Expanding the Reach. Traditional Ecological Knowledge And Technological Intensification in Beekeeping Among The Ogiek of Mau Forest, Kenya

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Research

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Abstract

Background

Initiatives for the promotion and intensification of beekeeping through the introduction of modern beehives are taking place in East Africa and elsewhere where beekeeping has been a long-standing livelihood practice. When innovations are introduced into people's livelihoods and culture, they can trigger multiple changes, aligned or not with the original intentions.

We carried out fieldwork in the Eastern part of the Mau Forest Complex, focusing on beekeeping activities among Ogiek beekeepers involved in a project aimed at promoting honey production through the modernization of the apiculture sector. The main aim of the study was to explore the relationships, tensions and complementarity of traditional and modern knowledge and practices and the ways in which they are employed in beekeeping strategies among the Ogiek, as well as to reflect on the changes that this intensification process triggers in the livelihoods of the Ogiek and in their relationship with Mau Forest

Methods

We conducted semi-structured interviews and free listing exercises with 30 Ogiek beekeepers. Other methods included guided field walks in apiaries and participant observation. We collected ethnobotanical data about the flora used in beekeeping and ethnographic information on traditional practices of apiary management and honey harvesting and storing.

Results

We report 66 species that are important for beekeeping purposes in 6 main use categories, namely melliferous species, and species used for making hives, placing hives, attracting bees, harvesting and storing honey. Our study reveals that the Ogiek still possess detailed knowledge of the forest's flora and its importance and uses. At the same time, they have moved beekeeping out of the forest into open areas of pasture and crop fields, adopting modern beekeeping techniques. The two beekeeping systems have complementary roles in the livelihoods of the Ogiek and rely on different paths of knowledge transmission and on different plant species. We highlight that modern and traditional beekeeping respond to the challenges and requirements of different ecological settings.

Conclusions

Our study indicates a complementarity of traditional and modern beekeeping and associated knowledge and practices within the livelihoods of the Ogiek, but it also suggests that the process of honey production intensification, by decoupling beekeeping from the forest, may weaken the relationship between the Ogiek and the forest, thus impairing the Ogiek's role as guardians of the forest, and eroding beekeeping-associated TEK. Further studies should target the promotion of forest beekeeping via the intensification of log hive production and valorisation of forest honey and associated TEK as well as floristic diversity.

Introduction

Beekeeping and honey have historically played, and currently have, a very important economic, social and cultural role among rural communities and ethnic groups of Eastern Africa (Crane, 1999). Small-scale apiculture has been a key element in the subsistence of rural and marginal communities. Besides its high nutritional value, honey is central to the cultural life of several indigenous groups and an important ingredient in folk medicine (Kidd & Schrimpf, 2000). Small-scale beekeeping and the traditional knowledge tied to this activity are therefore crucial for food security and food sovereignty across the tropics.

Considering the potential of beekeeping for income generation and poverty alleviation among rural dwellers, national governments and international institutions have implemented apiculture development programs aimed at expanding the practice, modernizing bee management, and increasing honey production (Adal et al., 2015). In East Africa, where forest ecosystems are critically threatened by human encroachment (Rudel, 2013), beekeeping is seen as a sustainable practice, whose maintenance and promotion can contribute to the conservation of forests and associated biodiversity, as well as to the resilience of local communities (Bradbear et al., 2002; Lowore et al., 2018). The strategy at stake in these initiatives is multi-level and aimed at the promotion of production in three main directions: intensification of production in terms of quantity per beehive/beekeeper, improvement of marketability, and expansion in terms of the number of beekeepers and land used. Overall, in the text we refer to *promotion* when speaking of the overall strategy, and to *intensification*, *valorisation* and *expansion* when referring to the individual components. As such, projects involving the promotion of beekeeping include, within their intensification component, initiatives concerning the introduction of modern beehives and techniques, as well as training and extension programs for local beekeepers. Projects of this kind have been developed in the last decade or so in several areas and contexts, and have mainly focused on the replacement of traditional log hives with modern hives, based on the notion that the latter have higher yields than the former (Dietemann et al., 2009). These initiatives have recognized in this strategy a suitable action to foster production and income while contributing to the preservation of ecosystems and their diversity (Anand & Sisay, 2011; Kumar Gupta, 2014). However, in complex social-ecological systems, innovations can have ripple effects that reverberate far and wide, thus re-shaping relationships within communities and between communities and the local environment (Volpato & King 2019). This is due to the fact that the introduction of new production methods like modern beehives can alter the variables and interactions in a system in so many ways that the range of possible outcomes becomes hard to predict (Chapin et al. 2010; Nelson et al. 2007). Because of these complexities, theoretically viable policies to support local livelihoods may have unintended outcomes (Smit & Wandel, 2006). The changes triggered by the introduction of a technological innovation permeate traditional knowledge and practices in multiple ways, and as such should be investigated, understood and embedded into development initiatives.

In Kenya, beekeeping is an integral part of the livelihoods of several ethnic groups and rural communities (Nightingale & Crane, 1983). It plays a fundamental role in communities living in forested areas and in arid and semi-arid areas as well, with most beekeepers relying on indigenous and traditional knowledge and skills, as traditional beekeeping is the most common production method in the country (Carroll & Kinsella, 2013). The practise is carried out in small-scale extensive systems, largely using traditional log hives scattered over large areas of forest and savanna (Affognon et al., 2015).

The promotion of beekeeping has been a central element in the rural development policies of the Kenyan government and international agencies (Heckle et al., 2018). The first attempts at promotion took place in the late 1960s through collaboration between the Ministry of Agriculture, the International Bee Research Association (IBRA), and the NGO Oxfam, with the national government further establishing an apicultural section under the Ministry of Agriculture. These initiatives aimed to increase productivity in the honey sector and facilitate the marketing of bee products by setting up producers' cooperatives (Kigatiira, 1976). The former objective was pursued through a shift from traditional log hives to modern hives (first KTB hives and then, since the early 2000s, Langstroth hives; Fig. 1), as the former were not deemed suitable to meet market demand for honey in terms of quality and quantity (Wilson 2006; Heckle et al., 2018).

Despite the great efforts made to promote and foster modernization of the beekeeping sector, the claimed production potential is still underdeveloped and the contribution of beekeeping to the improvement of rural livelihoods remains unexpressed (Carroll & Kinsella, 2013). Previous studies have reported that the adoption of modern hives has been slow as a result of their high cost for rural dwellers, due to not only the high cost and low availability of materials to build them, but also the lack of training on how to manage modern hives and their scarce adaptability to forest ecologies (Muli et al., 2015; McMenamin, 2017). In this context, while scholars have addressed drivers and variables connected to the adoption of modern hives and beekeeping techniques (Muriuki, 2010; Affognon et al., 2015; Hecklé, 2018), there is still conflicting information about the actual impacts of this innovation on traditional ecological knowledge (hereafter TEK) and on the ways of living in the environment by local communities. These aspects are of particular relevance in those contexts where beekeeping and honey have already been part of traditional livelihood strategies and the culture of rural and indigenous communities, as technological innovations and production intensification can trigger changes that feedback on the complex and dynamic relationships between humans and their surrounding environments, on the knowledge that underpins them, and on the sociocultural role of honey production and consumption (Ingram & Njikeu, 2011).

In order to investigate these issues, this study steps away from a representation that reproduces an antithesis between TEK and modernity (Ingold, 2011; Nyngren, 1999), and explores the relationships, tensions and complementarity of different knowledge and practices and the ways in which they are employed in beekeeping strategies. Specifically, we use beekeeping-associated ethnobotanical knowledge as a proxy for TEK, and ask ourselves in what ways the introduction of modern hives and the socioeconomic and environmental changes that occurred in the last few decades have transformed this knowledge and its related practices among the Ogiek of Mau Forest in Kenya. To this end, we carried out fieldwork in the Eastern part of the Mau Forest Complex, focusing on beekeeping activities among the Ogiek community in a context where local beekeepers are involved in a project aimed at promoting honey production through the modernization of their beekeeping practices. Although scholars have carried out ethnobotanical studies among the Ogiek in the past few decades (Marshall, 2001; Ngari et al., 2010; Amuka et al., 2014), beekeeping-associated TEK has been scarcely investigated and the interplay between modern beehives, TEK, and forest beekeeping has gone unacknowledged.

In this context, the main objectives of this study were: 1) to botanically investigate the main features of the ecological zones in which beekeeping is carried out; 2) to document the diversity of plants used in beekeeping and associated TEK; 3) to explore differences between traditional and modern beekeeping with regard to the knowledge and use of melliferous plants and also the flora used for the construction of beehives and for harvesting and storing honey; and 4) to understand the impacts that modern beekeeping techniques have upon the livelihoods of the Ogiek and their relationship with the forest.

The paper first introduces Mau Forest and the Ogiek community, focusing on the role of beekeeping in this indigenous group. We then present and discuss the results of the ethnobotanical study conducted in Mau Forest and address the established and emerging ecological relationship of Ogiek beekeepers with different areas of the forest and the agricultural frontier in which their livelihoods are embedded. We argue that the Ogiek complementarily use modern and traditional beekeeping technologies and techniques to address the specificities of the different ecological settings of the forest and the cultivated lowlands, in a way that suggests that modern techniques are instrumental in expanding the reach of beekeeping into deforested and cultivated areas. This challenges the assumption that TEK and modern knowledge and practices should be considered as antithetical realities, but opens the way to an exploration of the interactions of the forms of knowledge and the effects on *the livelihoods of the Ogiek* and on *their relationship with the forest*. We argue that beekeeping intensification might be improving the former but weakening the latter.

Background

Mau Forest, located in the Rift Valley of Kenya, is part of the largest remaining closed-canopy montane forest ecosystem in East Africa and the most important water catchment in Kenya (Were et al., 2013; Sloan et al., 2014). Besides being of indispensable value to the country's ecology, Mau Forest is also encroached upon by multiple economic activities such as energy production, agriculture and the timber industry (UNEP, 2008). During the last century, forest ecosystems have suffered from the intensification of anthropogenic activities (e.g. population growth, agricultural expansion, land privatization, logging) that have reduced indigenous forest cover (Klopp & Sang, 2011; Olang & Kundu 2011; Were at al., 2014), as much as 43.5% in the last 40 years in its Eastern part (Kweyu et al. 2020). While until the early 2000s this trend was linked to the conversion of indigenous forest to plantations of exotic trees like cypress and other conifers, in the last two decades the expansion of agriculture has been the main driver of deforestation. The changes in land use due to this advancement of the agricultural frontier have been driven by the quest for farm land by thousands of locals and internal migrants and by land allocation to potential voters by Kenyan politicians (Albertazzi et al., 2018).

Mau Forest has traditionally been inhabited by the Ogiek, a hunter-gatherer group belonging to the Nilotic ethnic mosaic (Huntingford, 1929; Blackburn, 1982; Sang, 2001). In the past, the Ogiek relied on the forest for subsistence, with mobile beekeeping and hunting as the main food procurement activities (Huntingford, 1929, 1955; Blackburn, 1974; Kratz, 1980). Each Ogiek clan had exclusive right of access to transects of land, called *konoito*, which comprised ecological zones located at different altitudes in the forest (Blackburn, 1971; 1982). This way of sanctioning and subdividing forest access was practical for maximizing the likelihood of each clan having enough honey and game throughout the year, as both wild animals and bees move vertically while tracking resources and flowering plants in different seasons in different forest habitats (Kratz, 1994). The Ogiek practiced an extensive beekeeping system based on traditional log hives distributed throughout the *konoito* and located high up in specific trees in the forest. Thousands of beehives were spread across the whole forest and honey production relied on the spontaneous occupation of the log hives by swarms of bees migrating through the forest.

Honey and beekeeping were central to the economic, social, cultural, and religious life of the Ogiek (Blackburn 1971, 1982, Huntingford 1929, 1955; Kratz 1980). Although wild game meat was the central element of the Ogiek diet, at least in quantitative terms, honey permeated their food culture and was used in a variety of preparations. The diversity of melliferous species was connected to a diversity of honey in terms of season of production, taste, colour, and food and medicinal uses. Honey from specific plants was used for brewing honey mead (*rotinik*), as a natural preservative for wild meat, and also as an ingredient for medicinal preparations. Besides their food and medicinal value, honey and its derivatives played a central role in traditional rituals, e.g. in circumcision ceremonies and dowry payments (Blackburn, 1982).

Mau Forest was the place where Ogiek social and cultural practices took place, where they procured the food they needed, and where their identity was rooted. Given its importance as a home and provider, the forest was managed in accordance to a set of ethical principles and customary norms (e.g. access) that defined Ogiek-forest relations. Trees, as constitutive elements of the forest, had an important cultural value and flowers from these trees provided the nectar and pollen needed for the production of a variety of honeys with diverse tastes, colours, properties, appreciation and cultural roles (Huntingford 1929). While the forest was the *oikos* where Ogiek lives unfolded, the unfolding of these lives in turn contributed to culturally shaping the forest and preserving associated biodiversity, leading the Ogiek to consider themselves ‘the guardians of the forest’. Beekeeping and honey were key elements of this interdependence.

However, the relationship between the Ogiek and the forest has changed in the last century with the encroachment of economic and extractive activities and a concurrent commodification of Ogiek livelihoods. Beginning in 1932, when Mau Forest was proclaimed Crown Land, and again in 1954, when the forest was declared a natural reserve and its management entrusted to the Ministry of Forest (Sang, 2001), the Ogiek were progressively evicted from the forest and resettled at mid-altitude, where they began growing crops and rearing livestock. Although relocation was explained as a way to protect the forest (as if Ogiek livelihoods and forest conservation could not coexist), exploitation of the forest for agricultural and extractive activities intensified when the establishment of exotic tree plantations to support the growth in the demand for timber predominated (Huntingford, 1929; Kimaiyo, 2004). In 1993, following a survey carried out by the Ministry of Environment and Natural Resources through the Kenya Indigenous Forest Conservation Programme (KIFCON), it was further suggested to resettle communities living close to the forest to guarantee its conservation (Lambrechts et al. 2007; Klopp & Sang, 2011; Langat et al., 2016). Eventually, the Ogiek filed a constitutional case against the Kenyan government in June 1997 to invalidate the settlement scheme and have their traditional land-resource tenure system recognized (Aka, 2017). This case was resolved in 2017 with the verdict of the African Court on Human Rights and Peoples’ Rights which found the Kenyan Government guilty of violating the rights of the Ogiek and recognized Mau Forest as their ancestral home and their role in safeguarding it (Majekolagbe & Akinkugbe, 2019).

After the promulgation of the Forest Act in 2005, the Ogiek and other indigenous communities living near Kenyan forests were granted management through Community Forest Associations (CFA) and allowed to once again carry out productive activities in the forest (Aka, 2017; Mutune et al., 2017). Some Ogiek communities, under the guidance of the Kenyan Government and international NGOs, have formed self-help groups (SHGs) and community-based organizations (CBOs). Members of the groups are involved in several activities such as agriculture, livestock keeping, planting of indigenous trees, and beekeeping, often receiving technical and financial aid from outsiders (Micheli, 2014a, 2014b; Chabeda-Barthe & Haller, 2018).

A century of displacement, replacement, and negotiation of their relationship with the forest eventually led the Ogiek to a more sedentary life, thus reducing their reliance on the forest itself (Kratz, 1980; Marshall, 2001; Micheli 2014b). At the same time, they experienced significant changes in their livelihoods and in their management of forest resources, which shifted from a subsistence model based on hunting and gathering to a system that integrated traditional livelihood activities with cash crop farming, which is influenced by external actors and introduced technologies, ideologies, and social relationships. It is within this socioeconomic and ecological framework that current beekeeping practices among the Ogiek should be understood.

Methods

Description of the study area

Fieldwork was conducted between August 2019 and February 2020 among Ogiek communities living in the Eastern Mau Escarpment. The study area is in the Mariashoni District, Molo Sub County, Nakuru, and covers 345.5 km2, extending from 2,100 m to 3,000 m above sea level (GOK, 2009). The major geomorphological features of the Mau Forest Complex include escarpments, hills, and plains. The climate is humid, with temperatures varying according to altitude and topography. The area has a bimodal rainfall pattern, with long rains between May and June and a short rainy season between September and November. Mean annual precipitation is 1,200 mm and mean annual temperature ranges from 12 to 16 °C, with the greatest diurnal variation occurring during dry seasons (Kundu, 2007).

The Eastern Mau Complex can be divided into four ecological areas: an open bushy forest at the edge of the plains (up to 2,100 m a.s.l.), a more dense forest with large evergreen, semi-deciduous and deciduous trees (2,100-2,600 m a.s.l.), an upper bamboo forest (higher than 2,600 m a.s.l.), and open grassland (2,800-3,000 m a.s.l) (Kratz, 1994). Floristically, there are both indigenous and exotic tree species in the area. *Juniperus, Podocarpus* and *Olea* species, which predominated in the past, have been cleared and replaced with conifer plantations (*Cupressus lusitanica* Mill., *Pinus patula* Schiede ex Schltdl. & Cham., and *Pinus radiata* D.Don) and eucalyptus (*Eucalyptus* spp.) trees. Indigenous shrubs and trees such as *Prunus africana* (Hook.f.) Kalkman, *Olea capensis* subsp. macrocarpa (C.H.Wright) I.Verd. and *Podocarpus latifolius* (Thunb.) R.Br. ex Mirb. are still present in less disturbed areas (Sang, 2001; Were et al., 2013; Albertazzi et al., 2018).

Figure 2 Map showing the study area and the visited localities (GPS points were recorded during fieldwork).

Ogiek livelihoods and honey production

Currently, the majority of the Ogiek in Kenya live in the Eastern Mau Escarpment, especially in the Mariashoni District. Of the 12,000 people currently living in the area, 4,000 are Ogiek. The area is also inhabited by Kikuyu, Kipsigis and Nandi communities (Micheli, 2014b).

Mariashoni village (S 0°22'06" E 35°49'28") is one of the most important trade and business centres in the Eastern part of the Mau Forest region. The economy of the area is based on cash crop farming (maize, potatoes, peas, and wheat), subsistence farming, and livestock rearing (cattle, sheep, and goats) (Kweyu, 2020). The Ogiek of Mariashoni live in small villages located at middle and lower altitudes (2,400–2,700 m a.s.l.), usually far from the remaining indigenous forest. Families own small plots of land where they grow agricultural crops and rear livestock (Micheli, 2016). Their major source of income is agriculture, with maize and potatoes the most important cash crops. The Ogiek sell their produce to middlemen at their homestead or they trade in the surrounding commercial centres such as Mariashoni, Elburgon, and Molo. While agricultural activities play a central role in the livelihoods of the Ogiek, members of the communities living in Mariashoni and the surrounding villages are allowed to carry out hunting and beekeeping in the forest, as long as they are part of the Community Forest Association (CFA).

While in the past honey was used for domestic consumption and informal exchanges, it has now also become an important source of income for local families. Honey is traded locally and in the nearest towns, from where it is then transported to major cities such as Nakuru and Nairobi. Since 2012, Ogiek beekeepers have been part of the Mariashoni Community Development Community-Based Organization (MACODEV CBO), which brings together around 350 beekeepers, organized into 12 SHGs, living in the villages and settlements of Mariashoni, Kiptunga, Ndoswa, Songwi, Lawina, Tertit, Kavorogo, Naisuat, Pergut, Orateg, and Savo (Manitese, 2019; Necofa, 2019). The cooperative aims to preserve the remaining indigenous forest by maintaining and promoting honey production and Ogiek cultural heritage. The MACODEV CBO finds its origin within a wider context of cooperation and development projects promoted in the area since 2004 by the Kenyan Ministry of Agriculture and the Kenyan NGO Network for Ecofarming in Africa (NECOFA). In this context, two Italian NGOs (Manitese and Ethnorêma) joined the project through a partnership with NECOFA. The main aim of the collaboration was to improve the livelihoods of the Ogiek in the field of sustainable agriculture and beekeeping. The first interventions carried out by the three NGOs were aimed at increasing honey production and marketing through a community-led project on beekeeping. Local beekeepers were introduced to modern beekeeping by way of training and workshops, and modern beehives and equipment were given for free to the SHGs, exposing the community to a new intensive method of production based on the use of modern beehives (KTBH and Langstrogh). After the launch of a community action plan in 2011, the MACODEV CBO was established (Manitese, 2019), and with its financial support members of the community-based organization started a refinery unit in Mariashoni, increasing their trade of honey. Eventually, in 2015, Slow Food Kenya and Slow Food International launched a project to promote Ogiek honey, preserve the Ogiek people’s cultural heritage and protect Mau Forest. In regard to beekeeping, the initiative pursues the improvement of product quality, the promotion of value-addition activities, and the creation of market channels. Since 2017, the International Fund for Agricultural Development (IFAD) joined the project via collaboration with Slow Food International (Slow Food, 2019).

Data collection

We collected ethnobotanical data on the local names of plants, their phenology, ecology and uses in beekeeping, as well as ethnographic information on traditional practices of apiary management and honey harvesting and storing, through in-depth semi-structured interviews, guided field walks in apiaries, participant observation, and a free listing exercise about the plants used in beekeeping. We conducted 30 semi-structured interviews and free listing exercises with Ogiek beekeepers that were members of 8 different SHGs, and 10 additional interviews with other relevant stakeholders (i.e. cooperative workers, non-Ogiek beekeepers, NGO representatives). Interviewees were selected in collaboration with the MACODEV CBO in order to be representative of the local population of producers in terms of age, gender, residence, and involvement in the honey sector. Most informants owned individual traditional log hives and belonged to a group with modern beehives. The apiaries were located in Mariashoni and surrounding areas, especially Kiptunga, Ndoswa and Songwi, at an altitude ranging from 2,350 m to 3,000 m a.s.l.

During the interviews, we asked informants to describe the diversity of plants and flowers used for beekeeping, their folk names, distribution, and uses (e.g. as melliferous plants, to build hives, to smoke out bees when harvesting honey, to store honey). We also collected information about beekeeping methods and tools, technical aspects related to the type of hive used, location of their apiaries, criteria used for their establishment, and management techniques. We paid particular attention to the differences between traditional and modern hives in association with knowledge about melliferous and other plants used for beekeeping purposes. During the walk-in-the-woods approach (Cunningham, 2001), we accompanied beekeepers in the forest and at hive locations during two different seasonal periods (January and August) and asked them to mention, among the plants we encountered, each species used in beekeeping and by bees in honey production.

Before each interview, informed consent was obtained from each interviewee, as recommended by the code of ethics of the International Society of Ethnobiology, and informants were explained in advance the rationale, aims, methods, and expected outputs of the project (ISE, 2008). Interviews were conducted in Swahili and Ogiek, in the presence of at least one research assistant that translated to and from English, and recorded with a digital voice recorder and then transcribed into English. For each plant species named by informants, voucher specimens were collected and used as prompts in other interviews for the purposes of triangulation of the information. For some plants for which specimens were not available, probable identification was obtained by asking the informants to describe the plant and its habitat and by comparing the recorded folk names with the existing literature (Beentje, 1994; Maundu, & Tengnäs, 2005; Agnew, 2013).

A vegetation survey was conducted in 8 apiary sites located in different ecological zones. The locations of the apiaries were recorded with GPS (global positioning system) and are reported in Table 1. Purposive sampling was employed during guided field walks along forest transects and through buffer zones. Specimens were then deposited in the Herbarium (NAI) of the University of Nairobi. Species identifications were made by the authors according to *Upland Kenya wild flowers and ferns: A flora of the flowers, ferns, grasses, and sedges of highland Kenya* (Agnew, 2013) and *Kenya trees, shrubs, and lianas* (Beentje, 1994). For botanical nomenclature, we followed the criteria set by the The Plant List Database (Plant List, 2013). Folk names were transliterated into the Roman alphabet with the help of a local research assistant fluent in Ogiek and English. Additionally, we consulted several bibliographic sources to confirm species names and uses (Beentje, 1994; Maundu, & Tengnäs, 2005; Agnew, 2013; Ingram et al., 2017; Onyango et al., 2019)

Table 1
Localization of the apiaries where the vegetation survey was conducted (GPS points were recorded during the fieldwork).

	Location	Altitude	Gps coordinates	Apiary
Site 1	Ndoswa	2480 m	S 0°21'48.45524" E 35°51'56.53972"	Modern hives (KTBH and Langstrogh) Traditional log hives
Site 2	Ndoswa	2520 m	S 0°21'48.97373" E 35°51'28.47342"	Modern hives (KTBH and Langstrogh) Traditional log hives
Site 3	Ndoswa	2553 m	S 0°21'32.27474" E 35°51'20.26846"	Modern hives (KTBH and Langstrogh) Traditional log hives
Site 4	Mariashoni	2649 m	S 0°22'10.86279" E 35°49'29.78768"	Modern hives (KTBH and Langstrogh) Traditional log hives
Site 5	Songwi	2835 m	S 0°27'40.64338" E 35°45'27.44520"	Traditional log hives
Site 6	Kiptunga	2924 m	S 0°27'18.66697" E 35°47'51.39118"	Modern hives (Langstrogh)
Site 7	Kiptunga	2927 m	S 0°27'25.90239" E 35°47'29.69104"	Traditional log hives
Site 8	Songwi	2938 m	S 0°25'25.26289" E 35°48'40.30319"	Traditional log hives

Interview transcripts were entered into NVivo qualitative data analysis software (version 12.5.0 - QSR International, Melbourne, Australia), and codes, concepts, and categories were generated during the analysis (Wainwright & Russell, 2010). All the data were organised and subsequently selected and condensed as tables. Data were analysed to identify the diversity of plants used in beekeeping and its associated knowledge regarding means of use and distribution in the surveyed areas. The relevance of the species was calculated based on the number of mentions by the interviewees. We lastly carried out a comparative analysis between species use and associated knowledge in modern and traditional beekeeping.

Results

Beekeeping: Areas, methods, apiaries, and management

An emic classification of the forest in association with beekeeping emerges from the interviews. It includes three main zones which the beekeepers distinguished on the basis of altitude and vegetation types: Lower Forest (2,300-2,600 m), Central Forest (2,600-2,800 m), and Upper Forest (2,800-3,000 m). The main distinction was drawn between the Upper and Lower Forest, while the Central Forest was regarded more as a transition zone with features of the other two.

The beekeepers highlighted different features in the floral composition of the three zones. In particular, they reported a progressive reduction of indigenous melliferous species, especially trees, moving from the Upper Forest to areas at lower altitudes. While in the Upper Forest and to a lesser extent in the Central Forest beekeeping was tied to the presence of indigenous species, in the Lower Forest the forest coverage decreased, being replaced by exotic tree plantations and plots of land cultivated with tubers and cereals. Hence, what the Ogiek have traditionally called the Lower Forest is actually no longer a forest and the landscape is one of an agricultural frontier, with cultivated plots, pastureland, and rows of exotic trees planted among the fields.

In regard to beekeeping systems, the research highlighted the heterogeneity of beekeeping activities in the area, which combine traditional and modern practices. An extensive beekeeping system based on traditional log hives and an intensive one that has adopted modern beehives (KTBH and Langstrogh) coexist and intersect in Ogiek livelihoods. Indeed, three main types of beehives were used in the study area: 1) traditional log hives, which are made from hardwood trees and have fixed combs as in a wild colony; 2) Langstroth hives, which are the typical Western-style hive with movable frames; and 3) Kenyan top-bar (KTB) hives, which employ movable top bars rather than frames (Adjare, 1990). These different hives were not used interchangeably but rather their use depended on several variables such as differential accessibility to hives and/or the material and skills to build them, intended ecological location, primary purpose (e.g. home-consumption, income generation), and social and cultural aspects (e.g. attachment to Ogiek cultural identity, food and medicinal properties of honey, etc.). Nonetheless, there was a clear spatial differentiation in the positioning of hives across the Mau landscape, with log hives in the forest and the two modern kinds of hives out of the forest, in and around cultivated fields. Because much of the spatial differentiation in the Mau landscape is vertical, with the agricultural frontier pushing into the forest from lower to higher altitudes, log hives predominated over modern hives at higher altitudes, and vice versa.

During field visits, we observed log hives especially inside the Upper Forest. They were hung on the branches of trees at a height of 5–10 metres above the ground and were spread across the forest at low density. In the Upper Forest area, we recorded only one apiary with modern hives. According to the informants, this is due to the fact that modern beehives do not perform well inside the forest because of cold temperatures, the presence of predators (e.g. honey badgers, safari ants), and disturbance by livestock grazing in the forest. All of these hazards increase the likelihood of bees abandoning the hive and migrating elsewhere.

In the cultivated lowlands modern beehives predominated. Apiaries were placed close to each other in fenced in open spaces (e.g. farmed fields, pastureland), preferably in the hedges of the remaining forest patches and with sources of water nearby. Some log hives were also present, usually in the same apiary in which modern hives were located or close to homesteads. In the latter case, and in contrast to the traditional setting, log hives were placed closer to the ground (1–3 m high).

All male, but no female, informants owned individual log hives in the forest, while modern hives were the property of each SHG. About 70–75% of the hives owned by members of the MACODEV CBO were traditional log hives, but their relative presence has been decreasing in favour of modern beehives in the last few years.

Diversity of species used in beekeeping

The plant species mentioned in the interviews and used by the Ogiek for beekeeping purposes are listed in Table 2, in alphabetical order of botanical name. For each species, we report the botanical name, botanical family, local plant name, growth habit, part(s) used, use in beekeeping, and relevance (calculated based on the number of mentions by the interviewees). In total, 66 species (65 plants and 1 lichen) were recorded during the interviews. The species were distributed across 36 botanical families representing 58 genera. Of these, 31 species have previously been reported in earlier studies that explored the knowledge of Ogiek beekeepers with regard to the local flora (Ichikawa, 1980; Ingram et al., 2017; Onyango et al., 2019). The vernacular names of 29 plants and their uses in beekeeping were also mentioned in ethnographic research carried out among Ogiek communities of Mau Forest (Huntingford, 1929, 1955; Blackburn, 1971; Kratz, 1990; Micheli, 2014b).

Table 2
PLANT SPECIES MENTIONED BY THE OGIEK FOR BEEKEEPING PURPOSES IN ALPHABETICAL ORDER OF BOTANICAL NAME.

Botanical name **Voucher specimen code**	**Family**	**Recorded folk name(s)**	**Growth Habit***	**Part(s) mentioned**	**Use(s)**	**Frequency of citation****
Abutilon mauritianum (Jacq.) Medik. (DMZ2020/001)	Malvaceae	Goldoiywet	S	Flower	Melliferous	+
Achyranthes aspera L. (DMZ2020/002)	Amaranthaceae	Sarurieet ap tisieet	H	Flower	Melliferous	++
Alchemilla sp. (DMZ2020/003)	Rosaceae	Nyaek***	H	Flower	Melliferous	++
Allophylus abyssinicus (Hochst.) Radlk. (DMZ2020/004)	Sapindaceae	Gipkosoriet / Maraisit	T	Flower	Melliferous	+++
Baccharoides lasiopus (O.Hoffm.) H.Rob (DMZ2020/005)	Asteraceae	Seregutiet	S	Flower	Melliferous	++
Brassica oleracea L. (DMZ2020/006)	Brassicaceae	Cabbage / Mboga	H	Flower	Melliferous (bees drink water from the leaves)	+
Brassica oleracea var. *viridis* L. (DMZ2020/007)	Brassicaceae	Sukuma wiki	H	Flower	Melliferous	+
Brassica rapa L. (DMZ2020/008)	Brassicaceae	Mulo	H	Flower	Melliferous	++
Carduus nyassanus subsp. *kikuyorum* (R.E.Fr.) C. Jeffrey (DMZ2020/009)	Asteraceae	Tegweyot	H	Flower	Melliferous	++

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

**** Frequency of citation: +++++: mentioned by 70% of the informants or more; ++++: mentioned by 50–70% of the informants; +++: mentioned by 30–50% informants ++: mentioned by 10–30% of the informants; +: mentioned by less than 10% informants.**

***** Nyaeck is a collective name of several herbaceous species used as a source of nectar and pollen by bees.**

Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
Carduus schimperi Sch. Bip (DMZ2020/010)	Asteraceae	Tegweyot / Nyaek ***	H	Flower	Melliferous (source of pollen)	++
Clematis simensis Fresen. (DMZ2020/011)	Ranunculaceae	Pisinda	CS	Bark	Ropes (ropes made from the woven fibres are used to fix the bark stripes around the log hives)	+
Clutia abyssinica Jaub. & Spach (DMZ2020/012)	Peraceae	Kiparnyat	S	Flower	Melliferous	+
Combretum molle R.Br. ex G.Don (DMZ2020/013)	Combretaceae	Kemeliet	T	Flower	Melliferous (source of pollen)	+
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight; mostly in lowlands)	+
Crassocephalum montuosum (S.Moore) Milne-Redh (DMZ2020/014)	Asteraceae	Musumioit	S	Flower	Melliferous	++
Cupressus lusitanica Mill. (DMZ2020/015)	Cupressaceae	Cypress	T	Flower	Melliferous	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Making beehives (timber used mostly for modern beehives)	+++
Cyathula cylindrica Moq. (DMZ2020/016)	Amaranthaceae	Mutumiat	CS	Flower	Melliferous	+
Dombeya torrida (J.F.Gmel.) Bamps (DMZ2020/017)	Malvaceae	Silibwet / Mukeo	T	Flower	Melliferous (considered the best source of nectar, producing the most valued honey)	+++++
				Branches	Smoking hives (smoke from burning branches is blown inside the log hive to stun the bees, before extracting the honeycomb)	+
					Attracting bees (branches are burnt inside the modern hives)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive)	+
Dovyalis abyssinica (A.Rich.) Warb. (DMZ2020/018)	Salicaceae	Nukiat / Kigorwet	T	Flower	Melliferous	++
Eucalyptus sp. (DMZ2020/019)	Myrtaceae	Eucalyptus / Blue gum	T	Flower	Melliferous	++++
				Trunk	Making beehives (timber used mostly for modern beehives)	+
Grevillea robusta A.Cunn. ex R.Br. (DMZ2020/020)	Proteaceae	Gravelia	T	Flower	Melliferous	++
				Trunk	Making beehives (timber used mostly for modern beehives)	+
Hagenia abyssinica (Bruce ex Steud.) J.F.Gmel (DMZ2020/021)	Rosaceae	Pontet	T	Flower	Melliferous (source of pollen)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	++
Helianthus annuus L. (DMZ2020/022)	Asteraceae	Sunflower	S	Flower	Melliferous	++
Helichrysum argyranthum O.Hoffm (DMZ2020/023)	Asteraceae	Karabwet	H	Flower	Melliferous	+++
Hymenophyllum sp. (DMZ2020/024)	Hymenophyllaceae	Susuot	H	Flower	Melliferous	+
				Leaves	Harvesting tools (to clean hands and the leather bag (*motoget*) after harvesting the honey)	++
					Harvesting tools (to cover the hole (*keruet*) in the centre of the log hive from which honey is harvested)	+
Hypoestes verticillaris (L.f.) Sol. ex Roem. & Schult. (DMZ2020/025)	Acanthaceae	Nerubat netui	H	Flower	Melliferous (source of pollen)	++

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
Ilex mitis (L.) Radlk. (DMZ2020/026)	Aquifoliaceae	Tongotwet	T	Flower	Melliferous	++
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	+
					Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive)	+
Jasminum abyssinicum Hochst. ex DC (DMZ2020/027)	Oleaceae	Mogoiywet	CS	Flower	Melliferous	++
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight; mostly in lowlands)	
Juniperus procera *Hochst.* ex Endl. (DMZ2020/028)	Cupressaceae	Torokuet	T	Bark	Covering of hives (before hanging the log hive on tree, it is covered with bark stripes)	+++

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
					Attracting bees (pieces of dry bark are burnt inside modern hives)	+
					Smoking hives (to smoke traditional log hives along with *Usnea* sp. before extracting the honeycomb)	+++
				Branches	Storing honey (in the past honey was stored in a hollowed log of *Juniperus procera* (called *kisungut*) placed one to few metres above the ground over a wooden frame in the forest)	++
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	++

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
					Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive; considered the best option for the log hive)	++++
Kniphofia thomsonii Baker (DMZ2020/029)	Xanthorrhoeaceae	Yamyamt	S	Flower	Melliferous (source of pollen)	++
Leonotis nepetifolia (L.) R.Br. (DMZ2020/030)	Lamiaceae	Mosipichiet	S	Flower	Melliferous	++
Lobelia bambuseti R.E.Fr. & T.C.E.Fr. (DMZ2020/031)	Campanulaceae	Kabosuet	S	Flower	Melliferous	+++
Lobelia giberroa Hemsl. (DMZ2020/032)	Campanulaceae	Tangaratwet	S	Flower	Melliferous	++
Microglossa pyrifolia (Lam.) Kuntze (DMZ2020/033)	Asteraceae	Komereriet	S	Flower	Melliferous	++
				Bark	Ropes (dry fibres (*sagoet*) to tie the two halves of the log hive)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Bark	Storing honey (dry fibres of *Microglossa pyrifolia* and *Yushania alpina* are interwoven to make a bag called *polleita*)	+
Micromeria imbricata (Forssk.) C.Chr (DMZ2020/034)	Lamiaceae	Chepsagitiet	H	Flower	Melliferous (source of pollen)	+
Mikaniopsis bambuseti (R.E.Fr.) C.Jeffrey (DMZ2020/035)	Asteraceae	Sereret	CS	Flower	Melliferous	++
				Branches	Harvesting (to climb the tree when the honey is harvested)	+
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight; mostly in lowlands)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
Mimulopsis alpina Chiov. (DMZ2020/036)	Acanthaceae	Sosonet	S	Flower	Melliferous (flowering takes places every 10–12 years. When it flowers, no circumcision ceremonies are held. It is a considered a bad omen)	++
Musa × paradisiaca L. (DMZ2020/037)	Musaceae	Banana / Ndizi	S	Flower	Melliferous	++
				Leaves	Covering hive (dry leaves to cover the traditional log hive before hanging the log hive on tree)	+
					Storing honey (basket to transport and store honey)	+
Nuxia congesta R.Br. ex Fresen. (DMZ2020/038)	Stilbaceae	Choruet	T	Flower	Melliferous (bees feed on it mainly during rainy season)	+++
Olea capensis subsp. *macrocarpa* (C.H.Wright) I.Verd. (DMZ2020/039)	Oleaceae	Masaita	T	Flower	Melliferous	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	+
					Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive; considered the best option for the log hive)	+
Olea europaea subsp. *cuspidata* (Wall. & G.Don) Cif (DMZ2020/040)	Oleaceae	Emitiot / Yemitioot	T	Flower	Melliferous	+
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	+
Oxalis corniculata L. (DMZ2020/041)	Oxalidaceae	Nyaek	H	Flower	Melliferous	++
Phaseolus vulgaris L. (DMZ2020/042)	Fabaceae	Bean / Maragwe	H	Flower	Melliferous	+
Pinus patula Schltdl. & Cham. (DMZ2020/043)	Pinaceae	Pine	T	Flower	Melliferous	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Making beehives (timber used mostly for modern beehives)	++
Pittosporum viridiflorum Sims (DMZ2020/044)	Pittosporaceae	Toponit	T	Flower	Melliferous	++
				Trunk	Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive; considered the best option for the log hive)	+
Plagiochila sp. (DMZ2020/045)	Plagiochilaceae	Susuot	Tr	Leaves	Harvesting tools (to clean hands and the leather bag (*motoget*) after harvesting the honey)	++
					Harvesting tools (to cover the hole (*keruet*) in the centre of the log hive from which the honey is harvested)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**
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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
Plectranthus sp. (DMZ2020/046)	Lamiaceae	Korpisiot	H	Leaves	Harvesting tools (To clean hands and clothes after harvesting the honey)	+
Podocarpus latifolius (Thunb.) R.Br. ex Mirb (DMZ2020/047)	Podocarpaceae	Saptet	T	Bark	Covering beehive (before hanging the log hive on tree, it is covered with bark stripes)	+
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	++
					Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive; considered the best option for the log hive)	++
Polyscias kikuyuensis Summerh. (DMZ2020/048)	Araliaceae	Ounet	T	Flower	Melliferous	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	+
					Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive; considered the best option for the log hive; softwood)	++
Prunus africana (Hook.f.) Kalkman (DMZ2020/049)	Rosaceae	Tenduet	T	Flower	Melliferous	+
				Bark	Covering beehive (before hanging the log hive on tree, it is covered with bark stripes)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	++
					Making beehives (the trunk is split in two in a longitudinal sense and used to build the log hive; considered the best option for the log hive)	+
Prunus sp. (DMZ2020/050)	Rosaceae	Plums	S	Flower	Melliferous	+
Rapanea melanophloeos (L.) Mez (DMZ2020/051)	Primulaceae	Korapariat	T	Flower	Melliferous (source of pollen)	+
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
Rhoicissus tridentata (L.f.) Wild & Drumm. (DMZ2020/052)	Vitaceae	Ingirenyit	S	Flower	Melliferous	+
Rubus pinnatus Willd. (DMZ2020/053)	Rosaceae	Chepseonik	S/CS	Flower	Melliferous	+
Rubus steudneri Schweinf. (DMZ2020/054)	Rosaceae	Taktakuet	CS	Flower	Melliferous	++
Schefflera volkensii (Harms) Harms (DMZ2020/055)	Araliaceae	Chelumbut	T	Flower	Melliferous	++
				Trunk	Placing hives (log hives are placed at the bifurcation of two branches strong enough to hold their weight)	+
Scutia myrtina (Burm.f.) Kurz (DMZ2020/056)	Rhamnaceae	Simbeywet	CS/T	Flower	Melliferous	+++
Searsia natalensis (Bernh. ex C.Krauss) F.A.Barkley (DMZ2020/057)	Anacardiaceae	Sirondit	S	Flower	Melliferous	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Placing hives (modern hives are placed under the canopy of the shrub)	+
Senna didymobotrya (Fresen.) H.S.Irwin & Barneby (DMZ2020/058)	Fabaceae	Senetuet	S	Flower	Melliferous	+
Solanum nigrum L. (DMZ2020/059)	Solanaceae	Wild managu	H	Flower	Melliferous	+
Solanum tuberosum L. (DMZ2020/060)	Solanaceae	Potato	H	Flower	Melliferous	++
Syzygium cordatum Hochst. ex Krauss (DMZ2020/061)	Myrtaceae	Lamaywet	T	Flower	Melliferous	+
Trifolium burchellianum Ser. (DMZ2020/062)	Fabaceae	Dabibit / Puputiet / Nyaek***	H	Flower	Melliferous (bees make propolis from it)	++
Usnea sp. (DMZ2020/063)	Parmeliaceae	Kurongurik	L	Leaves	Smoking hives (dry lichens are burnt with the bark of *Juniperus procera*, before harvesting the honeycomb)	+++

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

**** Frequency of citation: +++++: mentioned by 70% of the informants or more; ++++: mentioned by 50–70% of the informants; +++: mentioned by 30–50% informants ++: mentioned by 10–30% of the informants; +: mentioned by less than 10% informants.**

***** Nyaeck is a collective name of several herbaceous species used as a source of nectar and pollen by bees.**

Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
					Attracting bees (dry lichens are burnt inside modern hives)	+
Vernonia auriculifera Hiern (DMZ2020/064)	Asteraceae	Tepengwet	S	Flower	Melliferous	++
				Branches	Smoking hives (smoke from burning branches is blown inside the log hive to stun the bees, before extracting the honeycomb)	+
Yushania alpina (K.Schum.) W.C.Lin (DMZ2020/065)	Poaceae	Teegat	S/T	Flower	Melliferous	++
				Leaves	Harvesting tools (to cover the hole (*keruet*) in the centre of the log hive from which the honey is harvested)	+
				Branches	Smoking hives (dry branches cut into small pieces mixed with the branches of *Dombeya torrida* before harvesting the honeycomb)	+

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

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***** Nyaeck is a collective name of several herbaceous species used as a source of nectar and pollen by bees.**

Botanical name Voucher specimen code	Family	Recorded folk name(s)	Growth Habit*	Part(s) mentioned	Use(s)	Frequency of citation**
				Trunk	Storing (mature trunks are cut and one side is covered with cow or sheep skin. The container, called *soyet*, is used to transport and store honey)	++
Zea mays L. (DMZ2020/066)	Poaceae	Maize / Maindi	S	Flower	Melliferous	++++

*** Growth habit: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.**

**** Frequency of citation: +++++: mentioned by 70% of the informants or more; ++++: mentioned by 50–70% of the informants; +++: mentioned by 30–50% informants ++: mentioned by 10–30% of the informants; +: mentioned by less than 10% informants.**

***** Nyaeck is a collective name of several herbaceous species used as a source of nectar and pollen by bees.**

Asteraceae and Rosaceae were the most represented plant families with 9 and 6 species, respectively, largely reported as melliferous. Fabaceae, Brassicaceae, Lamiaceae and Oleaceae were represented by 3 species each, while the other plant families by only one or two species. The information concerning growth habit highlights that trees were the most mentioned category (30.88%), followed by shrubs (26.47%), herbs (25%), and climbing species (7.35%) (Fig. 3). The predominance of trees and shrubs is in line with previous work that reported their greater importance for African beekeepers (Adal et al., 2015; Onyango et al., 2019), and could be expected given the high reliance of Ogiek beekeeping on the forest for both melliferous species and construction purposes, as well as the embeddedness of Ogiek traditional cultural in the forest ecosystem and its main constitutive element, i.e. trees.

In regard to the plant parts most important for beekeeping purposes, flowers represented 60% of the total, followed by the trunk (22%), leaves (7%), bark (6%), and branches (5%). The relative predominance of flowers reflects the fact that most of the species mentioned were melliferous plants used by bees as sources of nectar and pollen, while other parts were used as a source of timber and bark for hive construction (log hives and modern beehives) and in other steps of beekeeping and honey production (e.g. honey harvesting and storing). In several cases, multiple parts of the same species were used.

Species used and vertical zoning

In regard to the floristic composition of the different areas, informants made a significant distinction between the species found in the Upper Forest and those in the cultivated lowlands. In the upper zone, regarded as that which remains of the original forest, the diversity of trees and shrubs mentioned for their use in beekeeping was high: out of the 66 plant species listed, 59 were in the Upper Forest, and they were largely trees. The species most often mentioned included *Nuxia congesta* R.Br. ex Fresen., *Dombeya torrida* (J.F.Gmel.) Bamps, *Podocarpus latifolius* (Thunb.) R.Br. ex Mirb, and *Ilex mitis* (L.) Radlk. On the edges of the Upper Forest, *Yushania alpina* (K.Schum.) W.C.Lin, *Micromeria imbricata* (Forssk.) C.Chr, *Trifolium* *burchellianum* Ser., *Lobelia bambuseti* R.E.Fr. & T.C.E.Fr., *Helichrysum argyranthum* O.Hoffm, and *Microglossa pyrifolia* (Lam.) Kuntze were the most common species.

A different situation emerges in the cultivated lowlands. The density and diversity of indigenous species decreased with lower altitudes. While in the Central Forest, beekeepers still relied on trees and shrubs as main nectar sources for bees and materials for beekeeping equipment, exotic trees and crops such as maize, eucalyptus (*Eucalyptus* sp.), and potato were mentioned as important species as well. On the other hand, in the Lower Forest, maize, bean, sunflower, *Eucalyptus* sp., *Grevillea robusta* A.Cunn. ex R.Br. and *Cupressus lusitanica* Mill., all exotic and/or cultivated species, were the most valuable species for beekeeping. Both for the Lower and Central Forest, however, informants also mentioned some indigenous plants like *Dombeya torrida*, *Nuxia congesta*, *Trifolium burchellianum*, *Leonotis nepetifolia* (L.) R.Br., and *Polyscias kikuyuensis* Summerh., as individual trees of these species still stand in the remaining patches of riverside forest and in the hedges of cultivated fields.

The findings from the interviews are in line with the results of the vegetation survey carried out in 8 different locations. The species most often mentioned by beekeepers were all identified in at least one site during the survey. *Dombeya torrida* was the only species found in all the locations, being a typical secondary species in montane forest. In the Upper Forest, *Podocarpus latifolius* was reported in 3 of the 4 apiaries while *Nuxia congesta* and *Ilex mitis* were found only in one site each. In the Lower and Central Forest, *Leonotis nepetifolia* was found in 2 of the 4 sites, being the most prevalent species.

Diversity of uses

Thirty-nine percent of the species mentioned in the interviews had more than one use in beekeeping. Particularly, species belonging to Cupressaceae, Plagiochilaceae, Anacardiaceae, Aquifoliaceae, Musaceae and Podocarpaceae families had a wider range of uses. Overall, trees had a greater diversity of use, as they provided nectar for bees and also materials for hive construction by beekeepers.

As reported in FIG. 4, we identified 9 different uses grouped into 6 main use categories, namely melliferous, making hives, placing hives, attracting bees, harvesting and storing. In total, 57 species were mentioned by the beekeepers as a valuable source of nectar and pollen, subdivided by growth habit into trees (36.8%), shrubs (29.8%), herbs (24.6%), and climbing species (8.8%). The large presence of flowers among the plant parts reported can be explained by the prevalence of melliferous species. Timber and bark from 20 different species were used in the construction of beehives, largely in traditional beekeeping, and an additional 13 plants were used to hang traditional beehives as well as to place modern hives. Trees (18) and shrubs (4) were the most-utilised species for these purposes. Leaves, bark, and branches from a smaller number of species were used for attracting bees (4), harvesting (13) and storing honey (4).

Melliferous species

Of the 66 species listed by the respondents, more than 85% were melliferous, i.e. they were a source of nectar and pollen for bees. Malvaceae, Myrtaceae, Poaceae, Asteraceae, Rhamnaceae, Sapindaceae and Stilbaceae were the most mentioned families. Overall, the most salient melliferous species was *Dombeya torrida*, as 86.6% of the informants regarded its flowers as the best source of nectar in all the ecological zones. The beekeepers agreed that when bees feed on it they produce large amounts of honey that can be distinguished by its whitish colour and its very sweet taste. Due to the long flowering period of the species, spanning from August to December (Beentje, 1994; Onyango, 2019), beekeepers regarded *D. torrida* honey as the most important monofloral honey harvested in the area.

The relevance of other melliferous species changes significantly with the location of the beehives. In the Upper Forest, besides *D. torrida*, trees such as *Nuxia congesta*, *Allophylus abyssinicus* (Hochst.) Radlk.) and *Ilex mitis* were the most valuable in this regard. The importance given to these species stems from their strong connection to the TEK of the Ogiek community. For instance, timber from *Ilex mitis* was used for the construction of traditional log hives and hives were hung on the same type of tree. Moreover, these species were also used for medicinal purposes as well as for cultural celebrations and traditional ceremonies. In particular, honey from *Allophylus abyssinicus* was regarded as a good treatment for malaria and the roots of *Nuxia congesta* were used in the treatment of stomach ache and joint problems (see also Ngari et al., 2010; Ndegwa, 2012, Maua et al., 2018).

In the cultivated lowlands, beekeepers instead highlighted the melliferous importance of blue gum (*Eucalyptus* sp.) and maize among exotic species and crops, while *Vernonia auriculifera* Hiern, *Baccharoides lasiopus* (O.Hoffm.) H.Rob, *Achyranthes aspera* L., and *Leonotis nepetifolia* were reported as the most valuable indigenous species. These species were also abundant in disturbed areas in the Upper Forest (Agnew, 2013).

Making hives

In total, 19 species provided important sources of raw material for building hives. In particular, the Ogiek used timber from 12 different tree species to build the structure of log hives (8) and modern hives (4), bark from 5 species to cover log hives before placing them in the tree, and fibres from one climbing species and one shrub were used as rope to tie together the two halves of the log hive and to affix the bark strips around the hives. The species most frequently used for this purposes were *Juniperus procera*, *Polyscias kikuyuensis*, *Podocarpus latifolius*, and *Dombeya torrida*, whereas *Pinus patula* Schltdl. & Cham. and *Cupressus lusitanica* were the most common trees used to build modern beehives.

Traditionally, the process of log hive construction begins with a fallen tree, of the right species, size, and condition of decomposition. Beekeepers split the trunk in two longitudinally, remove the bark and outer layers of wood, and use the inner wood (reddish in colour) to build the hive. They also remove the inner part of the log with a smoother and leave the split hollow trunk to dry for at least two weeks. Subsequent steps involve tying the two halves together with a rope (*sagoet*) obtained from dry fibres of *Microglossa pyrifolia* and closing the two ends, leaving a small entrance for the bees at one end. Before hanging the hive, beekeepers cover it with bark strips that are then affixed to the hive with a cord made from the woven fibres of *Clematis brachiata* Thunb. Bark is mostly harvested from mature *Juniperus procera* trees, removing only small portions so as not to damage the trees. The findings from the fieldwork are in line with the studies carried out by Micheli (2014) among the Ogiek of Mariashoni and Blackburn (1971) in Narok County. Although these authors provide a detailed description of the tools and techniques to build log hives, few species are identified and reported with their scientific names.

Hives made from *Juniperus procera* were considered particularly resistant (lasting up to ten years if managed properly) and warmer inside (with higher insulation capacity) compared to hives made from other trees, thus favouring bee occupation and persistence. In addition to *J. procera*, and as substitute when it was not available, beekeepers also used softwood trees such as *Polyscias kikuyuensis, Podocarpus latifolius* and *Prunus africana* (Hook.f.) Kalkman. In the cultivated lowlands, where tree density is low, the species used for hive-making included exotic trees like *Grevillea robusta* and *Pinus patula* for the body of the hive, and dry leaves of banana trees and the bark of *Microglossa pyrifolia* and *Vernonia auriculifera* to wrap the log hives.

The construction of modern hives involves different practices, techniques and raw materials. Firstly, while log hives are made primarily from fallen trees, modern hives are built with timber from fresh cut exotic species such as *Cupressus lusitanica*, *Pinus patula*, and, to a lesser extent, *Grevillea robusta*. According to Caroll (2006), these are the most used and suitable timbers for the construction of modern beehives, especially KTBH hives. However, beekeepers in the study area did not consider the timber of these trees as the most appropriate, as they judged that bees are not “used to these trees and do not feed on them [i.e. they are not a good source of nectar], they do not like their scent.” Timber from *C. lusitanica* was also regarded as cold and retaining humidity inside the hive (and more so when the timber is not dried properly), thus affecting bee activity and honey production. Since modern hives cannot be wrapped with bark, they were instead covered with an iron sheet, a practice which has also been introduced for log hives. External agencies have promoted the use of iron sheets, but informants stressed the ineffectiveness of this practice.

Another important difference between log hives and modern hives relates to how they were obtained. While log hives were built by Ogiek beekeepers themselves on the basis of TEK, most modern hives in the study area were gifted pre-made by NGOs and other organizations, involving little knowledge and skills on the side of beekeepers.

Placing the hives and setting the apiaries

Log and modern hives also presented notable differences in the location in which they were placed and in the criteria used to select those locations. Informants mentioned 14 plant species (13 associated with the Upper Forest) used to hang log hives. They included 10 trees, one shrub and two vines, with *Juniperus procera*, *Podocarpus latifolius*, *Prunus africana*, and *Hagenia abyssinica* (Bruce ex Steud.) J.F.Gmel being the preferred species. As discussed above, these species were also the ones most mentioned as melliferous and as sources of timber and bark for hive construction, and were thus characterized by their multiple uses (6 different uses for *Juniperus procera* and 3 uses for *Prunus africana*, *Podocarpus latifolius*, and *Ilex mitis*).

Log hives were usually placed at the bifurcation of two branches strong enough to support their weight (Fig. 5). Similar techniques have been reported for the Ogiek living in Kipkururek and Kapchepkendi north of Nakuru and on the Narok side of Mau Forest (Huntingford, 1929, 1955; Blackburn, 1971). Other selection criteria included the density of branches (few branches make it difficult to climb the tree, whereas numerous branches expose the hives to raids by honey badgers and safari ants) and exposure to wind. Hives were placed with the entrance facing downwind to avoid the cold and the sound of the wind beating against the hive. Finally, the density of melliferous species and distance to sources of disturbance for bees (e.g. livestock, people, wild animals, agricultural fields, etc.) were other variables considered in the hives' positioning. Hives belonging to the same beekeepers were placed at a considerable distance from one another, possibly at different altitude levels, in order to best exploit the different blossoming seasons of different trees. The spreading of hives over a wide area may also function as a risk insurance mechanism, as, by doing so, beekeepers reduce the risk of catastrophic losses of hives due to stochastic factors (e.g. theft, disease, etc.).

The level of importance and availability of the tree species mentioned above decreased with their decreasing density and changing ecologies from the upper to the lower areas. Thus, in the cultivated lowlands, informants instead relied on species such as *Mikaniopsis bambuseti* (R.E.Fr.) C.Jeffrey, *Combretum molle* R.Br. ex G.Don and *Jasminum abyssinicum* Hochst. ex DC to hang their hives. The changing ecology and the smaller size of these species in comparison with the former compelled beekeepers from the cultivated lowlands to place their log hives closer to the ground or on a wooden base, surrounded or covered by shrubby vegetation that provided shade and nectar (e.g. *Searsia natalensis* (Bernh. ex C.Krauss) F.A.Barkley).

Different criteria underpin the placement of modern hives and the setting of modern apiaries (FIG. 6). The first difference entails the hives' density, as modern hives in the cultivated lowlands were grouped in fenced apiaries, including up to 40 hives in the same location. Other criteria include proximity to a source of water, presence of melliferous species, shade, and distance from people and livestock. Modern hives were generally placed close to the homestead, at the edge of forest patches, close to rivers, or a combination thereof, and in any case not far from crop fields.

Attracting bees

Traditional Ogiek beekeeping relies on swarming bees to spontaneously colonize a log hive. To facilitate this, beekeepers employed practices to attract bees inside the hives. These practices were based on the use of *Juniperus procera* bark, which was burnt inside the hive before placing it on a tree, thus impregnating it with its scent. Propolis was also burnt for the same purpose as well as smeared inside the hive to close cracks and better isolate it.

Occupation of modern hives, in contrast, marks a decreasing reliance on local products and traditional practices, and an intensification of human intervention in the process. Techniques employed include the use of catch boxes to trap swarms and a mixture of water and sugar to feed bees during dry periods. Knowledge of such practices does not stem from vertical inter-generational transmission like TEK but rather from training and workshops promoted by national and international organizations through the MACODEV cooperative. Only a few informants actually employed traditional methods to attract bees in modern beehives, as most others preferred to burn branches, bark and leaves of *Dombeya torrida* and dry lichen (*Usnea* sp.) inside the hive and to smear the ashes on the inner walls. These last two practices were not reported by the informants as being used in the Upper Forest with log hives (although the two plants were important for other purposes, i.e. melliferous, hive construction, smoking the beehive), and seem to be attempts of adapting TEK to modern beehive management.

Harvesting and storing

Informants mentioned 7 species whose parts were used in 15 different ways to harvest and store honey. In the Upper Forest, beekeepers climbed the tree and cut off the hive's comb to harvest the honey. Besides a knife and a container, the beekeeper carried a bundle of green or dry lichen of the genus *Usnea*, locally known as *kurongurik*, which was burnt along with small pieces of *J. procera* bark, called *sasiat*. *Sasiat* and *kurongurik* were carried inside the *motoget*, a bag made from the leather of cow or red duiker (*Cephalophus natalensis*) (FIG. 7). Honey was harvested by stunning the bees with smoke and extracting the honeycomb from a small opening on the bottom of the hive otherwise plugged with leaves of *Hymenophyllum* and *Plagiochila* species, both locally known as *susuot*.

Harvested honey was stored in two different containers, namely *soyet* and *poleita*, made from *Yushania alpina* and *Microglossa pyrifolia*. The former, obtained by cutting a piece of bamboo and covering its ends with cow leather, was used to transport small quantities of honey as well as to harvest honey from stingless bees. The latter consisted of a bag made from dry fibres in which honey was preserved for a long time. Another storing technique, used in the past but currently abandoned in favour of plastic buckets, involves keeping honey in a *kisungut*, i.e. a hollowed log of *Juniperus procera* sealed with propolis, covered with leaves and mosses, and placed one to few metres above the ground over a wooden frame in the forest. The Ogiek maintained that honey could be stored in the *kisungut* for years, consumed during times of food scarcity, especially by children, and used as a means of exchange with neighbouring communities (Blackburn, 1971; Micheli, 2014b).

In the cultivated lowlands, with a limited presence of species such as *Juniperus procera, Dombeya torrida* and *Vernonia auriculifera* and prevalence of modern hives, beekeepers used smoker guns, provided by NGOs and other organizations, fuelled by dry branches, leaves, and sawdust to stun bees, with no further mention of the specific plants used.

Discussion

Despite the transformations that have involved Mau Forest and the livelihoods of the Ogiek over the past century, beekeeping is still a practice embedded in the material and cultural life of the Ogiek community, and local beekeepers still possess detailed knowledge of the forest's flora and its importance and uses. Although, due to the adoption of a more sedentary lifestyle, the Ogiek no longer base their livelihoods exclusively on the forest, they still have a strong material and cultural attachment to it and regard beekeeping and honey as main elements of their heritage. While knowledge of bees and their preference for specific melliferous species is an important part of local TEK, the Ogiek's expertise also entails uses of plants for hive construction, attracting bees, as well as harvesting and storing honey. These bodies of knowledge are the result of a long and complex adaptation process of the Ogiek to the ecological settings of Mau Forest, and have historically played an important role in the community's resilience (Huntignford, 1929; Blackburn, 1971).

At the same time, the Ogiek have recently moved beekeeping literally and metaphorically out of the forest and into open areas of pasture and crop fields, adapting their honey-production system and their relationship with bees to the new ecological conditions of the cultivated lowlands. This adaptation has involved the adoption and use of modern beehives, harvesting, and storing techniques, the development of knowledge about lowland melliferous species and bees' interactions with crop fields, a re-assessment of risks and opportunities, and a progressive integration of beekeeping into commercial chains for income generation and external sources of knowledge, training, and materials.

Despite the three-fold traditional division of the region into Upper, Central, and Lower Forest, the analysis of beekeeping-associated TEK suggests that the Ogiek carry out beekeeping today distinguishing between only two main zones: the Forest and the Lowlands. The Forest is the area still covered by primary Mau Forest, mostly concentrated in the Upper zone. Here, beekeeping has continued with traditional methods, is deeply embedded into the forest's ecology and its indigenous species, and TEK is rich and detailed (Micheli, 2014). The Lowlands comprise the former Central and Lower Forest today engulfed by the agricultural frontier and represent a fragmented landscape where the primary forest has been replaced with open fields of cash crops, pastureland and exotic trees, leaving behind only small forest patches. Across the Lowlands, beekeeping relies on modern hives and methods, is largely aimed at income generation, and ethnobotanical knowledge encompasses mostly exotic species and crops and is sourced from external agents. Thus, while the Lowlands have become the interface through which the Ogiek adapt and reposition their culture and identity vis a vis the global beyond (Chabeda-Barthe & Haller, 2018), the Forest maintains its role as the place of physical and cultural dwelling of log hives, a cyclical sense of time, the sweetest and most medicinal honey, and home consumption.

Beekeepers move daily between the Forest and the Lowlands, but despite this, there is little hybridization of knowledge and practices. Beekeeping appears to evolve through adaptive strategies that maintain a substantial distinction between traditional and modern practices and knowledge. The Ogiek justify this on the basis of the difficulties in fitting modern beekeeping to the Forest as a result of different factors, among which adverse weather conditions, presence of predators, and difficulties in colonizing modern beehives are the most common. Conversely, the replacement of indigenous trees by crops and exotic species in the Lowlands excludes the possibility of carrying out beekeeping using traditional log hives, and a divergence between the two beekeeping systems therefore arises. This divergence expresses an overall complementarity of traditional and modern practices, a complementarity that is functional to the expansion of beekeeping in the region beyond the limits of the Forest. Indeed, the two little-overlapping sets of beekeeping practices largely demand different sets of knowledge, with an increasing relevance of external sources of knowledge for that which concerns modern beehives and beekeeping in the Lowlands, and a persistence of vertical sources of TEK for that which concerns log hives and beekeeping in the Forest. Responding to different ecological conditions and challenges, these two sets of strategies are not antagonistic but rather complementary within Ogiek livelihoods: they allow the Ogiek to expand the reach of beekeeping from the Forest into the cultivated Lowlands.

This study, therefore, highlights that the reiteration of a heuristic opposition between tradition and modernity may be misleading in approaching the study of TEK and its change. Rather, it is necessary to contextualize the cultural and economic dynamics within the wider framework of livelihood and community adaptation to an environment in constant transformation (Volpato & King, 2019). The choices of individuals and communities and their struggles should be understood within this broader framework. Even the mantra of modern knowledge as an element of tout-court detachment of local communities from their environment may be misleading (Candea et al, 2015). In the case of the Ogiek, this can be identified at a material and technological level because, while traditional beekeeping depends on healthy forest ecosystems, the species therein, and knowledge about them, modern beekeeping relies instead on external inputs (e.g. knowledge, materials) purchased in markets and shops (e.g. timber and tools to build hives) as well as obtained through relationships with extension services officers and international NGOs. Conversely, it is through modern techniques that the Ogiek are able to claim vast swaths of land for beekeeping and honey production, opening a space of cultural appropriation of an environment otherwise distant from the values and practices of their tradition. At the same time, the relationship between TEK and modern knowledge shows hints of hybridization. Beekeepers in Mau Forest are experimenting with combinations of practices borrowed from different systems of knowledge, particularly in the field of beehive construction, adapting traditional devices to modern design, exploring the use of indigenous trees to build modern hives and traditional methods to promote bee colonisation of modern hives. Some attempts have also been made to improve traditional log hives with modern technology (e.g. the introduction of a queen excluder).

From the analytical lens of changing Ogiek-forest relations, the expansion of the reach of beekeeping in Ogiek livelihoods and toward the Lowlands can also be understood as a process of decoupling bees from trees and beekeeping from the forest, which reconfigures these relationships into open cultivated fields. Thus, while the advancement of agriculture is jeopardizing the very survival of Mau Forest (Kweyu et al. 2020), the adoption of modern techniques is allowing the Ogiek to maintain honey production in ways that fit with the ecological characteristics of the agricultural frontier. By decoupling beekeeping and the forest, the introduction of modern beehives makes the forest dispensable in terms of honey production. Beekeeping becomes embedded into the spatial and social frame of the agricultural frontier, and this allows it to survive the forest with further frontier advancement. If left unaddressed and unsanctioned, this process may weaken traditional beekeeping and the beekeepers' role as 'guardians of the forest' and undermine programs of forest conservation associated with the promotion of Ogiek honey.

Conclusions

This study is an endeavour to understand the dynamics of livelihood and cultural change and adaptation associated with processes involving the promotion (including the individual components of intensification, valorisation and expansion) of local and indigenous products. Using as a case study Ogiek honey production, we have addressed the changes occurring in Ogiek beekeeping with the introduction of modern beehives, focusing on beekeeping-associated TEK vis a vis changing livelihoods and ecological settings with the expansion of the agricultural frontier into Mau Forest. We have presented and discussed the beekeeping-associated TEK of the Ogiek of Eastern Mau Forest, as well as the strategies that the Ogiek employ for honey production in the diverse ecological settings of a vertically-zoned forest surrounded by an agricultural frontier.

We have shown that modern and traditional beekeeping, rooted in different systems of knowledge, are complementary within the livelihoods of the Ogiek largely in accordance with the ecological conditions in the selected apiary location: traditional in the forest, modern in the cultivated lowlands. Based on an analysis of the differences between traditional and modern beekeeping knowledge and practices within the changing sociocultural context in which they manifest, we have argued that research should leave aside any ontological opposition between tradition and modernity, and instead view the dynamics of cultural adaptation as the result of a complex process of adjustment to an environment in constant transformation. However, the complementarity of modern and traditional beekeeping in Ogiek livelihoods may conceal a contraposition of the two beekeeping systems when seen under the lens of their relationships with the forest. Results suggest that the agricultural intensification process may have the potential to decouple bees from trees and beekeeping from the forest, weakening the continuity in the role of the forest in the livelihoods of the Ogiek, and embedding honey, a traditional forest product, into the cultivated landscape of the agricultural frontier.

Between complementarity and contraposition, Ogiek beekeepers also experiment with hybrid forms of knowledge (e.g. by adapting traditional devices to modern design) and along with external actors (e.g. NGOs, a local agricultural college) are devising ways of improving the traditional log hive. Processes of knowledge exchange occur in both directions, and while they both have the potential to further refine local beekeeping practices and increase honey production, attempts at log hive modernization may further contribute to projects promoting Ogiek honey and concurrently support the relationship between the Ogiek and the forest.

This research is of relevance to policy makers, development institutions, and intervention programs that promote beekeeping in support of local livelihoods in forested areas of the tropics. Programs of intensification, valorisation, and expansion of honey production through the introduction of modern beehives into traditional forest-based beekeeping systems have the potential to complement traditional honey production in the forest and expand the reach of beekeeping into the cultivated surroundings. But in order to avoid, throughout the process, the risk of dissociating beekeeping from the forest and weaken the material and cultural links that tie indigenous populations to forest conservation, programs should seek to specifically target the promotion of forest beekeeping, via the intensification of log hive production and valorisation of forest honey and associated TEK as well as floristic diversity. A thorough understanding of local TEK and the involvement of community members from the very start of promotional projects may help policy makers and development institutions find endogenous elements that can be useful in the design of innovations supportive of beekeeper livelihoods and of the beekeepers' role in forest conservation.

Further studies could explore the potential for further hybridization of traditional and modern beekeeping-associated knowledge and practices and their outcomes and address knowledge dynamics within other promotional initiatives of indigenous honey, as well as in programs for the intensification and technological modernization of local productions. Further studies could also address the multiple ways in which TEK changes and is continuously adapted and hybridized with other forms of knowledge within the many different contexts in which promotional initiatives of local and indigenous foods are undertaken.

Declarations

Ethics approval and consent to participate

The research was approved by the Ethical Committee of the University of Gastronomic Sciences (Resolution 3.I, 4/6/2019)

Consent for publication

Not appliable

Availability of data and materials

Please contact author for data requests."

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Competing interests

The authors declare no conflict of interest.

Authors' contributions

DMZ: Conceptualisation, Methodology, Invesitgation, Data curation, Formal analysis, Validation, Visualisation, Writing – original draft. GV: Conceptualisation, Invesitgation, Data curation, Formal analysis, Writing – original draft. DCM: Investigation, Data curation, Formal analysis, Writing - revision. PCM: Investigation, Data curation, Formal analysis, Writing - revision. MFF: Conceptualisation, Methodology, Investigation, Formal analysis, Validation, Project administration, Supervision, Writing – original draft, revision; Editing.

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Figures

Figure 1

LOG HIVE, KENYA TOP BAR HIVE (KTBH), AND LANGSTROGH HIVE (PHOTO: DAURO MATTIA ZOCCHI)

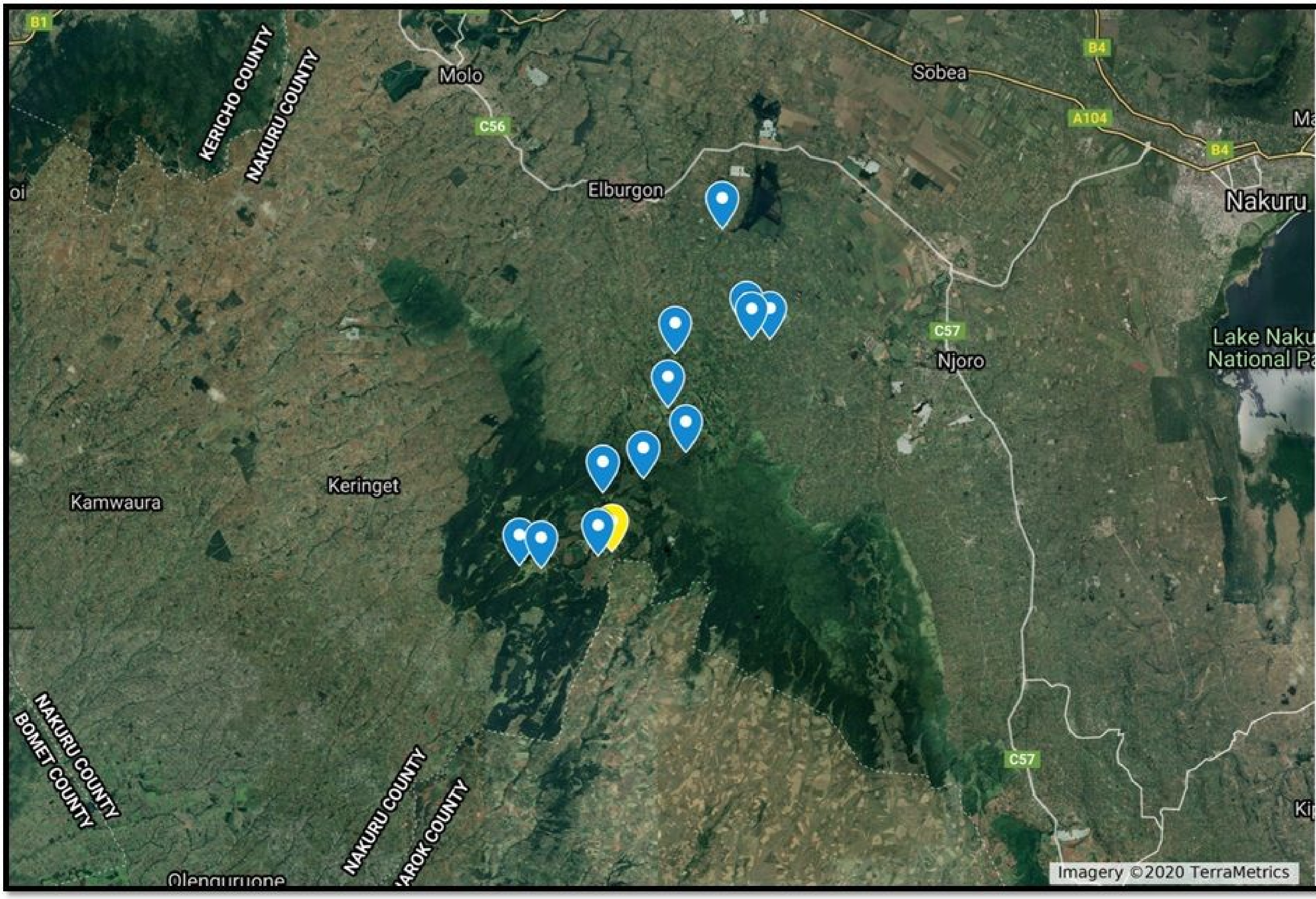

Figure 2

MAP SHOWING THE STUDY AREA AND THE VISITED LOCALITIES (GPS POINTS WERE RECORDED DURING THE FIELDWORK). (FILE CREDITS: Creative Commons Attribution-Share Alike 3.0 license)

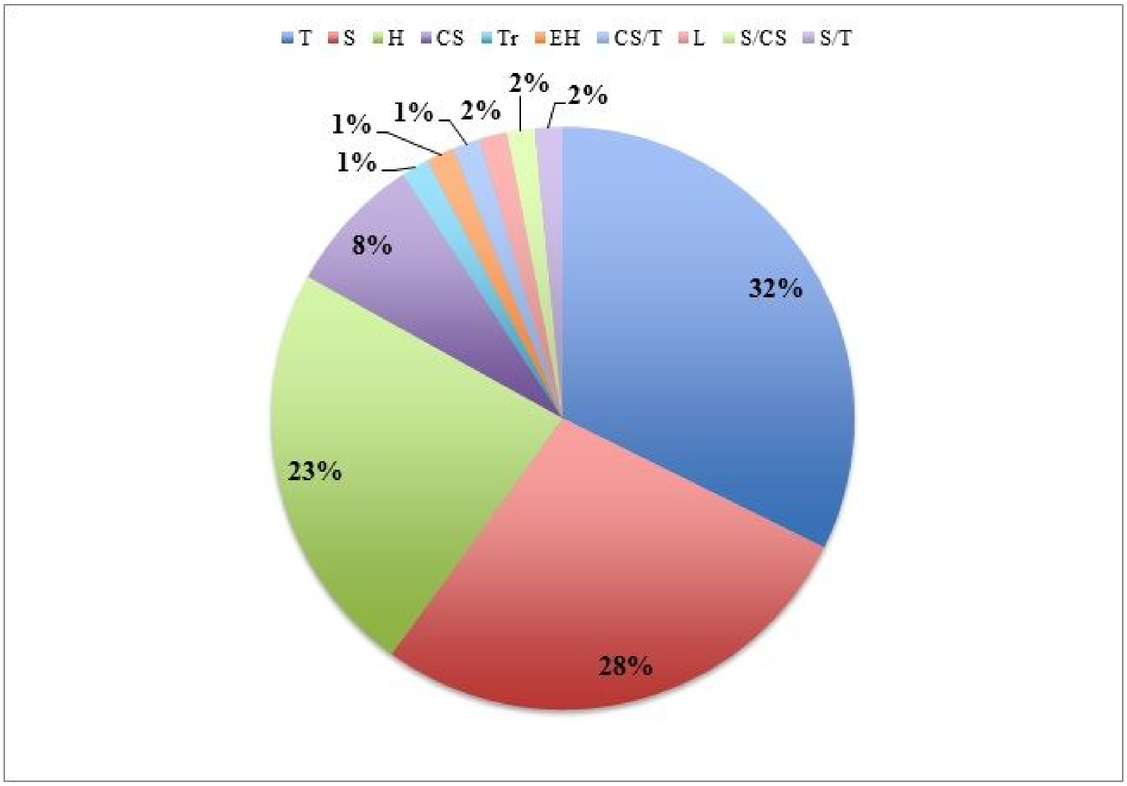

Figure 3

DISTRIBUTION OF THE SPECIES BY GROWTH HABIT Key: T, tree; Tr, Tree Trunk; S, shrub; S/CS, Shrubs / Climbing Species; S/T Shrubs / Tree; H, herb; L, lichen; EH, epiphytic herb; CS, climbing species; CS/T, Climbing Species / Tree.

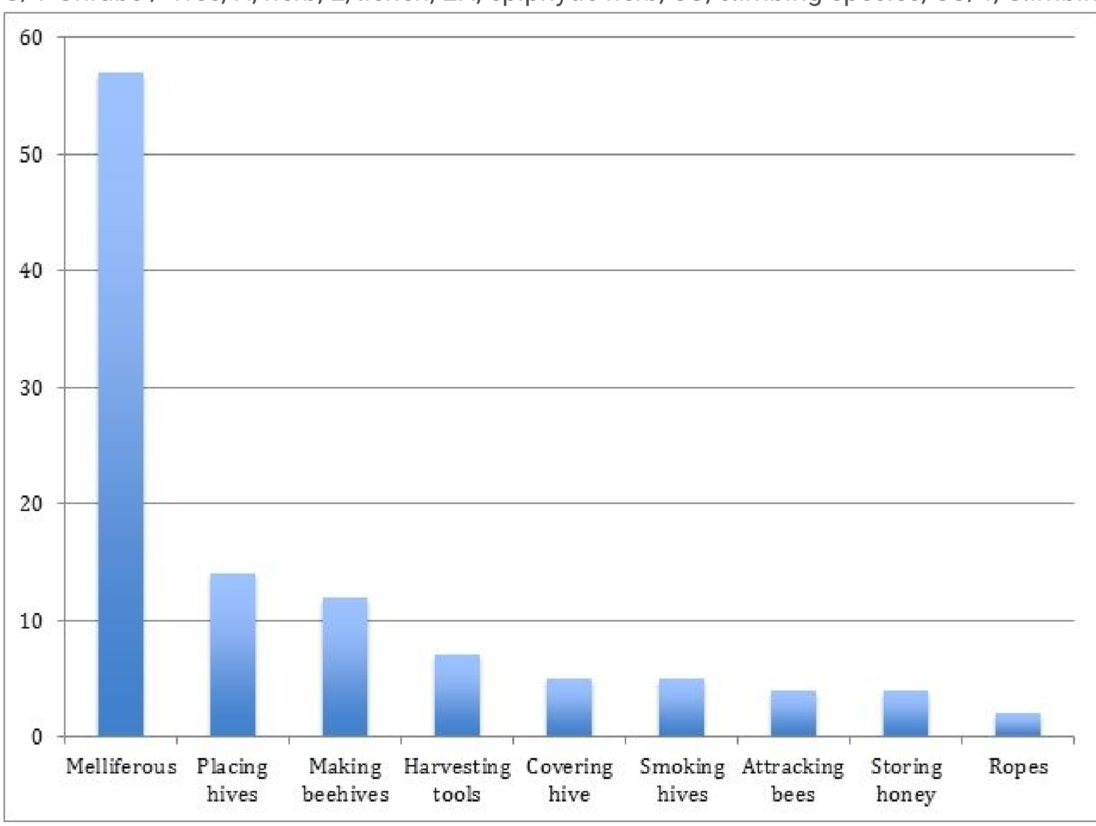

Figure 4

MEANS OF USE AND NUMBER OF SPECIES FOR EACH USE CATEGORY

Figure 5

TRADITIONAL LOG HIVE HUNG ON A TREE IN THE FOREST (PHOTO: DAURO MATTIA ZOCCHI)

Figure 6

MODERN APIARY SET IN THE LOWLANDS (PHOTO: DAURO MATTIA ZOCCHI)

Figure 7

TRADITIONAL HARVESTING TOOLS AND HONEY HARVESTING (PHOTO: DAURO MATTIA ZOCCHI)