as soil, climate, altitude, bee species and beekeeping practices are also important. But comparing regions where these factors are similar, bees will produce more honey under multifloral conditions and ecological balance.

This is verified by the many studies of the melliferous (nectar producing) flora of countries with good beekeeping potential. (Fact box 7)

FACT BOX 7

Country (region)	Number of important melliferous plants:
Botswana (Kalahari)	more than 60
India (Himachal Pradesh)	195
Malaysia (2 districts)	77
Mauritius	53
Mexico	85
Nepal	178
Sri Lanka	248
Thailand	106

In some tropical countries honey crops have been reported to sometimes exceed 50 kg per colony per annum (for instance Antigua, Guinea Bissau, Kenya, Mexico, and Rwanda). This indicates a good floral diversity. In some places honey production does not exceed 10 kg per colony. In such cases it is possible that output could be improved by appropriate community forestry activities.

If just one new tree with suitable nectar production is added to the local flora, it may be of vital importance for the beekeeping profitability. In Kashmir the introduction of the 'Tree of heaven' Ailanthus sp. flowering in spring gave an average surplus of 6 kg/colony from Robinia sp. later in the season. In Kerala it has been proposed to introduce four new perennials (Antigonon leptopus, Callistemom lanceolatus, Manihot glaziovii and Pongamia glabra) around rubber tree plantations Hevea brasiliensis in order to make better use of the honeydew flow from the rubber trees. It is estimated that 30% of all Indian honey is derived from rubber plantations (Nehru, C R, et al., 1989)

Some forestry projects have realised that forest degradation is also decreasing the number of bees and honey production. The FTP programme in Nepal reports a great lack of bees and suitable logs for beehives due to the disappearing forest.

Additionally the stress on forage crops and the cutting of leaves from trees for forage are severely limiting nectar production. The programme recommends emphasis on planting trees suitable for the '5 F', i.e. food, fodder, fuel, fertilizer and fibres. Maybe another 'F' could be added to the list for flowers?

Several community forestry projects have realised the need for a multi-species approach to tree planting. In the SIDA-supported project in Orissa, 20 different tree species are planted and monocultures avoided. Planting with a variety of tree species is also being encouraged in opium poppy growing areas of Burma.

The Vi forest in Kenya is reported to have tried as many as 80 different tree species in the project nurseries. (Östberg, 1988)

It must be concluded that the environmental threats to beekeeping are great, but there is a little light in the darkness. Perhaps the approach taken by the FTP programmes can be followed on a larger scale world-wide, and popular forest protection campaigns like the 'Chipko' movement in India can continue. This is based on the following 'Chipko' rules:

1. Protect existing trees and forest
2. Plant new trees according to local needs
3. Emphasize community forestry
4. Use locally-suited trees
5. Use fast growing species
6. Use multipurpose trees
7. Strive for floral diversity.
   (Chipko Andolan)

Floral diversity within the flight range of a honeybee colony is of utmost importance for the output from beekeeping (Bambadinka, Guiné-Bissau)

..... in Nepal ..... the cutting of leaves from trees, for forage is severely limiting nectar production (U.M.N. Laleng)

4. Possible negative aspects of beekeeping

In reviewing the benefits of bees for forests, trees and people, we must not ignore the fact that beekeepers are sometimes considered responsible for the destruction of trees. In some cases in East Africa decisions taken by local authorities have prohibited beekeepers from entering protected forests. Often such decisions are based on incorrect accusations, in other cases the beekeepers are guilty, but they could easily be taught how to avoid destructive behaviour. Some examples will be given to enlighten this discussion.

4.1 Honey-hunting in rain forests

Honeybee colonies have been so abundant in the deep forests of central Africa and South East Asia that there was never any necessity to develop hive-beekeeping. Instead honey-hunters have continued until today to climb trees and use fire to kill or subdue the bees and harvest honey and wax. In some cases (Zaire) they fell the tree before using fire and killing the bees. This is sometimes still practised in areas where forest resources are declining because regeneration of trees is slower than the rate of exploitation.

It is true that such behaviour will kill many bee-colonies and may cause forest fires. However, it is possible to defend this method of honey-hunting and explain such action from the honey-hunters' point of view. They are practising a traditional method of exploiting bees that has been effective and profitable for many generations. Until recently there has always been sufficient new colonies to harvest during the next season. The clearing created when a bee tree was felled would quickly be filled by new, fast-growing undergrowth. Honey-hunters were using methods that could be sustained by the forest. However, problems arise when forestry programmes or agricultural interventions limit native forests. Honey-hunters can no longer fell trees or kill bees, but instead must learn new methods and become beekeepers.

A beekeeping development project can be introduced fairly simply. Beekeepers can be trained to manage bees carefully, all year round. They can be taught to harvest honey and wax regularly and without killing bees. Such a project can multiply bee-colonies and expand to new sectors of the population. The new beekeepers will be motivated to protect their trees and forests.

4.2 Honey-hunting and camp fires

Honey-hunters and some traditional beekeepers often prepare a large camp fire at night. This is primarily because they camp out in the forest for weeks at a time, and make fires at their camp sites. They also need fire to produce smoke and light during their honey-hunting work: cool smoke has a calming effect on bees.

In the Sunderban forests of West Bengal, India and Bangladesh, and in Indonesia, honey-hunters need fires to protect themselves from tigers.

Honey-hunters are also involved in animal hunting and other forest activities. They are skilled in making and controlling fires and, because the forest is the source of their livelihood, they are careful not to cause forest-fires. Beeswax easily catches fire and a forest fire during beekeeping could quickly destroy many bee colonies and perhaps even cause the death of the hunter if he is not careful.

4.3 Log hives

In many areas where trees are abundant, traditional beekeepers use hollowed logs as hives for bees. Often these hives work well and are long lasting. However, as trees become scarce it is necessary to change to other materials such as straw, clay, bamboo or palm leaves for hive construction. Beekeepers will be interested in hearing arguments for such changes but may need some time for effective adjustment of their behaviour. It may be easier to persuade beekeepers to participate in community forestry programmes, if the trees planted will be suitable for making log hives.

4.4 Bark hives

The African miombo woodlands which extend from Kenya to Angola are very important for beekeeping and honey production. Traditionally the beekeepers mainly used bark from four of the most common miombo species for the production of beehives. The trees die from this practice. But this kind of beekeeping has been an important sideline or main income-generating source over many generations.

Foresters in, for instance, Ethiopia, Tanzania and Zambia often claimed that beekeepers were destroying forests. The introduction of modern boxhives (Langstroth and Dadant standard hives) was meant to decrease the use of bark hives and increase the honey output. In the North West Province of Zambia however, available data proves that efforts to modernise beekeeping failed and the project had to reorganize the work with beekeeping. (The same story is true in Tanzania.) The beekeeping survey section soon found that traditional beekeepers are good botanists and ecologists, and are also concerned with human interference and destruction of the forest. Their technology with bark hives is appropriate for the conditions, very profitable for the producer and not at all dangerous for the survival of the bark trees. These are: Julbernardia paniculata, Brachystegia longifolia, Brachystegia spiciformis and Cryptosepalum exfoliatum pseudotaxus.

Beekeepers can make up to five bark hives from a single tree and one hive may last for 20 years. When suitable bark trees are scarce they try to find other materials. The beekeepers understand well that the bark trees are also very valuable nectar producers.

Today the co-operative movement of beekeepers in Kabompo has developed into an export industry now introducing its pure organic products to the European market (Clauss, B, 1988). The co-operative members are still using bark hives and traditional methods.

4.5 Movable-comb hives

Attempts to modernise and extend beekeeping practices have often involved the use of complicated and expensive movable-comb hives. Such hives were originally designed in North America and Europe for the purpose of mechanised bee management and honey extraction. But such hives consume more wood than traditional hives. The use of equipment based on easily-available materials must therefore be recommended.

Modern movable-comb hives are best suited for intensive management by well trained beekeepers with some logistical support. Experience shows that movable-comb hives are not profitable for poor beekeepers. (see Fact box 8)

In many cases it is a great waste of sawn wood to use movable-comb hives, because they will soon be destroyed by termites and/or high humidity. The bees often abscond after attacks from wax moth, badgers, ants or other predators, or even excessive management by the beekeeper. This type of hive is not easily sited in trees and their placement on the ground makes them likely targets for vandalism or theft.

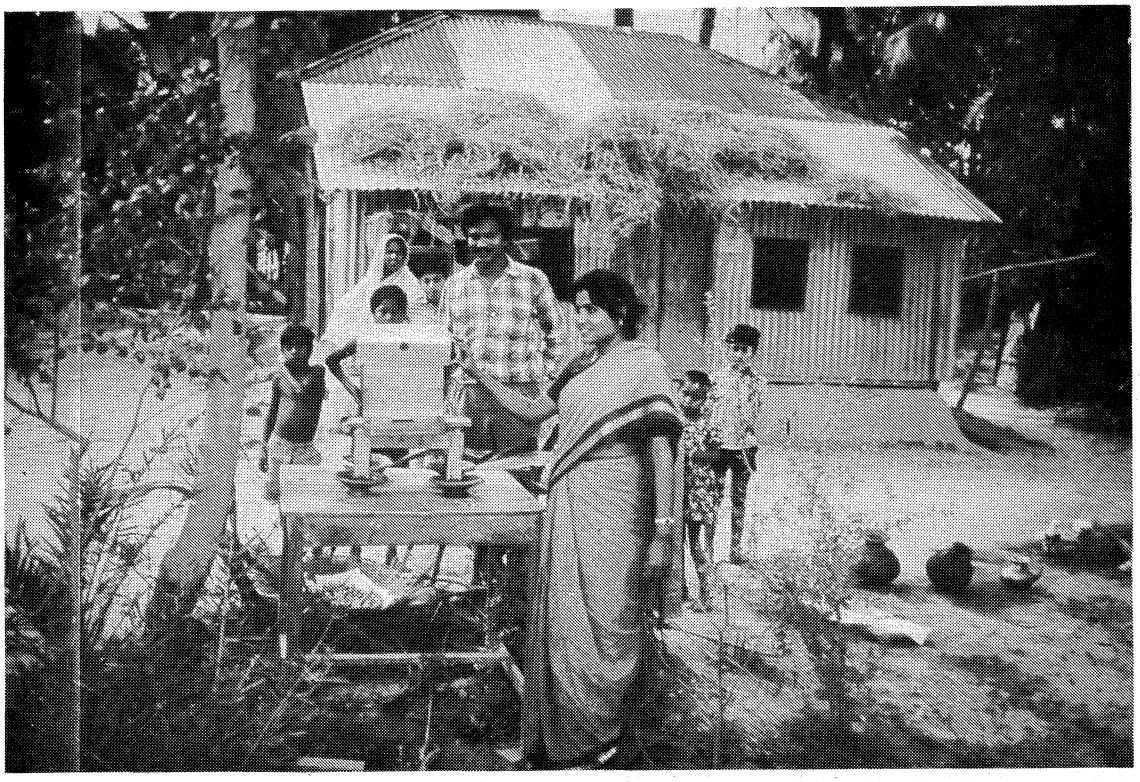
Traditional hives are hung securely in trees, and even if they are spoiled they are easy and cheap to replace before the next season.

An income comparison between modern box-hives and traditional bark-hives in Zambia came to the conclusion that the bark-hive beekeepers can easily receive a good income from their occupation and are considered 'the foremost guardians of the forest from which they receive their livelihood' (Wainwright, D, 1989).

FACT BOX 8

Cost of hive production

Country	Hive	Cost
Bangladesh	Fixed comb hives	5 - 50 T
	Top-bar hive made from cane	100 - 200 T
	Frame hives	200 - 500 T
North Yemen	Log hive (lasts 20 years)	25 Pounds
"	Basket hive made of bamboo or cane (lasts a few years)	4 Pounds
Tanzania	Traditional	20 - 40 Shs
"	Frame hive	500 - 1.000 Shs



In many cases it is a great waste of sawn wood to use movable-comb hives (RESP, Madaripur, Bangladesh)

Bees are easily observed foraging at ground level, but are impossible to see foraging high in trees (Dombeya tree in Funchal, Madeira)

Starfruit trees, Averrhoa carambola, will often flower all year round (Bandundu, Zaire)

5. General facts about bees and trees

5.1 Flowering biology of trees

We have already mentioned the importance of floral diversity (3.4.) for the forest environment and strategic tree species (3.1.) for the survival of bees. Under good conditions one single tree can produce a great number of flowers and give as much as 1 kg nectar per day. It is therefore necessary to understand the biology of flowering and nectar production in trees.

Some nectar-producers take 20 or 30 years to achieve a green mass and root system great enough to reach full flowering potential. Timber production programmes often focus on trees with a particular minimum stem diameter. Sometimes all tree species within a given area are felled even if just a small portion of them have value as timber. If timber producers understood the ecological importance of flowering trees and left less valuable species standing the bees would benefit. Replanting of clearings is also important for bees in the long term (see 5.3.).

Often the richest nectar-producing flowers are not eye-catching, and the conspicuous red flowers of some tropical tree species are rarely of interest to bees (these species are usually bird-pollinated). Bees are easily observed foraging at ground level, but are impossible to see foraging high in trees. Tree felling at flowering time is not advisable: not only will it destroy flowers, but the timber will be very heavy due to the rising sap.

Mature tropical trees are very complex ecosystems. A single tree may bear numerous species of flowering parasitic plants and honeydew producing insects which in turn are of benefit to bees. Some trees flower twice a year or give nectar twice a day. Some have successions of flowers over a period of up to three months. Starfruit trees Averrhoa carambola will often flower all year round. Some trees produce a very tasty nectar or nectar with a high sugar value (see 3.1.). Such trees must be carefully protected from careless exploitation. It may also be helpful to advise farmers not to cut fodder from bee forage trees before or during flowering.

Eucalyptus trees have been transferred from their native Australia to almost all parts of the tropics and subtropics. Many Eucalyptus varieties have evolved a high potential for nectar production in Australia where honeybees are not native and pollinating insects may be scarce. Out of 600 species as many as 300 have been planted in southern Africa. Loock (1970) estimated that 60 of these species were of value to bees. All were more or less suited to local conditions in different areas and flowering periods and value to bees varied considerably. The possibility of combining Eucalyptus species and thus providing flowering trees throughout the year could make conditions extremely good for beekeeping. Some species of Eucalyptus which are not particularly good for bees in Australia have shown high nectar potentials in other habitats, for example Eucalyptus gomphocephala and Eucalyptus rockwayi in North Africa. This lack of absolute knowledge about the Eucalyptus taxa may explain their varying reputation as bee trees in different parts of the world. The picture is even more complicated by the fact that species and their names are sometimes mixed, that a Eucalyptus tree rests for several years without flowering,

that the buds can sometimes rest for a year or so, that some species have a strong nectar smell without producing nectar and some species show variable flowering once outside their native habitat.

Generally, Eucalyptus are comparatively well studied but nectar production and flowering biology of native tree species are poorly known, making comparison difficult.

Research on the nectar producing potential and flowering biology of native tree species should have high priority, preferably combined with economic evaluation of the importance of beekeeping for the total value of tree or forest plantations.

Further research is also needed on the value of different Eucalyptus species before giving advice on suitable planting practices good for bees. A good example of effective research is provided by that of Eisikowitch & Masad in Israel (1980). They identified off-season bee plants that could thrive on marginal and stony lands in semi-arid areas of Israel. Almost all the species recommended were small and bushy Eucalyptus species not previously mentioned as valuable in other regions.

FACT BOX 9

Planting exotic Eucalyptus species

Advantages	Disadvantages
- some species are attractive to bees	- not all species are attractive to bees
- seeds are easy to gather	- often planted in monocultures
- easy to plant	- competes intensively with other trees or crops for underground water and nutrients
- not eaten by goats	- occupy a land area that will not be suitable for cultivation
- grow quickly	- an exotic tree that may be susceptible to pest or plant infections
- survive well under various conditions	- not a nitrogen fixing species
- give good firewood	- an exotic tree that may react unexpectedly to planting in a new area
- produce building poles	- no matter how many "advantages" the species offers it is not native and can therefore not have evolved to be as well suited to local conditions, or to participate in the local ecosystem to such an extent as the native species
- suitable as wind breaks or border trees	
- the taxa contains a great number of species suitable for a wide range of conditions	

"Often the richest nectar-producing flowers are not eye-catching, ..."
(Balanites aegyptica, photo: Nicola Bradbear)

Suitable combinations of different tree species should be investigated to establish planting recommendations for optimum honey production in a community forestry programme.

Of course, forests and forestry programmes cannot be managed solely for bees or honey production, but further studies of the economics involved may defend the incorporation of beekeeping into such programmes. Income from bees may be one of the fastest ways of achieving an economic output from community forestry activities. (see 2.1.)

5.2 Introduction of exotic species

Attempts must be made to save and restore native forests. Pollinating bees may help to safeguard the survival of such natural ecosystems and the associated multiplicity of organisms. But in many cases forest exploitation has come to a point where the restoration or replanting of native forest is impossible. Instead it is important to find and plant fast-growing, multipurpose trees that will compete with agriculture in such a way that the forest resource is developed rather than exploited. Many exotic, multipurpose trees have been identified in recent years. (See Chapter 6.)

However, before introducing exotic species into forestry programmes it is advisable to study and compare their behaviour under native and other habitats. As we have already seen (5.1.) there is no guarantee that a nectar source good in one place will be equally good elsewhere.

There is also a risk that a species may show results which do not correspond with expectations, or may even die out without flowering.

In some cases introduced species will thrive so well that they may be called invasive weeds by farmers as for instance the following trees: Azadirachta indica, Melaleuca leucodendron, Polygonum spp., Prosopis glandulosa, Rhus diversiloba, Schinus terebinthifolius, and Tamarix gallica.

Exotic species may also be too successful or popular so that the forest develops into a monoculture. As we have already seen, floral diversity is always preferable for bees. Monocultural forests are also highly sensitive to pests such as the Leucaena psyllid that has damaged many plantations in Thailand. Some introduced tree species may also secrete chemical compounds that inhibit growth of valuable plants or herbs on the surrounding forest floor. Examples of such trees are Eucalyptus globulus and Acacia mearnsii.

Prosopis species planted intensively in dryland Africa are recommended by some beekeeping advisors and banned by others (Kigatiira et al., 1988, Eisikowitch & Dafni, 1988). Further research is needed to provide appropriate advice for planting programmes with such exotic species.

5.3 Thinning, logging, planting and spacing of trees

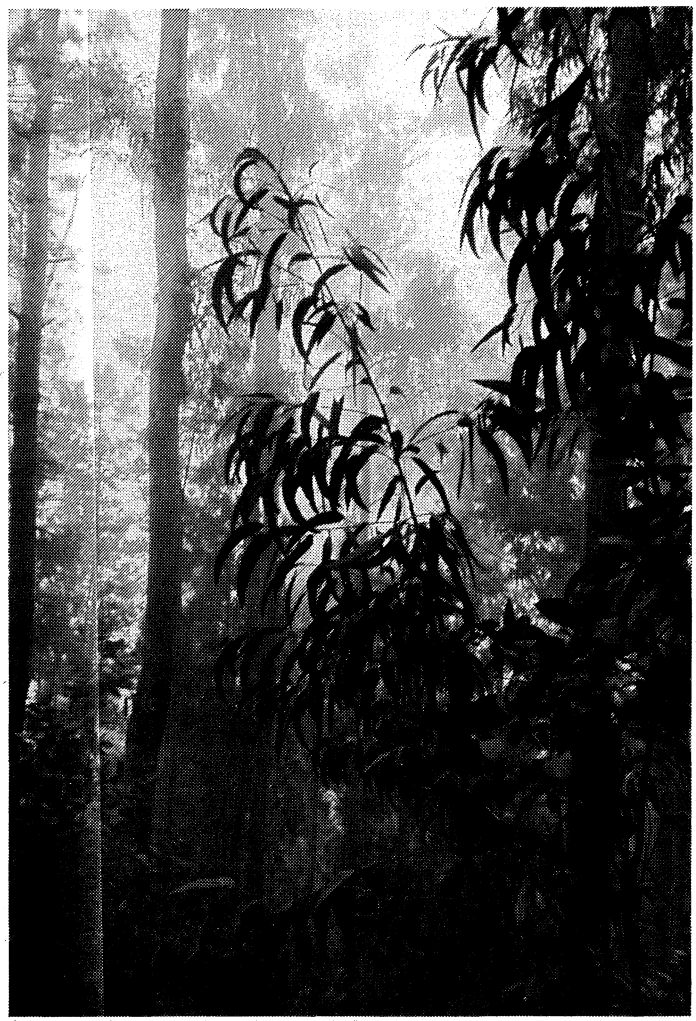
Conflicts will obviously arise if only one interest (pulp production, timber, fuelwood, forage production etc.) is allowed to direct forest activities. The forest will probably be overexploited at the expense of other interests.

Since beekeeping is a forest-based activity that has often been ignored as part of forest production and whose economic interest to society has been disregarded, it is often the beekeeping interest that will suffer from thoughtless treefelling and forest exploitation.

As this report is illustrating, the retention of native forests and regeneration of community forests is very important for the benefit of honey production and many other interests. It is essential to build up knowledge of the different uses of trees and how to exploit them without harm to the environment. We must also establish communication between all interests involved in forest activities, and allow for peoples' participation and influence in decision-making and practical work.

Such an approach will help to save species valuable to bees when thinning or logging the forest. Once the economic value of mature bee trees has been established, this information can be used in discussion of which trees to use for fuelwood and which to protect. It would also help when deciding which trees to leave when clearing land for cultivation, or when introducing ox ploughing of agricultural land. Also such knowledge could influence the choice of trees for planting as wind breaks or as

shade trees in plantations of crops. When rural populations are fully aware of the 'ecological price' of individual trees they will be motivated to control wasteful logging activities such as those mentioned in 3.4. Of course, the possibility of taking legal action must also be available for local people if they are to improve the situation. People who understand the total value of trees and forests will also understand the importance of replanting after felling, and replanting to extend forest land, save soil from erosion or just planting for future generations. From a beekeeper's point of view it is important to plant those trees that are valuable to bees (see Chapter 6). But it is also important to combine different trees in such a way that the floral calendar will be as profitable as possible. Correct planting techniques are also important. For example the spacing of trees can affect nectar production. Conventional foresters often prefer dense plantations of one or a few species. Trees are planted closely to prevent undergrowth and to optimise land use. Closely planted Eucalyptus grow well and produce tall and straight poles. But studies in South Africa have shown that Eucalyptus should be spaced at least 5 metres apart for optimal nectar production. Such a spacing will allow the growth of large crowns with plenty of flowers. (Loock, 1970).



Some introduced tree species may secrete chemical compounds that inhibit growth of valuable plants or herbs on the forest floor
(Victoria, Cameroun, Eucalyptus plantation)

In Tanzanian plantations of Pinus, trees are spaced 2.5 metres apart. This will not allow any melliferous plants to survive on the forest floor.

In arid regions such as Niger Acacia albida planted at 10 m spacing may be too dense for the scarce underground water resource. This may result in a poor nectar flow. As with all forestry interventions, viable seed, proper soil preparation, and efficient irrigation are necessary for good and quick results. Planting cuttings is often more successful than growing from seed, because the cuttings may develop into flowering trees 1-3 years before seed-grown plants.

5.4 Co-operation between foresters and beekeepers

As has already been mentioned several times, beekeepers must be involved in forest protection and development. Mutual understanding between foresters and beekeepers is therefore required. Beekeepers may be afraid of foresters and try to avoid contact with them. Foresters must be acquainted with the life, practices and interests of beekeepers, try to gain their confidence and then find a way for communication. The best solution might be by helping beekeepers so that they profit directly from foresters, for example by:

- Helping beekeepers with transport of honey
- Organizing the purchase and sale of honey
- Organizing the purchase of beeswax
- Providing waterholes for bees in the forest
- Prohibiting forest fires for the purpose of saving the beekeepers' hives
- Telling beekeepers where they can find wild bee colonies
- Giving beekeepers seeds of nectar producing plants
- Helping beekeepers to protect beehives from thieves.

These are all activities that a forester can be involved in without knowing much about beekeeping.

Beekeeping should always be recognised as an integral part of the curriculum for education and training of foresters and other rural development workers.

Current beekeeping training is often inappropriate for the conditions under which poor people live. Advanced beekeeping techniques are being taught instead of simple and cheap methods that might be more appropriate for local conditions.

Before trying to reform education curricula or trying to introduce new beekeeping techniques, a careful feasibility study is always advisable.

After the forester has gained the confidence of beekeepers, s/he may propose the formation of discussion groups. Such a group could address related questions and problems in their daily life, and the need for beekeeping development. Gradually the forester can introduce new subjects such as the need to stop burning bee colonies, the need for tree planting, the introduction of new kitchen stoves and other related matters.

Thus the forester may change from a controlling and guarding forest police officer to become a participating local leader focusing attention on environmental protection and forest resource development.

Beekeepers will gradually lose their traditional image of being rather singleminded individuals, and become a strong and respected group of co-operating forest developers.

Foresters can gain the confidence of beekeepers by helping them in various ways. Instructors visit at beekeeping cooperative in Jinotega, Nicaragua

6. Valuable nectar-producing tree species (listed according to vegetation zones and multipurpose values)

6.1 General information about valuable trees

Beekeepers and beekeeping development workers always look for trees that bees like. They make observations of flowering periods and whether bees are collecting nectar or pollen. They also determine whether more valuable trees could be introduced within the flight range of the bees.

Similarly, forest people and forestry development workers try to make optimum use of available tree species and consider the introduction of new tree species with supplementary or alternative uses.

These groups of forest dependents are all in great need of detailed information on tree species with more than one value. This report cannot include full information on all the valuable nectar producing trees and their other uses in various parts of the world. The report will direct the reader searching for further information about nectar producing trees.

Of the hundreds of valuable melliferous tree species recorded in the literature, lists of some with multipurpose values in different vegetation zones are presented in Sections 6.3. to 6.10. Section 6.11. identifies valuable multipurpose bee trees that need further documentation.

These lists are not complete, but provide a starting point for further studies. Where tree taxa contain several species valuable to bees, we indicate only the taxa and leave out the species names. We are also aware that the lists are incomplete in that species authorities and the family are omitted (i.e. Coffea spp., Ilex spp., etc.). Some plants such as bananas (Musa spp.) and papaya (Carica papaya) are included in the lists although they are not woody trees.

The ambition was only to present lists including tree species that have been mentioned by several authors as valuable to bees in one way or another. These are often just lists of trees where bees have been seen working, and generally the relative importance of each tree is not described as this kind of information can only be achieved by careful local studies. Foresters, beekeeping technicians and others working with community forestry activities will find the list helpful in guiding them to know which trees are valuable sources of pollen and nectar for bees, which trees are important to protect, or to plant for bees.

It is always advisable to ensure full use and development of local and domestic tree species before the introduction of exotic species is considered (see 5.2.).

6.2 Selected literature for further information on valuable bee trees

Most research on bee flora (melliferous flora) has been carried out in regions of temperate climate. The bee botany of many commercial fruit and seed crops in

industrialized countries has been studied in detail. In some studies the amount of nectar and pollen collected as well as the pollinating activity of individual bees has been fully described. By comparison bee botany research in the tropics is very meagre.

The following standard texts include information on the flowering and pollination of many tree crops:

Crane, E (ed.) 1975, Honey: a comprehensive survey, London (211 important honey sources and a world guide to published information on good honey sources).

Crane, E, 1978, Bibliography of Tropical Apiculture London 24 parts, including: Bee forage in the tropics, 166 references. Descriptions of pollen grains in tropical honeys, 157 references. Bees for pollination in the tropics, 128 references

Crane, E, Walker, P, 1983, The impact of pest management on bees and pollination. Annex A. Annotated bibliography on bee pollination of crops grown in the tropics and subtropics, IBRA (662 references on 105 crops).

Crane, E, 1990, Bees and Beekeeping, Heinemann/Comstock (464 important honey sources and their geographical distribution plus a list of 197 bee pollinated crop plants).

Free, J B, 1970, Insect pollination of crops, London (reprinted 1979, a comprehensive reference book that also states what information is lacking).

Free, J B, 1976, Insect pollination of tropical crops, Ilford (a small summary for the Central Ass. of Beekeepers).

McGregor, S E, 1975, Insect pollination of tropical crops, Proc. III int. Symp. Poll., 1974: 47-55 (lists tropical crops benefited by insect pollination).

McGregor, S E, 1976, Insect pollination of cultivated crop plants, Agriculture Handbook, USDA No. 496 (detailed information on 150 main crop plants).

Ordetx, G S, 1952, Flora apícola de la America tropical, Havana (a Spanish reference book with over 700 species from Latin America).

Pesson, P, Louveaux, J, 1984, Pollinisation et productions végétales, Paris (a French reference book of great value).

Smith, F G, 1960, Beekeeping in the tropics, London (contains a useful chapter on bee forage).

Lists of melliferous plants for particular countries or areas have been compiled. Some of these include a study of the floral calendar for a particular place (see also 3.1.). Such calendars are, however, very scarce or incomplete in developing countries, or do not clarify which trees are most valuable. The International Bee Research Association (IBRA) and its branch libraries hold copies of many reports of this kind (see addresses in Chapter 8). The following reports could be regarded as model studies which provide a flowering calendar for one location:

Clauss, B, 1983, Bees and beekeeping in Botswana, Gabarone

Mardan, M, Kiew, R, 1985, Flowering periods of plants visited by honeybees in two areas of Malaysia, Proc. 4 Int. Conf. Apic. Trop. Climates: 209-216

Villanueva, R, 1988, Important plant species for apiculture in Ejido plan del Rio, Veracruz, Mexico, Proc. 4 Int. Conf. Apic. Trop. Climates: 138-145

Bee trees can also be valued indirectly by microscopic study of the pollen found in honey. The following could serve as model reports on pollen spectra in honey (all three are published in: Proc. 4 Int. Conf. Apic. Trop. Climates, IBRA Cairo, 1988.):

Lobreau-Callen, D et al. The plants visited by Apis mellifera adansonii in Gabon and the Ivory Coast (pp. 410-421)

Mattu, V K et al. Pollen spectrum of honeys from Apis cerana colonies in Himachal Pradesh, India (pp. 146-153)

Ricciardelli d'Albore, G et al. Pollen spectrum of some honeys produced in Zambia and Malawi (pp. 279-283)

Thanks to the efforts made by IBRA in recent years, more information has become available on multipurpose trees that are also important nectar or pollen producers in the tropics and subtropics. The number of valuable trees listed has increased and data have become more precise over the years. However, hundreds of trees and many more herbs still need further study, and therefore both the recent literature and the lists in this report include trees needing further documentation: we refer to these as 'candidate trees'. The following publications present valuable lists of melliferous and multipurpose trees:

Crane, E, Walker, P, Day, R, 1984, Directory of important world honey sources, London (this publication is compiled from a database of 820 references and 2,569 plant species, out of which 467 are described in detail and 196 are listed separately as candidate plants. The document contains valuable data on the multipurpose characteristics of the species included).

Crane, E, 1984, Some multipurpose trees that are important honey sources in the tropics and subtropics, Proc. 3 Int. Conf. Apic. Trop. Climates, Nairobi: 192-197 (this list contains 82 of the honey sources mentioned in Crane, Walker and Day, 1984 that also provide food and/or fodder).

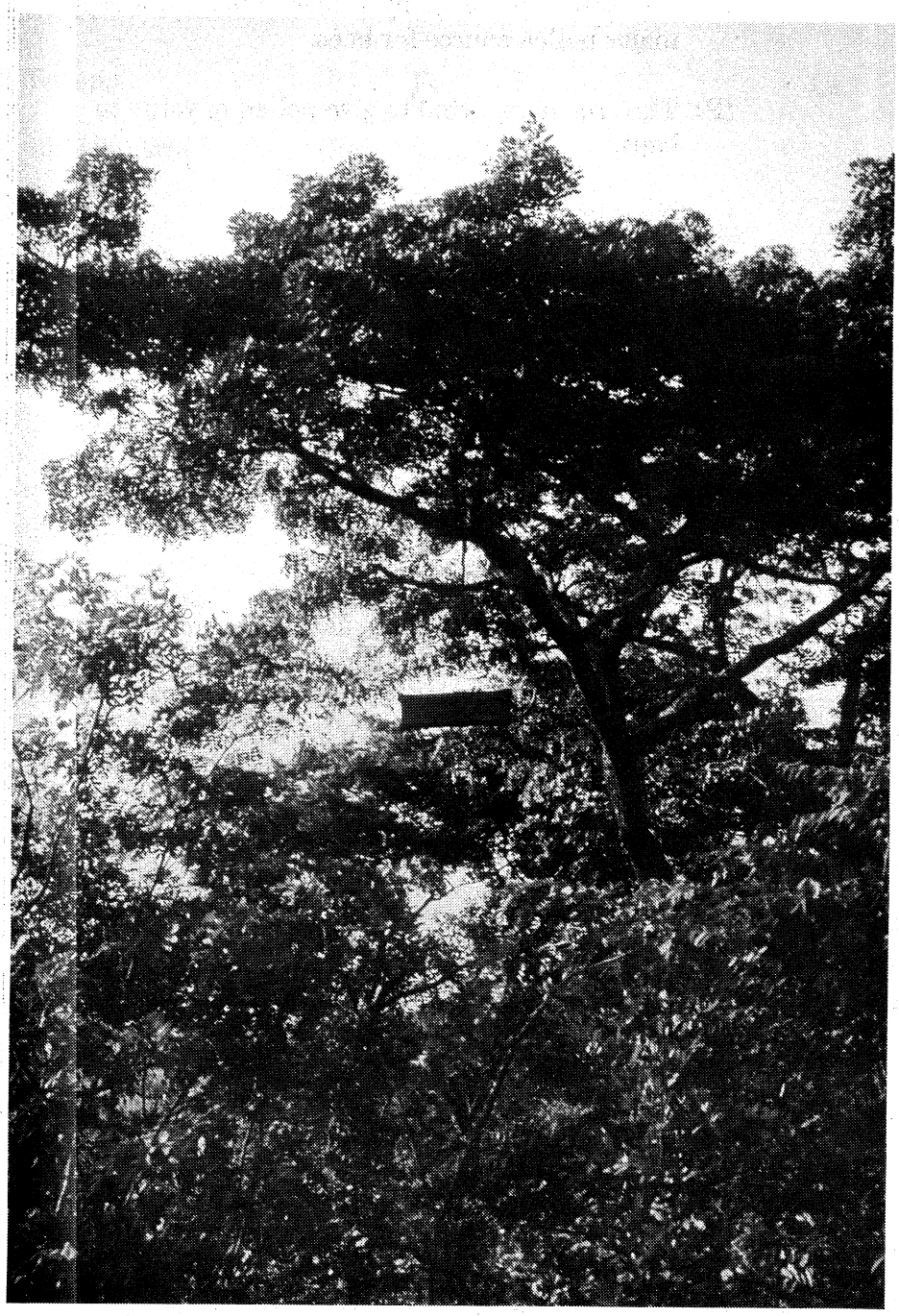
Crane, E, 1985, Bees and honey in the exploitation of arid land resources. Chapter 12, pp. 164-175 from Plants for Arid Lands. ed. G E Wickens, J R Goodin and D V Field, London

Eisikowitch, D, Masad, Y, 1980, Nectar-yielding plants during the dearth season in Israel, Bee World 61: No 1, pp. 11-18

IBRA, 1981, Planting for bees in developing countries, Source Materials for Apiculture 3 (31 recommended trees and shrubs with multipurpose values).

Townsend, G F, 1981, Honey producing trees in the tropics, ICRAF Newsletter No. 5, pp. 1-3

Much detailed information can also be obtained through the institutions listed in Chapter 8 or their respective publications.



Several authors have produced floral calendars for the "miombo" forest in East Africa. Traditional beehive in Brachystegia tree in Tanzania.
(Photo: Nicola Bradbear)

FACT BOX 10

Terms used

Vegetation zone:	Divisions between vegetation zones have been made as simple as possible. Some tree species are represented in many different zones (e.g. Citrus spp., Coffea spp., Cordia spp., Eucalyptus spp.).
Pollen:	P The tree is reported by at least one author as a major pollen source for bees. (P) The tree is reported to give pollen of value to bees. - No information.
Food:	Food for humans can be prepared from flowers, fruit, seeds, leaves, bark, etc.
Fodder:	The tree provides fodder for at least one kind of animal.
Fuel:	The tree has value for firewood production.
Timber:	The tree has value as timber.
Land:	The tree has a value for land use, land conservation or land development such as: windbreaks, shade, afforestation, land reclamation, living fences, firebelts, soil conservation, nitrogen fixation, organic mulch, weed control, erosion control, or sand stabilization.
Ornamental:	The tree has a value for amenities.
Others:	Other uses such as medicinal, insecticidal, oil, wax, gas, fibres, tannin, or dyes. The number given indicates number of other uses.

6.3 Nectar-producing species in lowland rainforest

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Anacardium occidentale	(P)	Fo		Fu	Ti			+4
Brachystegia laurentii	-							
Coffea spp.	(P)	Fo	Fd			La		
Cordia alliodora	(P)							
Cynometra alexandrii	-							
Eugenia spp.	-							
Gymnopodium antigonoides	-			Fu				
Haematoxylum campechianum	P				Ti		Or	+1
Hevea brasiliensis	-							+2
Ilex spp.	-							
Inga spp.	(P)					La		
Litsea glabberima	P							
Lonchocarpus spp.	-							
Musa spp.	P	Fo						+1
Nephelium lappaceum	(P)	Fo						+1
Pithecellobium spp.	P	Fo	Fd	Fu	Ti	La	Or	+3
Syzygium spp.	(P)	Fo	Fd	Fu	Ti	La	Or	+4
Terminalia spp.	(p)			Fu	Ti	La	Or	+3

Other good nectar producers in lowland rainforest: Acacia farmesiana, Alstonia bovrei, Combretum smeathmanii, Dalbergia kisantuensis, Erythrophleum guineense, Gaertnera paniculata, Gilbertiondendron dewevreii, Harungana madagascariensis, Mimosa pudica, Pentaclathra eetveldeana, Phyllanthus nivosus, Prosopis chilensis and Virectaria multiflora.

6.4 Nectar-producing species in highland forests

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Acacia polyphylla	-							
Aesculus spp.	P		Fd	Fu	Ti	La	Or	+1
Calcophyllum candidissimum	-				Ti	La		
Castanea sativa	P	Fo			Ti		Or	
Citrus spp.	P	Fo					Or	+3
Coffea spp.	(P)	Fo	Fd			La		
Cordia spp.	(P)	Fo			Ti	La		
Croton spp.	(P)							
Dombeya rotundifolia	P				Ti		Or	+1
Erica arborea	P				Ti		Or	+1
Eriobotrya japonica	P	Fo					Or	
Eucalyptus spp.	P		Fd	Fu	Ti	La	Or	+6
Gleditsia triacanthos	(P)	Fo	Fd	Fu	Ti	La	Or	
Gliricidia sepium	-	Fo	Fd	Fu	Ti	La	Or	+3
Grevillea robusta	(P)			Fu	Ti	La	Or	
Inga spp.	(P)					La		
Musa spp.	P	Fo						+1
Olea africana	(P)	Fo	Fd	Fu	Ti			+1
Robinia pseudoacacia	P	Fo	Fd	Fu	Ti	La	Or	
Tilia spp.	(P)				Ti	La	Or	+2
Tipuana tipu	-				Ti			
Trichilia glabra	-				Ti			
Vernonia polyanthus	(P)							
Vitex spp.	-	Fo						+3
Ziziphus jujuba	(P)	Fo					Or	

Other good nectar producers in highland forest: Albizia spp., Cupania spp., Matayba apetala, Ricinus communis, Rosa abyssinica and Triumfetta rhomboidoea.

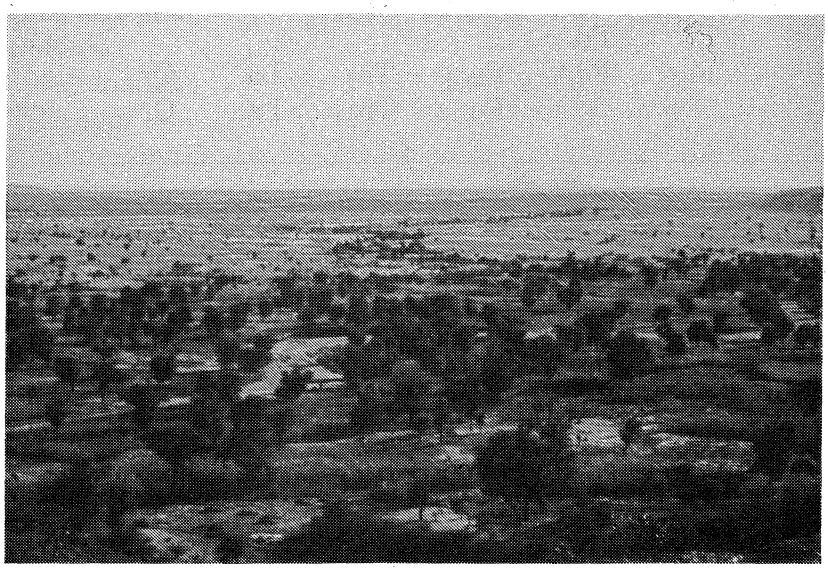
6.5 Nectar-producing species in wooded grassland (savannah)

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Acacia spp.	(P)	Fo	Fd	Fu	Ti	La	Or	+5
Azadirachta indica	(P)	Fo	Fd	Fu	Ti	La	Or	+4
Brachystegia spp.	(P)	Fo		Fu	Ti	La	Or	+4
Calycophyllum candidissimum	-				Ti	La		
Ceiba pentandra	P	Fo	Fd		Ti	La	Or	+1
Cochlospermum spp.	(P)					La		
Combretum spp.	-			Fu	Ti			+5
Cordia spp.	(P)	Fo			Ti	La	Or	
Cryptosepalum pseudotaxus	-							+1
Dialium engleranum	-	Fo						+1
Dombeya rotundifolia	P				Ti		Or	+1
Eucalyptus spp.	P		Fd	Fu	Ti	La	Or	+6
Faurea saligna	(P)				Ti			+2
Gilibertia spp.	-							
Isoberlina spp.	-				Ti			+2
Julbernardia spp.	-				Ti			+5
Leucas aspera	(P)							
Lonchocarpus spp.	-							
Madhuca longifolia	(P)	Fo						+2
Marquesia macroura	-				Ti			+1
Parkia biglobosa	-	Fo	Fd		Ti	La		+2
Prosopis spp.	P	Fo	Fd	Fu	Ti	La	Or	+2
Pterocarpus spp.	(P)				Ti			
Sclerocarya caffra	(P)	Fo	Fd					+2
Syzygium spp.	(P)	Fo	Fd	Fu	Ti	La	Or	+4
Terminalia spp.	(P)			Fu	Ti	La	Or	+3

Other good nectar producers in wooded grassland: Adansonia digitata, Albizia spp., Bauhinia spp., Burkea spp., Commiphora spp., Copaifera guineense, Erythrina spp., Erythrophleum, spp., Euphorbia spp., Ficus sycamorus, Grewia spp., Hymenocardia spp., Jacaranda mimosifolia, Lannea spp, Parianari spp., Protea spp., Pseudolachnos tylois, Schinus molle, Schwartzia madagascariensis and Vernonina spp.

6.6 Nectar-producing species in arid and semi-arid land

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Acacia spp.	(P)	Fo	Fd	Fu	Ti	La	Or	+5
Adansonia digitata	-	Fo	Fd		Ti	La		+4
Balanites aegyptiaca	-	Fo	Fd	Fu	Ti			+3
Combretum spp.	-			Fu	Ti			+5
Commiphora spp.	-		Fd	Fu	Ti			+2
Cordia spp.	(P)	Fo			Ti	La	Or	
Dombeya rotundifolia	P				Ti		Or	+1
Eucalyptus spp.	P		Fd	Fu	Ti	La	Or	+6
Euphorbia spp.	P	Fo				La		+1
Guaiacum officinale	-				Ti		Or	+2
Gymnopodium antigonoides	-			Fu				
Khaya senegalensis	-		Fd		Ti			
Leptospermum spp.	(P)				Ti	La		
Parkinsonia aculeata	(P)	Fo	Fd	Fu		La	Or	
Prosopis spp.	P	Fo	Fd	Fu	Ti	La	Or	+2
Terminalia spp.	(P)			Fu	Ti	La	Or	+3
Ziziphus spp.	(P)	Fo	Fd	Fu	Ti	La		+3



Acacia savannah - an important nectar resource! (Photo: Nicola Bradbear)

6.7 Nectar-producing species in coastal plains

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Acacia spp.	(P)	Fo		Fu	Ti	La	Or	+5
Anacardium occidentale	(P)	Fo		Fu	Ti			+4
Antigonon leptopus	P	Fo					Or	
Bombax ceiba	P	Fo	Fd		Ti	La		+2
Bucida buceras	(P)				It		Or	
Ceiba pentandra	P	Fo	Fd		Ti	La	Or	+1
Citrus spp.	P	Fo					Or	+3
Coccoloba uvifera	-	Fo						
Cocus nucifera	P	Fo	Fd		Ti		Or	+3
Cordia spp.	(P)	Fo			Ti	La		
Durio zibethinus	(P)	Fo						
Ehretia acuminata	(P)		Fd		Ti		Or	
Eucalyptus spp.	P		Fd	Fu	Ti	La	Or	+6
Haematoxylon campechianum	(P)				Ti		Or	+1
Litchi chinensis	(P)	Fo						
Mangifera indica	P	Fo				La	Or	
Melicoccus bijuga	-	Fo				La		
Musa spp.	P	Fo						+1
Nephelium lappaceum	(P)	Fo						+1
Parkinsonia aculeata	(P)	Fo	Fd	Fu		La	Or	
Persea americana	(P)	Fo						
Pithecellobium arboreum	(P)				Ti			
Psidium guajava	P	Fo			Ti			+3
Roystonea regia	P		Fd			La	Or	
Schinus terebinthifolius	-	Fo	Fd		Ti	La	Or	+3
Syzygium spp.	(P)	Fo	Fd	Fu	Ti	La	Or	+4
Triplaris surinamensis	-				Ti		Or	

6.8 Nectar-producing species in mangrove swamps

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Avicennia spp.	(P)	Fo	Fd	Fu	Ti			
Nyssa spp.	-	Fo			Ti		Or	
Rhizophora mangle	-			Fu	Ti	La		+4
Serenoa repens	(P)							

6.9 Nectar-producing species for agricultural land, roadside plantings and urban areas

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Anacardium occidentale	(P)	Fo		Fu	Ti			+4
Antigonon leptopus	P	Fo					Or	
Azadirachta indica	(P)	Fo	Fd	Fu	Ti	La	Or	+4
Carica papaya	(P)	Fo						+3
Cassia siamea	(P)		Fd	Fu	Ti	La	Or	+1
Castanea spp.	P	Fo			Ti		Or	
Ceiba pentandra	P	Fo	Fd		Ti	La	Or	+1
Citrus spp.	P	Fo					Or	+3
Cocos nucifera	P	Fo	Fd		Ti		Or	+3
Coffea spp.	(P)	Fo	Fd			La		
Diospyros spp.	-	Fo			Ti			+3
Durio zibethinus	(P)	Fo						
Elaeis guineensis	P	Fo	Fd	Fu				+2
Eucalyptus spp.	P		Fd	Fu	Ti	La	Or	+6
Euphoria longana	-	Fo						
Gliricidia sepium	-	Fo	Fd	Fu	Ti	La	Or	+3
Grevillea spp.	(P)			Fu	Ti	La	Or	
Litchi chinensis	(P)	Fo						
Malus spp.	P	Fo						
Mangifera indica	P	Fo				La	Or	
Melicoccus bijuga	-	Fo				La		
Moringa oleifera	P	Fo				La	Or	+3
Musa spp.	P	Fo						+1
Nephelium lappaceum	(P)	Fo						+1
Persea americana	(P)	Fo						
Prosopis spp.	P	Fo	Fd	Fu	Ti	La	Or	+2
Prunus spp.	(P)	Fo					Or	
Psidium guajava	P	Fo			Ti			+3
Roystonea regia	P		Fd			La	Or	
Sapindus detergens	(P)					La	Or	+3
Schinus terebinthifolius	-	Fo	Fd		Ti	La	Or	+3
Syzygium spp.	(P)	Fo	Fd	Fu	Ti	La	Or	+4
Tamarindus indica	P	Fo	Fd	Fu	Ti	La	Or	+3
Terminalia arjuna	(P)			Fu	Ti	La	Or	+3
Tilia spp.	(P)				Ti	La	Or	+2
Toona ciliata	(P)		Fd		Ti		Or	+2
Ziziphus spp.	(P)	Fo	Fd	Fu	Ti	La		+3

Other good nectar producers: Actinidia chinensis, Agave sisalana, Albizia spp., Aleurites spp., Annona spp., Averrhoa carambola, Bauhinia purpurea, Cola spp., Cydonia oblonga, Eugenia spp., Feijoa sellowiana, Ficus spp., Jacaranda mimosifolia, Macadamia integrifolia, Malpighia spp., Phoenix dactylifera, Pistacia vera, Pyrus spp. and Ricinus communis.

6.10 Nectar-producing species for commercial plantation

Tree name:	Pollen	Food	Fodder	Fuel	Timber	Land	Orna-mental	Others
Anacardium occidentale	(P)	Fo		Fu	Ti			+4
Ceiba pentandra	P	Fo	Fd		Ti	La	Or	+1
Citrus spp.	P	Fo					Or	+3
Cocos nucifera	P	Fo	Fd		Ti		Or	+3
Coffea spp.	(P)	Fo	Fd			La		
Dalbergia sissoo	-		Fd	Fu	Ti	La	Or	
Elaeis guineensis	P	Fo	Fd	Fu				+2
Eucalyptus spp.	P		Fd	Fu	Ti	La	Or	+6
Gmelina arborea	P			Fu	Ti			+1
Hevea brasiliensis	-							+2
Manihot glaziovii	(P)					La	Or	+1
Musa spp.	P	Fo						+1

Other good nectar producers for possible plantation use: Albizia falcataria, Balanites aegyptiaca, Cordia spp., Leucaena leucocephala, Melia azadirachta, Sclerocarya caffra, Shorea robusta, Tamarindus indica, Ziziphus abyssinica.

Cashew nut plantation in Guiné-Bissau

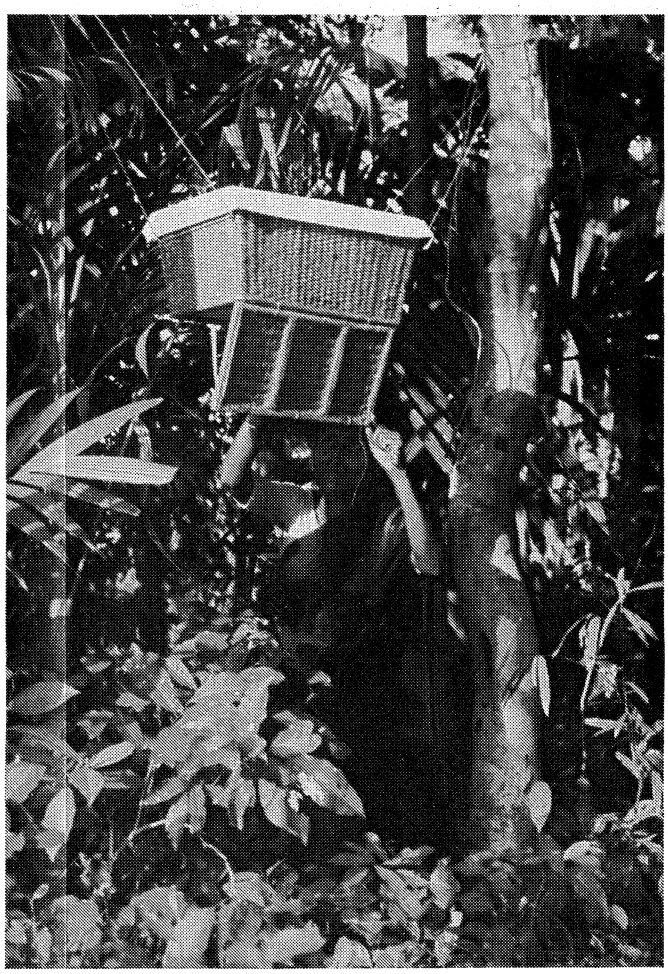
6.11 Candidate multipurpose trees also valuable to bees

Trees from various parts of the world are mentioned in the beekeeping literature, and project reports without reference to their eventual uses. Some of these trees may be characterised as valuable multipurpose trees after further study of their use in their local habitat.

Seeking full information about the values of the trees in the following list is outside the scope of this report. The list is important in the identification of valuable bee trees that need further documentation. Some of these trees are also mentioned in a list of 196 plants being candidates as important world honey sources published by Crane, Walker and Day (1984).

Only the botanical name and the country or region where each tree is being reported, is given in the list below:

Alchornea cordifola ..... Congo Brazzaville
Allophylus spp. ..... Zaire
Anogeissus leiocarpus ..... Sudan
Calliandra calothyrsus ..... Central America/Indonesia
Calophyllum inophyllum ..... Seychelles
Cedrela mexicana ..... Trinidad
Dovyalis spp. ..... Ethiopia
Drypetus seaiaria ..... Sri Lanka
Eurya spp. ..... China
Fagara chalybea ..... Zaire
Guazuma ulmifolia ..... Central America
Guiera senegalensis ..... Senegal
Justicia flava ..... Zaire
Lagerstroemia indica ..... India
Ligustrum compactum ..... Tropical Asia
Manilhara hexandra ..... Sri Lanka
Martenzia caryotaefolia ..... Trinidad
Monotes spp. ..... Zaire
Montanoa bipinnatifolia ..... Mexico
Myrtus communis ..... North Africa/Middle East
Neolitzea involuccata ..... Sri Lanka
Nypa fruticans ..... Thailand
Opuntia spp. ..... Mexico
Petrea arborea ..... Trinidad
Phaulopsis imbricata ..... Zaire
Piscidia piscipula ..... Belize
Rabdosia rugosa ..... Pakistan/India
Raphia vinifera ..... West Africa
Rhododendron spp. ..... Asia Minor/Central Asia
Rhoicissus tridentata ..... Zaire
Sapium sebiferum ..... China
Scaevola taccada ..... Seychelles
Scutia myrtina ..... South Africa
Shorea robusta ..... Bangladesh/Bhutan
Swietenia spp. ..... Trinidad



The "Mulderry" hive in Bangladesh - a good example of appropriate beekeeping technology! (Photo: Mogens Jensen)

Careful management of honeybees will secure pollination and a good income source. (Selangor, Malaysia)

7. Promoting bees and trees within community forestry

7.1 General advice

Beekeeping must be included in lists of income-generating forest-based enterprises (see 1.3.).

Beekeepers must be invited to take part in community forestry efforts (see 2.4.).

Honey and beeswax should always be included as valuable forest products (see 1.2. and 1.3.).

Honeybees should be encouraged as an integral part of any forest or tree ecosystem with particular value for the pollination of wild or cultivated crops (see 1.1. and 1.5.).

Beekeeping and beekeepers should always be regarded as a positive force in the development of the forest resources and must never be considered a threat.

7.2 Advice for foresters

Protect species diversity in local ecosystems (see 3.4.).

Gather information about the flowering biology, nectar and pollen values of local trees (see 5.1.).

Use local trees in extension before exotic trees are introduced (see 5.2.).

Gather information about exotic trees including their value as bee trees.

Design planting and management methods (i.e. planting of mixed species, irrigation, spacing, forage harvesting, thinning, clearing, spraying) that give optimum opportunity for bees to profit from forest developments (see 5.3.).

Learn more about the secrets of traditional and modern beekeeping practices in the local area and find out about the possibility for beekeeping development.

Seek co-operation with local beekeepers and hear their views about trees and forestry (see 5.4.).

Involve beekeepers in the project groups as individuals in order to stimulate a fruitful communication or create special beekeepers groups (see 2.4.).

If few beekeepers are available, take initiatives to study the potential for beekeeping development or even initiate training or other development efforts in the beekeeping sector.

7.3 Advice for beekeeping officers

Always speak up as the representative for beekeepers and demand the conservation and protection of existing forest resources.

Watch constantly for ecological change or different forest management practices in the local area.

Teach beekeepers about the value of trees and the importance of environmental care.

Stimulate beekeepers and their families to join community forestry activities.

Seek co-operation with the local forestry staff and learn as much as possible about their work, their projects and plans for the future.

Collect facts about local bee trees and further information for local forestry staff.

Try to act as a consultant when foresters are discussing the introduction of exotic species, and make them aware of the importance of choosing good bee trees.

7.4 Summary of research priorities

Bees:

1. Permanent beekeeping without killing bees or destroying trees.
2. Appropriate beekeeping technology (low cost, simple, sustainable and environmentally sound equipment and methods).
3. Cost-benefit analysis of beekeeping among poor people.
4. Testing methods for organic honey and beeswax.
5. Swarm attractants and bee tranquillisers of plant origin.
6. Biological methods for control of pests and predators in bee colonies.
7. Properties of propolis and other minor hive products.

Trees:

1. Conservation and reforestation of natural forest ecosystems.
2. The value and optimum use of native tree species.
3. The value, advantages and problems of exotic trees (multipurpose trees).
4. People's participation in community forestry activities.

5. Suitable planting and spacing practices for valuable trees.

6. Mixed planting of tree species in community forestry and agroforestry.

7. Sustainable methods for intensive exploitation of forest-resources (including correct thinning and clearing practices).

8. Flowering calendars of local and imported trees.

Bees and trees:

1. The nectar producing potential and flowering biology of native and exotic trees.

2. Identification of valuable bee trees and their respective cultivation practices, for use in community forestry activities.

3. Quantification of the economic values of bees and beekeeping in comparison to other forest activities.

4. The value of pollinating insects for cultivated crops.

5. The value of pollinating insects for seed set and regeneration of forest trees.

6. Development of alternatives to the use of logs or tree trunks as beehives.

7. Development of Rapid Rural Appraisal techniques for beekeeping in community forestry projects.

8. Evaluation of success and failure in beekeeping development projects.

General comments:

Research should always aim at solving problems of the target group in the country or the individual project (i.e. the poor segment of the population).

It is better in the long run if research can be carried out locally by nationals or by national research institutions.

New and appropriate research should always be preferred over the transfer of technology.

Research results should be implemented by extension and project staff.

8. Institutions holding data concerning bees and trees

AGRECOL The Centre of Appopriate Technology and Social Ecology c/o Ökozentrum, CH-4438 Langenbruck, Switzerland

APIMONDIA International Federation of Beekeepers' Associations 101, Corso Vittorio Emanuele, Rome, Italy

BOSTID The Board on Science and Technology for International Development, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418, USA

FAO Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy

FAO RWEDP Regional Wood Energy Development Programme, Maliwan Manion, Phra Atit Road, Bangkok 10200, Thailand.

FTPP Forest, Trees and People Programme, IRDC, Swedish University of Agricultural Sciences, Box 7005, S-750 07 Uppsala, Sweden

IBRA International Bee Research Association, 18 North Road, Cardiff CF1 3DY, Wales, UK. Branch Libraries:

Africa: InterAfrican Bureau for Animal Resources, PO Box 30786, Maendeleo Ya Wanake House, Monrovia Street, Nairobi, Kenya

Tropical Asia: Central Bee Research Institute, Khadi and Village Industries Commission, 1153 Ganeshkind Road, Pune 411 016, India

Eastern Asia: Institute of Honeybee Science, Tamagawa University, Machida-shi, Tokyo 194, Japan

Latin America: Universidad Nacional de Colombia, Departemento de Biologia, Apartado Aereo 3840, Medellin, Colombia

ICIMOD - International Centre for Integrated Mountain Development, GPO Box 3226, Kathmandu, Nepal

ICRAF - International Council for Research in Agroforestry, PO Box 30677, Nairobi, Kenya

ICRISAT - International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Hyderabad, India

ICRISAT - International Crops Research Institute for the Semi-Arid Tropics, Centre Sahelien, BP 12404, Niamey, Niger

IFP Programme - Indigenous Food Plants Programme, PO Box 48108, Nairobi, Kenya

IIED - International Institute for Environment and Development, 3 Endsleigh Street, London WC1H 0DD, UK.

IITA - International Institute of Tropical Agriculture, Oyo Road, PMB 5320, Ibadan, Nigeria

ILEIA - Info Centre for low external-input and sustainable agriculture, PO Box 64, NL-3830 AB Leusden, Netherlands

ITCI - International Tree Crops Institute, PO Box 283, Caulfield South 3162, Victoria, Australia

IUCN - Tropical Forest Conservation, Avenue du Mont-Blanc, CH 1196, Gland, Switzerland

KENGO - Kenya Energy and Environment Organisations, PO Box 48197, Nairobi, Kenya

NFTA - Nitrogen Fixing Tree Association, PO Box 680, Waimanolo, Hawaii 96795, USA

RITA/ALIN - Arid Lands Information Network, Casier Postal 3, Dakar-Fann, Senegal

SUAS - The Swedish University of Agricultural Science, The Int. Rural Development Centre, Box 7005, S-75007 Uppsala, Sweden

World Bank - 1818 H Street NW, Washington DC 20433, USA

9. List of beekeeping terms

(Extract from the IBRA Education Resource Pack, 1990)

Apiary ..... The location of a number of bee colonies.

Apiculture ..... The science of bees and beekeeping.

Apis ..... The genus to which honeybees belong.

Bee ..... Any insect belonging to the superfamily Apoidea. There are well over 20 000 species of bees; the most familiar are honeybees and bumble bees. An important bee characteristic is an ability to collect pollen.

Bee space ..... The space where honeybees walk and work, i.e. the space between two combs or between a comb and the wall of the hive.

Beeswax ..... Wax produced by honeybees (secreted by special glands on the underside of the bee) and used to build comb.

Brood ..... All stages of immature honeybees; eggs, larvae and pupae.

Cell ..... A single hexagonal wax compartment, the basic unit of comb. Each honeybee develops within a single cell, and honey and pollen are stored within cells.

Colony ..... Honeybees are social insects: they cannot live individually, only together as part of a colony. Each colony of honeybees contains one queen bee who is the female parent of the colony, a few hundred drone bees and thousands of worker bees.

Comb ..... The wax structure made of hexagonal cells in which honeybees rear young and store food.

Cross-pollination ..... The transfer of pollen between flowers of different plants of the same species. Plants that are not self-fertile must be cross-pollinated before they can develop seeds or fruit.

Drone ..... A male honeybee. Drones undertake no hive work: their sole function is to fertilize the queen.

Extractor ..... The honey extractor is a centrifugal machine in which honey is spun out of cells within comb.

Foundation ..... A thin sheet of beeswax printed with a hexagonal pattern. A sheet of foundation is placed in each wood frame and this serves as a base upon which honeybees build their comb.

Intermediate technology beekeeping often tries to avoid the costly system of using wax foundations.

Frame ..... A wooden rectangular frame that provides a strong support for wax foundation. A number of frames hang parallel to one another inside the frame hive.

Frame hive..... A hive which contains frames.

Hive..... Any container provided by man for honeybees to nest in.

Honey ..... Nectar or plant sap collected by bees, concentrated by them and stored in combs.

Honeydew ..... Insects such as aphids feed on large quantities of plant sap which they excrete almost unchanged (except for protein content). This sap collects on the leaves of plants and if collected by honeybees is known as honeydew.

Honeyhunting ..... The collection of honey from bees nesting in the wild.

Monofloral..... Monofloral honey is that produced by bees foraging predominately on a single flower species.

Nectar..... A sweet liquid secreted by flowers.

Nectaries..... Glands within plants that produce nectar.

Pollen..... The fine dust-like substances which are the male reproductive cells of flowering plants. Collected by bees as a source of protein.

Pollination..... The transfer of pollen from the anther of a flower to the stigma of that or another flower.

Pollination agent..... Bees act as pollination agents when they transfer pollen from one flower to another. In some cases pollinating agents include nectar-seeking birds and bats.

Propolis ..... Plant resins collected by honeybees and used by them to seal cracks and gaps within the hive.

Queen ..... The female parent of the colony, the only sexually developed female.

Royal jelly..... Glandular secretions of worker honeybees (bee milk) mixed with some regurgitated carbohydrates and fed to developing queen bees.

Self-pollination.....The transfer of pollen between flowers of the same plant, or within one flower. Self-pollination is only effective in self-fertile plants.

Smoker.....A metal can (often with bellows attached) used to generate smoke for subduing honeybees.

Swarm .....When a honeybee colony becomes large enough to divide into two, swarming takes place. When this happens a new queen is reared, the colony divides and a swarm leaves the hive. This swarm consists of a queen, drones and workers which form another colony in a new location.

Worker bees.....Female honeybees that make up the bulk of the colony and undertake all the work of the colony except for mating and egg laying. Workers are sterile females.

A good comb of brood from a movable frame hive in Kathmandu, Nepal

10. References

10.1. Periodicals

Agroforestry Today ICRAF

Apiacta APIMONDIA

Apicultural Abstracts IBRA

Baobab RITA/ALIN

Bee World IBRA

Beekeeping and Development (previously titled Newsletter for beekeepers in tropical & subtropical countries) IBRA

Cornucopia IAAD Newsletter IAAD, 3201 Huffman Blvd., Rockford, Il 61103, USA

FTPP Newsletter SUAS/FAO Rome

IFP Newsletter Indigenous Food Plants Programme

ILEIA Newsletter ILEIA

Science of Sustainable Development (Dec 1990) AMBIO Special Issue: Vol XIX No 8, AMBIO, Box 50005, S-104 05 Stockholm, Sweden

Unasylva FAO Rome

Wood Energy News RWEDP/FAO Bangkok

(The full institute addresses are given in Chapter 8)

10.2 Literature

B = publications about bees and beekeeping

T = publications about trees and forestry

BT = both subjects

T Skogen (1982) A report from Cellulose du Cameroun, CELLUCAM. The Forest 6-7 pp. 20-21 In Swedish

B Adey, M et al. (1986) Pest control safe for bees: a manual and directory for the tropics and subtropics. London, UK: IBRA

B Adjare, S (1984) The golden insect: a handbook on beekeeping for beginners. London, UK: Intermediate Technology Publications

B Akratanakul, P (1987) Beekeeping in Asia. Rome, Italy: FAO

BT Baumer, M C (1985) Apiculture and agroforestry. In Proceedings of the Third International Conference on Apiculture in Tropical Climates, Nairobi 1984 London, UK: IBRA 238-240

B Bradbear, N (1990) Beekeeping in rural development. London UK: IBRA

BT Björklund, L; Ståhl, Z (1988) Shifting cultivation and socio-economic aspects of the peasantry in the Tiro Botar-Becho forestry pilot project area, Ethiopia. SUAS Working Paper 77. Uppsala, Sweden

T Bohlin, F (1984) Planning of forestry for rural development. SUAS Working Paper 20. Uppsala, Sweden

T Celander, N (1983) Miombo woodlands in Africa - distribution, ecology and patterns of land use. SUAS Working Paper 16. Uppsala, Sweden

T Chambers, R J H (1988) Trees as savings and security for the rural poor. IIED Gatekeeper series No SA3 London, UK

T Chipko. Blue prints for survival. Chipko Andolan: India

B Clauss, B (1982) Bee keeping handbook. Gaborone, Botswana: Ministry of Agriculture

B Clauss, B (1983) Bees and beekeeping in Botswana. Gaborone, Botswana: Ministry of Agriculture

BT Clauss, B and Zimba, R (1988) Beekeeping development on the base of the existing traditional practises (Zambia - North-Western Province) in Proc. 4 Int. Conf. Apic. Trop. Climates, Cairo 1988. IBRA, London 1989

B Commonwealth Secretariat (1979) Beekeeping in rural development: unexploited beekeeping potential in the tropics with particular reference to the Commonwealth. London, UK: Commonwealth Secretariat

T Corlin, C et al. (1989) FTP in Vietnam, base-line and diagnosis study, socio-economic part. SUAS Working Paper 100. Uppsala, Sweden

B Crane, E [ed.] (1975) Honey: a comprehensive survey. London, UK: Heinemann

B Crane, E (1978) Bibliography of tropical apiculture. London, UK: IBRA

B Crane, E & Walker, P (1983) The impact of pest management on bees and pollination. London, UK: Tropical Development & Research Institute

B Crane, E et al. (1984) Directory of important world honey sources. London, UK: IBRA

BT Crane, E (1985) Bees and honey in the exploitation of arid land resources. In Plants for arid lands [ed. Wickens G E; Goodin, J R; Field, D V] London, UK: George Allen & Unwin 163-175

B Crane, E (1990) Bees and beekeeping. Oxford, UK: Heinemann Newnes

B Drescher, W; Crane, E (1982) Technical cooperation activities: beekeeping. A directory and guide. Eschborn, Germany: DGTZ

BT Eisikowitch, D: Masad, Y (1980) Nectar-yielding plants during the dearth season in Israel. Bee World 61 (1): 11-18

T Eisikowitch, D; Dafni, A (1988) The use and abuse of introducing honey plants. Bee World 69 (1): 12-14

B FAO (1986) Tropical and sub-tropical apiculture. Rome, Italy: FAO

T National Academy of Sciences (1980) Firewood crops - shrub and tree species for energy production. Vol. 1. Washington DC, USA

T National Academy of Sciences (1983) Firewood crops - shrub and tree species for energy production. Vol. 2. Washington DC, USA

T FAO (1989) Forestry and food security. In FAO Forestry Paper 90 Rome, Italy

B Free, J B (1970) Insect pollination of crops. London, UK: Academic Press

B Free, J B (1976) Insect pollination of tropical crops. UK: Central Association of Beekeepers

B Gentry, C (1982) Small scale beekeeping. Manual M-17. Washington DC, USA: Peace Corps Information Collection and Exchange

T Goppers, K et al. (1987) Forestry under the gun. SIDA evaluation report, Forestry, Nicaragua, SIDA Stockholm, Sweden

BT Ichikawa, M (1981) Ecological and sociological importance of honey to the Mbuti net hunters, Eastern Zaire. African Study Monographs Vol. 1. 55-68

BT International Bee Research Association (1985) Source materials for apiculture; No. 3 - Planting for bees in developing countries. London, UK: IBRA

BT International Bee Research Association (1976) Proceedings of the First International Conference on Apiculture in Tropical Climates, London 1976. London, UK: IBRA

BT ---- (1983) Proceedings of the Second International Conference on Apiculture in Tropical Climates, New Delhi, 1980. New Delhi, India: Indian Agricultural Research Institute

BT ---- (1985) Proceedings of the Third International Conference on Apiculture in Tropical Climates, Nairobi, 1984. London, UK: IBRA

BT ---- (1989) Proceedings of the Fourth International Conference on Apiculture in Tropical Climates, Cairo, 1988. London, UK: IBRA

BT International Commission for Plant-Bee Relationships (1962) International Symposium on Pollination, Copenhagen

BT ---- (1964) International Symposium on Pollination, London

BT ---- (1974) International Symposium on Pollination, Prague

BT ---- (1978) International Symposium on Pollination, Maryland

BT ---- (1983) International Symposium on Pollination, Paris

BT ---- (1990) International Symposium on Pollination, Tilburg

B Jensen, M (1990) Baselines as a part of a dynamic process. FTP Newsletter No. 9 & 10: 10-15 Uppsala, Sweden: SUAS

T Jönsson, S (1988) Forestry literature for development workers. Working Paper 63. Uppsala, Sweden: SUAS

B Kawa, M (1989) Therapeutic properties of propolis. IBRA Newsletter for bee-keepers in tropical and sub-tropical countries No. 15: 10

B Kevan, P G et al. (1990) Insect pollinators and sustainable agriculture. American Journal of Alternative Agriculture 5 (1): 13-22

T Kigatiira, K I et al. (1988) Prosopis spp. as multi-use trees in dry zones. Bee World 69 (1): 6-11

B Kvarnbäck, G; Svensson, B (1985) National Beekeeping Program, Nicaragua, Evaluation Report 1980-1984 with future recommendations. Sala, Sweden: Bikonsult HB

T Lindström, J (1988) FTP in Babati, Tanzania, base-line and diagnosis study, Socio-economic part. Working Paper 83. Uppsala, Sweden

BT Loock, E E M (1970) Eucalyptus species suitable for the production of honey. Bull. Dept. For., Pretoria No. 46: 1-8

T Lundgren, N (1980) Plantation forestry in tropical countries - physical and biological potentials and risks. In Rural Development Studies No. 8. Uppsala, Sweden

B McGregor, S E (1976) Insect pollination of cultivated crop plants. Agriculture Handbook, USDA No. 496. Washington DC, USA

T Nair, P K R (1980) Agroforestry species: a crop sheets manual. Nairobi Kenya: ICRAF

BT Nehru, C R et al. (1989) Nectar and pollen plants for extending the flow period in rubber-growing areas of India. Bee World 70 (3) 118-119

B Nightingale, J (1983) A lifetime's recollections of Kenya tribal beekeeping. London, UK: IBRA

BT Ntenga, G M; Mugongo, B T (1989) A study of traditional beekeeping in Babati district of the United Republic of Tanzania, Babati. Babati, Tanzania: FTPP

BT Ordetx, G S (1952) Flora apícola de la America tropical. Havana, Cuba: Editorial Lex

T Östberg, W (1988) We eat trees; tree planting and land rehabilitation in West Pokot District, Kenya. A baseline study. Working Paper 82. Uppsala, Sweden: SUAS

B Parent, G et al. (1989) Les miels dans la forêt du Shaba méridional. Bull. Rech. agron. Gembloux: 13 (2) 161-176

B Pesson, P; Louveaux, J (1984) Pollinisation et productions végétales. Paris, France: INRA

T Poulsen, G (1981) Important forest products in Africa other than wood and wood extractives. Rome, Italy: FAO

BT Smith, F G (1960) Beekeeping in the tropics. London, UK: Longmans

BT Storrs, A E G (1982) More about trees. Ndola, Zambia: Forest Department

B Svensson, B (1984) Beekeeping in the Republic of Guiné-Bissau and the possibilities for its modernization. Working Paper 17. Uppsala, Sweden: SUAS

B Svensson, B (1988) Beekeeping technology in Bangladesh. Sala, Sweden: Bikonsult HB

BT Townsend, G F (1981) Honey producing trees in the tropics. ICRAF Newsletter 5: 1-3

T Turnbull, C (1976) The forest people. London, UK: Pan Books

BT Villieres, B (1987) Le point sur l'apiculture en Afrique tropical. Dossier No. 11. Paris, France: GRET

B Wainwright, D (1989) Socio-economic comparison of beekeeping technologies in Zambia. In Proceedings of the Fourth International Conference on Apiculture in Tropical Climates, Cairo 1988. London, UK: IBRA 360-366

BT Wongsiri, S; Tangkanasing, P (1987) Publications of bee biology research unit at Chulalongkorn University (1984-1987), Bangkok, Thailand.

The rainforest - a complex but vulnerable ecosystem (Lukenie, Zaire)

Montanoa bipinnatifolia - a beautiful tree from Mexico of great value for bees and as an ornamental tree

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