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Towards Realization of Kenya's Full Beekeeping Potential: A Case Study of Baringo District

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ABSTRACT

In the Tugen community of Baringo District, Kenya, beekeeping is culturally defined as a man's job. Training is normally conducted by an experienced member of an apprentice's family or by a fellow beekeeper. While boys receive instruction in all aspects of beekeeping, the training of girls is restricted to non-productive roles. Women who wish to engage in beekeeping therefore lack most of the necessary skills and are required to hire men for hive construction, placement of hives in trees, pest management, honey harvesting and processing. Beekeeping is ranked second or third among the four most important income-generating activities with its relative economic importance increasing as potential for crop agriculture diminishes with altitude. 91% of beekeepers rely on fixed comb, traditional, log hives, which beekeepers make individually, receive as gifts or inherit. Where necessary to buy equipment, beekeepers do not look for credit but depend on savings or income generated from other economic activities at farm level. Beekeepers follow traditional colony management, harvesting and processing methods to produce honey. They sell crushed honeycombs as a crude product to middlemen who follow simple procedures to produce semi-refined honey. The grade of combs containing most of the pollen and brood is sold to brewers of traditional beer and other alcoholic beverages. Wax does not have an established route for trading and is discarded as waste or put into domestic use. There have been attempts to introduce Kenya Top Bar Hives (KTBH) as transitional, movable comb hives in order to raise the yield and quality of hive products in Kenya. In Baringo District beekeepers have not adopted this technology as they have no one reliable and close-by to help them when they encounter various difficulties in using such hives. Areas in which beekeepers would like to receive further training in order to improve colony management and productivity include bee biology, principles of management based on KTBH and other movable comb hives, quality harvesting and processing procedures as well as marketing. These areas comprehensively sum up current problems faced in beekeeping. With regard to the performance of KTBH, top bars are the only parts that must be made to precision. Newly manufactured bars in workshops varied by only 1 mm from the specified width of 32 mm. In the field, this precision was lost as dimensions of unseasoned wood adjusted on exposure to natural elements. Beekeepers also complained that extreme temperatures arose in KTBH during the hot season to the extent of wax melting and combs dropping from bars. Two variants of the KTBH were therefore tested for temperature regulation and one that was fitted with a modified flat cover, insulated by a timber ceiling and painted white, was found to attain significantly lower peak temperature than a normal KTBH. Placing hives in a thatched bee hut also kept them significantly cooler in all seasons compared to open and tree-shaded sites. A study of vegetation revealed that species composition varies widely from area to area with respect to plants that beekeepers consider as most important for beekeeping. Natural flowering gaps exist during the hot season at the beginning of each year causing bees to migrate elsewhere and not to return until conditions improve with the onset of rains. Since most beekeepers utilize land that is communally owned with several types of interests at times vested in the same plants, vegetation is reported to be declining and this calls for conservation measures to be put in place. Based on these findings, recommendations are made at the end of the study suggesting a way forward for beekeeping not only in Baringo District but also for other areas of Kenya.

KURZFASSUNG

In der Tugen Gemeinde des Baringo-Distriktes, Kenia, wird die Imkerei kulturell als Männerarbeit definiert. Der Lehrling wird normalerweise von einem erfahrenen Familienmitglied oder einem Imkerkollegen ausgebildet. Während Jungen in allen Aspekten der Imkerei ausgebildet werden, erhalten Mädchen nur Unterweisungen in unterstützenden Tätigkeiten. Wenn Frauen sich daher der Imkerei zuwenden möchten, verfügen sie meist nicht über die notwendigen Kenntnisse und müssen für die Errichtung von Bienenstöcken, Aufstellung der Bienenstöcke in Bäumen, Ungezieferkontrolle, dem Honigernten und der Weiterverarbeitung des Honigs Männer anstellen. Die Imkerei steht an zweiter und dritter Stelle der vier wichtigsten Aktivitäten zur Schaffung von Einkommen. Die relative wirtschaftliche Bedeutung der Imkerei wächst mit der Höhe, da sich gleichzeitig die Möglichkeit Feldfrüchten anzubauen verringert. 91% der Imker nutzen die traditionellen Hohlstamm-Bienenstöcke, die sie selbst herstellen, geschenkt bekommen oder erben. Wenn die Imker Gerätschaften kaufen müssen, nehmen sie keine Kredite auf, sondern nutzen Ersparnisse oder Einkommen aus anderen bäuerlichen Tätigkeiten. Die Imkerei basiert auf traditioneller Koloniebewirtschaftung, Honigernte und Verarbeitungsmethoden. Die Imker verkaufen den Rohhonig an Mittelsmänner, die daraus halbraffinierten Honig herstellen. Die Rückstände, die überwiegend aus Wachs und Brut bestehen, werden an Brauereien für die Herstellung des traditionellen Bieres und anderer alkoholischer Getränke verkauft. Das Wachs wird als Abfall entsorgt oder im Haushalt eingesetzt. Es wurde versucht, V-förmige Bienenstöcke, die sogenannten Kenya Top Bar Hives (KTBH) mit beweglichen Waben einzuführen, um Ertrag und Qualität der Imkereiprodukte in Kenia zu erhöhen. Im Baringo-Distrikt gibt es für die Imker keine zuverlässige oder ortsnahe Unterstützung bei Problemen mit diesen Bienenstöcken und daher wurde diese Technologie nicht eingeführt. Die Imker haben einen Weiterbildungsbedarf in Bienenbiologie, Koloniebewirtschaftung, Ernte- und Verarbeitungsmethoden sowie Marketing geäußert, um die Koloniebewirtschaftung und die Produktivität zu verbessern. In den obengenannten Bereichen werden die aktuellen Probleme der Imkerei deutlich. Im Bezug auf die Leistung der KTBH, sind die Querträger die einzigen Teile, die mit einer gewissen Präzision hergestellt werden müssen. Die in Werkstätten neu hergestellten Querträger, wichen um nur 1mm von den vorgegebenen 32mm ab. Im Feld ging diese Präzision verloren, da das nicht abgelagerte Holz, dass der Witterung ausgesetzt war, sich verzog. Die Imker bemängelten außerdem die extremen Temperaturen in den KTBH während der heißen Jahreszeit; wo das Wachs schmilzt und die Waben von den Querträgern fallen. Zwei Varianten der KTBH wurden daher für die Temperaturregulation getestet. Eine Variante mit einem modifizierten Flachdach, welches mit einer Holzdecke versehen und weiß angestrichen war, zeigte signifikant niedrigere Höchsttemperaturen als normale KTBH. Die Aufstellung der Stöcke in einer mit Gras bedeckten Hütte führte ebenfalls zu signifikant niedrigeren Temperaturen zu allen Jahreszeiten verglichen mit den offenen und beschatteten Standorten. Eine Vegetationsstudie der Bienenweidepflanzen zeigte je nach Gebiet eine unterschiedliche Artenzusammensetzung. Natürliche Unterbrechungen in der Blütezeit, die es in der heißen Jahreszeit am Anfang jeden Jahres gibt, führt dazu, dass die Bienen auswandern und erst wiederkehren wenn sich die Bedingungen mit dem Beginn der Regenfälle verbessern. Da die meisten Imker kommunales Land nutzen, ist der Nutzungsdruck auf die einzelnen Bienenweidearten

z.T. sehr hoch. Naturschutzmaßnahmen sind daher erforderlich. Aufgrund dieser Erkenntnisse wurden am Ende der Studie Empfehlungen gemacht, die einen Weg vorwärts für die Imkerei nicht nur im Baringo-Distrikt, sondern auch für andere Gebiete in Kenia aufzeigen können.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ASAL	Arid and Semi Arid Land
CBI	Centre for Promotion of Imports from Developing Countries
DAAD	Deutscher Akademischer Austausch Dienst
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
IBRA	International Bee Research Association
ICIPE	International Centre of Insect Physiology and Ecology
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KTBH	Kenya Top Bar Hive
NGO	Non-Governmental Organization
ZEF	Zentrum für Entwicklungsforschung

1 GENERAL INTRODUCTION

1.1 Highlight of characteristics of the Kenyan economy

Kenya is a developing, tropical, African country with an estimated population of about 30 million people. This population is characterized by high fertility and declining mortality as a result of which 50% of the people are aged below 15 years. This means that the working population supports a large and growing number of young people whose future needs include employment and opportunities for a good standard of living (Office of the President 1999).

Kenya's economic growth, employment creation and foreign exchange generation are largely based on agriculture (Ministry of Agriculture 1999). Direct agricultural contribution to the national GDP averaged 30% in the 1980's. A further 27% was attributed to indirect linkages with sectors such as manufacturing, distribution and others related to service delivery. The sector accounts for 80% of national employment mainly in the rural area, contributes about 60% of total export earnings and 45% of government revenue. This contribution has lately been adversely affected by a number of external forces, including fluctuating global prices for agricultural commodities, slashes in the government budget allocation to the sector and high inflation rates. Growth in the sector has therefore been on the decline resulting in low economic growth. This has made it necessary for the government to address the issue of rising poverty among Kenyans, a problem that it had hoped to eradicate through economic growth as outlined in various development plans since political independence in 1963 (Office of the President 1999).

According to the Welfare Monitoring Survey of 1994, the incidence of poverty was 47% in the rural areas and 29% in urban areas (Office of the President 1999). By 1999, it was estimated that 12.6 million people lived below the poverty line (US$1 per capita per day at 1986 prices). It was also found that the poor tended to be clustered into certain socially disadvantaged categories among which were households headed by people without formal education and pastoralists in drought prone arid and semi-arid land (ASAL) districts. The government has consequently drawn up a national plan that outlines its commitment to poverty eradication by 2015. The new approach is to fight poverty through encouragement of growth of economic opportunities for low-income people on their farms and in their enterprises in order to build upon the existing endowments of human and social capital.

Kenya has a total land area of 57.6 million ha of which only 16% has a high to medium agriculture potential for crops and dairy livestock (Ministry of Agriculture 1999). The greater proportion of land is therefore arid to semi-arid and characterized by soils with a low natural fertility that are prone to compaction and vulnerable to erosion. Baringo District is categorized as one among thirteen ASAL districts where most of the water that is available is saline. Such areas support some agriculture in 9 million ha, sedentary livestock keeping in 15 million ha while the remaining 24 million ha is extremely dry and only suitable for nomadic pastoralism. The contribution by ASALs to the national agricultural output is 3% and to the commercial output, 7%.

Pastoralists are unable to meet their subsistence requirements from their herds simply by eating whatever the herds produce in the form of meat, milk and blood. They supplement their diets by collecting honey, nuts and fruits, roots and berries and by planting if and when this is possible. Most importantly, they exchange parts of their herd products for cheaper agricultural goods. Livestock populations therefore show a tendency to increase basically due to the nature of the herd capital. With limited and circumscribed grazing areas, both the human and animal populations sooner or later create a situation whereby the carrying capacity of the land is exceeded, no matter what kind of management is practiced (Helland 1980). Land is prone to degradation under such circumstances.

Beekeeping is especially prevalent in the rangelands under circumstances where crop agriculture is limited and where the natural vegetation comprises of many species of plants suitable for bee forage. Honey is produced mostly following traditional approaches based on log hive technology (Nightingale 1976).

1.2 Traditional beekeeping practices in Africa

In tropical Africa, beekeeping practices vary only slightly from one area to the other across the continent, based on good knowledge of botany and ecology that makes beekeeping possible under very complex circumstances (Clauss and Zimba 1989). In the region as a whole, local honeybee races exploit scattered resources by moving about from area to area. This means that some hives remain empty for parts of the year especially under adverse weather conditions. African races of honeybees also have a high rate of swarm production. This can be advantageous to the beekeeper for filling empty hives with new colonies but lowers production per colony. Estimates of annual production can thus be misleading when based only on the number of hives owned without taking into account the occupation rate, which on average is 50- 60% (Kihwele 1989).

1.2.1 Definition of potential for beekeeping

FAO (1986) outlines what is required to produce good quality hive products in large quantities. To begin with, the most productive bee species and race should be selected, which is not the same for all areas of the world. Then it calls for optimum availability and use of bee forage, strict and continuing control of bee pests and diseases, adoption of satisfactory processing methods and more important than all else, research in all aspects of beekeeping to adopt practices to the requirements of each particular ecological zone. The people responsible for developing beekeeping in a country can become an obstacle to progress when they fail to admit that there is not a single type of hive, bee race, and variety of forage or management system that suits all possible situations. In particular, the wide variety of climates and vegetation in the tropics and sub-tropics makes it vital to approach each ecological situation without bias and preconceptions.

The most recent estimates place annual honey production in Kenya at between 60,000 – 100,000 tonnes (Mbae 2000). These figures are calculated by multiplying the number of log and other types of hives available in the country by the estimated average yield corresponding to each type of hive. Mbae suggests that only 10% of this potential has been realized. Ngurare (1997) estimated that 3,000 tonnes of honey were produced in 1995 in addition to 75 tonnes of wax. Mbae's estimates therefore make production comparable to records of twenty years ago, which stood at 13,000 tonnes of honey and 1,300 tonnes of wax in 1983 (Gatere et al. 1985). These facts suggest that production is inconsistent and possibly on the decline. By 1996, Kenya imported 30 tonnes of honey and 6 tones of beeswax from several regions of the world while at the same time exporting 2.8 tonnes of honey along with 21 tonnes of beeswax (Ministry of Agriculture 1996). This makes Kenya a net importer of honey and net exporter of wax with respect to external trade in honey and beeswax. Other hive products have not yet been developed and therefore the full beekeeping potential of the country has not been fulfilled.

1.3 Kenya's beekeeping improvement programme

The earliest attempts to streamline the beekeeping industry in Kenya were those in 1950 by the aid agency called OXFAM (Ministry of Agriculture 1967). They were geared towards provision of marketing facilities particularly in areas where trade in hive products was not yet established. They also aimed for improvement of the amount and quality of wax produced. Another desired outcome was provision of improved beekeeping equipment including simple two chamber hives and the adoption of fireproof smokers. As a result, refineries were established for improved honey extraction through County Councils while producers' cooperatives were set up for selling beeswax. Local users of wax were encouraged to purchase the Kenyan product.

During this era, most beekeeping improvement efforts went towards recovery of wax from traditional honey beer brewing processes. Some enterprising traders however got involved in selling table honey locally in competition with imported brands. By 1955, it was clear that honey exports to the Western world would be unpromising after taking into consideration processing, packaging and transport costs by the producer. These efforts nevertheless proved that sufficient wax of promising quality could be produced by traditional beekeepers for export in spite of the fact that amounts varied widely from year to year. It was also noted right from the start that sound management of the cooperatives posed the greatest challenge to the future of the industry. Ten years after the start of the marketing improvement programme, many of the cooperatives had wound up for one reason of mismanagement or another.

Areas covered by the OXFAM project included South Baringo, the area where the current study was undertaken. By June 1955, an instructor had been posted there to train local beekeepers on how to refine beeswax from beer waste. He would travel from village to village demonstrating to beer makers what needed to be done while putting them in touch with wax buying agents. Records indicate he was very successful and through his efforts, beekeepers produced first grade wax. The producers were keen and happy to receive good prices for an item they previously threw away and were greatly motivated by receiving cash on delivery. Unfortunately, records were not kept well and after a short while it was no longer possible to keep track of developments.

The next major development in the course of revitalizing the beekeeping industry in Kenya came about through a Canadian government-sponsored beekeeping project. It started with the training of apiculture extension officers in the Department of Apiculture of the University of Guelph in 1966. A survey followed in 1969 of the possibilities and requirements for beekeeping in East Africa. Townsend (1969) in his comprehensive report of this survey strongly recommended that direct attempts to change beekeeping practices from log or bark hives to movable frame hives be replaced with an intermediate approach that was less drastic and more affordable to the beekeeper. It was therefore considered necessary to develop an intermediate type of hive out of locally available materials that would cost the beekeeper little, if anything at all. Also, concerned about the fact that the whole of East Africa lacked well-trained personnel to carry out beekeeping developments, Townsend proposed training in modern management methods as follows -

1) For local beekeepers at District level, using well-established demonstration apiaries and supervised by someone brought in temporarily from another country or by local agricultural staff with training up to certificate or Diploma level in beekeeping.
2) Diploma course open to all those interested, at a forestry school already established at Olmotonyi, Tanzania. This school was envisaged to serve the whole of East Africa.
3) For staff already holding diploma level training and responsible for national programmes, a further six months training in another country with a well-established beekeeping industry in order to expose the trainees to advanced levels of beekeeping
4) A year's training at graduate level in the field of apiculture for personnel drawn from local universities and placed in charge of research.

Townsend (1969) also proposed a research agenda in the area of bee diseases and other scientific areas related to beekeeping. Problems experienced by beekeepers in the field were expected to be the subject of future investigation in order to achieve improvement of beekeeping performance. Other areas where further action was to be taken included testing of bee huts for suitability to deter vandalism on the basis that such huts had already been tried in the southern region of Africa with favorable results. This entire setup was considered a pre-requisite for a possible bee-breeding programme based on queen selection. Lastly, it was also recommended to involve the forestry department in beekeeping in order to ensure the incorporation of nectar and pollen plants in regular forest management plans, especially targeting varieties of eucalypts that were known to be good bee plants besides producing valuable timber.

Despite the fact that a change of emphasis was necessary during the course of implementation of this project, it produced commendable results within four years and was extended to last ten years (Drescher and Crane 1982, University of Guelph 1979). A transitional movable comb hive that imitated the Greek basket hive was developed, referred to thereafter as the Kenya Top Bar Hive (KTBH). In principle, it was a modification of a movable comb hive designed earlier by Paterson and Trendell (Crane 1990). According to Kigatiira (1976), it was necessary to conduct training to help beekeepers adopt new technology but as this was not expected to be an easy task, the Ministry of Agriculture decided to promote the hive only in response to interest expressed by individuals and groups. The level of commitment on the part of a trainer has to be high in such a situation as Klinger (1989) found out in Northern Malawi. In his case, it was necessary to make continuous follow up of those who received initial training, sometimes on individual basis, in order to ensure that beekeepers did not revert to traditional methods while using new technology.

Another output of the Canadian project was establishment, in 1971, of a beekeeping section in the Ministry of Agriculture in Kenya (Kigatiira 1979). This section was expected to guide research, oversee further developments and advice the government on policy matters. The section has to date produced a number of technical field guides on simple and efficient beekeeping practices suitable for use in Kenya ((Ministry of Agriculture 1974, Ministry of Agriculture undated (a), Ministry of Agriculture undated (b)). It continues to educate beekeepers of developments through publications such *Nyuki* Newsletter, a biannual bulletin of the National Beekeeping Station that has been in circulation since 1994. From humble beginnings, the section has to date evolved into a fully-fledged administrative division in the Ministry and continues to yield strong influence on the path of beekeeping development in Kenya.

1.3.1 Hive products and markets

In describing the market potential for Kenyan hive products, a Ministry of Agriculture report pointed to the large traditional beer market to which sales could be directed in a large-scale development project (Ministry of Agriculture 1967). This was because other more lucrative markets were considered to be limited. The honey that was most preferred for brewing was a grade in which brood, pollen and wax were mixed and hence it was not necessary for the beekeeper to concern him or herself with the quality of the product he harvested. Under these circumstances, the beer brewer could have become a wax trader too, if he wished, but the profits were already high enough for him to discard the crude wax rather than process it further. The concern of the Ministry at the time was to direct the marketing of hive products through cooperative societies, whereby the beer brewer would be sold a refined product while the beekeepers retained the wax for sale. Ways for expanding the beer market were suggested with the aim of giving cooperatives a monopoly for controlling the honey beer trade! This strategy was risky as it depended heavily on the reaction of beer brewers to a product that was to be modified and which could no longer guarantee beer flavor and other requirements of their industry.

Marketing of Kenyan hive products is still problematic to date in spite of the efforts made by the Ministry of Agriculture to resolve the issue. A workshop held in 1997, for example, brought participants together to debate how beekeepers could be assisted to market wholesome products (Ngurare 1997). The papers presented at this forum touched on a range of related subjects such as quality control and economic analysis of hive production but there was no agenda set concerning the way forward. As such, Kenyan beekeepers still have a lot to learn about innovative marketing strategies that can work at individual and corporate level (Ayers 1992, Mutia 2000, Paterson 1997, Rodenberg 1992, Sanford and Hoopingarner 1992).

A different approach was adopted with greater success in Zambia and Malawi as Krell et al. (1989) reported. Right at the outset, the aim was to give subsistence farmers good prospects for dealing in honey and beeswax and to explore the possibilities for export so as to earn the countries foreign currency. As such, even though it was known that beer brewers accepted lower quality products, Krell et al. (1989) set high quality production standards which were to be applied right at the stage of harvesting and followed through during processing. Beekeepers received training about selection of the types of combs to harvest and how to apply simple processing methods to achieve high quality production. Where such training was effectively done, it resulted in a cleaner product of acceptable export quality. Some minor problems were encountered in getting beekeepers to supply honey of low moisture content especially during the wet season but this did not discourage Krell et al. (1989) from pursuing their objectives. They saved the situation by offering premium prices for good products and intensifying training. The concerns that remained in the end included how to eliminate the smoky flavor of honey that was harvested according to traditional procedures but beekeepers were encouraged to adopt protective clothing thereby helping to minimize the level of smoking necessary when harvesting. The lessons learnt from this experience led Krell et al. (1989) to suggest that in exploring trading outlets, local markets should be targeted first, those in neighboring countries next and distant markets last in view of increasing freight costs.

Guidelines for quality standards of hive products for the European market are available from CBI of The Netherlands (1990). Traders who do not adhere to them are warned to expect to deal only in industrial grade honey that sells for less. This means that losses are possible after taking into account the costs involved in getting products to this market. This report therefore encourages those who wish to trade in hive products in the EU to aim right at the start for a more superior quality than may be required at national level.

1.4 Assessing the present situation of beekeeping in Kenya

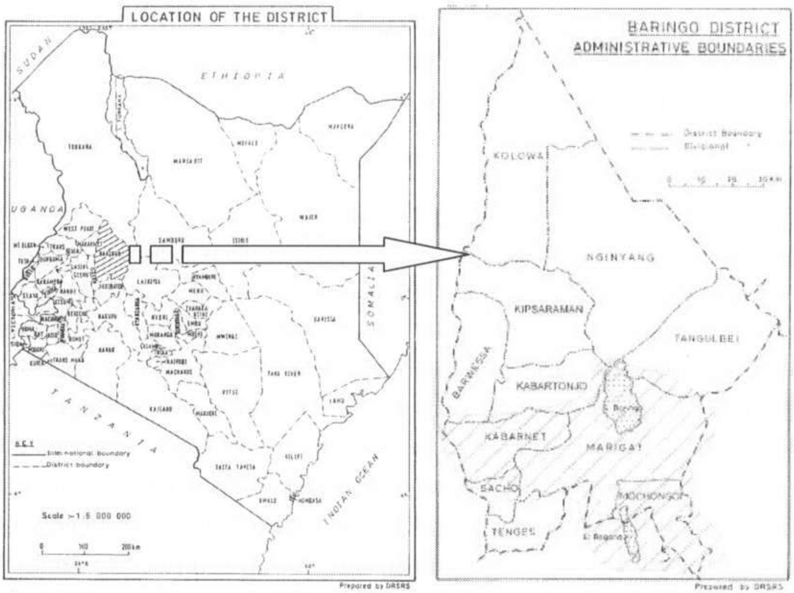
Recommendations by Crane (1985) are that the benefits of development programmes should be reviewed from time to time in order to gauge their impact on local beekeeping practices. In this way, lessons can be learnt from past experiences and corrections made in good time, where necessary. In Cost Rica, for example, development efforts did not bear much fruit in the first 100 years (Kent, 1984). When the right conditions were created however the country rose from the position of a virtual non-producer to an exporter of hive products. Kent suggested that a time frame of 10 – 20 years is realistic for beekeeping projects to become established as long as governments are willing to create a supportive economic environment. In Kenya, it has been shown that the government has been engaged in beekeeping improvements for the last fifty years. This is in recognition of the fact that beekeeping is an income-generating activity that can stimulate the rural economy (Kent 1984, Kigatiira 1979, Mulder 1986, Pomeroy 1993, Svensson 1991, Wix and Lyatuu 1981). The last comprehensive review of the situation was that by Townsend (1969).

Baringo District was selected as a study area to assess the current status of beekeeping in Kenya and to find out whether development efforts of the last thirty years have made a meaningful impact on beekeeping in a specific location. Detailed studies had not previously been undertaken in the area even though records indicate that the region contributes substantially to beekeeping at national level (Ministry of Agriculture, 1996). This study was also an opportunity to examine the roles that can be played by different actors in the industry, given that the government provides public extension services up to Divisional level and has a new policy to engage the private sector more at grass-root level. The collaborators to participate in this new venture will most likely be community-based development organizations such as the Church and other charitable non-governmental organizations that are the active agents of development at this level.

1.4.1 Geographical features of Baringo District

Baringo is one of seventeen districts in the Rift Valley Province of Kenya. The latest socio-economic and geographic data for the District are outlined in the Baringo Development Plan for 1997-2001 (Office of the Vice-President and Ministry of Planning undated) key features of which are highlighted here below.

The District covers an area of 8655 km^2 of which 140.5 km^2 is water surface contributed by Lake Baringo (130 km^2), Lake Bogoria (9.5 km^2) and Lake Kamnarok (1 km^2). It is approximately 210 km long in the North-South direction and 100 km wide in the East-West direction. Out of the 11 administrative divisions in the District, it was in the southern area comprising of Mochongoi, Marigat and Kabarnet Divisions that a socio-economic survey of beekeeping practices in Baringo was conducted. Not only is this particular area relatively well endowed with road infrastructure but also covers a cross section of ecological zones (Map 1).



Map 1: The study area (shaded) comprising of parts of Mochongoi, Marigat and Kabarnet Divisions in Baringo District, Rift Valley Province, Kenya. Marigat and Mochongoi are under Marigat Catholic Parish while Kabarnet falls in Kituro Parish.

The main topographical features in the District are river valleys and plains, the Tugen Hills, the floor of the Rift Valley and the Northern plateau. Loboi plain is in the eastern area between Lake Baringo and L. Bogoria. The Tugen Hills run in a North-South direction and are a conspicuous topographical feature in the South Western part of the District. Altitude varies from 762 m above sea level in the lowlands up to 2600 m in the steep hills that are bound by escarpments on the eastern and western parts. The valley floor consists of dry plains and the land rises once more in the eastern part of the District towards the Laikipia escarpment.

1.4.2 Topography and climate

Mean annual rainfall varies from 1500 mm in the highlands to 600 mm in the lowlands and is about 50% reliable. There are normally two rainfall seasons in a year; the long rains starting from the end of March to the beginning of July while short rains start at the end of September and end in November. Temperature is greatly influenced by altitude. Mean annual maximum temperature is between 25° to 30°C in the southern part of the District, the hottest months being January to March. Mean annual minimum temperature varies between 16° – 18°C but this can drop to 10°C in the Tugen Hills. Higher average temperatures are experienced further northwards.

1.4.3 Natural Resources

Land and soils

Highland areas have well drained fertile soils with high potential for agriculture. In the lowlands, complex soils of various textures and drainage conditions occur. There are areas with rich alluvial deposits but shallow stony soils with rocky outcrops and lava boulders are more characteristic of the zone. This makes the lowlands essentially a rangeland with socio-economic activities based around beekeeping and livestock rearing. The lower midland area around Marigat is overgrazed and requires controlled and planned grazing to arrest its current level of degradation. Subsistence farming is undertaken wherever irrigation is possible in the lowlands.

Water Resources

Water shortages are prevalent throughout the District with occupants of rangelands having to travel long distances in search of the scarce resource. Lack of water in marginal and dry areas, especially during prolonged drought, accelerates loss of livestock. It has also been associated with the annual migration of honeybees, as they cannot do without water for regulation of hive temperature under conditions extreme heat. Springs in the District are unevenly distributed with over 80% being found along the Tugen Hills. Only about 9% of all the fresh water springs are large enough to be developed or improved. With the exception of Weseges, rivers in the District (Perkerra, Molo, Kerio, Loboi, Suguta, Ol Arabel) are fresh water sources with a fluoride content is less than 1.5 mg/l.

Several water dam sites have been identified for domestic, livestock, industrial and irrigation purposes within the district. The largest potential for irrigation is found in the lowlands east of the Tugen Hills in the Lake Bogoria-Baringo basin and in the Kerio Valley (Chepalambus – Kinyach area). The central government operates and maintains the majority of water points. The rest are maintained either by community groups or charitable institutions as, rather surprisingly, the local County Council does not run any. Many of the existing water points are therefore over-utilized while some are not in operation on account of the high costs involved in maintenance.

1.4.4 Resource exploitation

Forestry

Forests that have been set aside by law (gazetted) cover an area of 22,954 ha and make 94% of the total forest cover of Baringo District. The balance of 1393 ha has been identified by Baringo County Council for forestry in Marigat Division but has yet to be gazetted. Natural forests cover 96.5% of the total area designated as forests. Plantations of exotic timber species take up the balance. Timber is considered the main forest products whereas posts, poles, fuel-wood and tree seedlings are regarded as minor products. Other important additional benefits derived from forests include amelioration of climate, water flow regulation and soil conservation. The District's demand for forest products is not satisfied by local production and as such, forestry development efforts are directed towards afforestation. At the same time, agro-forestry is promoted as an additional means to achieve self-sufficiency. An Environmental Management Committee addresses such forestry issues in the District.

Agriculture

Livestock production is a major economic activity of the inhabitants of Baringo District. Cattle, goats, sheep and bees are the main types of livestock from which products such as beef, milk, shoat meat, hides and skins as well as honey are derived. Donkeys and camels are reared in East Baringo. Most of the slaughter animals are concentrated in Kolowa, Nginyang and Tangulbei Divisions and production of skins and hides is highest there. Dairy cattle are found in Kabarnet, Kabartonjo, Sacho and Tenges where about half of the households keep improved, high-value herds. Poultry keeping is mainly practiced under extensive management. Goats are considered to have low production costs and are therefore kept in large numbers by almost all households in the district.

1.5 Objectives and hypotheses

1.5.1 Objectives

The objectives of this case study of beekeeping in Baringo District were as follows:

i) To document socio-economic circumstances of beekeepers in the District.

ii) To document the level of technical knowledge currently vested in beekeepers in the Tugen community

iii) To document beekeepers' knowledge of bee plants and study vegetation characteristics at selected sites so as to quantify the diversity of plants available to bees in areas under different land uses at various altitudes.

iv) To assess the performance of KTBH as a movable comb hive and suggest ways to handle with the problem of overheating that beekeepers complain of.

1.5.2 Hypotheses

The following questions were raised as hypotheses for this study:

1. Does beekeeping play an important role in the local economy in areas of Baringo where it is traditionally established?

2. Do beekeepers in the Tugen community in Baringo District undergo adequate training out of which they acquire good knowledge of the local bees, plants and beekeeping equipment?

3. On what vegetation does beekeeping depend? Is it abundant and well conserved?

4. Is technical knowledge applied for optimal management of bee colonies?

5. Have beekeepers in Baringo District readily adopted new beekeeping methods as a result of awareness created by agricultural extension services?

6. The Kenya Top Bar Hive, based on the principle of movable combs, has been promoted widely by the Ministry of Agriculture as superior technology compared to fixed comb, traditional log hives but:

- Is it produced according to specifications and does it operate as expected after installation?

- Does it maintain tolerable temperatures for bees when put to use in hot areas?

7. Following exposure to modern beekeeping methods, have beekeepers in the study area altered their traditional management practices and diversified hive production?
8. Are marketing channels well established in the study area for fair trade in hive products?

The results of this study are presented in separate chapters according to the different topics investigated as follows –

- Socio-economic aspects of beekeeping in Baringo District
- Beekeeping practices of the Tugen community of southern Baringo District
- Performance of KTBH as an introduced type of hive in a hot, dry area
- Vegetation characteristics of representative sites across the study area
- General discussion, conclusions and policy recommendations.

Crosscutting issues are examined at different levels in each chapter and wherever possible, findings of the socio-economic survey are linked to the findings of the studies that followed.

2 SOCIO-ECONOMIC ASPECTS OF BEEKEEPING IN BARINGO DISTRICT

2.1 Introduction

Beekeeping is regarded to be an agricultural venture that requires little or no land except a space to stand or hang a hive; very little labor, almost no capital and most of the other inputs are considered to be locally available (Crane 1985, FAO 1986, Rubio 2001, Svensson 1991). Opinion is divided however with Lim (1994) stating that the major obstacles facing beekeepers in tropical countries are considered to be lack of capital well as shortage of appropriate technical assistance for beekeepers. Other constraints facing beekeepers in developing countries are lack information on suitable internal/external markets and relevant processing technology for product diversification. Under these circumstances, development partners come in to assist with projects aimed at improving traditional techniques or at introducing apiculture in new areas (Jones 1999).

In Baringo District of Kenya, the Development Plan for 1997 to 2001 estimates honey production to have been 79 tones in 1995, the latest year for which statistics were available at the time of compilation of the plan (Office of the Vice-President and Ministry of Planning undated). Beekeepers earned KShs. 7.2 million (1 US$ = KShs. 75 in 2001) from the sale of this product and this compared favorably with other activities in the livestock- rearing sector. Milk, for example, earned farmers KShs. 6.6 million in the same period. It was expected that earnings could have been higher and lower incomes were blamed on an inadequate marketing infrastructure.

This chapter examines socio-economic issues facing beekeepers in Baringo District. The District Development Plan for 1997-2001 reports that distribution of income is uneven, with 50% of the total population living below the poverty line. The share of income is generally lower in less educated households but this is confounded by the fact that more income generating opportunities exist in high agricultural potential areas than in areas with a marginal potential for agriculture. Observations in the informal sector also show that lowly educated artisans earn more income than many of those who are more highly educated but employed in the public sector. As such, the general picture may not necessarily reflect the socio-economic circumstances of people in particular situations. For the purpose of the current study, it was considered necessary to obtain primary data from beekeepers on specific issues concerning beekeeping as an economic activity.

The issues investigated revolved around technical and entrepreneurial skills of beekeepers as these play a role in the production of goods and services in the sector. Access to suitable land and the need for credit were examined and marketing issues tackled by tracing how hive products and their derivatives change hands from source to the point of delivery to end-users.

2.2 Data base and methodology

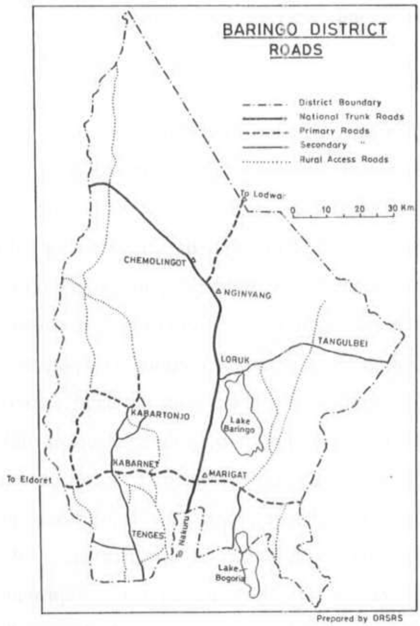
The study area covered the southern part of Baringo District where Tugen people are traditionally engaged in beekeeping. To the East and West were the highland zones of Laikipia Escarpment and the Tugen Hills respectively. The floor of the Great Rift Valley made the area of low-lying plains in between. Fourteen beekeeping areas were selected with good proximity of each other and within 10 km on either side the Nakuru-Maoi-Kabarnet and Marigat-Lake Bogoria-Mochongoi roads, which transect this area. Beekeepers were listed from 72 villages spread over a distance of approximately 80 km, with Marigat town in the middle (Map 2).

All the selected areas occurred within the Catholic Deanery of Baringo such that, for logistical reasons, the study was carried out in collaboration with staff of an agricultural programme in two parishes of this Deanery. Kituro Parish covered mid-elevation areas up to the Tugen Hills while Marigat Parish covered the foothills of the Tugen Hills, the lowlands and Laikipia escarpment. Selected sites were as follows:

Marigat Parish - Arabal, Sandai, Kapkuikui, Parkaren, Maoi, Koriema and Kibingor.

Kituro Parish - Kipkaech, Kitumbei, Kituro, Kapkomoi, Kasore, Sesya and Patkawanin.

A person qualified for consideration as a beekeeper on the basis that he or she managed at least one bee colony independently. With the help of local contact persons, 750 beekeepers were listed in the entire study site out of whom only 23 were women. 224 beekeepers were selected to participate in interviews, representing 30% of all listed beekeepers. The probability for selection of a male beekeeper was random and proportional to size of the parish, area and village from which he hailed. All female beekeepers on the list were included in the sample in order to capture the views of this gender. In this way, 174 beekeepers were selected for interview from Marigat Parish and 50 from Kituro Parish.



Map 2: Approximate location of study sites. Fourteen areas were chosen that lay within 10 km of either side of the Nakuru-Marigat-Kabarnet and the Marigat-L. Bogoria road that continues on to Mochongoi.

Beekeepers were interviewed with the help of survey assistants who were recruited from the locality of each site. Interviews by the assistants were based on a questionnaire that was first developed in English and then translated into the local Tugen language (Samor dialect) while the author conducted interviews by direct translation of the English questionnaire into Kiswahili, the national language of Kenya.

Besides recording individual beekeeper data such as age, religious affiliation and marital status, information was gathered on type of ownership of land utilized for beekeeping; level of formal education attained by beekeepers; type of hive technology in use; training avenues; years of experience; knowledge about honeybee forage, bee biology and behavior; approach adopted for apiary management; gender roles in the industry; production constraints as well as the harvesting, processing and marketing of products. Beekeepers also gave their views concerning the usefulness of local beekeeper support networks especially with respect to the prevailing marketing situation. Data were analyzed using SPSS and Excel software packages.

2.3 Results

2.3.1 Role of beekeeping in the local economy

In the rural semi-arid area of Baringo District, beekeeping was listed among the four most important income-generating activities (Tab. 2.1). It is regarded as a separate activity from livestock keeping contrary to the official view where beekeeping falls under livestock rearing. In Kituro, where there is good potential for intensive agriculture at high altitude, farming was ranked first, with coffee as a cash crop. Beekeeping was ranked in the third position, after livestock keeping. The potential for crop agriculture however declines with altitude such that in the lowland area of Marigat, livestock keeping was in the first rank of importance while beekeeping took the second position among the key income generating activities (Fig. 2.1). Sustainable crop production in the lowlands is possible only under irrigation. This shows beekeeping is a viable option for diversification of economic activities in marginal areas. When in season, hive products are sold to generate cash that goes a long way in improving rural livelihood.

Charcoal burning is another alternative with the possibility for quick cash rewards where undertaken in beekeeping areas of Baringo District. It was mentioned by a surprisingly low number of beekeepers as being among the four main economic activities. Even then they placed it in the third rank of importance or lower which can be interpreted to mean that beekeepers recognize it as an activity that obviously conflicts with beekeeping interests.

Tab. 2.1: Beekeepers' ranking of four most important economic activities in Baringo District. Beekeeping is ranked more highly in the pastoral area of Marigat where there is limited crop farming potential than in Kituro where the potential for rain-fed crop farming is higher.

Ranked position (by decreasing order of important)	Economic activity	
	Marigat Parish	Kituro Parish
1	Livestock	Crop farming
2	[a]Beekeeping	[a]Livestock
3	[b]Crop farming	[b]Beekeeping
4	[abc]Small-scale business	[c]Small-scale business

[a]in addition, formal employment mentioned in this position.
[b]in addition, charcoal burning mentioned in this position.
[c]Small-scale business refers mostly to flour milling or keeping shop to sell groceries, food, etc.

(a) (b)

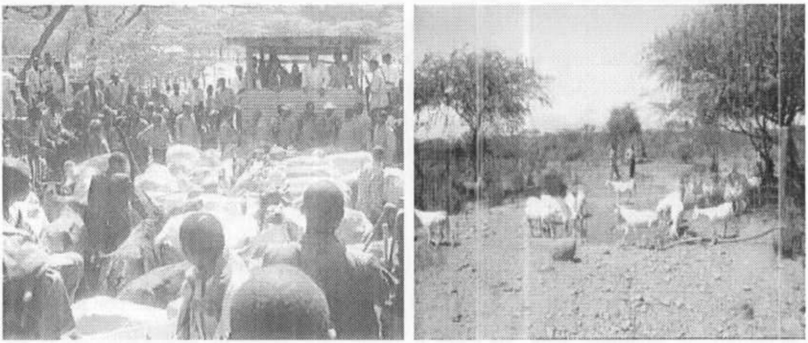


Fig. 2.1 Livestock keeping, a leading economic activity in the lowlands of Baringo District is. Shown here are (a) cattle on sale at an auction in Marigat (b) goats roaming freely in herds in the countryside.

2.3.2 Land ownership (tenure)

In the study area, some of the land is demarcated into individual parcels with restricted user rights while the rest is held in communal trust. Beekeepers consider the most important benefit derived from such land tenure arrangements to be unrestricted access to forage and water resources on common land (Tab. 2.2). In Kituro Parish where human population is higher, common land is limited and when beekeepers need to expand their enterprises, they do so in the lowlands where such land is more available. Formal allocation of land into individual parcels bearing title deeds was in progress in Kituro at the time of the survey. 40% of beekeepers from Kituro Parish consequently reported utilizing individually owned land compared to only 1% who did the same in Marigat Parish. The other perceived benefit of access to common land is that aggressive local bees are kept in isolated apiary sites away from homesteads or places frequented by people. There is positive interaction among members of the community when beekeepers from distant locations meet and share resources in common apiary sites.

Tab. 2.2: Benefits that beekeepers derive from existing land tenure arrangements in Baringo District. Beekeeping is favored by unlimited access to resources on communal land, which enables beekeepers to set up apiaries on land beyond that which they control individually.

Type of benefit derived from prevailing land tenure arrangements	[a]% positive responses
Unlimited access to forage and water	31.0
Crops add to the variety of plants available for bee forage	11.0
Apiaries are located in quiet areas away from homes and livestock	5.0
Distances from homesteads to apiaries are shortened	3.0
Beekeeping favours conservation of vegetation in the landscape	2.0
Beekeeping on communal land facilitates positive community interaction	0.4

[a]Responses do not add up to 100%, as this was an open question to which some beekeepers gave no answers.

Beekeepers also face various limitations that are influenced by type of land ownership. Those interviewed expressed general concern over the condition of vegetation on common land, as certain plants are open to over-exploitation by competing users in the community. In such areas, tall trees are the preferred apiary sites for reasons of shade and security but they are reported as becoming increasingly scarce. In isolated public areas beekeepers also lose hive products to honey badgers or thieves. Other complaints were about having to cover long distances on foot to apiaries as the land closer to the settled areas become congested or unavailable (Tab. 2.3).

Tab. 2.3: Types of beekeeping constraints experienced in relation to land ownership in Baringo District.

Type of constraint experienced by beekeepers	[a]% beekeepers mentioning constraint	
	Marigat Parish	Kituro Parish
Not enough trees available on which to place hives	16.0	2.0
Disturbance by wild animals	9.0	0.5
Thieves breaking into hives to steal hive products	8.0	4.0
Not enough forage available to sustain bee colonies	4.0	2.0
Long distances between homesteads and apiaries	4.0	2.0
Noise from heavy farm machinery in irrigated areas	2.0	0.0
Loss of access to suitable sites with land demarcation	1.0	2.0

[a]Responses do not add up to 100%, as this was an open question to which some beekeepers gave no answers.

Of other possible uses that land under beekeeping could be put into, beekeepers were of the opinion that is not well suited for crop agriculture. They consider that such land is more compatible with conservation of the environment. To them, well-conserved land has the additional qualities of having an enhanced capacity for water conservation, enhancing survival in this arid area. The area being so harsh in some of the locations, however, 7% of the beekeepers interviewed considered land under beekeeping to have no other viable economic use (Fig. 2.2).

Livestock and bees compete for shade, water and forage or fodder plants that they utilize in common. This situation is influenced for the worse by the cultural value attached to livestock as a measure of wealth in the Tugen Community. A strong tendency towards overstocking is perpetuated when individuals aspire to own as many head of livestock as possible and in the process, pasture is overgrazed and water resources overexploited. This leads to land degradation and undermines the productivity of beekeeping. This conflict between livestock keeping and bees is therefore evident in the beekeepers' opinion that the best alternative use for land under beekeeping is to set it aside for environmental conservation.

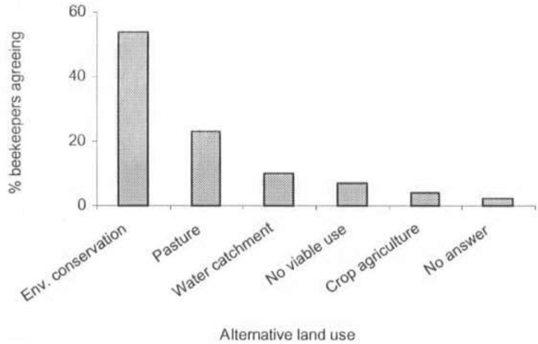


Fig. 2.2: Alternative uses for land that is currently utilized for beekeeping in Baringo District. Of all possible uses, beekeeping is considered most compatible with environmental conservation but in direct conflict with pasture where the carrying capacity of land is exceeded by overstocking in pastoral areas.

Access to land for beekeeping in Baringo therefore has the added dimension of not just having a place for a hive to stand but also beekeepers having to share common land that serves other, sometimes conflicting, interests.

2.3.3 Characteristics of beekeepers

The mean age of beekeepers was 40 years, the minimum age of those interviewed being 18 and the maximum 70 years old. This shows that people in the most productive age bracket are actively engaged in beekeeping. The youngest beekeeper listed was a boy aged 12 years, from Kituro. He already had a good reputation as an amateur beekeeper but the concepts in the questionnaire were too difficult for him to complete an interview Nevertheless it was noted that he appeared very enthusiastic and had accumulated a lot of information on the subject already.

Of the 224 beekeepers interviewed, 90% were male. All women beekeepers hailed from Marigat Parish. The Catholic religion is dominant in the area given that 61% of the beekeepers subscribe to this faith. The rest are either Protestant (30%) or Traditionalist (9%) by religious affiliation. Religious matters were of no consequence in the end since development agents did not show any bias towards a particular religious group when directing their assistance to the community.

Concerning the beekeepers' level of formal education, 30% of those interviewed had not received any. The rest were at stages of literacy ranging from basic reading and writing skills to university level (Tab. 2.4).

Tab. 2.4: The level of formal education of beekeepers. Approximately one third of them possess no reading or writing skills. This limits the effectiveness of formal training programmes and requires more emphasis to be placed on practical demonstration of essential concepts especially in modern beekeeping.

Highest level of education attained	[a]% beekeepers who have attained level
No formal education	29.9
Primary Sch. (7 - 8 years)	52.2
Secondary Sch. (up to 12yrs)	9.4
College (up to 17 yrs)	5.8
University (minimum 21 yrs)	0.4
Adult education (basic reading, arithmetic and writing skills)	1.3

[a]Responses do not add up to 100%, as this was an open question to which some beekeepers gave no answers.

Traditional beekeeping practices are based on informal opportunities and an individual's level of formal education does not matter. More advanced beekeeping however requires one to have a good grasp of bee biology and behavior for application in colony management. Practical training will be necessary to communicate these concepts to an audience part of which is handicapped in reading. Those who can read and write do not have access to training materials written in a language they can understand.

The level of beekeepers' experience was taken to be the numbers of years that an individual was continuously engaged in beekeeping. This was positively correlated with age, having a correlation coefficient of 0.67 that was significant ($p < 0.01$). This is what one would expect in a situation where people are actively engaged from an early age in helping older beekeepers to undertake basic tasks. Based on this exposure, young people gradually move on to become independent beekeepers as soon as they can obtain their own hives. They continue accumulating experience by seeking technical advice from fellow beekeepers whenever necessary.

2.3.4 Beekeeping equipment and capital requirements

Equipment

91% of the beekeepers interviewed used fixed comb, traditional, log hives while 8% of interviewees used movable comb, Kenya Top Bar Hives (KTBH) in addition to log hives. Only 1% of the beekeepers were therefore engaged in beekeeping based only on KTBH. No other type of movable comb or movable frame hive was reported about. Altogether there were 6031 log hives reported amongst the 224 beekeepers interviewed. Each therefore owned 27 such hives on average. The maximum number of log hives owned by an individual in the survey was 500. The total number of KTBH available among interviewees was 63 of which only 4% were based in Kituro Parish. In Marigat Parish, the highest number of KTBH owned by an individual was 12 while in Kituro it was 4 (Tab. 2.5).

Tab. 2.5: Ownership of different types of hives in Baringo District. Majority of beekeepers still use traditional log hives while those who have ventured into using movable comb hives have only tried the KTBH. Beekeepers own hundreds of log hives in some instances but no one owned more than 12 KTBH.

No. of hives	% beekeepers who own this number of hives (by type)	
	KTBH	Log Hives
0	91.5	0.0
1 - 20	8.5	61.9
21 - 40	0.0	22.0
41 – 60	0.0	11.0
61 – 80	0.0	1.9
81 – 100	0.0	0.5
>100	0.0	2.5

When asked to list the equipment they use, interviewees mentioned a wide range of accessories that goes hand in hand with traditional beekeeping (Fig. 2.3). The proportion of beekeepers that mentioned each item reflected its perceived importance. The list includes axes for felling of trees and construction of hives as only recently has the process been mechanized and then only to the extent of using a power saw to fell trees and cut them into logs. Such machinery is usually hired. Smokers are made out of firewood that is gathered locally. Leather is obtained locally and used for making harvesting bags and covers for traditional honey storage barrels.

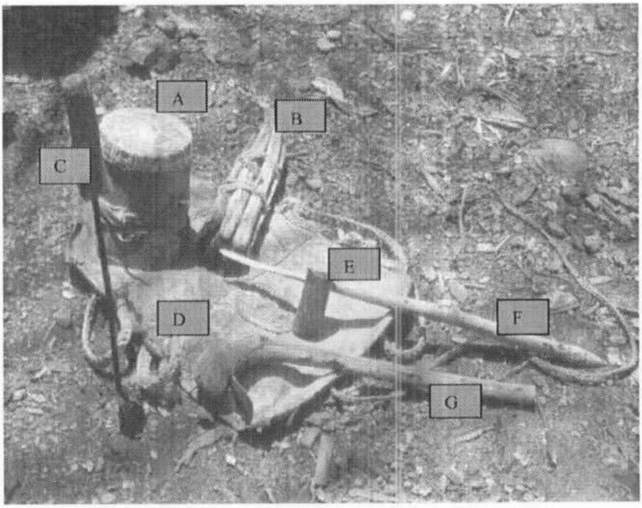


Fig. 2.3: A selection of traditional beekeeping tools and accessories. (a) Wooden honey storage barrel ("*Keete*") (b) smoker ("*Sisto*") (c) drill ("*Kolomeito*") (d) harvesting bag ("*Tokolta*") (e) wedge ("*Shong'eito*") (f) wooden hive tool ("*Sekete*") (g) chisel ("*Kipkongoito*"). They are made out of locally available materials except for the metal blade of the chisel and the drill, which are derived from recycled metal.

Wire, axes, 'pangas' (machetes), storage drums and recycled 4 l paint containers (commonly referred to 'gallons') are purchased from hardware shops or dealers in hive products. Protective clothing is not considered necessary for traditional harvesting and is not locally available (Tab. 2.6).

Beekeepers assemble in open-air workshops to learn the necessary skills in hive making from one another. They share equipment for making or repairing log hives for which there is no possibility of obtaining services from a modern workshop. More details on the construction process are given in Chapter 3.

KTBH and their accessories are available in specialized equipment workshops. The full range of accessories one can expect to get includes hive tools, bee brushes, overalls, bee veils, smokers, queen excluders, feeder boxes, catcher boxes and observation hives. Modern processing equipment is available in the form of wax extractors and honey straining clothes. Only one among the beekeepers interviewed reported having invested protective clothing in the form of overalls.

Tab. 2.6: Essential equipment required for beekeeping following traditional practices. Tools for hive construction were given most weight followed by harvesting tools. Vernacular names are in brackets.

Tool (with vernacular name in Tugen where known)	Purpose	Ranking of importance by % beekeepers mentioning tool
Axe (*Laiya*)	Hive construction	65.9
Chisel (*Kipkongoito*)	Hive construction	52.0
Hive tool (*Sekete*)	Harvesting	51.6
Wedge (*Shong'eito*)	Harvesting	48.4
Smoker (*Sisto*)	Harvesting	42.2
Panga (*Pange*)	Harvesting	41.3
Traditional harvesting bag (*Tokolta*)	Harvesting	41.3
Metal drill (*Kolomeito*)	Hive construction	37.0
20 l Plastic bucket (*Ndoo*)	Storage	23.3
Wire (*Waya*)	Securing hive on tree	15.7
Rope (*Kambanasit*)	Harvesting	15.2
4 l metal container (*Galonit*)	Harvesting	3.6
200 l drum	Storage	1.5
Power saw	Hive construction	1.3

Capital requirements

84% of interviewees reported they finance their business from savings they make from sale of honey, livestock or farm produce in addition to income from other businesses or salaried employment and wages. 82% of them realize savings in the cost of equipment by making it themselves while 65% of them need to buy hives. The other ways by which hives can be obtained is by receiving them as gifts (19%), through inheritance (7%) and least likely of all as project donations (4%). None of the beekeepers in the survey required any credit to operate their business.

The price of a log hive depends on its size as well as the wood it is made from. The size ranges from what are considered small hives with an average capacity to produce 4 l of crude honey per harvest up to the very large ones with a capacity for 20 l bucket of the product. Hives made out of durable timber such as *Podocarpus falcatus* or *Olea europea* cost from KShs. 400 to KShs. 1200 depending on size. This makes the average price of a log hive comparable to the price of a KTBH, which in year 2000 cost KShs. 950 (mean foreign currency exchange rate was 1 US$ = KShs. 75 in 2001). The finding is contrary to the common belief that traditional logs almost cost nothing to acquire.

2.3.5 Training

Role of gender

Traditional beekeeping involves tedious manual procedures and among the Tugen people, it is culturally defined as men's work. Harvesting, in particular, requires good tree climbing skills and confidence in handling bees unprotected. The roles of men and women, boys and girls are well understood and skills are developed to enhance the capacity of each to fulfil his or her perceived roles (Tab. 2.7).

As children, boys are exposed to more tasks than girls. Boys receive training in almost all aspects of beekeeping while girls are never required to make beehives, process honey or brew beer. Cultural taboos that instil fear of bees in women or ill fortune should they engage in harvesting reinforce these labour divisions and keep women from breaking the rules. This means that when women wish to become independent beekeepers they incur additional costs in comparison to their male counterparts as they have to buy ready made hives and hire men to harvest and process honey for them. Against these odds, nearly 25% of the women interviewed had nevertheless managed to become full time beekeepers.

Training agents

Beekeepers receive training in traditional beekeeping methods from an experienced family member, especially a grandfather where applicable, or local beekeepers. There are no formal opportunities to learn these methods. Opportunities to observe what goes on in a colony are limited because apiaries are often located far away from homesteads and when hives are opened at harvest time, beekeepers work in a hurry on account of the aggressive nature of bees. The content of training that is passed from generation to generation is thus a mixture of fact and myth.

Short courses in modern beekeeping are offered in agricultural colleges and by institutions engaged in beekeeping, the closest one to beekeepers in Baringo District being located in the neighbouring Nakuru District (Baraka Agriculture College, Molo). A modern approach is pursued whereby bee biology and behaviour are taught and applied during practical training in colony management. However, fees are charged which beekeepers find prohibitive. Most beekeepers have therefore to be content with brief exposure at no cost when the Ministry of Agriculture organizes 'open' days held at a local level or during annual agricultural fairs held for a week at the District Headquarters (Tab. 2.8).

Tab. 2.7: Gender roles in beekeeping as practiced by the Tugen people of Baringo District. Men undertake most of the work but specific types of assistance are received from boys, girls and women. The type of exposure and training received by girls and boys prepare them for roles in adulthood.

Activity in beekeeping related to	% beekeepers who mentioned task was performed by			
	Females <12 years old (Girls)	Females >12 years old (Women)	Males <12 years old (Boys)	Males >12 years old (Men)
Equipment:				
Construct hives	0.0	0.4	19.0	45.0
Make other selected items of equipment such as ropes, bags, etc.	1.3	1.3	0.4	0.4
Repair hives	0.4	0.4	0.5	0.5
Hive installation:				
Hang hive up in a tree	0.0	0.0	6.3	24.0
Transport hive to apiary	13.0	62	5.4	12.5
Routine management:				
Inspect hives for occupation/condition	0.4	0.4	5.4	9.4
Pest control	0.4	0.0	12.0	9.0
Harvesting:				
Collect materials for/ light smoker	0.4	3.1	12.5	2.2
Harvest honey	0.4	0.4	27.0	62.0
Transport honey	6.5	29.0	4.9	7.6
Processing and selling:				
Process honey	0.0	0.4	0.0	1.8
Brew beer	0.0	0.4	0.4	1.3
Sell honey	0.4	0.8	0.4	8.0

Tab. 2.8: Training agents for traditional and modern beekeeping methods. Apprentices learn traditional beekeeping methods informally "on-the-job" while helping family members or local beekeepers. Majority of beekeepers have not received any training in modern beekeeping methods except where brief contact has been made with extension agents, experienced beekeepers or a Beekeepers' Association.

Training agent	% beekeepers receiving training in traditional beekeeping methods	% beekeepers receiving training in modern beekeeping
Experienced family member	52.5	0.5
Local beekeeper	47.5	1.0
No training received	0.0	92.0
Short course by extension agent	0.0	4.5
Beekeepers' Association	0.0	2.0

Having poor access to technical support causes great difficulties for any beekeepers who adopt modern beekeeping equipment. They end up following traditional management approaches while using modern hives and fail to reap full benefits from their investment. To bridge this technical gap, beekeepers requested for training in future as follows:

- record keeping for better control of management operations (54.5% of beekeepers)
- how to operate modern hives (38.7%)
- about basic bee biology in a bid to understand the organisation of bee colonies (27%)
- how to manipulate bee colonies for optimal production of desired products (5.4%)
- modern harvesting techniques to improve on quality of products (3.2%)
- entrepreneurial skills for marketing purposes (2.7%)
- about how to grow suitable plants that can enrich bee forage in the area (0.9%)
- new processing techniques for production of higher quality products (0.4%)

2.3.6 Demand and supply of hive products

Honey is harvested in the lowlands from September with a peak in December each year and 58.6% of those interviewed placed high value on crude honey as a commodity for sale. A similar proportion regarded it as food especially during times of drought when vegetables are in short supply. It was also reported as a supplement in the diet and is recommended especially for lactating mothers. 10% of those interviewed regarded it as a traditional gift item. Honey is also highly valued as medicine in a situation where 74 health facilities serve an entire district's population of over 400,000 people. As such, people often take it as a first aid measure in cases of emergency. 45% of the respondents resort to honey as medicine in its own right or as a sweetening ingredient for bitter herbal drugs that are available from traditional doctors at local level. 34.2% of the interviewees reported that honey was used in traditional beer brewing.

76% of the beekeepers sell their produce to middlemen who are specialized traders mostly operating as general merchants in the larger trading centres of the District. These merchants pay cash on delivery of honey. Middlemen from outside the region also participate in market days set aside for each trading centre by the Baringo County Council. Local middlemen stock between 20 and 30 buckets of crude honey (each weighing approximately 25 kg) per harvest but annual demand exceeds local supply. When honey is not available locally, middlemen obtain it from neighbouring areas such as Pokot District or as far away as Kitui District in the Eastern Province of Kenya. Honey is sometimes imported from the Miombo woodlands of Tanzania through a supply chain linking the suppliers in Baringo District to an international market. This gap in supply shows that beekeepers in Baringo would be assured of good profit if only they could exercise more control over the flow of honey into local markets rather than selling everything at once during harvest at throw away prices. Middlemen take advantage of such a lack of organisation on the beekeepers' part to reap handsome profits details of which are given below.

Pricing

Transactions between beekeepers and middlemen are on cash basis and a fairly large capital base is required on the part of the middleman. Finance is therefore an important and limiting factor that determines the volume of trade individual middlemen can absorb. At the average price of KShs. 450 per 'gallon' (referring to a recycled 4 l paint container, mostly metallic) of crude honey the annual capital invested in 30 buckets of honey is KShs. 67,500 (approximately $900 at 2001 mean foreign exchange rates). This is a substantial investment in a nation where per capita income was estimated at $280 in 1997. A profit of at least 12.5% is expected when middlemen trade in hive products during the year that follows.

Beekeepers employ some strategies for coping with a market that is prone to flooding with honey at harvest time. The most common approach is that they sell their produce as early as possible in the harvesting season, which tempts them to sell un-ripened honey. Those who are not urgently in need of cash store it for several months after harvests awaiting better market prices. In such cases, 46.6% of respondents said they stored honey in sealed modern plastic containers. 20.3% of respondents stored honey in traditional wooden barrels (*Keete*). Least of all, honey was stored in sealed metal containers (*debe* or drum) by 9.9% of respondents. The rest of the interviewees did not answer the question on honey storage. Where applicable, the store is usually a cool, dry place in the homestead such as a cereal granary.

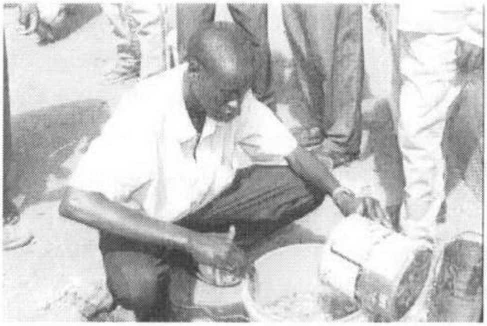
Crude honey

Honey is sold in independent sections of regular markets where trading lasts for only a few hours on each trading day, starting by mid-morning and ending by mid-day. Since trading centres in this sparsely populated area are normally a long way from homesteads and due to poor road networks, beekeepers deliver only limited quantities of honey at a time, mostly on foot. Honey is therefore usually packed and sold in recycled 4 l paint containers since such small quantities are light enough to carry. Where the terrain allows, bicycles are a common means for delivery of bulk quantities of honey that is packed in 20 l buckets (Fig. 2.3).

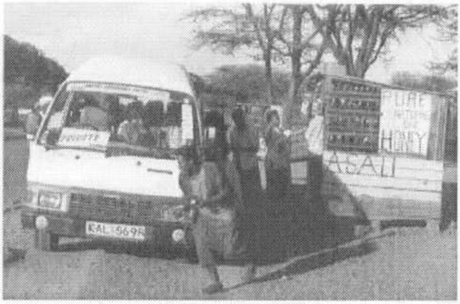
46% of the beekeepers deal only in crude honey. The price is based on a 4 l 'gallon' and calculated on this basis for bulk quantities - there are 5 gallons to each bucket which therefore costs five times the price per 'gallon'. A wide range of prices is offered over a season and they tend to rise or fall in multiples of KShs. 50. The range of possible prices reported was between KShs. 200 and KShs. 700. The price that is offered on a particular trading day depends on how many middlemen participate in the market and the volume of crude honey coming in (demand/supply basis). When pricing crude honey; the only quality consideration that is taken into account is its wax content. Higher prices are offered for lower wax content.

Semi-refined honey

Only 16% of the beekeepers interviewed said they traded in semi-refined honey which means that 38% of them did not disclose the type of honey they dealt in. Semi-refined honey is retailed by beekeepers and middlemen alike in roadside kiosks or shops along the main roads passing through the study area. It is sold in quantities ranging from 0.15 l for the cost of KShs. 50 to 1 l for KShs. 300. The range in seasonal price for bulk quantities of semi-refined honey tends to rise in multiples of KShs. 100 per 'gallon' from a minimum of KShs. 500 to a maximum of KShs. 1000. Crude honey is occasionally sold by 'gallon' in the kiosks (Fig. 2.4) a)



b)



c)

Fig. 2.3: (a) A 'middleman' buys a "gallon" of crude honey from a beekeeper during a market day at Maoi, Baringo District. Individual beekeepers deliver limited quantities on each occasion and so middlemen bulk honey from different sources into 20 l buckets. (b) Selling honey in exclusive honey speciality stalls along the Marigat – Nakuru highway (c) Selling honey alongside seasonal farm produce at a bus stop in Marigat Township. Travellers are key targets.

78% of the beekeepers in the study considered their business to be profitable. Of the 22% who thought it was not, 2.7% blamed it on a poor marketing infrastructure while another 2.7% said they experienced wide fluctuations in yields due to environmental influences over which no-one had control. 1% of the beekeepers considered themselves inadequately trained to operate profitably. The fact that honey was an additional source of food and medicine for the family encouraged the remaining 15.6% of interviewees to persevere under their circumstances. In spite of all shortcomings listed, this survey confirms that beekeeping plays an important role in the local economy of Baringo District. Honey production employs people of all productive ages in the study area, especially men. Women are not heavily engaged in production but are very actively involved in small-scale retail businesses that are important trading outlets for hive products in Baringo.

Beer brewing

Traditional honey beer is brewed when there are occasions to celebrate, including the honey harvest, or as a gesture of appreciation for assistance rendered by members of the community towards a task undertaken for an individual. The grade of honey that is preferred for brewing contains brood and pollen, which takes immediate care of a grade of honey that does not store well. Middlemen buy crude honey of this quality to supply to commercial outlets dealing in cheap, honey-based, alcoholic, herbal beverages ("*Miti ni Dawa*") in urban areas of Kenya. In Baringo, honey beer is available in local commercial outlets for only a limited period. The cheaper, local alternative is brewed from maize flour ("*Busaa*").

In the study area, 20 litres of honey beer are made from every 4 l 'gallon' of second grade of crude honey (from which liquid honey has partially been removed). 25 litres of beer can be made using one 'gallon' of first grade honeycombs and 30 litres are obtained from the same quantity of semi-refined honey. 1 litre of this type of beer was sold for KShs. 40 in year 2001. A brewer therefore made more than 100% profit for every 'gallon' of second grade honey if purchased at an average price of KShs. 400.

During the beer brewing process, crude honey yields about 25% – 50% of crude wax by volume, depending on original quality. This wax is discarded as a waste product as there is no established channel for trading in the commodity. When brewing is carried out at home, beekeepers store crude wax for smearing hives to attract bee swarms with. It also has wide application in sealing leaking containers or else it is thrown away.

2.3.7 Beekeeper support networks

81% of respondents were not aware of the existence of beekeeper support networks a few of which operate only in Marigat Parish. These voluntary associations have objectives such as to increase producer prices for hive products, provide an effective marketing organization and improve the quality of honey to a level adequate for bottling. 19% of interviewees reported marketing their honey through cooperatives and belonged to one group or another among those established in the study area. These are:

- Bogoria Original Pure Honey
- Poi Women Group Beekeepers
- St. Teresa Women's Group
- Parkaren Beekeepers' Association
- Maoi Honey Project (supported by Christian Children's Fund)
- Sandai Beekeepers Self-help Group
- Mbechut Women Self-help Group
- St. Paul's Women Group
- Mogoswok Beekeepers Coop. Society (now defunct).

Those who had not joined any groups gave various reasons for it. Men, for example, could not join groups where membership was restricted only to women. Other beekeepers belonged to groups whose membership was reserved for parents of children receiving support from charitable organizations operating in the area. 3.1% of the beekeepers complained that they could not afford group membership fees but did not disclose the amount of money required. Another 2.7% just kept away from such associations because from past experience they were wary of groups that lacked clear objectives. Collapse of a well-established cooperative in the area (Mogoswok) has disillusioned many people concerning benefits of joint ventures. The cooperative disintegrated while still owing beekeepers money and for fear of a repeat of such history experience, some people shy away from joining beekeeper support networks. Many would rather trade individually. Yet others considered themselves too old to join any groups or claimed they did not have the required family ties on which membership of existing groups was based (1.8%). The remaining 73.4% did not disclose reasons for not joining any of the groups.

Group members for their part reported that they enjoyed more stable prices for their produce when compared to trading individually in the open market. Group members also had enhanced opportunities to learn about modern beekeeping and gain access to modern equipment through their associations.

2.4 Discussion

This study provides an overview of the socio-economic circumstances of beekeepers in Baringo District based on responses by a sample of beekeepers to a questionnaire. It was not intended to give an in-depth analysis of the economic situation but rather to highlight economic circumstances that could influence performance of the beekeeping sector. The questionnaire approach was useful as it contained many open-ended questions that allowed the beekeepers to express their honest opinion on issues on most occasions. It was also originally intended to gather data on yield of hive products but this was not accomplished. Instead, the survey brought to light the fact that log hive sizes are not standardized which means yields cannot not be calculated based simply on average yields per hive and numbers of hives owned. The view of local honey traders however is that production is inadequate to meet the local annual demand.

This study confirms that beekeeping is an important economic activity in the rural community in Baringo District where it creates employment for people of all productive ages. It a means for generating much needed cash especially in the pastoral community occupying lowland areas. These findings are in agreement with official records that portray beekeeping as an important part of livestock production in Baringo District (Office of the Vice-President and Ministry of Planning undated). Meat, milk and honey are produced in all administrative Divisions of this District but beekeeping is more prevalent in the lowlands. Horticultural cash crops as well as food crops are grown under irrigation in Marigat. This explains why beekeeping was consequently placed second in rank of importance to livestock keeping in Marigat. Various types of food and cash crops are grown in all areas of the District with Kabarnet Division, in which Kituro Parish falls, having potential for rain-fed cash crops such as coffee, cotton and pyrethrum. Beekeepers therefore placed crop farming first among the most important income generating activities in Kituro while beekeeping took the third place after livestock keeping.

Beekeeping in the Tugen community of Baringo District was found to be subject to cultural restrictions that limit women's participation. This situation is comparable to that in the Akamba community of Makueni and Mwingi Districts of Kenya (Kyengo and Muriuki 1999, Mutungi et al. 1997). Under these circumstances women are handicapped because they are not taught essential hive production skills. Ogaba and Akongo (2001) reported that women's participation in beekeeping Uganda is likewise inhibited. Women therefore stand to gain wherever there is an innovative change in management practices. Kenyan women can imitate the example of fellow women in Zambia who have developed a system of mutual assistance that enables them to participate successfully in traditional beekeeping using a variety of available hive designs and accessories (Forest Department - IRDP 1992). They will need such support to overcome taboos surrounding their involvement some of which are based on myth and fear of bees. Lack of skills for climbing trees also makes it necessary for women to hire men to harvest honey for them. Women groups are therefore encouraged to adopt movable comb hives that are designed for installation close to the ground (Mann 1985). Protective clothing is also available to go hand in hand with modern hives so that beekeepers no longer have to fear stinging by bees. In practice however a change of technology is not easy to implement and the current study shows that men and women in Baringo still mostly follow traditional methods fifty years after the modernisation programme commenced in Kenya. The technical challenges faced by beekeepers in Baringo District in adoption of movable comb technology are dealt with to a greater depth in Chapter 3 and 4.

Available government statistics are very optimistic when they show that there were 7425 KTBH in Baringo District in 1995 (Ministry of Agriculture 1996). This is a much higher number than suggested by the 63 hives found in the current study. It is likely that this number of hives was once installed but many might since have fallen into disuse in the absence of an effective training and technical support system. Development agents promoting the use of modern beekeeping technologies in the study area therefore need to adopt more effective methods for delivery of technical support services to beekeepers at grass-root levels. This role has already been commissioned for them in a revised extension policy of the Ministry of Agriculture that creates room for the private sector to operate as an active partner in extension (Ministry of Agriculture

1999). The commitment of the private sector to the welfare of the beekeeper will be demonstrated when development activities are broadened to cover essential training in modern beekeeping which the public sector has not been effective in delivering. It was established through the current study that there is a demand for future training by beekeepers in Baringo District. Those interviewed suggested that they would like to learn more about basic biology of bees and how to operate modern beekeeping equipment, among other things.

An appeal by the people is an important starting point for training as it can be developed further into group training activities incorporating individual needs of trainees. Those wishing to engage in training of beekeepers in the study area should however bear in mind that various literacy levels have been attained by individual beekeepers. This situation where a sizeable proportion of people have not acquired basic formal education reflects circumstances where parents may lack awareness of the importance of education, which is then confounded by poverty that has been responsible for bringing Kenyan school enrolment rates down since 1989. The bottom 10% of all households had a net enrolment rate of 63% at best in 1999 and it is in this category the Baringo District fits (Office of the President 1999). People without formal education will require adequate repetition of new concepts, as the use of textbooks is not possible. Those who can read and write could however be furnished with relevant handouts to facilitate learning on their own as well as revision of specific theory from time to time. This approach is particularly recommended since the formal school curriculum does not cover beekeeping and sufficient practical activities and demonstrations around an apiary would be essential for aiding all beekeepers to understand the theory behind modern beekeeping methods.

Mulder (1986) was of the opinion that training of beekeepers is most effective when conducted by local people. With respect to the current study, a model for agriculture extension engaging local staff is already in place in the Agriculture Development Programme of the Catholic Deanery of Baringo. Mulder suggested that such people would make appropriate trainers of beekeepers. They are already be trained in beekeeping themselves but might require further training as trainers. The great advantage of adopting this model would be that such people live within the community and trainees could pay them consultation visits beyond training meetings. As such, the usual logistical problems concerning transport would not arise. A further recommendation is that such staff should be given jurisdiction over areas they can effectively manage as at the time of the study one 'animator' was responsible for an entire Parish and this was an area much too large to cover without transport facilitation. This model appears more effective than one proposed in the revised government extension policy whereby a field extension worker will be expected to gather problematic issues at the grass-root levels for further action by someone specialized at the administrative Division level. Again the question that arises is one of logistics and the efficiency of relaying messages back and forth between the beekeeper and the specialist operating higher in the administrative chain.

Against this background, it is hereby suggested that the future strategy for beekeeping development in Kenya should take into account the prevailing socio-economic situation of beekeepers in different regions of the country. FAO (1986) outlines that apicultural development can be gradually achieved by adopting a three-phase approach that builds infrastructure, educates beekeepers, produces suitable equipment and ensures that accompanying scientific research is conducted. This will at first only require a change of procedures even though it would be worthwhile at this stage to try using multi-chamber fixed comb hives that have been proposed for improved honey quality production (Corner 1985, Paterson 1989). The use of transitional single chamber hives can follow during an intermediate phase with gradual adoption of multiple-chamber top bar hives as a medium-term goal (Paterson 1989). The final stage of development would be expected to incorporate training of beekeepers in handling movable frame hives and their accessories, this being the most advanced level of technology possible. This approach can be modified to recognize different starting points and to expand the range of hive products with the development of new markets.

Currently, the beekeeper operates as producer and retailer of hive products. There are arguments against conducting business in this way especially when there is enough honey retailed to ruin the price on the whole crop (Deimer 1998). The current situation has arisen in response to a bad history of mismanagement of cooperatives that has eroded the confidence of beekeepers in such institutions, making them prefer to operate individually than by a common front. To help restore people's confidence in self-help groups, their leaders should receive training in managerial and entrepreneurial skills as these are poorly developed in Baringo District. Half of the commercial concerns that are registered annually do not make it to the second year of operation in this District for the reason of mismanagement (Office of the Vice-President and Ministry of Planning undated). All possible interventions should be made to regulate activities of middlemen in the marketing sector, a matter of general concern because they offer exploitative prices for commodities. Such traders build up their stock of hive products at the expense of beekeepers when the honey crop is abundant. They fill the vacuum in organized trading where cooperatives have collapsed and make most of their profit by selling their stock long after the harvests, when hive products are in short supply.

It is regrettable that a market for wax has not been successfully developed in Kenya even though it is well established elsewhere in the region (Fichtl 1994, Ntenga 1976). This situation had been reversed nearly fifty years ago by using simple techniques (Ministry of Agriculture 1967) and it would therefore not be difficult to produce wax again as long as a market can be developed for it. The government should recognize the potential of wax as an external trade commodity and assist beekeepers to develop markets for it. It is here that the organization of beekeepers at national level would be advantageous. They could pressurize the government for answers to their marketing problems and it is therefore encouraging to note the recent revival of the Kenya Beekeepers Association (Muriuki 2000).

Apart from the lack of a marketing system that is geared towards exportation, Baringo District also lacks adequate infra-structural facilities to support advanced methods of honey collection and quality control. A good road network would ease the current burden on beekeepers in transporting equipment and products. Marigat Division with 273 km of classified roads and Kabarnet Division with 111 km were currently rated as having the best road networks while Mochongoi Division with only 32 km of classified roads has the least developed network in the District (Office of the Vice-President and Ministry of Planning undated). The government therefore needs to prioritise plans to open up new roads especially in high potential areas. Likewise, improved telecommunications, power supply and development of water resources would attract and retain the services of development partners from the private sector and open up the way for industrialization in beekeeping. Water development has special significance for bees in the arid areas of Baringo where they require it for keeping hives cool under conditions of extreme heat. More about helping bees to keep hives cool is covered in Chapter 4.

Land is not normally considered to be a serious constraint to beekeeping as so little is required for individual hives to occupy. Besides, nectar and pollen sources are tapped for free (Bradbear 1985). In Baringo District, the current study revealed that traditional beekeepers mostly depend on communal land and are becoming increasingly concerned over the shortage of trees for hanging hives in. This situation could have arisen out of increased demands made on resources by a rising human population that is estimated to be growing at 5.4% per annum. Land in Baringo District is coming under increasing pressure of conversion from its original state to other uses to serve human interests (Office of the Vice-President and Ministry of Planning undated). The most competitive use identified for land that is suitable for beekeeping is livestock rearing since most land in the district is not very well suited for agriculture. Beekeepers recognize this conflict of interests and argue that the land under beekeeping should be devoted to environmental conservation with which it is more compatible. This shows there is need for developing an environmental management plan involving beekeeper and other stakeholders to determine the contribution each party should make towards environmental conservation. More on the vegetation resources is covered in Chapter 5.

2.5 Conclusions

This study confirms the importance of beekeeping as an economic activity in Baringo District and in the cultural context of the Tugen people who regard it as a man's occupation. Women beekeepers are found only in the lowland pastoral zone where there are fewer opportunities for diversification of the economy. It also points out that beekeepers are currently still largely dependent on traditional methods of honey production. Wax is treated as a waste hive product but the development of external markets can help to absorb this valuable product. Training is therefore required during harvesting and processing in order to raise the quality and quantity of honey and open the way for new hive products. The public sector has not been very effective in the past in delivering the necessary technical support to achieve this and the challenge to the private sector will be how it can become more actively engaged in providing extension services in future. The approach that is recommended is to aim for improved the quality of hive products by training beekeepers to follow appropriate production and processing methods while based on the log hive then gradually introducing more advanced technology for a wider diversity of hive products.

The government is required to play a more active role in development of external markets, and to take steps to minimize exploitation of beekeepers by middlemen in the industry. Beekeepers for their part need come together in the form of groups and begin to actively seek solutions to their common marketing problems, which cannot be tackled on individual basis. A strong beekeepers' association could help to coordinate the beekeepers' groups and to give them a chance to open dialogue with the government concerning the need for better infrastructure in support of improved performance in the industry.

3 BEEKEEPING PRACTICES AMONG THE TUGEN PEOPLE OF BARINGO DISTRICT, KENYA

3.1 Introduction

Africa has the oldest tradition of beekeeping in the tropical region. Hives are made out of locally available materials and are considered to cost very little in comparison to more advanced equipment that is available elsewhere in the world (Corner 1985, Crane 1985, Paterson 1985). The previous chapter has nevertheless pointed out that when it is necessary for beekeepers to purchase log hives, they are equivalent in price to the introduced Kenya Top Bar Hives, and sometimes even more expensive, depending on their quality. Simple equipment and procedures are adopted for harvesting and processing hive products. Seasonal management cycles also take into account the fact that tropical honeybees swarm frequently and have a natural ability to escape excessive disturbance (absconding) coupled by an ability of adult bees to move from one area to another in instances where forage is in short supply (migration). Beekeepers throughout sub-Saharan Africa therefore leave bees to vacate hives at will but do what they can to attract occupation (Forest Department - IRDP 1992). Traditional beekeepers depend entirely on natural bee movement for initial stocking of hives. A limiting characteristic of African bees is that their colonies naturally do not grow as large as those of the European honeybee nor store as much honey (Clauss and Zimba 1989, Crane 1990).

In Kenya, beekeeping development is a mandate of the Ministry of Agriculture. General guidelines for simple and efficient beekeeping have been developed which outline the biology and behavior of bees and advise beekeepers on seasonal activities that should be undertaken for improved management of colonies ((Ministry of Agriculture 1974, Ministry of Agriculture undated (b)). These guidelines are based on the Kenya Top Bar Hive whose use is promoted by the Ministry of Agriculture on the basis that it gives beekeepers the best chances for controlling aggressive bees at harvest time, thereby facilitating preservation of bee colonies (Ministry of Agriculture 1979). Adopting this system of management is considered to be advantageous over traditional methods since movable comb hives and their accessories present opportunities to generate better quality and a wider range of hive products.

To harmonize the quality of hive products in Kenya, standards have been set at national level for table honey (KS 05 – 344) and beeswax (KS 05 – 1279) that are intended to guide beekeepers on the permissible harvesting and processing procedures to follow (Odwori and Aleke 1997). These standards not only demand that honey be graded by undertaking technical tests at the source but also insist that only plastic or stainless steel containers should be used for storage. Quality standards are nevertheless a new concept for traditional beekeepers who normally deal in crude honey. Much of what they produce is absorbed by a beer industry for which pollen and brood, technically regarded as impurities in honey, give added value to the brewing process (Clauss and Zimba 1989, Ministry of Agriculture 1967, Vorwohl 1989). Quality standards are therefore for the benefit of those who wish to penetrate external and export markets in which quality of a different nature is strictly enforced. Concerned about the fate of honey produced in Africa for trade on the world market, Wix (1989) and Wainright (1989) have suggested practical ways to produce good quality honey, which include educating beekeepers on the types of combs to harvest and improved processing methods to follow.

Nightingale (1976) briefly documented a number of traditional beekeeping practices among ethnic communities of Kenya in which he covered the Tugen people of Baringo District, the focus of the current study. They belong to a larger group of tribes called the Kalenjin and occupy a dry hot area of the Rift Valley Province where they pursue a predominantly pastoralist economy. Income earned from the sale of hive products supplements their meager cash earnings. Against this background, current practices in Baringo District are re-examined three decades after the introduction of modern beekeeping methods in Kenya. The intention is to document the level of technical knowledge that is currently vested in beekeepers in the Tugen community.

3.2 Methodology and database

The methodology followed for conducting this survey of beekeeping practices is the same as that for the main socio-economic survey described in greater detail in Chapter 2. In brief, beekeeping areas of Kabarnet, Marigat and Mochongoi Divisions in Baringo District all fall within the Catholic Deanery of Baringo and for logistical reasons the socio-economic survey was conducted in collaboration with the Agriculture

Development Programme of the Deanery. Two Church Parishes were selected in order to cover the widest possible range of ecological zones in the beekeeping areas of the District. Marigat Parish was selected as it adequately covered the foothills of the Tugen Hills, lowlands on the Rift Valley floor and Laikipia escarpment to the east. Kituro Parish incorporated areas to the west, from middle elevation to highland areas on the Tugen Hills.

In collaboration with local contact persons, grass-root agricultural staff ('animators') of the two Parishes concerned first drew up lists of all known beekeepers within their areas of jurisdiction. A person qualified for consideration as a beekeeper on the basis that he or she managed at least one bee colony independently. 750 beekeepers were thus listed altogether in the two parishes of which all the 23 women hailed from Marigat Parish.

Personal interviews were administered on a sample of 224 beekeepers (about 30% of total) based on structured questionnaires that were first developed in English then translated into the Tugen language. 174 beekeepers were drawn from Marigat Parish where beekeeping is widely practiced while 50 represented Kituro Parish, an area where beekeeping activity less intense. Male beekeepers were randomly drawn into the sample proportionally to size of each parish, the selected areas and specific villages within. All women who were listed were selected for interview on gender basis. Respondents provided personal details about age and education status then answered questions covering several topics related to beekeeping. They shared knowledge about biology and behavior of local bees, the plants on which beekeeping depended, types of hives in use, bee colony management practices as well as honey harvesting and the processing procedures followed. Further observations were made and practices documented in greater detail during the year that followed the survey. Data was analyzed using SPSS and Excel software packages.

3.3 Results

3.3.1 Routine tasks in beekeeping

As previously described in Chapter 2, beekeepers receive some assistance in performing routine tasks according to roles that are culturally defined for household members. Activities in the annual beekeeping cycle vary with the seasons. For the lowland zone, the annual beekeeping cycle begins with a hot, dry season in January at the time when harvesting concludes. By then, bees are faced a shortage of forage and water, prompting them to migrate. More details are as outlined below:

Month	Main activities
January	End of honey harvest and hottest time of the year. Most bee colonies migrate elsewhere in search of forage and water.
February	Beekeepers acquire or construct new log hives to expand on their enterprise, where required.
March	Old hives are cleaned up and repaired; new ones hang up in trees, where acquired.
April	Long rain season and main reproductive swarming period. Many hives that had been deserted during the dry season are re-occupied by bees.
July	Beekeepers harvest honey from minor nectar flows, starting with the smallest hives.
December	Main honey harvest in the lowlands and the start of the hot season. Bees are likely to begin migrating to other areas

Bees were reported to re-occupy hives in the lowlands as soon as foraging conditions returned to normal, following the rains. This calendar features similar activities to those in the highlands with the exception that seasons vary slightly such that main harvest takes place in August in the highlands.

3.3.2 Construction and siting traditional log hives in apiaries

Beekeepers or hive artisans look for dry, standing trees or sound fallen ones of recommended species such as *Terminalia brownii, Ficus sycomorus, Grewia similis* or *Podocarpus falcatus* out of which hives are to be made. The lower section of the tree trunk is cut by axe or power-saw into logs of desired thickness and length. Using the same tools, the logs are then split in half, length-wise. The inner part of each half is etched out with an axe and a special chisel (*Kipkongoito*), leaving a thick outer wall. The result is that overlaying the two separate troughs forms a hollow cylinder (Fig. 3.1).

Fig. 3.1: Traditional log hive workshop. Hives comprise of two matching wooden troughs that form a cylinder when overlaid and open from the front against the longer, loose joint at the rear.

If not incorporated as built-in end pieces to each half of the hive, covers are measured and made out of separate slabs of wood so as to fit each end. They are fixed to the troughs using strong, flexible wire or wooden pegs fitted through drilled holes. Drills (*Kolomeito*) are made out of metal rods of various diameters bearing wooden handles, as shown in Chapter 2. During the process of hive construction, they are heated to high temperatures over an open fire after which they are driven through wood by hand. A notch is cut in the middle section of the front side of the hive along the line where the two halves are joined when overlaid. It acts as a connection point to the inside of the hive and is useful for opening it. Two widely spaced holes are drilled into the uppermost part of each section of the hive. It is through them that ropes are passed in order to lift sections of the hive separately to a secure and final apiary destination, usually on the branches of a tall, thorny tree, where the hive is reassembled and fixed firmly in place using wire.

There are two main methods of placing log hives in trees. The first is by placing a hive in a horizontal position on branches of a tree then securing it by wire. The other is by attaching a loop of strong wire to the hive to create a handle then suspending it from a strong branch by a wooden hook (Fig.3.2).

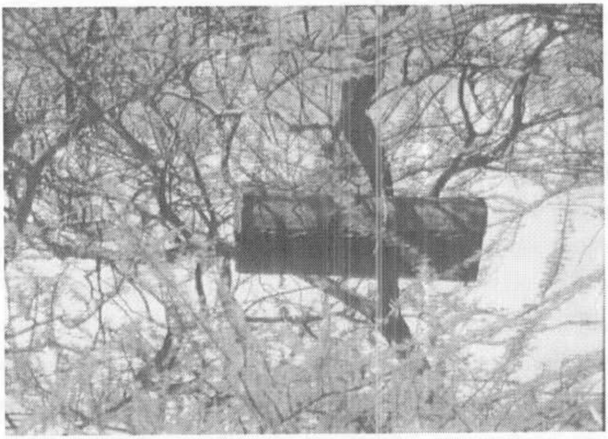


Fig. 3.2: A traditional log hive suspended by wire from a wooden hook hangs securely in the canopy of a thorny tree.

3.3.3 Beekeepers' knowledge about bees

Types of bees

Beekeepers are familiar with the physical appearance of local bees and reported that both light and dark coloured varieties occur together in the same colonies. They were referring to *Apis mellifera scutellata*, a medium sized tropical African bee race that occurs in open woodland, mainly at about 500 – 1500 m above sea level. They also distinguished honeybees from ground- and tree-nesting sting less bees (Fig. 3.3).

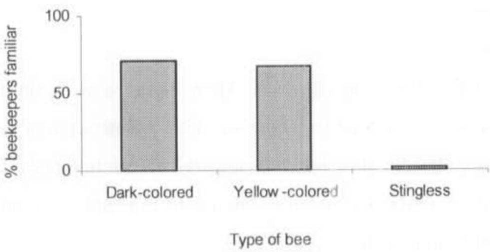


Fig. 3.3: Beekeepers' familiarity with the local bee characteristics. Colonies of the honeybee *Apis m. scutellata*, contain both light and dark coloured bees with which beekeepers are equally familiar.

Roles of bees in a colony

Beekeepers were most familiar with worker honeybees for which they identified up to four roles correctly, namely building of honeycombs, feeding larvae, guarding the colony as well as foraging for nectar and pollen. Workers however do much more since they undertake, in total, thirteen different non-reproductive tasks in the colony. Division of labour among them is such that they pass through a progression of tasks with age (age polyethism) starting with cell cleaning and ending with foraging. Beekeepers were not aware of these details. Concerning drones, their primary role is a reproductive one, about which half of those interviewed were aware of. Almost 90% of the beekeepers correctly assigned the queen the role of laying eggs while the rest claimed never to have seen her. By assigning her a leadership role, a mere 3% of beekeepers associated a normally queen functioning with her second role, which is cohesion of the colony (Tab. 3.1).

Tab 3.1: Beekeepers' knowledge of the roles played by different bees in a colony. The reproductive roles of the queen and drones were correctly understood but workers were assigned fewer roles than they normally perform.

Type of bee	% Beekeepers who identified given number of roles for different bees in the colony				
	1 role	2 roles	3 roles	4 roles	No answer
Drone	54.9	0.0	0.0	0.0	45.1
Worker	39.7	37.5	10.7	4.5	7.6
Queen	87.9	2.7	0.0	0.0	9.4

3.3.4 Bee behaviour

Seasonal migration

Beekeepers reported that bees moved about when forage was in short supply and/or when the weather became unfavorable. There was no consensus about the specific areas to which bees migrated but the direction was generally from lowlands to highlands and vice versa. The peak of movement from highlands to lowlands was said to take place between January and March each year (Fig. 3.4).

Bees were thus expected to return to the hives they had abandoned in the lowlands once the environment became more favourable. According to beekeepers this took place mostly between March and August each year even though others were not so sure and suggested it lasted the entire year (Fig. 3.5).

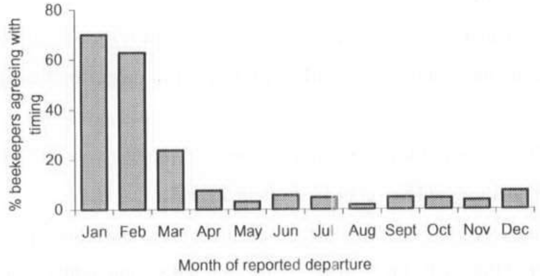


Fig. 3.4: Seasonal migration of bees in Baringo District. According to observations made by beekeepers, it takes place between highlands and lowlands or vice versa. The peak of departure from lowlands coincides with the dry hot period of the year (January - March).

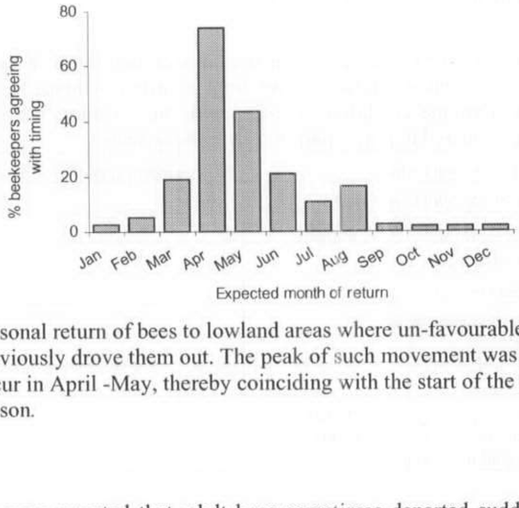


Fig. 3.5: Seasonal return of bees to lowland areas where un-favourable conditions previously drove them out. The peak of such movement was reported to occur in April -May, thereby coinciding with the start of the long rain season.

Absconding

83% of beekeepers reported that adult bees sometimes departed suddenly from hives leaving the brood behind. Several reasons were given for such absconding behaviour the most important of which were invasion of hives by ants and attack by honey badgers. It was nevertheless difficult for beekeepers to distinguish between absconding and migratory behaviour and therefore departure for lack of food and water was erroneously regarded as absconding (Tab. 3.2).

3.3.5 Management of bee colonies

In view of the fact that bees move about during dearth periods, 92% of beekeepers undertake management activities mostly with respect to preparing deserted hives for re-occupation. The majority sweep hives clean to remove nests created by mice and wasps as well as cobwebs, using brooms made out special plants such as *Croton dichogamus* that leave behind an attractive scent for bees (Tab. 3.3).

At present, 58% of beekeepers visit their hives only once per year, at harvest time. Another 21% visit their hives twice annually, the additional trip being for confirmation of hive occupation by bees or for cleaning and repairing empty hives (Fig. 3.6). The labour and time inputs per colony are therefore minimal and a lot more effort and time goes into walking the long distances between hives and homesteads. 96% of those interviewed expressed interest in spending more time in managing the colonies if this would translate into higher cash returns.

Tab. 3.2: Reasons given by beekeepers for bees absconding hives in Baringo District. The most common problems arise from invasion of hives by ants or honey badgers. Extreme conditions of heat, cold, rain, wind or noisy environments are all considered to play a part in chasing bees away.

Cause of absconding by bees	% beekeepers agreeing with this cause
Pests ("*kelek*" & "*makunen*" ants)	43.5
Wild animals especially honey badgers	39.3
Lack of food or water	18.8
Extreme cold or heat	6.7
Poor harvesting techniques	4.9
Leaking beehives	3.1
Strong wind	1.3
Too much noise from farm machinery	0.9
Smoke from machinery or fires when preparing land for cropping	0.4

Tab. 3.3: Common procedures undertaken to prepare hives for reoccupation by bees following migration or absconding. They are aimed at providing clean, safe environments that are attractive to bees.

Management practice	% beekeepers who have adopted practice
Sweep hives clean	81.7
Remove old combs	23.2
Repair hive	9.8
Apply attractant to hasten hive occupation	8.0
Control ants	6.7
Reposition hive securely in tree, if necessary	2.7
Relocate hive to better site, if need be	2.2
Mask honey badger scent where required	0.9
Place thorns at tree base to deter honey badgers	0.9

3.3.6 Harvesting and processing procedures

The recommended time for harvesting honey is when bees have ripened and sealed (capped) it but beekeepers in Baringo District have devised generally accepted alternative methods to determine when to harvest honey. 70% of those interviewed considered the length time lapsed since key nectar plants bloomed expecting that by the time all flowers have withered; bees have had sufficient time to ripen honey and seal it (Tab. 3.4). A third of the beekeepers consider the extent to which cracks in hive have been sealed in propolis. The time for harvesting coincides with when most cracks are sealed. Another 20% of respondents interpreted the presence of bees resting outside hives to indicate storage of large quantities of honey. They did not understand that this was a sign of heat stress. More on hive temperature trends in this area is covered in Chapter 4.

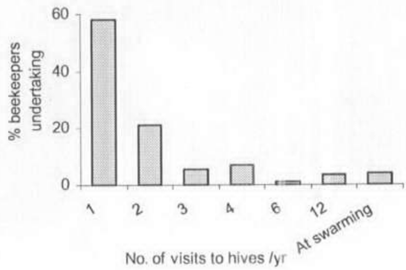


Fig. 3.6: Frequency of hive inspection visits. The majority of beekeepers visit hives once a year when they harvest honey. Others visit hives for a second time to inspect occupation by bees or to clean them out if found empty.

Tab. 3.4: Ranking of methods followed by beekeepers in determining the right time to harvest honey. Most of them wait for a while after the main flowering (nectar flow) is over before harvesting honey. Others are guided by changes in bee behaviour or follow the lead of more experienced beekeepers.

Indicators for the right time to harvest honey	% beekeepers who follow given indicator
Time lapsed since plants flowered	70.3
Extent of sealing of cracks in the hive with propolis	29.7
When bees rest in groups outside hive	19.4
When bees use all possible exits to the hive	4.1
Testing combs for honey by inserting sticks into hives	2.7
Looking out for time when experienced beekeepers start	1.8
Listening to the fullness of the sound of bees in the hive	1.4
Presence of a large bee population in the hive	0.9
Bee behaviour – bees are docile once they store honey	0.9

Harvesting procedures

Harvesting takes place at night and the concerned beekeeper is assisted by at least one other male member of his household or male colleague (Fig. 3.7). It is carried out without protective clothing. To minimize stinging, beekeepers stripe instead to the barest level of underclothing so as not to trap bees against their bodies.

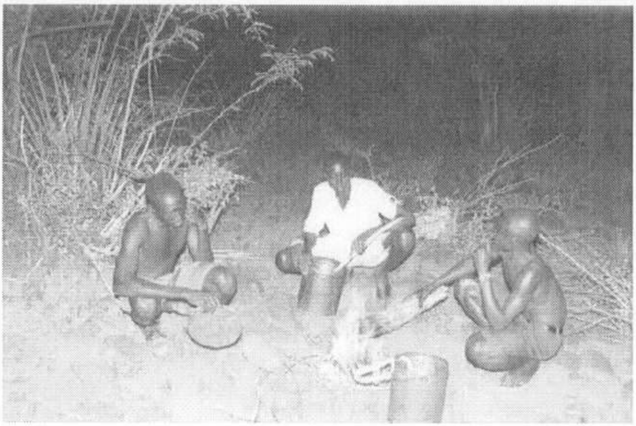


Fig. 3.8: A beekeeper (left) is assisted to light a smoker *(sisto)* over an open fire. Clothes have been partially shed (piled in the background) in preparation for harvesting, which proceeds with bodies unprotected. The person in the middle is holding a wooden hive tool (*sekete*), pointed into a 'gallon'.

Traditional equipment is covered in Chapter 2 based on which the harvesting procedure in now described. A locally assembled smoker is required, which can be carried over from a previous season or is made out of firewood that is fetched by an assistant and lighted at the harvesting site. Once up the tree and in reach of a targeted hive, the beekeeper and others assisting him first secure their positions on the branches. They open the hive by pushing the unsharpened, thicker end of a wooden hive tool *(Sekete)* into a notch that is built into its side. This forces the hive to open slightly along the front side joint after which more effort is applied by hand to separate the covers but keeping them connected along the rear joint. A wedge (*Shong'eito*) is placed between the covers to keep them open wide enough for the beekeeper to get a good view of the combs when working. The "smoker" (*Sisto*) serves the dual purpose of a light as the beekeeper blows smoke from it to calm bees and in its glow ascertains the state of combs that are attached at the top cover of the hive. Those that have capped honey are selected for harvest and cut away at the top with the flat blade of the sharpened end of the hive tool. Combs that that are found bearing brood and un-ripened honey are left intact for bees to use.

Combs are placed into a bag (*Tokolta*) that is made traditionally out of leather or into any other available container as long as it is clean and has a well-fitting lid, such as a recycled 4 l paint tin ('gallon'). At the end of the task, after closing the hive and securing it back into position on the tree, the load of honey is lowered by rope and the smoker dropped to an assistant waiting to receive them below. The beekeeper may perform traditional rituals at this point to appease his bees if he upholds traditional religious values. The beekeeper proceeds to harvest from other hives on the same night wherever ripened is available and as long as he has sufficient aides to assist in transporting the accumulating yield back home.

Processing

77% of the beekeepers interviewed dealt in crude honey, which is obtained by breaking honeycombs into smaller pieces by hand or using a stick. Honey from brood combs is known to spoil rapidly and is separated at harvest time from the pure honeycombs. The former grade is considered best for immediate consumption or brewing of traditional beer. Honey from pure honeycombs stores better and in the long term is used as food or medicine in the home. It can also be sold or exchanged as a valuable traditional gift.

In Baringo District, the processing methods followed to obtain a semi-refined honey out of the crude product are as outlined below:

1) Break honeycombs into small pieces by hand and place them in a storage container. Crush them more finely using a cooking stick. Seal container. With time, most of the liquid honey will seep to the bottom while wax will float. The wax is held out of the way by hand as the fluid contents are dispensed when required.

2) Break honeycombs into small pieces by hand and place them in a container. Crush them more finely using a cooking stick. Place the container in the sun to warm its contents. Filter honey through a nylon fabric into a packaging container and seal with a tight-fitting lid.

3) Break honeycombs into small pieces by hand and place them in a cooking pot. Crush them more finely using a cooking stick. Place pot on low fire and melt the contents. Sieve using nylon fabric and dispense fluid contents into packaging containers.

4) Break honeycombs into small pieces by hand and place them in a cooking pot. Crush them more finely using a cooking stick. Use a water-bath for warming the honeycombs. Sieve using nylon fabric and dispense honey into packaging containers.

52% of those who sell refined honey prefer exposing crude honey to the sun first to warm it followed by skimming of the wax that floats on top, by hand. The remaining beekeepers heat honey in different ways in processing it (Fig. 3.8).

Storage and packaging

Where the beekeeper is not urgently in need of cash, honey is stored to avoid trading when markets are flooded with hive products, usually at harvest time. Honey is also reserved for future domestic use. Traditional storage containers are wooden barrels (*Keete*) that are fitted with lids made out of leather so as to keep out dirt and pests. These have almost been completely replaced in modern times by 20 l plastic buckets with fitted lids. Food granaries are cool and dry and are the appropriate places for storage within a homestead. Semi-refined honey is decanted directly into recycled bottles of between 150 ml to 1 l in volume. On request, it can also be packaged in bulk quantities using 4 l 'gallons' or 20 l buckets (Fig. 3.9).

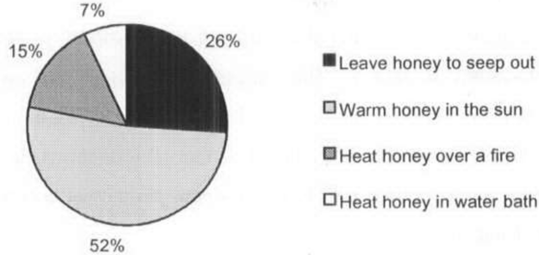


Fig. 3.8: Methods followed for processing honey in Baringo District. Heat is applied to various extents to hasten flow of honey but can damage quality if it raises the temperature of honey above 71°C.

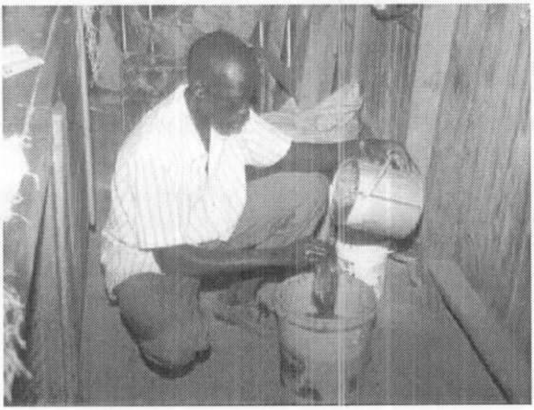


Fig. 3.9: Simple processing methods are followed in refining honey in Baringo District. The one shown here allows crude honey to settle in a container first after which the fluid honey is directly put into bottles.

3.3.7 Difficulties encountered in traditional beekeeping

It is preferred to place hives in secure places where they are out of reach of human and animal interference, usually at great heights in the sturdy branches of tall forage trees such as *Acacia tortilis*. All suitable trees growing along seasonal and permanent river courses are already well exploited and for lack of alternatives, other shorter shade trees such as *Tamarindus indica* are at times acceptable for placing hives in, thereby compromising hive security (Tab. 3.5). Beekeepers sometimes travel 20 km or more in search of suitable apiaries, well into interior regions of the area where there are no roads. This creates problems in transporting materials and products. Beekeepers also consider the aggressive nature and absconding characteristics of local bee races as they select quiet locations for apiaries. The concern of beekeepers over swarming and poor processing skills are justified and can be addressed using of additional equipment and accessories. This however which would take more investment on the beekeeper's part and the immediate prospects appear to be poor considering that beekeepers already feel burdened by rising costs.

A new problem has risen with intensified farming practices whereby broad-spectrum pesticides are applied without due regard for their effect on bees. As a result, die from pesticide poisoning when they forage on crops on which such chemicals have been applied. A solution should be found to solve for this paradox as bees at the same time provide pollination services that improve yields of certain cash crops such as papaya, watermelons, citrus and coffee. Beekeepers in the irrigation schemes in Marigat are more aware of the problem than those in Kituro although both areas are affected.

Tab. 3.5: Problems encountered by beekeepers in Baringo District. Some arise from bee characteristics or environmental factors that are beyond the control of beekeepers while others have to do with poor transport or market infrastructure. Pest control and processing skills need improvement.

Management problem encountered	% beekeepers who experience problem
Loss of honey due to pests or theft	25.7
Flooded markets at harvest time	14.5
Lack of water	10.0
Low hive occupation rates	4.1
Rising costs of equipment	3.2
Poor transport infrastructure	2.7
Aggressiveness of bees	2.7
Poor processing skills	1.4
Apiaries located far away	0.9
Pesticide poisoning	0.9
Colonies weakened by swarming	0.5

Areas for improvement

53% of those interviewed considered their current level of performance to be below the optimum production level that could be expected of their enterprises. In order to improve on it, they ranked a number of suggestions according to order of priority they would give each intervention so as to achieve optimum production (Tab. 3.6).

Tab. 3.6: Suggested management priorities for improved hive production in Baringo District. Most beekeepers believe they can improve hive production by modernizing their equipment or applying more efficient management methods on log hives. The idea of improving forage availability was very appealing but only a few people believed that it was necessary to increase the number of hives they owned.

	% beekeepers agreeing with priority level *(1 = highest priority, 5 = lowest priority)*				
Management aspect for future action	1	2	3	4	5
Modernize equipment	36.0	17.5	19.9	14	2.4
Improve availability of bee forage	23.1	17.9	25	25	0.0
Maintain stronger bee colonies	19.0	18.5	21.8	25	4.7
Manage log hives in better manner	10.4	28.9	21.8	23	6.2
Improve marketing infrastructure	1.9	0.0	0.5	1.0	3.8
Improve hive occupation rates	1.4	3.8	0.0	1.0	1.4
Attend training seminars	0.9	0.0	0.0	1.0	0.9
Pest control	0.9	2.3	0.5	0.0	2.3
Access reliable sources of water	0.5	0.0	0.0	0.0	2.4
Increase number of hives	0.5	0.0	0.5	1.0	1.9

Beekeepers were realistic about their environmental limitations but they were keen to improve on colony management skills through training where possible. A concern about marketing was raised yet again, which together with development of infrastructure and water resources are issues in which the beekeeper requires the support of development agents. Beekeepers did not consider themselves in a position to alter hive occupation rates to a large extent but the answer already lay in their wish to modernize equipment.

3.4 Discussion

The results of this study indicate that beekeeping in southern Baringo is still largely based on traditional, fixed comb, log hives. Based on available records for Baringo District, a smaller proportion of beekeepers have installed Kenya Top Bar Hives in the study area than expected (Ministry of Agriculture 1996). It was also surprising to find that those who have adopted KTBH apply traditional management practices in the same way as on log hives, with beekeepers visiting colonies only once or twice annually. Bearing in mind that yields are characteristically low in the tropics, Paterson (1985) was therefore right to question the value of investing in high-cost advanced hives when it was not expected that beekeepers could spend longer time than was necessary when dealing with aggressive bees. The attitude of beekeepers in Baringo District is that they are ready to spend more time attending to bees if it can be rewarded with higher monetary returns. Beekeepers' suggestions for areas where future management improvements are required are a realistic assessment of all the obstacles to be overcome along the path towards improved performance of the industry in this area. As such, modernization of equipment, though of high priority, should not be pursued in isolation but should be supported with increased research in adopting it to suit local conditions.

Beekeepers in Baringo District are aware of a problem of low occupation rates and they undertake a number of activities in the management cycle to make hives more habitable by bees, including sweeping, repairing damage and smearing beeswax in them to attract swarms. This is similar to the situation reported elsewhere in Africa where the initial occupation rate of traditional hives depends on the natural bee population of an area (Forest Department - IRDP 1992). The results however compare poorly with the 90% occupation rate possible in more advanced beekeeping systems (Corner 1985). In the latter, the method employed for stocking hives is by package bees or colony division.

Catcher boxes have been recommended for stocking top bar or frame hives in the tropics with swarms collected from natural reservoirs in locations where bee populations are high. Swarms may also be collected along migration routes that are well known to beekeepers (Crane 1990, Nightingale 1976). Something is already known about movement of bees in Baringo, which is reported to take place between highlands to lowlands during the long rains (April/May). A movement in the reverse direction takes place when forage becomes scarce in the lowlands (December/January). The principle of stocking could be tested on traditional log hives, using suitable swarm catching devices and methods along migration routes.

The nomadic behaviour of bee colonies in Baringo District is attributed to seasonal changes in availability of forage, water and temperature. Additional resources would be required to bridge existing gaps in order to maintain colonies in the same hives from season to season. Feeding colonies during dearth would be one possibility for preventing bees from leaving and is appropriate for strengthening colonies at an appropriate time ahead of the nectar flow but the cost would have to be evaluated against the benefits of such intensive management. This practice also requires bee colonies to be placed under a management system that utilizes movable combs. The other strategy that could be incorporated under intensive management for increased hive productivity is swarm prevention. This can be undertaken in movable comb hives based on good understanding of bee biology. Under the current circumstances, the aggressive nature of bees prevents even experienced beekeepers from learning much about what goes on inside a bee colony. As such, knowledge of bee biology is limiting since what beekeepers observe outside the hive and when harvesting is not enough to support intensive management. Training in the area of colony management is thus necessary.

A high location is essential for securing hives in Baringo District from interference by livestock and for discouraging badgers and vandals from robbing them. Beekeepers also take precautions against smaller intruders such as wasps and squirrels that occupy hives after they are vacated by bees. Suspending log hives or KTBH from greased wires further deters ants by blocking their advance towards the hive. When other types of hives are considered for installation closer to the ground, ant-proof stands and hedges or fences would be required for keeping them out of reach of animals and the public. Practical management of bees under Kenya conditions using the KTBH is covered in the Beekeepers' Guidebook ((Ministry of Agriculture undated (a)).

KTBH are based on the principle of movable combs and are already in use in the study area although in limited numbers. Their use should be encouraged as such technology is flexible and allows colonies that are considered too small to be united into productive units, provided both are healthy. The combs may be mixed without any preparation but as it is necessary to remove one of the queens from the two colonies, the beekeeper should be familiar with characteristics of both colonies in order to determine which queen to keep to propagate the more desirable behaviour. Such management cycles could be timed so as to produce maximum strength of colonies during the main honey flow for maximum colony productivity. After the honey harvest, bees can be utilized to stock more hives. A queen rearing programme to go hand in hand with such intensive management is already practiced using tropical *Apis mellifera* in South Africa, and has been successfully carried out in Tanzania and Zimbabwe (Crane 1990). It relies on natural mating by queens and therefore limits breeding to the extent of rearing daughter queens of the best performing colonies with respect to desirable characteristics. It still makes a difference however when selection is made in favour of increased honey production, gentler bees and high fecundity of the queens. A more advanced bee-breeding programme would require artificial insemination and can be a long-term goal. In this regard, beekeepers can benefit from an apicultural development programme such as the one proposed by the International Centre of Insect Physiology and Ecology (ICIPE), based in Kenya. This organisation has plans to transfer technology to small holders at a later date to enable them commercialise production of the most recent products of the hive including pollen, propolis, royal jelly, bee venom and bee brood (Raina et al. 2000). These products are unknown to beekeepers in Baringo District but they can be gradually introduced to diversify hive production.

Given the aridity of the study area, especially the lowlands, it would worthwhile to consider migratory beekeeping, which requires colonies in to be transported in movable frame hives. Nightingale (1976) was engaged in this type of management for which he modified the top bars in KTBH for better transportation and he reported success. In Baringo this type of management would enable a beekeeper with superior bee stock to maintain it rather than lose it with every dearth as is currently happening. It has already been mentioned that there are irrigation schemes in the lowlands where horticultural crops are produced and that highland areas are well suited for rain-fed agriculture. These are the two areas migratory beekeeping can be tested in and there would be nothing to stop beekeepers from travelling further a-field to make additional income by trading in pollination services. Vegetation resources in the area and how they can be developed further in support of beekeepers is covered in greater detail in Chapter 5.

Beekeepers in Baringo District are currently following honey harvesting and processing methods that do not aim for a pure product. There is usually little need warming honey prior to filtration in the tropics as it can be processed at hive temperatures (35°C). Where heat is applied, temperature should not exceed 71°C because excessive heat damages honey in various ways. Some of the processing methods employ heat that could easily cause smoking and burning of the product if not properly monitored. Townsend (1976) blamed such inferior processing methods for producing honeys that are unattractive in appearance thereby allowing the place of local honeys to be taken up by imported ones. In pursuit of better quality hive products, he also suggested introducing a comb grading system on which to base the price of honey received at buying centres. Corner (1985) also suggested that better quality honey could be obtained from log hives simply by following improved harvesting procedures. Those he proposed included separating capped and partially uncapped honeycombs from those containing brood and large amounts of pollen as well as dark from white combs. He emphasized that bees should be brushed off before placing combs into harvesting containers and that such should be covered immediately afterwards to prevent contamination by drowned bees.

Isola (1991) who worked among resource poor beekeepers in Guinea Bissau describes how progress was rapidly achieved with respect to quality production in this country. He was involved in a beekeeping project that supplied village centres with honey extractors, honey presses, honey filters, storage tanks and small buckets. Some of the larger centres were supplied with solar wax extractors as well. While all equipment was initially tested, eventually most of the honey was extracted using the press because combs were too small for the extractor. Allowing honey to drip from uncapped combs placed on wire mesh also gave very good results. These efforts produced a marked increase in honey quality for which beer brewers were willing to pay more. At the end of this one-year project, beekeepers had been trained in making equipment locally and had identified suitable alternatives for items that either cost too much such as glass for the wax extractor or whose material was not available locally, such as the stainless steel tanks. Isola emphasized that having beekeepers organized into groups means they can share processing equipment thereby lowering the cost of investment on individual basis while in the process improving hive production.

Future action could be taken along the lines suggested by Townsend (1976) in order to deal with the beekeepers' current concern over marketing. He described the establishment of honey collecting centres as a first requisite for developing beekeeping in an area and for successful operation he suggested the centres should pay cash for hive products on a graded basis. The aim of these centres should be to re-process honey and possibly pack it for a local market. Wix (1989), on the contrary, suggested that beekeepers should operate individually where the local market permits and only if unable to sell the whole crop should they come together through cooperatives or sell to middlemen. The latter option appeals to beekeepers in Baringo District who have experienced a poor history of cooperatives. In the long run, cooperatives would nevertheless be more advantageous as they would give beekeepers the opportunity to install equipment of a size suitable for the area and with a scope for analytical and process control that can enable them to penetrate the export market. This gives them all the more reason to re-group as they are beginning to.

3.5 Conclusion

The short-term goal for up-grading the performance of beekeeping in Baringo District should be to improve on current practices based on fixed-comb traditional hives. Beekeepers would also realize higher returns in their enterprises if they could deal in wax rather than discard it as is currently the case. They urgently need assistance to enable them to sell this product in external markets, ultimately targeting the export market.

In the medium term, there will be need to change both the procedures and to invest in movable comb technology to enable the beekeeper to manipulate colonies so as to obtain high yields of honey and beeswax. This will require increased knowledge of bee biology for which training will be necessary. Within such a set up, the beekeeper would have the opportunity to inspect hives and get to learn the character of his colonies. Movable comb hive equipment will permit the beekeeper to carry out seasonal management programmes that optimise production by maximizing the strength of colonies. The beekeeper in the meantime could learn more about his or her colonies by making more frequent visits. This will acquaint him with those that possess desirable characteristics for propagation through a selection programme. Adoption of more advanced management procedures would allow the beekeeper to engage in queen rearing and with it to venture into production of package bees and royal jelly. Production could be diversified eventually to incorporate pollination services and the practice of migratory beekeeping.

The long-term objective of development Baringo should ultimately be to expose beekeepers to the most advanced level of technology possible, that is, movable frame hives. These will also cost more and require a higher level of training and may not be appropriate for all situations because environmental conditions limit the honey flow in some areas. Where possible however, they offer the possibility for producing the widest range of products possible.

4 BEEKEEPING EQUIPMENT

4.1 Introduction

The Kenya Top Bar Hive (KTBH) was one significant outcome of a beekeeping development project in Kenya that was supported by the Government of Canada in the 1970's (Fig. 4.1). It is a transitional hive, intermediate in technology between the fixed comb traditional hives and the more advanced movable frame hives (Ministry of Agriculture 1974). Several variants of the top bar hive are available for which specifications for various components vary from slightly from one designer to another (Paterson 1985). KTBH in particular is a modification of one that was first developed in England by C. J. Tredwell and P. Paterson (Crane 1990). The principle of a movable comb hive is that bars or frames help to maintain a correct "bee space", a gap of given width which allows bees to move about in the hive between any two facing surfaces. Top bar spacing in a hive should be the same as the center-to-center distance between adjacent worker brood combs in the wild nests of similar bees. The top bar is the only component of a transitional hive for which precision is necessary since it is intended to reflect comb spacing requirements specific to a bee race. When the sides of a hive are vertical, bees do not attach combs to hive walls when this space is also allowed between each comb and the inner hive wall. Bees are less inclined to attach combs to hive walls when these slope between 10^{o} to 40^{o} to the vertical (Crane 1990).

Movable combs give the beekeeper freedom to manipulate and manage bees for surplus honey production. It was thus expected that both quantity and quality of hive products would improve dramatically once this hive was adopted by local beekeepers in Kenya (Kigatiira 1976, 1985). Reservations were nevertheless expressed by Paterson (1985) and Crane (1985) whose concern was that new technology could impose financial strain on the beekeeper and that the need for better quality products should be driven by demand. The technology developed in temperate regions also requires further research to suit it for bees with different characteristics in the tropical environment (Kigatiira 1985, Corner 1985).

In Kenya, KTBH is mostly produced in workshops that are equipped with special wood working machines and is supplied on order. A workshop of this kind is located in the Kerio Valley Development Authority offices at Kabarnet in Baringo District but it does operate normally as orders to supply KTBH are very irregular.

In all modern workshops where KTBH are manufactured on regular basis, different parts of the hives are first produced *en masse* to satisfy the entire order then combined at random afterwards for assembly of individual hives (Fig. 4.2). Such a manufacturing approach requires the various parts to be very well standardized. It was further noted that workshops receive little, if any, feedback on performance of equipment once it is installed in the field. Within the information gap that is created, some things can and do go wrong.

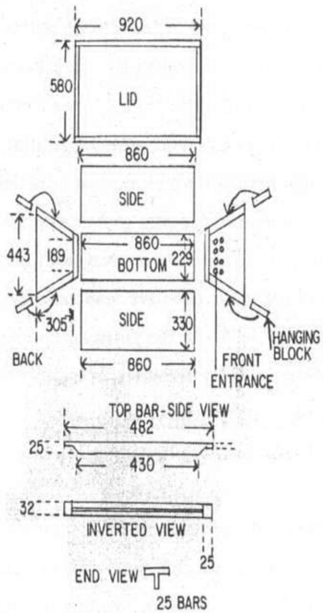


Fig. 4.1: Dimensions of various parts of the Kenya Top Bar Hive according to original specifications (mm). Drawing by Stephanie Townsend (FAO, 1986).

Fig. 4.2: Top bars that have been produced *en masse* to satisfy an order are seen here in storage. They are eventually distributed at random to different hives during final assembly of KTBH.

4.1.1 Top bars

Top bars are meant to fit together to form a solid cover over the hive so that bees cannot pass between them. All bars are supposed to be similarly spaced so that any individual comb can be removed from the hive and replaced. In Baringo District, it was observed that components of KTBH undergo substantial changes or fail altogether once installed in the field. Top bars in particular are subject to warping causing great inconvenience to beekeepers when bars do not fit smoothly back together as expected after colony inspection. It takes great effort to accomplish a good fit. Beekeepers take corrective measures by replacing faulty top bars with locally made substitutes. Standard specifications are compromised in the process, causing hives to malfunction.

A closer look into colonies occupying KTBH also revealed that honeycombs were occasionally constructed across neighbouring top bars even though standard bar spacing was supposed to guide bees to construct single straight combs along each one. This defeated the initial objective of having movable bars as misaligned combs break during routine inspection.

4.1.2 Hive temperature

At ambient temperatures above 30°C, bees in a nest can generate enough warmth to cause an overheating problem in their brood nests (Seeley 1985). The upper limit for brood nest temperature is 36°C with long-term excesses of 2 – 3°C causing disruption to normal metamorphosis. Bees have therefore a need to cool their hives as well as they can heat them. Lindauer (1955a) conducted detailed experiments to investigate the water requirements for brood rearing and cooling of hives and concluded that in a hive without brood, bees need not bother much about regulating temperature. They avoid heat beginning with initial hot spots within the hive and eventually move out and cluster in front of the hive entrance when it gets too hot inside. In a bee colony that is rearing brood, the behaviour of workers begins to change as soon as 30°C is attained in a hive. It begins with the dispersal of bees all over the hive to dissipate heat, followed by fanning behaviour to improve air circulation in the hive as heat builds up. Finally, bees resort to collection of water or dilute nectar whose absorption of heat for evaporation helps to cool the hive. The temperature at which dispersal starts to be supplemented with fanning is 36°C or lower with bees deploying themselves throughout the brood nest.

The exposure of the bee nest to sun, its insulation and colony strength all play a part in determining the point when hive cooling behaviour is initiated (Lindauer 1955b). When the colony is brood-less, bees may partially evacuate their nest and form a mass of hanging clustered bees just outside the nest entrance when conditions of temperature (and humidity) become extreme. This reduces heat production inside the hive and facilitates nest ventilation. Such behaviour has been recorded to start when the coolest region of a brood nest reaches more than 34°C (Seeley 1985). Such clusters are observed by beekeepers in Baringo District but as reported in Chapter 3, beekeepers wrongly interpret them as an indicator of ripeness of honey in hives.

Beeswax in heavily laden combs softens and collapses above 40°C (Seeley 1985). In Baringo, this was confirmed to occur in occupied KTBH during the hot season, a problem beekeepers had informally complained about. Beekeepers however did not report the same problem in log hives and it became necessary to investigate hive temperature with intention to moderate conditions for bees in hot situations. This was after having come to appreciate the scarcity of water in the study area.

The objectives of studying hive equipment were to examine:

1) Whether new top bars conform to width specifications in KTBH and how bees respond to variations after hives are installed for use.

2) How internal hive temperature varies in the course of a day in differ

4.2 Materials and methods

4.2.1 Top bar measurements

Two workshops that actively manufacture KTBH were selected where width of new top bars could be measured. Each bar is required to be 32 mm wide and a measurement of 64 mm was therefore expected across two adjacent bars after fitting randomly selected bars as usual on a KTBH. Width across two adjacent bars was measured using fine callipers, approximately 5cm from the edge and a score given to indicate whether the measurement was equal (0), above (+) or below (-) the expected width. Assessments were made first on bars along one side of the hive (left) then along the other (right). The last six bars were then fitted upside down so that the width between centred, protruding ridges on the underside of adjacent bars could be measured. The ridges were required to be spaced 32 mm apart so as to guide bees to build a single honeycomb on each bar while maintaining the correct bee space.

Measurements of this nature were also made in the field in hives that were occupied by honeybees and others that had remained empty. In the former case, the manner in which combs were attached to bars was noted along with comb contents. Hives from a third manufacturer were encountered in the field.

4.2.2 Hive temperature measurement

An experiment was conducted in which diurnal internal and external hive temperature under different shade conditions was monitored on hourly basis over 24-hour cycles. Three types of KTBH were incorporated in the study, one being the normal type while the other two had covers modified in a manner to improve heat insulation. All hives are described here below.

Normal KTBH

This was a hive purchased as usual from a regular workshop for the purpose of this experiment. The cover was made of a corrugated iron sheet (Gauge 32) supported by softwood timber (*Pinus patula*) rectangular frame. A drawing of one such hive showing dimensions of all its component parts is provided (Fig. 4.3).

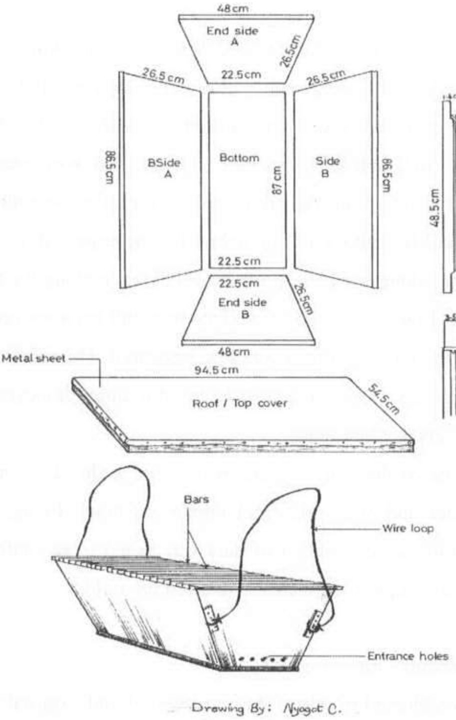


Fig. 4.3: Components and appearance of a normal KTBH selected at random from among those in the hive temperature study.

The experiment also incorporated two modified covers of the KTBH as follows:

Flat modified cover

The usual softwood timber frame that supports an iron sheet cover has a cross-section of 2.5 cm x 2.5 cm. This was replaced with one measuring 2.5 cm x 15 cm. The frame was fitted half way up with a flat timber ceiling made out of 15 cm x 2.5 cm pieces of wood laid one immediately beside the other across its length. An iron sheet (Gauge 37) was fitted as a roof with a 7.5 cm protruding edge to protect the timber frame. A slight slope was incorporated into the cover by making one of the longer sides 2.5 cm shorter than the other in order to improve drainage. The cover was coated with white paint on the outside to minimize heat absorption.

Pointed roof cover KTBH

The ceiling for this cover was made out of two pieces of solid softwood planks measuring 30 cm x 25 cm that were attached to the usual frame and inclined towards each other to meet at a point above, creating the appearance of a pointed roof. Triangular end pieces were fitted at both ends to create a solid wooden ceiling on all four sides. This ceiling was then covered with a thin flat iron sheet (Gauge 37) to protect the wood from agents of decay. The original design for this cover was developed on experimental basis by staff at the National Beekeeping Station, Kenya.

Log hives - Tugen style

Log hives are hollow wooden cylinders whose construction details were given in Chapter 3. These were purchased locally at Chemeron in Baringo District and incorporated small, medium and large sizes.

Experimental design

In a split Latin Square design, each one of the four types of hives was placed under four different shade conditions – an open site devoid of shade, under the shade of a tree (*Tamarindus indica)*, in the shade of a garage shed roofed in asbestos and finally in a thatched bee hut constructed in indigenous Tugen style (Fig. 4.4). The experiment was replicated over four days, with each one of the four types of hives being subjected as a group to different shade conditions on each day (Tab. 4.1).

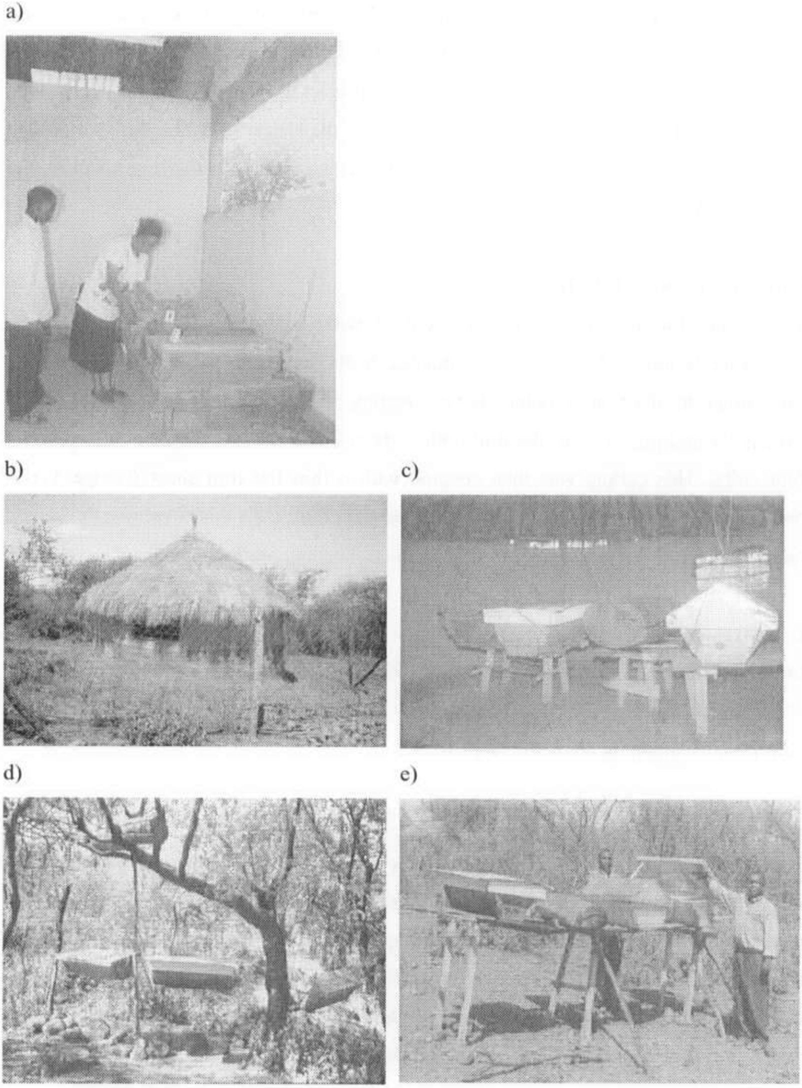


Fig. 4.4: Shade and hive conditions in the temperature regulation experiment (a) Garage shed (b) thatched bee hut (c) close-up view of hives inside bee hut (d) under a *Tamarindus indica* tree (e) the open site.

Digital thermometers, each bearing twin probes, were used for measuring internal and external hive temperature simultaneously. The experiment was conducted across three seasons distinguished as cold and dry (July), hot and wet (October) or hot and dry (December). Data were analysed using General Linear Models of repeated measures in SPSS.

Tab. 4 1: Allocation of different types of hives at random to various shade treatments in the experiment on hive temperature regulation at Chemeron, Baringo District.

Day	Hive type under each shade condition by identification no.															
	Thatched bee hut				Open site				Shade of a tree				Garage shed			
	[a]N	[b]Pt	Log	[c]Fl	N	Pt	Log	Fl	N	Pt	Log	Fl	N	Pt	Log	Fl
1	3	6	12	15	4	7	9	13	1	5	19	14	2	8	11	-
2	1	5	10	13	2	8	11	15	4	6	9	-	3	7	12	14
3	4	7	11	14	3	5	10	-	2	8	12	15	1	6	9	13
4	2	8	9	-	1	6	12	14	3	7	11	13	4	5	10	15

[a]N – normal KTBH [b]Pt – Pointed-roof cover KTBH [c]Fl – Flat modified roof KTBH

4.3 Results

4.3.1 Top bar measurements

New top bars

Width across two adjacent top bars was expected to be 64 mm. While still at the workshop, 43.5% of the pairs of bars complied with the standard measurement. 43.1% of the pairs of bars were above it and only 13.2% were under it. When distance between the ridges was measured, the minimum fell 2 mm below while the maximum was 2 mm over the specification of 32 mm. Distances between adjacent ridges were nevertheless mostly as expected with nearly 99% of them falling within 1 mm below or above the required measurement on either end (Tab. 4.2). One of the two workshops visited produced consistently more bars of the correct measurements than the other.

Top bars in empty hives in the field

KTBH from three producers were evaluated for top bar compliance to specified width in empty hives in the field. Of the 328 bars examined in 13 hives in different locations, 22% were from one producer, 56% from a second producer while a third producer contributed the remaining 22%.

Tab. 4.2: Distances between waxed ridges on underside of adjacent, new top bars when fitted at random on KTBH. Most of them fell within 1 mm above or below the specified width of 32 mm.

Deviation from	% ridges in category of deviation	
specified width (mm)	Measurement on left-side of bars	Measurement on right-side of bars
-2	0.9	0.0
-1	5.2	1.7
0	85.2	73
+1	8.7	23.5
+2	0.0	1.7

Width across two adjacent top bars in empty hives in the field varied much more than it did in workshops. The range of width measurements fell by as far as 4 mm below and rose up to 6 mm above the 64 mm requirement. Deviations away from the specified width were mostly above the specification (Tab. 4.3).

The width across adjacent bars thus varied by a fairly large margin away from the expected measurement with a maximum possible difference of 10 mm between the most narrow and the widest of all pairs of bars. This large deviation in the expected bar width in the field prompted an investigation about how well bees utilize bars in the field.

Comb construction in occupied KTBH

The bee colonies inspected were of various sizes and had utilized available hive space to different extents. The smallest colony occupied only 4 top bars while the largest colonies had long been established and had utilized all the 24 bars provided. 8 out of the 13 colonies inspected had utilized more than half of the 24 available top bars but only 2 had used all available bars.

Honeycombs were constructed in any one of three possible ways along the top bars –

1) A single comb was built along one top bar
2) Two combs were built on the same top bar or

3) A comb began on one bar and then was built across to the next bar.

Tab. 4.3: Proportion of adjacent top bars in empty hives in the field that measured as expected, were under or above the 64 mm specification. Between the narrowest and widest pairs was a 10 mm difference.

Deviation away from specified width (mm)	% Right-hand top bars with this measurement	% Left-hand top bars with this measurement
-4	1.5	1.5
-3	0.0	3.0
-2	4.5	3.0
-1	0.0	11.9
0	11.9	20.9
1	25.4	28.4
2	14.9	14.9
3	13.4	9.0
4	11.9	7.5
5	10.4	0.0
6	6.0	0.0

Results showed that single combs were constructed on each of the bars in 85% of all bars examined. Combs were constructed across top bars in 7% of all those considered while two combs were constructed on each of the remaining 7% of bars (Tab. 4.5).

The smallest colony had constructed only single combs on each top bar. Combs were built across adjacent bars in 25% of the larger colonies occupying more than half of a hive. Only in 15% of the hives did all three types of construction occur together - double combs, combs built across bars and single combs. Whether the measurement was taken on the left or right hand side of the hive, the proportion of adjacent bars bearing specified width, went over or were below it, was the same. Results for the left hand side are presented.

53% of all single combs were built on top bars that were above the expected measurement, 10% were built on bars of width below the expected measurement while 22% of the combs were built on bars that were spaced exactly as specified. This finding reflects the fact that majority of top bar width measurements in the field are likely to be above the specification, as previously presented in the section on top bars in empty hives.

Tab. 4.5: Types of comb constructed by honeybees in KTBH in Kenya. Single combs occurred in 85% of all bars considered. An abnormal construction of either single combs occupying two bars or two combs occurring on each bar was encountered with equal chances on the remaining bars.

Hive No.	No. of combs by construction style Single	Double	Across 2 bars	Total combs thus built
1	4	0	0	4
2	6	1	1	8
3	9	0	0	9
4	9	2	0	11
5	11	1	0	12
6	9	1	3	13
7	14	0	0	14
8	11	3	0	14
9	13	0	2	15
10	15	0	1	16
11	10	5	6	21
12	24	0	0	24
13	24	0	0	24
Percent of combs	86	7	7	100

Likewise, one was more likely to encounter double combs and others crossing over from bar to bar when top bars exceeded the specified measurement rather than fell below it (Tab. 4.6).

Tab. 4.6: Types of comb encountered on top bars. They occurred singly, in double or crossed over from one bar to bar. Single combs occurred most frequently on top bars in all width measurement categories.

Category of width of adjacent top bars on left hand side of hive	Type of comb constructed on bar (%) Single	Double	Crossing from bar to bar
Measured as expected (64 mm)	22	2	1
Measured more than expected	53	4	6
Measured less than expected	10	1	1
Total	85	7	8

4.3.2 Hive temperature measurements

Diurnal temperature trends in hives

Regardless of season, type of shade and type of hive, mean internal hive temperature over an entire 24-hr period followed the same general trend. It started to rise as soon as the sun rose in the morning (between 0600 – 0700 hrs) and increased rapidly at first and then more gradually until a peak temperature was attained at about 1500 hrs. The drop thereafter was gradual at first and then more rapid around sunset (between 1800 - 1900 hrs). Temperature continued to drop gradually for the rest of the night, with the lowest temperature being recorded at 0600 hrs, just before sunrise. Significant differences in temperature became evident only when data analysis was restricted to daytime between sunrise and sunset, specifically during the period between 0800 hrs to 1700 hrs. In the cold season, temperature varied significantly between 0800 hrs and 0900 hrs and from 1200 hrs to 1300 hrs in the normal KTBH compared to the modified KTBH whose flat cover was insulated with a timber ceiling and painted white. During the hot season, significant temperature differences occurred in the same hives for a period extended by one hour or more around these times. An ANOVA table of repeated measures for within-subjects effects (time of day and interactions with shade, season and type of hive) and between-subjects effects (place, season, type of hive and their interactions) shows all the factors and interactions that were significant (Appendix 1).

Temperature trends in different types of hives

When temperature was averaged across seasons and types of shade, hives fell into two subsets according to the mean internal hive temperature attained. The cooler subset consisted of KTBH with both types of modified covers and the log hives. The group that attained higher mean temperatures consisted of log hives, the KTBH bearing an insulated pointed roof and the KTBH bearing a normal roof. The difference in internal hive temperature between the normal KTBH and the modified variant that had a flat, insulated, painted cover was significant at 5% level (Tab. 4.7 and Appendix 1).

Tab. 4.7: Mean internal hive temperature in different types of hives at Chemeron, Baringo District. There was a significant difference between subsets, caused by a temperature difference in the normal KTBH and the flat roofed KTBH, one of its variants in the experiment.

HIVE TYPE	N	Subset by mean temperature (°C)	
		1	2
KTBH: Flat, painted white	35	28.3	
KTBH: Pointed, insulated	48	28.5	28.5
Log	48	28.7	28.7
KTBH: Normal cover	48		29.3
Significance		0.681	0.143

Means for groups in homogeneous subsets are displayed, based on Type III Sum of Squares.

Temperature trends under different shade conditions

When temperature was averaged across seasons and types of hives, the type of shade that hives were subjected to had significant effect on internal hive temperature. Thus all hives remained coolest when placed in a thatched bee hut and attained highest mean temperature when placed in an open area devoid of shade. An intermediate level of temperature was experienced in hives placed in the garage shed and tree shade. Mean temperature difference between the hut and the open site was just over 6°C (Tab. 4.8).

Tab. 4.8: Mean internal hive temperature in different types of shade at Chemeron, Baringo District. There were significant differences between the subsets, with the hut being the coolest shade environment.

SHADE CONDITION	N	Subset by mean temperature (°C)		
		1	2	3
HUT	45	25.8		
GARAGE	45		28.0	
SHADE	44		28.8	
OPEN	45			32.2
Sig.		1.000	0.062	1.000

Means for groups in homogeneous subsets are displayed, based on Type III Sum of Squares.

Temperature trends in different seasons

When temperature was averaged across types of shade and types of hives, significant differences occurred in mean internal hive temperature across seasons (Tab. 4.9).

Tab. 4.9: Mean internal hive temperature during different seasons at Chemeron, Baringo District. There were significant differences between the subsets, which set apart October as the hottest season.

SEASONAL CHARACTERISTIC	N	Subset by mean temperature (°C)		
		1	2	3
Cold, dry (July)	60	24.7		
Hot, dry (December)	59		30.0	
Hot, wet (October)	60			31.4
Significance		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed, based on Type III Sum of Squares.

It is against the hot, wet season in October (hereafter referred to simply as hot season) that comparison with the cold, dry season in July (hereafter referred to simply as cold season) that further comparison is made of hive performance. Internal hive temperature is also compared against a critical internal temperature of 30°C at which bees would theoretically be required to initiate behavioral change for cooling hives.

During daytime in the cold season, hives attained the lowest internal temperature when placed in a thatched bee hut (Fig. 4.5 and Appendix 2). In this situation, log hives attained the lowest peak temperature of 23°C and normal KTBH the highest temperature at 25°C. The highest peak temperature occurred in the open site where log hives on average attained 33°C and the normal KTBH attained 35°C. The modified KTBH with an insulated flat cover was the coolest hive in the open site where it attained 30°C during the cold season. Mean external temperature during the cold season rose to a peak of 31°C in the open site. Hives in the tree shade and the garage performed at immediate level attaining 29°C as the highest internal hive temperature in normal KTBH and 27°C in log hives or pointed KTBH respectively, during the cold season.

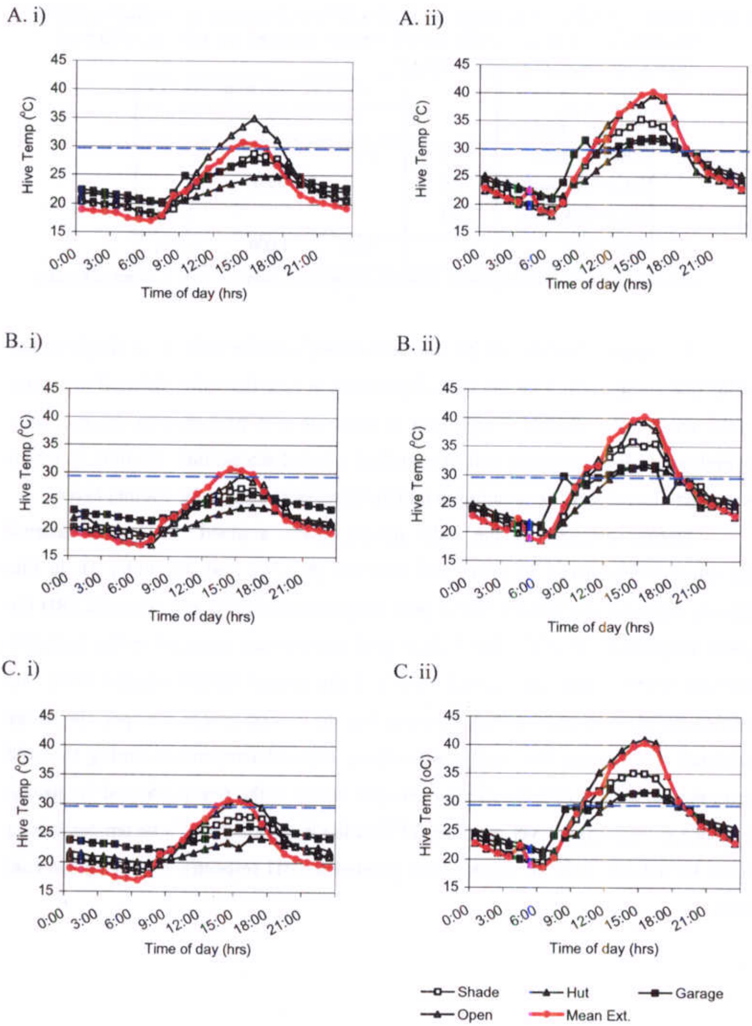


Fig. 4.5: Diurnal internal temperature in KTBH bearing different covers and placed under different shade conditions during a (i) cold season and (ii) hot season (dotted line marks a critical internal hive temperature of 30°C). A) normal cover of corrugated iron, un-insulated B) wooden ceiling under a flat iron roof, painted white C) wooden ceiling under pointed iron roof, not painted.

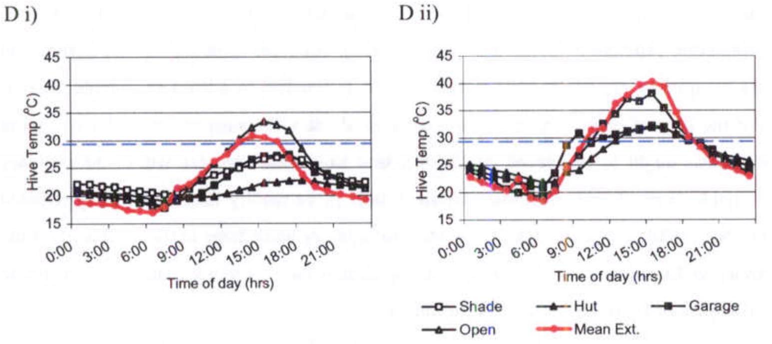


Fig. 4.5 contd.: Diurnal hive temperature in D) traditional log hives under different shade conditions during a (i) cold season and (ii) hot season. Temperature was coolest in all hives in the thatched bee hut.

During the hot season, peak internal hive temperature in the hut averaged 32°C in all hives. Peak external (ambient) temperature averaged 40°C during this time of year. Flat KTBH in the open site attained a peak temperature of 39°C, pointed KTBH attained 41°C and the normal KTBH 40°C. Log hives were coolest at 38°C in the open site. The garage more or less functioned like the bee hut during the hot season with all hives attaining a peak of 32°C. This made it a cooler environment than the tree shade at that time of the year where the hottest temperature attained was 40°C in the pointed KTBH. Log hives attained 38°C in the tree shade and Flat KTBH 36°C while KTBH attained 35°C under these same conditions.

4.4 Discussion

Top bar measurements

Findings of this study indicate that hive equipment workshops visited in different areas of Kenya manufacture top bars precisely within a margin of 1 mm of the specification of 32 mm width. This implies that carpenters have received a commendable level of training to the extent recommended for appreciating the value of "bee space" in movable comb hives and the role played by top bars in maintaining it (Crane 1990, FAO 1986). On the issue of production of quality equipment, however, different areas where improvements can be made in the Kenyan situation include matching and regular maintenance of tools for the different construction processes so as to improve production efficiency (Gathiongo 1997). Paying attention to details would ensure that the equipment, especially hive entrance holes, is finished to a level acceptable to bees. For the sake of making hives more readily available to beekeepers in rural areas, more emphasis ought to be placed on the fact that hand tools that are within the ordinary carpenter's reach can substitute electrical tools more readily than is currently realized (Kabue 2000). This means that carpenters in ordinary workshops in the rural beekeeping areas could produce specialized hive equipment if they were adequately trained in the principles of KTBH construction and function.

Greater attention should also be paid to the manufacturing process to ensure the stability of hive parts under field conditions (Gathiongo 1997). Dimensions of large components of the hive can be stabilized during the construction process. This can be achieved during the construction process by splitting the 30 cm planks specified for the sides and base into half, along the grain and rejoining them using suitable wood glue with the grain reversed (D. Wittmann pers. com.). Workshop superintendents should also be prepared to season timber in their own yards before putting it to use. This is because material stocked by timber merchants is usually freshly sawn and disposed of at high moisture content. It is therefore not suitable for immediate use in high precision woodwork. The frustration of working with hives whose components are unstable at times causes beekeepers to shun the new technology altogether. As a precaution against equipment failure, manufacturers should introduce quality control checks in the manufacturing process for equipment. It is also necessary for workshops to assess performance of equipment they produce after it is installed in the field or obtain a feedback on how it performs from the users. The weaknesses should be noted and adjustments made in the manufacturing process as a measure to restore beekeepers' confidence in movable comb hives. This type of self-evaluation will be required especially by those workshops that intend to advance in future to the manufacture of movable frame hives. These require precision in more components and greater attention will have to be paid to the selection and handling of raw materials and tests will be useful to assess how they perform in the field.

Hive temperature

One of the four flat-roofed modified covers for KTBH developed technical problems that prevented its replication for a fourth time in the experimental design thereby impairing balance of hive type treatments. Keeping in mind however that different hives were assigned at random to the different types of shade over the four days in each of three seasons, the single modified hive that was missing on each day is not expected to have greatly influenced the results. Temperature was also measured using thermometers from three different manufacturers with slightly varying degrees of accuracy. Since each thermometer was assigned at random to a hive, it was assumed that the errors arising from the different manufacturers cancelled out.

Considering 30°C as the critical temperature above which bees would theoretically have to initiate behavioral change for hive cooling, there is evidence that this would not be necessary during the cold season if hives are kept in a hut where the highest temperature attained was 25°C. Hive temperature during the hot season exceeds the critical temperature by only 2°C in the hut, in normal KTBH, while temperature in the tree shade increases to 40°C in the pointed KTBH, the peak in the shade for that season. At this level, not only would the melting point of wax have been reached in this hive but also the critical temperature for initiating water collection for hive cooling would already have been exceeded by 10°C already while going well above the critical brood temperature of 35°C. The situation was only slightly worse in the open site where the pointed KTBH attained 41°C.

From the point of view of performance by KTBH with different cover modifications and their interaction with the shade factor, the critical hive temperature of 30°C would only exceeded in the normal hive during the cold season when placed in an open site. In the hot season, it would be exceeded in all KTBH in all types of shade conditions. Tree shade was ineffective for keeping hives sufficiently cool in the hot season. The log hive performed better than KTBH by attaining a peak of 38°C during the hot season in which case combs would not melt but it still exceeds critical brood rearing temperature, which can partly explain why bees abscond under conditions of water scarcity in the hot season (Lindaeur 1955a).

Beekeepers in Baringo District had earlier reported about the gathering of bees in groups outside hives, an indicator of heat stress that they mistakenly interpreted as an indicator of ripeness of honey inside. Absconding of colonies has already been linked to high temperatures in KTBH in Malawi (Klinger 1989). Bees under the circumstances could benefit from the provision of adequate shade and water throughout the year to help them cut down on the time and energy spent in cooling hives at the expense of foraging (Seeley, 1985). Such a saving of time and energy in turn could translate into higher productivity of colonies especially as forage becomes less available during the hot time of the year. More on the flowering patterns of plants is covered in Chapter 5.

Jay and Frankson (1972) reported no significant effect of altering hive covers in combination with shading and ventilation of hives on brood nest temperature in the tropics. In the current study, significant differences occurred only at certain times of the day between the temperature in KTBH bearing normal tin covers and those bearing a flat wooden ceiling which was also painted white. The temperature difference was 1°C when averaged for season and type of shade and overall not as high as the 3 – 5°C reported after similar modification of empty hives in Canada (Jay and Frankson 1972). Further work should be carried out in this area to investigate how improvements can be made on such gains since bees, like all other organisms, display less tolerance to heat after the optimum temperature is reached. Where a colony is brood-less, Lensky (1964) found that individual bees resort to high water intake once temperatures exceeded 45°C. Mortality occurs above 50°C.

Bees in Baringo face a continuous challenge cooling hives when water is scarce. Aware of the undesirable effects of extreme temperature on colonies, beekeepers take great care in selection of sites with respect of provision of good shade. Shade trees are pruned from time to time so as to encourage strong crown regeneration and improve shade quality. Crane (1990) encourages beekeepers to do all that is possible to keep hives cool when managing colonies in very hot conditions. In the case of Baringo District, bee huts could be the way forward towards realizing the fullest yields of hive products possible, as they are also more secure environments that can deter honey badgers and thieves.

4.5 Conclusion

Investigations on top bar width measurements in KTBH in workshops showed that they are produced very closely to the width specification of 32 mm. Most of the adjacent pairs of new bars measured fell over or under the 64 mm requirement by 1 mm. This is a commendable effort on the part of producers considering they sometimes have to manufacture hive parts in large quantities at a time to supply their orders. Upon installation of KTBH in the field, the space between adjacent top bars in occupied hives showed wider variation, mostly over the requirement of 64 mm, by as much as 6 mm. Such variations are mostly caused by warping and can be corrected by paying closer attention to the condition and characteristics of timber as a construction material.

Bees utilized top bars either by building single combs, two combs on each bar or combs starting on one bar then going over to the next. The occurrence of unusual types of comb construction was in the same proportions whether were bars spaced as required, over or below the specification. This phenomenon should be investigated further with higher precision to determine other factors to which it can be attributed and to minimize it as it interferes with movement of combs and takes colony management back to a situation of working with fixed combs.

Bees are faced with a problem of extreme temperatures that are experienced during the hot season in the lowland areas of Baringo District. Thus beekeepers carefully select apiary locations so as to place hives in the best shade conditions possible. In this study that took place at Chemeron, two ways of dealing with the overheating problem were investigated. The first was to modify the design of covers for KTBH while the second was to improve shade conditions thereby benefiting all types of hives under consideration. It was demonstrated that internal hive temperature varied significantly between KTBH with one type of insulated, painted cover and those with normal covers. Such modification, coupled with improved shading such as in a shed or bee hut, could help bees in keeping hives cool during the hot season. There are other causes of stress to bees as outlined in Chapter 3 that require to be addressed as well. Among them, forage availability is tackled in greater detail in Chapter 5.

5 VEGETATION IN BARINGO DISTRICT

5.1 Introduction

Vegetation characteristics of a region are considered to be an important indicator of its potential for beekeeping. Ngethe (1985), for example, found that in Kitui District of eastern Kenya, honey is produced from herbs, shrubs and trees growing in unmanaged bush land and various types of woodland. The most important nectar or pollen plants belonged to the Leguminosae, Acanthaceae, Amaranthaceae, Anacardiaceae, Boraginaceae, Apocynaceae, Balanitaceae, Chenopodiaceae, Combretaceae, Euphorbiaceae, Malvaceae, Solanaceae, Verbanaceae and Tiliaceae families. He went on to describe the resources supplied by these plants to beekeepers, some being important sources of nectar and pollen while others were used in traditional procedures for scenting new hives to attract swarms. Ichikawa (1982) and Chikamai et al. (1999) reported that the same plant families are associated with beekeeping under similar climatic conditions in northern areas of Kenya.

Kihwele (1985) described the plant families occurring in the Miombo woodlands of Tanzania and pointed out that with their clearing to provide land for tobacco farming, not only did the bee colony density in the area decrease but also beekeepers had to travel long distances (up to 40 km) in search of good apiary sites. These constraints had a negative impact quality and quantity of honey and beeswax produced in the country. Clauss (1985) was also of the opinion that the potential of land for beekeeping depends on the nature of the vegetation it supports. He described the flowering patterns of the arid Kalahari region in Southern Africa and reported long flowering periods for some plants. They bloomed when it rained and at the same time produced new buds that would open after the next rains. Herbaceous plants (annuals and perennials) contributed more to honey harvests than trees and bushes as long as normal to good amounts of rainfall were received at reasonable intervals. Frequent showers that moistened the ground were considered more important for development of flowering in herbaceous plants than a few heavy ones. These Kalahari studies showed that even the driest areas that received as little as 250 mm rainfall per annum had good beekeeping potential if vegetation remained undisturbed.

Mardan and Kiew (1985) for their part argue that having knowledge of the flowering patterns of plants in a given area is an essential first step towards increased honey yields. This is based on the fact that the flowering sequence can be anticipated and hives moved about, where possible, to exploit nectar flows. The floral calendar of an area however usually varies from year to year since flowering depends on the weather. It serves the more useful purpose of showing the sequence of flowering of various plants in a given area thereby helping to identify the main flowering and dearth periods so that eventually suitable plants could be grown to bridge flowering gaps.

In Baringo District of Kenya, striking differences are observed in both structure and apparent composition of vegetation as one travels from one area to the other along altitude and the associated rainfall gradient. Land is put into different uses depending on location - with highland areas having a higher potential for rain-fed agriculture than the lowlands. Beekeepers from all over the study area are keen to advance their activities based on knowledge they have about vegetation in the landscape and other resources available to bees. Studies were undertaken for confirming the composition and structure of vegetation in selected areas. This was so as to assess the overall distribution and condition of beekeeping vegetation in the landscape.

5.2 Materials and methods

5.2.1 Beekeepers knowledge of plants utilized by bees

The methodology for selection of beekeepers to participate in a socio-economic survey is presented in great detail in Chapter 2 and 3. In brief, 224 beekeepers were selected from fourteen different locations in the lowland and highland areas of Baringo District (Marigat and Kituro Catholic Parishes respectively). They were interviewed on socio-economic and technical issues based on a questionnaire one of whose sections was devoted entirely to bee plants. The topics covered included naming of important trees, shrubs and undergrowth for beekeeping (in vernacular) according to the resources drawn from them (pollen or nectar or propolis) or other purposes served by them in beekeeping, their flowering patterns, how people utilized them locally, general changes in the vegetation over the last thirty years, causes of decline in tree and shrub cover (where applicable), as well as the types of conservation measures adopted for plants and how effective these were perceived to be in serving the purpose. Later on, local elders pointed out the vegetation mentioned in the survey to a plant taxonomist who facilitated translation of vernacular to botanical names.

5.2.2 Species composition

Transects measuring 5 m x 50 m were laid out in five of the selected sites representative of the main land uses in the study area. The sixth transect was in farmland where vegetation was very dense and in order to retain accuracy, a smaller transect measuring 5 m x 10 m was laid out then replicated five times. Plants were categorized as trees when they exceeded 3 m in height and as shrubs when they attained a total height of 1 m – 3 m. Trees and shrubs were mapped according to species and their exact location in transects. Plants that grew below 1m in height were taken to be the undergrowth layer in the transects and were studied in nested quadrats of 1 - 2 m^2. For trees and shrubs, height to the base of the crown, crown diameter and depth were estimated so as to outline the vegetation structure. For plants below 1 m in height, the species and number of individuals present were noted. Plants were identified to species level on the spot where possible or specimens collected where necessary for identification at a later date at the University of Nairobi herbarium. Sites were selected to capture a wide range of land use types, as follows:

1. Tarambas Forest, 2039 m a.s.l. – a closed canopy forest reserve at the peak of Morop Hill in the Tugen Hills. It is managed by the Forest Department in the Ministry of Natural Resources. Beekeepers in Kituro Parish maintain a number of log hives in its fringes. The detailed vegetation study was conducted on its west-facing slope near Kituro Shopping Centre (Fig. 5.1 (a)).
2. Sesya village, 1815 m a.s.l. - a high elevation, marginal agricultural potential area on the eastern face of the Tugen Hills just below the Tarambas forest reserve. The land supports one rain-fed food crop per year and lies fallow for the rest of the time. The study site was located in a fenced garden during the fallow phase so as to capture the diversity of vegetation outside the cropping cycle (Fig. 5.1 (b)).
3. Tiring'onwonin village in Kibingor, 1301 m a.s.l. - a medium elevation pastoral zone where the land is heavily degraded and the vegetation stunted from excessive grazing. During the dry season crowns of trees of suitable

species are cut back to provide animal fodder. The study site was in an open grazing area (Fig. 5.1 (c)).

4. Chemeron, 1200 m a.s.l. – located in a medium elevation area served by seasonal streams. Goat rearing and beekeeping are predominant activities in this sparsely populated area. The study site was one of the rolling hills typical of the area (Fig. 5.1 (d)).

5. Loboi, 1035 – 1061 m a.s.l. – The study site supported dense vegetation on a steep hillside that dropped rapidly into an extensive, low-lying swampy area. Dominant activities in the area are livestock rearing and farming under irrigation. Beekeeping is practiced on the hills (Fig. 5.1 (e)).

6. Molo River, Parkaren, 1037 m a.s.l. – a lowland pastoral area where agricultural activities are only possible under irrigation served by the permanent Molo River. Along the riverbank grows dense vegetation suitable for beekeeping. The surrounding areas are rocky and bear scanty vegetation (Fig. 5.1 (f)).

5.2.3 Floral calendar

A record was maintained from Aug 2000 to Dec 2001 of flowering in the lowlands based on observations made along a 40 km stretch of the Nakuru – Kabarnet road between Maoi and Patkawanin shopping centers. This was so as to capture the flowering patterns of as many plants as possible among those that beekeepers mentioned as important for beekeeping.

5.2.4 Data analysis

Beekeepers' knowledge

Data gathered by means of the questionnaire was analyzed using SPSS software.

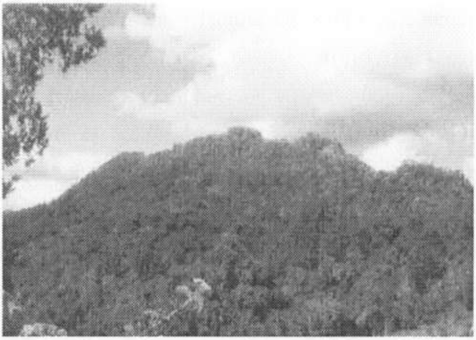


Fig. 5.1 (a): Tarambas Forest Reserve at the top of Morop Hill, among the Tugen Hills. This is a closed canopy indigenous forest along whose fringes beekeepers maintain hives.

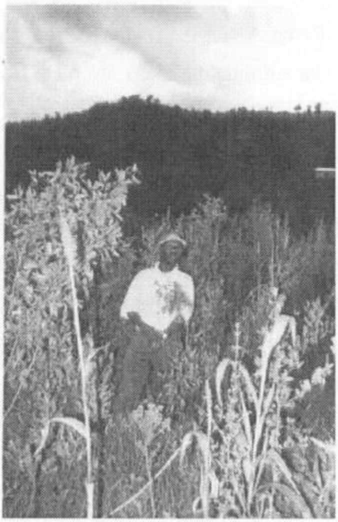
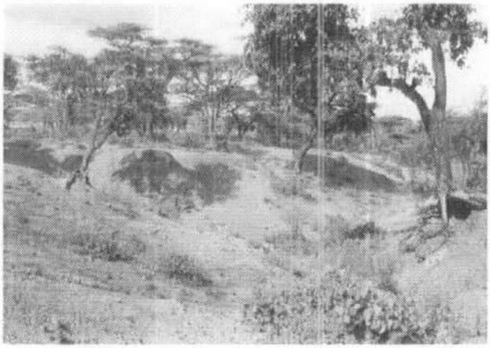


Fig. 5.1 (b): The plant taxonomist at work in farmland in Sesya. In the foreground is sorghum that has regenerated wildly during the fallow phase and still dominates vegetation. The tallest plants have regenerated from tree stumps that are pruned back during the cropping season.

c)



d)

e)

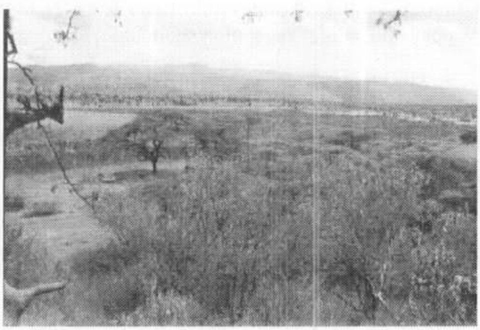
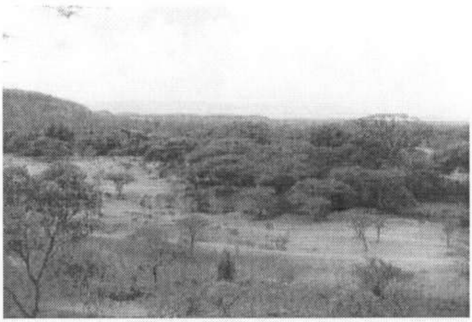


Fig. 5.1 contd. (c): Tiring'ongwonin, a pastoral area that is severely eroded. (d) Characteristic vegetation of Chemeron area, dominated by shrubs and rich in bee plants (e) View of Loboi swamp, an important source of water in the lowlands. On the surrounding hills are plants, such as those in the foreground, which are useful for beekeeping.

f)



g)

Fig. 5.1(f): Molo River at Parkaren. Vegetation grows tall and dense along the riverbank and makes good sites for apiaries. The area is bare and eroded immediately beyond it. On the horizon are the Tugen Hills. (g) Vegetation on a hillside beside Molo River bank. Note that the ground is very rocky and natural vegetation short and sparse.

Measurement of similarity

Similarity indices show the extent to which species composition in transects was alike. The Sørensen coefficient of similarity was selected as it can be calculated from qualitative (presence /absence) data and gives weight to species that are common to two samples rather than those that only occur in either sample. It is calculated as follows:

$$S_s = \frac{2a}{2a+b+c}$$

where

S_s = Sørensen coefficient of similarity
a = number of species common to two quadrats/samples
b = number of species in sample 1
c = number of species in sample 2

Species diversity

The simplest expression of diversity is the total number of species in a sample (species richness). As this measure is very sensitive to the skills of an observer and sample unit area, more objective measures of diversity are based on the Shannon –Wiener index (H') and evenness (equitability) of species distribution. A sample unit with more even abundances is, all else being equal, more diverse than a sample unit with abundant and rare species. Density characteristics were derived from vegetation data and H' is calculated as:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

where s = the number of species

p_i = the proportion of individuals or the abundance of the ith species expressed as a proportion of the total cover

ln = log base $_n$

Based on an assumption that the samples taken are large enough to include all species in the community, the units of H' are the log of the number of species of equal abundance. Its minimum value is zero, when one species is present. It is medium in sensitivity to rare species, and is relatively independent of sample size except if the sample is too small (McCune and Grace, 2002).

Evenness within a site may be calculated using the formula:

$$J = \frac{H'}{\ln s}$$

where s = average species richness.

The higher the value of J, the more even the species distribution is within a quadrat (Kent and Cocker 1992). Where there is perfect equitability then

$$H' = \ln s \text{ and } J = 1.$$

5.3 Results

Baringo District has low montane forests characteristic of the ASALs and dominated by trees that in the case of Tarambas Forest Reserve form a closed forest. The main trees encountered in the forest include *Podocarpus, Olea*, *Combretum*, *Diospyros* and *Teclea* species. Deciduous woodland occurs in lower altitudes where vegetation is dominated by *Acacia tortilis* in close association with other plants such as *Salvadora persica* and *Commiphora* species. The shrub-land, of which Chemeron was the representative area, is dominated by *Acacia mellifer*a, *A. senegal, A. reficiens* and *A. tortilis*. Deciduous and evergreen thorn bush also constitutes an extensive vegetation cover type in the mid- to low elevation areas from Parkaren to Tiring'ongwonin where *Acacia reficiens*, *A. senegal*, *Euphorbia* sp. and *Combretum molle* are dominant.

5.3.1 Beekeepers' knowledge of plants associated with bees

Floral calendar

Beekeepers were asked about flowering patterns of plants as they recalled them and their answers compared to what was observed in the field during the year that followed the survey. Their expectations were well matched with what occurred during the main flowering period at the end of the dry period and start of the short rains (Tab. 5.1).

The knowledge beekeepers have of flowering appears therefore to be of a general nature and prompts use of a floral calendar for gathering specific data about flowering outside the normal range. A calendar maintained for bee plants in the lowland area of Marigat Parish shows that most trees and shrubs flower between May and November. *Prosopis* sp. is an introduced tree that flowers as frequently as *Acacia senegal* but on the contrary attracts bees in large numbers. There is a general scarcity of flowers during the hot, dry months of December and January (Tab. 5.2).

Flowering of undergrowth plants in the lowlands occurred in July to September. *Pupalia lappacea* is a widely distributed undergrowth plant that beekeepers reported supplies bees with nectar when rains are sufficiently heavy to stimulate flowering. Acacia *mellifera* and *Aloe secundiflora* are among the important plants that contribute to the main nectar flow in October/November.

Tab. 5.1: The flowering pattern of selected plants according to views of beekeepers and compared to observations made in the field. Beekeepers were right about most plants flowering at the end of the dry season but only *Acacia brevispica* and *A. senegal* flowered all year round according to field observations.

	Flowering (+) end of dry season (Sept/Oct, Feb/Mar)		Flowering (+) after rains (Apr/May), (Jul/Aug/ Nov)		Flowering (+) throughout year - ahead, during and after rains	
Plant species	[a]beekeepers of this view (%)	Was seen in the field	[b]beekeepers of this view (%)	Was seen in the field	[c]beekeepers of this view (%)	Was seen in the field
Acacia brevispica	8.0	+	31.0	+	5.4	+
A. elatior	12.5	+	1.3		5.4	
A. mellifera	25.0	+	33.8	+	17.0	
A. reficiens	8.5	+	4.5	+	8.9	
A. senegal	9.0	+	9.0	+	8.9	+
A. tortilis	38.0	+	12.5	+	35.0	
Aloe secundiflora	2.0	+	1.8		0.9	
Croton dichogamus	9.8	+	23.7		0.9	
C. megalocarpus	1.8	+	6.7		0.9	
Hypoestes aristata	0.4		5.8		0.9	
Justicia whytei	1.3		8.0	+	0.9	
Pupalia lappacea	0.9		12.1	+	1.8	
Tribulis terrestris	0.0		18.8	+	0.0	
Vernonia auriculiflora	0.9	+	1.3		0.0	

[a,b,c]Figures in each column do not add up to 100% since this was an open question and the beekeepers mentioned each of the plants independently. The two most frequently mentioned are highlighted in bold in each column.

Shrubs such as *Acacia brevispica*, *A. hockii* and *A. senegal* always have individuals in a right physiological state to flower about every second month whenever light showers fall by chance outside the regular rainy seasons of the year. *Acacia tortilis* is considered to be an important pollen plant in the lowlands while *Croton dichogamus* is perceived as an important nectar plant in mid-high elevation areas (Tab. 5.3).

Tab. 5.2: A floral calendar for bee forage in Marigat Parish during 2001. Plants bloomed with rains in April /May and with showers in July/August. Main flowering was around the short rains in September.

	Month of the year - 2001											
Plant Species	J	F	M	A	M	J	J	A	S	O	N	D
A. elatior									+	+		
A. hockii			+	+	+	+	+		+	+		
A. mellifera										+	+	
A. nilotica				+	+		+	+	+	+		
A. senegal		+		+	+		+	+	+	+	+	
A. reficiens						+	+	+				
A. tortilis							+	+	+	+	+	
Acacia brevispica		+		+			+	+			+	
Agave sisalana									+	+		
Aloe secundiflora										+	+	
Boscia spp.										+		
Cissus rotundiflora		+								+		
Combretum molle											+	+
Euphorbia sp.										+		
Justicia whytei							+	+			+	
Portulaca oleracea							+	+			+	
Prosopis sp.		+			+		+	+	+	+	+	
Pupalia lappacea											+	
Tribulus terrestris							+	+			+	
Zizyphus mucronata									+			

Tab. 5.3: Beekeepers' knowledge of resources obtained by bees from selected plants in Baringo District. The three most important sources of pollen, nectar and/or both are highlighted in bold letters.

	% Beekeepers who mentioned plant as a source of		
Plant species	[a] Nectar & Pollen	[b] Nectar only	[c] Pollen only
Acacia brevispica	6.3	9.4	**9.4**
Acacia elatior	6.3	8.9	2.7
Acacia mellifera	**15.2**	**56.3**	-
Acacia reficiens	**13.8**	**9.8**	9.4
Acacia senegal	2.7	6.7	8.0
Acacia tortilis	**10.7**	5.4	**17.9**
Aloe secundiflora	3.1	1.3	1.8
Croton dichogamus	8.9	**16.5**	2.7
Croton megalocarpus	3.6	1.8	3.1
Graminae family	2.2	2.7	0.9
Hypoestes aristata	0.4	3.6	0.4
Justicia whytei	1.8	3.1	-
Pupalia lappacea	4.0	4.9	**8.0**
Vernonia auriculiflora	1.8	-	1.8

[a,b,c] Figures in each column do not add up to 100% since this was an open question and the beekeepers mentioned each of the plants independently.

It was not possible to monitor flowering for the highland area of Kituro Parish except when the author occasionally passed through. In February, maize that is considered to be an important pollen plant in this arable zone flowers at the same time as *Croton megalocarpus*, which occurs in the nearby indigenous forest but is also a common shade tree on farms. *Vernonia auriculiflora* and *Pterolobium stellatum* also flower at this time. *Coffea arabica* flowers in July to September then the year concludes with the flowering in November of *Dodonea viscosa* and *Grevillea robusta*, an exotic timber species. Field observations would be necessary to confirm the resources that each plant was reported to offer for bees.

5.3.2 Knowledge about bee-plant interactions

51% of beekeepers mentioned cross-pollination as a benefit derived by forage plants from association with honeybees. 66% of those interviewed knew that bees collect pollen from plants to feed their young and one beekeeper went to the extent of distinguishing it as a protein source. Beekeepers knowledge of this aspect is therefore fairly good. It means that they possess important background knowledge for further development of managing bee colonies for crop pollination as a new concept to diversify beekeeping activities.

Bee forage

Beekeepers reported that they depended on many kinds of plants including trees, shrubs and undergrowth. 47 plant families were represented altogether in the list compiled out of the interview (Appendix 3). Leguminosae and Euphorbiaceae families contribute to all levels of vegetation while Compositae, Amaranthaceae and Acanthaceae families make up a large part of the undergrowth. Flacourtiaceae and Verbanaceae families are well represented in the shrub layer.

In most cases, bee plants in Baringo District are of indigenous nature except for exotic fruit trees such as citrus and introduced trees like *Grevillea robusta* or *Eucalyptus* species. Sisal (*Agave sisalana*) plantations are located about 50 km away from the study area but beekeepers reported that sisal is an important plant that supports bees during local dearth periods. *Prosopis* sp. (Mesquite) has been introduced in the lowland region and flowers frequently attracting bees in large numbers but pastoralists hold it in low regard as it easily turns into an invasive plant displacing grasses in areas of pasture. The complete list of plants derived from the interview is also given according to Tugen vernacular or common names (Appendix 4).

5.3.3 Beekeepers' ranking of plants by importance

Acacia trees were placed high on the list when beekeepers were asked to name the plants they relied on. Criteria used for ranking were however not disclosed (Tab. 5.4). Beekeepers considered *Acacia brevispica* and *A. senegal* as important possibly based on frequent flowering even though there was little bee activity observed on them. At the same time bees were observed in large numbers on *Boscia angustifolia* but beekeepers ranked it lowly. This suggests that other than just considering flowering patterns in isolation, beekeepers took into account other less obvious factors when ranking plants.

Shrubs of importance were listed by order of importance to all beekeepers as follows:

Croton dichogamus (54%), *Acacia brevispica* (46%), *Dovyalis abyssinica* (29%), *Lantana camara* (24%), *Zea mays* (16%), *Dodonea viscosa* (9%), *Euphorbia* sp. ("Mutagar/ie" – 6%), *Acacia senegal* (6%), *Vernonia auriculiflora* (5%) and *Acacia reficiens*. (5%). Undergrowth of importance were listed by order of importance as *Tribulus terrestris* (58%), *Pupalia lappacea* (47%), *Justicia whytei* (23%), *Euphorbia* sp. ("Eelo" – 17%), *Aloe secundiflora* (16%), *Graminae* family ("Suswek" – 16% and "Seretion" – 14%), *Hypoestes aristata* (15%), *Pennisetum clandestinum* (7%) and *Leucas grandis* (7%).

Local uses of bee plants

Bee forage plants serve alternative uses in Baringo District. Thick fencing, for example, is required to protect crops in seasonal gardens from being browsed upon by free roaming herds of goats. It takes a lot of plant material to make such fences even though they are short-lived, many of them not lasting beyond a single cropping season. This is a matter of concern since important bee plants such as *Acacia mellifera* are used in fencing. In addition, *A. elatior* and *A. tortilis* also supply poles, branches and rafters for construction of homes and other building structures. Other bee forage trees supply animals with fodder during the dry season. *Croton megalocarpus* is an important nectar plant in the highlands that does not serve many other uses and is abundant on farms and in the indigenous forest of Tarambas (Tab. 5.5).

Shrubs are utilized mostly for house construction purposes. Among the bee plants that serve this purpose are *Acacia brevispica* and *A. reficiens*. *Croton* *dichogamus* is also utilized for construction but is more useful for fencing and medicine. *Vernonia auriculiflora* and *A. senegal* are not popular for serving other purposes (Tab. 5.6). At undergrowth level, most bee plants are also utilized as fodder for livestock. Grass is highly valued for fodder and thatching huts. A plant such as *Hypoestes aristata* has medicinal value (Tab. 5.7).

Tab. 5.4: Beekeepers' ranking of 5 most important trees (1= most important, 5= least important) in the six different areas of Marigat Parish. *Acacia* spp. dominate the list with other plants mostly in lower ranks.

		% beekeepers ranking tree in this position in given area						
Rank	Tree species	[a]Kapku	[b]Kibin	Molo	Maoi	[c]Korie	Arabal	Sandai
1	*Acacia mellifera*	97	95	100	100		96	100
	A. tortilis					89		
2	*A. tortilis*	89		86	79		63	91
	A. mellifera					82		
	A. elatior		86					
3	*A. reficiens*	66		43				64
	A. tortilis		71					
	A. senegal				50	61		
	"Ng'olpel/wo(et)						58	
	Acacia elatior					61		
	A. brevispica			43				
4	*A. senegal*	51		36				
	A. reficiens				43			
	A. nilotica					21		
	Terminalia brownii		67					
	Combretum molle						48	
	Maerua triphylla							41
	Zizyphus mucronata					21		
5	*Boscia angustifloia*			29	29			
	A. brevispica	11			29			
	A. reficiens		33				33	
	Combretum apiculatum					14		
	Maerua triphylla			29				
	Olinia rocheatiana							27

[a]Kapku - Kapkuikui [b]Kibin – Kibingor [c]Korie - Koriema

Tab. 5.5: Alternative uses for selected bee forage trees in Baringo District. They are used in fencing, construction, fodder and other minor domestic uses.

Alternative uses for bee forage plant	[a] % Beekeepers mentioning this tree as suitable for given use			
	Acacia mellifera	*A cacia elatior*	*Acacia tortilis*	*Croton megalocarpus*
Fencing	9.3		4.0	
Firewood	4.2	0.5	2.7	0.4
Construction	6.5	1.9	3.1	
Fodder	6.0	0.9	4.0	
Food	1.4			
Medicine	0.9	0.4		
Charcoal		0.4	0.9	0.4
For hanging beehives in		0.4	0.9	

[a] Figures in each column do not add up to 100% since this was an open question and the beekeepers mentioned each of the plants independently.

Tab. 5.6: Alternative uses for selected bee forage shrubs in Baringo District. They are utilized mostly in construction but also in fencing, for medicine and fodder.

Alternative use to bee forage	[a] % Beekeepers mentioning shrub in response to each given use				
	Croton dichogamus	*Vernonia auriculiflora*	*Acacia brevispica*	*Acacia senegal*	*Acacia reficiens*
Fencing	7.6		2.7	0.4	2.7
Firewood	2.2	0.4	0.9	-	-
Construction	6.3	0.4	8.5	0.4	2.7
Fodder	1.3	0.4	4.0	-	0.4
Food	0.4	0.4	1.3	-	
Medicine	9.0			0.4	
Charcoal					
For hanging beehives in					

[a] Figures in each column do not add up to 100% since this was an open question and the beekeepers mentioned each of the plants independently.

Tab. 5.7: Alternative uses for selected bee forage undergrowth plants in Baringo District. They are utilized as fodder, for medicine or house construction.

Alternative use other than bee forage	[a] % Beekeepers mentioning herb in response to each given alternative use			
	Pupalia lappacea	*Hypoestes aristata*	*Tribulus terrestris*	Graminae
Fencing				
Firewood				
Construction				3.6
Fodder	4.5	1.3	1.3	3.6
Food			0.9	
Medicine	0.4	4.0	0.9	
Charcoal				
For hanging beehives in				

[a] Figures in each column do not add up to 100% since this was an open question and the beekeepers mentioned each of the plants independently.

The entire range of uses disclosed with respect to other bee plants is listed in Appendix 5.

5.3.4 The changing landscape

Older beekeepers were aware of changes in the vegetation in the last three decades. They reported that trees and shrubs were on the decline mostly due to a combination of several factors rather than from a single cause. Conversion of land into alternative uses was considered by some to be a major cause of the decline while others thought trees have been over-exploited for supplying construction materials. Others said that trees have succumbed to increasing incidences of drought. Trees are also a source of fuel wood or charcoal and in the drier lowlands, crowns of particular types are cut back to supplement animal fodder whenever shortages occur in undergrowth. Such trees sometimes fail to recover (Fig. 5.2).

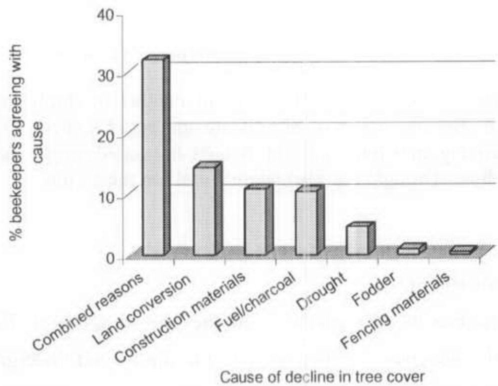


Fig. 5.2: Perceived causes of decline in tree cover in beekeeping areas of Baringo District. The given causes have acted singly or in combination. Leading among them is the increasingly conversion of land into other uses. Harvesting of raw materials for construction, fencing or fuel has also depleted vegetation.

Shrubs are put into alternative uses mostly in construction of structures. They are also utilized in fencing of gardens or demarcating goat pens in homesteads. They have generally been on the decline as a rising human and animal population in Baringo District places increasing demands on them for several reasons. Beekeepers associated decline of shrubs specifically with conversion of land into other uses such as agriculture or collection of fuel wood. Droughts are reported to be taking place more frequently in the study area thereby causing a decline of those shrubs that are not well adopted for extended periods without water (Fig. 5.3).

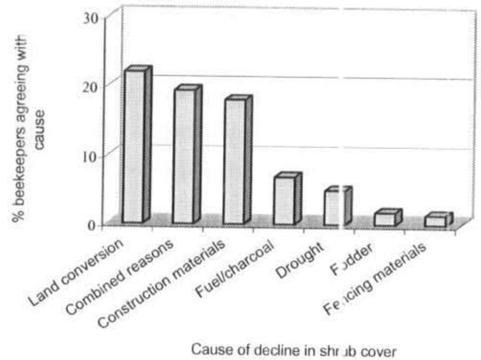


Fig. 5.3: Beekeepers' perspective of causes of decline in shrub cover in beekeeping areas of Baringo District. Shrubs are important sources of construction, fuel and fencing materials and shrub land has increasingly been converted into agriculture. Drought has also taken its toll on the shrubs.

Conservation measures

Concerning conservation of vegetation in the landscape, over 70% of beekeepers consider natural regeneration to be adequate for shrubs and undergrowth. About 50% also take this measure to be adequate for conserving trees. Additional activities have nevertheless been tested that include deliberate planting to replace any vegetation harvested, abiding with cultural regulations governing rotational utilization of pasture and maintaining the correct carrying capacity of livestock on the land (Tab. 5.8).

Tab. 5.8: Approaches tested for conservation of trees, shrubs and undergrowth in Baringo District. Out of several alternatives available, beekeepers mostly rely on natural regeneration and only a small percentage take deliberate action towards conservation.

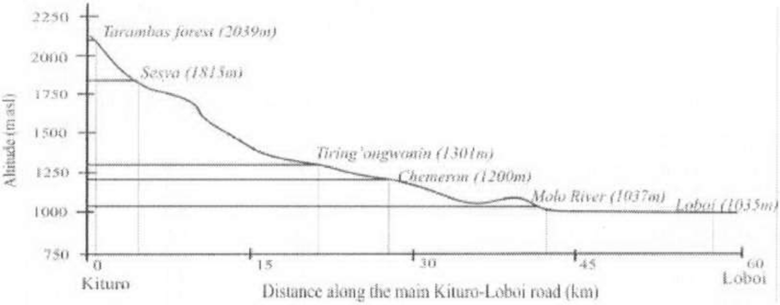
Conservation method for vegetation	% Beekeepers agreeing that conservation method has been adopted for		
	Trees	Shrubs	Undergrowth
Natural regeneration	57.9	73.2	73.6
Replacing plants that are harvested	9.5	3.6	2.7
On-farm planting to enlarge vegetation base	10.9	6.3	4.5
Rotational grazing to conserve pasture	6.3	5.4	4.5
Riverine vegetation not interfered with	0.9	0.9	0.4
De-stocking to correct carrying capacity of land	10.4	0.4	2.2
Combination of measures	0.9	7.1	5.8
No answer	3.2	3.1	6.3
Total	100	100	100

5.3.5 Physiognomy data

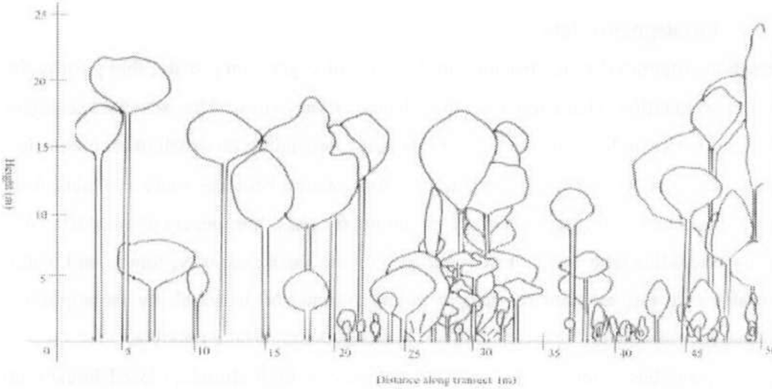
Vegetation structure data is presented in the form of vegetation profiles that portray the different vegetation characteristics in selected study sites. The structure changes noticeably between different sites in the landscape depending on distribution of species. Plants also get taller and grow more densely as moisture becomes more available from ground sources or rain (Fig. 5.4). In selecting apiary sites, beekeepers attempt to match site characteristics with bee colony requirements for shade, security, forage and water. They also take into account the danger posed to man and livestock by an aggressive local bee race and therefore locate apiaries in isolated sites where possible.

Tarambas is for the large part an indigenous, high altitude, closed forest with robust trees that appears capable of providing bees with adequate security and shade. Its profile contrasts sharply with the open woodland in Tiring'ongwonin, at lower altitude, with its sparse vegetation cover. Neither of the two sites support a great deal of beekeeping because the latter cannot satisfy beekeepers' requirements for security and shade while the former is regulated by law to minimize human impact on the forest.

a) Sketch of location of study sites along an altitude gradient of the land



b) Tarambas forest



c) Tiring'ongwonin

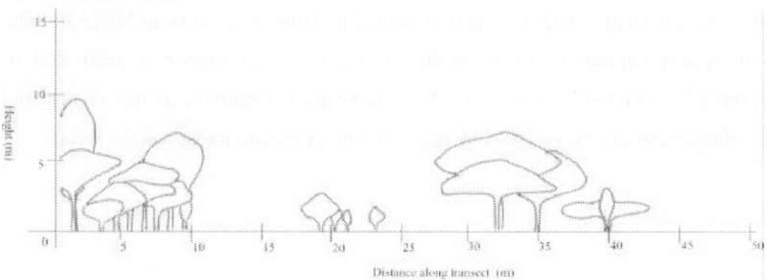
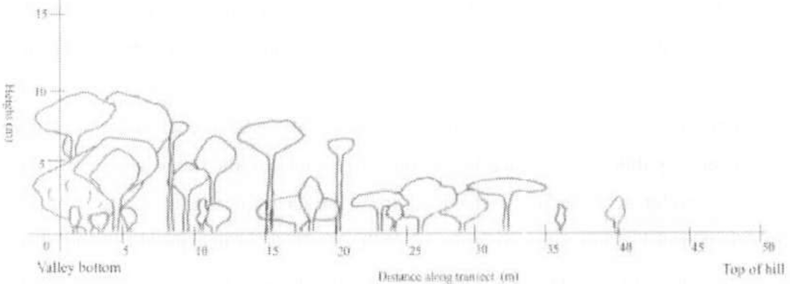
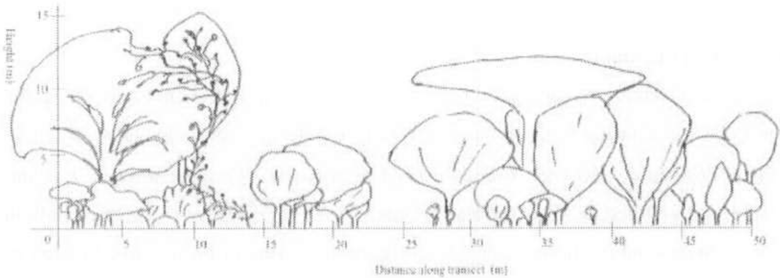


Fig. 5.4: (a) A sketch of the altitude and location of study sites from Kituro at the top of the Tugen Hills (Morop Hill) to the lowland area of Loboi (b) Tarambas, a closed forest at 2039 m a.s.l. On a west-facing slope, trees grow to a maximum height of 25 m. (c) Tiring'ongwonin at 1301 m a.s.l. Trees are scattered and forage or security is inadequate for beekeeping.

d) Chemeron



e) Molo River at Parkaren



f) Loboi swamp

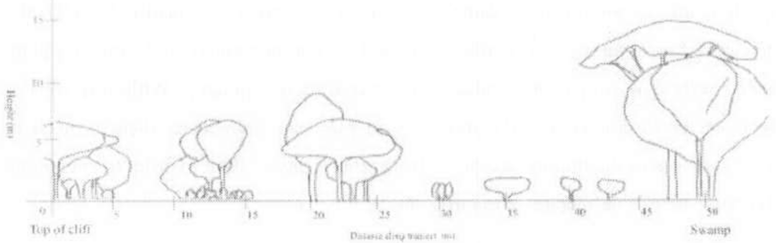


Fig. 5.4 contd.: (d) Chemeron at 1200 m a.s.l. Trees grow up to 10 m in shallow valleys but vegetation becomes progressively shorter and sparse uphill. Acacia trees and shrubs in this area are good sources of nectar and pollen (e) Molo River bank at 1037 m a.s.l. Riverine vegetation comprises of tall trees reaching 15 m in height and undergrowth is dense. Many bee plants are present and provide nectar and pollen as well as secure sites for placing hives in (f) Loboi swamp at 1035 m a.s.l. Trees grow up to 15 m tall beside the swamp. Hives are placed in trees at the top of the cliff avoiding a public road at foot of the cliff. Many of the plants are good sources of nectar and pollen.

Of sites in the lowland zone, Molo River is well endowed with vegetation to meet beekeepers' requirements for shade, water and security. It is highly exploited also for the reason that it offers a limited chance for beekeeping along a narrow strip of a riverbank in an otherwise highly denuded zone. Loboi swamp has tall plants growing close to its edge that could provide good shade for places close to a water source. There is however a public road going along the edge and, in the interests of security, beekeepers prefer to place hives on shorter trees further up in the hills away from the road. Chemeron has tall trees growing in shallow valleys, which provide good shade and secure sites for hanging hives in. Shrub grows densely where the rocky ground permits. The greatest limitation for beekeeping is availability of water, available only in the form of seasonal streams

5.3.6 Floristic data

Plants present in both tree or shrub years at the same time as in the undergrowth can be taken to be regenerating to a certain extent. In the study sites, these included *Abutilon, Acalypha, Balanites, Barleria, Cassipourea, Commicarpus, Conyza, Maerua, Pavetta, Podocarpus, Solanum and Trichocladus* (Appendix 6 a & b). Plants represented only in the upper layers and not in the undergrowth layer are worthy of further investigation as they could be having regeneration problems. The regeneration of acacias in particular appears to be poor and conservation measures may be required to safeguard their future since they are important bee plants. Additional measures are justified under the circumstances, as natural regeneration alone has not prevented a decline in plant resources, especially in pastoral zones characterized by overgrazing. With only 15% of those interviewed considering the measures in place as inadequate, there is need to create awareness of the importance of environmental conservation in order to encourage more people to take deliberate action in its favor.

Measurement of similarity between sites

The Sørensen coefficient of similarity (S_s) was calculated for vegetation in the different sites based on presence/absence data for undergrowth and the tree or shrub layer ((Appendix 6 (a) & 6 (b)). At high altitude, Tarambas forest and Sesya each had unique plant composition even though not greatly separated by altitude. This was an indication that conversion of land into agriculture had a deep impact on the cultivated site at Sesya, altering it completely in comparison with natural forest vegetation close by (Tab. 5.9).

An analysis for similarity was also conducted for undergrowth. It showed there was vegetation at Molo River or Tarambas Forest was unique compared to the rest of the sites. Tiring'ongwonin appeared to be a transition zone with some plants in common with Chemeron and Loboi both of which are lower in altitude but also with Sesya at higher altitude (Tab. 5.10).

Tab. 5.9: Sørensen coefficient of similarity (%) for trees and shrub vegetation in beekeeping areas of Baringo District. In the highland, Tarambas forest and Sesya each had unique plant composition while the highest similarity was between Loboi Swamp and Molo River, two neighboring sites in the lowlands.

Site	Sørensen coefficient of similarity (S_s)					
	Tarambas	Tiring'ongwonin	Chemeron	Molo River	Loboi	Sesya
Tarambas forest	-					
Tiring'ongwonin	0	-				
Chemeron	0	10.5	-			
Molo River	0	7.1	18.2	-		
Loboi swamp	0	8	29.4	29.8	-	
Sesya	0	0	0	0	0	-

Sesya also had something in common with a site as far down in the lowlands as Chemeron. This suggests that similar undergrowth is widely distributed across different altitudes, but that unique types occur under unusual circumstances such as in a riverine situation or in a closed-canopy forest.

5.3.7 Measurement of plant diversity

The Shannon-Wiener index of diversity was calculated for different sites based on species density data with the result that Tiring'ongwonin was identified as the most diverse site even though it had fewer species than Tarambas forest. Chemeron area was least diverse with most uneven distribution of the few species present on the landscape (Tab. 5.11 & Appendix 7).

Tab. 5.10: Sørensen coefficient of similarity (%) for plants growing less than 1m high in beekeeping areas of Baringo District. Undergrowth was very diverse and Tiring'ongwonin had something in common with other sites. Molo River and Tarambas forest were unique sites.

Site	Sørensen coefficient of similarity (S_s)					
	Tarambas	Tiring'ongwonin	Chemeron	Molo River	Loboi	Sesya
Tarambas forest	-					
Tiring'ongwonin	0	-				
Chemeron	0	9.5	-			
Molo River	0	0	0	-		
Loboi swamp	0	9.1	0	0	-	
Sesya	0	4.7	15.8	0	0	-

Tab. 5.11: Plant species diversity and evenness for undergrowth growing in six beekeeping areas of Baringo District. Diversity and evenness of distribution were highest for the Tiring'ongwonin site and least for Chemeron.

Area	No. of species	Shannon-Wiener index (H')	Evenness index (J)
Tiring'ongwonin	19	2.22	0.75
Molo River	25	2.14	0.66
Sesya	30	2.11	0.62
Loboi	20	1.67	0.56
Tarambas Forest	32	1.90	0.55
Chemeron	13	0.94	0.37

In this case, considering only the number of species without accounting for evenness of their distribution would have produced misleading results. The inequality of distribution of plant species in Tarambas and Chemeron areas is a reflection of the manner in which species are clustered in the landscape.

At Chemeron, *Acacia mellifera*, *A. brevispica*, *A. senegal*, *A. tortilis* and *Combretum* sp. were among tree and shrub species matching those beekeepers had listed in an earlier survey as the most useful for bees. This was the best match between trees that beekeepers mentioned during the socio-economic survey and a site where subsequent detailed vegetation studies were undertaken. Tarambas forest had nothing in common with the top ten tree species in the beekeepers' list. Among shrubs, *Grewis similis* was the only one present in the forest that was also mentioned by beekeepers. There were no trees on farmland at Sesya but at the shrub layer it stood apart from other sites in its unique species composition, representative of farmland during the fallow phase. It had little in common with the beekeepers' lists of the most important bee plants.

5.4 Discussion

Floral calendar

Considering that rainfall in the lowland areas was erratic during the study period (2001), extended documentation would be necessary in order to capture year-to-year flowering pattern variations. The goal of refining the calendar presented in this study would turn it into a more useful tool for future forecasting of the availability of resources for bees in the study area. As it stands, it points out a flowering gap in December and January, which is a dry, hot period in the lowlands and coincides with the period when bees migrate to other areas as described in Chapter 3. The value of plants that beekeepers regard as useful to bees should therefore be determined as they include *Acacia brevispica* and *A. senegal* both of which flower during the dearth period. Depending on their proven value, some of these local plants could be propagated in the afforestation programme on communal land in the District in combination with other introduced woody perennials to extend the period when nectar and pollen are available to bees in the affected areas.

Another avenue that is pursued for the development of forestry in the Baringo District is promotion of agroforestry systems. Agro-silvi-pastoral systems that combine trees or shrubs, herbaceous food crops and pasture would a suitable way to approach the propagation of plants for beekeeping. Examples of situations where such systems have been successful include "Gum" gardens of Sudan (Baumer 1985). In these gardens, *Acacia senegal* is grown in 15-year rotation cycles with crops while incorporating animals in the system to browse on the land after crop harvests. All plants that flower at the end of the rains can serve this purpose well but in particular, *Acacia albida* has also been recommended in Sudan where it has become the main source of pollen and nectar for bees during three critical months ahead of the rains.

It is difficult to accommodate herbaceous crops in agroforestry systems in ASALs because they are more sensitive to moderate changes in climatic conditions than woody perennials. In Baringo District, where irrigation permits, food crops that also cater for bees could be grown not only to improve food security for local residents but also to feed bees, especially at times of the year when land lies normally lies fallow. This would be the opportunity to grow short duration crops for bridging the flowering gaps for bees. *Eucalyptus* species are multi-purpose trees, which originated in areas with very little rainfall and they would be worth trying for extending the flowering period for bees. In this case, they do not have to be evaluated for timber that requires them to grow tall and straight but rather for profusion of flowering during the critical months and suitability for growing on the rocky outcrops of Baringo District. *Eucalyptus brockwayi* was tested among others in Israel and was found useful. For Baringo, it would present the additional benefits of giving a hardwood suitable for charcoal, fuel wood and tool handles.

Beekeepers' knowledge of plants

Traditional beekeepers have been commended for their acute powers of observation and deduction about behaviour and response of African bees to their environment. Their knowledge of bee flora, in particular, is believed to be extensive and exhaustive (Clauss and Zimba 1989, Corner 1985). In Baringo District, beekeepers' knowledge covered a wide range of topics related to bee plants that have been presented in this chapter. Their general knowledge has been shown to be dependable but specific information is limited. It means that there is need to evaluate the plants listed by beekeepers more objectively such as by analysing honey samples for pollen. Vorwohl (1976) presented results of such an analysis for Kenya and other tropical countries but cautioned that pollen grains only document the plants visited by bees. He recommended using centrifuged rather than pressed honey samples to obtain the pollen spectrum from nectar producing plants. Kahenya and Gathuru (1985) did this for several areas of Kenya but did not cover Baringo District. Nevertheless, results of their analysis indicate that the main plant genera on which bees depend are Croton, Vernonia, Acacia, Newtonia, Euphorbia, Abutilon, Justicia, Amaranthus, Combretum, Coffea, Crotalaria, Terminalia and Acalypha. Many of the plant genera that were mentioned by beekeepers as well as those recorded in the study sites in Baringo appear on these more objective lists. Quantitative techniques would help to distinguish which among the plants are the more important sources of pollen (Handel 1983) or nectar (Kearns and Inouye 1993) and the flowering strategies adopted by plants individually and in the total population for ensuring visitation by bees (Dafni 1992). Information so gathered can be used for evaluating the best plants and methods for propagating them for beekeeping.

Beekeepers used individual criteria for ranking importance of plants which they did not disclose but results suggest that quality of flowers, quantity and sequence of flowering of one plant compared to others were considered when judging the value of plants for bees. The beekeeper's main objective is to obtain honey that will meet taste preferences of the consumer and therefore his or her judgment of plants is also based less obvious criteria, such as honey palatability. Beekeepers, for example, reported that honey from *Boscia angustifolia* is bitter which can explain in part why such plants are lowly regarded even though they attract bees in large numbers when in flower. In contrast, honey from *Acacia mellifera* was praised highly for its "sweetness". Undergrowth supplements trees and shrubs and beekeepers did not lose sight of its importance, reporting that a minor honey flow is possible in the lowlands based on this source.

Vegetation characteristics

Profiles of vegetation in the study area indicate that requirements for shade, security and forage are not satisfied in all sites. Also, the first impression created is that Molo River bank adequately meets such requirements especially as it has a permanent water supply. It was surprising however to find in reality that KTBH placed beside the river remained unoccupied for two years in a row. Beekeepers therefore cannot always have a guarantee for occupation of hives based on physical characteristics of the site alone. They are prepared to periodically relocate empty hives on trial and error basis as part of the routine activities covered in Chapter 3. They do so until bees occupy the hives.

Beekeepers rely also more heavily on natural regeneration of bee plants than on taking deliberate steps towards its conservation, especially of undergrowth. As vegetation faces increasing demands from rising human and livestock populations, a decline of forage trees has been reported that is not matched by a change of attitude among local residents towards conservation. To tackle this situation will not be easy because of the complex land, forest and tree tenure issues that are involved. A clear understanding of the rights of local residents is therefore necessary in order to pave way for participation of stakeholders in decision-making with regard to conservation (Anderson 1998).

Since conservation of natural resources might not appeal to local residents as a desirable goal in its own right or for the sake of future generations, it would be important to identify a target audience for the message. The small group of beekeepers who believe more could be done to conserve bee plants could initially be more receptive of such a message compared to other sections of pastoral communities and could act as a link between partners in environmental conservation and local communities. A programme developed for the purpose of plant conservation might also stand better chances for success where soil conservation aspects are built in. Soil erosion is a serious environmental problem in communal land in Baringo District but not much has been done to arrest it. Young (1989) lists 55 tree and shrub species belonging to 32 genera that have a potential for maintaining or improving soil fertility among them *Acacia tortilis, A. albida, Zizyphus mauritania* and many others which already occur naturally in Baringo District. Finding other areas where agroforestry interventions could help propagate multi-purpose bee plants can therefore work in favor of those creating awareness of the need for conservation of vegetation. These interventions should be pursued not only with determination but also patience as conservation of land that is open to use by local people depends on a change of behavior of users while planners are required to be flexible enough to learn from their mistakes. This establishes a framework for negotiating desired outcomes with the affected people in the long run (Sayer 2001).

5.5 Conclusion

The vegetation characteristics of beekeeping areas of Baringo District have been considered from both the perspective of beekeepers' knowledge and information gathered from more detailed studies in selected sites. They show that bee plants are unevenly distributed in the landscape and that requirements for maintaining bee colonies are not satisfied in all sites. Lowland areas of Baringo District are characterized by a lack of flowers coinciding with the hot dry season at the beginning of each year. Beekeepers therefore adopt a flexible management system in which hives are initially placed in the best location possible but are moved about as necessary to ensure they finally become occupied. The vegetation resources available are reported to be declining, especially with respect to important trees and shrubs, several of which have other local uses. Beekeepers mostly rely on natural regeneration and will need encouragement and time to develop a better attitude towards effective plant conservation.

6 GENERAL DISCUSSION

Economic importance of beekeeping

Findings of a socio-economic survey conducted in the course of this study revealed that beekeeping is ranked in the second or third position among the top four most important economic activities in Baringo District. The sector currently engages people of all educational backgrounds and in the productive age group of between 18 and 55 years or older. It therefore creates job opportunities and generates additional incomes for people in semi-arid pastoral areas and can be developed further to support the rural economy in accordance with the objectives of the national poverty eradication plan (Office of the President 1999).

Hive products

According to the findings of this study, crude honey is the major hive product that is produced and traded in Baringo District. Beekeepers cannot satisfy the annual demand for the product and do not venture into production of other products under the current terms of trade. The question of wax processing nevertheless should be addressed urgently as at the moment the product is either discarded as waste from honey refining and bee brewing or put into domestic use. This situation is a big contrast to the 1950's when wax trade thrived in the region and therefore takes beekeepers nearly fifty years backwards in time. A similar situation to the one currently being experienced in Baringo existed in Tanzania and the suggested way out of it was by prioritizing market development for wax (Ntenga 1976, Wix and Lyatuu1981). Kenya can therefore learn useful lessons in developing trade routes for wax from the experiences in Tanzania and Ethiopia, two of her neighbors who are currently well established in the trade. This can be the turning point at which a gradual programme of product improvement and diversification could be introduced.

Training

Beekeeping is culturally defined as a male occupation in the Tugen community and honey production is based on fixed comb log hives and technical skills that are informally passed from one generation to the next. As such, there are specific tasks that members of a beekeeper's household can assist in that determine the type of training that is given to boys and girls and the jobs they perform in adulthood. This case study showed that beekeepers in the traditional system acquire good knowledge of their environment, provide substantial inputs in the form of labour, technical and entrepreneurial skills have a capacity for self organization and possess social and cultural wealth but they need sufficient opportunity to widen and diversify their resource base through education and training. This requires external inputs and partnerships which recognize that the intended beneficiaries of development projects have useful inputs to contribute. If development initiatives can be approached from this perspective, they will succeed because they will show respect for the culture of people, placing emphasis on what happens to them rather than on material things. One assumption that should be dropped is that poverty is just a condition of "not having" and "not being able to" as it portrays the poor as unproductive (Fernades 1988).

A comprehensive proposal that was made by Townsend (1969) on how training could proceed in order to improve the technical skills of beekeepers is still relevant for situation in Kenya to date. A forestry school in Tanzania remains unrivalled as the most advanced institution teaching beekeeping in the East African region but has been joined by others offering certificate courses in agriculture and incorporating aspects of beekeeping such as Baraka Agriculture College under the Diocese of Nakuru, Kenya. Short courses lasting one to four weeks are also offered at the National Beekeeping Station while groups collaborating with current beekeeping projects of ICIPE benefit from one-day training sessions twice a month with representatives attending an additional 2-month course each year (Mbae 1997, Raina et al. 2000). Such formal training attempts to impart theoretical and practical knowledge concerning movable comb hives and their accessories and how these can be applied to modernize existing beekeeping systems so as to increase hive production.

Adoption of movable comb hives

Findings of the current study are that only a few beekeepers in Baringo District have invested in movable comb Kenya Top Bar Hives and even then they do not place much value on accessories. They are not in good contact with the extension agents who are expected to train them in the use of such equipment and therefore continue to follow traditional colony management, honey harvesting and processing methods after installation of top bar hives. Training should cover basic facts about bee behavior and biology which traditional training does not emphasize. Technical support is therefore essential for those who purchase this type of equipment to help them develop an appreciation of the added benefits of movable comb technology in comparison to traditional fixed comb hives and so that they can realize good returns on investment (Gichora et al. 2001). Such knowledge will empower beekeepers to manipulate colonies so that bees can produce an abundant surplus of products over and above what they require for their survival.

Diversification of hive products

Movable comb/frame hives and their accessories have been recommended for use in situations where beekeeping is viewed as a commercial venture because they make it easier to harvest honey and to apply centrifugal extraction methods that ensure products of high quality (Corner 1985, Ogetonto and Gathuru 1985). Besides, such equipment can enable beekeepers to produce high yields of wax and a wide range of hive products including pollen, propolis, royal jelly and package bees for external markets (Crane 1990). There are disadvantages of frame hives however that include their high costs and vulnerability of stored combs to the wax moth when attempts are made, in principle, to carry over combs from one season to the next. It makes top bar hives the more preferable movable comb equipment as honey and wax are harvested annually from them thereby eliminating the wax moth problem (Corner 1985). In Kenya, the government through the Ministry of Agriculture has therefore over the last thirty years promoted the Kenya Top Bar Hive (KTBH) as a transitional hive for honey and wax production while aiming for introduction of movable frames as appropriate for other products. ICIPE is currently engaged in research to help farmers to adopt frame hives, which are also now promoted by NGOs for use in areas of high beekeeping potential.

General issues of top bar hives

Nightingale made some modifications on top bars in KTBH to give additional support to honeycombs and to enable him transport occupied hives without breaking the combs (FAO 1986). Further developments on design were anticipated in Kenya but they have not gone beyond the use of original wooden materials (Crane 1985, Crane 1990, Paterson 1985). This means that in Kenya, such hives and their accessories are still only available from selected workshops where sophisticated equipment was installed through national beekeeping development projects in the past (Gathiongo 1997). These workshops are located far away from beekeepers in rural areas making it necessary to transport hives and accessories over long distances at an additional cost to the buyer. Also, while wood was cheap in the past, timber prices have gone up considerably over time to reach exorbitant current levels that make the hives very costly to purchase.

To bring the hives out of institutional workshops and into the sheds of local artisans will require that local carpenters and users alike be exposed sufficiently to the principles of the hive design. The manufacturing process should be modified to accommodate simpler tools and materials, an attainable goal since this has happened in other developing countries and can be accomplished in Kenya, too (Kabue 2000, Paterson 1989). The hive body has increasingly been modified to suit different situations, being made out of whatever suitable materials are readily available such as cow dung, bamboo, scrap lumber or mud (Fichtl 1994) and straw (Isola 1991).

Performance of KTBH in hot areas

Those beekeepers in Baringo who have adopted top bar hives face difficulties with top bars warping upon installation in the field. This study suggests that bars are made to the correct specifications in workshops but warping occurs in the field, which interferes with top bar precision. It also causes problems of handling after colony inspection as a lot of effort of must be expended to get bars to realign on the hive. Beekeepers therefore replace faulty bars out of necessity but without paying enough attention to specifications. The effect of bar spacing on comb characteristics did not become clear from this study. Exact measurements of individual bars would be required rather than scoring for width compliance with specifications. Such measurements could also be useful in determining how much variation bees will tolerate in bar spacing before resorting to extra-ordinary construction of combs on bars. From the findings, a range of tolerance could be specified in order to maintain movable combs as originally intended in top bar hives. Field observations further raise a question as to whether *A. m.*

scutellata attempts to revert to the natural patterns of comb arrangements that at times are oblique (Kihwele 1989, Mbaya 1985). This phenomenon should be studied further.

Temperature regulation in KTBH

Beekeepers complained that Kenya Top Bar Hives did not regulate heat effectively during the hot season and when this was investigated, it was shown that hives bearing normal covers attained the highest temperature during the cold season, in an open site. During the hot season ambient temperature averaged 40°C and all hives benefited from complete shade such as in a garage shed and in a bee hut where temperature did not exceed 32°C. Hives placed in the shade of *Tamarindus indica*, a common tree, performed more of less like in the open site. Modifications were also made to KTBH covers with the result that the type which was insulated by a timber ceiling and painted white remained significantly cooler compared to the one bearing a normal cover. These findings showed that the bee hut provided effective shade for hives throughout the year and that in the hot season it maintained all hives at the threshold temperature of 32°C at which bees would have to initiate cooling behaviour using water (Lindauer 1955a). The bee hut could offer additional benefits such as security against thieves and honey badgers and thus would have practical advantages in Baringo District. The need for providing shade for bees under hot conditions also has implications on productivity since honey stores are consumed for fuelling the activities required for regulating brood nest temperature, which translates into lower hive yields. Special management can be followed at times of drought, such as feeding the colony and restricting brood rearing, where equipment permits (Lindauer 1955b, Crane 1990). These findings also point to the fact that providing bees with forage in the absence of water may not be sufficient to keep bees from vacating hives during dry spells and as a matter of necessity water resources should also be developed in beekeeping areas so as to encourage bees not to vacate hives during dry seasons.

Vegetation

According to information gathered from beekeepers as well as a floral calendar maintained for the lowlands in Baringo District, flowering gaps were identified in December and January that coincided with the time when bees migrate from there. A number of alternative uses were also identified for key bee plants. Detailed studies further revealed that the composition of vegetation varies widely in the landscape with respect to distribution of what beekeepers consider as key bee plants. These factors, singly or in combination, affect hive productivity in different locations and make it necessary for beekeepers to search far and wide for locations they consider to serve bee requirements well. This is possible while land is still under communal tenure. The increasing pressure placed on such land by a rising human and livestock population is however starting to cause conflicts among different users who compete for limited resources. Beekeepers therefore complain of shortages not only of forage but also of trees for placing hives in. This suggests that without a deliberate conservation programme in place, natural regeneration alone cope with increased exploitation of resources. All stakeholders with vested interests in communal land should therefore join together to develop and implement a conservation programme that is sensitive to both local land characteristics and uses.

One way of dealing with the dearth period faced by bees would be to identify opportunities on communal land where suitable plants that flower during the period when a shortage has been identified could be propagated (Baumer 1985). All plants that were mentioned by beekeepers should therefore be evaluated for their usefulness to bees and those found to possess the right flowering characteristics incorporated in afforestation projects in the District (Townsend 1969). On individually owned land, beekeepers should also utilize every opportunity to grow plants that support beekeeping, including managing the land under irrigation to propagate plants that supply bee requirements, especially during months when there is a shortage of forage in the natural landscape. Suitable plants can also be incorporated in agro-forestry systems, especially soil conservation.

Roles of the government

The government will be expected to continue to take care of macro-economic stability by strengthening monetary and public sector finance management. It remains the responsibility of the government to improve the provision of infra-structural services, enhance external and domestic competitiveness of the economy, address the social aspects of development particularly through targeted poverty interventions, increased access to social services and curbing of corruption. Such reforms in government policy are expected to create investment opportunities and responsibilities for the private sector in several areas that in the past were restricted, including provision of research and extension services. The Ministry of Agriculture will retain the core function of formulation and monitoring of policy while facilitating appropriate agricultural extension services and extension –research liaison.

Research

Much can be learnt from reviewing past experiences in the country and from all the suggestions made about how to advance beekeeping in Kenya. The present situation has partly arisen from the fact that research lags behind the management problems faced by beekeepers. Taking the advice of FAO (1986), research should be undertaken to address issues such as pest and disease control and to adopt new production and processing technology to conditions of particular ecological zones. As research is not a core function of the Ministry of Agriculture, collaboration with partners who have an established research mandate and capacity are necessary and should be enhanced. They way forward for research and extension in beekeeping for Baringo District will be to strengthen partnerships between the Ministry and relevant institutions of research in forestry and agriculture as well as institutions of higher learning, all of which are represented on the ground in the area (Gichora et al. 2001).

Market development

In view of the fact that traditional processing methods yield honey that is contaminated with smoke particles, dead bees and pollen, Ogentonto and Gathuru (1985) suggested using cloths for straining honey from uncapped combs or placing the comb in suitable wire cages then using a bicycle driven centrifuge to extract honey. These methods were expected to raise product quality to meet requirements of external markets. A proposal by Townsend (1976) was that honey from various parts of the country should be graded at harvest time and the best grade transported to a central government honey where equipment was to be made available to process it to meet international standards. Such a strategy addressed the two major problems in developing and retaining markets, namely, continuity of supply and quality of the product (Corner 1985). In the new millennium, beekeepers are therefore encouraged to re-direct their beekeeping efforts towards a pure product that is consistently of the highest quality and available in reliable and steady supply. To achieve this, they will need to access information about external markets and their quality requirements in order to guide them in their operations (Jones 2000).

Beekeepers as stakeholders in beekeeping development

According to Fernades (1988), the poor should be assisted by development agents to mobilize and pool resources so as to enable them to achieve economies of scale or levels of knowledge or influence that are beyond the reach of an individual. To meet marketing requirements, beekeepers would, for example, be better off selling their commodities through groups. This is starting to happen in parts of the study area and must be encouraged at national level as it has the additional benefit of creating a common front for beekeepers to press the government to create better economic conditions for advancement of the beekeeping industry. These groups can succeed if beekeepers are allowed take charge of their own affairs without undue interference from their administrative or political leaders, as was the case in the past.

Beekeeping development can thus benefit from FAO guidelines for promoting people's participation in rural development through self-help organizations (Newiger 1988). These are outlined in the Peasants' Charter, which states that "rural development strategies can realize their full potential only through the motivation, active involvement and organization at the grassroots level of rural people with special emphasis on the least advantaged in conceptualising and designing policies and programmes and in creating administrative, social and economic institutions, including cooperatives and other voluntary forms of organization, for planning, implementing and evaluating them." The actors who are needed are those who can actively create conditions in which mobilization and organization of the poor people is made possible. Such partners should concern themselves with advancement of effective means and structures within local organizations for dealing with the forces and policies that directly affect the lives of people. Actors with resources and political influence should fight for effective political, economic and legal conditions that will enable struggling organizations of such rural folk to function in an autonomous manner. Newiger (1988) warned that "until the majority of rural people in developing countries can be mobilized through their own organizations, the technology and other resources being offered are not likely to be utilized adequately and efficiently by the small holders and rural labourers and the goods and services produced will not be adequately distributed." This weakness can be addressed by promoting people's participation in the institutions and systems that govern their lives, as a basic human right.

Role of extension agents

Regardless of who provides extension services, the Ministry of Agriculture has defined the primary role as one of facilitating transfer of technical knowledge and skills from experts to farmers. The aim should be to empower farmers to make wise choices within the available market opportunities and constraints (Ministry of Agriculture 1999). The extension policy of the Ministry was recently reviewed acknowledging the limited resources it now receives from the government and appreciating the strong capacity of the private sector and NGOs involved in agriculture and rural development. The Ministry plans to foster new partnerships with private enterprises, co-operatives, farmer organisations, women groups, charitable organisations and small-scale savings groups, trade associations and industrial organisations. The resources of such institutions have not been fully harnessed in support of agricultural development in the past and a broad-based private sector input is expected to lead to agricultural growth.

It has already been suggested in Chapter 3 for the case of Baringo District that the current approach taken by the Catholic Church for advancing agricultural development at grass root level is appropriate for the circumstances and can act as a model for other organizations. Maina and Omollo (undated) have likewise recommended a participatory approach to extension in dry land areas. Their opinion is that farmers themselves are the best agents for management and implementation of extension activities, although in some approaches the person responsible can be drawn from a government agency or an NGO. This approach facilitates farmers to share experiences and to receive training one from the other through regular meetings. The training may take several forms, among them the farmer-to-farmer approach whereby one farmer in the community trains his or her neighbours by holding regular meetings with individuals or groups. Another approach recognizes innovative farmers as a source of innovation and inspiration to their neighbours. Field days, demonstrations, fairs and exhibitions are part of another approach that is popular with the Ministry of Agriculture. It involves holding events that last from one to several days but can be made more participatory by holding such events in a farmer's field rather than in a far away venues that farmers cannot access easily.

In cross visits, one group of farmers is facilitated to visit another area where promising technologies have been adopted to solve similar problems. The visitors learn much by seeing technologies at work and in questioning their counterparts and exchanging ideas. Farmer field schools is a widely applied approach to pest management that enables farmers to gain a deep understanding of their field ecosystems as they discover how best to manage pests. At the same time they learn about crop physiology, agronomic methods, the characteristics of different crop varieties, soil fertility, handling of pesticides and health issues as well as management skills. This approach can be adopted for teaching new methods of beekeeping based on gaining better understanding of bee biology.

Finally, in a *manyatta* approach, an extension agent lives and travels with a nomadic pastoralist group, staying several months at a time to teach them different skills. It is an effective approach but takes great sacrifice on the agent's side. Participatory extension is facilitated through existing groups in the community and where they do not exist, it is necessary first to help local people to form them. These are practical approaches that are relevant and applicable to beekeeping extension in Baringo District that should be tested.

6.1 Conclusions

Seen from a historical perspective, beekeeping developments in Kenya in the last fifty years have not had an impact in Baringo District as far as technology transfer is concerned. Beekeepers still depend largely on log hive technology and follow traditional colony harvesting and processing procedures. Beekeepers who participated in this study nevertheless showed great interest in advancing their industry. This presents development agents with an opportunity to provide training for improving product quality within the traditional beekeeping system while gradually taking beekeeping as far as possible towards movable comb technology in future under more intensive beekeeping systems. It is proposed to fill the gaps identified in flowering by planting specific trees that flower during the critical period when forage is limiting. The adoption of bee huts is proposed as a method to improve the shade available for hives thereby cutting down on the need for bees to collect water for cooling hives at a time when it is in short supply. The government already supports water development projects in the District but the County Council of Baringo will be required to play a more active role at local level.

A summary of the present situation in Baringo District and suggested way forward interventions in the future is presented in a flow chart (Appendix 8). It shows that much remains to be done especially in the area of intensive management for which adoption of modern types of equipment and new approaches to management of colonies will be necessary. The new extension policy of the Ministry of Agriculture supports the involvement of a number of stakeholders and development partners in the beekeeping sector. The Ministry, as custodian of beekeeping development in Kenya, therefore has the responsibility to initiate collaboration with relevant organizations whose services are required to advance the course of beekeeping. The full potential of beekeeping in Kenya will be realized after studying technical, socio-economic and environmental factors affecting hive production in all areas of the country. A long-term commitment is required on the part of the government to create an economic environment conducive for further beekeeping development. This will include extension and maintenance of road infrastructure, development of water resources, power and telecommunications in each region in order to attract investment and support further growth in the sector.

6.2 Recommendations

1. Comprehensive surveys should be undertaken for documentation of technical, socio-economic and environmental factors affecting production in all beekeeping areas of Kenya. This will generate data for launching improvement programmes based initially on existing traditional beekeeping systems, where applicable, then gradually working towards wider adoption of modern beekeeping methods. The aim should to achieve self-sufficiency in the country in diverse hive products directing surplus production to export trade.

2. Participatory extension approaches should be adopted, drawing staff from target communities and first training them in the use of movable comb hives. The staff should then be trained as trainers and placed in charge of demonstration apiaries for the purpose of training interested beekeepers. For logistical reasons, demonstration apiaries should be located close to beekeepers to give them the opportunity to gain practical experience in modern beekeeping methods under local conditions. Women should be encouraged to participate and receive training in beekeeping following modern methods as these do not violate cultural values.

3. The support of active research partners will be essential for beekeeping development. This calls for a comprehensive beekeeping research agenda to be developed for various areas of Kenya, with roles of institutions collaborating with the Ministry of Agriculture well defined according to their capacity and comparative advantage with respect to specific problems.

4. Hot, dry seasons in ASALs present bees with serious shortages of water, forage and shade. Planting programmes should be undertaken for propagating plants that flower during critical months. Water resources should also be developed and bee huts promoted for provision of shade thereby enhancing the survival of bees during dearth periods.

5. The infrastructure supporting production, processing and marketing of hive products is poorly developed and in need of further expansion to attract investment and facilitate growth in the sector. Beekeepers confidence in cooperatives could be restored by adopting transparent and accountable management styles.

7 SUMMARY

7.1 Introduction

Beekeeping is widely practiced in Kenya in support of which a number of beekeeping development initiatives have been taken in collaboration with the Ministry of Agriculture. Among the earliest were those in 1950 by the British aid agency called OXFAM. They were aimed towards provision of marketing facilities particularly in areas without established trade in hive products, improvement of the amount and quality of wax produced as well as provision of improved beekeeping equipment. Honey refineries were established through County Councils for improved honey extraction, while producers' cooperatives were set up for selling beeswax. Local users of wax were encouraged to purchase the Kenyan product. Areas covered by the OXFAM project included South Baringo whose inhabitants have a well-established tradition of beekeeping.

The Canadian government supported a beekeeping development programme in Kenya that started in 1971. Its main objective was to upgrade beekeeping equipment from the fixed comb traditional hives to a movable comb technology so as to improve on quality and quantity of hive products. It also aimed to establish a beekeeping section in the Ministry of Agriculture in Kenya. One significant outcome of the ten-year project was development of a movable comb Kenya Top Bar Hive (KTBH) Another was establishment of a section within the Ministry of Agriculture for advising the government on policy matters concerning training, research and development in beekeeping.

Fifty years after the first beekeeping improvement project was initiated by OXFAM, the current study assessed the status of the industry in Baringo District, a semi-arid area of Kenya where beekeeping is traditionally practiced among the Tugen people. The study was conducted with the objective of establishing the socio-economic circumstances under which beekeepers in the area operate. It also aimed to document the level of technical knowledge that is currently vested in beekeepers including knowledge of plants and their phenology, knowledge of bees and colony management as well as performance of KTBH once installed in the field.

7.1.1 Objectives

The objectives of this case study of beekeeping in Baringo District were as follows:

i) To do cument socio-economic circumstances of beekeepers in the region

ii) To document the level of technical knowledge currently vested in beekeepers in the Tugen community

iii) To study vegetation characteristics at selected sites so as to quantify the diversity of plants available to bees in areas under different types of land uses.

iv) To assess the performance of KTBH as a movable comb hive and suggest ways to handle with the problem of overheating that beekeepers complain of.

7.2 Materials and methods

This study was conducted in three distinct phases. The first comprised of a socio-economic survey during which 224 beekeepers from Marigat and Kituro Catholic Parishes were selected for interview. They represented 30% of all beekeepers listed and were asked questions concerning a number of technical and economic issues related to their occupation as relevant to the objectives of the study. During a second phase, six sites were selected to represent areas under different land uses and detailed vegetation studies undertaken so as to describe the characteristics of plant communities in the landscape on which beekeeping depended. In the course of studies, it also became clear that the adoption rate of KTBH was very low and that for those who possessed such hives, it was difficult align top bars on hives after routine hive inspection. Top bars are the only part for which precision is required in this transitional type of hive and therefore during a third phase of the studies, measurements were made to determine how well their width conformed to specifications. This took place first in workshops on top bars that were newly manufactured and afterwards on others that had been put to use in the field.

Beekeepers complained of KTBH attaining such high internal hive temperatures that at times combs melted. Such high temperatures were also suggested as a cause for bees to abscond. An experiment was therefore conducted in which the covers for KTBH were insulated by fitting them with wooden ceilings and then different designs tested for temperature regulation alongside the normal KTBH as well as a traditional log hives. All hives were also placed in four different shade conditions- 1) under a *Tamarindus indica* tree, 2) an asbestos roofed garage shed and 3) a thatched bee hut. These conditions were contrasted with 4) an open site devoid of shade in order to determine the most conducive shade for keeping hives coo in dry, hot areas.

Detailed studies were undertaken of the composition of vegetation by laying transects in selected sites representative of various land use types.

7.3 Results

7.3.1 Cultural aspects of beekeeping

Findings of the socio-economic survey were that in the Tugen community of Baringo District all available members of a beekeepers household are assigned different tasks in beekeeping. The job is culturally nevertheless defined as men's work and boys receive thorough training to enable them in adulthood to take over responsibility from the elders. Girls and women play a complementary role by assisting in the process when required, especially in transporting materials. Cultural restrictions reinforce these gender roles by prohibiting women to climb trees, a necessity when it comes to hanging hives in position or when harvesting honey according to traditional practices. A few enterprising women overcome these barriers by hiring men to undertake jobs on their behalf that they are prohibited to do, including processing of honey or brewing beer.

7.3.2 Beekeeping practices

The traditional beekeeping system is based on fixed comb log hives. These are located in isolated areas far from homesteads since beekeepers acknowledge the aggressive nature of local bee races. Beekeepers are not familiar with what normally goes on inside colonies, which they visit once or twice a year but understand that local bees are nomadic by nature, migrating in response to a limited supply of forage and water and absconding in response to unfavorable environmental conditions, pests and plundering by animals or man. Beekeepers take such nature and movement of bees into account in their management practices, expecting bees to occupy hives or leave hives for various reasons and at different times of the year. They depend on swarms for initial stocking and to improve chances for occupation of hives, they maintain them in a clean and habitable condition for bees. Hives are scattered far and wide in all suitable sites most of which occur on communal land where beekeepers are free to exploit all available resources.

7.3.3 Modern beekeeping methods and extension

Attempts to introduce the more technologically advanced movable comb hives and their accessories are faced with many logistical difficulties in Baringo District. Most notable is the fact that there is little contact between traditional beekeepers and extension staff of the Ministry of Agriculture whose mandate is to promote modern beekeeping methods based on this type of technology. Brief contact during 'open' days or at agricultural fairs is not enough to transfer the technology and a more practical approach to extension is required.

7.3.4 Performance of Kenya Top Bar Hives

Top bar conformity to specifications

With respect to KTBH, the width of top bars is specified as 32 mm. Newly manufactured bars in the two workshops varied mostly by 1 mm from this specification. Top bars showed more variation after installation of hives in the field, going beyond the specification by 6 mm at most or falling below it by up to 4 mm. This was attributed to warping caused by unseasoned wood or to replacement of faulty bars by beekeepers with some whose measurements were not precise. Besides the normal construction of a single comb on each top bar, bees were observed to construct two combs on single bars or single combs going across neighboring bars. When investigated further this was found to occur on all bar sizes, whether they adhered to specifications or not and so did not provide clear indications as to whether such multiple or crossing combs were a response of bees the inconsistency of "bee space" as a result of the warping of top bars.

Temperature trends in different hives

With respect to hive temperature, different hives under different shade conditions displayed similar trends over 24 hour cycles. When analysis was restricted to daytime between 0800hrs to 1700hrs, temperature varied significantly different 0800hrs and 0900hrs and from 1200hrs to 1300hrs in the normal KTBH compared to the modified KTBH whose flat cover was insulated with a timber ceiling and painted white. During the hot season, significant temperature differences occurred in the same hives for a period extended by one hour or more around these times.

A thatched bee hut made out of local materials remained the coolest shade for placing hives in all seasons. It brought the hot season peak temperatures in all types of hives down to 32 ^{0}C in situations where peak external temperature averaged 40 ^{0}C. The garage and tree shade were similar environments during the cold season while the hut and garage acted as similar environments in the hot season. The tree shade had no clear advantage over the open site during the hot season.

Bee forage resources

From qualitative data gathered by means of the survey questionnaire, the most important trees and shrubs that beekeepers mentioned are from the Leguminosae, Anacardiaceae, Combretaceae, Euphorbiaceae, Rhamnaceae, Flacourtiaceae, Compositae and Verbanaceae families. Undergrowth is mostly from Amaranthaceae, Acanthaceae and Compositae families. *Acacia* species are ranked among the most important forage plants regardless of whether they occur in the immediate neighbourhood of beekeepers' homes or far away. Such wide knowledge of plants can be attributed to the fact that beekeepers travel long distances to find suitable locations for their hives and are familiar with plants far from their homes. The most well known nectar-producing shrub is *Acacia mellifera* while *A. tortilis* is considered as the most important pollen source. Bee plants serve many other purposes such as supplying materials for fencing, construction, charcoal burning and fodder. Acacia trees are especially important in this regard. Undergrowth provides fodder and medicine and occasionally is harvested to supply vegetables. Some grasses are useful for thatching houses. Such competing uses place increasing pressure on the vegetation in the face of a rising human and livestock population with tree and shrub cover reported to be declining. Nevertheless over 70% of beekeepers still considered natural regeneration to be adequate for conservation. Transect data analysis showed that there is a wide diversity of plants, which are unevenly distributed in the landscape. The most important bee plants were not present in all study sites.

7.4 Way forward

The natural resources available to the beekeeper are bees, vegetation and water on which he or she applies technical knowledge to manipulate colonies to make surplus products. The nature of the local bee race, *Apis mellifera scutellata*, is that it is nomadic and aggressive and not as productive when compared with other races in use elsewhere in the world. It is nevertheless well adapted to the difficult semi-arid environment in Baringo District. Research is necessary to bring about a better understanding of its biological traits, which are the basis of behavior. Based on such knowledge, the beekeeper can induce or increase the particular behavior in colonies that is most useful to him at any given time while suppressing traits that are considered undesirable. Beekeepers should therefore be encouraged to gradually adopt movable comb hives that allow them to inspect colonies and spend more time attending to their colonies than they currently do. Learning more about colonies can open the way for selection and breeding of honeybees with desirable characteristics as a number of heritable traits that can increase honey yields of a colony and are convenient for the beekeeper become apparent. Adopting movable comb hives will further facilitate diversification of hive products.

Concerning top bar hives, detailed studies should be also be carried out to establish whether the unexpected types of combs encountered in KTBH were caused by misalignment of top bar as a result of warping or whether is an expression of the natural tendency of the local bees to make several types of combs in hive cavities. With respect to temperature regulation in hives in hot dry areas of Baringo District, the bee hut offered better shade than some of the ordinary trees that are commonly available. Besides, it can be a secure environment for hives, protecting them against honey badgers and theft. It is therefore recommended as the best type of shade for hives in Baringo District among those investigated.

An effective approach to participatory extension would be the establishment of demonstration apiaries at localized levels. These would not only serve the practical purpose of training beekeepers in new colony management methods but also would provide extension staff with the opportunity to experience and resolve management problems that beekeepers are likely to be faced in practice. To be fully effective, extension staff would have to be accessible enough for beekeepers to consult whenever need arises. It would therefore be best if extension staff could be drawn from the local community and themselves initially trained sufficiently in the methods they are expected to train beekeepers in.

Hitherto not much attention has been paid to the quality of hive products in Baringo District since local markets absorb crude products as they offered. This situation creates problems in marketing at the peak of the harvesting season when products flood the market. The quality of hive products can be improved immensely by taking simple steps during harvesting such as grading of combs by contents and appearance and then adopting improved processing methods based on simple techniques and equipment. It is proposed that beekeepers should receive training to meet requirements of external markets thus giving them more options for marketing. The revival of cooperatives would enable beekeepers to install suitable equipment for quality processing and to consistently meet the large volumes demanded by most external markets.

An outline of how the potential of beekeeping in Baringo District can be fully exploited is provided as a model that can be adopted for use in other parts of Kenya (Appendix 8).

7.5 Recommendations

1. Comprehensive surveys should be undertaken for documentation of technical, socio-economic and environmental factors affecting production in all beekeeping areas of Kenya. This will generate data for launching improvement programmes based initially on existing traditional beekeeping systems, where applicable, then gradually working towards wider adoption of modern beekeeping methods. The aim should to achieve self-sufficiency in the country in diverse hive products directing surplus production to export trade.
2. Participatory extension approaches should be adopted, drawing staff from target communities and first training them in the use of movable comb hives. The staff should then be trained as trainers and placed in charge of demonstration apiaries for the purpose of training interested beekeepers. For logistical reasons, demonstration apiaries should be located close to beekeepers to give them the opportunity to gain practical experience in modern

beekeeping methods under local conditions. Women should be encouraged to participate and receive training in beekeeping following modern methods as these do not violate cultural values.

3. The support of active research partners will be essential for beekeeping development. This calls for a comprehensive beekeeping research agenda to be developed for various areas of Kenya, with roles of institutions collaborating with the Ministry of Agriculture well defined according to their capacity and comparative advantage with respect to specific problems.

4. Hot, dry seasons in ASALs present bees with serious shortages of water, forage and shade. Planting programmes should be undertaken for propagating plants that flower during critical months. Water resources should also be developed and bee huts promoted for provision of shade thereby enhancing the survival of bees during dearth periods.

5. The infrastructure supporting production, processing and marketing of hive products is poorly developed and in need of further expansion to attract investment and facilitate growth in the sector. Beekeepers confidence in cooperatives could be restored by adopting transparent and accountable management styles.

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9 APPENDICES

Appendix 1: Internal Hive temperature trends based on General Linear Model analysis.

i) Within -Subjects Factors: Measure_ 1

TIME	Dependent Variable
1	H8 (0800 hrs)
2	H9
3	H10
4	H11
5	H12
6	H13
7	H14
8	H15
9	H16
10	H17 (1700 hrs)

ii) Between –Subjects Factors

SUBJECT		N
PLACE	GARAGE	45
	HUT	45
	OPEN	45
	SHADE	44
SEASON	1	60
	2	60
	3	59
TYPE	FLAT	35
	LOG	48
	NORMAL	48
	POINTED	48

iii) Tests of within-subject effects: ANOVA table showing the effect of time, type of shade, hive and season on internal hive temperature (0800 – 1700hrs).

Source (Sphericity assumed)	Type III Sum of Squares	df	Mean Square	F
Hour of day	14209	9	1579	894.8[a]
Hour*Shade	3080.6	27	114.1	64.7[a]
Hour *Season	511.9	18	28.4	16.1[a]
Hour *Hive Type	129.2	27	4.8	2.7[a]
Hour*Season*Hive Type	107.5	54	2.0	1.1
Hour*Season *Shade	547.8	54	10.1	5.8[a]
Hour*Hive Type*Shade	255.9	81	3.2	1.8[a]
Error (Hour)	2366.2	1341	1.8	

[a]Significant at $p< 0.01$

iv) Tests of between-subjects effects

Source (Sphericity assumed)	Type III Sum of Squares	df	Mean Square	F
Intercept	144296	1	144296	64525.2
Shade	902.4	3	114.1	64.7[a]
Season	1501.6	2	750.8	335.7[a]
Hive Type	21.6	3	3.2	2.7[a]
Season *Shade	45.0	6	7.5	3.4[a]
Hive Type*Shade	27.0	9	3.0	1.3[a]
Season*Type	27.6	6	4.6	2.1
Error (Hour)	333.3	149	2.2	

v) Tests of within-subjects contrasts (Time, shade, hive type, season)

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME	Level 1 vs. Level 2	792.164	1	792.164	201.566	.000
	Level 2 vs. Level 3	424.766	1	424.766	197.290	.000
	Level 3 vs. Level 4	419.782	1	419.782	445.001	.000
	Level 4 vs. Level 5	242.117	1	242.117	258.803	.000
	Level 5 vs. Level 6	221.754	1	221.754	238.526	.000
	Level 6 vs. Level 7	132.700	1	132.700	129.358	.000
	Level 7 vs. Level 8	27.813	1	27.813	22.936	.000
	Level 8 vs. Level 9	5.896	1	5.896	2.341	.128

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
	Level 9 vs. Level 10	330.554	1	330.554	82.387	.000
TIME * SHADE	Level 1 vs. Level 2	186.968	3	62.323	15.858	.000
	Level 2 vs. Level 3	259.029	3	86.343	40.103	.000
	Level 3 vs. Level 4	125.775	3	41.925	44.444	.000
	Level 4 vs. Level 5	34.648	3	11.549	12.345	.000
	Level 5 vs. Level 6	31.078	3	10.359	11.143	.000
	Level 6 vs. Level 7	25.844	3	8.615	8.398	.000
	Level 7 vs. Level 8	2.373	3	.791	.652	.583
	Level 8 vs. Level 9	70.418	3	23.473	9.319	.000
	Level 9 vs. Level 10	111.463	3	37.154	9.260	.000
TIME * SEASON	Level 1 vs. Level 2	143.905	2	71.952	18.308	.000
	Level 2 vs. Level 3	13.246	2	6.623	3.076	.049
	Level 3 vs. Level 4	22.013	2	11.007	11.668	.000
	Level 4 vs. Level 5	17.292	2	8.646	9.242	.000
	Level 5 vs. Level 6	1.380	2	.690	.742	.478
	Level 6 vs. Level 7	8.692E-02	2	4.346E-02	.042	.959
	Level 7 vs. Level 8	14.753	2	7.376	6.083	.003
	Level 8 vs. Level 9	14.511	2	7.256	2.881	.059
	Level 9 vs. Level 10	178.692	2	89.346	22.269	.000
TIME * HIVE TYPE	Level 1 vs. Level 2	43.627	3	14.542	3.700	.013
	Level 2 vs. Level 3	.965	3	.322	.149	.930
	Level 3 vs. Level 4	2.437	3	.812	.861	.463
	Level 4 vs. Level 5	2.613	3	.871	.931	.427
	Level 5 vs. Level 6	10.448	3	3.483	3.746	.012
	Level 6 vs. Level 7	3.492	3	1.164	1.135	.337
	Level 7 vs. Level 8	5.709	3	1.903	1.569	.199
	Level 8 vs. Level 9	8.296	3	2.765	1.098	.352
	Level 9 vs. Level 10	5.144	3	1.715	.427	.734

TIME * SHADE * SEASON	Level 1 vs. Level 2	53.112	6	8.852	2.252	.041
	Level 2 vs. Level 3	80.897	6	13.483	6.262	.000
	Level 3 vs. Level 4	17.790	6	2.965	3.143	.006
	Level 4 vs. Level 5	12.806	6	2.134	2.281	.039
	Level 5 vs. Level 6	8.890	6	1.482	1.594	.153
	Level 6 vs. Level 7	7.512	6	1.252	1.220	.299
	Level 7 vs. Level 8	12.140	6	2.023	1.669	.133
	Level 8 vs. Level 9	19.455	6	3.243	1.287	.266
	Level 9 vs. Level 10	49.774	6	8.296	2.068	.060
TIME * SHADE * HIVE TYPE	Level 1 vs. Level 2	105.308	9	11.701	2.977	.003
	Level 2 vs. Level 3	54.093	9	6.010	2.792	.005
	Level 3 vs. Level 4	10.406	9	1.156	1.226	.283
	Level 4 vs. Level 5	13.173	9	1.464	1.565	.131
	Level 5 vs. Level 6	16.115	9	1.791	1.926	.052
	Level 6 vs. Level 7	18.218	9	2.024	1.973	.046
	Level 7 vs. Level 8	8.118	9	.902	.744	.668
	Level 8 vs. Level 9	4.748	9	.528	.209	.993
	Level 9 vs. Level 10	23.118	9	2.569	.640	.761
TIME * SEASON * HIVE TYPE	Level 1 vs. Level 2	11.118	6	1.853	.471	.829
	Level 2 vs. Level 3	6.641	6	1.107	.514	.797
	Level 3 vs. Level 4	2.648	6	.441	.468	.831
	Level 4 vs. Level 5	4.871	6	.812	.868	.520
	Level 5 vs. Level 6	8.065	6	1.344	1.446	.201
	Level 6 vs. Level 7	6.900	6	1.150	1.121	.353
	Level 7 vs. Level 8	3.638	6	.606	.500	.808
	Level 8 vs. Level 9	16.519	6	2.753	1.093	.369
	Level 9 vs. Level 10	14.198	6	2.366	.590	.738

Source	TIME	Type III Sum of Squares	df	Mean Square	F	Sig.
Error(TIME)	Level 1 vs. Level 2	585.579	149	3.930		
	Level 2 vs. Level 3	320.798	149	2.153		
	Level 3 vs. Level 4	140.556	149	.943		
	Level 4 vs. Level 5	139.393	149	.936		
	Level 5 vs. Level 6	138.523	149	.930		
	Level 6 vs. Level 7	152.849	149	1.026		
	Level 7 vs. Level 8	180.678	149	1.213		
	Level 8 vs. Level 9	375.293	149	2.519		
	Level 9 vs. Level 10	597.817	149	4.012		

Appendix 2: Diurnal internal temperature in different types of hives at Chemeron, Baringo District

	Temp (°C), Cold Season - Pointed KTBH				Temp (°C), Hot Season - Pointed KTBH			
TIME	Shade	Hut	Garage	Open	Shade	Hut	Garage	Open
0:00	20,6	21,8	23,8	20,8	23,5	24,8	24,5	22,8
1:00	20,5	21,6	23,6	20,3	22,9	24,7	23,4	21,8
2:00	20,1	21,0	23,3	20,0	22,0	23,7	23,0	21,1
3:00	20,1	21,1	23,2	19,8	20,8	23,1	22,4	20,6
4:00	19,6	20,8	23,1	19,5	20,2	22,8	22,1	20,0
5:00	19,2	20,2	22,6	18,8	19,5	22,0	21,6	19,2
6:00	19,0	20,1	22,3	18,5	19,5	21,6	20,9	18,7
7:00	18,8	20,0	22,3	18,1	20,6	21,4	24,1	20,5
8:00	21,5	20,5	21,9	19,6	24,3	23,8	28,8	25,0
9:00	22,2	20,5	22,2	21,0	27,0	24,3	29,0	28,5
10:00	22,9	21,0	23,0	23,4	29,7	26,4	28,5	32,0
11:00	24,7	21,6	23,6	25,4	32,0	28,2	29,5	35,2
12:00	25,6	22,3	24,0	27,1	33,4	29,8	32,3	36,9
13:00	26,4	22,8	24,7	28,4	34,3	31,3	30,9	39,1
14:00	27,2	23,4	25,3	30,0	35,1	31,6	31,5	40,4
15:00	27,9	22,6	26,0	30,9	35,0	31,8	31,6	41,0
16:00	27,8	24,1	26,2	30,4	34,2	31,6	31,8	40,4
17:00	27,5	24,1	26,2	29,5	31,8	30,7	30,4	34,6
18:00	25,8	23,9	27,3	26,8	29,8	29,6	29,3	30,5
19:00	24,0	23,1	26,2	24,4	28,8	28,6	28,3	28,6
20:00	22,8	22,8	25,1	22,9	27,5	27,2	26,6	26,0
21:00	22,1	22,6	24,7	22,2	25,8	26,6	25,8	25,0
22:00	21,2	22,6	24,3	21,6	24,5	26,2	25,3	24,1
23:00	21,1	22,1	24,2	21,1	23,7	25,6	24,8	22,9

	Temp (°C), Cold Season - Log hive				Temp (°C), Hot Season - Log hive			
TIME	Shade	Hut	Garage	Open	Shade	Hut	Garage	Open
0:00	21,0	21,2	22,1	20,6	23,7	25,1	24,3	23,7
1:00	20,5	20,6	22,1	20,3	23,0	24,8	23,7	23,0
2:00	20,0	20,5	21,7	19,8	22,1	24,0	23,0	22,1
3:00	19,6	20,3	21,6	19,6	20,6	23,6	22,6	20,6
4:00	19,5	20,3	21,1	19,4	20,0	23,0	22,1	20,0
5:00	18,9	19,8	20,9	18,8	19,5	22,4	21,2	19,5
6:00	18,6	19,5	20,6	18,3	19,4	21,9	20,9	19,4
7:00	18,1	19,1	20,3	17,9	20,6	21,9	23,6	20,6
8:00	19,1	19,5	20,7	19,4	24,7	23,8	28,6	24,7
9:00	19,6	19,7	21,5	21,3	26,8	24,0	30,9	26,8
10:00	20,5	19,8	22,8	23,1	29,4	26,1	29,0	29,4
11:00	21,9	19,9	23,7	25,9	32,6	27,9	29,9	32,6
12:00	23,4	20,4	24,4	28,0	34,4	29,5	30,6	34,4
13:00	25,3	21,0	25,0	30,3	37,1	31,0	31,3	37,1
14:00	26,5	21,5	25,5	32,3	36,7	31,4	31,7	36,7
15:00	27,1	22,3	26,6	33,4	38,2	31,9	32,2	38,2
16:00	27,3	22,4	26,9	32,8	35,5	31,6	32,0	35,5
17:00	27,4	22,6	26,9	31,8	32,4	30,9	30,6	32,4
18:00	26,1	22,7	26,4	28,5	30,1	29,8	29,5	30,1
19:00	24,1	22,5	25,4	25,3	29,0	29,0	28,6	29,0
20:00	23,4	22,1	23,9	23,8	27,9	27,6	26,8	27,9
21:00	22,6	21,9	23,3	22,9	25,9	26,8	26,1	25,9
22:00	22,1	21,6	22,6	21,8	24,7	26,4	25,5	24,7
23:00	21,8	21,3	22,5	21,3	23,6	25,8	24,7	23,6

	Temp (°C), Cold Season - Flat KTBH				Temp (°C), Hot Season - Flat KTBH			
TIME	Shade	Hut	Garage	Open	Shade	Hut	Garage	Open
0:00	20,2	21,8	23,3	19,8	23,9	24,8	24,0	23,2
1:00	20,2	22,1	22,7	19,3	23,2	24,3	23,5	21,9
2:00	19,8	20,6	22,5	19,1	22,2	23,3	22,5	21,0
3:00	19,6	20,4	22,4	19,0	21,1	22,8	22,2	20,6
4:00	19,4	20,0	22,0	18,0	20,8	22,2	21,6	19,9
5:00	18,7	19,7	21,7	17,5	19,9	21,7	21,3	19,1
6:00	18,6	19,2	21,4	17,2	19,9	21,2	21,3	18,6
7:00	18,4	18,9	21,3	17,0	19,9	19,5	25,6	20,3
8:00	19,7	19,2	21,9	19,2	22,7	21,7	29,8	24,8
9:00	20,9	19,2	22,4	20,9	27,0	23,8	28,0	27,3
10:00	23,0	20,1	23,8	22,3	29,5	25,8	28,2	30,5
11:00	24,4	20,9	23,9	24,1	31,5	27,5	29,6	32,7
12:00	25,2	21,8	24,3	25,7	33,2	29,3	30,1	34,7
13:00	25,9	22,5	24,7	26,9	34,5	30,8	31,3	35,3
14:00	26,7	23,1	25,1	28,0	35,9	31,2	31,4	39,5
15:00	27,3	23,7	25,7	29,7	35,1	31,5	32,0	39,4
16:00	26,8	23,9	26,1	28,5	35,5	31,2	31,7	38,0
17:00	26,4	23,7	26,0	28,0	32,1	30,8	25,7	33,3
18:00	25,0	23,3	25,6	24,3	30,0	29,7	28,9	29,4
19:00	23,0	22,3	24,8	24,0	29,1	28,7	28,0	28,0
20:00	22,0	21,7	24,5	21,0	28,2	27,0	24,5	26,4
21:00	21,2	21,7	24,2	20,9	25,7	26,3	24,7	25,3

	Temp (°C), Cold Season - Flat KTBH				Temp (°C), Hot Season - Flat KTBH			
TIME	Shade	Hut	Garage	Open	Shade	Hut	Garage	Open
22:00	20,9	21,5	24,0	20,7	24,7	26,0	25,5	24,0
23:00	20,7	21,4	23,5	20,3	24,0	25,5	24,6	22,7

	Temp (°C), Cold Season - Normal KTBH				Temp (°C), Hot Season - Normal KTBH			
TIME	Shade	Hut	Garage	Open	Shade	Hut	Garage	Open
0:00	20,5	21,7	22,4	20,4	23,3	25,1	24,4	22,4
1:00	20,2	21,8	22,2	20,1	22,6	24,1	23,6	21,6
2:00	19,8	21,4	21,9	20,0	21,9	23,7	23,1	20,8
3:00	19,7	21,0	21,6	19,9	20,7	23,1	22,6	20,0
4:00	19,4	20,8	21,4	19,6	20,0	22,6	22,3	19,6
5:00	18,8	20,6	20,9	18,4	19,5	21,8	21,4	18,6
6:00	18,5	20,4	20,5	18,3	19,1	21,4	21,0	18,0
7:00	18,0	20,1	20,3	17,9	20,3	21,4	23,9	20,4
8:00	19,1	20,4	21,9	20,4	24,0	23,6	29,0	24,1
9:00	21,2	20,7	24,9	22,4	27,0	24,2	31,5	27,6
10:00	23,1	21,3	23,8	25,4	29,3	26,1	29,0	31,5
11:00	24,3	21,9	24,8	28,3	31,8	27,7	29,8	34,3
12:00	25,6	22,8	25,7	30,1	33,0	29,2	30,5	36,1
13:00	26,5	23,5	26,6	32,0	33,9	30,8	31,4	37,9
14:00	27,7	24,0	27,0	33,5	35,4	31,3	31,8	38,0
15:00	28,9	24,7	27,7	35,0	34,6	31,5	32,0	39,6
16:00	28,4	24,8	27,4	33,1	34,0	31,3	31,9	38,8
17:00	28,0	24,8	27,1	31,3	31,5	30,8	30,1	35,5
18:00	25,9	24,4	26,1	27,5	29,9	29,7	29,4	29,9
19:00	23,7	23,5	24,8	24,4	28,8	26,0	28,4	28,1
20:00	22,6	23,0	23,8	22,9	27,4	24,7	26,8	25,4
21:00	21,9	22,3	23,3	21,8	25,5	26,5	26,0	24,4
22:00	21,1	22,2	23,0	21,4	24,3	26,1	25,3	23,6
23:00	20,8	22,3	22,8	20,9	23,4	25,3	24,5	22,8

Appendix 3: List of families and representative plants as mentioned by beekeepers during a survey of beekeeping in Baringo District, Kenya.

Plant Family	**Trees**	**Shrubs**	**Undergrowth**
Acanthaceae			*Hypoestes aristata* *Blepharis linearifolia* *Justicia whytei*
Agavaceae		*Agave sisalana*	
Aloeaceae			*Aloe secundiflora*
Amaranthaceae			*Cyanthula dodecandra* *Allenthara pungens* *Amaranthus hybridus*
Anacardiaceace	*Boscia coricea* *Ozoroa insignis* *Rhus natalensis* *Lannea schweinfurthii*		
Annonaceae	*Uvaria schiffleri*		
Apocynaceae	*Acocanthera schimperi*	*Carissa edulis*	
Balanaticeae	*Balanites aegytiaca*		
Boraginaceae	*Cordia africana*		
Burseraceae	*Commiphora* spp.		

Plant Family	Trees	Shrubs	Undergrowth
Capparaceae	*Maerua triphylla* *Boscia angustifolia*	*Capparis sepiara*	
Caricaceae	*Papaya carica*		
Celephraceae		*Mystoxylon aethiopicum*	
Celestraceae	*Maytenus acuminata*		
Combretaceae	*Terminalia brownii* *Combretum molle* *Combretum apiculatum* *Terminalia spinosa*	*Terminalia spinosa*	
Compositae		*Kleinia squarrosa* *Vernonia auriculiflora* *Psiadia punctulata* *Tarconanthus camphoratus* *Acanthospermum australe*	*Tagetes minuta* *Spiranthes mauritania* *Galinsoga parviflora* *Bidens pilosa* *Sphaeranthus ukambensis*
Convolvulaceae		*Ipomea hildebrandtii*	
Cucurbitaceae			*Citrullus lanatus*
Cupressaceae	*Juniperus procera*		
Ebenaceae	*Euclea divinorum*		
Euphorbiaceae	*Croton megalocarpus* *Croton macrostachyus* *Croton dichogamus*	*Croton macrostachyus* *Euphorbia spp.* *Acalypha indicum*	*Euphorbia* sp. *Cleome hirta*
Flacourtiaceae		*Dovyalis caffra* *Dovyalis macrocalyx* *Dovyalis abyssinica*	
Graminae		*Eleusine indica* *Zea mays* *Sorghum sudanese*	*Cympogon/Hyperiens* spp *Cynadon dactylon*
Labatiaceae		*Ocimum suave*	*Plecanthus* sp.
Leguminosae	*Acacia mellifera* (Vahl) *Acacia elatior* *Acacia tortilis* *Acacia brevispica* *Acacia nubica* *Acacia senegal* *Acacia nilotica* *Acacia reficiens* *Acacia seyal* *Tamarindus indica* *Albizia amara* *Prosopis chilensis*	*Acacia nilotica* *Acacia brevispica* *Acacia senegal* *Acacia reficiens* *Acacia hockii*	*Acacia nilotica* *Senna didymobotrya* *Arachis hypogaea* *Pterolobium stellatum*
Moraceae	*Ficus sycomorus* *Ficus thoningii*		
Musaceae	*Musa spp.*		
Myrtaceae	*Eucalyptus* spp. *Syzygium guineense*		
Oleaceae	*Olea europea*		
Oliniaceae	*Olinia rochetiana*		
Phytollaceae			*Pytollacca dodecandra*
Podocarpaceae	*Podocarpus falcatus*		
Proteaceae	*Grevillea robusta*		
Rhamnaceae	*Zizyphus mucronata* *Berchenia discolor* *Zizyphus mauritania*		
Rubiaceae	*Vangueria infinista*	*Vangueria acutiloba* *Tapiphyllum mucrunulatum*	

Plant Family	Trees	Shrubs	Undergrowth
Rutaceae	*Zanthoxylum chalybeum* *Vepris glomerata*	Citrus trees *Teclea nobilis*	
Salvadoraceae	*Salvadora persica*		
Sapindaceae	*Pappea capensis*	*Dodonea viscosa*	
Sapotaceae	*Mimusops kummel*		
Solanaceae		*Solanum incanum*	*Solanum nigrum*
Sterculiaceae	*Dombeya rotundifolia*		
Thymelaeaceae			*Gnidia latifolia*
Tiliaceae	*Grewia similis*	*Grewia similis*	
Verbanaceae		*Lantana trifolia* *Lantana camara*	*Lantana camara*
Vitaceae			*Cissus quandrangula* *Cissus rotundifolia*
Zygophyllaceae			*Tribulus terrestris* *Tribulus serentiana*

Appendix 4: Complete list of plants utilized for beekeeping in Baringo District by common name and/or Tugen vernacular

TREES (>3 m tall at maturity)

Common name **Botanical Name**
(K)Oburwo *Maytenus acuminata* (Thunb.) Brakelock Celestraceae
Anon/(e) (Mutungwo/ Sebilit) *Ozoroa insignis* Delile Anacardiaceae
Banana *Musa* sp. Musaceae
Borowo *Dombeya rotundifolia* Planch. Sterculiaceae
Chemanga *Acacia senegal* L. Leguminosae
Chepchoboiwo *Olinia rocheatiana* A.juss. Oliniaceae
Chepiwo *Acacia nilotica* L. Leguminosae
Chepketieng'wo Anacardiaceae
Chepkorian *Vepris glomerata* F. Hoffm. Rutaceae
Chuine (Acacia sp.) Leguminosae
Cypress *Cupressus lusitanica* Cupressaceae
El dumeyon *Maerua triphylla* A. Rich Capparaceae
Grevillea *Grevillea robusta* R. Br. Proteaceae
Kebeitwo *Vangueria infausta* Burch. Rubiaceae
Kelwon *Acokanthera schimperi* Benth. & Hook. Apocynaceae
Kemel *Combretum molle* G. Don Combretaceae
Kibiriyokwo *Pappea capensis* Eckl. & Zeyh. Sapindaceae
Kipchepkwere *Ekebergia capensis* Sparm. Meliaceae
Kokchan/ (te) *Zanthoxylum chalybeum* Engl. Rutaceae
Kolewo (Kelelwet) *Croton dichogamus* Pax Euphorbiaceae
Koloswo *Terminalia brownii* Fresan Combretaceae
Kormotwo (Euphorbia sp.) Euphorbiaceae
Kornis/(ta) *Acacia brevispica* Harms Leguminosae
Kotutwe *Albizia amara* Roxb. Leguminosae

Kunyeukwo	*Prunus africana* (Hook.F.) Kalkaman Rosaceae
Kures	*Euphorbia candelabrum* Kotschy. Euphorbiaceae
Lamayw/o (e)	*Syzygium guineense* (Willd.) DC Myrtaceae
Lelna	*Acacia seyal* Delile Leguminosae
Likwonde	*Boscia angustifolia* A. Rich Capparaceae
Lokoiwo	*Ficus sycomorus* L. Moraceae
Lolowe	*Mimusops kumel* A.DC. Sapotaceae
Maringam	*Eucalyptus canaliculata* Maiden. Myrtaceae
Mesketwe	*Combretum apiculatum* Sond Combretaceae
Moinee	*Lannea schweinfurthii* (Engl.) Engl. Anacardiaceae
Mokoiwo	*Ficus sycomorus* L. Moraceae
Muchukwa	*Berchenia discolor* Klotzsch Rhamnaceae
Mutagar/(ie)	Euphorbiaceae
Nerkw/o (e)	*Acacia nubica* Benth. Leguminosae
Ng'olpel/wo (wet)	
Ng'orore	*Acacia mellifera* (Vahl) Benth. Leguminosae
Ng'oswo	*Balanites aegyptiaca* (L.) Delile Balanitaceae
Noi/wet (wo)	*Zizyphus mucronata* Willd. Rhamnaceae
Oimen (Kornis)	*Acacia brevispica* Harms Leguminosae
Oriswo	
Orwe	*Tamarindus indica* L. Leguminosae
Otonwo (Ote)	*Croton megalocarpus* Hutch. Euphorbiaceae
Parmukuto	Leguminoseae
Parsul/(e)	*Acacia reficiens* Wawra Leguminosae
Papaya	*Carica papaya* L. Caricaceae
Penee	*Podocarpus falcatus* Mirb. Podocarpaceae
	Prosopis chilensis (Mol.) Stuntz)) Leguminoseae
Samute	*Cordia africana (*L.) Lam. Boraginaceae
Sesia	*A. tortilis* Forssk. Leguminosae
Simbolwo	
Sirikwo	*Boscia coricea* Pax Capparaceae
Sirwo	*Rhus natalensis* Krauss Anacardiaceae
Sitewo	*Grewia similis* K. Schum. Tiliaceae
Sokoteiwo	*Salvadora persica* L. Salvadoraceae
Tegemet	*Uvaria scheffleri* Annonaceae
Telesyon	*Commiphora* sp. Burseraceae
Tesia (Tisie/Tisia)	
Tikitwe	*Terminalia spinosa* Engl. Combretaceae
Tilolwo	*Zizyphus mauritania* Lam. Rhamnaceae
Tirimie	*Ficus thonningii* Blume Moraceae
Tirionde	*Acacia elatior* Brenan Leguminosae
Tiwet	
Toboswa	*Croton macrostachyus* Delile Euphorbiaceae
Tololokwo	*Sclerocarya birrea* A. Rich. Anacardiaceae
Torokwo	*Juniperus procera* Endl. Cupressaceae
Uswo	*Euclea divinorum* Hiern Ebenaceae
Yemtit	*Olea europaea* L. Oleaceae

SHRUBS (1 – 3 m tall at maturity)

Common Name	**Botanical Name**
(K)Oburwo	
Chemanga	*Acacia senegal* L. Leguminosae
Chepiwo	*Acacia nilotica* L. Leguminosae
Cheplusw/a(o)	*Maerua subcordata* (Gilg.) De Wolf Capparaceae
Citrus (Lemons/oranges)	Rutaceae
Hamsalawa	*Combretum hereroense* Schinz Combretaceae
Kaawewonde	
Kahawa (coffee)	*Coffea arabica* L. Rubiaceae
Kamatapile	
Kametebre	*Ocimum suave* L. Lamiaceae
Kamoskoi (Komosgoi)	*Lantana camara* L. Verbenaceae
Kasupwe/Kipnaget (Parasitic)	
Katayakan	
Kayeba	*Dovyalis caffra* (Hook F. & Harvey) Warb. Flacourtiaceae
Kekech	*Tapiphyllum mucronulatum* Rubiaceae
Kelelwe	*Croton dichogamus* Pax Euphorbiaceae
Kelwon(de)	*Acokanthera schimperi* Apocynaceae
Kembirwo	*Phyllanthus sepialis* Mull. Arg. E
Kibitokchan	
Kimaruru	*Euphorbia* sp. Euphorbiaceae
Kimor/oto (to)	*Capparis sepiara* L. Capparaceae
Kinsye	
Kipkolol	*Mystoxylon aethiopicum* (Thub.) Loes) Celestraceae
Kipsameswe	*Kleinia squarrosa* Cufed. Compositae
Kipsikiryo	*Acanthospermum australe* (Loefl.) Kuntze Compositae
Kipsomoku (Three?)	
Kipungeiwo	
Kiris/(ie)	*Gnidia latifolia* (Oliv.) Gilg. Thymelaeaceae
Komo/lowe (lwo)	*Vangueria apiculata* K. Schum. Rubiaceae
Konorbei (Desert rose)	
Kornis	*Acacia brevispica* Leguminoseae
Kuryonde	*Teclea nobilis* Delile Rutaceae
Leketetwe	*Carissa edulis* (Forssk.)Vahl Apocynaceae
Lelekwe	*Tarconanthus camphoratus* L.) Compositae
Logurun	*Acalypha indica* L. Euphorbiaceae
Lokutwo	Capparaceae
Lopotwe	*Solanum incanum* L. Solanaceae
Makonge (Sisal)	*Agave sisalana* Perr. ex Engelm. Agaveceae
Mbirikwo	
Mesketwe	*Combretum apiculatum* Sond. Combretaceae
Mintililwo	*Dovyalis abyssinica* (A. Rich.) Warb. Flacourtiaceae
Mosong	*Sorghum sudanese* Anders. Graminae
Mutagar/(ie)	*Euphorbia* sp. Euphorbiaceae
Ng'irmon	
Noskech	*Psiadia punctulata* (DC.) Vatke. Compositae

Pandek *Zea mays* Graminae
Parsul *Acacia reficiens* Wawra Leguminosae
Peek *Eleusine indica* L. Graminae
Sekechewo *Lantana trifolia* L. Verbanaceae
Sepeiwo/Supeywe/Sipeiwo (Climber used as roofing rafter)
Sewesion
Sing'iritw/o (e) *Ipomea hildebrandtii* Vatke Convolvulaceae
Sirwe *Rhus natalensis* Krauss Anacardiaceae
Sitewo *Grewia similis* K. Schum. Tiliaceae
Tebe/ng'wet (ng'wa) *Vernonia auriculiferara* Compositae
Tikitw/e (o) *Terminalia spinosa* Engl. Combretaceae
Tilatil *Acacia hockii* De Wild Leguminosae
Tobilikwo (Tibirikwe) *Dodonea viscosa* (L.) Jacq. Sapindaceae
Tobosw/a (e) *Croton macrostachyus* Hochst. ex Del. Euphorbiaceae
Topirpirwo *Dovyalis macrocalyx* (Oliv.) Warb. Flacourtiaceae
Toronwo *Grewia lasiocarpa* A. Rich Tiliaceae
Uswe (root grass) *Pennisetum* sp. Graminae

UNDERGROWTH (<1 m tall)

Common Name Botanical Name
Bangiwo *Tagetes minuta* L. Compositae
Bitapit *Spiranthes mauritania* Compositae
Che(Rorowo) *Cissus rotundifolia* (Forssk Vitaceae
Chebles *Tribulus zeyheri* Sond. Zygophyllaceae
Chelelmet
Cheluwoyon
Chepitirwo
Chepkerta *Amaranthus hybridus* L. Amaranthaceae
Chepkik (Sekuut(ie) (Nut grass) Graminae
Chepkotiwo (blackjack) *Bidens pilosa* L. Compositae
Chepkution (Kitonda) *Portulaca oleracea* L. Portulacaea
Chepng'anian
Chesiwayan
Chobirwo *Acacia nilotica* L. Leguminoseae
Chomiswe *Sphaeranthus ukambensis* Vatke & O. Hoffm. Compositae
Chumiswo *Pyrostia africana* T. C. E. Fr. Labiatae
Eelo *Euphorbia* sp. Euphorbiaceae
Kamatebar
Kap(Cheptilil/)/(wo)
Katayakan
Kelaran *Justicia whytei* S. Moore Acanthaceae
Ketibelon
Kibarak *Blepharis ciliaris (L.)* B. L. Burtt Acanthaceae
Kibitokyon
Kimanyangoi
Kimorto *Capparis sepiaria* L. Capparaceae
Kipkoskoliny

Kipng'eiwo/(n) *Hyparrhenia rufa* (Nees) Stapf Graminae
Kiprungu *Leucas grandis* Vatke Lamiaceae
Kipsingiryo *Allenthara pungens* Kunth. Amarathaceae
Kirisie *Gnidia latifolia* (Oliv.) Gilg. Thymelaeaceae
Kisakian *Cleome hirta* (Klotzsch) Oliv. Capparaceae
Kisipirie (climber) *Pterolobium stellatum* (Forssk.) Brenan Leguminoseae
Kisuchon *Solanum nigrum* L. Solanaceae
Kitonda *Portulaca oleracea* L. Portulacaeae
Koburwo *Senna didymobotrya* (Fresen.) Irwin & Barneby Leguminosae
Komosgoi *Lantana camara* L. Verbenaceae
Ling'ok *Pupalia lappacea* Amaranthaceae
Lobotwo *Solanum incanum* L. Solanaceae
Lomara *Pennisetum* sp. Graminae
Loote
Maunde
Muigutwo
Ngatayet
Njugu (Groundnuts) *Arachis hypogaea* K. Leguminosae
Nornor(ie) *Tribulus terrestris* L. Zygophyllaceae
Nyorombi *Cynadon dactylon* L. Graminae
Nyuguswo Graminae
Patkawa/*Senetwo *Phytollacca dodecandra* (L.) Her. Phytolaccaceae
Salwan *Cynodon dactylon* (L.) Pers. Graminae
Sambalak
Seretion *Pennisetum clandestinum* Chiov. Graminae
Simboiwo
Simowo
Sirar(ye) *Hypoestes aristata* (Vahl) Roem.& Schult Acanthaceae
Sitakit *Galinsoga parviflora* Cav. Compositae
Sowesyon *Plectranthus caninus* (Roth) Vatke. Labiatae
Sung'urutit *Cissus quandrangula* L. Vitaceae
Susonde/?Suswo *Pennisetum* sp. Graminae
Suswek (Grass) *Cynodon dactylon* L. Graminae
Tamnapkwe *Cyanthula polycephala* Baker Amaranthaceae
Taplelian *Blepharis linariifolia* Pers. Acanthaceae
Teng'eretwe (Cheraa) *Aloe secundiflora* Engl. Aloeaceae
Turkoyon (Tirikion, Turugyon) Leguminoseae
Water melon *Hosludia opposita* Vahl Labiateae

Appendix 5: The various local uses for selected plants of importance to beekeeping in Baringo District, Kenya

Type of Plants	Local uses															
	Construction			Food & related							Hive			Tools		
	Timber, rafters & posts	Thatch	Fibre	Edible leaves or fruits	Smoking milk calabashes	Fodder	Medicine	Fencing	Firewood	Brooms	Construct	Cleaning	Repair	Handle	Honey harvest	Soil conserv -ation
Trees																
1	+	-	-	+	-	-		+	-	-	-	-	-	-	-	+
2	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
3	+	-	-	-	-	+	-	-	+	+	+	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
5	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
8	+	-	+	-	-	+	-	-	+	-	-	-		+	-	-
9	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
10	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shrubs																
1	+	-	-	-	-	+	-	+	+	+	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
4	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-
Under																
1	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
2	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
4	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
5	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-
7	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
11	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

Trees - 1. *Ozoroa insignis* 2. *Eucalyptus* spp. 3. *Terminalia brownii* 4. *Ficus sycomorus* 5. *Acocanthera schimperi* 6. *Zanthoxylum chalybeum* 7. *Combretum molle* 8. *Grewia similis* 9. *Balanites aegyptiaca* 10. *Combretum apiculatum*

Shrubs - 1. *Dodonea viscosa* 2. *Croton dichogamus* 3. *Lantana camara* 4. *Zea mays* 5. *Psiadia punctulata* 6. *Sorghum sudanese*

Undergrowth – 1. *Pennisetum cladestinum* 2. *Pennisetum* sp. 3. *Justicia whytei* 4. *Pupalia lappacea* 5. *Cyanthula polycephalla* 6. *Tribulus terrestris* 7. *Arachis hypogaea* 8. *Leucas grandis* 9. Graminae 10. Euphorbiaceae 11. *Cleome hirta*

Appendix 6 (a): Species list for plants under 1m in height (undergrowth) in various areas of Baringo District.

Species		Area where species occurs (1 = present, 0 = absent)					
		Tarambas	Tiring'ongwonin	Chemeron	Molo River	Loboi cliff	Sesya
Abutilon longespsii	(Malvaceae)	0	1	0	1	0	0
Abutilon mauritanum	(Malvaceae)	0	1	0	0	1	0
Acacia tortilis	(Mimosaceae)	0	1	0	0	0	0
Acalypha indicum	(Euphorbiaceae)	0	0	0	0	1	0
Achyranthus aspera	(Apocynaceae)	0	0	0	1	1	0
Acocanthera sp.	(Apocynaceae)	1	0	0	0	0	0
Agdatum conzyoides		0	1	0	0	0	1
Aloe secundiflora	(Aloeaceae)	0	0	0	0	0	0
Amaranthus hybridia	(Amaranthaceae)	0	0	0	1	0	0
Astasia schimperi		0	1	0	0	0	1
Balanites aegyptiaca	(Balanaticeae)	0	0	0	0	0	0
Barleria acanthoides	(Acanthaceae)	0	0	0	1	0	0
Barleria sp.	(Acanthaceae)	0	0	0	1	0	0
Bidens pilosa	(Compositae)	0	0	0	0	0	1
Cassipourea sp.			1	0	0	0	0
Cissus quadrangula	(Vitaceae)	0	0	0	0	0	0
Cocorus sp.		0	1	0	1	0	0
Commelina begalensis	(Commelinaceae)	0	1	1	1	0	0
Commicarpus sp.		0	0	0	0	0	0
Commicarpus stelution		0	0	1	0	0	0
Conyza salutalis		0	0	0	0	0	1
Crotalaria A	(Leguminosae)	0	0	2	0	0	1
Crotalaria B	(Leguminosae)	0	0	0	0	0	1
Cynodon plectostayus	(Graminae)	0	0	0	0	0	1
Cynoglossa sp.		0	0	0	0	0	1
Dovyalis abyssinica	(Flacourtiaceae)	1	1	0	0	0	0
Dregea schimperi		0	0	0	0	0	0
Eragrotolis sp.	(Graminae)	0	0	0	0	0	1
Euclea divinorum	(Ebenaceae)	0	0	0	0	0	1
Euphorbia hirta	(Euphorbiaceae)	0	1	0	0	0	1
Indigofera arrecta	(Papilionaceae)	0	0	1	0	0	0
Indigofera sp.	(Papilionaceae)	0	0	0	0	0	1
Kalachoe lancelata	(Crassulaceae)	0	0	0	0	1	0
Lannea cornwala	(Anacardiaceae)	0	0	0	0	0	0
Leucas sp.	(Labiatae)	0	0	0	0	0	1
Lycium ellipitica	(Solanaceae)	0	1	0	0	1	0
Maerua subcordata	(Capparaceae)	0	0	0	0	0	0
Myrsine africana	(Myrsinaceae)	0	0	0	0	0	1
Newtonia whytii		0	0	0	0	0	1
Ocimum suave	(Labiatae)	0	0	0	0	0	1
Ovalis convulata		1	0	0	0	0	1
Paudiatha sp.		1	0	0	0	0	0
Pavetta sp.		1	0	0	0	0	0
Podocarpus sp.	(Podocarpaceae)	1	1	0	0	0	0
Pupalia lappacea		0	1	0	0	0	0
Pylanthus amarus		0	0	0	0	0	1
Sida ovata		0	0	0	1	0	0
Solanum incanum	(Solanaceae)	1	0	0	0	0	0
Solanum nigrum	(Solanaceae)	0	1	0	0	0	0
Triadix prumean		0	0	0	0	0	1
Trichocladus sp.	(Hamamelidaceae)	1	0	0	0	0	0
Vernonia (swamp)	(Compositae)	0	0	0	0	1	0
Vernonia holstii	(Compositae)	1	0	0	0	0	0
Withania indica	(Solanaceae)	0	0	0	0	0	1

Appendix 6 (b): Species list for trees and shrubs (>1 m tall) in Baringo District.

Species		Area where species occurs (1=present, 0=absent)					
		Taram	Tiring'	Chemeron	Molo R.	Loboi	Sesya
Abutilon longespsii	(Malvaceae)	0	0	0	1	0	0
Acacia brevispica	(Mimosaceae)	0	0	1	0	0	0
Acacia mellifera	(Mimosaceae)	0	0	1	1	1	0
Acacia nilotica	(Mimosaceae)	0	0	1	0	0	0
Acacia reficiens	(Mimosaceae)	0	1	0	0	0	0
Acacia senegal	(Mimosaceae)	0	0	1	0	0	0
Acacia tortilis	(Mimosaceae)	0	1	1	1	1	0
Acalypha indicum	(Euphorbiaceae)	0	0	1	1	1	0
Acocanthera sp.	(Apocyanaceae)	1	0	0	0	0	0
Balanites aegyptiaca	(Balanitaceae)	0	1	0	1	0	0
Barleria acanthoides	(Acanthaceae)	0	0	0	0	1	0
Boscia angustifolia	(Cappareceae)	0	1	0	0	0	0
Boscia colresia	(Cappareceae)	0	0	0	1	0	0
Candaba parinosa		0	0	1	0	1	0
Canthium sp.		0	0	0	0	1	0
Capparis sp.	(Cappareceae)	0	0	0	1	0	0
Cassipourea sp.		1	0	0	0	0	0
Cissus rotundifolia	(Vitaceae)	0	0	0	1	1	0
Climber A		1	0	0	0	0	0
Combretum sp.	(Combretaceae)	0	0	1	0	0	0
Commicarpus sp.		0	0	0	1	0	0
Commiphora No. 2	(Burseraceae)	0	0	0	0	1	0
Commiphora sp.		0	0	0	0	1	0
Conyza salutalis		0	0	0	0	0	1
Cordia sinensis	(Boraginaceae)	0	0	0	1	0	0
Diospyros sp.		1	0	0	0	0	0
Dodonea sp.	(Sapindaceae)	0	0	0	0	0	1
Dovyalis sp.	(Flacourtiaceae)	1	0	0	0	0	0
Dovyalis abyssinica	(Flacourtiaceae)	0	0	0	0	0	1
Dragea abyssinica		0	0	0	1	0	0
Euclea sp.		0	0	0	0	0	1
Euphorbia candelabra	(Euphorbiaceae)	0	1	0	0	0	0
Ficus sycomorus	(Moraceae)	0	0	0	1	0	0
Gnidia subcordata	(Thymelaceae)	0	0	0	0	0	1
Gamphocarpus sp.	(Asclepiadaceae)	0	1	0	0	0	0
Grewia bicolor	(Tiliaceae)	0	0	1	0	1	0
Grewia sp.		1	0	0	1	1	0
Grewia vilosa		0	0	0	0	1	0
Lantana camara	(Verbanaceae)	0	0	0	1	0	0
Maerua subcordata	(Capparaceae)	0	0	0	1	1	0
Microglossa sp.		1	0	0	0	0	0
Newtonia whytii		0	0	0	0	0	1
Olea sp.	(Oleaceae)	1	0	0	0	0	0
Paldithus sp.		1	0	0	0	0	0
Pavetta sp.		1	0	0	0	0	0
Phytosporium sp.		1	0	0	0	0	0
Podocarpus sp.	(Podocarpaceae)	1	0	0	0	0	0
Rhus natalensis	(Anacardiaceae)	0	0	0	0	0	1
Salvadora persica	(Salvadoraceae)	0	0	0	1	1	0
Schlebera sp.	(Oleaceae)	1	0	0	0	0	0
Secamone sp.	(Asclepiadaceae)	1	0	0	0	0	0
Solanum incanum	(Solanaceae)	0	0	0	1	0	0
Sorghum sudanese	(Graminae)	0	0	0	0	0	1
Sterculia africana	(Sterculiaceae)	0	0	0	0	1	0
Strychnos sp.	(Loganiaceae)	1	0	0	0	0	0
Tamarindus indica	(Leguminosae)	0	0	0	1	0	0
Tarconanthus sp.	(Compositae)	0	0	0	0	0	2
Tagetes minuta	(Compositae)	0	0	0	0	0	4
Teclea nobilis	(Rutaceae)	1	0	0	0	0	0
Teclea simplicifolia	(Rutaceae)	1	0	0	0	0	0
Tephrosia sp.	(Leguminosae)	0	0	0	0	0	1
Terminalia brownii	(Combretaceae)	0	1	0	0	0	0
Tinnia aethiopica		0	0	0	0	0	1
Tordoria sp.		1	0	0	0	0	0
Trichocladus sp.	(Hamamelidaceae)	1	0	0	0	0	0
Trimeria glaliforosa		1	0	0	0	0	0
Vangueria sp.	(Rubiaceae)	1	0	0	0	0	0
Vernonia sp.		1	0	0	0	0	0
Zanthoxylum chalybeum	(Rutaceae)	0	1	0	0	0	0

Appendix 7: Species density in selected beekeeping areas of Baringo District.

Species	Tiring'ongwonin No. stems/ha
Abutilon mauritinum	800
Acacia reficiens	20
Acacia tortilis	120
Acalypha indicum	3200
Aloe secundiflora	600
Balanites aegyptiaca	840
Boscia angustifolia	20
Cissus quadrangula.	1400
Commicarpus sp.	600
Commelina begalensis	200
Dregea schimperi	200
Euphorbia candelabra	40
Gamphocarpus sp.	80
Indigofera arrecta	400
Maerua subcordata	600
Pupalia lappacea.	200
Solanum nigrum	200
Terminalia brownii	20
Zanthoxylum chalybeum	20

Species	Chemeron No. stems/ha
Acacia brevispica	575
Acacia mellifera	225
Acacia nilotica	25
Acacia senegal	50
Acacia tortilis	50
Acalypha indicum	700
Candaba parinosa	25
Combretum sp.	25
Commelina begalensis	2600
Commicarpus stelution	400
Crotalaria sp.	400
Grewia bicolor	25
Indigofera arrecta	18000

Tarambas forest

Species	No. stems/ha
Acocanthera sp.	40
Barleria sp.	15000
Cassipourea sp.	560
Climber A	80
Cyperus sp.	80000
Diospyros sp.	200
Dovyalis sp.	240
Erythroccoca	500
Ficus sycomorus	80
Grewia sp.	5040
Diospyros abyssinica	5000
Issoglossa	85000
Microglossa spp.	40
Ochna	5000
Olea sp.	40
Paldithus sp.	160
Pavetta sp.	5120
Phytosporium sp.	40
Podocarpus sp.	133560
Schlebera	320
**Schoexiphium lehmanii*	5000
Secamone sp.	15160
Strychonos sp.	80
Teclea nobilis	80
Teclea simplicifolia	80
Teridium sp.	10000

Sesya

Species	No. stems/ha
Agdatum conzyoides	30000
Astasia schimperi	20000
Bidens pilosa	280000
Cynadon plectostachys	120000
Conyza salutalis	20200
Crotalaria A	10000
Crotalaria B	10000
Cynoglossa sp.	30000
Dodonea viscosa	600
Dovyalis abyssinica	200
Eleusine indica	28600
Eragrotolis sp.	20000
Euclea sp.	35800
Euphorbia hirta	250000
Gnidia subcordata	200
Indigofera sp.	160000
Leucas sp.	30000
Maerua lanata	10000
Myrsine africana	20000
Newtonia whytei	20400
Ocimum suave	10000
Ovalis convulata	20000
Pylanthus amarus	20000
Rhus natalensis	2400
Tagetes minuta	600
Tarconanthus sp.	5000
Tephrosia sp.	3200

Species Tarambas contd.	No. stems/ha
Tordoria sp.	40
Tricholadus sp.	1149
Trimeria glaliforosa	104
Vangueria sp.	120
Vernonia holstii	5040

Species Sesya contd.	No. stems/ha
Tinnia aethiopica	200
Triadix prumean	10000
Withania indica	10000

	Molo River, Parkaren
Species	No. stems/ha
Abutilon longespsii	360
Acacia mellifera	80
Acacia tortilis	40
Acalypha indicum	2040
Achyranthus aspera	2600
Amaranthus hybridia	1200
Balanites aegytiaca	40
Barleria acanthoides	2400
Barleria sp.	200
Boscia colresia	80
Caparius sp.	160
Cissus rotundifolia	80
Cocorus sp.	800
Commelina begalensis	400
Commicarpus sp.	40
Cordia sinensis	80
Dragea abyssinica	80
Ficus sycomorus	40
Grewia sp.	120
Lantana camara	160
Maerua subcordata	160
Salvadora persica	40
Sida ovata	200
Solanum incanum	120
Tamarindus indica	40

	Loboi swamp
Species	No. stems/ha
Abutilon mauritanum	600
Acacia mellifera	105
Acacia tortilis	105
Acalypha indicum	2910
Acyranthus aspera	2600
Barleria acanthoides	140
Candaba parinosa	35
Canthium sp.	35
Cissus rotundifolia	35
Commiphora No. 2	35
Commiphora sp.	35
Cordia sinensis	35
Grewia bicolor	70
Grewia vilosa	35
Kalachoe lancelata	200
Lycium ellipitica	400
Maerua subcordata	140
Salvadora persica	35
Sterculia africana	35
Vernonia (swamp)	5600

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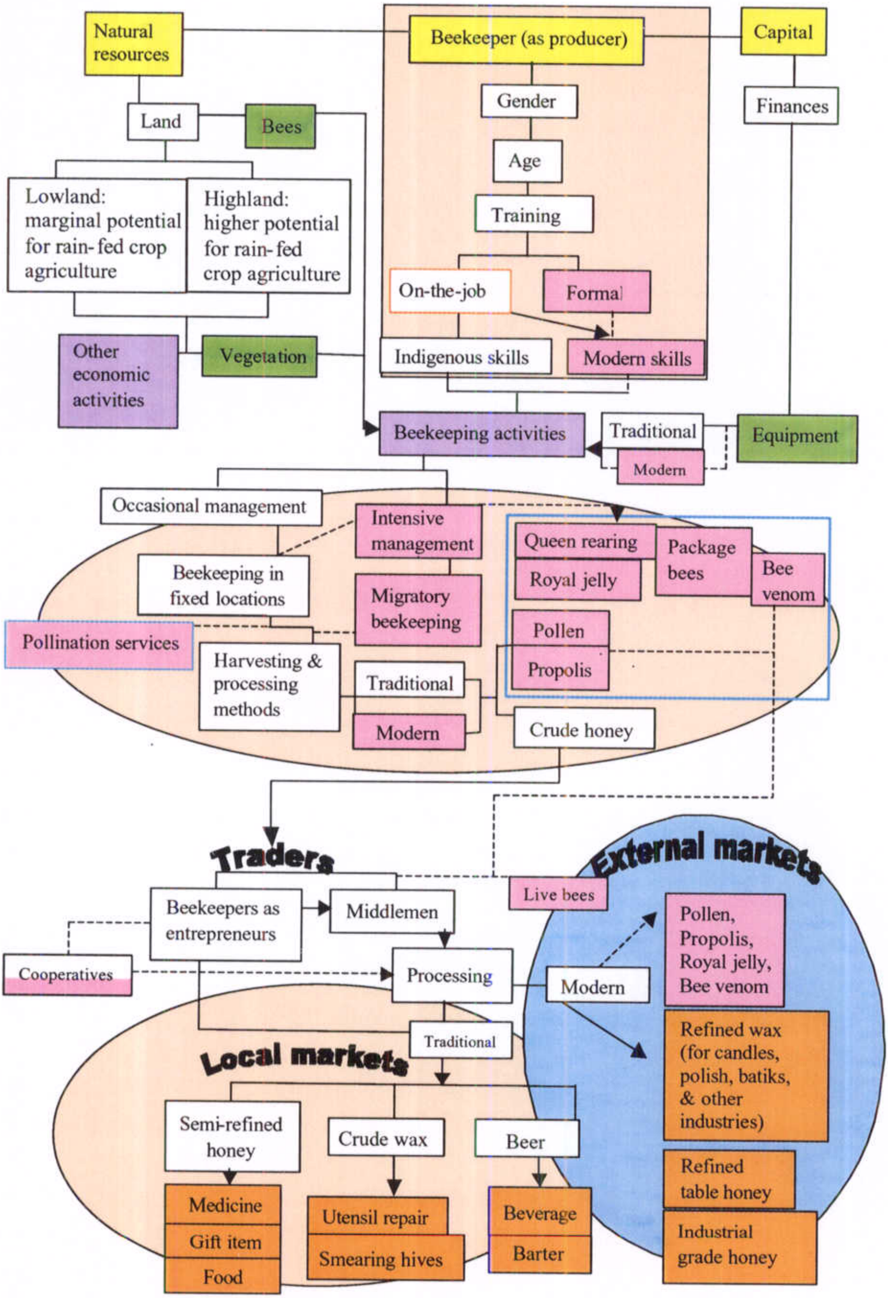

Natural resources
Beekeeper (as producer)
Capital
Land
Bees
Gender
Finances
Age
Lowland: marginal potential for rain-fed crop agriculture
Highland: higher potential for rain-fed crop agriculture
Training
On-the-job
Formal
Other economic activities
Vegetation
Indigenous skills
Modern skills
Beekeeping activities
Traditional
Modern
Equipment
Occasional management
Intensive management
Queen rearing
Package bees
Royal jelly
Bee venom
Beekeeping in fixed locations
Migratory beekeeping
Pollen
Pollination services
Propolis
Harvesting & processing methods
Traditional
Modern
Crude honey
Traders
External markets
Live bees
Beekeepers as entrepreneurs
Middlemen
Pollen, Propolis, Royal jelly, Bee venom
Cooperatives
Processing
Modern
Refined wax (for candles, polish, batiks, & other industries)
Traditional
Local markets
Semi-refined honey
Crude wax
Beer
Refined table honey
Medicine
Utensil repair
Beverage
Gift item
Smearing hives
Barter
Industrial grade honey
Food

Appendix 8: A flow chart outlining the current status and proposed future direction for beekeeping in Baringo District, Kenya. It starts at the top by identifying three key factors of production - namely, natural resources, labor (beekeepers as producers) and capital. It portrays how each factor is related to others in the process by highlighting three phases of production – acquisition of skills and equipment, honeybee colony management activities and marketing of hive products. The current situation (white boxes) is shown alongside the un-exploited potential (pink boxes). It is suggested that this potential can be harnessed by intensifying management using movable frame hives and their accessories and by adopting correct handling procedures at harvest time as well as during product processing, packaging, storage and marketing. Research will be necessary to support adoption of technology under prevailing socio-economic and ecological situations.

LEGEND

- Factors of production
- Existing situation on the ground (2001)
- Main inputs for beekeeping
- Economic activities
- Most accessible avenue for training
- Goods and services to be developed
- **POTENTIAL YET** to be developed
- Beekeepers fully involved
- Beekeepers not involved
- End uses for hive products

→	Direction of input by key components
——	Existing route
------	Potential route