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Preamble

This Special Edition is dedicated to presenting papers from The 1st Continental Symposium on Honey Production, Bee Health and Pollination Services in Africa, held at the Safir Hotel, Cairo, Egypt from 6-8 September 2015.

The overall theme of the Symposium was 'The Future of the African Bee' in line with the aspirations of the Heads of State and Governments of the African Union as captured in the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. The aim was to provide a platform for knowledge sharing to inform policy and decision making.

The Symposium was structured around a plenary session with keynote addresses, three parallel sessions developed on the domains of trade and market access, pests and diseases, pollination services, policy reform, capacity development and technology transfer and impact of environmental stressors and a poster session. Presentations, many of which provoked animated debate and inquiry, brought to light new information, highlighted innovations and untapped opportunities, and emphasized the need for African grown solutions to its challenges. Focused group discussions provided a critical platform for delimitation of the state of knowledge, gaps and priority actions for apiculture development in Africa. Key recommendations have fed into action planning by the African Apiculture Platform (AAP), a continental multi-stakeholder platform, and will inform Member State and Regional Economic Communities (REC) policy reform and decision making.

The Symposium brought together scientists, private sector actors, practitioners, policy makers and other stakeholders to share the latest advances in practice, policy reform and research. Over 100 participants attended from forty Member States, (Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central Africa Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Democratic Republic of Congo, Ethiopia, Egypt, Germany, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe, four RECs (COMESA, IGAD, ECCAS, CEBEVIRHA), international organizations (OIE, Croplife), private sector practitioners (Arab Beekeepers Union), eminent scientists, researchers, sector experts and staff from the African Union and two of its technical agencies AU-IAPSC and AU-IBAR.

AU-IBAR partnered with icipe to host the Symposium, which was financially supported by the European Union.

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Chief Animal Production Officer,
Editor in Chief of the Bulletin of Animal health and Production in Africa
AU-IBAR

KEYNOTE ADDRESSES

KEYNOTE ADDRESS

THE FUTURE OF THE AFRICAN BEE: A CALL TO MAINSTREAM BEEKEEPING TO ENHANCE DELIVERY OF THE MALABO DECLARATION

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INTRODUCTION

Honorable Minister for Agriculture and Land Reclamation of the Arab Republic of Egypt, Prof. Saleh Helal, the Director, AU-IBAR, Representatives of international organizations, Directors of animal production and veterinary services of African Union Member States, eminent scientists, distinguished guests, ladies and gentlemen: it is with great pleasure that I address the 1st Continental Symposium on Honey Production, Bee Health and Pollination Services in Africa.

Honeybees play a vital role in improving agricultural productivity, preserving biodiversity and promoting sustainable livelihoods.

The bee is one of the most economically important insects, producing honey and other hive products, and pollinating crops that account for more than 35% of global food production. Insect pollination is valued at billions of dollars each year and other millions are generated by the annual sales of honey and other hive products, underscoring the significant contribution of bees to agriculture. Any decline in bee populations in Africa, as has happened in other regions, will impact negatively on pollination and have economic effects on food security and human welfare. Decimation of bee populations will also have ecological consequences, reducing the diversity of wild plants and disturbing the wider ecosystem stability.

The theme of this symposium is 'The Future of African Bee'; this should be reflected on in the context of the African Agricultural Transformation Agenda.

WHAT IS THE FUTURE OF THE AFRICAN BEE?

First of all we must think of sustaining the existence of bees and the proliferation and sustenance of their colonies, especially in the light of the rapid losses of bee populations in some regions of the world and of major environmental stresses. Secondly we must address ourselves to the role that African bees can play in Africa – are we harnessing their full potential, are we doing this efficiently? Thirdly, and not least, we must ask the question what contribution bees can make to Africa's development outcomes, the welfare and health of its people, its resources, environments and economies. I believe that many of the technical issues will be addressed by our presenters in the course of this Symposium. I would like to raise issues related to the aspirations of the political leadership of Africa.

Africa is rising: in the last decade Africa had six of the fastest growing economies in the world, and was the second fastest growing continent globally. This period of sustained high economic growth coincides with the first ten years of implementation of the Comprehensive Africa Agriculture Development Program (CAADP). This is not by chance: agriculture is at the core of most of

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Africa's national and regional economies, and is central to achieving distributive and sustained growth. The CAADP has provided a platform for Africa to own, set and drive to its agricultural and development agendas.
The Year 2014 was celebrated as the African Year of Agriculture and Food Security but also provided an important landmark for critically reviewing how we have conceptualized and conducted the business of agriculture. It was a good point to inquire whether or not our articulation of the sector, priorities for investment and actions were procuring the desired outcomes against the Millennium Development Goals benchmarked against the Year 2015. Africa has made remarkable strides in reducing poverty: but food and nutrition insecurity persist. The elimination of hunger, an indignity to many of our people, remains a perennial challenge.

To address these and other gaps, African Leaders renewed their commitment to agricultural sector led growth, outlining goals and objectives for the next ten years in the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. The Declaration recognizes the gains that have undergirded attainment of positive growth performance of the agriculture sector and seeks to consolidate them while addressing the gaps. The Malabo Declaration commits Africa to:

a. Adhere to the principles and values of the CAADP process: agriculture led growth, evidence based planning, productive partnerships and alliances, exploitation of regional complementarities, country level implementation and regional coordination
b. Enhancing investment finance in agriculture: It underscores the need to prioritize actions to attain public investment targets imperative for vitalizing public goods that are essential for creating a more dynamic enabling environment for attracting increased private sector investment.
c. Ending hunger in Africa by 2025 by: doubling current agricultural productivity levels, access to quality and affordable inputs, supply appropriate knowledge and information, access to water, affordable mechanization, reduce post-harvest losses by 50% by 2025, social protection, early warning, increased consumption of locally produced food items, improved nutritional status
d. Halving poverty by the year 2025 through inclusive agricultural growth and transformation: sustain agricultural growth of at least 6%, public-private partnerships; job creation, preferential promotion of women and youth in agri-business
e. Boosting intra-African trade which should triple by 2025; and
f. Enhancing resilience of livelihoods and production systems to climate variability and other related risks

The Malabo Declaration therefore addresses itself to a number of issues, but I would like to dwell on some areas that are of particular relevance to Africa's Apiculture sector. This being one of the oldest livelihood and income generating activities on the African continent, it exemplifies much of the best of the continent, and also some of the most persistent challenges.

KEYS TO THE FUTURE OF THE BEE

1. **Knowledge and information systems are an important key to the future: we live in an information age where knowledge is power.** The beekeeping sector is disarticulated – its best potentials are not being harnessed in Africa i.e., its ecosystem services for both crop pollination and for maintenance of biodiversity which is crucial given the growing environmental stresses.

   Even within apiculture, information and technologies are not fully deployed: there is a huge waste of valuable hive products that remain unknown to most beekeepers. The development of apicultural products remains largely rudimentary. Much of the indigenous knowledge that holds answers for the sector is undocumented, and beekeepers are still relying on unproductive methods and technologies entrenched by tradition rather informed by knowledge. There is proof that some African indigenous knowledge may have answers for the serious challenges other regions around the world face. Beekeeping is not in the school curicula, research is fragmented, and beekeeping remains in the technical domain – largely within the fields of entomology, ecology and or crops and not integrated. More comprehensive and integrated evidence based research is needed to inform policy and decision making in the sector and to develop critical linkages with other sectors especially the crop sector.

In all possibility, a large part of the potential of the beekeeping sector remains locked in the information and knowledge beekeepers do not have, are unaware of, or cannot access.

2. **Addressing food and nutrition security and eliminating hunger that are major causes of poverty and underdevelopment in Africa:**
   Multi-disciplinary approaches are needed to attend to food and nutrition security issues. Pollination services should be recognized as a key input, accorded equal status to water, fertilizer and other agro-chemicals if the goal of increased production and productivity are to be achieved. Insect pollination is particularly important for horticultural crops i.e., fruit and vegetable which are lacking in many contemporary diets of especially the poor. African diets have increasingly shifted from traditional diets that strongly integrate fruit and indigenous vegetables to starchy carbohydrate such as maize, cassava and rice, with pulses (beans, peas and lentils) for the poorer households and meat for wealthier households. Increased pollination increases production as well as quality of the foods which would drive down the cost of fruits and vegetables, making healthier diets more affordable for more families. Bees also produce medicinal products such as pollen, royal jelly and propolis that have anti-bacterial properties, and high levels of some vitamins that can be used therapeutically. Bee venom is also a known medicinal product. Africa needs food policies to support production and consumption of healthy foods if it is to avert the looming socioeconomic crisis related to non-communicable diseases as a result of consumption of unhealthy food: pollination services that promote production of fruit and vegetables should be a key pillar in that policy.

3. **Inclusive prosperity through public support for women, youth and other disadvantaged sectors:** Exclusion of women from beekeeping is a prominent feature of beekeeping unlike other agricultural activities. Beekeeping should also be a major option proffered for arid and semi-arid areas where there are limited options for livelihoods and income generating activities, as well as for communities affected by long-term conflict and insecurity or transiting out of such situations. However, I would like us to focus on youth issues. Africa's has the youngest population in the world with about a third of the population (300 million) between 10 and 24 years, and 60% in the bracket 10 to 35 years. In many countries and regions inappropriate policies have diminished the ability of youth to engage meaningfully in economic, social and governance activities of society and undermining social cohesion and political stability. Even though literacy rates have increased from 58% to 66.6% for girls and 72 to 78% for boys since 2000 unemployment remains dispportionate among the youth with youth making up 60% of the unemployed. Agriculture in particular has increasingly become unattractive to youth who are not satisfied with expending energy in non-income generating activities that are non-wage earning that is why the agricultural population is rapidly aging, and unable to adopt or generate innovations. Across the continent where there has been an enabling environment, youth have come up with super-innovative ideas of immense economic value.

Greater investment is needed in agriculture which can generate the greater employment opportunities and multiplier effects than sectors that are receiving the larger share of investments like the extractive and services sectors, but only deliver a limited number of jobs. Investment in the sector should start with curricula that include skills and enterprise development. Africa must view her large youth population as an opportunity, a demographic dividend, to have human capital (large proportion of working age persons) for economic development. The beekeeping sector, with low capital outlays especially for apiculture could provide an entry point for youth employment. There is great untapped potential for entry into the sector along its many value chains.

4. **Increased market access and trade.** The large percentage of beekeeping products are either consumed within households and communities or sold farm-gate. Beekeeping is more often a supplementary activity, non-wage earning, with marginal profits. Marketing channels are poorly developed and inefficient, incurring huge losses along the entire value chain. There is limited progress made even at policy and regulatory level to develop beekeeping as an agro-industry, with little agribusiness development. This hampers value addition and competitiveness, even though African bees and beehive products have high potential to enter lucrative niche markets. Countries across Africa are failing to meet export standards to European and other exotic markets, and are unable to organize even to supply countries intra regionally that are importing honey and other hive products. Polices are needed to promote the sector as a key agricultural sector and remove the stigma of a supplementary activity that doesn't warrant substantive support and investment. Public sector investments such as regulations and extension services would create an enabling environment for agribusiness development.

5. **Stressing the significance of enhancing conservation and sustainable use of all of our natural resources.** The ecosystem services that bees provide for ecological stability and sustenance cannot be underscored. Climate change and variability, pollution and degradation have taken immense toll on Africa's natural resources key to its productive capacity and sustainable economic development for now and posterity. The contribution of bees to biodiversity maintenance are key to the health of environments for all other natural resource based economic activities such as livestock grazing, rejuvenation of crop land, recycling of nutrients into water bodies for fisheries and the health of forests. Policies are needed to value and provide mechanisms to attach and enforce collection of revenues and payment of penalties from utilization and misuse of these ecosystem services.

To achieve the goals set out by the Malabo Declaration, it cannot be business as usual in the beekeeping sector. Africa must rethink the real value of the potential contribution of beekeeping especially in addressing what have been some of its most intractable challenges. Bees offer practical, low cost avenues for increasing production and productivity of food, and for improving nutrition. Africa has the comparative advantage of capacity to offer innovative products and to enter niche markets.

The sector has a tremendous potential for disadvantaged segments of the population including women, youth, communities in chronic conflict and insecurity or transit situations. It has a high multiplier capacity, with value chains capable of spawning additional jobs for artisans and to create industrial opportunities. Africa can benefit from a wealth of information, draw on knowledge from an endowment of a legacy of a long tradition of beekeeping which could form the basis for strong evidence based research. Spinoffs would be better and more natural linkages between beekeeping and the crop sector and sustainability of natural resources. Aligning the beekeeping sector to the

Malabo Declaration therefore requires political commitment and fundamental reforms in policy and practice to mainstream it across the productive sectors.

This continental symposium on honeybee production, bee health and pollination services in Africa was therefore organized with the objective to provide a platform to share information and take stock on the recent advances in research and technology development and identify gaps and priority actions that will inform the future of beekeeping research and development agenda in the next decade.

The symposium is organized with two plenary sessions at the beginning and the end of the symposium to set the scene and build consensus on priority action. There are three parallel sessions on: Environmental stressors, trade and access to market; Bee health, disease risk and technology development; and Beekeeping and pollination industries, policy and livelihoods. A total of 30 papers will be presented and 13 posters displayed under these themes over the next three days. Breakout session will provide opportunities for group discussions identification of key issues and priority actions in research and development to enhance the contribution of the honey bee to the African Agricultural Transformation Agenda

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SPECIAL REMARKS AT OFFICIAL OPENING OF THE SYMPOSIUM

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Honorable Minister for Agriculture and Land Reclamation of the Arab Republic of Egypt, Prof. Saleh Helal, Representatives of International Organizations, Directors of animal production and veterinary services of African Union Member States, the organizing committee members, eminent scientists, distinguished guests, ladies and gentlemen:

Let me take this opportunity to sincerely thank the Government and people of the Arab Republic of Egypt for hosting the 1st Continental Symposium on Honey Production, Bee Health, and Pollination services.

The location of this Symposium in this historic city of Cairo could not have been better selected: Egypt has a profound ancient tradition of beekeeping, which dates thousands of years. Beekeeping was particularly important in the extensive irrigated lands of the lower Egypt where there where abundant flowers, but also wild honey was searched for often under the protection of the royal archers. The bee became the symbol of the country; pharaohs were known as Bee Kings, and the sanctuary of Osiris, a much worshipped god was the Mansion of the Bee. The bee was so important that it was associated with the Sun itself. Honey and wax were treasured commodities in Egyptian society, as were other medicinal products from bee hives. Archaeologists have found honey in ancient Egyptian tombs, preserved over thousands of years, a testament to its eternal shelf-life. Beekeeping remains an important economic activity in Egypt. It is therefore befitting that this 1st Continental Symposium on Honey Production, Bee Health and Pollination Services is held here in the Arab Republic of Egypt.

Your Excellences, Ladies and Gentlemen, this Symposium is co-hosted/sponsored by African Union-InterAfrican Bureau for Animal Resources, icipe FAO, EISMV and the European Union: the contributions of all partners have made this important event possible.

The presence and participation of African Union Member States, especially the Directors of Animal Production and Veterinary Services, of various organizations, eminent scientists, private sector and other actors in apiculture graces this important gathering and lends strength to the importance of the apiculture sector.

We are here today to consider the Future of the African Bee. Honey production, which has generated millions of dollars annually, has been the main focus of beekeeping across the African continent. While we must strategize to find ways to improve honey production, our gathering here today must carve out a path for realizing the true value and potential of beekeeping to this continent.

Bees are critical to the health, productivity and sustenance of our ecosystems. They are responsible for pollination of over 250,000 species of agricultural, medicinal, fibre importance and other flowering plants. It is estimated that pollination, contributes to the production of about one third of the food we eat, and is especially important for horticultural crops - vegetables and fruits.

With the added value that insect pollination generates valued at billions of dollars each year, the bee, which contributes significantly to pollination, is then not only one of the most economically important insects, but also a critical component of our agricultural systems, and essential if Africa is to realize its goals of food and nutrition security, that are core to the health and wellbeing of Africans.

We must therefore step both up and out: step up to strengthen beekeeping for production of honey, and for harvesting other important hive products that are generally wasted now. But also equally important, we must step out of the narrow view of beekeeping to harness pollination and other ecosystem services from beekeeping.

This calls for rethinking our policy directions, with implications not just for beekeepers but for the entire way in which we view production, in which we view and develop the livestock and crop sectors, and the health of our environments. It calls for us to review how we view, organize and deploy our inputs. It calls for us to recognize and value pollination services at per with water, fertiliser, and other agro-inputs. It calls for one approach to animal, crop and environmental health.

This is an exciting opportunity: we are here over these few days to think together of a better way to harness the African Bee. This platform gives us the opportunity to share recent developments, to exchange knowledge and new ideas.

Last year Africa celebrated the Year of Agriculture, and the first ever Livestock Development Strategy for Africa was endorsed by the Council of Ministers of Agriculture. The political climate is right for a rethink and re-strategizing for the beekeeping sector, a process whose time is long overdue.

The Bee symposium Secretariat received 98 abstracts for consideration showing casing research across the continent and beyond, highlighting innovation and best practice, specifying areas where we need to improved and where policy, legislative and regulatory reform is imperative and calling for increased and more efficient public and private sector investment. Because of the limited time over the three days were are here, only a limited number of papers will be presented.

I wish once more to thank the Government and People of the Arab Republic of Egypt for hosting this important Symposium: we sincerely appreciate the hospitality and the arrangements that you have made for this occasion.

I thank you all and I look forward to engaging and productive deliberations.

BEE DISEASES: EXAMINING OPTIONS FOR THEIR MANAGEMENT IN AFRICA

Wolfgang Ritter[1,2] and Ute Schneider Ritter[2]
[1]Expert of the World Organization for Animal Health, at CVUA Freiburg/ Germany
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Abstract

In Europe and Asia, the problem of damage to bees by Varroa-Mites has primarily been attacked by increased medical treatment: in Europe, in 1980, they started with one treatment per year and have meanwhile arrived at four to five yearly treatments, depending on the region. The side-effects of the treatment have weakened the colonies additionally and have made them susceptible, especially to viruses and also to some bacterial diseases (Ritter, 2014b). Though honey production is less affected, the handling of the colonies has become more complicated, more work-intensive and more cost-intensive. The management of Varroosis in Europe and America has not been successful up to now and even ended up in a total failure sometimes. To copy this for Africa would mean to make the same mistakes twice and to finally fail as well. The situation in parts of Africa, especially in East Africa, already reveals possible solutions. Though the Varroa mite has been spread there for a long time already, heavy losses as experienced elsewhere have not occurred, even without treatment. A sustainable solution for Africa can only consist in strengthening the native bees and in creating a modified African way of beekeeping instead of introducing foreign bees and European and American management methods.

It is necessary to go the African way to have healthy bees and to strengthen colonies sustainably!

Key words: Bee losses, bee diseases, American foulbrood, Nosemosis, Varroosis, African way of beekeeping

By honey production the honeybee offers an important food item for human consumption. But by pollinating plants for a better harvest they contribute even more (Biesmeijer, 2014; Galleai et al. 2009). During the past decades, more and more bee losses have occurred. Some already call it bee death (Van der Zee *et al.,* 2012). For these losses of bee colonies a series of causes have been identified (Neumann and Carreck, 2010). An essential one seems to be the change in agriculture which is increasingly based on monocultures. The lacking biodiversity leads to an unbalanced bee nutrition and makes the bees more susceptible to diseases. Moreover, industrial agriculture requires the repeated application of pesticides. Substances in the pesticides highly toxic to bees already in very small quantities, like neonicotinoids, contribute substantially to the generally unfavourable living conditions for bees (Johnson *et al.,* 2010; Pistorius, 2014).

Diseases seem to be an important if not the main cause for the increase in loss of bees (Neumann and Carreck, 2010). American Foulbrood (Paenibacillus larvae), however, is obviously not such a critical one in Africa (Davison et al., 1999). This classical bee disease, already known from descriptions of Greeks and Romans in ancient times, has been endemic within the whole spreading area of Apis mellifera, and so also within Africa. In North Africa, American Foulbrood appears from time to time. But only in South Africa, where the more European and American beekeeping methods have been popular, it has become a more and more serious problem. In East, West, and Middle Africa, however, it does not seem to be of importance (Ellis and Mum, 2005; see also www.cabi.org/is/datasheet/78183).

One bee predator, the Small Hive Beetle Aethina tumida, is endemic in Africa south of the Sahara. However, only rarely does it causes problems for the domestic bees there (Ellis and Hepburn, 2006). An isolated evidence in Egypt did not persist. After this beetle had been imported to North America, Australia and recently also to Europe, it has been controlled actively there. The effects of its probable spread in North Africa, especially in the Maghreb Region, remains to be seen.

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Due to global trade bees will be confronted the first time with other diseases. Among them, the parasites originating from Asia, the mite Varroa destructor and the intestinal fungus Nosema ceranae. In the course of evolution, the honeybee Apis cerana, native to Asia, could have developed various defence mechanisms against both mites (le Conte *et al.,* 2010). Only colonies of the European species Apis mellifera, imported in the middle of the past century, have suffered there from weakening or were even lost.

The Varroa mite has been spread for a long time already in North and South Africa. Its distribution could also be proved in West and Middle Africa and, since very recently, in East Africa (Muli et al. 2014). Because of the epidemiology of this parasite, it can be concluded that is has been spread all over Africa for many years already (Ellis and Mum, 2005). Certainly, the same is valid for a number of viruses newly discovered by means of the simple proof by molecular-genetic methods (Muli et al. 2014). Probably, they have been endemic for a long time already but could not be attributed to specific symptoms of a disease. This is also valid for the Deformed Wing Virus (DWV) and Acute Bee Paralysis Virus (ABPV) transferred by the Varroa mite. It is highly probable that these viruses have been spread in Africa and as well as in Europe for a long time. But only with the Varroa mite, which injures the bees when sucking, could they overcome the bees' natural defence against viruses. Today, it is assumed that Varroosis consists of a factor of infection by the parasite Varroa destructor and its accompanying viruses (Ritter, 2014a).

With the increasing knowledge about the spreading of viruses and parasites evolves the fear of a similar development in Africa with serious bee losses like in North America and Europe. Whether it becomes real in Africa and to which extent cannot be finally concluded today. One difficulty results from the fact that there are many different native bee races on the African continent (Hepburn and Radloff, 1998). In Europe as well as in North America and in parts of North Africa, the differences between the bees races spread there have increasingly narrowed because of breeding activities in addition to the impact of the intense bee trade. The African bee races, on the other hand, differ considerably, not only in their behaviour like e.g. their preparedness to defend their nest but also in their susceptibility to diseases. Therefore, possible problems and approaches to a solution will not be identical everywhere in Africa (Ruttner, 1992). This is going to be demonstrated on the basis of the actual global situation of Varroosis and Nosemosis.

Originally, the intestinal parasite Nosema apis was only endemic within the European and the African bee races of Apis mellifera. Especially in Northern Europe, where there are cold winters, Nosemosis often caused diarrhoea (Ellis and Mum, 2005). Until the Varroa mite first appeared in 1980, Nosema apis was regarded as the most frequent cause of bee losses there (Fries, 2014). In subtropical and the more in tropical regions, this pathogen did not play an important role. In Africa it was even nearly unknown. In Asia, the native Apis cerana was exclusively infected by another species of intestinal parasite, the Nosema ceranae (Fries, 2014). In China, in the 1970s, it was the first time that Nosema ceranae was identified on the recently imported European Apis mellifera. The parasite had changed its host without problems because of the similar biology of both bee species. Since the turn of the millennium, the parasite on its new host has spread quite rapidly all over the world. Nearly everywhere it replaced Nosema apis prevalent until then (Paxton *et al.,* 2007). This is proved for the larger part of Europe and America and seems to be so also in Africa. This difference in epidemiology can be explained by some biologic characteristics: Both Nosema species multiply best at the normal brood temperature of 34°C. Above 37°C, Nosema apis can no longer develop, whereas Nosema ceranae still completes its full cycle. Many spores can survive above 60°, when Nosema apis has been killed. Below 34°C, Nosema cerana develops less favourably. After 24 hours of frost, the majority of spores are dead, while Nosema apis maintains its pathogenic power for longer (Fries, 2014).

Traces of diarrhoea inside and in front of the hive are typical for Nosema apis. Weakened bees often crawl at the entrance hole. Gradually the colony becomes weaker and most often dies. Also with the 'new' Nosema, crawling bees are seen in front of the hive, but visible diarrhoea occurs rarely, and spots of excrement are infrequently found. Nosema apis multiplies sufficiently only in older bees, like winter bees. However, Nosema ceranae can multiply well in shorter-living summer bees. The colonies are weakened throughout the year and do not develop properly. Absconding colonies (where all the bees had left their nest) experienced in Spain and other Mediterranean countries have not so far occurred in Northern Europe (Higes et al. 2009). Obviously, this is due to Nosema ceranae's poor tolerance of cold and it's much better multiplication capacity in warmer climates.

Regarding Nosemosis it can be concluded that the change from Nosema apis to Nosema ceranae was accompanied at the same time by a change of pathogenesis and epidemiology. According to today's knowledge, the currently spread Nosema ceranae does not cause problems for the bees under cool and moderate climatic conditions. In subtropical regions, however, it may cause damages and losses. Until now, there is a dearth of reliable data from tropical regions. In Africa, the distribution of Nosema spp. has only rarely been proved until today. If Nosema ceranae continues to spread in Africa and the effects this will have on the African bee remain to be seen (Muli *et al.,* 2014).

In Asia, the mite Varroa destructor switched from its original host, Apis cerana, to the newly imported Apis mellifera, nearly at the same time Nosema ceranae did so. Starting from the year 1975, it could have spread quite quickly all over the world on this bee species. Only parts of Oceania are supposed to be still Varroa free (Ellis and Mum, 2005). After its distribution in parts of Africa was reported some time ago, it is not surprising that it has now been detected several times also in East Africa. Until today, however, there are no reports from there about damages and losses. An extensive survey is still to be done.

Differences in the mite's pathogenicity are possible and known. Whereas, in Europe and America, Varroosis has been regarded as one of the essential causes for bee losses, the situation is different in larger parts of South and Central America (le Conte, 2010). Originally, there were no honeybees in America. Only from the beginning of the 15th century did settlers started to import them. The European bee races were not well adapted to the climatic conditions in the tropical regions of America. In the 1950s of the past century, African bees were imported to Brazil for research purposes. The hybrid of the European and the African bee, which was better adapted to the subtropics and tropics was able to spread rapidly from Brazil via South and Central America until the South of the USA (Sheppard *et al.,* 1991). These Africanized bees are more aggressive and show an increased swarming impulse, and, on the other hand, they are less susceptible to diseases than the originally spread European bee races. They have a higher defense capacity, especially against the Varroa mite (Ritter and de Jong, 1984). Opposite to North American and Europe, Varroa control is therefore not necessary in many South American regions (Rosenkranz *et al.,* 2010).

This is surprising because in tropical and subtropical regions the conditions for the Varroa mite are much better than in North America and Europe. So, the Varroa mite can multiply there much easier, because of the uninterrupted breeding activity of the bees. The first assumption that the differences between the bee races might be responsible could not be proved. So, the well-known characteristics for mite infestation tolerance like grooming and brood hygiene seem to be similarly strong with both bee races (Aumeier *et al.,* 2000). Consequently, other factors must play a role. This becomes especially obvious when in one region with the same climatic conditions and the same bee race differences are stated between individual apiaries and management methods. This could be demonstrated in South America for Brazil, in North Africa for Tunisia, but also in other regions like in Yemen (Ritter *et al.,* 1980). In apiaries where bees are kept using European and American management methods, losses are more probable than in apiaries with traditional management. European and American management methods focus primarily on achieving a plentiful honey yield. This way of management ranges from the keeping of artificially composed colonies where the larger the better, to swarming prevention by all means, often supported by breeding strictly towards high performance and low swarming impulse. Opposite to this, colony management methods in parts of South and Central America are basically oriented towards a smaller hive dimension and colony multiplication by natural swarming (Seeley, 2007; Seeley and Smith, 2015). Swarming causes a decrease in brood rearing for two to three weeks and therefore no Varroa reproduction occurs during this period. Furthermore a good relation between number of bees and hive space results in a more effective hygiene behavior, and the constant renewal and selection by swarming makes the colonies less susceptible. In parts of West, Middle and East Africa, the situation is similar to the one of the Africanised bees in America and the Apis cerana in Asia. There, the bees are kept in relatively small hives. As soon as the exterior conditions deteriorate, e.g. because of drought or food scarcity, the bees leave the hive and abscond to other regions. Exactly in time for the next nectar flow they come back. The beekeepers catch them in hives hung up in trees. The hives are shifted to a central place and kept there until harvest and the next escape. Also ill and weakened colonies quit the hives and leave infested brood behind. Those which return are healthy in general, because only healthy colonies form swarms. This natural selection is one of the strengths of native bees in parts of Africa. Apiaries run by European and American management methods often achieve larger honey yields per colony. But this way of beekeeping is more difficult and connected with higher expenditure. Mainly the medicaments needed for disease control but also the financial investment for the procurement of new hives and involved logistic costs for transport and maintenance cause additional expenses. As a whole, beekeeping by European and American management methods is less favourable, especially for small farmers. Moreover, the small credits needed to introduce these methods and the following indebtedness have to be taken into account.

Future projects in Africa should consider these coherences. They must aim at saving traditional beekeeping with small hives, possibilities for absconding and multiplication by swarming. Hive systems with mobile combs are of advantage because they allow control of the colony's condition. However, the level of top bar hives like those originally developed for Kenya or similar systems should not be exceeded. Neither in Africa nor in South and Central America are the management systems for beekeeping developed in North America and Europe used in small farming. More likely, they lead to problems and losses. Therefore, it is better for Africa to cut its own path and to aim at finding an African solution. Though this will not solve all problems of beekeeping it represents an important step towards a better, more bee compatible future. This goal cannot be reached without external help. For future programs it is therefore important to highlight recognized issues, knowledge gaps, and possible actions.

Issues

(A = whole Africa, N = North Africa, E = East Africa, M = Middle Africa, W = West-Africa, S = South Africa)

The following issues have been recognized or are assumed:

- Networks (beekeeper-consultant-laboratory-administration) do not exist or are insufficient (N?, E,M,W)
- The networks (beekeeper-consultant-laboratory-administration) function more top down than bottom up (N)
- Diseases and parasites are not detected when colonies are handled at night in the dark (E,M,W)

- Changes in colonies especially in relation to diseases are not properly recognised by the beekeepers and the local consultants (N?, E, M, W, S?)
- It is very difficult to examine traditional hives stored in a solid construction (O,M,W)
- Laboratories in charge of examination are often lacking in know-how and equipment to diagnose diseases properly and to provide indications to consultants and beekeepers about possible causes (N?, E, M, W)
- The introduction of European and American colony management systems has produced more problems than solutions (A)
- The side-effects of medicaments reduce the bees' defence capacity against diseases (A).
- The application of medicaments involves an increased financial dependence on third parties (A).
- The application of medicaments may cause residues in honey and decrease honey quality (A).
- Consultancy objectives are defined on the basis of the distribution of pathogen agents and parasites and not on their damaging effect (pathogenesis) (A)
- In general, the introduction of foreign bee races aggravates bee health problems (A).
- Breeding programs, especially regarding European breeding goals like softness, low swarming impulse and high productivity, lead to more bee health problems (A).

Gaps

The following conditions and connections are not known or not known exactly enough:

- The spreading of diseases and parasites (O,M,W)
- The sustainability of damaging effects of diseases and parasites (A)
- The effects of the applied management method (African or European and or American) on the development of diseases (A)
- The effect of swarming on the development of Varroosis and other diseases (A)
- The influence of pesticides on a colony's susceptibility to diseases (A)
- Damage margins in respect to population margins of parasites which require control measures by bioengineering techniques or treatment by medicaments

Actions

The following actions must be taken:

Establish networks comprising all levels (beekeepers, local consultants, regional laboratories, national laboratories, and administration) functioning top down and bottom up (A)

The African management method must enable colony handling by daylight in order to be in a position to identify and evaluate diseases, parasitic diseases and other problems. (E,M,W)

Support the upholding of the African management method with modifications, however, e.g. regarding mobile hives (E,M,W)

The African management method must be modified towards a mobile construction at top bar hive level in order to facilitate diagnosis and therapy of diseases (E, M, W)

The identification of diseases must be improved at all levels (N?, E, M, W, S?)

Training courses on beekeeper and laboratory level are important in order to facilitate the recognition and solution of problems (N, E, M, W, S?)

The staff of laboratories have to be trained in examination methods and the laboratories must receive the necessary equipment for diagnosing diseases in order to be in a position to provide indications for consultants and beekeepers about possible causes of problems (N?, E, M, W)

Residues of pesticides and related connections to bee health must be investigated (A)

Apart from defining the presence of pathogen agents and parasites it is most important to define their damaging effect (pathogenicity) in order to deduce from there consultancy objectives (A)

Abandon the general application of medicaments without examination if they are really needed

(A)
The import of bees has to be stopped as far as possible in order to avoid blending with the adapted native bee races.

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BEE POLLINATION INDUSTRY IN AFRICA: STATUS, CHALLENGES AND OPTIONS FOR ENHANCEMENT.

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OPENING REMARKS

Honorable Ministers and delegates from all over the continent, distinguished guests from across the world, colleague scientists, ladies and gentlemen; I am really honored and privileged to be invited to present a Keynote address on our first ever symposium on Honey Production, Bee Health and Pollination Services in Africa here in Cairo, the capital city of this historic nation, Egypt. I believe the forum is going to give us the opportunity to link up with issues pertaining to the rest of the world so as to find lasting innovative solutions to problems of Beekeeping and Pollination in Africa. In the next two days we will be arriving at serious policy decisions that will culminate in far-reaching recommendations to our governments in charting a better way forward towards food security. Today I am happy to share with you about 'Bee Pollination Industry in Africa: Status, Challenges and Options for Enhancement.'

Ladies and gentlemen, I will like to begin by reminding us of a few facts. By 2050, the Earth will need to feed nine billion people off the same amount of land, water and natural resources. This means that agricultural production alone must increase by seventy percent, according to the World Bank. Agriculture already accounts for more than two thirds of the world's freshwater use and is a contributor to deforestation. A seventy percent expansion in agricultural production cannot follow a business-as-usual scenario and still be sustainable. Healthy Ecosystems underpin sustained and sufficient food production. Biodiversity and ecosystems deliver crucial services to humankind, from producing food to mitigating extreme weather, controlling pests, reducing the impact of disasters and keeping water clean as well as providing medicines. In order to ensure that food production is increased to meet the demands of the additional 2.6 billion people expected to inhabit the planet by 2050, it is important that food producing ecosystems are protected and degraded ecosystems are restored.

Approximately thirty-five percent of global production from the world's major food crops depends on pollination. This ecosystem service, valued at USD $353.6 billion annually, is currently under threat due to the loss of bees and other pollinators caused by degraded habitats. If we truly wish to foster the resilience of our agricultural systems and secure a steady supply of food for future generations, this environmental aspect must be integrated within the Sustainable Development framework.

INTRODUCTION

Pollination is the process of moving pollen from the male anthers to the female stigma within the same flower or in another flower or individual plant. The transfer of pollen can occur inanimately by gravity, wind and water or via living animals (Figure 1.0). Bees are thought to be the most important pollinators in most environments, including agroecosystems, but many other animals also provide pollination services, including birds, bats, flies, butterflies, moths and beetles. The process of pollination occurs prior to fertilization, which produces fruits, vegetables and seeds for food production, as well as the spread of a plant's genetic material, and thus is critical for

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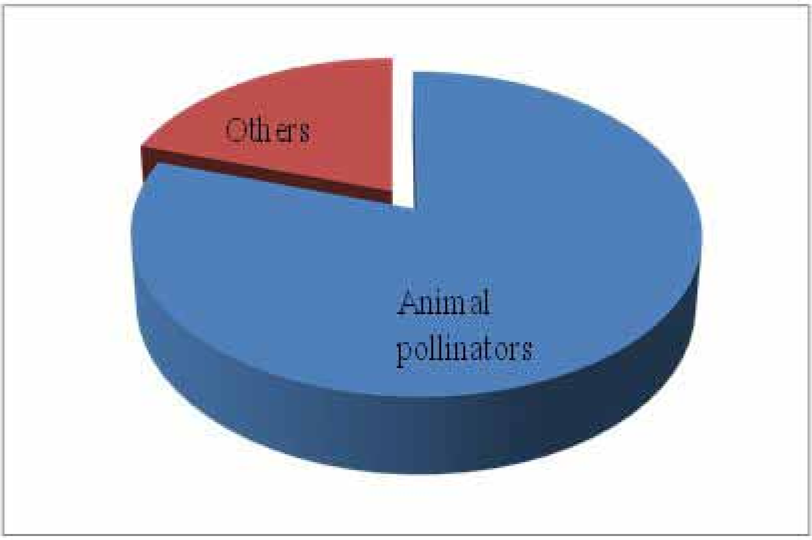

Figure 1: Pollinators

agriculture (Buchmann and Nabhan, 1996).

Pollination therefore is an example of a keystone ecosystem service that is crucial for agricultural productivity, as well as the promotion of broader diversity and ecosystems. Eighty-six percent of all flowering plant species require an animal pollinator to reproduce (Ollerton *et al.,* 2011). About one-third of food production depends on animal pollinators and seventy-five percent of all fruits and vegetables increase production when visited by animals (Klein *et al.,* 2007). And yet pollination services have not received adequate recognition within many policy environments in Africa.

Pollination is responsible for providing humankind with a wide variety of food, mainly horticultural crops. Pollinators such as bees, birds and bats affect thirty-five percent of the world's crop production, increasing outputs of eighty-seven of the leading food crops worldwide, as well as many plant-derived medicines. Pollination is therefore critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems.

Human activity, which has been premised on the assumption that pollination is a free and abundantly available ecological service, has put a large pressure on pollinators by both increasing their demand while at the same time destroying their habitat. Horticulture has rapidly expanded over the last decades, while the landscape has become more uniform due to intensive agriculture. Lack of pollination has increased awareness of the value and management requirements of this service. Effective pollination requires resources, such as refuges of pristine natural vegetation. Where these are reduced or lost, pollinators are becoming scarce and adaptive management practices will be required to sustain food production.

Pollination depends to a large extent on the symbiosis between species, the pollinated and the pollinator, and often is the result of intricate relationships between plant and animal: the reduction or loss of either affecting the survival of both. Many plants are wind pollinated, while animal pollinators include bees (over 25,000 bee species identified), and to a lesser extent butterflies, moths, flies, beetles and vertebrates (bats, squirrels, birds and some primates (Figure 2.0).

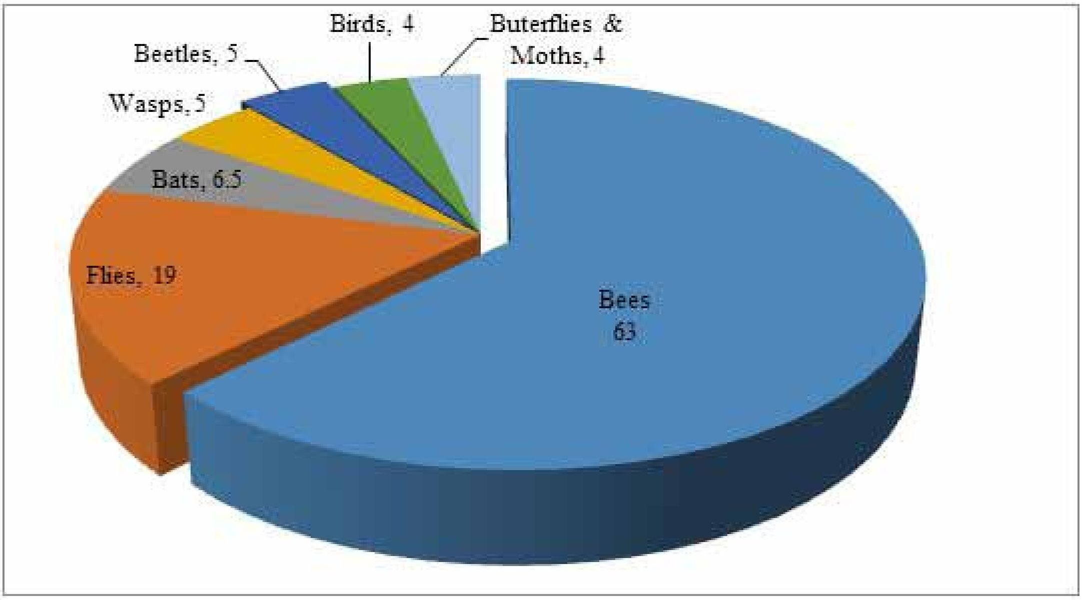

Figure 2: Animal pollinators

THE POLLINATION INDUSTRY

Pollination is a process vital to food security and ensuring the availability of a diverse human diet. Seventy-five percent of the world's major food crops, from cash crops such as cacao to vegetables such as pumpkins, and broccoli, and fruits such as apples, cranberries and melons, benefit from or are reliant on animal-mediated pollination. While these crops account for only thirty-five percent of the world's food production by volume (Klein *et al.,* 2007), they provide greater nutritional value in terms of micronutrient content. For example, ninety-eight percent of the available vitamin C, fifty-five percent of available folate and seventy percent of vitamin A come from animal-pollinated crop plants. In contrast, most staple crops such as rice and wheat are not reliant on pollinators for reproduction. These crops may represent a larger share of global caloric intake, but contain relatively few vitamins, minerals and other micronutrients important for human health (Eilers *et al.,* 2011).

Some crops, including blueberries and cherries, are 90-percent dependent on honey bee pollination; one crop, almonds, depends entirely on the honeybees for pollination at bloom time. For many others, crop yield and quality would be greatly reduced without honey bee pollination. In fact, a 1999 Cornell University study documented that the contribution made by managed honey bees hired by U.S. crop growers to pollinate crops amounted to just over $14.6 billion. Vegetables such as corgettes, peas and beans, as well as fruit and some nut trees, including apples, pears, raspberries, strawberries, blueberries, and almonds, among many other food crops, need bees if a good yield is to be realized. Bees also pollinate many of the flowers, plants and trees that provide food for other creatures.

The value of honey, pollen and royal jelly notwithstanding, the world would not be the same without beans, tomatoes, onions and carrots, not to mention the hundreds of other vegetables, oilseeds and fruits that are dependent upon bees for pollination. Nor can the contribution of honeybees to the production of bee-pollinated forage plants, such as clover, for livestock be underestimated. No human activity or ingenuity could ever replace the work of bees and yet, it is largely taken for granted. It is often not realized just how easy it is to help or hinder their effectiveness as crop pollinators nor how much is lost by their loss.

Bees pollinate about one-sixth of the world's flowering plant species and some 400 of its agricultural plants. Poorly pollinated plants produce fewer, often misshapen fruits and lower yields of seeds with inevitable consequences upon quality, availability and price of food. One of the few farm activities that can actually increase yields, rather than simply protect existing yields from losses, is to manage bees to encourage good pollination. Without bees, many flowering plants fail to set seeds and conversely, without flowering plants, there is no food for bees. Although one-third of the world's food production relies on animals for pollination and that the estimated annual value of this service is worth US$226 billion, it is projected that insect pollinators may account for more than one-third US$1 trillion in annual sales of agricultural products worldwide (Munyuli, 2010). The ecological, agricultural and economic importance of pollinators is immense and greatly underestimated. Different bee species behave differently and different crops have different pollination requirements. The shortage of pollinators affects both farmers and beekeepers: any interventions that can enhance the numbers and effectiveness of bees are economically beneficial to beekeepers and farmers

An important distinction must be made between wild and managed pollinators (honey bees). Both wild and managed pollinators can provide pollination services for agricultural crops. Globally, honey bees (Apis mellifera) are the predominant pollinators managed for agricultural use. Honey bees have the capacity to increase yield in the majority of animal pollinated crops (Klein *et al.,* 2007). However, native bees and other wild pollinators also contribute substantially to agricultural production, and their significance worldwide has only been recently appreciated. Specifically, a new global study found that crop yields respond more positively to increases in wild pollinator densities than to increases in honey bee densities. While both honey bees and wild bees contribute to crop pollination, honey bees, it is now known, cannot fully substitute for the positive yield effects attributed to wild pollinators. Although a market has emerged to rent managed pollinators to farmers to pollinate large monoculture crops under intensive production, many farmers around the world rely entirely on wild pollinators (Garibaldi *et al.,* 2013).

THE BEE POLLINATION INDUSTRY IN AFRICA

For the majority of African countries subsistence agriculture is the main livelihood. Many cash crops, vegetables and non-timber forest products including medicinal plants and nuts that support African economies depend on pollination services delivered by different types of pollinators (Munyuli, 2010; Munyuli, 2011). By increasing food security, pollinators contribute to the improvement of livelihoods and to the significant increase of income of some of the world's poorest people found in Sub-Sahara Africa. African economies that over rely on pollinator-dependent agricultural crops are therefore at high risk should there be a significant decline in pollinator populations.

The African Pollinator Initiative (API) was started in 1999 by a group of persons from across the African continent, informed by increasing recognition worldwide that pollinators play a key role in ecosystem health, both in farmers' fields and in wild landscapes. The API was interested in and committed to protecting, understanding and promoting the essential process of pollination for sustainable livelihoods. At that point there was a paucity of information on pollination on the continent: virtually nothing was known about the effectiveness of pollinators of wild plant species. The bulk of research on both crop plants and wild ecosystems resided in South African studies, with little scientific literature from most of the rest of the continent.

STATUS

In February 2002, API was inaugurated and identified four components of an action plan: public education and awareness raising; mainstreaming pollination, conservation and restoration, and capacity building. In 2009, three African countries (Ghana, Kenya, and South Africa) participated in the Global, GEF/UNEP/FAO pollination project which involved seven countries from around the world. One of API's core functions is to facilitate networking, including through its website http://www.mendeley.com/groups/2230761/african-pollinator-initiative/. The number of scientists undertaking studies on pollinators and pollination biology in Africa both within and outside the continent has grown although much of the research has been in Ghana, Kenya and South Africa, with a number of publications including for formal education. But other countries including francophone countries are also involved in research. Capacitation of students through formal education institutions, farmers, agricultural extension agents, technicians, journalists and other stakeholders is on-going in many countries. Improved beekeeping has increased greatly on the continent especially in Egypt, Tanzania, Kenya, Cameroon, Ethiopia, Tanzania and Ghana, among others. The policy environment for pollination has improved in some countries, bolstered by awareness raising through public seminars, policy briefings and public media campaigns.

Other pollination initiatives have mushroomed including the Global Shea alliance which investigates the opportunities of integrating shea butter production and beekeeping and pollination; the bee, the bird and the butter project (Ghana, Bourkina Faso and Mali); the Global Cashew Alliance project which incorporates beekeeping into cashew plantations. A Danida funded project involving University of Copenhegen and three African countries is focused on valorization of agriculture through Geographical Indications (GI), with honey branded as a GI product. Many African Experts are involved in global pollination assessment programs with the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) where they serve as authors, reviewers and coordinate assessment assignments. A crop of African bee taxonomists has been trained who will be critical in overcoming the taxonomic impediments to the growth of the pollination industry. Bee Museums and Bee Centres are being established in a few countries. There is an emerging interest in keeping stingless bees (Meliponiculture) on the continent such as the establishment of the International Stingless Bee Centre in Ghana. Promotional activities of the centre include ecotourism, environmental education, hive product development and marketing, research and training.

CHALLENGES

Despite the fact that the bee pollination industry is yet nascent in most of Africa, much has been achieved in a short time, but there are still major gaps and opportunities for improvement and sustained growth. A number of challenges need to be addressed: The African Pollinator Initiative is poorly funded, and lacks a secretariat to coordinate its activities, and link with similar initiatives. Virtually all pollination projects and researches have been through external funding. The research agenda is therefore largely externally driven with research that doesn't address the most critical needs of the industry on the continent. African nations need to drive their own agenda in conserving pollinators as a critical means to promote food security: public sector investments should be set aside to promote pollination studies and research on the continent.

Because of the limited knowledge of pollination among farmers and beekeepers, beekeeping is mainly viewed as part-time enterprise and not as a profitable business enterprise. A negative perception predominates about the stinging behavior of the African honeybee: this has put off many people from learning about the benefits of bees to man and the environment. Even trainers in beekeeping lack an understanding of the biology of African honeybees and entrepreneurial knowledge of the beekeeping as a sustainable business. There is a general lack of public appreciation of the link between beekeeping and crop pollination, human well-being and livelihoods as well as environmental health.

The capacity of Pollination service is currently being degraded due to the global decline in pollinator abundance (MEA, 2005b). Global declines in pollinator population and diversity are due to a number of factors including habitat destruction, pesticide misuse, diseases, pests and parasites, invasive species and climate change. These individual drivers may combine to produce negative synergistic effects (Potts *et al.,* 2010). Multiple policy approaches in a variety of sector must be adopted to mitigate the declines. Despite their importance to human well-being and biodiversity, ecosystem services face increasing threats worldwide with consequent negative impacts on human quality of life. Sixty percent of ecosystem services are being degraded or not being regenerated fast enough to meet demand (MEA, 2005a)

Despite the reliance of agriculture on ecosystem services, many agricultural and land management practices are contributing to broader ecosystem service decline. Agricultural intensification has resulted in the conversion of forests and grasslands to agricultural lands, reducing the land available for wildlife habitats including pollinators (Foley *et al.,* 2011; Power, 2010). Some form of agricultural intensification have increased water pollution, proliferated pest and weed resistance, increased incidence of pesticide toxicity impacting on bee and human health (Foley *et al.,* 2011).

OPTIONS FOR ENHANCEMENT

Landscape Management Options

Munyuli (2011) outlined various management options for enhancement of pollination including pollinator-friendly semi-natural habitat, natural habitat, field, and landscape management strategies. Other options include compensation of farmers for sustainable conservation of pollinators in agricultural landscapes; policies for conservation of pollinators in agricultural landscapes, strategies for dissemination of information on pollinators, monitoring pollinator communities in rural landscapes and policies to reduce pollinator-unfriendly farming practices.

Beekeeping options

Beekeeping options exist from improvement of pollination; these include improving traditional beekeeping methods; encouraging modern beekeeping and management; instituting bee health as part of beekeeping; promoting stingless beekeeping (meliponiculture); and streamlining value product packaging, value addition and marketing structures.

Policy options

A greater appreciation of the value that pollinators add to food security, ownership of Africa's research agenda and investment in bee research will enhance the growth of the pollination industry in Africa. Greater collaboration between policy makers and researchers will provide evidence and practical options to protect and restore natural areas that provide critical habitats and foraging ecosystems for pollinators. These efforts must be backed up by enforcement of regulations on beekeeping and environmental health.

CONCLUSION

There has been progress in growing and expanding the bee pollination industry in Africa. However gaps exist, and there are many opportunities to strengthen it. Key is the need for governments to recognize the critical role that pollinators play in ensuring food and nutrition security of the majority of subsistence farmers, and can play in improving production and productivity of many crops of importance as human foods in a situation of limited land. Honey bees are also important in maintenance of ecosystem health. Government investment in research is critical for conservation of pollinators. Policies are needed to support the pollination industry including pollinator friendly management practices that enhance pollinator populations in both managed and natural habitats.

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SESSION 1: TRADE AND MARKET ACCESS, AND IMPACT OF ENVIRONMENTAL STRESSORS

THE IMPACT ON ENVIRONMENTAL STRESSORS ON APICULTURE IN AFRICA

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Abstract

Honeybees are important as pollinators of agricultural crops as well as of producers of bee products like honey and beeswax. Honeybees are exposed to various environmental stressors that can significantly affect apiculture. These stressors can vary in their prevalence and impact between different regions. In Africa, apiculture has a long tradition. Nevertheless, there is only limited data available about the influence of environmental stressors on beekeeping specifically on this continent is limited in comparison to certain other regions. A review of information available is provided in this article. There are close to 310 million bee colonies in Africa but only an estimated 14-18 millions of them are managed, which is a completely different scenario than in most other continents. According to the limited data available, colony losses do occur in Africa, and where they were recorded, at more or less comparable levels like in Europe or North America. In general, stressors that play a relevant role on global level are to a certain extent prevalent in Africa too, with parasites and pathogens being of key importance as factors influencing bee health, as in other continents. Many of the relevant species appear to have been introduced to Africa only relatively recently, and to be just in the status of spreading there. In general, honeybees in Africa appear to be more resilient against many of these pathogens and parasites, compared to the European honeybee. Most notably, the parasitic Varroa mite which has been identified as the most important individual factor adversely affecting bee health in Europe and North America, does not appear to be a problem of comparable dimension in Africa. Beyond those issues, habitat loss, factors related to beekeeping practices, and the indiscriminate or careless use of pesticides has been identified as relevant stressors impacting bee health and apiculture in Africa.

Keywords: Apiculture, Beekeeping, Africa, Honeybees, Environmental Stressors, Bee Pathogens

L'IMPACT DES FACTEURS DE STRESS ENVIRONMENTAUX SUR L'APICULTURE EN AFRIQUE

Résumé

Les abeilles jouent un rôle important en tant que pollinisatrices des cultures agricoles et productrices de miel et de cire et autres produits de la ruche. Les abeilles sont exposées à divers facteurs de stress environnementaux susceptibles d'affecter l'apiculture de manière significative. Ces facteurs de stress peuvent varier dans leur prévalence et impact selon les différentes régions. En Afrique, l'apiculture a une longue tradition. Néanmoins, les données relatives à l'influence des facteurs de stress environnementaux sur l'apiculture, spécifiquement pour le continent africain, restent limitées par rapport à certaines autres régions du monde. Cet article examine les informations disponibles sur le sujet. L'Afrique compte près de 310 millions de colonies d'abeilles, mais on estime à 14-18 millions seulement le nombre de colonies gérées, une situation complètement différente de celles de la plupart des autres continents. L'examen des quelques données disponibles fait ressortir que des pertes de colonies se produisent en Afrique, et là où elles ont été enregistrées, elles se situent à des niveaux plus ou moins comparables à celles de l'Europe ou de l'Amérique du Nord. D'une manière générale, les facteurs de stress qui jouent un rôle significatif au niveau mondial sont, dans une certaine mesure, répandus également en Afrique, les parasites et les agents pathogènes étant d'une importance capitale en tant que facteurs influant sur la santé des abeilles, comme pour les autres continents. La plupart des espèces concernées semblent avoir été introduites en Afrique au cours d'une période relativement récente, et elles sont toujours en cours de propagation. En général, l'abeille africaine semble plus résistante contre un grand nombre de ces agents pathogènes et parasites par

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rapport à l'abeille européenne. Plus particulièrement, l'acarien parasite Varroa, qui a été identifié comme étant le facteur individuel le plus important affectant négativement la santé des abeilles en Europe et en Amérique du Nord, ne semble pas être un problème de dimension comparable en Afrique. Outre les problèmes susmentionnés, la perte de l'habitat, les facteurs liés aux pratiques apicoles et l'utilisation aveugle ou négligent des pesticides ont été identifiés comme des facteurs de stress ayant des répercussions sur la santé des abeilles et l'apiculture en Afrique.

Mots-clés : apiculture, élevage des abeilles, Afrique, abeilles mellifères, facteurs de stress environnementaux, agents pathogènes de l'abeille

Introduction

Honeybees are of great importance for humans, on one hand as producers of honey and beeswax, for many millennia honey was the only sweetener available to early Af¬rican, Middle Eastern and European civilizations (van Engelsdorp & Meixner 2009). Apiculture has a long history, especially in Africa: early records of beekeeping come from ancient Egypt, be¬fore 2600 BC. Motifs in rock paintings in Southern Eastern Africa depict honey hunting (Chandler 1076, Eardley et al. 2009).

Even greater than the relevance of bees as productive factor for hive products is their importance as pollinators in agriculture: studies have shown that 52 of the 115 leading global food commodities are dependent on pollination by bees and other insects, which directly or indirectly benefits 35% of our human diet (Klein et al, 2007), and the yearly total economic value of crop pollination worldwide was calculated to €153 billion, which equals 9.5% of the value of the world agricultural production used for human food in the reference year 2005 (Gallai et al. 2009). In South Africa, Allsopp (2004) estimates the worth of pollination to 3.2 billion Rand, for western Kenya, Muli et al. (2014) indicates a worth of pollination of 3.2 mio US $ in eight key crops.

As bees have been domesticated for a long time, and due to their importance in production, there are early records about bee health issues as a consequence of environmental stressors existing. A compilation of historic records is for instance provided by Fleming (1871). Early records of bee mortality from the British Isles in the 10th century are mostly associated with adverse weather conditions, reflecting the lack of understanding of pathogens and mechanisms behind diseases prevailing at that time. In later historic reports of bee mortalities, there were already more accurate and detailed descriptions that allow the identification of historic environmental stressors (e.g. Heydenreich 1804).

In the recent years, a lot of concerns have been raised about declining honeybee health; and indeed, there are some regions where increased colony mortality rates have regularly been recorded. A lot of research has recently been done into this topic, especially in Europe and North America (e.g. van Engelsdorp & Meixner 2009, Neumann & Carreck 2010, Chauzat et al. 2013, 2014, Smith et al. 2014, Staveley et al. 2014). Results suggest that there are multiple environmental and other stressors which can affect bee health. The individual stressors seem to vary in their degree of prevalence and in the severity of their impact between different geographical regions, and, to a certain extent, also between different years. Likewise, there is no consensus in the scientific community about the relative importance of the respective stressors.

Africa is a region from which there is so far only limited information available about the status of bee health and about locally relevant influencing factors. In their global overview about colony losses, Neumann & Carreck (2010) for instance observed that there were no reports of high colony losses in Africa, and concluded that one of the likely factors behind this is the relatively pronounced resistance of the African bees against the Varroa mite. However, at that time, there were generally not too many data available about the health situation of honeybees in Africa.

In the following, an attempt is made to provide a general overview about environmental stressors influencing bee health in Africa, according to the information available to date, and to provide a comparison of the situation in Africa vs. other regions that have so far been in the focus of bee health research.

Environmental Stressors Affecting Apiculture in Africa

General situation – Population development and colony losses

There are ca. 14 to 18 mio managed honeybee colonies in Africa (Crane 1990, Hussein 2000, Johannsmeier 2001, Dietemann et al. 2009), compared to ca. 310 million colonies in total in the continent (Dietemann et al. 2009, Pirk et al. 2014). Managed bee colonies are therefore just a small fraction of the overall colony number, in contrast to Europe and North America (Moritz et al. 2007, Dietemann et al. 2009). However, according to FAO data, the total number of managed bee colonies in Africa has increased by ca. 130% over the last half century (Aizen & Harder 2009). Beyond this, there do not seem to be too many accurate data about honeybee population development in the individual countries. From Kenya, Muli et al. (2014) reports a decline of bee colonies and decrease of honey production, but without providing detailed data.

Likewise, there are not too many data available about honeybee colony losses in African countries. Neumann & Carreck (2010) state that there are no reports of high losses from Africa. However, later studies show that there can be, at least regionally, relatively significant mortality rates. For instance, Pirk et al. (2014) report from South Africa loss rates of 29.6% in 2009/10 and of 46.2% in 2010/11 (Pirk et al. 2014). According to data of the international research network COLOSS, overwintering losses in Algeria were 8% in 2013/14 and 12% in 2014/15, and in Egypt 22% in 2014/15 (COLOSS 2014, 2015).

Overall, there do not appear to be indications for a general honey bee colony decline in Africa, although declines on local level cannot be excluded. Available information suggests that colony losses and mortalities do not seem to be uncommon in Africa as well, and that loss rates are roughly comparable to what we see in Europe and North America. However, the information on which this is based is derived from only on the results from few countries and of few years, so that a definitive and scientifically robust statement and about the situation in Africa as a whole cannot be made definitively so far. What can be assumed is that the situation regarding population dynamics and probably also colony losses in Africa might be fundamentally different from the circumstances prevailing in Europe and North America due to the high number of feral bee colonies and the, in relation to that, low number of managed hives.

Parasites and diseases

The most important factors acting as environmental stressors to bee health are clearly parasites and diseases; there is wide consensus in the scientific community that they are among the main threats to bee health (Genersch 2010, Ratnieks & Carreck 2010, Neumann & Carreck 2010, Smith et al. 2014, Staveley et al. 2014). A lot of bee pathogens and parasites have been described from a great variety of taxonomic groups, e.g. mites, beetles, funguses, bacteria, and viruses. An overview of relevant parasites and diseases is given e.g. by van Engelsdorp & Meixner (2009), Genersch (2010), and Genersch et al. (2010a). The vast majority of studies into the effects of these stressors to bee health have been conducted in Europe and North America.

There is, however, also data available from Africa, which allows to a certain degree to get a picture of the situation on the continent. Many of the parasites and diseases which are problematic at global level, and especially in Europe and North America, have also been found to be prevalent in Africa.

The most important individual threat to honeybees in Europe and North America is the parasitic mite Varroa destructor. It was imported from East Asia, where it was originally a parasite of the Asian honeybee, Apis cerana, a few decades ago, and has since this time rapidly spread over the globe, with exception of Australia (e.g. Van Engelsdorp & Meixner 2009, Rosenkranz et al. 2010).

In Africa, V. destructor has been recorded in many countries, including South Africa, Zimbabwe, Kenya, Niger, Senegal, Nigeria Algeria, Morocco, Libya, and Tunisia (Allsopp 2004, Pirk et al. 2014, Scholmke & Schmolke 2003, Allsopp 2006, Muli et al. 2014, Bradbear 1988, Ongus 2006, Dietemann et al. 2009, Akinwade et al. 2012).

In South Africa, V. destructor has been discovered in 1997, first in the Cape Region, but has subsequently spread through the country (Allsopp 2004). Although it was reported to have initially caused colony losses, it does apparently normally not seem to cause significant colony mortality or other substantial adverse effects to bee health in South Africa (Allsopp 2004, Allsopp 2006, Strauss et al. 2013, Pirk et al. 2014)

In Kenya, V. destructor was probably introduced between 1998 and 2009; It has been found in apiaries in various places in Kenya, except the remote north (Muli et al. 2014). It seems, however, not to substantially affect colony size or health, so that chemical control does not appear to be needed (Muli et al. 2014). Similar findings are reported from Nigeria where V. destructor was recently reported in the country, but apparently with no negative impact to bee health (Akinwade et al. 2012).

Apparently, V. destructor in Africa is far from being a bee health problem of similar dimensions as in Europe and North America. It remains however unclear what factors make the African bees less sensitive to Varroa than the European bees. The relevant mechanisms may include a higher level of hygienic behavior, a lower level of mite reproduction on pupae, lower attractiveness to Varroa, and absconding and the swarming behavior (Guzman-Novoa e al. 1999, Ruttner 1987)

The microsporidian gut parasite Nosema has likewise been found in various African countriesincluding South Africa, Kenya, and Zimbabwe (Fries et al. 2003, Swart 2003). In Kenya it has apparently been introduced relatively recently, and does not seem to affect bee health significantly (Muli et al. 2014).

The small hive beetle (Aethina tumida) is indigenous to Sub-Saharan Africa and is very widespread there. It was exported to North America and Australia where it is can cause considerable damage to bee colonies (Neumann et al. 2013); recently it has also been recorded as present in Europe (e.g. Mutinelli 2014). Although it can cause problems in Sub-Saharan Africa as well, it appears not to be a major threat to bee health there (Pirk et al. 2014, Neumann & Elzen 2004, Lundie 1940, El-Niweiri et al. 2008, Dietemann et al. 2009). In Northern Africa, the species is present as well, but apparently not as common as in Southern Africa (Mostafa & Williams 2000, Neumann & Elzen 2004, El-Niweiri et al. 2008, Dietemann et al. 2009, Zelalem Mengistu & Jibat Beyene 2014)

Next to the Varroa mite, viruses are considered a major cause of bee mortality in Europe and North America; more than 20 species have been identified which are infesting honeybees (e.g. Moore et al. 2015, McMenamin & Genersch 2015). In Africa, various viruses have also been recorded including Deformed Wing Virus (DWV), Black Queen Cell Virus BQCV) in Uganda (Kajobe et al. 2010), and Acute Bee Paralysis Virus (ABPV) in Kenya (Muli et al. 2014). In Kenya, virus prevalence was found to be correlated with Varroa infestation levels, in Uganda, in contrast, the BQCV was apparently not distributed by Varroa. The data from Kenya suggest that the viruses were relatively recently introduced to the country; there were not found in the remote North of the country. In general, virus prevalence was less pronounced than in Europe or North America, and viruses did not seem to affect bee health significantly (Muli et al. 2014)

American Foulbrood (Paenibacillus larvae) seems to be absent or present at low levels in African countries (Fries & Raina 2003, Dietemann et al. 2009). In South Africa it was not found in surveys of 1997/98 and 2003; there were likewise no findings in Kenya, Uganda, Tanzania, and Senegal (Fries & Raina 2003, Allsopp & Goszczynska 2011). In 2006/08 however, there were positive detects in South Africa, followed by a severe outbreak in the Cape Region in 2009 (Allsopp & Goszczynska 2011). Nevertheless, African bees seem to be overall less sensitive to this pathogen than European bees; the reasons for this are unclear, but hygienic behavior traits, swarming activity, and apicultural practices may play a role here (Danka & Villa 1994, Dietemann et al. 2009, Allsopp & Goszczynska 2011).

Chalcbrood (Ascosphaera apis) a fungal disease has been identified as a factor causing bee mortality for instance in South Africa (Pirk et al. 2014).

Apis mellifera capensis worker bee social parasitism is a phenomenon unique to Southern Africa; outside of their native range, A. m. capensis worker bees parasitize nests of other subspecies by producing pseudo-queens which eventually achieve reproductive dominance over the colony. In South Africa it is an important cause of colony mortality (Allsopp 2004, Pirk et al. 2014).

There are many other, less specific pests and predators of honeybees; in Ethiopia, for instance, Zelalem Mengistu & Jibat Beyene (2014) list ants, honey badgers, bee-eater birds, wax moths, and spiders.

Overall, the situation regarding the prevalence of bee diseases and parasites in Africa appears quite different from Europe and North America. Most of the relevant pathogens do also occur in Africa, but many of them seem to have been introduced there relatively recently, and are currently spreading there. In rather remote areas, many of the pathogens appear not to have arrived yet, but they probably will do at some point of time, especially if apicultural practices like long-distance migration and trading of bee colonies or of queens increases. Generally, African honeybees seem to be more resistant to some major diseases, compared to European honeybees as prevailing in North America and Europe (see also Dietemann et al. 2009). The reasons for this are not ultimately understood, however, it seems to be justified to assume that hygienic behavior, the stronger tendency to swarm or abscond, traditional beekeeping practices, and physiological parameters may play a role.

Habitat loss

Another potentially important stressor to honeybee health is the loss of appropriate habitats for nesting and foraging. For managed honeybees, in particular the latter aspect is likely to be of relevance, but since in many African countries managed colonies are restocked with feral swarms, loss of nesting habitats may also be important. Dietemann et al. (2009) state habitat loss to be the possibly most significant factor affecting honeybee populations in Africa. However, there are no quantitative data provided, and most publications have not analyzed this issue in detail.

Beekeeping practices

Apicultural practices are not an environmental stressor as such, but play an important role in determining which stressors bee colonies are exposed and the degree of vulnerability.

Beekeeping practices in Africa are heterogeneous. In many countries, beekeeping is predominantly practiced by smallholder farming communities (e.g. Torto 2011, Muli et al. 2014), where traditional beekeeping practices prevail. These include trapping swarms from wild populations in empty hives which are set out for this purpose, a practice which is there more common than managed breeding. In traditional beekeeping, basket, clay, grass, bark, or log hives are used. The beekeeping industry in these countries is mostly not developed according to European or North American paradigms (Dietemann et al. 2009, Muli et al. 2014). In other countries, e.g. in Egypt, Tunisia, and South Africa, also modern beekeeping practices are prevalent (Hussein 2000, Johannsmeier 2001, Dietemann et al. 2009), whereas in some countries traditional and modern practices coexist (e.g. Kenya). In South Africa, commercial beekeeping is advanced and conducted according to European and North American standards, there is a well-developed beekeeping industry with a strong pollination service component and accordingly migratory beekeeping (Allsopp 2004, Pirk et al. 2014).

In general, the numbers of bee hives per beekeeper in Africa tend to be rather small: in many countries especially in North, West and East Africa, average numbers are approximately 15 hives per beekeeper (Hussein 2000, Dietemann et al. 2009). Larger operations with more than 250 hives do for instance exist in Tanzania, Zambia, and South Africa (Ntenga & Mugongo 1991, Clauss 1992, Dietemann et al. 2009).

There is limited specific data available that demonstrates how the various apicultural practices differentially influence the stressors to which bee colonies are exposed. However, findings like the observation of Pirk et al. (2014) that migratory beekeepers in South Africa tend to have higher losses than stationary beekeepers suggests that beekeeping practices do influence bee health stressors. Interestingly the findings from South Africa are in contrast to observations from North America where there were no significant differences of colony loss rates of migratory vs. stationary beekeepers (e.g. van Engelsdorp et al. 2010b).

It seems to be likely that also some traits and patterns of traditional African beekeeping may determine exposure of environmental stressors, and might in particular be a factor contributing to the less severe effects that certain pests and pathogens have on bee health in Africa compared to Europe and North America. One aspect may be that the vast majority of African bee colonies are feral, and managed colonies are frequently recruited from the stock of feral bees. Thereby most of the colonies should still be subjected to natural selection for resistance to pathogens. In this system, there is likewise no breeding over generations with artificial selection of characters which make bee colonies easier to handle for the beekeeper, but more sensitive to pathogens, e.g. a weaker swarming tendency, as was done in Europe and North America. Moreover, the limited breeding and trade of bee colonies and queens in traditional beekeeping may retard the spread of new pathogens. A similar effect may be caused by the fact that there is less large-scale long-distance migration in traditional beekeeping. However these aspects cannot entirely account for the less pronounced effects that some pathogens and pests seem to have in Africa, because similar observations of a lesser impact of pathogens and pests is also observed for instance in South Africa where traditional beekeeping practices are not predominant. There do not appear to be much concrete data to provide evidence of the interrelationships between beekeeping practices and the effects of pathogens under specifically African scenarios; however, assumptions which postulate such relations do not appear unjustified.

Pesticides

A potential stressor which is controversial and much debated is pesticides (see e.g. Oliver 2012a, b, Eisenstein 2013). Although most larger-scale investigations did not show a correlation between pesticide exposure and increased colony mortality (e.g. Chauzat et al. 2009, van Engelsdorp et al. 2009, 2010a, Genersch et al. 2010b), there is consensus that pesticides, when applied indiscriminately or not according to the safety directions specified on the product label can severely damage bee colonies.

In some countries, mostly in Europe, there are surveillance systems to record and investigate cases of bee intoxications by pesticides. Results of these programs suggest that in the monitored countries the number of incidents caused by pesticides is relatively low in number and declining by tendency (e.g. Barnett et al. 2007, Seefeld 2008, Thompson & Thorbahn 2009). Such systems are not in place in Africa, nor are there systematic long-term monitoring programs that would over a longer time periods measure residues of agrochemicals in bee hives and correlate them with health parameters. Due to these facts, it is difficult to judge to what extent pesticides are a relevant stressor to bee health in Africa. There are some scientific data available, but only from relatively few countries, and not all of them generated according to standardized procedures.

In a survey in Kenya, residues of four substances were found in bee hives, mostly at low levels; apparently they were not a relevant issue for bee health (Muli et al. 2014). The finding of a relatively low number of residues is in contrast to observations in Europe and North America, where the number of substances found as in-hive residues was, at least in some regions, substantially higher (e.g. Mullin et al. 2010, Genersch et al. 2010b). Van der Valk (2012), on the other hand, report a relatively high input of intrinsically bee-toxic products in key crops in Kenya.

In a survey from Ethiopia, over 75% of beekeepers indicated that they lost bee colonies due to indiscriminate use of pesticides applied as foliar treatment (Zelalem Mengistu & Jibat Beyene 2014; Kerealem et al. 2009) either through mortality or by absconding (Melaku et al. 2008, Zelalem Mengistu & Jibat Beyene 2014). Insufficient communication between farmers and beekeepers with regard to applications of pesticides was emphasized to be a problem in Ethiopia by Zelalem Mengistu & Jibat Beyene (2014). The same authors highlight that there is no clear policy and legal regulations for bee-safe pesticide use in Ethiopia. Chandler (1976) indicated that intoxications of bees in East Africa mostly occur due to direct overspray, rather than drift or residual toxicity; in how far this still reflects the current state is difficult to judge.

Overall it can be assumed that bee intoxication incidents caused by indiscriminate application of pesticides or by application practices which are not in compliance with best practice recommendations to ensure a bee-safe use do occur in various African countries. Moreover, it may be justified to assume that overall exposure of bees to pesticides is very heterogeneous in different regions in Africa, with relatively low exposure especially in regions of extensive agriculture in Africa, compared to agricultural areas with intensive framing and large monocultures in North America and Europe, but also in Africa.

Generally, it can be stated that the safety of pesticides to bees is fundamentally dependent on the way they are used. Many insecticides, for instance, are more or less intrinsically toxic to bees. Such products in particular need to be applied under consideration of appropriate mitigation measures that avoid the exposure of bees. These measures are product-specific and are normally specified on the product label. They may be for instance avoiding an application during the flowering period of a bee-attractive crop, restricting the application to times of the day where bees are not present in the crop, or covering or removing bee hives that may be exposed to spray drift in or next to the crop. It is important that such mitigation measures take into account local specificities; for instance Chandler (1976) points out that it has to be considered for mitigation measures in Africa that African bees forage longer hours per day than European bees; moreover, covering hives would be difficult in hot climates, and even impossible for log hives in the trees. Data from Europe suggest that well-defined and enforced mitigation measures can be very protective and can to a great extent prevent intoxications of bees by agrochemicals (e.g. Thompson & Thorbahn 2009). However, there do not too many scientifically solid data appear to be available which would allow substantiated conclusions about to what extent mitigation measures for bees are enforced and complied with in agricultural practice in Africa.

Another important element to ensure a bee-safe application of pesticides is the legislation governing the use of pesticides, and namely the risk assessment in the product registration process. For this, there are rather elaborate risk assessment systems for bees in force in various countries. In Europe, there is a well-established, protective system in place since decades which has been regularly updated and adapted to the latest state of science (EPPO 2010a, b). A recently proposed new draft scheme (EFSA 2013) is still heavily and controversially debated and may not be feasible for implementation in its current setup (see e.g. Campbell 2013). For the United States and Canada, another new scheme has recently been published (United States Environmental Protection Agency et al. 2014). In most African countries, no detailed or complex evaluation schemes for the bee safety of pesticides are in place as a part of the product registration process, but in some countries (e.g. South Africa) there are approaches to revise the legislation that deals with bee safety of pesticides and to optimize the respective regulations accordingly.

Overall, there are various measures which can be applied to optimize the bee-safe use of pesticides; for the specific situation in Africa, the most relevant approaches include: 1) optimization of safety and risk mitigation measures for pesticide applications, and of their enforcement; 2) optimization and harmonization of the product label language that governs the bee-safe use of pesticides; 3) improvement of the communication and collaboration between farmers and beekeepers; and 4) optimization of the legislations and policies regulating the environmentally safe use of crop protection products.

Conclusions

Honeybees are exposed to a broad range of various environmental stressors in Africa, which can be having an impact to apiculture. Available specific data on the prevalence and influence of most of them is limited in Africa in comparison to certain other regions, especially Europe and North America, nevertheless, some tendencies and general trends can be derived from the information that is known. Colony losses have been reported from some countries in Africa, at more or less comparable levels like in Europe or North America. However, it is difficult to assess how representative these figures are for the whole continent. In general, many stressors that play a relevant role on global level seem to be prevalent to a certain extent in Africa too. As in other regions, parasites and pathogens appear to be of key importance as factors influencing bee health in Africa as well. Many of the relevant pest species appear to have been introduced to Africa only relatively recently; some seem to be in the status of spreading there. Generally, honeybees in Africa appear to be more resilient against many of these pathogens and parasites, compared to the European honeybee. For instance, the parasitic Varroa mite does not seem to be a problem of comparable dimension in Africa as in Europe and North America. Likewise, the influence of Nosema, viruses and some other pathogens seems to be limited so far. Furthermore, habitat loss, factors related to beekeeping practices, and the indiscriminate or careless use of pesticides have been identified as relevant stressors impacting bee health and therewith apiculture in Africa.

Generally, it can be stated that environmental stressors in Africa are similar to those which prevail in other regions, but their impact, relative importance as a health-influencing factor, frequency, and degree of incidence can be very different from the situation on other continents. Data available are limited, so for future successful management of these stressors it will in the first place be of essential importance to generate more monitoring data on bee health across the different countries of the continent, and thereby to complete and optimize our knowledge about factors impacting bee health in Africa.

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IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON BEEKEEPING PRODUCTIVITY

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Abstract

This study investigated impacts of climate variability and change on Beekeeping productivity in Sunya, Kijungu and Olgira villages in Kiteto District in Manyara region in Tanzania. Specific objectives of the study were to identify the contribution of honey bees to community livelihoods, to identify climate related factors which influence honey bee productivity, to characterise impact of climate variability and change on honey bees productivity, to identify the role of climate services and indigenous knowledge on linking changing climate with bee keeping activities and to identify possible adaptation measures that beekeepers use to respond to the impact of climate variability and change. Beekeepers were purposively selected based on their experience, with a snow balling approach was used to come up with more experienced and long term practitioners of beekeeping activities. Data were analyzed by using Statistical Packages for Social Sciences (SPSS) version 20 and Rainfall data were analysed using Microsoft Excel.

Climate Change and Climate Variability have negative impacts to the productivity of honeybees; altering plant flowering time, increasing water stress especially in situations of drought, thus reducing pollen and nectar availability, inhibiting movement, affecting bee communications, causing physical damage of hives, colony starvation and retarding bee forage activities.

In response to climate change beekeepers have adapted to reduce impacts by shifting to pollen rich areas, providing food for bees, providing water, changing hive types, changing apiary location, putting hives in tree shadows, use of over-dimensioned wooden hive and changing harvesting methods and time. Nonetheless beekeepers face serious constraints and interventions are needed to strengthen the capacity of beekeepers to adapt through integrating climate services with available indigenous knowledge and local practices.

Key Words: Beekeeping, climate change and variability, vulnerability and adaptation

EFFETS DE LA VARIABILITE ET DU CHANGEMENT DU CLIMAT SUR LA PRODUCTIVITE APICOLE

Résumé

Cette étude a examiné les effets de la variabilité et du changement du climat sur la productivité apicole dans les villages de Sun Ya, Kijungu et Olgira du District de Kiteto dans la région de Manyara en Tanzanie. Les objectifs spécifiques de l'étude étaient d'identifier la contribution des abeilles mellifères aux moyens de subsistance communautaires, d'établir les facteurs liés au climat qui influent sur la productivité des abeilles mellifères, afin de décrire l'impact de la variabilité et du changement du climat sur la productivité des abeilles mellifères, de cerner le rôle des services climatologiques et des connaissances autochtones sur les liens entre le changement climatique et les activités apicoles, et de définir les mesures d'adaptation possibles que les apiculteurs utilisent pour faire face à l'impact de la variabilité et du changement du climat. Les apiculteurs ont été choisis expressément en fonction de leur expérience ; et une approche « boule de neige » a été utilisée pour identifier des pratiquants expérimentés et de longue date dans les activités apicoles. Les données ont été analysées en utilisant le progiciel de statistiques pour les sciences sociales (SPSS) version 20, et des données pluviométriques ont été analysées en utilisant Microsoft Excel.

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Les changements et la variabilité climatiques ont des impacts négatifs sur la productivité des abeilles mellifères, ils affectent la période de floraison des plantes, augmentent le stress hydrique en particulier dans les situations de sécheresse, et réduisent ainsi la disponibilité du pollen et du nectar, inhibent le mouvement des abeilles, affectent les communications de ces dernières, provoquent des endommagements physiques des ruches, la famine dans les colonies d'abeilles et le retard des activités de butinage des abeilles.

Face aux changements climatiques, les apiculteurs ont trouvé des moyens d'adaptation pour réduire les impacts : le déplacement vers les zones riches en pollen, la fourniture d'aliments aux abeilles, l'approvisionnement en eau, le changement des types de ruche, le changement de l'emplacement du rucher, l'installation des ruches à l'ombre d'un arbre, l'utilisation de ruches en bois surdimensionnées et le changement des méthodes et du temps de récolte du miel. Néanmoins, les apiculteurs sont confrontés à de sérieuses contraintes ; et des interventions sont donc nécessaires pour renforcer leur capacité d'adaptation à ces changements par l'intégration des services climatologiques aux savoirs autochtones existants et aux pratiques locales.

Mots-clés : apiculture, changement et variabilité climatiques, vulnérabilité et adaptation

Introduction

Beekeeping has great potential for reducing poverty and stemming forest degradation (URT, 1998a; Liwenga and Masao, 2009). In Tanzania, beekeeping plays a major role in socio- economic development and environmental conservation: it is a source of food (honey and brood); raw material for various industries (e.g. candles, cosmetics, textiles, and lubricants), medicine, providing employment and income (URT, 1998). Beekeeping also contributes to biodiversity conservation and improved crop pollination (Mwakatobe and Mlingwa, 2005). It is an important source of income especially for communities living close to forests and woodlands (BfD Journal 89, 2008). It is estimated that the beekeeping sector generates US$ 1.7 (€1.3) million each year from sales of honey and beeswax, and employs about two million rural people (Mwakatobe and Mlingwa, 2005).

The effects of climate change are already being observed on ecosystems and species in all regions of the world due to the 0.74□C rise in global mean temperature (GMT) that has been experienced since pre-industrial times (Rosenzweig et al. 2007; Solomon et al. 2007). Responses include changes in phenology and shifts in species ranges (Walther et al. 2002; Root et al. 2003), with the first extinctions attributable to climate change acting synergistically with disease already reported in amphibians (Pounds et al. 2006; Bosch et al. 2006). The ocean has already acidified by 0.1 pH units since pre-industrial times due to the direct effects of increasing atmospheric concentrations of carbon dioxide from the pre-industrial level of 280 ppm to the 2005 level of 379 ppm CO_2 (Solomon et al. 2007).

Pollinators are among the ecosystem organisms that are affected as they have specific climatic requirements, and are therefore vulnerable to climate changes impacts. Climate change brings about extremes in weather condition e.g high wind, dampness, frost, drought, humidity, high temperature and flooding. These can induce different responses in pollinators. For example, increased temperatures may postpone plant flowering time which subsequently negatively impacts the ecology of the pollinator reducing their productivity (Louveaux J et al. (1966).

Research gap

Major conditions which favour beekeeping are likely to be affected by the impacts of climate variability and change. Climate variability and change directly influence honey bee behaviour and physiology as they alter the quality of the floral environment and increase or reduce colony harvesting capacity and development (Ruttner F. 1988). The full range of climate change and variability impacts is yet to be known, but it can define new honey bee distribution ranges and give rise to new competitive relationships among species and races, as well as among their parasites and pathogens (ibid). A major effect of climate change on honey bees is the impact on the distribution of the flower species on which the bees depend for food (Thuiller et al. (2005).

There is limited information in literature on the possible effects of climate change and variability affecting honey bee ecology, ecosystem services and productivity in Tanzania. The goal of the study was to assess these impacts based on five main research questions: what is the contribution of honey bees to community livelihoods, what climate related factors influence honey bee productivity, what are impacts of climate change and variability on honey bee's productivity, what are the roles of climate services in beekeeping regarding timing for the season; and what are the possible adaptation measures can beekeepers put in place to respond to and mitigate the impacts of climate change and variability.

Materials and Methods

The study area

The study was carried out in Kiteto District in Manyara Region, Tanzania. Kiteto district covers an area of 16,685 square Kilometers, which is about 34.1% of the Manyara Region. The District is bounded by Simanjiro District to the North, Kilindi District to the East, Gairo and Kongwa Districts to the South, Chamwino and Kondoa Districts to the west (Map.1). It lies between latitude 40° 31 and 6° 03'S and longitudes 36° 15' and 37° 25'E. The economy of the District is natural resource based, and the main source of livelihoods being agriculture and livestock keeping.

The Climate and Topography

The District is generally considered to be arid/semiarid. Average temperature is 22°C, with the hottest months from July to November, and the coolest being March to June. The District receives an average of 350mm - 700mm of rainfall. The terrain is characterized by plains with scattered ridges or rows of hills, and lies between 1,000m – 1,5000m above sea level, with low land areas from 1,100m – 1,300m`while the high land areas from 1,300m to 1,500m.

Methods

Three villages in Kiteto District, Kijungu, Sunya and Olgira, known to have a high production of honey were selected. From each village forty (40) beekeepers were selected for the study.First a few beekeepers were purposively selected based on their experience, and a snowball approach was used to identify and recruit other respondents who were experienced and long term beekeepers. Key informants such as beekeeping officials and honeybee traders were also included in the study, for a total sample size of 120 respondents. Quantitative and qualitative data were collected using Focus Group Discussions (FGD), structured interviews and participant observation. Both the qualitative and quantitative data were analyzed using Statistical Packages for Social Sciences (SPSS) version 20. Temperature and rainfall data from meteorological stations were analyzed using Microsoft Office Excel 2007.

Results and Discussions

Contribution of honey bees to community livelihoods

Honey and its associated products are used in a multiple socio-economic and cultural activities. However, the main sources of household income in the area of study were subsistence farming, dairy farming, beekeeping and cash crop cultivation. About 78% of respondents depend on agriculture for their livelihood, of which 58.33% are engaged in small scale farming, while 15% and 6.67% are engaged in cash crop and dairy farming, respectively. Beekeeping is a key source of income for only 20% of the households: with about 5% of the respondents solely depending on beekeeping for their livelihood.

The beekeeping industry has multiple benefits such as income, food, and a source of raw materials for making local brew (Kimbi *et al.,* 1998; Krell, 1996). It is used as a sweetener for products such as potatoes and beans, a substitute for sugar in tea and porridge and drugs, and to replace butter on bread. Honey is valued for its medicinal properties of preventing skin infections and reducing scarring (Dumronglert, 1983; Liseki and Mmbaga, 1998 and Krell, 1996). Beekeeping provides ecosystem services contributing to pollination of different vegetation species (Liseki and Mmbaga, 1998). Studies indicate that honey bees are responsible for 80% of insect pollination (CCB, 1999). Honey is used in traditional ceremonies like marriage and circumcision as well as paying dowry in Kiteto District. For these communities where honey it part of the cultural fabric, honey is revered as a symbol of the sweet side of life in the society

Climate related factors influencing honey bee's productivity

The results of this study showed that 52.94% of respondents attributed decline in honey bee keeping productivity with climate change and pests. Nearly twenty percent (19.61%) linked the decline to inadequate/below normal rainfall. Other factors that respondents attributed to the decline in honey production include poor equipment (7.84%), deforestation (5.88%) and apiary location (1.96%). A small number of respondents (11.76%) responded that they did not know the cause of the decline. A number of studies have shown that deviation of climate from the normal range can affect the developmental period of honey bee immature stages, emergence rate, wing morphology, and the colour of emerged bees (Tautz *et al.*, 2003; De Grandi-Hoffman et al,. 1993. Ambient temperature has a great effect on foraging activity, with high temperatures having a negative effect on bee foraging (Cooper and Schaffer 1985; Al- Qarni 2006; Blazyte-Cereskiene *et al.*, 2010) and very low temperature below (10 °C) preventing or reducing flight activity (Joshi and Joshi 2010).

Climate and Bee Productivity

Rainfall

The study showed that honey production is a climate sensitive practice. Above average rainfall washes out nectar, a main component of honey and inhibits foraging activity which results in tendency of bees consuming stored honey as food. Moderate Rainfall promotes maximum yield as it facilitates plant flowering and availability of nectar and pollen. In Kiteto District, there was a trend in decline in rainfall from 1990s to 2013 and increases between 1995 to 1999 with a slight increase in 2006. During 2006 and 2008 where the amount of rainfall was 890.2mm and 722.6mm, the average honey production increased to an estimated 658,351Kg and 632,000Kg respectively (Figure 1). The result showed that there was a significant increase in amount of honey harvested with increase in amount of rainfall. Similar studies by William, (2010), show that nectar production is also directly proportional to rainfall. In drought years, bee losses are greater than in rain

Table 1: Climatic factors and their influence on honey production

Climatic factor	Production outcome	Studies with similar findings
Low rainfall	Low production	
Moderate rainfall	High production (350mm - 700mm)	Poole *et al.*, 199
High Rainfall	Low production > 700mm	Poole *et al.*, 1992
High temperature	Low production > 330C	Cooper, Schaffer 1985; Al-Qarni 2006; Blazyte-Cereskiene *et al.*, 2010
Low temperature	Low production < 100C	Joshi, Joshi 2010
Moderate temperature	High production 220C – 310C	
Moderate wind	High production	
Coldness and dampness	Low production	

Source: Field survey data, July, 2014 and Liwenga and Masao (2009).

seasons as it causes more fires which cause complete loss of forage and lack of water.

The honey production increase from 2011 to 2013 contrary to the deficits in rainfall is attributable to the increases in the number of hives kept by individuals and groups under the Land Management Programme (LAMP) Phase II programme. The programme which focused on poverty reduction through sustainable management of natural resources provided more than 700 modern hives that saw an increase in honey production in 2011, 2012 and 2013 of 451,100kg, 454,825kg and 592,600kg respectively.

Temperature

The study revealed that temperature also negatively impacted on the survival of bee colonies. Above normal temperatures precipitated water shortages increasing the distances travelled by worker bees in search of water. Ambient temperature also has a great effect on foraging activity impacting collection of nectar and pollen (Cooper and Schaffer 1985; Al-Qarni 2006; Blazyte-Cereskiene *et al.,* 2010). In more extreme temperatures bees tended to abscond, and shift their geographical location to more conducive environments. Moderate temperatures favoured more bee productivity and consistency. Very low temperatures below 10 °C are known to prevent flight activity (Joshi and Joshi 2010).

Effect of Wind on Beekeeping

The study found that high winds had negative impacts on both bee hives and colonies. Although winds are important in keeping hives cool, strong winds tend to blow away bees from their targets and act as barrier to bee communication. Bees use waggle and round dances to communicate to each other on the location and distance to forage, water and pollen; and pheromones in instances of emergencies. Heavy winds interfere with this mode of communication. Heavy winds also increased physical damage to hives, and endangered the colony especially the queen bee.

Adaptation measure to Climate change and variability and their challenges

Findings from the study area revealed that, climate change is impacting the beekeeping sector and is one of the factors that reduces honey production. Beekeepers have developed options to adapt to these impacts, including: shift to pollen source, preparing and providing food for bees, provision of water, using different types of hive, transferring apiary location, increasing the number of beehives, planting trees, putting hives in trees shades, use of over-sized wooden hives and changing harvesting methods and time. Lack of finance, limited access to credit and markets, persistence of drought, weak infrastructure conditions and limited access to climate information constituted serious constraints in beekeepers capacity to adapt to the impacts of climate change and variability.

Conclusion and Recommendations

The study findings show that climate change and variability have a negative impact on beekeeping productivity in the study villages in Kiteto district. Climate change and variability exposed bees to increased environmental perturbations and stresses. Beekeepers could link impacts of climate change and variability to negative impacts on production, but are unable to utilize weather forecasts to modify and adapt their practices. Climate change and variability has direct effect on colony productivity, for in instance prolonged drought, strong wind and heavy rainfall have caused colony starvation and retarded bee forage activities hence low honey production. There is a strong need to strengthen the capacity of beekeepers and other stakeholders within the beekeeping sector to address climate change and variability. Innovative approaches are required through participation of different actors such as beekeeping extension service providers, media, NGO's, private sector and policy makers/ politicians. A strategy is needed to increase communities' knowledge on utilization of climate services: weather forecast should be provided on a seasonal basis in addition to daily forecasts. Climate change and variability should be mainstreamed into planning process.

In order to enhance the coping strategies with long term adaptation strategies government should increase the number of extension officers and access to credit that have a large influence on beekeeper decisions to adapt, establish apisilviculture schemes in order to lessen dependence on rain fed beekeeping given the increasing occurrence and severity of droughts. Current factors that hinder coping and adaptation to climate change and variability in the study villages need to be addressed in order to build beekeepers' resilience to climate change and climate variability impacts.

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ASSESSING THE USE OF CROP PROTECTION PRODUCTS FOR POTENTIAL RISKS TO HONEY BEES

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Abstract

Honeybees are an important part of agricultural ecosystems due to their activity as pollinators. In the scope of bee colony losses reported from some regions, there is an intense ongoing discussion about the multiple factors potentially affecting bee health. One of the factors central in these public debate is pesticides. In the context of this discussion, regulatory authorities in many countries are considering how to revise their national assessment schemes to evaluate the safety of pesticides to bees.

It is important that risk assessment systems are globally as consistent as possible. They need to be protective, scientifically robust, yet pragmatic, easy to interpret and implement. This review outlines a risk assessment system which fulfills these criteria.

The system presented is based on the principles of the EPPO (European and Mediterranean Plant Protection Organization) 170 Approach which is successfully used in Europe and is demonstrably protective. It is a tiered, hierarchical system relying on internationally validated study designs. The goal is protection of the bee colony, its health and productivity.

The higher-tier assessment is based on semi-field and field studies. Such studies provide direct evidence in cases where the lower-tier laboratory-based assessment did not yield conclusive results, and they include the option to consider realistic exposure scenarios in specific cases.

For the bee-safe use of crop protection products, risk management is critical as a measure to minimize exposure; therefore risk management and risk mitigation are integral to the proposed scheme. At any stage during the tiered risk assessment, it may be appropriate to consider risk mitigation measures.

Keywords: Honeybees, Pesticides, Risk assessment, Ecotoxicology

EVALUATION DE L'UTILISATION DES PRODUITS DE PROTECTION DES PLANTES CONTRE LES RISQUES POSES AUX ABEILLES MELLIFERES

Résumé

Les abeilles mellifères constituent une partie importante des écosystèmes agricoles en raison de leur activité en tant que pollinisatrices. Suite aux pertes de colonies d'abeilles signalées dans certaines régions, des discussions intenses sont en cours sur les multiples facteurs susceptibles d'affecter la santé des abeilles. L'un des facteurs essentiels évoqués dans ces débats publics est l'utilisation de pesticides. Dans le contexte de ces discussions, les autorités réglementaires dans de nombreux pays sont engagées dans un processus de réflexion sur la manière de réviser leurs systèmes d'évaluation nationale pour apprécier la

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sécurité des pesticides pour les abeilles.

Il importe que les systèmes d'évaluation des risques soient globalement aussi cohérents que possible. Ils doivent être protecteurs et scientifiquement robustes, mais pragmatiques, faciles à interpréter et à mettre en œuvre. Cette étude décrit un système d'évaluation des risques qui répond à ces critères.

Le système présenté est basé sur les principes de l'Approche 170 de l'OEPP (Organisation européenne et méditerranéenne pour la protection des végétaux), qui est utilisé avec succès en Europe et est manifestement protectrice. Il s'agit d'un système hiérarchique à différents paliers, basé sur la conception des études validées au niveau international. Son objectif est la protection, la santé et la productivité des colonies d'abeilles.

L'évaluation du niveau supérieur est basée sur des études en conditions semi-naturelles et naturelles. Ces études fournissent des informations factuelles directes dans les cas où une évaluation en laboratoire du palier inférieur n'a pas donné de résultats concluants, et elles comprennent la possibilité d'envisager des scénarios d'exposition réalistes dans des cas spécifiques.

En ce qui concerne l'utilisation des produits de protection des cultures de manière sûre pour les abeilles, la gestion des risques est essentielle en tant que mesure de minimisation de l'exposition ; donc la gestion et l'atténuation des risques font partie intégrante du système proposé. À tout moment au cours de l'évaluation des risques à plusieurs paliers, il peut être approprié d'envisager des mesures d'atténuation des risques.

Mots-clés : abeilles mellifères, pesticides, évaluation des risques, écotoxicologie

Introduction

Honey bees (Apis mellifera) are social insects that live in colonies (bee hives in apiculture) of typically 10,000 to 60,000 individuals. To feed the colony, bees forage for nectar and pollen in flowering plants including many agricultural crops. Honey bees have been domesticated by humans for millennia and their biology is relatively well-understood. They are economically very important for pollinating flowering crops, and hive products like honey and beeswax are also commercially significant.

Due to its particular economic and social importance, risk assessment approaches specifically for the honey bee have been established for some time to protect bees from potentially adverse side effects of crop protection products. Pesticide toxicity tests on honey bees were first conducted in the 1920s (for example those cited by Brasse *et al.,* 2007), and since then, increasingly sophisticated risk assessment systems have been developed and adapted with the state-of-the-art science. Currently, the valid guidance for bee testing and risk assessment in the European Union is laid down in the EPPO (European and Mediterranean Plant Protection Organization) testing guidelines and assessment schemes (EPPO, 2010a, b). An additional scheme that has recently been proposed in Europe is the EFSA (European Food Safety Authority) Draft Guidance Document on bees (EFSA, 2013). This latter scheme, however, has since its publication been a subject of considerable controversial debate (Campbell, 2013). At least for certain parts, there are substantial difficulties for implementation due to the highly conservative nature of the fundamentals of the document and a lack of practicality for some of the new requirements. Therefore this guidance has for two years since its publication not been approved, and it is not apparent that it can be implemented in its current form. In North America, another risk assessment system for pollinators outlined in the Guidance for Assessing Pesticide Risks to Bees (USEPA *et al.,* 2014; Fischer and Moriarty 2011) has been suggested for implementation.

Influenced by these developments, regulators in other countries in regions other than Europe and North America, are considering revision of their national risk assessment approaches for bees. The intention in this review is to provide relevant information on procedures and principles for a risk assessment for bees that might be helpful in this context, and to present a scheme that has in its principles proven to be protective in Europe and that can be recommended for adaptation in other regions.

To be effective, a risk assessment system should fulfill some key criteria: (i) it should be based on scientific principles, (ii) be robust and pragmatic, (iii) be based on validated criteria, and (iv) be compatible with other existing ecotoxicological risk assessment schemes.

A well-validated risk assessment scheme that fulfills these criteria was developed in Europe in the 1990s (EPPO, 1993) and has been updated several times to reflect the latest state of the science. The approach taken in the development of the scheme was empirical and aimed to represent a worst-case scenario. It compared laboratory toxicity data to field studies and incident data, and calibrated the ratio of the application rate (expressed as g active substance per hectare) to the toxicity (LD50 expressed in µg active substance/bee) – the so-called hazard quotient (HQ). From this extensive database (Aldridge and Hart, 1993; Mineau *et al.,* 2008), it was determined that for HQ values of <50, overall risks to bee colonies are low, the colonies are not affected in the field and therefore there are no long-term effects. This approach has been extensively validated with data collected from bee incidents and shown to be protective of bees under practical use conditions (Thompson and Thorbahn, 2009). The scheme has also been updated to incorporate scenarios representing soil and seed treatments thus including, where relevant, systemic properties of pesticide products (EPPO, 2010b).

The risk assessment scheme described below follows this overall assessment approach adopted by Crop Life International. This includes an initial definition of the protection goals for the scheme, followed by the core effects and exposure data required for the risk characterization. After the preliminary assessment, further options for risk refinement and/or mitigation are then discussed. Finally, the implications for implementation and enforcement of the risk assessment are considered.

General Principles

If in practice exposure of honeybees can occur both the hazard (toxicity) of the compound and also the potential exposure to the organism is then considered.

The risk assessment described here is a tiered system based on a hierarchy of studies. In a tiered approach, products of low toxicity and low risk are rapidly excluded; whereas products with a potential to harm honey bees are progressed to higher and more realistic tiers of evaluation. Consequently, it is usually not necessary to generate extensive and elaborate measures of toxicity and exposure in tier I risk assessments. By establishing clear guidance for exposure of pollinators to crop protection products a more informed risk assessment process can be developed and utilized.

Higher-tier studies have a greater level of complexity and more realistic exposure components than lower-tier studies. Lower-tier studies are typically based on artificial exposure scenarios, whereas higher-tier studies employ a more or less realistic exposure scenario. Whereas lower-tier studies primarily aim at determining intrinsic effects or toxicities of a test substance, higher-tier studies are designed to test the potential risk of a product in real-life agricultural use. Higher-tier tests are normally triggered by adverse effects seen in lower-tier tests. However, the results of higher-tier studies are generally regarded as more significant than lower-tier test results, and thus override the findings of lower-tier studies. Where results of higher-tier tests are available, the next lower testing tier is not necessarily needed.

The potential risk from the use of pesticides to honey bees is initially determined by comparing the inherent toxicity of the pesticide in the laboratory to the worst-case exposure level of bees to the pesticide following agricultural use. Risk is a product of toxicity and exposure, so if either the toxicity or exposure is negligible, then it follows that the risk will also be negligible. Laboratory tests are conducted which measure the effects of topical exposure (contact toxicity) and exposure through feeding (oral toxicity) routes.

One caveat to this approach is that a small number of insecticides work by interfering with larval development (so-called insect growth regulators) and for this mode of action, an additional evaluation of potential effects on juvenile bees is also required.

For pesticides that exhibit low inherent toxicity via oral and contact routes (>100 µg/bee, the internationally agreed limit dose), risk can be considered a priori to be negligible, since toxicity is very low and exposure will not be high enough to raise concerns. This approach has also been validated in practice since there is substantial evidence that pesticides of such low inherent toxicity do not cause bee kill incidents under normal agricultural use conditions.

Maximum potential exposure for honey bees result from foliar spray applications to the crop (at the agricultural use rate) when bees are foraging (i.e., 100% of applied exposure). Exposure in crop following treatment or in under-story vegetation is still relatively higher), as is potential exposure in off-crop habitats (see Table 2). Exposure via dietary routes is also typically very low. Consequently, if an in-crop foliar spray use identifies low risk, it can be robustly concluded that risks from all other routes will also be low because exposure from these routes is significantly lower.

The purpose of this risk assessment scheme is to provide scientific support for regulatory decision-making. It therefore considers products containing individual active substances and, where relevant, several active substances. Indeed, although simultaneous exposure to residues of several products is possible (e.g., in tank mixes or from sequential use of products), risk assessment tools do not permit the practical evaluation of the enormous number of permutations of possible mixtures and range of exposure levels that may occur in the field. This issue may however be of some importance under some limited circumstances (e.g., if the risk of constituent products is very high) and so should be considered during any risk management processes. Similarly, the assessment scheme is designed to assess risks to healthy, viable bee colonies. Diseases, parasites or other stressors may affect honey bee colony health but remain beyond the scope of typical regulatory risk assessments. Finally, this risk assessment considers uses of pesticides that are compliant with Good Agricultural Practices and does not consider misuse which is not routinely regulated in the context of a risk assessment scheme since these practices are illegal.

Protection Goals

- The honeybee colony, not the individual, is the target of the protection goal (due to the specific social and genetic system of the honeybee, the colony is considered as a meta-organism).
- There should be no direct acute or chronic effects that damage the viability/survival of the colony (through assessment of the number of individuals: adults and brood).
- There should be no direct acute or chronic effects that damage the functionality of honey bee colonies including their pollination function (crop yield), their production of honey and/or other commercial hive products.
- All assessments must take into account background (control) mortality.

Supporting information on Protection Goals

The effects of loss of adults and brood on the viability/survival of the colony can be addressed through the use of population models such as BeeHave (Becher et al. 2014). Such population models should take into account the effects of seasonality on colony development. The models should be used to identify the setting of thresholds of concern, e.g. 20% forager loss, to determine biological significance rather than relying solely on statistical analysis of significance.

Although hive weight can be used to indirectly measure honey/nectar stores, effects on crop yield cannot be directly measured and it is considered that this is measured indirectly by assessing the strength of the colony.

Indirect effects on food availability (such as from herbicide use) are not covered by this protection goal. Such effects belong to the management of honeybees by the beekeeper i.e. should a food resource be removed from the agricultural landscape where the colonies are placed it is expected to trigger a relocation or need for other food supply.

Core Data Set for Risk Assessment

Core Effects Data Package

In a tiered risk assessment system, the study package required to characterize the potential risks to non-target organisms is always determined by the intrinsic characteristics of the product and by potential exposure scenarios. Therefore the number of core studies that are generally needed to define the intrinsic properties of a product is usually limited. For bees, the key core studies assess the acute oral (feeding exposure) and the acute contact (dermal exposure) toxicity to adult organisms. In special circumstances, further optional lower-tier studies types may be required to cover specific effect or exposure scenarios.

Acute oral and acute contact toxicity for adult bees (laboratory)

The two laboratory tests for acute oral and acute contact toxicity are conducted according to the OECD Guidelines 213 and 214 (OECD, 1998a,b), their design is clearly defined and they are relatively straightforward to conduct. The main endpoints of the studies are the oral and the contact median lethal dose (LD50), and behavioral endpoints can be optionally assessed. For essentially non-toxic products (LD50 > 100 µg a.s. (active substance)/bee, or LD50 > 200 µg product/bee for mixture products) the test may be conducted as a limit test (i.e. testing of 100 µg/bee or 200 µg product/bee as single dose).

Acute oral and contact toxicity should be tested for each active ingredient and for each representative formulation unless the toxicity of a formulation can be reliably predicted from the toxicity of the active ingredient or of another formulation, then the formulation tests may be omitted. For mixture products, the acute test is likewise recommended but may as well be omitted if the toxicity of the product can be reliably predicted from the toxicities of the ingredients. Acute toxicity should be determined for all products; the only exception are products for which, according to their use pattern or application type, an exposure of bees is highly unlikely, e.g. indoor uses, non-systemic soil granules etc.

Chronic oral test for adult bees (laboratory)

A design for a chronic laboratory test with ten day dietary exposure is available, but still in the process of validation as an OECD Guideline; until that is finalized the only reliable published methodology is from the French Commission des Essais Biologiques (CEB, 2012). A chronic laboratory test should only be needed under exceptional circumstances for the following reasons:

- There are only few application scenarios which would entail chronic exposure; the most relevant one is seed or soil applications of systemic products. In the case of exposure to foliar applications, new blooms of the treated crop replace old ones, thus the potential for exposure will rapidly decrease (Nonetheless the possibility of residues in bee-collected pollen and nectar being brought to and stored in the hive may have to be considered for specific, rather persistent compounds, since this scenario might in specific cases lead to chronic exposure of the hive bees, queen and bee brood.)
- There are only very few compounds which have a pronounced chronic toxicity without displaying acute toxicity – therefore such chronically toxic compounds would be highly likely to trigger higher-tier testing in the acute oral test anyway.

Therefore, for chemicals with low acute toxicity and/ or low persistence, there is probably no need for this test.

Chronic tests should be conducted with the active substance rather than with formulations, as bees will not be exposed to the formulation over longer times. For dietary exposure estimates, life-stage consumption data (Rortais *et al.,* 2005) should be compared with chronic toxicity data to estimate chronic risk. There is no test method to assess chronic contact toxicity as this exposure scenario for bees do not occur.

Larval testing

Testing of bee larvae under standardized conditions is substantially more complex and challenging than testing adults, because bee larvae are very delicate and require specific rearing conditions and essentially rely on the care of the nurse bees and the very specific ambient conditions maintained in the bee hive. There are two alternative ways to overcome this issue, either creating exactly the conditions needed for the larvae to develop and to survive, in the laboratory, which inevitably makes the test relatively complex; or, testing the larvae in the context of the colony. For both approaches, a test design is available.

In the bee brood feeding test (Oomen *et al.,* 1992), bee colonies are exposed to 1 L of sugar solution in the hive which is spiked with the test item at the concentration of the spray solution of the respective product (in case more realistic exposure data are available, concentrations adapted accordingly may be tested). Effects to the bee brood are then assessed over at least one brood cycle. The endpoint of this test is a dietary NOEC (= No Observed Effects Concentration). Due to its unrealistic exposure scenario, and especially the unrealistically exaggerated dosing of the test item, this test is actually a lower-tier test though it has some higher-tier traits (like the use of entire colonies). As with other higher-tier studies, it requires an isolated setup of the test hives in order to avoid access to alternative food sources.

An alternative approach is the larval laboratory test according to the OECD 237 (OECD, 2013) Guideline. In this test, isolated bee larvae are exposed in the laboratory. The endpoint of this test is the LD50. The conduct of this test is relatively complicated and requires some experience.

As there are only very few compounds that are not toxic to adult bees but do display a pronounced larval toxicity, most compounds that are toxic to larvae will trigger higher-tier testing by adult effects anyway and do not need to considered separately in lower tier for larval toxicity. Brood testing should therefore only be required in the following cases:

- The substance is an insect growth regulator (IGR)
- The substance is otherwise specifically larvicidal or is specifically used to control juvenile stages of arthropods
- There are indications that the substance has specific toxicity to juvenile stages of arthropods (from ecotoxicological testing with other non-target organisms, from early screening, from efficacy testing, from considerations related to the mode of action)

Bee brood studies should normally be conducted with the active substance rather than with a formulation, as bee larvae are fed with strongly processed food in which a formulation is highly unlikely to remain stable.

Testing of Metabolites

Normally, metabolites (breakdown products from active ingredients/ parent molecules) do not need to be considered separately in lower-tier bee testing: intrinsically toxic substances will trigger higher-tier testing anyway in which the metabolites are automatically covered. On the other hand, there are only relatively few intrinsically non-toxic substances where metabolites display pronounced toxicity.

In exceptional cases, however, metabolites may be taken into consideration for lower-tier risk assessment namely:

- Where the metabolite is the actual active principle of a substance, i.e. where a precursor is applied and a metabolite subsequently formed in the environment develops the activity of the product against the target pest
- Where there are indications that the substance has metabolites which are specifically toxic to arthropods in contrast to the parent molecule (from

ecotoxicological testing with other non-target organisms, from early screening, from efficacy testing, from considerations related to the mode of action)

- Where chronic exposure to a metabolite is possible, but not to the parent molecule (e.g. soil systemic or seed treatment uses of compounds which degrade quickly but have more stable metabolites)

In all of these cases, the main route of exposure is oral, though in the first and the second case exposure to residues on treated crops may occur. In cases where oral exposure is the only relevant exposure route, the consideration of contact toxicity may be omitted with a respective justification.

Core Exposure Data Package

Crop protection products are the only chemical products that are intended to be applied directly onto crops in agricultural ecosystems. As such, they have led to the development of dedicated risk assessment processes that involve a thorough description of exposure routes for a number of non-target species, including honeybees. Guidance has been available for many years, which aims at characterizing the potential exposure of honeybees to pesticide products with the corresponding need for an assessment of risk (EPPO, 2003; EPPO, 2010b; USEPA, 2014).

Most products are typically applied either by spray to the above ground part of plants, or to soil either directly (by spray or granules) or they may aim at protecting crop seeds in which case the seed itself is coated with the product before planting. A limited number of products may also be used specifically such as trunk injection, where topical intervention to control tree pests is needed.

The method and timing of the application will affect whether bees are exposed and, if so, by which routes. The physico-chemical properties of the active ingredient can also impact exposure which may affect the distribution of the substance within the plant and also the duration of exposure.

The routes of exposure and bee stages that may be exposed vary depending

Table 1: Likelihood of exposure to honeybees through various routes

Exposure	Occurrence related to the application method	Adult	Larvae
Nectar	Application by spray during flowering	+++[1]	+
	Residues from soil or seed treatment, if the product is systemic		
Pollen	Application by spray during flowering	+ to +++	++[2]
	Residues from soil or seed treatment, if the product is systemic		
Water[a]	From field puddles forming after application (mostly spray)	+ to ++	+[3]
	From guttation droplets, sporadically in guttation-forming crops and under certain weather conditions		
Nesting Material	Through residues in wax, which may occur when nectar or pollen may be brought back to the hive	+	+
Foliar residues (contact and direct spray)	Application by spray during flowering	+++	-
Direct spray	Application by spray during flowering	+++	-

(+++: significant; ++: medium; +: low; -: none)

[a]Collect water for cooling (evaporative cooling; take up into crop, regurgitate it and flap wings to distribute) and honey production ; [1]particularly for nurse bees; [2]bee bread [3]provided by nurse bees.

Table 2: Typical exposures of honeybees as a proportion of application rate

Exposure route	Exposure level (typical % of application rate)	Rationale
Bees in crop at treatment	High (100%)	Bees foraging in a flowering crop when applications are made
Bees in crop after treatment (dry residues)	Moderate (<1% up to 50% after one week)	Foliar residues dissipate and degrade when exposed to air, light and moisture
Bees in under-story vegetation in perennial crops (e.g. flowering weeds in vines and orchards);	Moderate (<1% up to 50% after one week)	Foliar residues dissipate and degrade when exposed to air, light and moisture
Bees in foraging on off-crop on adjacent crops or natural vegetation i.e., resulting from spray drift	Low-moderate (<1% up to 5% for arable crops; <1%-20% for high crops immediately after spraying, before foliar dissipation occurs as described above)	Worst-case spray drift measurements demonstrate these maximum exposure levels for off-crop environments
Seed treatment uses and soil (including drip or drench) treatment uses via translocation in the plant	Very low: (<1%)	Relatively little of the chemical treated on the seed is translocated to the nectar or pollen, even for the limited number of 'systemic' chemicals that move freely in plants
Exposure via bees drinking water in the treated field e.g., from puddles, adjacent surface water, guttation (dew) droplets (where relevant)	Very low (<1%)	Drinking water does not constitute a significant source of exposure for the entire hive population

on the application method. These routes are summarized in Table 1, together with an indication on their relative importance in terms of likelihood of occurrence (from Fischer and Moriarty, 2014).

When performing a risk assessment, exposure estimates and/or measurements need to reflect the potential route of exposure and also the level and extent of exposure for the test organism. Table 2 compares the potential exposures for honey bees as compared to the full application rate (i.e., 100% of applied exposure). It can be seen that the maximum potential exposure results from foliar spray applications to the crop (at the agricultural use rate) when bees are foraging (i.e., 100% of applied exposure). For other potential routes, exposure is typically much lower (as summarized in Table 2). Consequently, if an in-crop foliar spray use identifies low risk, it can be robustly concluded that risks from all other routes will also be low because exposure from these routes is significantly lower.

Thus it is not always necessary to consider all potential routes of exposure, as long as the needs for the risk assessment can be met. The spray application of a product at flowering at night may or may not result in an exposure to forager bees on the day after, depending on the dissipation routes and kinetics on and within flowers and leaves. These properties have been used for many years to determine risk mitigation options for products used to control pests during bloom.

Exposure levels used in the risk assessment are either defined using the maximum application rate on a specific crop, or for residues in nectar/pollen or water through default values and calculations that rely on a compilation of available residue data for diverse crops and products, further standardized to account for the application rate of the product of concern. If the risk assessment performed based on these default estimates indicates potential risks, then refinements may be considered via measurements of residues in crop matrices relevant to bees in tunnel studies.

These estimates or measurements may focus on in-crop exposure routes or when necessary on off-crop exposure routes as for example in field margin flowers or crops. Exposure to residues off-crop may as an example occur consecutively to spray (or dust) drift onto flowers at the field margin. The routes of exposure considered in the risk assessment are similar as for an exposure in field but with lower exposure levels as only a small fraction of the product is expected to drift off the cultivated area.

The duration of exposure, which triggers acute or chronic exposure estimates in the risk assessment, is actually poorly represented in risk assessment schemes as estimates usually represent exposure levels at the time of application (i.e. maximum application rate) or estimates in food or water calculated based on the maximum application rate (e.g. EFSA, 2013 or USEPA *et al.,* 2014). The dissipation of residues on leaves or flowers, or the dilution of residues in plant matrices (like nectar or pollen) brought back to the hives, are rarely considered in exposure estimates calculations. These may therefore be accounted for in higher tier studies in tunnels or in the field, through a direct measurement of residues in these matrices and/or the measurement of the related effects at the colony level. Multiple applications are, when recommended, taken into account in the higher tier risk assessment (an individual honeybee is, due to its short lifespan, not likely to be exposed to multiple subsequent applications of the same product).

The residues mentioned in Tables 1 and 2 include the active substance and degradation products "of concern" to honeybees. These are identified among metabolites formed in the plants treated, which have not lost the activity on insects throughout the degradation process. A small proportion of active ingredients actually degrade into products that keep some activity (also called toxophore) since metabolism processes involve hydrolysis and solubilization reactions that in most case degrade the toxophore. Each metabolite or degradation product is however checked for its residual activity and any relevant degradation product is considered in the residue definition and associated assessments (EPPO, 2010b; USEPA *et al.,* 2014).

Since applications involve formulations which may contain several active ingredients, a risk assessment is therefore performed for each of them through dedicated testing. The quantification of residue levels is however performed on each active ingredient independently since its fate in plants or other environmental compartments is not influenced by its co-formulated products.

Risk Characterization

With the data from the studies conducted, the potential risk of the pesticide use under evaluation can be characterized in the risk assessment. A schematic diagram of the risk assessment system presented here is depicted in Fig. 1. The risk assessment should follow a defined scheme, which does not preclude a certain degree of flexibility on a case-by-case basis. It is important that a risk assessment corresponds to the study requirements, and therefore each study should have a defined place in the risk assessment scheme, with clarity on the requirements or data that trigger the need for the study, and the consequences of adverse effects seen in the study. There is no point in a requirement for studies which do not correspond to the risk assessment scheme and of endpoints of which cannot be interpreted and used in the risk assessment.

Crop attractiveness to bees and exposure of bees in the crop

The first step of the risk assessment is to identify whether bees are likely to be exposed to the treatment or not. If this is not the case, the risk assessment can end here and the product can be considered a priori safe to bees. Uses which are unlikely to cause exposure of bees are for instance indoor uses or soil applications of non-systemic compounds.

Whether or not bees can be exposed to a treatment is then likewise determined by the attractiveness of a treated crop to bees. It has must be noted that attractiveness to bees is not limited to only those crops which require insect pollination or that are used as a honey crop by beekeepers. However, a crop can normally be considered non-attractive to crops when it is harvested as a whole before it flowers (e.g. cabbage, lettuce), or when it is spray-treated out of the flowering period. The following points have then to be taken into consideration:

- Spray applications especially in high crops may lead to an exposure of bees on flowering weeds in the understory of the crop. To assess this, it is first important to evaluate whether under the typical growing conditions of the respective crop in the respective country there may be flowering weeds in significant numbers in bloom during application time. If this is the case, the risk assessment can be calculated with deposition rates reduced by a vegetation dilution factor rather with the full application rate (as the treated crop will filter out most of the applied product), or mitigation measures (e.g. remove flowering weeds before application) may be prescribed on the label.
- Likewise, spray drift may occur when a product is applied as foliar spray, thereby bees may be exposed in surrounding crops or weeds. This can be addressed by calculating the risk assessment with the relevant drift rates instead of the full application rate, or alternatively by prescribing mitigation measures (e.g. to avoid spray drift into flowering crops) on the label
- Pre-flowering spray applications of certain systemic compounds may lead to residues in flowers, but only in cases where the compound has significant two-way systemicity (i.e. significant translocation in xylem as well as in phloem). The number of such compounds is rather limited, so that this will need to be considered only in exceptional cases.
- In the case of soil use of systemic compounds, there may be exposure independent of the application timing, as residues may be translocated to nectar and pollen. In case of annual crops this should be taken into consideration for all uses which are applied before flowering of the crop. In perennial crops, residue pattern may be more complex and should be considered on a case-by-case basis.
- Residues of soil-applied substances may remain in the soil after harvest of the treated crop, and, in specific cases, be taken up again by subsequently grown crops. However, even in cases where this may happen, residues in bee-relevant matrices of rotational crops are usually lower or at maximum as high as in directly treated crops, so that residues in blossoms of rotational crops do not need to be considered as a specific route of exposure.
- Some crops may become attractive to bees when they are infested with significant densities of aphids which are producing honeydew. However, this is only relevant in a limited number of specific crops. Moreover, if a proper crop management is applied, this should play no role anyway, as excessive abundances of aphids are not desirable and therefore will be controlled by appropriate treatments before they reach relevant densities.
- A few crops may have alternative mechanisms of bee attractiveness, e.g. beans by extrafloral nectaries, or sugarcane by sugar sap leaking from cut stems after harvest. These few cases are exceptional and should be dealt with on a case-by-case basis.

It should be noted that it is very difficult to define systemicity, especially since systemicity may be very diverse in extent and traits depending on the physico-chemical characteristics of a substance. Most substances, with a few exceptions, are systemic to a certain extent; however, in most cases the level of translocation will not be biologically relevant in the context of the bee risk assessment. As a pragmatic tentative definition for systemicity, substances are here classified as systemic when they have the potential to build up relevant residue levels in nectar and pollen even when not directly applied to the flower.

First-tier risk assessment

In case bees may be exposed to a compound or its residues, a risk assessment needs to be conducted. The initial step is the first-tier risk assessment. This is basically a comparison between toxicity as measured in lower-tier studies (i.e. studies that measure intrinsic toxicity), and exposure. Here, two assessment sub-schemes need to be distinguished:

Spray-applied products: a Hazard Quotient (HQ) is calculated for both oral and contact toxicity. This is a quotient of the application rate (expressed in g a.s./ha) and LD50 (oral or contact) (expressed by µg a.s./bee). It can equally be calculated by expressing the application rate as g product/ha, if the toxicity is also expressed in µg product/bee; this should especially be done in the case of mixture products). If both oral and contact HQ is smaller than 50, the evaluated use is considered safe. If one of them or both are greater than 50, higher-tier risk assessment is required. The HQ is derived from an empirically validated, very robust approach: in a large-scale study it was recognized that there is a correlation between the intrinsic toxicity in conjunction with the application rate of a product on one hand, and the likelihood of the respective product to cause bee kills under field conditions (Aldridge and Hart, 1993). This study was based on the evaluation of a large number of incident reports. It was found out that for products with a HQ > 2500 there is a high likelihood that they will kill bees when applied in flowering crops. For products with a HQ < 500, the likelihood to be involved in a bee kill is negligible. Therefore the HQ trigger of 50 for higher tier testing contains a safety factor of at least 10.

Soil-systemic applications: since the main route of exposure is oral, in a first step, residues in nectar and pollen of the treated crop are compared to the oral LD50. If analytically measured residue levels in nectar or pollen are available, the 90th percentile of the measured residue levels are used in this comparison, otherwise residue levels found in entire blossoms can be used as a surrogate, although they will frequently lead to an overestimation of exposure. If there are no measured residue figures available, a residue concentration of 1 mg/kg can be used as a hypothetical worst-case concentration as conservative assumption for the first-tier risk assessment (EPPO, 2010b). In order to convert the residue figures into doses which can be compared with the LD50 figures, the food intake parameters given by Rortais et al. (2005) can be used as a conservative approximation. By dividing the LD50 by the respective exposure dose, a toxicity exposure ratio (TER) is calculated. Per potentially exposed bee category according to Rortais et al. (2005), one TER is determined. If all TER figures are greater than 10, the use is considered safe. If at least one of the TERs is smaller than 10, there can be a calculation of a chronic TER as a second step. Here, the chronic dietary NOAEC from the chronic laboratory test (see below), if available, is compared with the mean residue concentration in the respective matrix (NOAEC divided by residue concentration). If this ratio is greater than 1, the use can be considered safe, otherwise a higher-tier risk assessment is required. The step of the first-tier chronic TER calculation can be skipped in case there are no chronic toxicity data available; in this case the next step is directly the higher-tier risk assessment.

Substances toxic to bee brood: If a product contains a substance which specifically targets developmental stages of insects, the risk needs to include the available brood tests in addition to adult toxicity data. In case of a spray-applied product, either a honeybee brood test according to Oomen (Oomen et al. (1992) may be conducted with an exposure concentration equivalent to the spray solution, or a larval laboratory test to determine an

LD50. In case there were no adverse effects seen in the Oomen test, the use is considered safe. In case of effects, higher tier testing may be triggered.

In case of a soil-systemic application, an Oomen test performed on the average measured residue concentration (or alternatively a 1 mg/kg residue level as generic worst-case assumption) can be considered, or alternatively a larval laboratory test to determine an LD50. In case no adverse effects are observed in the Oomen test, the use is considered safe. In case of effects, higher tier testing may be triggered. If a larval study was performed, the LD50 is compared to the 90th percentile of the measured residue levels in bee-relevant matrices of the treated crop (or alternatively a 1 mg/kg residue level as generic worst-case assumption). These figures are converted into doses using the food intake parameters given by Rortais et al. (2005) which can be used as a conservative approximation. If the resulting TER is greater than 10, the use is considered safe, otherwise higher-tier risk assessment is required.

Mitigation measures in the context of risk assessment: At any step of the risk assessment it is possible to omit the next higher tier in case that a potential risk is indicated, if instead risk mitigation measures are prescribed which prevent the exposure of bees.

Risk refinement

Higher-tier studies and refinement to inputs to risk assessment

If higher tier risk assessment is triggered, this is done on the basis of higher-tier study data (i.e. semi-field and full-field data). If there are semi-field or full-field studies available where the use under evaluation was tested in a surrogate crop or in the target crop, and no adverse effects on colony level were seen, then the use can be considered safe. Higher tier studies result in integrative endpoints, they cover all relevant aspects of colony health.

Depending on the questions to be answered, the range of parameters that can be measured within a semi-field or a field study include for instance:

- Colony strength: ascertained through measurements of forage activity, flight activity and number of dead bees.
- Weight of the hive
- Pollen, honey and nectar stores: ascertained through measurement of percent comb coverage.
- Mortality at the hive: ascertained through measurements with dead bee traps or collecting sheets
- Mortality of drones and pupae: ascertained through visual inspection of frames
- Mortality in the crop: ascertained through collection sheets in the treatment site.
- Presence of the same queen
- Foraging activity in the crop: measured at the food source or at the hive entrance
- Behavioural abnormalities and sub-lethal effects
- Optionally, residues in pollen, nectar, pollen pellets, as well as residue measurement in wax, bee bread and dead bees: measurements of exposure inform assessment of risk.
- Assessment of the brood: this measurement may include an estimate of the number of adults, the area containing cells, eggs, larvae and capped cells)
- Disease and/or pest levels

Due to the integrative endpoints tested in semi-field and field studies, they may be used to directly evaluate risks in the higher tier risk assessment for both spray applications and soil-applied uses of systemic compounds, and for substances potentially toxic to adult bees or bee brood.

Full-field studies are a step higher in the tiered assessment compared to semi-field data. Therefore field study results override the results of semi-field studies. Highly bee-attractive, standardized crops like oilseed rape/canola, mustard, or Phacelia are worst-case crops in terms of bee exposure and therefore are commonly used as surrogates for the crops on which the uses are intended. Therefore, a study on a surrogate crop is usually deemed adequate to cover all crops of the use pattern of a product. If a study is done in a realistic target crop of the use pattern, the options to extrapolate the results to other crops should be discussed on a case-by-case basis, considering parameters such as the duration of the flowering period and the attractiveness of the tested crop compared to the crop of concern. On the other hand, if a study shows adverse effects in a worst-case surrogate crop but not in a realistic target crop, the use in this tested target crop may nevertheless be considered safe. For any kind of higher tier risk assessment and interpretation of higher tier study results, expert knowledge is indispensable.

Semi-field and field studies

Semi-field and field studies may be conducted for regulatory purposes if lower tier assessments trigger further evaluation of a chemical's potential to cause adverse effects. Such a study or studies should provide greater insight into whether adverse effects to bees are likely to occur under real-world field use of the pesticide in question. As such, the objective of the regulatory study(ies) may be to try to indicate, both quantitatively and qualitatively, what the possible effects may be under more environmentally realistic or relevant conditions.

Semi- field (tunnel/ tent) tests

For a worst-case assessment of exposure, semi-field or tunnel studies can be conducted. In these studies, colonies are placed within a tent or mesh tunnel and exposed to the treated crop during or immediately after application.

Since it is not practically feasible to conduct exposure studies in every crop, realistic worst case model crops should be used for assessing exposure of bees under field-relevant use conditions in semi-field and field trials. Choosing a realistic worst case model crop should include the following considerations:

- Attractive to bees
- Provides both nectar and pollen
- Provides sufficient flower density and sufficient duration of flowering

EPPO (2001) proposes Phacelia, oilseed rape (canola), and mustard. Buckwheat (Fagopyrum esculetum) may also be used. Application parameters (i.e., rate, interval, formulation) used in any higher-tier study should be those that are expected to produce the greatest potential exposure that is prescribed by the product label being assessed.

Using a highly bee-attractive crop would simulate a worst-case exposure to residues in pollen and nectar. Because of the controlled nature of semi-field studies for foliar-applied products, the location of the study is not as important as is for a field study, so that they are universally valid. Therefore, data from semi-field studies may be useful in risk assessments beyond the country in which it was performed, assuming that maximum application rates are assessed.

Field tests

A field study is designed to measure exposure and/or effects and is performed on a crop that is grown outdoors with no enclosure. The crop is established and maintained following good agricultural practices. While the bees are free flying and able to seek out alternative food sources, alternative sources of pollen and nectar should be minimalized.

Field trials may be carried out if an acceptable risk is not estimated by either lower tier tests or the proposed risk mitigation is undesirable. Questions to be answered from a field test should be based on the results of lower-tier studies, whether laboratory or semi-field. For example, if behavioral effects are observed in a semi-field study, it may be desirable to see if these are observed under more realistic field conditions. It may also be more appropriate to conduct a field study where a semi-field study is not considered to be appropriate (i.e., it is not necessary to always follow the tiered approach). For example, it may be relevant when there is the likelihood of long-term effects following short-term exposure.

Bees generally tend to forage on sources close to the colony, but there are some bees that will forage further afield and these individuals could bring additional residues into the colony. Consequently, in order to ensure adequate isolation from other (alternative) sources of pollen and nectar, the site ideally should be located at least 2-3 km from alternative cultivated sources of pollen and nectar, including pollen and nectar from trees.

Where the results of field studies do not suggest that the tested use would be safe under field conditions when bees are exposed, risk mitigation measures have to be taken in order to prevent exposure of bees to the treatment.

Risk mitigation

If necessary, specific risk mitigation measures may accompany the registration in providing detailed conditions of use on the product label to prevent or to reduce the exposure of bees (as for example in Europe (EPPO, 2010b) and North America (Fischer and Moriarty, 2014). Risk mitigation measures for bees may for instance include:

- Adaptation of application rate
- Modification of application timing (for example application in the evening, after daily bee flight)
- Avoiding of application during crop bloom
- Agronomic practice (e.g. removal of blooming weeds in the culture prior to application; avoiding of spray drift)
- Recommendations for apicultural practices minimizing exposure of bees (e.g. covering hives during application)

Mitigation measures have to be defined on a case-by-case basis, under consideration of the characteristics and the toxicity profile of the product, the specific features of the treated crop, and specific local conditions which may additionally influence the exposure of bees.

The prescribed risk mitigation measures have to be outlined on the product label. Here, it is of essential importance that the recommendations for risk mitigation are clear, easy to understand for users, and practically applicable.

The efficacy of each of these tools at mitigating risks to bees is being increasingly documented in the literature (e.g. Thompson and Thorbahn, 2009, Alix *et al.,* 2014).

Implementation and Enforcement

Risk assessment and risk management requires that standards are set to ensure quality and safety and this includes standards for testing, packaging, product labelling including details of its use, storage and disposal. It is the responsibility of all parties involved in production, distribution, supply and use of the product to implement these in a responsible manner. Adherence to these standards and responsible action is achieved and encouraged through compliance monitoring which covers inspection and incident reporting. It also requires an active response process in order to take appropriate action to manage incidents or to make modifications based on a better understanding of the situation in use.

Ensuring the implementation and enforcement of quality and safety standards includes:

- Regulatory approval process for products based on a risk assessment and risk management.
- The use of testing schemes which are in line with internationally recognized principles covering the data and risk assessment methodology including
  - A tiered approach to risk assessment
  - Characterization of the potential risk based on the properties of the chemical
  - Routes of exposure based on the characteristics of the product and its intended application method
  - Assessment of the risks relevant to the products' intended use and conditions of use
- Extrapolation from existing data is encouraged where relevant, for the sake of reducing experimentation and animal-welfare.
- Consideration of published research in peer review journals must be reproducible and relevant to the conditions of use to be included as part of the weight of evidence.

- Clarity of recommended uses and conditions of use for users.
- Label text should cover requirements for safe use including use rates and mitigations relevant to the situation in use
- Training and support for pesticide users
  - In the use and handling of pesticide
  - To help establish the importance of a honey bee risk assessment and management with users, bee keepers, distributors, extension services, etc
- Training and support for bee keepers in managing honey bee health particularly in queen selection, disease control and during adverse weather.
- Establish a forum for the development of best farming practices for the protection of bees
  - Time of spraying of insecticides
  - Promote farming practices preserving ecological recovery areas in general
  - Build relationship with bee keepers and ecological experts
- Post registration surveillance or monitoring can be used to establish if proposed mitigation is being effective or needs modifying. It should be
  - conducted according to clear protocols and scientific standards and not be ad hoc
    - » used to check or ensure adherence to agreed standards are achievable in practice
  - to gain a better awareness of the conditions of use in order to optimize the beneficial consequences and minimize/avoid any undesirable/ unacceptable ones
- Incident reporting procedures
    - » timely reporting and follow up conducted with a view to establishing validity and probable cause.
  - any active response required to manage incidents should be appropriate to the findings and based on sound evidence

Conclusions

In this article we present and discuss a risk assessment scheme for bees which is based on robust science yet pragmatic and easy to implement. It is derived from and fully compatible with the system currently used in the European Union, where it has been proven to be protective of bees, as evidenced by low numbers and declining incidents of bee intoxication by pesticides. We recommend this system to national regulators as an option for consideration to introduce a new or revised risk assessment system for bees where existing regulations are considered inappropriate or not fully protective.

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DES DISPOSITIONS RESPONSABLES À PRENDRE POUR LA PROTECTION DES ABEILLES CONTRE LES EFFETS NÉFASTES DES PESTICIDES.

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En considérant l'effet néfaste des maladies, des parasites, du changement climatique et d'autres facteurs environnementaux (les OGM par exemple) sur la survie des abeilles, la baisse de leurs populations dans certaines parties du monde ne saurait être attribuée aux seules pesticides. En plus, l'impact de ces derniers sur les abeilles serait substantiellement amoindri si les bonnes pratiques phytosanitaires étaient appliquées lors des traitements contre les nuisibles des végétaux.

RESPONSIBLE ACTIONS TO PROTECT BEES AGAINST PESTICIDE ADVERSE EFFECTS

Abstract

Considering the negative impact of diseases, pests, climate change and other environmental factors (e.g. GMOs) on bee survival, the decline in bee populations in some parts of the world cannot be attributed solely to pesticides. In addition, the pesticide impact on bees would be substantially reduced if good phytosanitary actions were applied during treatment against harmful plant pests.

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Introduction

Le présent document est un recueil des résultats de recherche et d'enquêtes pertinentes sur l'impact des pesticides sur les abeilles en particulier et autres pollinisateurs en général. Il présente aussi une liste non-exhaustive de bonnes pratiques phytosanitaires dont nous assurons la vulgarisation conformément aux missions qui nous sont dévolues en tant que bureau technique de la CUA en charge de la coordination des politiques et pratiques phytosanitaires en Afrique.

Les abeilles dans le milieu naturel

Les abeilles produisent du miel aux vertus nutritionnelles et thérapeutiques énormes. En butinant (de fleur en fleur), ces insectes pollinisateurs participent à l'amélioration de la production de nombreuses cultures et contribuent aussi à la qualité des récoltes. À l'échelle mondiale, 80% des plantes à fleurs se reproduisent grâce aux insectes auxiliaires; les abeilles en particulier.

Elles sont rencontrées dans les champs, les friches, les pâturages, les forêts et les jardins, et aussi autour des points d'eau naturelle et/ou artificielle partageant le même espace dans les exploitations agricoles avec les insectes nuisibles. Les abeilles et autres pollinisateurs bien qu'étant des organismes non-cibles lors de traitements phytosanitaires, sont régulièrement affectés par les pesticides.

Qu'est ce qu'un pesticide ?

Les pesticides, étymologiquement « tueurs de fléaux » sont aussi appelés produits phytosanitaires. Les producteurs de pesticides utilisent aussi l'appellation « produits phytopharmaceutiques », pour être plus souples et positifs. Les pesticides sont des produits dont les propriétés chimiques contribuent à la protection des végétaux. Ils sont destinés à détruire, limiter ou repousser les éléments indésirables à la croissance des plantes, tels que les insectes, les maladies et d'autres espèces végétales considérés comme nuisibles.

Sous la dénomination de "pesticides", sont compris: les insecticides, les acaricides, les fongicides, les herbicides, les parasiticides…….

L'intérêt de l'utilisation des pesticides en agriculture

Un adage dit que l'agriculteur ne récolte que ce que lui aura laissé le ravageur dans le champ ou dans le silo.

Le traitement phytosanitaire par l'usage des pesticides et autres moyens de lutte devient une activité essentielle. Rarement contournée par l'agriculteur.

Par leur usage, les pesticides ont contribué de façon importante à l'augmentation significative de la production d'aliments au cours des 50 dernières années. La possibilité d'améliorer les rendements à la ferme signifie que les agriculteurs peuvent produire plus d'aliments pour répondre aux besoins actuels sans avoir à augmenter les superficies cultivées. Par ricochet, cela protège la biodiversité. Puisque, moins la production agricole touche aux habitats fauniques, forêts, milieux humides et prairies, meilleur c'est pour l'environnement.

L'impact des pesticides sur la vie des abeilles

A l'instar d'autres insectes cibles nuisibles de la famille des hyménoptères ou non, les pesticides sont létaux aux abeilles. Certains de ces pesticides sont déjà, à de petites doses, toxiques pour les abeilles. Sans aller jusqu'à les tuer directement, ils empoisonnent le système nerveux, entrainant des pertes de l'orientation et des troubles du comportement. Ils les rendent aussi moins actives et entrainent très souvent un affaiblissement du système immunitaire et même l'atrophie des larves.

Les matières particulièrement dangereuses pour les abeilles sont les néonicotinoïdes. Les trois d'entre eux qui sont réellement reconnus toxiques et utilisés dans les insecticides sont la clothianidine, l'imidaclopride et le thiaméthoxam. Ces trois substances ont été interdites par l'Union européenne par précaution, en attendant d'avoir plus de données sur leur impact négatif sur les abeilles, les bourdons et l'ensemble de la biodiversité.

A ces trois néonicotinoïdes s'ajoutent l'acétamipride destiné au traitement des pucerons et, le thiaclopride utilisé pour le traitement des céréales.

La dérogation à l'interdiction d'utilisation des pesticides

Au regard des désagréments causés par les pesticides sur les abeilles et autres pollinisateurs, on est tenté restreindre davantage les possibilités de leur utilisation. S'il demeure interdit de traiter les cultures et les peuplements forestiers visités par les abeilles avec des insecticides ou des acaricides dangereux, il est désormais possible de traiter ces végétaux, avec un produit bénéficiant de la « mention abeilles ». Cela doit se faire impérativement en dehors de la présence d'abeilles.

L'emploi d'insecticides et acaricides en période de floraison ou de production d'exsudats est cependant possible sous deux conditions:

Si l'intervention a lieu en dehors des périodes de butinage, c'est-à-dire tard le soir ou tôt le matin

Le produit insecticide ou acaricide employé bénéficie d'une mention « abeilles »

La « mention abeilles »

Il existe trois types de «mention abeilles » pouvant être attribuées aux insecticides ou acaricides :

1. Emploi autorisé durant la floraison en dehors de la présence d'abeilles.
2. Emploi autorisé au cours des périodes de production d'exsudats, en dehors de la présence d'abeilles ;
3. Emploi autorisé durant la floraison et au cours des périodes de production d'exsudats, en dehors de la présence d'abeilles

Les voies d'intoxication

Qu'elle soit aiguë ou chronique, l'intoxication peut se faire par deux principales voies:

1. Contact:

- l'abeille est exposée directement à un produit dangereux,
- l'abeille se pose sur une fleur ou sur la végétation traitée avec un produit persistant ;
- l'abeille reçoit des traînées de vapeurs ou de poussières toxiques au-dessus des plantations limitrophes de celles qui sont en fleurs.

2. Ingestion:

- En prélevant du nectar ou du pollen sur des fleurs contaminées suite à une pulvérisation ;
- suite à un enrobage de semence avec un produit systémique et persistant ;

Préservation de la santé des abeilles

La préservation de la santé du cheptel apicole implique la mise en place de bonnes pratiques au niveau de :

- la gestion des ressources alimentaires des abeilles ;
  Favoriser la présence des pollinisateurs pour la pollinisation de vos cultures en implantant des espèces mellifères autour de vos parcelles et de vos ruches. Maintenir des ressources alimentaires en dehors des périodes de floraison des cultures mellifères en laissant des plantes messicoles s'implanter au bord des champs pour favoriser la biodiversité florale et mellifère.
- la maîtrise des risques sanitaires du cheptel ;
- la communication entre apiculteurs et agriculteurs ;
  Ils doivent chacun à son niveau tenir compte de l'exploitation de l'autre et surtout être conscient de la relation symbiotique qui les lie.

s'appuyer sur des justifications agronomique pour établir la nécessité d'utiliser les insecticides.

Si le pesticide est requis

- Il faut assurer un choix judicieux de l'insecticide à appliquer.
  A ce niveau, les produits homologués sont recommandés.
  Connaître impérativement l'écotoxicité des produits phytosanitaires avant de les appliquer sur les cultures ou les zones non agricoles.
- Vérifier l'indice de risque pour l'environnement ainsi que les symboles de risques (ou pictogrammes) décrivant le degré de toxicité pour les abeilles.
- Eviter les heures de butinage des abeilles ;
  Butinage est fait de 7heures à 18heures en fonction de la longueur du jour
  Température de butinage 13 à 30°C
  Seuil de la température d'abreuvage 8 à 46°C
- Eviter les traitements en période de floraison de la culture alors que les abeilles sont abondantes.
- Eviter les risques de dérive de pesticides
- Ne jamais laisser d'eaux polluées par des substances actives chimiques autour des parcelles ou sur votre exploitation
- Rendre non attractifs pour les abeilles les couverts herbacés et fleuris entre-rangs dans la parcelle à traiter.
- pratique de la lutte intégrée contre les nuisibles des végétaux.

Elle consiste à combiner plusieurs méthodes de lutte pour combattre un ou plusieurs nuisibles.

Les méthodes les plus utilisées sont les suivantes

- **La lutte prophylactique,** qui consiste à appliquer des mesures préventives contre les organismes nuisibles,
- **La lutte chimique,** qui utilise des pesticides pour les éliminer,
- **La lutte raisonnée,** qui se caractérise par un emploi rationnel de préparations phytopharmaceutiques (choix de produits, doses, ...)
- **La lutte variétale,** qui consiste à utiliser des variétés résistantes ou tolérantes aux maladies et/ou ravageurs,
- **La lutte biologique,** qui consiste à gérer les populations de ravageurs par l'utilisation d'un auxiliaire (prédateur ou parasite naturel de l'organisme à éliminer).
- **La Protection Biologique Intégrée (PBI),** qui privilégie la lutte biologique.

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HONEY RESIDUES MONITORING, SAMPLES COLLECTED FROM THREE OF THE EAST AFRICAN'S COUNTRIES (UGANDA, KENYA, AND SOUTHSUDAN) MARKETS

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Abstract

Beekeeping plays an important role in enhancing food security and sustainable agriculture as it contributes significantly to enhancing production and productivity of crops. Honey and other hive products contribute to income generation for some countries, and for countries where pollination services exist, beekeeping is a strategic enterprise. A major challenge that African honey producers face is access to both local and international markets due to underdeveloped marketing systems and inadequate quality control. The aim of this study was to screen for existence of pesticides and anti-biotic residues in the African beehive products from selected markets and to determine whether it is within the limits of EU range of Maximum Residue Levels (MRLs) or not. Secondly to investigate whether the honey from those selected markets meets minimum quality and labelling requirements based on EU and CODEX Standards. A market survey was done in three countries of east Africa (Uganda, Kenya and South Sudan), and 36 samples were collected from three different markets from different region in each country.

Analysis was conducted using Gas chromatography mass spectrometry (GC-MS) for pesticides residue analysis, and High Performance Liquid Chromatography (HPLC) for antibiotic analysis. The result shown that none of targeted organochlorine nor organo-phoshate pesticides appeared in the tested samples. There were also no targeted antibiotics were present in the samples. This result could be an indication that either the farmers and honey producers in those countries (Kenya, Uganda and South Sudan) abide by the food Safety measures and procedures, or there is a limited utilization of the targeted drugs and pesticides in study countries.

SURVEILLANCE DES RÉSIDUS DE PESTICIDES DANS LES ECHANTILLONS DE MIEL RECEUILLIS SUR LES MARCHES DANS TROIS PAYS DE L'AFRIQUE DE L'EST (OUGANDA, KENYA ET SOUDAN DU SUD)

Résumé

L'apiculture joue un rôle important dans l'amélioration de la sécurité alimentaire et l'agriculture durable, car elle contribue de manière significative à l'amélioration de la production et de la productivité des cultures. Le miel et les autres produits de la ruche contribuent à la génération de revenus dans certains pays, et là où il existe des services de pollinisation, l'apiculture est une entreprise stratégique. Le défi majeur auquel les producteurs de miel africains sont confrontés est l'accès aux marchés locaux et internationaux, en raison du sous-développement des systèmes de commercialisation et de l'inadéquation du contrôle de la qualité. Le but de cette étude était de détecter la présence de résidus de pesticides et d'antibiotiques dans les produits de la ruche africains dans certains marchés, et de déterminer si ces résidus se trouvent ou non dans les Limites des maximales de résidus (LMR) de l'UE. Deuxièmement, l'étude visait à déterminer si le miel trouvé sur ces marchés sélectionnés satisfaisait aux exigences minimales de qualité et d'étiquetage fondées sur les normes de l'UE et du CODEX. Une étude de marché a été réalisée dans trois pays de l'Afrique de l'Est (Ouganda, Kenya et Soudan du Sud), et 36 échantillons ont été recueillis dans trois marchés de différentes régions dans chaque pays.

L'analyse a été effectuée par chromatographie en phase gazeuse couplée à la spectrométrie de masse (GC-MS) pour l'analyse des résidus de pesticides, et par chromatographie liquide haute performance

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(HPLC) pour l'analyse des antibiotiques. Selon les résultats, aucun des pesticides organochlorés ou organophoshatés ciblés n'a été identifié dans les échantillons testés. En outre, aucun antibiotique ciblé n'était présent dans les échantillons. Ces résultats pourraient être une indication que soit les agriculteurs et les producteurs de miel dans ces pays couverts par l'étude (Kenya, Ouganda et Soudan du Sud) se conforment aux mesures et procédures de sécurité sanitaire des aliments, soit ils utilisent de façon modérée les médicaments et pesticides ciblés.

Introduction:

Safety of food and feed is one of the main objectives in consumer health policy. Maintaining a high level of protection is vital not only for public health, but also to preserve consumer confidence in food. The preamble to regulation No 178/2002 of the European Parliament and of the Council (EC) (European Commission 2002) states that "man has no divine right over the food. He must compete for this with weeds, diseases, insects and other organisms" (Grodner, 1996). This quote clearly reflects the situation in the area of production and processing of food.

More than ten thousand species of insects and mites, one thousand five hundred species of fungi and six hundred plant species have been identified as harmful to agriculture (Grodner, 1996; Pimentel *et al.,* 2000). The production of plant and animal products requires the use of large quantities of chemicals (plant protection agents, veterinary drugs, fertilizers, etc.), which could lead to increased production and improved quantity. The quality of the final product is usually related to particular visual parameters like colours, size and general appearance. However, in terms of food, the use of these chemicals raises many questions about food safety including the presence of chemical residues in the final consumable product. Consumer safety is a major priority for governments, especially of developed countries, and food safety is a criterion for the trading and pricing on the market.

Antibiotics can find their ways to bee products not only from beekeepers but also from the environment. In a study conducted in Greece by Karampournioti (2004), it was found that bees collect and readily transfer to their hives bactericides that are used against Erwiniaamylovora. Out of one hundred sixty-six Greek citrus honeys that were analysed, one hundred forty-six were found to have antibiotic residues of sulphonamides and streptomycin originating from the therapeutically products that had been used in citrus plants (Karampournioti, 2004). Similarly in a South Germany study by Wallner (1998) forty samples out of one hundred eighty-three (21%) were found with residues. Bees may also transfer antibiotics through water since sulphanimide and tetracyclines are used in drinking water from poultry farms, rabbit cages and other animals. The manure of pigs and cows treated with sulphonamides or sulpha-compounds could also be the vector. Some herbicides products, like Asulan may be degradated to sulphanilamide and bees harvesting nectar can transfer it into the hive (Bogdanov and Edder, 2004; Kaufmann and Kaenzig, 2004). Finally bees may rob honey from colonies of other apiaries that had been treated by antibiotics and in this way can contaminate their hives and products to detectable levels.

Tetracycline is used by beekeepers in order to control American Foulbrood Disease (AFB) and European Foulbrood Disease (EFB). Normally, it degrades in 6-10 weeks (Matsuka and Nakamura, 1990; Gilliam *et al.,* 1979). In some cases tetracycline was detected in honey, even after three years, because of the high dose used by beekeepers (Shakarya and Akopyan, 1973). The problem with streptomycin is that it may cause ototoxicity and nephrotoxicity. It is considered more dangerous than oxytetracycline and less hazardous than sulfathiazole and chloramphenicol in terms of side effects. According to the Food Standards Agency of UK, an Indian honey was found to be contaminated by streptomycin in 2003 (Mayande, 2007).

East African countries are able to meet sanitary requirements and obtain international certification for export of quality honey free of chemical residues (pesticides, chemicals and antibiotics) approved by the respective National Bureau of Standard bodies to countries such as Saudi Arabia, Australia, Japan and EU countries including Germany, the UK, Spain, Italy, Belgium, Switzerland and France. In support of production of wholesome bee products, bee experts sensitize beekeepers on the adverse effects of pesticides on bee health and on quality of bee products, encouraging the beekeepers to locate their apiaries far from agricultural farms especially commercial farms where pesticide usage is heavy. In Kenya, crop farmers near apiaries are advised to use less toxic pesticides and to apply the pesticides early morning or late evening when bees aren't foraging for nectar. Consequently in Kenya most of the honey in the market is certified organic (Kangaveet, personal communication).

Heavy metals, pesticides and antibiotics all endanger bee families. Pesticides might cause a high mortality rate among bees. The presence of contaminants such as pesticides, heavy metals or their residues in tissues of bees and in honey or other bee products can be discovered by suitable laboratory analyses (Tonelli, 1990; EC Regulation, 2005). While heavy metal concentration in honey has been researched widely, there is limited data in literature about the presence of pesticides in honey especially in Africa. Studies on pesticides in several areas in Italy has provided about the diffusion of pesticides within agricultural environments, and side effect of crop protection practices (Ghinis and Girotti 2004; Rissato, 2007).

In the case of antibiotics, specific MRL values have not been known because their presence in honey and bee products was not expected. Data in literature suggests that although the presence of acaricides (coumaphos, chlorfenvinphos, fluvalinate, amitraz) and antibiotics (tetracyclines, oxitetracycline) can be detected, such as in the case of coumaphos which was found in 14% of the samples tested, the detected residues do not represent a risk for food safety (Sabatini *et al.,* 2003).

Since September 1st 2008, the European Commission set new Maximum Residue Levels (MRLs) of some pesticides in honey, which are within the range of 10 and 50 ng/g(2005). Regulation (EC), 2005 on Maximum Residue Levels (MRLs) of pesticides in products of plant and animal origin. Honey can be used as an indicator of environmental pollution with radioactive elements (Tonelli *et al.,* 1990).

Studies show that the demand for residue-free honey, organic honey and other bee products continues to rise rapidly in the national, regional and export markets. In February 2002, the world honey market was strongly affected by a European Union (EU) ban on Chinese honey, following the identification of antibiotics in samples of Chinese honey. Since China was Europe's largest supplier of honey, this immediately led to a shortage of honey meeting EU criteria, and honey prices increased rapidly. The EU currently represents an excellent market opportunity for small producer groups in developing countries, with European and other buyers interested to buying more honey from African markets if it can meet EU criteria (Bradbear, 2009).

Materials and Methods:

Collection of samples: A total of 36 samples were collected from local markets: Yei, Maredi and Yambio in South Sudan; Gulu, Mbarara and Arua in Uganda; and Kakamega, Thika and Mwingi in Kenya. These samples were of locally produced honey, and were stored in their original containers at room temperature in a dark place.

Extraction Procedure

Pesticides: Honey (5 g) was mixed with 50 ml of water and agitated by a stir bar for 10 min. At the same time, 0.5 g of C18 sorbent was introduced into a 100 _ 9 mm ID glass chromatography column with a coarse frit No. 2 and covered with a plug of silianized glass wood at the top. The solid phase was preconditioned by passing 10 ml of methanol and 10 ml of water with the aid of a vacuum pump to avoid dryness. The sample was passed through the solid phase, after that, the retained pesticides were eluted by passing first 10 ml of ethyl acetate, followed by 4 ml of methanol, and then 1 ml of dichloromethane. The eluate was evaporated to 0.5 ml, using a gentle steam of nitrogen, and transferred quantitatively with methanol into a 1-ml volumetric flask, obtaining a final extract in 100% methanol. For the analysis 1 íl was injected into the GC-MS system.

Gas Chromatography-Mass Spectrometry. GC analysis was carried out on a Trace GC-MS 2000 (Thermo Finnigan, Manchester, UK) system with Xcalibur-software-based data acquisition. The injector temperature was 220 °C, and the detector one was 280 °C. Sample was injected in the splitless mode, and the splitless was opened after 60 s. A fused silica capillary column (30 m _ 0.25 mm I.D., 0.25 ím) with chemically bonded phases DB-5 was used. The oven temperature was as follows: initial temperature of 150 °C, held for 1 min, increased to 230 °C at 3 °C min-1, held for 5 min, and then increased to 250 °C at 3 °C min-1 and held for 15 min. The MS ionization potential was 70 eV, and the temperatures were as follows: ion source 250 °C, transfer line 200 °C, and analyzed at 230 °C. (Cristina *et al.,* 2003).

Antibiotic: honey sample was subjected to a de-proteinizing chemical procedure using CAN. Two grams of honey sample was placed into a 10ml test tube and shaken intensively with 3ml CAN for 1 min. the mixture was centrifuged for 15 min at 5000 rpm. The supernatant was collected and dried under Nitrogen stream at 40 °C. The residue was re-dissolved in methanol, filtered through 0.45 µm filter membrane and 10 µl was injected into an HPLC System.

HPLC Analysis of Antibiotics: A Hitachi (D-2000 Elite system manager) with a dual pump (L-2130), auto sampler L-2200 and UV-Visible detector L-2420 was used for the quantification of targeted antibiotic residue, in which the separation was achieved using Column oven L-2300 and column Intersil ODS-3 C18 (GL Sciences Inc. Tokyo Japan 5µm, 250×4.6 mm). All solvents were filtered through 0.45 µm sartonpolymide membrane by filtration assembly of (Rocker-300 Model Taiwan) and degassed by ultrasonic cleaner Ceia (Model CP-104 Italy). The determinations of these compounds were performed. Streptomycin and tetracycline residue were quantified by a modified method (Shafqat, U. *et al.,*2012; Albino, *et al.,* 2005). The identical chromatogram was quantified by the peak area of sample with that of standard in same retention time.

Results

There were no residues of tetracycline or Streptomycin detected from any of the honey samples collected from all the markets in all three countries. Extracts from the samples were analysed for two organochlorines (Endosulfan and Lindane) and two organophoshates (Chlorpyrifos and Malathion) by Gas Chromotogarphy Mass Spectrometer. The result revealed that none of the mentioned pesticides were detected or exceeded their detections level which was (0.001mg/kg). None of the organochlorines and organophosphates was found in the samples of the three countries.

Discussion

Although previous studies in Kenya (Irene, 2012) shown that honey samples had tetracycline and oxytracycline residues below the limit of detection which was set at 0.005 ug/ml; but the absence of tetracycline and streptomycin residue in those samples could be an indication that honey producers in Kenya and Uganda either abide by the food safety

Table 1: Antibiotics, retention time and limit of detection

Antibiotic	Retention time (min)	Limit of detection (µg/ml)
Tetracycline	9.942	0.005
Streptomycin	8.48	0.005

Table 2: Pesticides group, retention time and limit of detection

Pesticide	Group	Retention Time (Min)	Limit detection (mg/ml)
Endosulfan	Organochlorine	16.17	0.001
Chlorpyrifos	Organophosphate	22.83	0.001
Lindane	Organochlorine	13.57	0.001
Malathion	Organophosphate	12.50	0.001

requirement procedures or they are not using antibiotics at all. In the case of South Sudan the farmers are not using antibiotics in the control of bee disease and are not aware of them. This is unlike in East Africa where the possible occurrence of residues of antibiotics in honey has become major issue because of the expansion of modern agriculture. This result could also means that the environment from which the bees collect their nectar is not polluted; or on the other hand the result could show the strong enforcement of regulations and the role of standards bodies, food safety and related stakeholders in these three countries.

The presence of Antibiotics in the honey is a great concern in other continents. According to Baggio *et al.,* (2009) although 6.8% of imported honey on Italian market comes from Africa, only 1.7% honey was found with antibacterial residues.

The fact that no pesticides were detected or exceeded the admitted level of 0.001 mg /kg does not necessarily mean that farmers are not using pesticides. It is possible that apiculture activities are carrying out far from the industrial agricultural farms. Previous studies in Kenya shown that Lindane has been in long term use for seed dressing to protect crops against ants, but it is currently listed as a restricted pesticide due to its long persistence and toxicity, whereas endosulfan and chlorpyrifol are currently used as insecticides (PCPB, 1998). The use of organochlorine and organophosphate pesticides are prohibited in South Sudan. Moreover, the high residues of Lindane and Endosulfan in the environment indicates that some farmers are still applying them illegally, and hence more strict control measures against the used of these compounds needs to be put in place. They were established by a survey and were found in the stockiest shops and used in the farms (Musa *et al.,* 20011).

Conclusions

The presence of drugs and pesticide residues in honeybee products is dangerous for consumer health, reducing the quality of the products and leading to low competition in global markets. The quality of honey produced in the countries studied met the Codex Standards and EU regulations, and they were free of the residues studied. Honey produced in region is able to penetrate the EU market if proper measures are put in place.

Markets are full of unlabelled and adulterated honeys. Microbial and non microbial contaminants which include pesticides, herbicides, antibiotics, or heavy metals have been reported in various honey samples all over the world. Therefore, consumption of honey without knowing its source and safety might carry significant health hazards. Labelling of honey must be supported by analysis that confirms its provenance and safety. Health authorities in all nations have to introduce firm legislations and laws that control and regulate honey production, handling, and analysis to ascertain its safety. Raw honey was not subjected for analysis.

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LABELLISATION DES MIELS ET VALORISATION DES SPÉCIFICATIONS RÉGIONALES, CAS DE LA RÉGION BOENY À L'OUEST DE MADAGASCAR

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Résumé

À part la classification des miels par rapport à sa couleur, leurs origines florales ou géographiques pourront être utilisées comme critères dans le processus de labellisation de ce produit. Dans la région de BOENY à l'ouest de Madagascar, les acteurs apicoles ont entamé un processus pour la valorisation des miels produits dans cette région. Ce processus nécessite la mise en place de la plate forme multi-acteurs régionaux qui pilote les activités dénommé « Plate Forme Miel de Boeny ». Des outils ont été également conçus : des guides, des manuels, des supports de communication permettant de mieux gérer et de contrôles la qualité des miels. Des dispositifs de suivis et de contrôle sont en vue, mais aussi la création des références de qualité et la labellisation devront se baser sur des cadres réglementaires légales.

Mots cles : Madagascar, Région Boeny, miels, labellisation, certification, qualité.

HONEY LABELING AND REGIONAL SPECIFICATION DEVELOPMENT – THE CASE OF BOENY REGION, WESTERN MADAGASCAR

Abstract

Apart from the classification of honeys based on their colors, their floral or geographic origins can be used as criteria in labeling this product. In Boeny, western Madagascar, beekeeping actors initiated a process of adding value to honeys produced in this region. This process necessitates putting in place a regional multi-actor platform to pilot activities, known as "Boeny honey Platform." Actors have also designed tools, including guides, manuals, and communication media, to better manage and control the quality of honeys. Monitoring and control mechanisms are in prospect as well as the creation of quality benchmarks, and labeling should be based on legal and regulatory frameworks.

Keyzords: Madagascar, Boeny Region, honeys, labelling, certification, quality.

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Introduction

La tradition apicole de Madagascar est ancienne (VESTALYS, 2008) et la production de miel par ruche est particulièrement abondante, grâce à une flore mellifère exceptionnelle. Madagascar figure parmi les 25 hotspots de biodiversité identifiés comme prioritaires pour la conservation des espèces (MYERS et al, 2000). L'Apis mellifera var.unicolor, introduite au XVII Siècle (RAMAMONJISOA, 1992), y est endémique (TRIBE, 1987, CRANE 1990). C'est une race travailleuse, docile et facile à élever (RUSTICA, 2011).

Pour la région de Boeny à l'ouest de Madagascar, la production des apiculteurs traditionnels et améliorés confondus ne représente qu'environ 2 % de la production totale estimée à environ 3 Tonnes par an en 2003 (LAGARDE, 2004). Grâce à l'intervention des différents projets et programmes depuis ces dernières décennies, les nombres des apiculteurs utilisant des ruches améliorées et modernes augmentent progressivement. L'objectif pour la plate forme régionale miel de la région BOENY jusqu'à fin 2006 est de produire 40 Tonnes de miel de qualité, soit le 10% de la production nationale estimée à 4000 Tonnes (source FAO, 2010).

La norme malagasy sur le miel sortie en 2004 prévoit sur l'étiquetage différentes mesures dont de mentionner la région d'origine géographique et la source florale ou végétale (CITE, 2007) mais elle semble abstraite aux apiculteurs et aux consommateurs. Des fraudes et des tromperies sur les produits y sont fréquentes. Pour distinguer les miels de la région BOENY parmi les autres produits sur le marché national, pour garantir son authenticité et sa qualité vis-à-vis des consommateurs, la plate forme miel de la Région BOENY, avec l'appui du Programme d'appui aux gestions de l'environnement entrepris par la coopération Germano Malagasy GIZ[1] (PAGE/ GIZ) a entamé la démarche sur la labellisation des miels produits par les apiculteurs professionnels de cette région. L'hypothèse est que cette mise en place de références de qualité sur le miel créera une image de marque positive pour le miel de la région, renforcera la valeur ajoutée du miel et satisfera les besoins des clients exigeant le respect des qualités pour les miels destinées à la consommation humaine.

[1] *GIZ : Gesellschaft für Technische Zusammenarbeit*

Materiels et Methodes

Pour parvenir à ces fins, la démarche méthodologique suivante a été entreprise :

- Mise en place d'une plate forme multi acteurs régionaux, pilotés par la région de BOENY, cette plate forme regroupe les différents maillons de la chaîne de valeur miel. Quelques arrêtés régionaux, proposés par la plate ont été élaborés pour combler les vides juridiques des textes et lois sur l'apiculture et la plate forme. 3 noyaux durs effectuent des réflexions thématiques pour la promotion de la chaîne de valeur, les commissions élaborent des cahiers techniques comportant des propositions et recommandations spécifiques à chaque thématique traitée.
- Conception et opérationnalisation d'un dispositif d'informations apicoles régionales : un référentiel régional alimenté par différents acteurs constituant la plate forme.
- Mise en place d'un système de traçabilité du miel par l'immatriculation des ruchers, la mise à disposition des outils de suivis des ruches, des récoltes, des extractions, des conditionnements et vente des miels.
- Création des références de qualités à chaque type de miel : selon les origines géographiques des miels et les spécificités melliferiques selon son caractère organoleptique, son spectre pollinique, deux critères physico-chimiques HMF[2] et teneur en eau.
- Conception des outils : guide de bonnes pratiques apicoles, guide et cahier de charge pour certification ainsi que des supports de communication permettant la promotion des références de qualités.
- Mise en place d'un système de contrôles internes et externes à 3 niveaux : contrôle

[2] *HMF : HydroxyMéthylFurfural, indicateur du vieillissement et du chauffage du miel*

7 miels typiques ont pu être distingués et feront l'objet d'une labellisation et certification :

Label selon l'origine du terroir de production	Label selon l'origine florale typique de la région	CCP : Certification de conformité Miel de BOENY
Miel de Forets et du parc naturel protégé d'Ankarafantsika	Miel de Palissandre *Dalbergia sp*	Miel toutes fleurs de BOENY
Miel royal de la relique forestière d'ANDRIAMISARA (Roi de Boeny)	Miel de Mangrove	
Miel de savane	Miel de Jujubier *Zizyphus sp*	

sur l'exploitation, les contrôles de la localisation des ruchers et les contrôles sur les produits finis.

Trois sortes d'analyses ont été réalisées pour l'authentification des miels : les analyses polliniques, les analyses physico-chimiques et les analyses sensorielles (RASOLOARIJAO, 2013) . 10 échantillons de miel ont été analysés grâce aux partenariats avec le laboratoire palynologique de l'université d'Antananarivo et l'Agence de Contrôle de la sécurité sanitaire et de la Qualité des Denrées Alimentaires (ACSQDA).

Résultats

Sur 10 échantillons de miels analysés, prélevés dans 10 zones différentes à forte potentialité melliferiques à dominance de 2 ou 3 essences mellifères : 3 types de miel pourraient être dénommés : miel de palissandre, miel de mangrove, miel de jujubier. Les valeurs de fréquence relative sont supérieures à 45 %, selon les catégories proposées par LOUVEAUX et al (1970,1978), VON DER OHE et al. (2004). Ils pourront être classé miel de cru

3 autres types de miel seront dénommés selon l'origine géographique spécifiée :

- Miel de Forêt produit dans les alentours du parc national protégé de Ranomafana
- Miel royal : produit autour de la dans la relique forestière d'Andriamisara qui était parmi des rois de cette région, ainsi lié à la culture et à l'histoire de l'ethnie SAKALAVA. Ce sont des miels polyflorales constitués d'un ou de plusieurs pollens d'accompagnement : 16 ≤ fréquence ≤ 45%, LOUVEAUX et al (1970,1978), VON DER OHE et al. (2004)
- Miel de Savane produit dans un terroir largement occupé par 2 essences mellifères. Ce sont des miels polyflorales.

Deux propositions sous forme de cahier technique relatives à cette appellation ont été élaborées.

Grâce à la collaboration avec des experts nationaux et les personnes ressources, les 2 cahiers techniques formulés sont les suivantes :

1 cahier technique sur la gestion et protection de l'environnement reflétant les potentialités melliferiques actuelle de la région Boeny et l'identification des aires géographiques pouvant répondre aux critères définies pour la labellisation.

1 cahier technique sur la qualité et commercialisation des miels comportant des propositions des démarches et définitions des critères et normes sur l'appellation de miel de palissandre, miel de mangrove et miel de jujubier. La norme du BNM 020-2004 concernant la norme malagasy sur le miel et le décret n° 206-835 relatif à la collecte et au traitement du miel qui a n'apporte pas de précisions sur ces critères.

Discussion et Conclusion

Les dénominations des miels de crus ont été basées sur la catégorisation proposée par LOUVEAUX et al (1970,1978), VON DER OHE et al. (2004), Madagascar doit avoir une norme nationale sur l'appellation qui sera basée sur les spécificités des différentes régions à Madagascar. L'appellation des miels doit être fondée sur une norme légale acceptée par tous les acteurs nationaux.

D'après les analyses polliniques, les miels des différentes régions de Madagascar sont assez originaux pour qu'il soit possible de les distinguer et de leur attribuer un nom adéquat (RAMAMONJISOA, 2007). 7 types de miels ont été dénommés dans la région de Boeny à l'ouest de MADAGASCAR. Les résultats de ces actions feront l'objet de proposition pour l'appellation des miels à Madagascar.

Ces appellations ainsi que l'authenticité des miels valorisent les miels, cette affirmation est prouvée par l'augmentation des valeurs ajoutées obtenues lors de la vente des miels labellisés : supérieures à 15% par rapport aux conventionnelles. Mais la promotion de ces labels ainsi que la démarche de certification de l'appellation des miels restent encore un grand pas à franchir.

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HONEYBEE COLONY MARKETING AND ITS IMPLICATIONS FOR QUEEN REARING AND BEEKEEPING DEVELOPMENT IN WERIELEKE DISTRICT, NORTHERN ETHIOPIA

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Abstract

Government and NGOs are promoting beekeeping as a tool for poverty alleviation in Ethiopia. This increased promotion is creating increasing demand for bee colonies in the Northern part of the country such as Tigray region. Thus, colony marketing is an important venture in Werieleke district of Tigray region. This research was conducted in Nebelet and Maikinetal colony market centres of the district. It investigates the market and its implications through interviewing 120 market actors. Descriptive statistics, ANOVA and Pearson correlations were run using JMP5 statistical package. Traders in Nebelet were men who compose producers and traders. In Maikinetal, they were producers and hunters. Colony traders in Nebelet were experienced in colony multiplication through swarming and able to transport safely from highland areas of 40km radius. Traders in Maikinetal were less experienced youngsters who hunt colonies from valleys of Werie. Customers use the markets as source of colony for start up, expansion and replacement. Several youth who bought fewer colonies were found in Nebelet implying their attraction to beekeeping as employment option. There was better involvement of women in purchasing colonies as contrasted to selling, which reflect their improving participation in beekeeping. Price of colonies has significantly varied spatially and temporally ($P < 0.0001$) in association with their number and strength. Regardless of its valuable contribution to beekeeping development, colony marketing has been neglected. Consequently, several constraints were pointed-out as faced in transporting and marketing colonies. Colonies have been flowing from highlands to lowlands, which can cause genetic mix-up, disease transmissions and failure to adapt. Selling virgin queens and deserting worker bees at market were common practices indicating low understanding of beekeepers on bee biology. Therefore, law should be established in order to standardize colonies and queens sold, conserve bee diversity and avoid disease transmissions. Beekeepers should be empowered to rear queens and multiply their own colonies.

Keywords: Beekeeping, Bee colony marketing, Queen bee rearing

COMMERCIALISATION DES COLONIES D'ABEILLES MELLIFERES ET SES IMPLICATIONS POUR L'ÉLEVAGE DE REINES, ET DÉVELOPPEMENT DE L'APICULTURE DANS LE DISTRICT DE WERIE LEKE DANS LE NORD DE L'ETHIOPIE

Résumé

Le Gouvernement et les ONG sont engagés dans un processus visant à promouvoir l'apiculture comme un outil de réduction de la pauvreté en Éthiopie. Cette promotion conduit à une demande croissante de colonies d'abeilles dans la partie nord du pays tels que la région du Tigré. Ainsi, la commercialisation de colonies d'abeilles est une entreprise importante dans le district de Werieleke de la région du Tigray. La présente recherche a été effectuée dans les centres de marchés de colonies d'abeilles de Nebelet et Maikinetal du district précité. Elle a étudié le marché et ses implications grâce à des entrevues avec 120 acteurs du marché. Les statistiques descriptives, l'analyse de variance ANOVA et les corrélations de Pearson ont été faites en utilisant le progiciel statistique JMP5. Les marchands de Nebelet étaient des hommes, comprenant des producteurs et des vendeurs, tandis que ceux de Maikinetal étaient des producteurs et des

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chasseurs. Les marchands de colonies de Nebelet étaient expérimentés dans la multiplication des colonies par essaimage et pouvaient les transporter en toute sécurité dans les zones montagneuses sur un rayon de 40km. Les marchands de Maikinetal étaient des jeunes moins expérimentés qui chassaient des colonies dans les vallées de Werie. Les clients utilisaient les marchés comme sources de colonies pour le démarrage, l'expansion et le remplacement. L'on a recensé à Nebelet plusieurs jeunes qui avaient acheté moins de colonies, une indication de leur attirance pour l'apiculture comme option d'emploi. Les femmes étaient plus impliquées dans l'achat des colonies plutôt que leur vente, ce qui reflète leur participation à l'amélioration de l'apiculture. Les prix des colonies ont montré une variabilité considérable dans l'espace et le temps (P <0,0001), et ceci a été associé à leur nombre et force. Indépendamment de sa précieuse contribution au développement de l'apiculture, la commercialisation des colonies est négligée. En conséquence, plusieurs contraintes ont été signalées comme défis pour le transport et la commercialisation de colonies. Des colonies ont été transportées des hautes terres vers les plaines, avec comme conséquences éventuelles un brassage génétique, les transmissions de maladies et l'incapacité à s'adapter. La vente au marché de reines vierges et d'abeilles ouvrières déserteuses était une pratique courante qui fait penser à une faible compréhension de la biologie des abeilles par les apiculteurs. Par conséquent, il est nécessaire de mettre en place une loi pour définir des normes sur les colonies et reines vendues, conserver la diversité des abeilles et éviter les transmissions de maladies. Les apiculteurs devraient être habilités à élever des reines et à multiplier leurs propres colonies.

Mots-clés : apiculture, commercialisation de colonies d'abeilles, élevage d'abeilles reines

Introduction

Endowed with diverse agro-ecologies, Ethiopia is regarded as highly suitable for beekeeping (Jacobs et al, 2006). The country is home for 10 million bee colonies (Girma, 1998), of which 5.15 are domesticated (Central statistical agency [CSA], 2009). Ethiopia produced 54,000 tons of honey in the production year 2010/2011 (CSA, 2012). Tigray is one of the highest potential centres for beekeeping in the country and it is known for its special brand of "Tigray white honey" (Taddele and Nejdan, 2008). Development efforts in Tigray region have therefore focused on modernizing Tigray's beekeeping away from traditional practices, through provision of modern equipment and capacity building. As a result, the percentage of bee colonies nested in movable frame hives has reached 21% as contrasted to the national status, where movable frame hives contribute to less than 3%. The average honey yield of the traditional hives in Tigray is 10 kg per hive per year while that of modern hives is 16 kg per hive per year (CSA, 2012), which underscores the benefits from the development interventions.

These efforts are challenged by shortage of bee colonies. This under supply is futher exacerbated by absconding and prohibitively high prices for the bee colonies in the market. The population of domestic colonies has declined from 5.15 million in 2009 (CAS, 2009) to 4.99 million in 2011 (CAS, 2012). Some of the known reasons for the decline in the population of honeybee colonies include absconding and reduction of swarming due to introduction of movable frame hives (Yigzaw et al, 2010). The effect has been a steep rise in the demand for honeybee colonies, making colony multiplication and sale at local markets an increasingly crucial source of colonies for apiary start ups, expansion or replacement. Colony markets which have become important source of income for some beekeepers, and a lucrative business for traders, are particularly common in the semi-arid areas of Northern Ethiopia such as Bure district of Amhara region (Yigzaw *et al.,* 2010) and districts of Tigray region Ahferom (Nuru, 2008) and Werieleke (Teweldemedhn and Yayneshet, 2012). Colony markets are important source of income for colony traders, both traders and producers. Two distinct marketing channels are evident in the colony marketing in Tigray: farm gate colony marketing at individual producer's apiary and colony marketing at central market places. Nebelet and Maikinetal are the major market places located in Werieleke district. Despite their importance, only limited research (E.g. Nuru, 2008) has been carried out on this unique practice of colony marketing. The objectives of this study were to assess the origin and destination of honeybee colonies, price trends (price differentials, profit margins and longitudinal data), constraints and opportunities of honeybee colony marketing.

Materials and Methods

Description of study area

The study was conducted in Werieleke district of Tigray (13o45' to 14 o10'N latitude and 38o50' to 39o20'E longitude). Two small towns Nebelet and Maikinetal were purposefully selected, as these are the only towns in the district where the practice of colony marketing exists. These two towns boast of colony markets that are major centres of the colony marketing in the region.

Sampling and data Collection

Visits were made to the markets during the weekly market days and this was repeated for six market days (from the 4th week of July to the 1st week of September) throughout the colony marketing season in the year 2011. Personal observations and semi-structured questionnaires were employed to characterize colony traders, customers, market and marketing infrastructure (including transport facilities and the physical market infrastructure), colonies (products on offer in the market), and price trends within the season and over the years (covering the period 1999 to 2010). The research also attempted to reconstruct the history and evolution of the colony markets by interviewing older colony traders. Five colony traders and five colony customers were selected from each market centre on each data collection day. Hence, a total of 120 actors were interviewed using semi-structured questionnaires. Colony market day and market place were considered as independent factors.

Data analysis

Descriptive statistics were used to summarize variables such as sex and modes of transporting colonies. Colony prices were tested for statistical significances in a two-way ANOVA using the model $y_{ij} = \mu + \tau_i + \beta_j + \tau_i \beta_j + \varepsilon_{ij}$. Where: y_{ij} is the result for the ith market day in the jth market place, μ-overall mean, τ_i is the effect of the ith market day where i=1 to 6, β_j is the effect of the jth market place where j=1 to 2; $\tau_i \beta_j$ is the interaction effect. ε_{ij} – error term

Statistical significances for nominal and ordinal data were tested using chi-square test in order to characterize colony market actors. Pearson correlation was calculated for price trends of colonies, honey and hives. All statistical analyses were carried out using SAS-JMP5 statistical package.

Figure 1: Nebelet colony market centre

Results

Poorly equipped markets

Information from a key informant, who was has been a colony trader in Nebelet for close to three decades, revealed that colony marketing in Nebelet was started in the early 1980s, which was verified by other elders in the community. The initial colony market was located at the farmlands in the southern vicinity of Nebelet town. It was, however, transferred to the wastelands to the south-east of the town before it was transferred again to its current location in the eastern part of the town, when the second site was allocated for other livestock marketing activities in the early 2000s. . The site of the current colony market in Nebelet is rocky, well drained, devoid of plants, nearer to the main entry and exit road in the East ward of the town (Figure 1). A key challenge is the inadequate safety measures: people and animals pass through the edge of the market area without the necessary safety precautions.

Historical information tracing the time of establishment of colony marketing in Maikinetal was difficult to find. This current market is located in the peripheries of the main entry and exit road in the north-western part of the town on a hill side devoid of infrastructure: scattered Acacia trees are used as shelters (Figure 2).

Key characteristics of colony markets actors and marketing

Key market actors in the central colony marketing in Werieleke district include colony traders, customers; but also labourers and mediators are involved.

Colony producers

Some beekeepers who are able to multiply honeybee colonies are taking advantage of the growing business of colony marketing. They use splitting and swarming methods of colony multiplication. Splitting was started in 2005 at demonstration centre and since 2007 it has been diffused to beekeepers in Werieleke district and neighbouring Ahferom district. Splitting method of colony multiplication is practiced by those who own modern frame hives in Ahferom and Werieleke districts. Most modern hive owners were trained on splitting but they were not doing splitting due to lack of equipment and inadequate training, except few beekeepers who split their colonies to reproduce for replacement, start-up or sales. Queen rearing for the purpose of replacing old or undesirable queens doesn't exist in the area. Hence, it is more appropriate to describe this practice as 'colony multiplication' than as queen rearing. In this practice, mother colonies are split into one queen right and another one or more queenless colonies. Splitting into more than one queenless is rare. Each queenless colony develops one queen regardless of the number of pupa queens. When more colonies are needed, beekeepers re-split the same

Figure 2: Maikinetal colony market centre

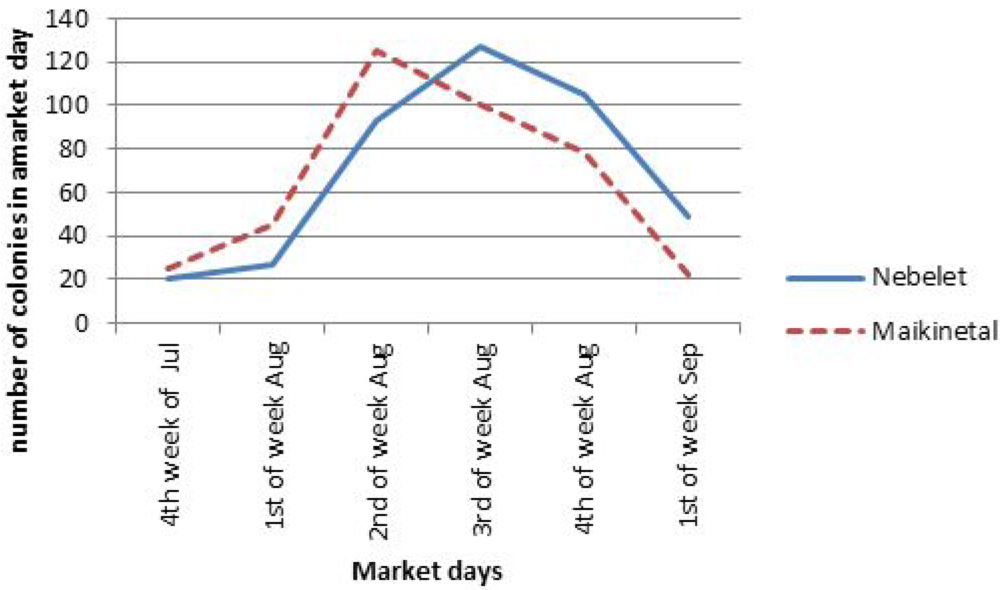

Figure 3: Number of colonies present in Nebelet and Maikinetal

Figure 4: Varieties of colonies in the colony markets

colony after being strengthened or split other colony(ies) when available.

On the other hand, traditional beekeepers in Ganta-Afeshum district practice colony multiplication by taking the advantage of reproductive swarming. They manipulate and encourage their colonies to swarm by putting in small hives, frequently smoking and removing old combs. When beekeepers observe signs of swarming, they watch the colonies carefully during 8:00 to 11:00 AM. When bees swarm, the beekeepers follow them, observe their nesting area, spray water on them, shake the plant branch, collect all bees in a basket, bring them to a shelter, catch the queen and cage her. The queen stays caged until the colony becomes settled and starts foraging. Another option is to let the queen freely moving in the colony after clipping her wings.

The colonies

Colonies supplied to the markets were nested in traditional hives made of cow dung, and of either conical or cylindrical shape. The number and strength of the colonies in the markets varied across the market days in the summer season. In both markets, the numbers of hives colonies on offer for sale reached theirwere lowest in July, peaked in the second and third weeks of August in Maikinetal and Nebelet, respectively (Figure 3). The strength (number of bees and amount of resources in

Figure 6: Ways of colony transporting to and from market

the hives) of the colonies generally tended to increase up to mid-August. After this, young and poorly established colonies started to appear in the markets (Figure 4). Assessments and feedback from respondents indicated that colonies in Nebelet were generally stronger than those on offer at Maikinetal.

While the market at Nebelet focused on selling hives produced off site and transported to the market, the Maikinetal market displayed greater diversity of products. A curious and controversial practice was observed in Maikinetal: beekeepers went to the market with empty hives with no worker bees and caged queen(s). These beekeepers would then smear the hives with aromatic plants, put the queens inside the hive and hang them on trees in the market. By evening, the hives would be filled with as many worker bees as a weak colony in the same market (Figure 5).

Sale of queen bees alone was a common practice in Maikinetal. The price of a queen was 15 Ethiopian Birr (US$ 0.75). Beekeepers did not provide feed for the queens in the cages. It was also evident that there was indiscriminate capture of queens for the market, with no regard to their fecundity.

Transporting colonies

Both honeybee colony traders and customers transported their good and purchases to and from the markets on foot, carrying them on the shoulder or head. In some cases, labourers were involved in transporting colonies these were male often landless youths and young family members or relatives of the traders. The youth were paid daily wages in cash but family members and relatives were not paid, i.e., unpaid work.

In Nebelet, traditional hives that contain colonies for sale were fixed on top of a forked wooden support of equal or longer than the hive to hold it in place and minimize breakage. While this practice was considered essential by colony traders in Nebelet, in Maikinetal both traders and customers preferred to carry the hive in a woven basket called 'Kefer' (Figure 6).

During transportation, hive lids varied from homemade dry dung and 'sefee' to dark/thick cloths and thin/transparent well ventilated meshes. To avoid heat accumulation inside the hives that affects the bees, transporters embark on travel early in the morning. In addition, transporters monitor the sound of the bees in the hive to detect distress: increased vibrating sounds signal distress, and to reduce the temperature of the hive, transporters seek shelter, usually a tree, to rest and cool down the hive by opening the lid. This was a common practice for Nebelet. Where there were longer distances to market, actors practiced different mechanisms to avoid or minimize risks (Table 1).

Breakage of combs was one of key challenges in transportation of colonies.

Figure 7: Comb breakage and prevention technique during colony transport

Figure 8: Knowledgeable beekeeper orienting colony customers at Maikinetal

To minimize breakage, traders in Nebelet supported combs with dried cow dung. This method was unknown to both traders and customer in Maikinetal and consequently there was greater incidence of breakage with injury to the colony (Figure 7).

Colony traders

Colony traders in both market centres were exclusively males: it is a male dominated domain with no women involving in the honeybee colony marketing business. The traders in Nebelet were significantly older ($P<0.0001$), had longer experience in participating in colony selling and travelled longer distances to reach the market than those who were selling colonies in Maikinetal. The average age of colony traders was 45.17±6.86 years for those in Nebelet and 34.3±5.40 years for those in Maikinetal. Traders travelled on the average one way walking time to reach the market in Nebelet and Maikinetal, 4 h 16 min, and 3 h and 27 min, respectively. Most of the traders in Nebelet (88.33 %) sold colonies that they had multiplied themselves through colony swarming and splitting; the remaining minority (11.77%) purchased and collected colonies from beekeepers' apiaries to sell them at the central market.

Traders in Maikinetal were producers (using splitting and swarming) and hunters (capturing colonies from hives in the wild) in equal ratio. Hunters were mainly youth from the lowlands.

Colony marketing

The average number of colonies sold was 2.5±0.97 and 2.0±0.93 per day per person in Nebelet and Maikinetal, respectively (Table 2). An open marketing system, whereby price is determined through direct negotiation between traders and customers is practiced. The price is determined based on the strength and quality of the queen and colony. Critical factors considered in the price negotiation include presence of a queen, its age and its fecundity, and the docility of the worker bees. However, many customers lacked the capacity to properly evaluate colonies sought

Table 1: Practices used during transporting colony in Nebelet and Maikinetal markets

Practices	Nebelet		Maikinetal		P-value (market place Type of actors Interaction)
	Traders	Customers	Traders	Customers	
Type of hive holder used					=0.896
Forked tool (wooden)	30(100)	5(16.67)	14(46.67)	0(0)	=0.883
Woven/'Kefer'	0(0)	25(83.33)	16(53.33)	30(100)	=0.993
Type of hive lid used					
Mesh	18(60)	13(43.33)	15(50)	9(30)	=0.676
Thick cloth/sack	7(23.33)	17(56.67)	9(30)	21(70)	=0.0196
Dung	3(10)	0	4(13.33)	0	=0.999
'Sefee'	2(6.67)	0	2(6.67)	0	
Resting of bees for ventilation					=0.999
Rest	23(76.67)	3(10)	8(26.67)	6(20)	= .999
Do not rest	7(23.33)	27(90)	22(73.33)	24(80)	=0.999
Support for combs?					=0.967
Use	25(83.33)	0(0)	0(0)	0(0)	=0.967
Do not use	5(16.67)	30(100)	30(100)	30(100)	=0.967
Caging of queen in the market					
Cage	30(100)		0(66.67)		
Do not cage	0(0)		10(33.33)		

Numbers in parenthesis are percentages

Table 2: Characteristics of colony traders in Nebelet and Maikinetal markets

Parameters	Nebelet (N=30)	Maikinetal (N=30)	X^2, P-Value
Sex			
-Male	100 (30)	100(30)	
-Female	0 (0)	0 (0)	
Average age (years)	45.17±6.86a	34.3±5.40b	P<0.0001
One way distance (hours) to the market	4.27±1.22 a	3.45±0.95 b	P=0.0055
Number of years participated in selling bees	16.1±5.01 a	8±3.25 b	P<0.0001
Number of colonies sold			
-colony/day/person	2.47±0.97	2.03±0.93	P=0.0862
-colony/season/person	4.73±1.62	4.37±1.38	P=0.436
Proportion of traders by type			
- Producers	86.67(26)	50 (15)	
- Hunters	0 (0)	50 (15)	X^2 29.327
-Traders	13.33(4)	0 (0)	P<0.0001

N.B: -Numbers in parenthesis are frequencies
-Means with different superscripts along the rows are significantly different

Table 3: Risks and remedies for customers and traders in Nebelet and Maikinetal markets

Category	Risk	Remedies
	Queenless colony	- Look for presence of brood
		- Look for queen if caged
		- Agreement
Customers	Quality of queen	
	- Age	- Bright colour of combs and regularly patterned larva
	- Fertility/clipped wing	- Presence of larva
	- Aggressive bees	- Observation
Traders	Loss /deserting/robbing workers bees	- Isolating away from suspected colonies
		- Pushing away suspected colonies
		- Closing bees within their hive

Table 4: Characteristics of colony customers in Nebelet and Maikinetal markets

Parameters	Market places		P-value
	Nebelet (N=30)	Maikinetal (N=30)	
Sex			
Male	90 (27)	93.33 (28)	0.639
Female	10 (3)	6.67(2)	
Average age (year)	43.07 ± 7.47^{b}	48.27 ± 6.42^{a}	0.0054
Colonies purchased/person	1.27 ± 0.45^{b}	1.53 ± 0.51^{a}	0.0366
Type of hive to be used			
Modern	83.33 (25)	90 (27)	0.221
Traditional	16.67(5)	10 (3)	
Supplier of modern hives			
Relief Society of Tigray	83.33 (25)	80 (24)	0.739
Bureau of Agriculture & rural development	16.67(5)	20 (6)	
Training			
Trained	76.67 (23)	73.33(22)	0.766
Not trained	23.33(7)	26.67(8)	
Percentages of customers by type			
Start up	30 (9)	36.67 (11)	0.678
Expansion	36.67 (11)	40 (12)	
Replacement	33.33 (10)	23.33 (7)	

-Numbers in parenthesis are frequencies
-Means with different superscripts along the rows are significantly different

Table 5: Pearson correlation between colony price, honey price and cost of modern hive

	Colony price in Nebelet	Colony price in Maikinetal	Honey price (modern)	Honey price (traditional)
Colony price in Maikinetal				
R	0.956	1		
P	0.044			
Honey price (Modern)				
R	0.976	0.958	1	
P	0.024	0.042		
Honey price (Traditional)				
R	0.996	0.941	0.984	1
P	0.004	0.059	0.016	
Cost of hive				
R	0.778	0.794	0.895	0.814
P	0.222	0.206	0.105	0.186

R- Refers to value of Pearson correlation, and P -refers to provability value

Table 6: Colony price in Nebelet and Maikinetal during 4th week of July to 1st week of Sep (2010)

week	**market place**		**P value**
	Nebelet	**Maikinetal**	
4th July	637±1.64^{de}	535±11.64^{gh}	**P market Place<0.0001**
1st August	687±11.64^{bcd}	565±11.64^{fg}	**P marketing Week<0.0001**
2nd August	733±11.64^{bc}	596±11.64^{ef}	**P interaction<0.0001**
3rd August	925±11.64^{a}	520±11.64^{ghi}	
4th August	883±11.64^{a}	483±11.64^{hi}	
1st September	763±11.64^{b}	473±11.64^{i}	

Means with different superscripts within a row and column differ significantly (p<0.05)

the assistance of more knowledgeable people (Figure 8).

The risks that customers and traders face and the remedies they employed are summarized in Table 3. The major risk for traders was the loss of worker bees in the market through desertion/ movement to other colonies in the market. Traders had to be alert to the condition of other colonies in their vicinity to minimize the risk of theft of worker bees by traders who aim to attract and gather worker bees in the market.

The key risk for customers was purchase of a colony without a queen, or with an infertile queen or purchase of a weak colony. The key remedy was keen observation and ability to reach an agreement/guarantee to ensure a quality purchase.

Colony customers

Male colony customers accounted for 90% in Nebelet and 93% in Maikinetal. Customers in Maikinetal were older than those of Nebelet (48.3±6.42 VS 43.1±7.47). Higher numbers of colonies were purchased per person per day in Maikinetal than in Nebelet (1.53±0.51 VS 1.27±0.45). Most of the purchased colonies in Nebelet and Maikinetal (85% and 90%), respectively, were for modern frame hives (Table 4).

Inter-annual colony price trend

The average price of a colony was significantly (P=0.0039) higher in Nebelet than in Maikinetal (771.33 vs 528.67 Ethiopian Birr). The price of bee colonies had been increasing continuously at an average rate of 11.3% and 13.1 % per year over the period of 1999-2010 for Nebelet and Maikinetal, respectively. The average price per colony was 231±25.14 and 125±20.14 in 1999 and grew to 925±41.43 and 596±35.65 in 2010 for Nebelet and Maikinetal, respectively (Figure 9).

Strong positive correlation was found between colony prices in both markets, price of honey of modern and traditional hives in the district, as well as cost of modern hives (Table 5).

Intra-annual (seasonal) colony price trend

The prices of bee colonies significantly varied between the two market places ($P < 0.0001$) and among market days ($P < 0.0001$). In Maikinetal, it slowly increased from the beginning of the marketing season and reached its peak in the second week of August. On the other hand, the price of a colony in Nebelet sharply increased from the beginning of the marketing season and reached its peak in the 3rd week of August (Table 6).

Discussion

Although Nebelet and Maikinetal could be among the oldest honeybee colony market places in Northern Ethiopia, they have remained neglected. The locations of these markets have been changed several times in favour of other developments. No consideration has been given to basic requirements such as suitability of site and safety precautions for traders, customers, and the communities in the vicinity. There has been no infrastructure development, and there are no public services to support the market. Despite the compulsory apicultural Proclamation of Ethiopia gazetted in the Federal Negarit Gazeta, (2009) that states colony marketing should avoid accidental bee sting attack against persons or animals, it is apparent that the markets have not received the necessary attention and support from local authorities and experts. No taxes were levied from sales at the colony markets in Werieleke District which could be a contributing factor to the lack of infrastructural development at the market. In nearby Enticho town colony market taxes are collected (Nuru, 2008).

Bee colony multiplication and trade have remained male dominated, with men from the highlands transporting and selling bees to male and female headed households in the lowlands and midlands for both traditional and modern hives. This is a reflection of the low potential for honey production (CSA, 2012) of the mountainous areas of Ganta-Afeshum and Ahferom districts which are characterized by less vegetation and climates of windy, cold and comparatively wet with bimodal rainfall patterns. In such areas, bees tend to be more broody than productive in storing honey (Verma, 1989).

The bees in the highlands of Tigray are thought to be Apis mellifera monticola (Amsalu *et al.,* 2003) although Meixner et al (2011) assert that the whole of Ethiopia has a single race. Apis mellifera monticola is known for its calm behaviour, good performance in cool highland areas but fails to adapt in hot lowland areas (Ruttner, 1988). Bees located in the lowlands of Tigray are classified as Apis mellifera jementica (Amsalu *et al.,* 2003).

The sources of from which colonies are supplied to the different colony markets could be indicative of tendency towards swarming and absconding, level of skill of beekeepers and potential of the areas. Colonies can be sourced by hunting/trapping from areas having suitable habitat for bees to live in wildly. However, in the mountain areas of Tigray having less vegetation where beekeepers are specialized on colony multiplication, swarming colonies have less chances to escape and enter someone else bait hive (Nuru, 2008) and hence difficult to get colonies by hunting. The abundant availability of wild honeybee colonies that are being hunted and brought back from the lowlands to the colony markets by youths harbouring in the lowland areas is a plausible explanation for the high rate of absconding among the bees sold to the lowlanders. Annual colony absconding per household in Werieleke district is the highest in the lowland areas Teweldemedhn and Yayneshet (2012). The practice of transporting colonies from the highlands to the lowlands and valleys of Werieleke district is also a potential pathway for genetic erosion and disease transmission. The differences in needs indicated the possibility for development of bee ecotypes adapted to the different agro-ecologies.

The existence of significantly younger customers who bought fewer bee colonies in Nebelet, as compared to that in Maikinetal, is an indication of the growing involvement of landless youth in the highlands and midlands in beekeeping. Beekeeping offers an attractive entry point for rural livelihood improvement due to the low initial capital outlay, low demand for land/land ownership and technological requirements compatible with indigenous knowledge systems (Bradbear, 2003). Beekeeping is particularly well suited for wastelands where there are limited productive options (Jacobs *et al.,* 2006). Unlike in the sale of colonies which was a male domain, women were also involved in purchasing bee colonies in both market centres. This agrees with Yigzaw et al. (2010) who noted that the number of women beekeepers is increasing in recent years as the extension is trying to gender mainstream in agricultural interventions.

The variation in the number and strength of bee colonies on offer for sale throughout the marketing season and at different markets places is a factor of dependence on the natural growth conditions in the region. Both strength and number of colonies increased steadily up to the second and third weeks of August in Maikinetal and Nebelet, respectively. After this period, small colonies started to appear not only as a result of prime swarming but also after (successive) swarming, which are locally called 'elet' to mean that weak colonies. Hence, the proportion of young colonies increased up to the end of the marketing season in both places. Colonies of the midland market (Nebelet) were generally stronger than that of the lowland market (Maikinetal). The controversial and unethical practice at Maikinetal market of capturing worker bees by causing them to desert other traders' hives has had a detrimental effect on the strength of colonies on sale, and been a major point of contention among traders there. Customers question the quality of bees collected in such a manner. Equally contentious is the sale of young queens arrested in traditional cages with no evidence of their fecundity. The age of such queens rises questions on the likelihood that they will be fertilized, given that the mating flight is generally restricted to within 26 days of age (Cramp, 2008; Sammataro and Avitabile, 2011). Experiences from Australia show that queen bee marketing is advanced that high quality queens are delivered through the postal service in specially conditioned containers with attendants and sufficient feed. Customers in developed countries receive information on the age and fertility of the queens sold by nucleus hives (Doug, 2009). There are still fundamental gaps in the understanding on the biology of queen bees in Tigray and building this capacity is a prerequisite for success in beekeeping in the region. Areas such as Bure district of Amhara region where colony marketing is recently emerging using hunting as its sole source are reported to have occupancy rates of modern frame hives as low as 40% (Yigzaw et al, 2010). These gaps hold policy and research implications for introducing appropriate queen rearing techniques in Ethiopia.

Underdeveloped transport infrastructure in association with rugged terrain restricted the honeybee colony traders and customers to travel on foot for transporting bee colonies to and from the markets. A long tradition of colony marketing has allowed beekeepers in Nebelet develop means to enable safe transportation and delivery of bee colonies under the prevailing conditions with remarkable innovation to avoid heat accumulation, suffocation and damage. However, the lowlanders who were selling and purchasing colonies in Maikinetal market, with a shorter history of bee colony marketing, were less aware the innovations.

In a marketing system where there is no standard for the products on offer, and pricing is highly dependent on negotiation, colony customers are exposed to risks in relation to the quality of the colonies and queens. Many of the customers were purchasing colonies for start ups and therefore had low skill levels, and therefore had to resort to the option of hiring skilled persons to mediate the transactions or buying from known/recommended traders. Policies, regulation and enforcement and extension services are needed to reduce this risk to beekeepers: currently the extension office has not addressed this risk. Deliberate actions to cause worker bees to desert/ emigrate from the hives of other traders, offering queenless colonies, and selling unfertilized queens were among the major problems observed due to poor technical backup and inadequate regulation enforcement. Conflicts have arisen because of the practice of collecting of worker bees by deserting from other colonies in the market. Such colonies are highly prone to absconding shortly after arrival to their destination since a colony of old workers without a queen and larvae, or a colony with unfertilized queen have no chance of producing bees for the next generations.

The escalation in the inter-annual price of a colony could be associated with the introduction of modern frame hives, increasing price of honey and overall decline in the purchasing power of the Ethiopian currency (Birr). A growing beekeeping industry usually creates demand for bee colonies (Krell, 1996). Prices of colonies significantly increased in other regions too prompted by shortage of colonies as a result of degradation, agricultural intensification, negative effects of agrochemicals, increased demand due to introduction of large number of hives, curtailing of natural multiplication due to introduction of modern hives and lack of skill of colony multiplication (Yigzaw *et al.,* 2010). The strong positive correlations among colony prices in both market centres, price of honey of modern and traditional hives, as well as cost of modern hives supports this argument. As long as the commercialization of beekeeping increases through provision of modern beehives while beekeepers are not trained how to produce their own bee colonies, the price of colonies can be expected to continue to rise. Prices of colonies are direct reflection of the quality-demand-supply for the colonies as clearly seen in this research. The price of colonies was generally higher in Nebelet than Maikinetal because colonies in Maikinetal were heterogeneous ranging from very weak, less established, hunted colony to well established. Demand for colonies was higher in Nebelet than that of Maikinetal as new beekeepers around Nebelet solely relied on the market for colonies in contrast to that of new beekeepers around Maikinetal who also hunted for wild bees.

Similarly the intra-annual and spatial patterns in price of colonies were peg to the issues of quality-demand-supply of colonies. Colonies at the beginning of the marketing season were generally weak and they continued to be stronger through time until a new pattern came. Similarly, the supply of colonies at the beginning of marketing season was limited because the time for colony multiplication is later in the season. Customers were reluctant to purchase colonies at the beginning of the season when the fate of weak colonies and rainfall was unpredictable; confidence increased with more predictable rainfall. The aim of colony buyers was to establish colonies before the rainy season ended. The price of colonies reached its peak earlier in Maikinetal than Nebelet due to agro-ecological differences. Since the lowland areas were characterized by vegetation that blooms quickly after the start of the rainfall, the strength of bee colonies and the demand for colonies grow faster.

Conclusion

Colony trade is an important source of income for male beekeepers in the business of bee colony multiplication and marketing. The main means of colony multiplication are through swarming and splitting; but unethical and controversial practice of instigate bees from other colonies to abscond and capturing them to establish a new colony is also utilized even though it causes agitation among colony traders. The colony markets, patronized by both men and women, are an important source of colonies for start ups and expansion of beekeeping.

In spite of its valuable contribution to beekeeping development, colony marketing has been neglected, and there are many gaps for improving the current system to harness it for promoting beekeeping and improved rural livelihoods, incomes and employment. The physical markets require basic services and infrastructure, policies and options are needed to improve bee colony transportation, ensure quality standards of products on offer especially of queens, improve market efficiency and conserve the honeybee genetic resource. Research on queen rearing focusing on identifying suitable seasons, race classification and performance evaluation, can help to transform the beekeeping sector in Tigray. Higher education and research institutions should focus on the establishment of bee centres committed for research and breeding programs. Extension services are needed to raise awareness and for capacity building of both traders and customers/beekeepers on key aspects of colony multiplication and purchase across agro-ecological zones.

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SESSION 2: HONEY BEE DISEASES, CAPACITY DEVELOPMENT, TECHNOLOGY INNOVATION AND TRANSFER

THE STATUS OF HONEYBEE PESTS IN UGANDA

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Abstract

Beekeeping provides enormous potential for income generation, pollination and sustainable use of forest resources. In Uganda, honey production potential is enormous and in 2005; Uganda was licensed to export honey to the EU, creating an immense opportunity. However, the potential for beekeeping is not fully exploited. Many pests attack honeybees causing enormous losses. This descriptive study that took a participatory action research approach, evaluated how beekeepers managed honeybee pests. Data collection was carried out from 2009 to 2012 from four of the ten agro-ecological zones of Uganda. These zones are classified on the basis of distinct vegetation type, elevation and climatic conditions. Eleven honeybee pests and predators that affect beekeeping production were documented. The important pests causing economic losses were black ants, small hive beetles, wax moths and bee hornets. Effective methods for pest control and management applied by beekeepers included mechanical methods and bio-control. The mechanical methods included keeping the apiary tidy; avoiding throwing combs around apiaries and frequent smoking to drive out small hive beetles. At least 28% of the beekeepers developed local organic (bee-safe) methods for pest control. To manage the ants, many beekeepers applied ash at the apiaries. They hanged their hives using wires and kept their apiaries tidy. The use of hive stands placed in used engine oil also helped reduce many pests. Some beekeepers swatted bee hornets to reduce colony abscondment. The pests led to absconding of many colonies. Honey production with the traditional hives was most affected by the pests; followed by the top bar hive. Frame hives were the least affected by the pests. Many beekeepers lacked adequate information for managing the pests limiting the methods used to control the pests. There should be detailed study of the important honeybee pests in order to design best management practices.

Key words: Honeybees, Honeybee pests, ants, wax moths, small hive beetles, Uganda

LA SITUATION DES PARASITES DE L'ABEILLE MELLIFERE EN OUGANDA

Résumé

L'apiculture présente un énorme potentiel de génération de revenus, de pollinisation et d'utilisation durable des ressources forestières. En Ouganda, le potentiel de production de miel est énorme, et en 2005 le pays a été autorisé à exporter du miel vers l'UE, un immense débouché. Cependant, le potentiel de l'apiculture n'est pas pleinement exploité. De nombreux parasites attaquent les abeilles, et sont à l'origine d'énormes pertes. Cette étude descriptive, qui a utilisé une approche de recherche-action participative, a évalué la manière dont les apiculteurs géraient les parasites des abeilles. La collecte de données a été réalisée de 2009 à 2012 dans quatre des dix zones agro-écologiques de l'Ouganda. Ces zones sont classées sur la base du type distinct de végétation, de l'altitude et des conditions climatiques. Onze ravageurs et prédateurs d'abeilles, qui affectent la production apicole, ont été documentés. Les ravageurs importants, qui ont entraîné des pertes économiques, étaient les fourmis noires, les petits coléoptères des ruches, les fausses teignes et les frelons d'abeilles. Les méthodes efficaces de contrôle et de lutte antiparasitaire appliquées par les apiculteurs comprenaient les méthodes mécaniques et la lutte biologique. Les méthodes mécaniques comprenaient l'ordre et la propreté dans les ruchers, le fait d'éviter de jeter des rayons

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de miel autour des ruchers et l'enfumage fréquent pour chasser les petits coléoptères des ruches. Au moins 28% des apiculteurs a développé des méthodes (sûres pour les abeilles) biologiques locales de lutte antiparasitaire. Pour la gestion des fourmis, de nombreux apiculteurs avaient recours à l'application de cendres aux ruchers. Les apiculteurs suspendaient leurs ruches à l'aide de fils de fer et gardaient leurs ruchers ordonnés. L'utilisation de supports de ruches placés dans de l'huile moteur usée a également contribué à réduire les parasites. Certains apiculteurs chassaient les frelons d'abeilles pour réduire la fuite des colonies. Les parasites ont conduit à la fuite de nombreuses colonies. La production de miel utilisant la ruche traditionnelle a été la plus touchée par les parasites, suivie de la ruche à barrettes supérieures. Les ruches à cadres étaient les moins affectées par les parasites. Beaucoup d'apiculteurs ne disposaient pas d'informations suffisantes sur la lutte contre les parasites, limitant ainsi les méthodes utilisées pour combattre ces organismes nuisibles. Il faudrait mener une étude détaillée des parasites importants des abeilles afin de concevoir les meilleures pratiques antiparasitaires.

Mots-clés : abeilles mellifères, parasites des abeilles mellifères, fourmis, fausses teignes, frelons d'abeilles, Ouganda

Introduction

Beekeeping in Uganda is important as a source of food, employment, rural poverty alleviation, environmental conservation and diversification of the export base (Commonwealth Secretariat, 2002; FAO, 1990; MAAIF, 2000; TUNADO, 2003). Compared to other agricultural projects, beekeeping is a relatively low investment venture that can be undertaken by most people, including the vulnerable (women, youths, disabled and elderly). Pharmaceutical and cosmetic industries use bee products such as honey, propolis, royal jelly, bee venom and beeswax (UEPB, 2005). Honey and bee brood are sources of carbohydrate and protein food that rural people can obtain at minimal cost (FAO, 1990). One of the most important services honeybees render to mankind is pollination of agricultural and forestry crops (Muli et al 2014). There is demand for bee products both locally and internationally: in 2005, the European Union licensed Uganda to export honey to its market, thus creating an immense opportunity. Uganda has not yet exploited the opportunity to expand into niche markets for special flavoured and organic honeys. Efforts to increase production to meet demand are however constrained by various challenges related to production, processing, packaging, storage and marketing (UEPB, 2005).

Declines in honeybee populations in East Africa due to nest habitat destruction, use of agricultural chemicals, nutritional imbalance, pests, predators and diseases have been reported (Muli et al 2014). Limited studies have been undertaken to ascertain trends in bee populations in Uganda. Some known honeybee pests in Uganda include ants, wax moth, hive beetles, lizards, birds and termites; however, there is a paucity of information in literature about honeybee pests existing in the different agro-ecological zones of the country (MAAIF/UBOS, 2010). There is no national honeybee pest surveillance system and Uganda is yet to put in place an efficient honeybee pest control system necessary for honeybee pest eradication and creation of pest free export zones. The economic impact of honeybee pests on the production of honey and other bee products is poorly understood: with indication that some known pests of honeybees that are economic importance elsewhere not similarly impacting causing honeybee colonies in the Ugandan ecosystems. Uganda needs policies, safe, effective, and environmentally acceptable forms of pest control for the growth of beekeeping industry and to safeguard the qualities of bee products. This study therefore documented the honey bees in Uganda, assessed their prevalence and examined and document organic (bee-safe) methods of insect pest control.

Materials and Methods

Study sites

Data collection was carried out from 2009 to 2012 from four of the ten agro-ecological zones of Uganda. These agro-ecological zones are classified on the basis of distinct vegetation type, elevation and climatic conditions. Zones were purposively selected (Figure 1) based on the number of active bee farmers groups and the records of honey productivity in those zones. In the mid northern agro-ecological zone, the selected districts include Lira, Dokolo, Pader and Kitgum. In Lake Victoria Crescent agro-ecological zone, Luwero and Nakasongola districts were selected. In southern dry lands agro-ecological zone, Mbarara district; and in the Western highlands agro-ecological zone, Kabarole district study (Table 1).

Research design and methodology

The study took a Participatory Action Research approach with respondents interviewed and also capacitated to actively

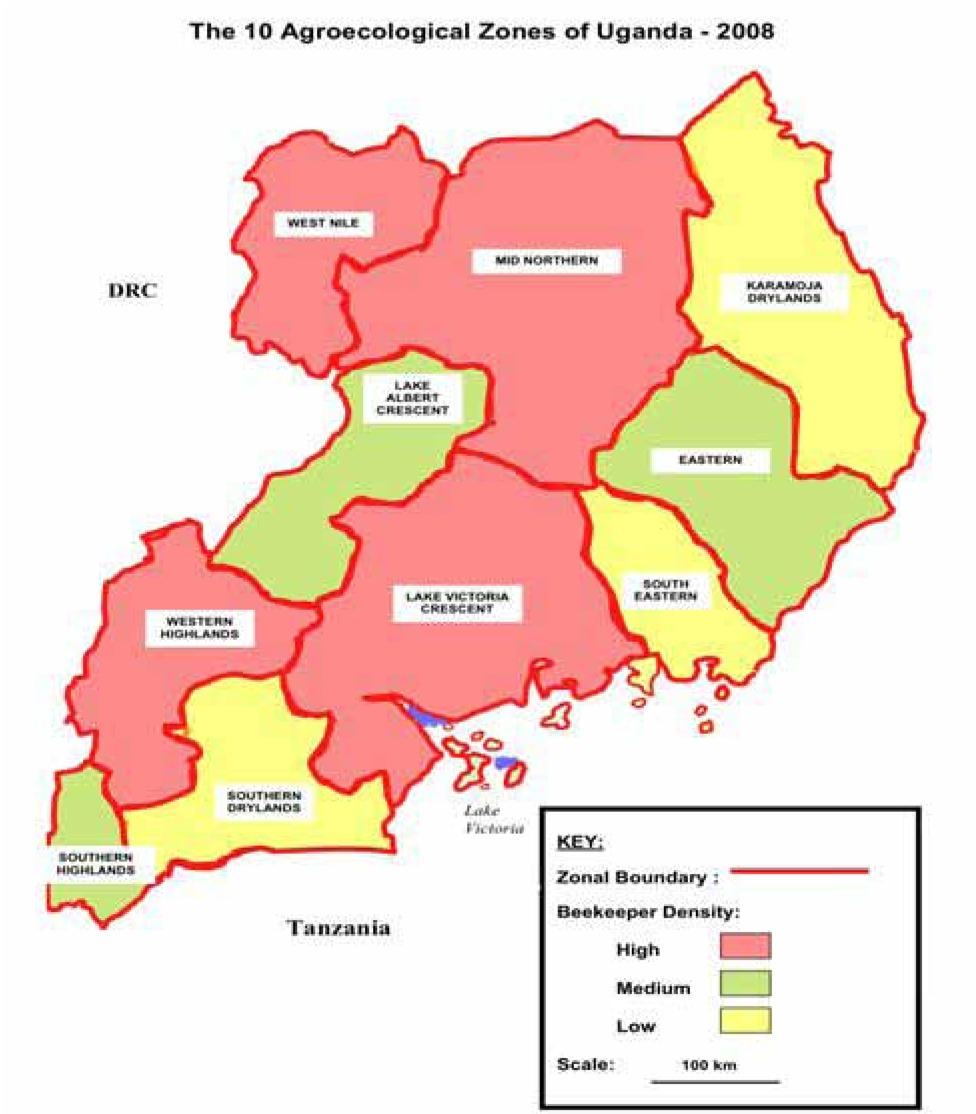

Figure 1: Agro-ecological zones of Uganda

Table 1: Districts of agro-ecological/honey production zones of Uganda

No	Agro-ecological zone	General vegetation	District
1.	Southern Highlands	High altitude forest, Forest / Savannah Mosaic at high altitudes and Swamp Forest	Kisoro, Kabale, Rukungiri, Kanungu
2.	Southern Dry lands	Vegetation contains forests, savanna mosaic and grass savanna.	Rakai, Sembabule, Mbarara, Ntungamo
3.	Lake Victoria Crescent	Forest / savanna mosaic characterized by patches of dense forest in the south and scattered trees in shrubs and grassland of the north.	Masaka, Mpigi, Luwero, Kampala, Mukono, Kayunga, Wakiso, Kiboga, Nakasongola, Kalangala, Mubende
4.	Eastern	Vegetation ranges from montane forest to high open moorland	Pallisa, Tororo, Kumi, Kaberamaido, Katakwi, Soroti Mbale, Sironko, Kapchorwa
5.	Mid Northern	Flat terrain covered by thick savannah grassland	Lira, Apac, Kitgum, Gulu, Pader
6.	Lake Albert Crescent	Vegetation ranges from rainforest to savanna grasses	Masindi, Hoima, Kibale
7.	West Nile	Savanna vegetation with open mixtures of trees and shrubs standing within tall grass	Arua, Moyo, Adjumani, Yumbe
8.	Western Highlands	Natural equatorial forest vegetation and rich natural savannah grasslands in the relatively drier areas	Bushenyi, Kasese, Bundibugyo, Kamwenge, Kyenjojo, Kabarole
9.	South East	Vegetation predominantly forest / savanna mosaics, which are a mixture of isolated forest remnants and colonising savannah trees integrated with grasses and shrubs.	Jinja, Iganga, Bugiri, Busia, Kamuli, Mayuge
10.	Karamoja Drylands	Vegetation is characterized by thorny bushes, cammiphora woodlands, occasional small trees and patches of grassland.	Moroto, Kotodo, Nakapiripiri

participate in the research and disseminate successful technologies to other beekeepers. Stakeholder mapping through guidance by district entomologists, beekeeping NGOs, local leaders and elders resident in the area, beekeepers and key informants was undertaken. Snowballing was used to identify, recruit and motivate other beekeepers to participate in the research; gender was a major consideration at selection and throughout the process of conducting PRA exercises. Key informants were identified on the basis of their organisational and community positions, reputations, and knowledge of the issues under study. Their insights, recollections, and experiences provided an important and logical starting point for the compilation of data about the social reality of beekeeping sector.

Using Participatory Rural Appraisal (PRA) tools and key informant interviews, information was collected on beekeepers indigenous knowledge honeybee pests, their prevalence and control. A research was conducted to determine the effect of honeybee pests on the production of honey. Samples of bees, infected combs and bee products were collected from beehives in different agro-ecological zones, and preserved for laboratory analysis. Beekeepers were involved in a participatory manner.

A feasibility trial of local materials and techniques for honeybee pest control method was undertaken. The approach of partnering, in the technology development process was a strategy for increasing the probability of beekeepers owning and adopting the technologies. The participatory trials also gave the opportunity to establish beekeepers' assessments of the technologies, and to observe their ideas for modified and innovation.

A survey was administered to one hundred twenty (120) respondents in Luwero (Lake Victoria Crescent, Lira and Pader (Mid northern) districts in which both qualitative and quantitative data was collected. Additional data was collected from key informants using information guides/checklists.

Results and Discussions

Socio-economic characteristics and honey production

The majority of respondents were male (58 %) while 42% were female. Most of the respondents (88%) were between the ages of 30 to 59. At least 65% of the respondents had primary education and 18% had secondary education. Beekeepers owned a variety of hives; at least 62% owned traditional hives which included log hives, pot hives, grass hives and bamboo hives. Thirty two percent (32%) of the beekeepers owned top bar hives, while only 6% used frame hives. The average number of hives owned by beekeepers was low, with 47% of beekeepers owning less than 10 hives. At least 22% of the owned 10-19 hives. Only 15% of the respondents owned more than 30 hives. Honey production per hive was generally low. On average, 44% of the respondents owning traditional hives produced less than 5 Kg of honey per hive. Thirty six percent (36%) of the respondents that owned Top bar hives produced 5-9 Kg of honey per hive, while 20% of the respondents that owned frame hives produced more than 15 Kg of honey per hive (Table 2).

Common honeybee pests in Uganda

The research documented eleven honeybee pests and predators that affect beekeeping in the study zones (Table 3). Pair-wise ranking revealed that the pest of greatest economic importance were black ants (Monomorium minimum), small hive beetles (Aethina tumida), wax moths (Galleria mellonella), bee hornets (Vespa ssp.) and birds. Snakes, spiders and rats were the least important pests. Termites attacked and destroyed bee hives that were not well managed. Monitoring and identifying predators and pests, and observation of changes in colony behaviour were the most important means of diagnoses of presence of pests and predators in the hives. Some common observations included sighting of pests in the hives, abnormal behaviour such as frequent in-and-out flights of bees without any visible loads, reduction in hive occupancy and absconding.

Introducing an appropriate honeybee pest control method requires proper recognition of the causal organism. Apart from mechanical control methods of dealing with the obvious insect pests, rational means of control could only arise after the cause of the injury has been known (Barasa, 2005). This study documented eleven pests and predators that attack honeybees and the hives in Uganda. Some of these organisms may simply

Table 2: Total honey production (Kg) per hive (N=120)

Type of hive	Honey production (Kg/hive)	Percentage of respondents
Traditional hive	< 5	44
Top bar hive	5 to 9	36
Frame hive	>10	20

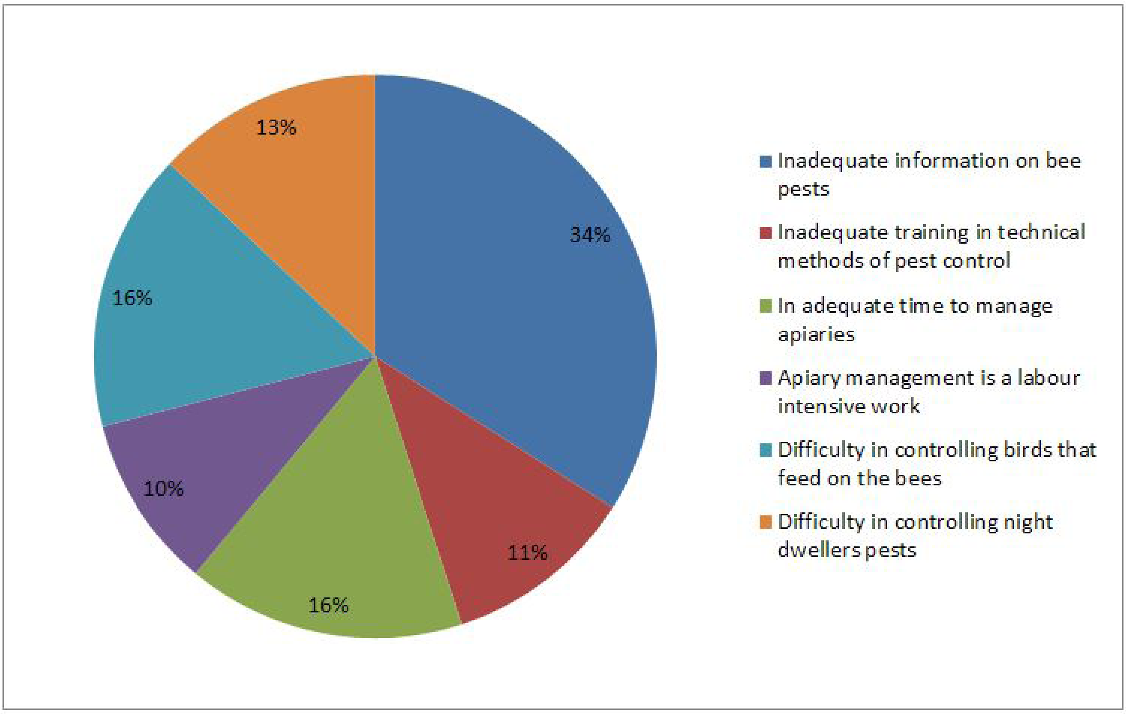

Figure 2: The most common problems faced by beekeepers in control of honeybee pest

use the hive as a place to nest or shelter for their own young, but other cause harm of an economic nature by feeding on honey, pollen, brood remains or beeswax, and in some cases triggering absconding by the colony. Almost all hives were attacked by pests but the severity of the pest infestation varied and was also dependent on the management practices in place. The traditional hives were prone to pest infestation probably a factor of the materials they are made of such as grasses that are natural habitats for the pests. In addition, the structure of the traditional hives makes access for control of pests difficult because of the limited accessibility to the hives. The frame hives in general had the least pest infestation because the beekeepers could easily inspect the hives and control the pests.

The black ants are one of the most important honeybee pests causing economic losses to beekeepers (FAO, 2006). They suck out the honey and kill the pupae and eggs. They are too small to be stopped by beehive guards and in many cases make the bees leave the hive. The large hive beetle (Oplostomus fuligineus) (20mm long) and the small hive beetle (Aethina tumida) are common pests. They cause damage to combs and setup fermentation of stored honey. Both types of hive beetles eat pollen and honey, but the Oplostomus species also eats brood. Bees can be seen trying to remove Aethina but its hard slippery carapace makes it impossible to grasp. Aethina lays eggs on occupied combs and in cracks and crevices (MAAREC, 2000). The greater wax moth (Galleria mellonella) and the lesser wax moth (Achroia grisella) are opportunistic pests and will quickly lay eggs on older, abandoned honey combs where a weak colony is in residence. Both types of wax moths are generally found wherever there are honey bees and particularly in warm conditions. In the wild, the wax moth plays a part in completely destroying old, useless combs and bees will eventually reoccupy the clean nesting site and build new combs. Beekeepers however, suffer great economic loss when frames of drawn combs built on foundation wax are infested by wax moth. Bees in a strong colony are able to remove small wax moth larvae from the hive.

Strong colonies are therefore the best defence against infestation of wax moth. When the moths do succeed in gaining entry to a beehive they lay their eggs on the combs and in cracks in the hive body. The wax moth larvae develop in eight growth stages and when hatched, the larvae burrow their way through the wax leaving trails of silken tunnels and black faecal droppings. Their preferred food is found in old brood combs where they eat the pupal cases living brood cells. Between each successive pupation stage, the growing larvae become more voracious until the comb is destroyed and all that remain are a mass of silken webbing and faeces. The mature larvae of the greater wax moth cause great damage to wooden frames and hive bodies. They curve out depressions in the wood, settle into the depressions and spin their final cocoons. When they do this by the hundred, frames can be weakened to the extent that they have to be discarded. These frames are difficult to clean, but they are worth saving, pulling out the bulk of the silk and then scalding them briefly with the frame of a blow torch will clean them up. Birds feed on the bees especially those that forage for nectar. These birds strategically position themselves near the hives and capture the bees that are flying out or into the hive. This greatly reduces on the population of the bees in the hives hence resulting in the reduction in the production of the hives.

Termites feed on the equipment used in beekeeping especially those made out of wood for example the beehives. Termites do not eat the honey or the bees themselves, but they are agents of biodegradation of wood since many of the beehives are made typically of wood. FAO (1990) noted that termites are only after the wood and may not be classified the pest. Hives placed on the ground or bee equipment left lying on the ground or stacked directly on the ground may be subject to termite infestation. If termites destroy the bottom boards, the bees may not have a bottom entrance and the colony could have difficulty in moving. Lizards where reported by the respondents that they eat the bees and the honey. Lizards stay very close to the hive or accommodate itself comfortably between the lid and the hive body, if they can find an entrance; they may feed indefinitely on the bees. Bees are also eaten by the lizards as they locate the apiary.

The local management practices used to control the pests

The participatory rural assessment exercises identified a number of effective methods applied by beekeepers to prevent and control honeybee predators and pests (Table 4). Most methods applied indigenous knowledge or used locally available and sustainably accessible

Table 3: Prevalence of honeybee pests and predators affecting colonies

Pests (Scientific name)	Pests (Common name)	Most common (very frequent)	Common (frequent)	Not common (rare)
Vespa ssp.	Bee hornets			X
Merops ssp.	Birds		X	
Mellivora capensis	Honey badger			X
Varanus ssp.	Lizards		X	
	Rats			X
	Red ants	X		
Monomorium minimum	Black Ants	X		
Aethina tumida	Small hive beetles		X	
	Snakes			X
	Spiders			X
Galleria mellonella	Wax moths		X	

Table 4: Methods for honeybee pest control

Pests (Scientific name)	Honeybee pest	Damage	Control method
Monomorium minimum	Black ants	Ants raid bee hives to consume hive products such as nectar, honey, sugar and even bee's bodies. Ant attacks sometimes trigger colony absconding	• Apply ash at the apiary • Use bio-pesticides • Keeping the apiary tidy and clean (sanitation) • Frequent inspection of hives • Hang hives using wires • Use of hive stands placed in used engine oil • Put a ring of grease on the hive stand
Vespa ssp.	Bee hornets	Capture bees at hive entrance, suck the haemolymph and grind the carcass into a fine paste for feeding its larvae Bee hornet attacks some result in colonies absconding	• Swatting of bee hornets reduced colony abscondment
Merops ssp.	Birds	Bee eating birds predominantly eat flying bees which they catch in the air	• Scaring and chasing away bee eating birds
Mellivora capensis	Honey badger	Honey badgers destroy bee hives to consume honey	• Fencing off apiaries • Suspension of hives in trees • Laying traps
Varanus ssp.	Lizards	Lizards feed on the bees.	• Beehives should be installed on a platform, with metal conical lizard controllers nailed on the legs to prevent lizards from reaching the hives
	Rats	Adult rats move into bee colonies and make their nest in the hive away from the bee cluster. They chew combs to make way for their nest	• Hive entrance should be reduced
Aethina tumida	Small hive beetle	Small hive beetles damage honey combs, feed on brood and destroy honey capping	• Smoke the bee hives frequent if there are many pests

Pests (Scientific name)	Honeybee pest	Damage	Control method
	Snakes	Some snakes eat bees	• Hive entrance should be reduced • Keeping the apiary tidy and clean (sanitation) • Hang hives using wires
	Spiders	Spider constructs webs around bee hives. When the bees are caught by the web, the spider eats them	• Destroy all spider webs found near hives
Macrotermes bellicosus	Termites	Termites destroy bee hives and other beekeeping equipment	• Destroy termite mounds near the apiary
	Wasps	Wasps build nests inside bee hives and discourage bees from colonising the hives	• Avoid throwing/ scattering combs and honey around the apiary
Galleria mellonella	Wax moths	Wax moths destroy the combs in a bee hive. The bees sometimes abscond	• Hive entrance should be reduced

materials. They were organic/ environmentally safe, and cost effective. Prevention was mostly through mechanical methods which included keeping the apiary tidy and clean, proper disposal of combs away from the apiary, application of ash near the hive stands in the apiary and fencing off the apiary. Beekeepers used a number of methods to control pests and predators: frequent smoking of hives was done to drive out small hive beetles. At least 28% of the beekeepers made bio-pesticides which they used in the control of most of the pests. The major ingredients in the bio-pesticides included, red pepper (Capsicum sp) neem tree (Azaradichta indica) and Tephrosia sp. Most of the bio-pesticides were mixed with ash from any burnt firewood and urine from livestock. These were sprinkled directly on the pests or in their path. Keeping the apiary tidy and clean was the most effective way to control pests.

The experienced beekeepers demonstrated some good knowledge of local pest control methods, especially pests like black ants, red ants and termites. Various parts of plants and plant extracts are known to be either toxic or repellent to pests of crops and trees and are widely used by small scale farmers. For example, extracts from plants such as neem (Azadirachta indica, red pepper, Tithonia sp., Tephrosia vogelii, wood ash, cow dung and urine have been used to control termites in the field (Wardell, 1987; Logan *et al.,* 1990). The extent of the local methods used by the beekeepers to control and manage the pest and diseases varied from individual to individual and they also ranged from mechanical methods to chemical methods. Most of the pests, especially the crawling pests where controlled by siting the hives on wires and was considered as effective method in controlling the crawling pests. Nsubuga (2000) reported that the beekeeper in Luwero district controlled ants by siting the hives on wires that were greased. The grease made the movement of these pests on the wire difficult thus such wires were avoided by the pests. Hive stands whose legs were

A textbox containing a public brief on the status of honeybee pest in Uganda

Beekeeping provides enormous potential for income generation, pollination and sustainable use of forest resources. In Uganda, honey production potential is enormous and in 2005; Uganda was licensed to export honey to the EU, creating an immense opportunity. However, the potential for beekeeping is not fully exploited. Many pests attack honeybee colonies causing economic losses. This descriptive study that took a participatory action research approach, with researchers partnering with beekeepers to evaluate and build their capacity to manage honeybee pests in four agro-ecological zones. Eleven honeybee pests and predators were documented.The pests of economic importance were Monomorium minimum, Aethina tumida Galleria mellonella and Vespa ssp. The following are the research, educational/capacity building and policy and regulatory framework priorities related to management of honeybee pests arising from this research:

1. Research priorities
   a. Indebt study of the important pests and developing control methods
   b. Design best management practices for honeybee pests
   c. Disseminate information on honey bee pests control methods to beekeepers

2. Educational priorities
   a. Educate public on honey bee best management practices
   b. Share best management practices with beekeepers
   c. Improve information transfer techniques (e.g., extension)
   d. Develop and maintain stakeholder collaborations

3. Regulatory priorities
   a. Develop national honeybee pest surveillance system

placed in old engine oil container or a grease ring between the hive and the ground were also used in the control of the crawling pests. The hive stands were alternatively treated with used engine oil which is mostly quite effective (FAO, 1990 and MAAREC, 2000). Metal plates can also be placed on the stands to prevent lizard from reaching the hives. Nsubuga (2000) also suggested that a combination of ash and grease can be used to control ants.

Nkunika (2002) reported that some extracts from plants such as Neem tree, wild tobacco, Tephrosia spp and dried red pepper have been used to control termites in the field and in storage. Most of these bio-pesticides are not harmful to the bees as compared to the inorganic pesticides. Majority of the ingredients used in the control of the pests and diseases were locally available and most of them affordable to the farmers as many of them had planted the Neem tree and Tephrosia vogelii on their farms since most of them where practicing agro-forestry where by the trees in turn provided forage for the bees. The beekeeper also reported that good hive management can be an effective method of controlling pests and disease in the bee colonies. According to MAAREC (2000), good hive management, including regular changing of wax foundation in the brood chambers can control the hive beetles. Good hygiene in the hives can also control the wax moth, hive beetles since these thrive in damp hives. Ntenga and Mugongo (1991) emphasized that good hive management is important in colony development where by a stronger colony can easily defend itself from the pests. This, coupled with regular hive manipulation and inspection, can be used to control most of the pests and diseases. With regular manipulation and inspection of the hives, the beekeeper can be able to notice any pests or symptoms of the disease hence are able to mount an early control on these pests and diseases.

Challenges experienced by beekeepers in controlling honeybee pests

The most common problems encountered were: lack of adequate information (lack of training, poor access to extension services); time consuming methods that compete with other livelihood and income generating activities (Figure 2). There are also challenges with management of flying predators and pests, lack of capacity and skills to implement the more technical methods of pest control (inadequate technical knowhow, poor access to the technologies and the labour intensive nature of the control and management options available to beekeepers.

Control of honey bee pests is not an easy task because there are many huddles involved. Beekeepers reported numerous problems that limited their efforts in controlling pests and diseases. Inadequate information about the pests and their control measures was a major problem that the farmers experienced. According to Agnes and Frans 1993, subsistence farmers in Africa are generally poorly educated and very poorly served by overstretched extension systems. Therefore, extension services about honey bee pests and thus their biology and ecology, identification depending on the symptoms or damage provides farmers with a more objective basis for making decisions about the pests. Time constraint was another problem experienced by the farmers since most of them were not full time beekeepers. Therefore, farmers inspected their hives occasionally. Also some of the methods used by the farmers to control the pest for example the physical removal and killing the pests such as the wax moth where effective at night because the moth flies away during the day. Since the black ants are too small, a lot of time is usually spent in their control. Pests that are mobile and others that attack the bees at night (lizards, birds and other mammals) cause massive reduction in the colony populations. They cause serious problems during their control because they are unpredictable. Understanding and using the different techniques for pest control also cause confusion to the beekeepers. Most of the beekeepers do not have adequate knowledge about bio-pesticides and sitting hive on the wires. As a result of inadequate and effective pest control, some colonies absconded while other hives were seriously damaged.

Effects of the honeybee pests on hive production

There was a significant effect of pests (mainly black ants, small hive beetles and wax moth) on the quantities of honey produced per hive per harvest as seen with the situation without and with pest. At least 41 % of the farmers reported that pests led to the absconding of their colonies. Honey production with the traditional hives was most affected by the pest with a 35% loss in yield; followed by the top bar hive with a 21% loss. Frame hives were the least affected by the pests with a 15% loss. Pests have a significant effect on the quality and quantity of honey produced (MEERAC, 2000). Pests like black ants that feed on the honey can reduce on the quantity of the honey produced. Other pest like lizards, birds, mammals that feed on the bees reduce on the colony population and strength hence reducing the quantity of honey produced. The wax moth, small and large hive beetles that lay eggs on the honey combs (Marchand and Marchand, 2003); contaminate the honey and other bee products such as bees wax which consequently affects the quality of the hive products. The effects of the pests were detrimental in the traditional hives and least with the Langstroth hives. This is because the traditional hives are more susceptible to the pests since these hives can easily harbour the pests; besides traditional hives are more difficult to manipulate in a bid to control the pests and diseases than the Langstroth hives. Absconding of the colony is one of the effects of the pests and diseases on the honey bees. African bees often depart from their hives by absconding instead of the normal swarming process. There are many factors that contribute to the absconding of the African bees and among them are the frequent attacks by diseases and pests such as lizards, mice, wax moths, ants or animals among others. Absconding reduces the production of the hives because the hive becomes empty. Pests especially the termites destroyed the hive since they feed on the wood which in turn reduced on the number of hives and led to the absconding of the bees where the bottom of the hive was eaten out by the termites (MAAREC, 2000). The destruction of the hives forced the farmers to replace the hives frequently which was very expensive for the farmers. Some of the farmers decided not to replace the hive which they said was worthless. This consequently affected the production of the bee products.

Conclusion

We conclude that there are many honeybee pests and predators that affect beekeeping production in Uganda, the important ones being black ants, small hive beetles, wax moths and bee hornets. Beekeepers developed effective methods for pest control and management. These include keeping the apiary tidy; avoiding throwing combs around apiaries and frequent smoking to drive out small hive beetles. Experienced beekeepers developed local organic (bee-safe) methods for pest control. To manage the ants, many beekeepers applied ash at the apiaries. The pests led to absconding of many colonies. Honey production with the traditional hives was most affected by the pests; followed by the top bar hive. Frame hives were the least affected by the pests. Many beekeepers lacked adequate information for managing the pests limiting the methods used to control the pests. There should be detailed study of the important honeybee pests in order to design best management practices

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PROFILING OF HONEY BEE VIRUSES IN KENYAN HONEY BEE COLONIES

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Abstract

Honey bee population worldwide is dwindling due to a number of interrelated factors among them pathogens such as viruses, bacteria, fungi and metazoan parasites. These factors negatively affect agricultural production as well as the apiculture industry which is dependent on a seasonal abundance of honey bees year-round. As a result, food security and livelihood is compromised due to loss of pollinators. Majority of viruses infecting honey bees are positive-sense single-stranded RNA viruses of the order Picornavirales. The economically important viruses of bees in this order belong to family Dicistroviridae and Iflaviridae. Paenibacillus larvae and Melisococcus plutonius are bacteria known to cause bee brood diseases. This study aimed at identifying the viruses circulating in Kenyan honey bee colonies using next generation sequencing. Ribonucleic acid (RNA) was extracted from sixteen libraries and was used in cDNA synthesis using superscript II. The cDNA converted to dsDNA using Klenow reaction and used in amplification. 454 pyro sequencing was performed on genome sequencer FLX system. The resultant single reads were analyzed using CLC Genomic workbench. The reads were mapped on the full genomes of the identified viruses and then de novo assembled. The resultant contigs were interrogated using basic alignment search tool (BLAST) on national center for biotechnology information (NCBI) database. The contigs were exported to MEGA6 and used in phylogenetic analysis. The viruses identified belonged to family Iflaviridae and included deformed wing virus, Kakugo virus and Varroa destructor virus-1. Melissococcus plutonius and Enterococcus faecalis were also detected. Of the sixteen libraries sequenced, two libraries; Busia_adult and Siaya_brood reported the incidences of iflaviruses while five libraries had reads matching with M. plutonius and E. faecalis. There is need for a strategy in place for the management of bee diseases to enhance bee health and quality of hive products.

Key words: Bee viruses, Paenibacillus larvae, Melissococcus plutonius, Iflavirus, Next generation sequencing

ETABLISSEMENT DU PROFIL DES VIRUS DES ABEILLES MELLIFERES DANS LES COLONIES D'ABEILLES MELLIFERES AU KENYA

Résumé

Dans le monde entier, les populations d'abeilles mellifères sont en baisse en raison d'un certain nombre de facteurs interdépendants, dont les agents pathogènes tels que les virus, les bactéries, les champignons et les parasites métazoaires. Ces facteurs ont des répercussions négatives sur la production agricole, ainsi que sur l'industrie de l'apiculture qui est dépendante d'une abondance saisonnière des abeilles tout au long de l'année. En conséquence, la sécurité alimentaire et les moyens de subsistance sont compromis en raison de la perte de pollinisateurs. La majorité des virus qui infectent les abeilles mellifères est constituée de virus à ARN monocaténaire de sens positif de l'ordre des Picornavirales. Les virus (des abeilles) économiquement importants dans cet ordre appartiennent aux familles Dicistroviridae et Iflaviridae. Les larves des Paenibacillus et Melisococcus plutonius sont des bactéries connues pour provoquer des maladies du couvain d'abeilles. Cette étude visait à identifier les virus circulants dans

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les colonies d'abeilles kenyanes en utilisant le séquençage de prochaine génération. L'acide ribonucléique (ARN) a été extrait de seize bibliothèques et utilisé dans la synthèse d'ADNc en utilisant le Superscript II. L'ADNc converti en ADNdb en utilisant la réaction de Klenow et utilisé dans l'amplification. 454 pyroséquençages ont été réalisés sur le séquenceur génomique FLX. Les lectures simples obtenues ont été analysées en utilisant le logiciel CLC Genomic workbench. Les lectures ont été mappées sur les génomes complets des virus identifiés, puis assemblés de nouveau. Les contigs obtenus ont été interrogés à l'aide de l'outil BLAST (Basic Alignment Searh Tool) sur la base de données du centre national d'information sur la biotechnologie (NCBI). Les contigs ont été exportés vers MEGA6 et utilisés dans l'analyse phylogénétique. Les virus identifiés appartenaient à la famille Iflaviridae et comprenaient le virus de l'aile déformée, le virus Kakugo et le virus-1 destructeur de Varroa. Melissococcus plutonius et Enterococcus faecalis ont également été détectés. Des seize bibliothèques séquencées, deux bibliothèques, Busia_adult et Siaya_brood, ont rapporté des incidences d'iflavirus tandis que cinq bibliothèques avaient des lectures correspondant à M. plutonius et E. faecalis. Il est nécessaire d'adopter une stratégie en place pour la gestion des maladies des abeilles afin d'améliorer la santé des abeilles mellifères et la qualité des produits de la ruche.

Mots-clés : virus des abeilles, Paenibacillus larvae, Melissococcus plutonius, Iflavirus, séquençage de prochaine génération

Introduction

Honey bee is the mainstay of honey production and crop pollination and the most managed and efficient pollinator of most crops worldwide (Potts *et al.,* 2010). Pollination affects diversity and quality of human diet (Klein *et al.,* 2007); and the global value of insect pollination has been estimated at US dollars 212 billion worldwide (Gallai *et al.,* 2009). Recently honey bee populations have been reported to be on the decline in most parts of the world (Granberg *et al.,* 2013, Ellis *et al.,* 2010; Potts *et al.,* 2010). The decline has been characterized by sudden loss of worker bees from colonies without signs of dead or diseased bees, despite presence of abundant breeding cells, pollen and honey (Le Conte *et al.,* 2010). The decline has been attributed to interaction of multiple factors (Anderson and East, 2008), including both environmental and human induced (Moritz *et al.,* 2010). Among the factors are pests and diseases, poor nutrition, hive management and incidental pesticide exposure (Vanbergen, 2013; Potts *et al.,* 2010; Johnson *et al.,* 2009).

The known bee parasites and bee diseases include varroa mites (Varroa spp.), Tropilaelaps mite (Tropilaelaps spp.), tracheal mite (Acarapi woodi), bee louse (Braula spp.), Aspergillus spp., American foul brood (Bacillus larvae), European foul brood (Melissococcus plutonius) and protozoan Nosema spp. Bee mites play a major role in the spread of bee pathogens exacerbated by human movement of bees for pollination and trade (Sammataro *et al.,* 2000). A number of viruses have been associated with varroa mite; V. destructor at varying degrees. The mite weakens bee's immune system triggering viral multiplication leading to death (Le Conte *et al.,* 2010; Rosenkranz *et al.,* 2010). Varroa mites have also been shown to transmit bee bacteria through feeding bites. Another parasitic bee mite, Tropilaelaps mercedesae has been described as a bee virus vector especially in the transmission of Deformed Wing Virus in European honey bees.

Honey bees have been reported to host about 18 viruses which mostly persist as unapparent infections and cause no disease symptoms (Genersch and Aubert, 2010), unless stressful conditions are introduced. Healthy looking bee colonies may harbor a number of potentially harmful virus infections (Di Prisco *et al.,* 2011). Honey bees are known to be infected by multiple viruses (Bromenshenk *et al.,* 2010; Forgach *et al.,* 2008; Cox-Foster *et al.,* 2007). The members of Iflaviridae which affect bees include deformed wing virus (DWV), Sac brood virus (SBV), Varroa destructor virus-1 (VDV-1) and Kakugo virus (Chen *et al.,* 2012), while the members of Discitroviridae attacking bees include black queen cell virus (BQCV), acute bee paralysis virus (ABPV), Kashmir bee virus (KBV), Israel acute paralysis virus (IAPV).

Five honeybee viruses that have been reported in Africa include ABPV, IAPV, SBV, BQCV and DWV (Mumoki *et al.,* 2014). Bacteria Melisococcus plutonius, the causative agent of European foul brood is an important disease of honey bee A. mellifera distributed worldwide (Forsgren *et al.,* 2013). In Africa it has been reported in Algeria and Malawi; South Africa, Algeria, Libya, Morocco, Tanzania, Tunisia, Senegal and Guinea Bissau (Mumoki *et al.,* 2014). In Kenya, Muli et al 2014 reported presence of varroa mites, Nosema spp., deformed wing virus, black queen cell virus and acute bee paralysis virus. Lee *et al.,* (2010) suggest presence of more benign diseases in this region.

With the assumption that Kenyan honey bee colonies harbor more pathogens than the reported ones, this study aimed at establishing the current status of bee pathogens and their distribution across different geographic regions using next generation sequencing on the 454 GS FLX pyro sequencing platforms.

Materials and Methods

Study sites

The study sites included Ijara, Magarini, Busia, Siaya, Narok, Marigat, Kwale and Voi in Kenya between November 2012 and June 2013. In Ijara and Magarini districts in Kenyan Coastal strip samples were collected between 31st November and 4th December 2012; in Busia and Siaya districts in Western Kenya from 9th to 14th February 2013; in Narok and Marigat districts in Rift Valley, from 9th to 14th April, 2013, while in Kwale and Voi districts in the Coast samples were collected between 5th and 11th June, 2013.

Sample collection

Samples were collected from ten hives from different apiaries in each site. Modern hives were targeted, that is either langstroth or Kenya top bar hives because they are easy to work with compared to the log hives. Further, use of modern hives is promoted in country. Consent to collect samples from bee colonies was obtained from beekeepers and land owners through the Kenya Livestock Production Officers in the Ministry of Agriculture, Livestock and Fisheries stationed in the intended data collection districts. All beekeepers visited had prior knowledge of the visit and were present during the sample collection exercise.

Samples of adult bees and immature bees (brood) were collected from the brood chamber. The samples were preserved singly in cryovials which were labelled and barcoded and the information entered in excel spread sheets, including date of sample collection, name and coordinates of the sites and the type of sample. Samples were transported in dry ice and immediately transferred to liquid nitrogen gas on arrival at the laboratory.

Library preparation; cDNA and DsDNA synthesis and PCR

To make libraries, individual brood and adult bees were crushed in liquid nitrogen using sterilized pestles. RNA extraction was performed using RNeasy extraction kit following the manufacturer's protocol. Good quality RNA for brood and for adult bees was pooled for each site. Sixteen libraries were generated and used in downstream analysis. Complementary DNA (cDNA) for each of the libraries was synthesized using superscript II as follows; a reaction of 4µl of RNA and 1µl of primer A, was heated at 65oC for 5 minutes and then put on ice for 1 minute. To the reaction; 4µl of 5X RT 1st strand buffer (Invitrogen), 2µl 0.1M DTT (Invitrogen), 1µl of dNTP (10mM), 2µl of BSA 10mg/ml and 0.2µl RNase OUT (400U/µl) were added to make a total reaction of 14.2µl. The reaction was incubated for 2minutes at 250C. 0.5µl of superscript II enzyme was then added to it and incubated at 250C for 10 minutes, 420C for 50 minutes, 700C for 15 minutes and at 40C for infinite.

The cDNA was converted to double stranded DNA with interspersed sequences of the 20nt on one DNA strand using Klenow reaction. 0.5µl (2.5 units) of the 3'-5'exo-Klenow DNA Polymerase was added to the cDNA reaction and incubated at 370C for

60 minutes, 750C for 10 minutes and 40C for infinite. 5µl of the resultant reaction was added to 37.5µl of distilled water, 5µl of 10X PCR buffer (with Mg+), 1µl of 12.5 mM dNTP, 1µl of 100pmol/µl primer B and 0.5µl of PWO Taq. PCR was performed at 940C for 1minute, 30 cycles of 940C for 30 seconds, 500C for 30 minutes, 720C for 1minute, and final extension of 720C for 7 minutes and 40C for infinite. PCR product was sequenced using 454 GS FLX (Roche Diagnostics Corporation) at BecA hub ILRI, single 454 sff reads were generated.

Sequence analysis

Sixteen libraries composed of pooled bee brood and adult bees from eight study sites were sequenced through GS FLX 454 pyro sequencing platform. Single 454 reads were generated and a general blast was performed which revealed presence of deformed wing virus, Kakugo virus, sac brood virus, Varroa destructor virus-1, Tomato ring spot virus and bacteria Paenibacillus larvae. The reads were further analyzed using CLC Genomics Workbench. Quality control was performed on the reads, which were then mapped against the genomes of deformed wing virus, Kakugo virus, sac brood virus, Varroa destructor virus-1, Tomato ring spot virus and bacteria Paenibacillus larvae which were identified in the general blast. The libraries were each run against the genomes mentioned above one at a time and those that mapped were assembled through de novo assembly. The resultant contigs were each interrogated through BLAST on NCBI database. The contigs that matched were exported to MEGA6 for phylogenetic analysis.

Results

Virus sequences

Five viruses associated with honey bees' health were detected in the general blast. These included Kakugo virus, deformed wing virus, sac brood virus, varroa destructor virus-1 and Tomato Ring Spot virus (TRSV). Kakugo virus (KV), DWV, SBV and VDV-1 are iflaviruses belonging to family iflaviridae and are positive sense single stranded bee viruses. Tomato ring spot virus is a nepovirus infecting plants and it belongs to family Secoviridae (Table 1).

Following mapping on reference genomes and de novo assembly, contigs were generated for Kakugo virus (8), deformed wing virus (1) and varroa destructor-1 (6). The contigs were further interrogated through BLAST on NCBI database and they gave matches for the above mentioned viruses plus a recombination of VDV-1 and DWV. Phylogenetic analysis revealed that Siaya brood library grouped with deformed wing virus, Kakugo virus, Varroa destructor-1 virus and recombinant VDV-1 and DWV. Busia library on the other hand grouped with SBV, KV and VDV-1 (Fig 1).

Bacteria sequences

Paenibacillus larvae was detected through general blast of the study libraries in raw reads. All the sixteen study libraries were mapped against the full genome of Paenibacillus larvae as the reference. The libraries which mapped with the reference were de novo assembled using CLC genomic work bench and the resulting contigs were interrogated on local blast on NCBI database. Contigs of five libraries out of the sixteen libraries matched with Melisococcus plutonius and Enterococcus

Table 1: Shows viruses identified in raw reads; family classification; number of reads and contigs formed in each virus; the most prevalent viruses were Varroa destructor virus-1 and Kakugo virus

Virus	Virus family	Reads	Contigs
Kakugo virus	Iflaviridae/Iflavirus	59	8
Deformed wing virus	Iflaviridae/Iflavirus	2	1
Sac brood virus	Iflaviridae/Iflavirus	2	0
Varroa destructor virus-1	Iflaviridae/Iflavirus	76	6
Tomato ring spot virus	Secoviridae/Nepovirus	6	0

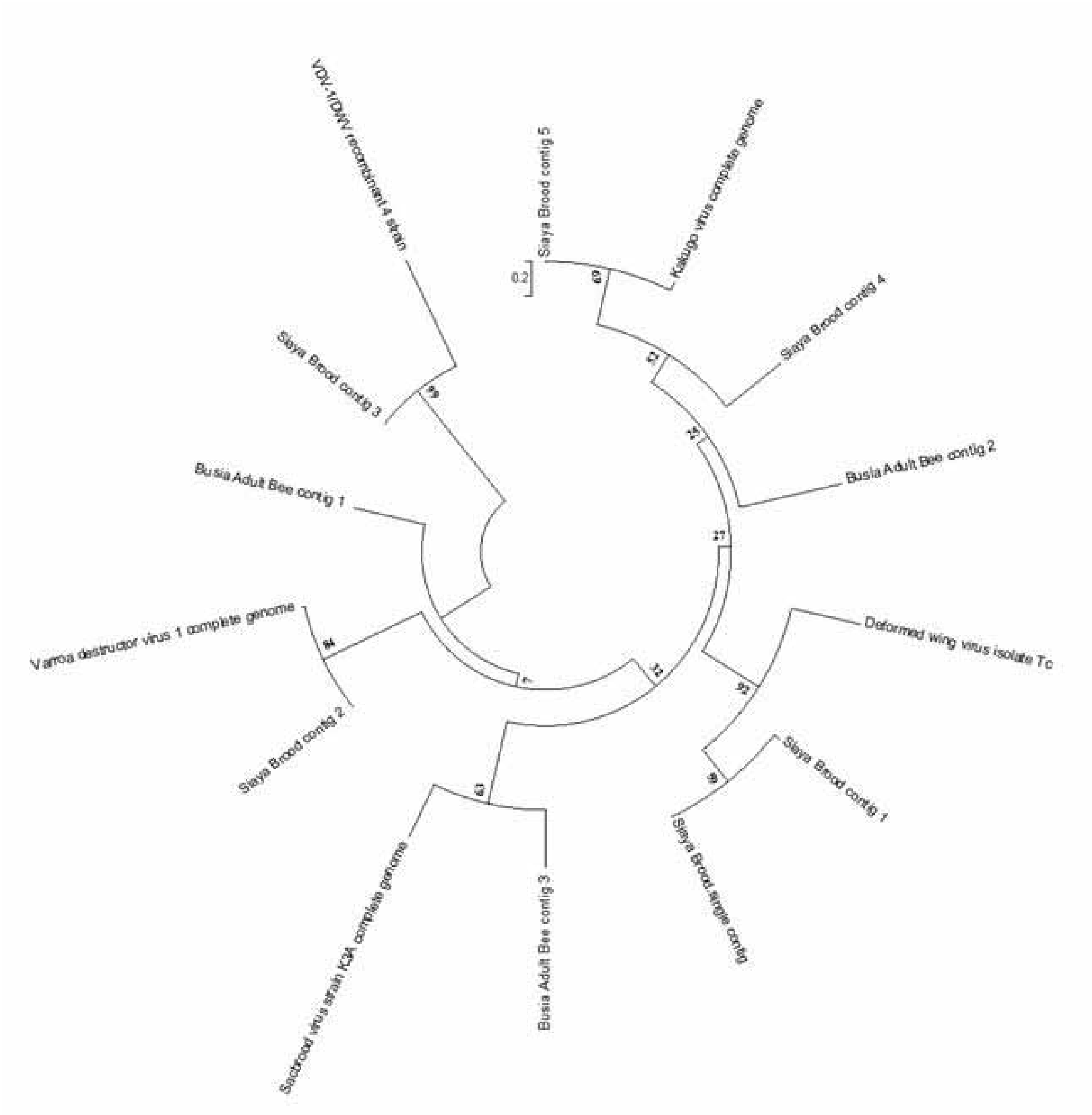

Figure 1: Phylogenetic tree of iflaviruses identified in the study against reference sequences from the NCBI database using Neighbor–joining; substitution model of maximum composite likelihood, bootstrap value of 1000, unrooted.

faecalis. The five libraries included Voi_adult, Ijara_adult, Busia_brood, Busia_adult and Narok_adult. Busia_adult and Narok_adult libraries had the most number of matching contigs (Table 2). Phylogenetic analysis using neighbor-joining show the relationships amongst the bacteria Melisococcus plutonius and E.faecalis from the different libraries (Fig.2).

Discussions

The viruses revealed in the sixteen study libraries belonged to the family iflaviridae. These included deformed wing virus, Varroa destructor virus-1, and Kakugo virus. The viruses were more prevalent in Siaya_brood and Busia_adult libraries which had more contigs matching with the said viruses. Phylogenetic analysis of the study showed that contigs from

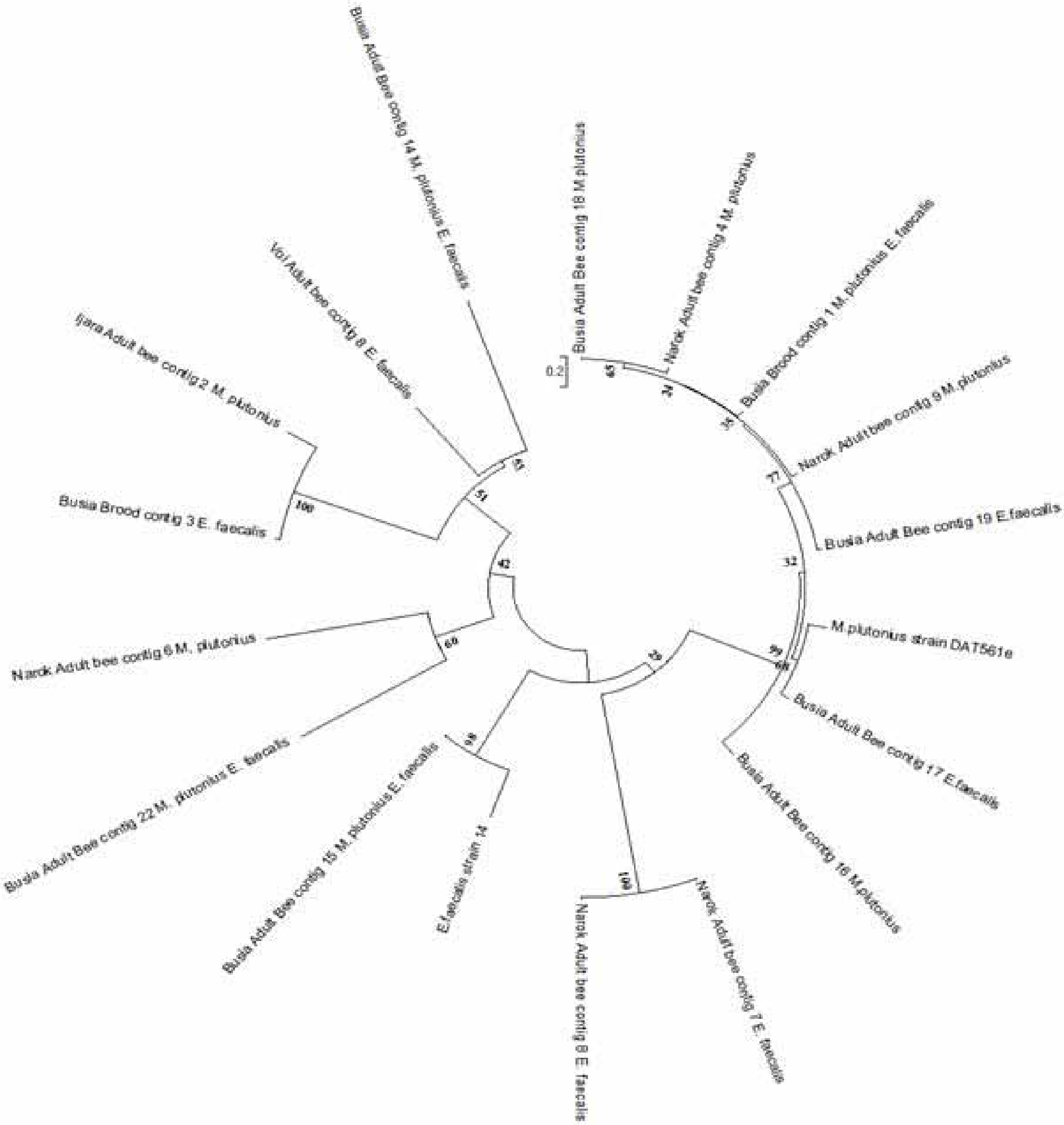

Figure 2: Phylogenetic analysis of bacteria, Melisococcus plutonius and Enterococcus faecalis detected in the study libraries against reference sequences from the NCBI database using Neighbor–joining; substitution model of maximum composite likelihood, bootstrap value of 1000, unrooted tree.

Siaya_brood library matched with KV, VDV-1, DWV and VDV-1/DWV recombinant strain; while contigs from Busia_adult bee library matched with KV, VDV-1 and SBV. Siaya_brood library had the highest number of contigs (six) matching with Iflaviruses compared to Busia_adult bee library which had three contigs.

Bacteria M. plutonius and E. faecalis were observed in the study contigs of five libraries Voi_adult, Ijara_adult, Busia_brood, Busia_adult and Narok_adult. Phylogenetic analysis using neighbor –joining method, some contigs from Busia_adult, Busia_brood and Narok_adult libraries grouped with the reference M. plutonius strain DAT561e from the NCBI database. Two contigs from Narok_adult library grouped together, a contig from Busia_adult library grouped with E. faecalis strain 14 obtained from the NCBI database. Another contig from Busia_adult grouped

Table 2: Libraries whose raw reads mapped with Paenibacillus larvae

Library	Reads	Number of Contigs formed	Number of contigs that matched with *M. plutonius* and *E. faecalis*
Voi_adult	239	8	1
Voi_brood	132	2	0
Ijara_adult	124	5	1
Ijara_brood	143	0	0
Magarini_brood	267	7	0
Marigat_adult	6	0	0
Marigat_brood	78	0	0
Narok_adult	157	9	5
Narok_brood	102	5	0
Busia_adult	1556	24	7
Busia_bood	777	7	2

with a contig from Narok_adult library. Other contigs from Busia_adult, Voi_adult, Ijara_adult and Busia_brood libraries grouped together.

American foulbrood disease (AFB) is generally regarded as the most destructive microbial disease affecting bee brood. It is caused by a spore-forming Paenibacillus larvae, which only affects bee brood. In the raw reads Paenibacillus larvae was observed, however, after interrogating the contigs obtained from de novo assembly on local blast at NCBI database, the contigs matched with European foul brood, M. plutonius and the secondary causative organism of EFB, E. faecalis.

This study revealed presence of bacteria and viruses in honey bee colonies. The viruses identified all belonged to family Iflaviridae. Kakugo virus and Varroa destructor-1 virus were the most prevalent iflaviruses reported in this study. These viruses have not been reported in the country in the previous studies. The incidences were high in Busia_adult and Siaya_brood libraries. The bacteria detected was Melisococcus plutonius which causes European foul brood (EFB) and Enterococcus faecalis which is a secondary agent of EFB. Bacteria incidences was higher in Busia_adult and Narok_brood libraries. In Africa, Melisococcus plutonius has been reported in Angola, Malawi, South Africa, Libya, Morocco, Tunisia, Tanzania, Senegal and Guinea Bissau.

The libraries from Busia indicated presence of both bacteria and viruses. Libraries, from Siaya did not reveal presence of bacteria. Contigs from Siaya libraries also grouped with VDV-1/DWV recombinant strain.

Conclusions

Bee diseases are transmitted through beekeepers' hive manipulation practices, movement of bees to boost colonies and movement and sharing of bee equipment. There is need to carry out intense honey bee disease surveillance and capacity building of stakeholders to reduce possible transmission of pests and pathogens throughout the country.

It is important to carry out regular, monitoring to detect changes in bee health status in the country and also to ensure early detection of disease threats. The inspections will give information on disease prevalence and would guide in coming up with a management strategy towards eliminating or containing disease spread in the country.

The risk factors observed in this study which contribute to the spread of pests and diseases of honey bees include the lack of knowledge on bee pathogens and their presence. This has contributed to the spread of the pathogens through trade, sharing of bee equipment and transfer of live bees and queen bees to strengthen colonies across the country. It is important to have regulatory measure in place to control the above mentioned risk factors. Further, when carrying out risk analysis of pests for imports of honey and bee products it is important to check for the pathogens associated with the pests infesting bees.

Determination of disease free status of certain pests and diseases are critical in the trade of bees and other hive products. The data obtained in this study would feed into the pest and disease monitoring plan that the country lacks towards export of bee and bee products into the European Union market.

Public brief for the benefit of policy

Bee health is important in the promotion of food production and food security worldwide. It is therefore important to put some policies in place to protect bee population.

1. Policy on the use of agricultural pests and disease control products (livestock and crop)
2. The interaction between beekeepers and the community, the issues of compensations in case of bee attacks on livestock and human beings should be addressed.
3. Handling of bees and bee products to control against contamination of bees products and reduce transmission of bee pests and diseases through poor bee management practices
4. Regulate/control movement of live bees, queen and bee equipment.
5. Regulations on the use of acaricides and antibiotics for control of bee pests and diseases
6. Bee pathogens exist in the country, intensive plan should be put in place for regular monitoring of bee health status including checks at entry points.

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OCCURRENCE OF NOSEMA SPECIES IN HONEY BEE COLONIES IN KENYA

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Abstract

Honey bees (Apis mellifera) provide critical pollination services and livelihood for small-holder farmers in Kenya, thus contributing to nutrition and food security. While honey bee colonies in North America and Europe are in decline due to parasites and pathogens, little is known about the status and effects of the honey bee pathogens and pests on the honey bee populations in Africa. A nationwide survey was conducted in 2012/2013 across eight agro-ecological zones to assess the presence of Nosema microsporidia and quantify the levels of infection. Nosema microsporidia occurred throughout the eight ecological zones. Infection levels were negatively correlated with altitude, suggesting that environmental factors may play a role in the honey bee host-pathogen interactions. Infections levels were higher in the coastal region than in the interior. There was no evidence of colony size reduction in areas where the Nosema microsporidia was in abundant. The results suggest that Nosema could be an exotic pathogen and may have been recently introduced in Kenya and is spreading to all ecological zones. However, its impact on honey bee populations is not yet known. This study thus provides baseline data for further detailed survey and analysis of the impact of this pathogen to the Kenyan honey bee colonies with a view of establishing any form of resistance mechanisms of the Kenyan honey bee colonies compared to the European honey bee colonies.

Key Words: Honey bee, Nosema, Kenya

PRESENCE D'ESPECES NOSEMA DANS LES COLONIES D'ABEILLES MELLIFERES AU KENYA

Résumé

Les abeilles mellifères (Apis mellifera) assurent des services de pollinisation cruciaux et des moyens de subsistance pour les petits exploitants agricoles au Kenya, contribuant ainsi à la sécurité nutritionnelle et alimentaire. Si les colonies d'abeilles d'Amérique du Nord et d'Europe sont en déclin à cause des parasites et agents pathogènes, on a peu d'informations sur l'état des colonies d'abeilles d'Afrique et les effets des agents pathogènes et parasites des abeilles sur les populations d'abeilles du continent africain. Une enquête nationale a été menée en 2012/2013 dans huit zones agro-écologiques afin d'évaluer la présence de Nosema microsporidia et quantifier les niveaux d'infection. Nosema microsporidia était présente partout dans les huit zones écologiques. Les niveaux d'infection étaient négativement corrélés avec l'altitude, ce qui fait penser que des facteurs environnementaux peuvent jouer un rôle dans les interactions hôtes-pathogènes. Les niveaux d'infection étaient plus élevés dans la région côtière par rapport à l'hinterland. L'on n'a noté aucune preuve de réduction de la taille des colonies dans les zones où Nosema microsporidia était abondante. Les résultats laissent penser que Nosema pourrait être un agent pathogène exotique qui aurait été récemment introduit au Kenya et est en cours de propagation dans toutes les zones écologiques. Cependant, son impact sur les populations d'abeilles mellifères n'est pas encore connu. Cette étude fournit donc des données qui peuvent servir de base pour la poursuite d'une investigation plus détaillée, et pour une analyse de l'impact de cet agent pathogène dans les colonies d'abeilles kenyanes, en vue d'établir une forme quelconque de mécanismes de résistance des colonies d'abeilles kenyanes en comparaison avec les colonies d'abeilles européennes.

Mots-clés : abeille mellifère, Nosema, Kenya

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Introduction

Nosemosis or Nosema disease is a highly infectious disease of the digestive tract of honey bees which infects all castes of adult bees only. It is caused by Nosema, a microsporidian (Liu *et al.,* 2006). There are two species of Nosema, namely Nosema apis, which mostly parasitizes western honey bee, and Nosema Ceranae, which parasitizes the eastern honey bee (Fries *et al.,* 1996; Higes *et al.,* 2008, 2006). Nosema has been reported to increase mortality of adult bees during the cold weather due to accumulation of spores in the bee's rectum (Mussen, 2011). Infected colonies are also unable to produce enough royal jelly to feed the brood (Robinson *et al.,* 1991; Whitefield *et al.,* 2006). The ovaries of an infected queen degenerate and eggs atrophy significantly reducing fecundity (Hamdan, 2007). Nosema infections are known to decimate whole colonies.

Nosemosis, which is often referred to as a 'silent killer' does not have any obvious characteristic symptoms and it is therefore overlooked by most beekeepers (Hornitzky, 2005). It can be easily confused with other honey bee diseases due to its nonspecific symptoms. Nevertheless, infected bees may show a number of symptoms such as defecation inside the hive, presence of yellow or yellowish brown excrement stains on top bars of frames, combs, bottom board and on the inside and outside walls of the hive because they suffer from a form of dysentery (Higes *et al.,* 2008; Martin-Hernandez *et al.,* 2007). Infected colonies also often fail to build up in ideal weather condition, which is a sign of poor brood rearing (Bailey, 1955; OIE, 2008). Infected bees may have characteristic distended abdomens and crawl about in front of the hive with their wings spread out. Others are unable to fly or only fly short distances when they leave the hive (Fries, 1988, 1993). Sometimes heaps of dead bees are found on the ground in front of the hives during the cold weather (Fries, 1993).

Furgula and Mussen (1990), reported that the losses caused by Nosema may be as high as, or even exceed that caused by other honey bee diseases. The severity of Nosema infections varies from one colony to the other and may be dependent on the season and time of the year (Fries, 2010; Gisder *et al.,* 2010). Nosema spores can remain viable for a long time in the hive (Malcolm *et al.,* 1963; Gochauer *et al.,* 1975; Martin-Hernandez *et al.,* 2009; Gisder *et al.,* 2010).

Nosemosis is widely spread in temperate areas, where it is particularly troublesome during long periods of cold weather when bees are confined to their hives leading to the accumulation of spores in their rectum (Pickard, *et al.,* 1989). Recent studies have shown that several honey bee pathogens and pests including Nosema, which were initially thought to be confined in temperate regions, are spreading out to the tropical climates (Muli *et al.,* 2014; Higes, *et al.,* 2009). The changing climatic conditions may probably be impacting the distribution of honey bee pests and pathogens in the tropics. This survey documents the occurrence and spread of Nosema in different agro-ecological zones of Kenya and quantifies infection rates of Nosema in honey bee colonies.

Materials and Methods

Study area:

The study was carried out in different agro-ecological zones in Kenya. Eight sampling sites; Kwale has an average temperature of 26.2 oC, average annual precipitation of 1053mm, altitude of 997m and the distance from the coast 17.75 km, Voi has an average temperature of 25.4 oC, average annual precipitation of 570mm, altitude of 591m and the distance from the coast 142.81 km, Narok has an average temperature of 16.8 oC, average annual precipitation of 797mm, altitude of 1827m and the distance from the coast 534.14 km, Marigat has an average temperature of 24.6 oC, average annual precipitation of 652mm, altitude of 1062m and the distance from the coast 648.16 km, Busia has an average temperature of 22.0 oC, average annual precipitation of 1775mm, altitude of 1200m and the distance from the coast 794.98 km, Siaya has an average temperature of 23.3 oC, average annual precipitation of 1352mm, altitude of 1224m and the distance from the coast 751.77 km, Garissa has an average temperature of 28.7 oC, average annual precipitation of 370mm, altitude of 151m and the distance from the coast 399.2 km, and Magarini has an average temperature of 27.3 oC, average annual precipitation of 956mm, altitude of 410m and the distance from the coast 21.39 km. This qualifies them to have different vegetation cover, determined by their climatic conditions, rainfall and altitude.

Sampling technique:

Honey bee samples collected from 72 colonies in 43 apiaries distributed in different agro-ecological zones. At least 10 honey bee colonies were sampled in all sampling areas (sites) within the eight agro-ecological zones, except in Garissa and Magarini, where four and eight colonies were sampled respectively. Standard methods were used for sampling (Traver and Fell, 2011). A total of 30 adult honey bees were collected at the underside of the hive lid by scooping them using a 50ml conical plastic centrifuge tube and secured with a lid to prevent them from escaping. The honey bees were left for 30 minutes to get immobilized and then 40 ml of 70% ethanol was added to the tube to preserve them. The samples were then transported to the laboratory for analysis.

Analysis of samples: Thirty adult bees previously preserved in 70% ethanol were taken and placed on a filter paper for ten minutes to drain the ethanol. Their abdomens were snipped off and ground using a mortar and pestle. Thirty millilitres (30 ml) of distilled water was added and mixed to make a suspension. The suspension was decanted and the honey bees' debris discarded. A drop of the mixture was taken using a clean Pasteur pipette and placed on a clean glass slide, and a cover slip was placed. The wet preparation was observed under a light compound microscope using X10 objective, then X40 objective for the presence of Nosema spores. The positive samples were quantified using an improved Neurbeaur counting chamber (Gary et al, 2012).

The honey bee suspension mixture was inoculated to a clean counting chamber using a clean Pasteur pipette, avoiding overloading and creation of air bubbles and left to settle for three minutes. Microscopic observation of the spores was done using a light compound microscope starting with the X10 objective followed by the X40 objective lenses (L'Arrive and Hrytsak, 1964). The Nosema spores were counted in the five large squares including those that touched the upper and the right sides, but excluding those that touched the lower and the left sides. The calculation was done using the formula obtained from Cantwell 1970; Oliver, 2013; Hornitzky, 2005, 2009 and OIE 2008.

Number of spores per bee = (Total number of spores counted) x (4 x 106) / Number of squares counted

Data analysis

Data on the number of Nosema spores per honey bee from the sampling sites in the different agro-ecological zones areas were analyzed using analysis of variance (ANOVA), by R software.

Results

Nosema spores were found in all the sampled sites, although the infection rate and the spore density differed significantly ($P < 0.05$) amongst different agro-ecological zones. Kwale had the highest honey bee infection rate at 9.7%, and also the highest percentage of the infected honey bee hives (70%). Busia, Garissa and Siaya had the lowest infection rate with 1.4% of the hives infected (Table 1). Different regions had varied population densities of Nosema spores. Kwale had the highest average of the counted spores, at 445,000 and Garissa had the lowest at 12,500 (Figure 1). Whereas the highest Nosema spores density per bee (1,150,000) was recorded at Magarini and the lowest at Garissa (50,000) (Table 1).

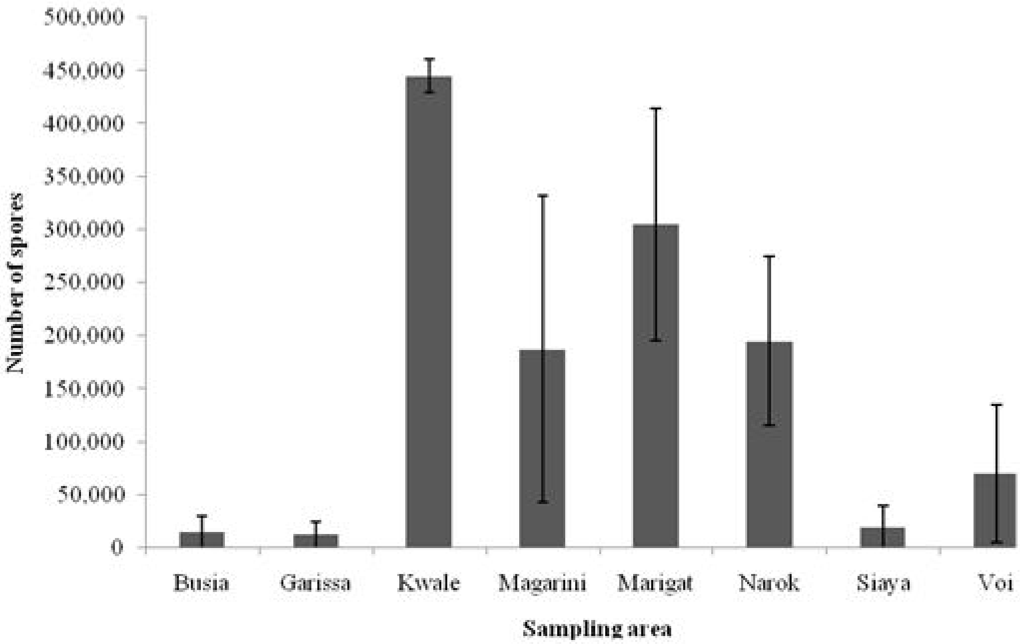

Figure 1: Average number of Nosema spores in the honey bee hives in different agro-ecological zones in Kenya

Table 1: Infection rates of Nosema in honey bee colonies

Agro-ecological zones (Regions)	Number of Hives (30 bees/Hive)	Number of bees sampled per area	Number of Hives Infected	Highest Number of spores/bee/area
Magarini	8	240	2 (25%)	1,150,000
Kwale	10	300	7 (70%)	1,000,000
Marigat	10	300	5 (50%)	800,000
Narok	10	300	5 (50%)	750,000
Voi	10	300	2 (20%)	650,000
Siaya	10	300	1 (10%)	200,000
Busia	10	300	1 (10%)	150,000
Garissa	4	120	1 (25%)	50,000
Total	72	2,160	24	

Magarini and Kwale fall in the coastal region

Discussion

The study revealed the presence of Nosema in all the agro-ecological sites sampled under this survey. Although it is not known whether this pathogen is native or exotic to Africa, it was evident that the microsporidian shows tremendous infestation behaviour since it was not obstructed by vegetation type, climatic conditions as well the area altitude. However, while Nosema spores were found in honey bee colonies in all these diverse ecological and geographical conditions, there were variations observed in Nosema infestation levels. There was negative correlation between the levels of infestation and the altitude suggesting that the low altitude provided optimal environmental conditions for the survival of the pathogen.

Despite presence of Nosema, the honey bee colonies appeared to perform well in both the dry and wet season, with sufficient amounts of honey stored for the bees and their brood. Though most beekeepers in the surveyed areas were neither aware of the Nosema's presence nor observed any negative impact in the survival and productivity of their colonies, some apiculturists reported poor stocking rates to their hives in recent years, a situation which is being associated with several pathogens and pests and which is causing decline in population of honey bee colonies in the country. Hence, the need for a multi-year/longitudinal study to reveal the impact of Nosema.

Nosemosis is a worldwide problem and it has been reported in every continent (Furgula and Mussen, 1990). Research has not been carried out to indicate the safe levels of infection and anything less than one million spores per bee is deemed acceptable (Beaverlodge and Fries, 2006). However, higher levels raise a lot of concern depending on the time of the year or the season in temperate areas. Moreover, when the infection level is below 10,000 spores per bee, no spore is seen over the entire haemocytometer grid and the diagnosis is considered to be 'not detected' or 'ND', but this is not an indicator that there is no infection, which relates to the finding of others (Mussen, 2011).

Despite the presence of the micorsporidian in all the honey bee colonies sampled, it is not certain on how and when this fungus invaded the honey bee colonies in the sampled areas. The species of the Nosema were not identified since the Nosema spores were only identified microscopically for their presence and most of the honey bees sampled did not show the characteristics and signs associated with nosemosis. It is most likely that Nosema is present in all colonies all the time, and only likely to cause bee losses when conditions favour the microorganism growth (Somerville and Hornitzky, 2007). Hence, the need to carry further analysis by use of molecular tools to capture the 'none detectable' Nosema spores below 10,000 thresholds, identify the Nosema species present in Kenyan honey bee colonies and further carry out a detailed research to capture the impact of this fungal pathogen on colony productivity in the bee keeping areas of the country.

Conclusion

This study has demonstrated that Nosema is present in all the agro-ecological zones sampled despite their diversity in the country. It is notable that all bee keepers visited were not aware that honey bees harbour this pathogen and did not have information on its impact on their colony and productivity. As higher levels of infestation were found in warm areas, there is a need for a thorough research on this pathogen and its impacts on apiculture industry. This will lead to development of effective monitoring system for detection and control of this pathogen by the relevant authorities.

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Recommendations

1. National monitoring apiaries should be set up and more surveys carried in different agro ecological zones to monitor the trend of Nosema infections in the Country. This will help in establishing levels of Nosema spores in dry and wet seasons when longitudinal studies are carried on a specific bee colony over a period of time.
2. To reduce proliferation of Nosema and institute management options, a comprehensive survey of bee keepers should be carried out around the country and education of farmers on better hive management practices,.

3. Molecular analysis on Nosema should be carried out to identify the specific species infecting the Kenyan honey bees. Different species show difference in their virulence to bees infected with the spores.

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PARTICULARITÉ DU TRAITEMENT À L'ACIDE FORMIQUE DE VARROA DESTRUCTOR (ACARI, VARROIDAE), PARASITE D'APIS MELLIFERA DANS LES CONDITIONS TUNISIENNES

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Résumé

Varroa destructor est un acarien parasite de l'abeille responsable d'un affaiblissement de la colonie et suspecté d'être impliqué dans les processus de mortalités hivernales. Pour contrôler ce parasite, plusieurs scientifiques et apiculteurs ont eu recours aux produits chimiques. En dépit de leur efficacité, la répétition de ces pesticides a causé certains problèmes comme la toxicité, la résistance ainsi que la contamination des produits de la ruche. Pour ces raisons, les chercheurs tentent de trouver d'autres moyens relativement sûrs tels que l'acide formique. Le traitement par l'acide formique (AF) a été utilisé depuis plusieurs années en Europe pour tenter de lutter contre Varroa avec des concentrations de 80% et plus. Dans ce travail nous avons cherché à voir l'effet de l'AF sur Varroa et l'abeille dans les conditions tunisiennes.

Nos résultats ont montré que les fortes concentrations avaient des effets néfastes sur les abeilles alors qu'une concentration de 30 à 40% de l'acide formique a montré une efficacité de 90% et 75% respectivement sur les varroas phorétiques et de 90% sur les varroas dans le couvain operculé sans aucun effet sur la reine pour la concentration 30%. Ceci pourrait s'expliquer par les caractéristiques comportementales de l'abeille tunisienne Apis mellifera intermissa dans les conditions contraignantes du climat tunisien.

Mots clés : Apis mellifera, varroa destructor, acide formique, infestation

EVALUATION DES RUCHES DE TRANSITION ET DES RUCHES MODERNES POUR LA PRODUCTION DE MIEL DANS LA MID RIFT VALLEY DE L'ETHIOPIE

Résumé

L'étude a été menée dans les districts Adami Tulu et Arsi Negelle, de septembre 2009 à juin 2012, dans le but d'évaluer la productivité des ruches de transition et des ruches modernes. Sur la base de la capacité des apiculteurs, une ruche en blocs (box hive) moderne et une ruche de transition construite avec des matériaux disponibles localement ont été utilisées dans chacune des exploitations apicoles visées par l'expérimentation. Les ruches traditionnelles ont été utilisées comme témoins. Avant le début effectif de cette étude, une session de formation théorique et pratique a été donnée à un total de 60 apiculteurs sur les sites sélectionnés. Après la formation, les apiculteurs ont été organisés en groupe de recherche agricole (RFA : Farmers' Research Group) pour mener ensemble toutes les activités de recherche. Les données relatives au rendement en miel ont été recueillies et analysées en utilisant la procédure du modèle linéaire général du Système d'analyse statistique (2006). Le rendement annuel moyen global en miel a clairement révélé que le rendement de la ruche moderne (23,18 kg / ruche) et de la ruche de transition (13,88 kg / ruche) était significativement plus élevés (p <0,05) que celui de la ruche traditionnelle (6,08 kg / ruche). Une différence significative (p <0,05) a été notée entre les trois sites représentatifs. Il a été conclu que l'utilisation de ruches améliorées combinée avec de meilleures pratiques

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de gestion peut augmenter le rendement en miel et produire du miel de meilleure qualité par rapport à la ruche traditionnelle. Il est recommandé aux organismes gouvernementaux et non gouvernementaux de se concentrer particulièrement sur l'intensification et la promotion de l'adoption de la ruche de transition pour les apiculteurs artisanaux et la ruche moderne pour les apiculteurs professionnels/commerciaux afin d'améliorer leur revenu.

Mots-clés : ruche de transition, ruche moderne, évaluation, miel, colonies d'abeilles, rendement

Inroduction

Environ 100 espèces d'acariens sont recensées chez les différentes races d'abeilles à travers le monde. Cependant, seulement quelques acariens (Varroa spp, Acarapis woodi and Tropilaelaps clareae) sont extrêmement nuisibles pour les abeilles. Il existe deux espèces connues de varroa (contenant 18 génotypes) : Varroa jacobsoni qui a été décrit pour la première fois par Oudemans (1904) et infeste Apis cerana dans la région de Malaisie-Indonésie et Varroa destructor (Anderson and Trueman, 2000) qui infeste Apis cerana en Asie et Apis mellifera dans le monde entier (Baker, 2010). En Tunisie, varroa a été introduit en 1975 et l'espèce qui a colonisé les colonies tunisiennes a été identifiée en 2003 comme étant Varroa destructor, haplotype Korea.

Varroa destructor est un acarien parasite de l'abeille responsable d'un affaiblissement de la colonie et suspecté d'être impliqué dans les processus de mortalités hivernale. Le cycle du parasite est lié à celui de la larve d'abeille puisqu'il se déroule dans la cellule operculée (ponte, éclosion, stades larvaires et fécondation). Le varroa affectionne particulièrement les cellules d'abeilles mâles car le cycle est plus long et la température est plus élevée. Pour se nourrir varroa ponctionne l'hémolymphe des nymphes et des abeilles adultes

Pour contrôler les maladies et les parasites de l'abeille mellifère y compris la varroase, plusieurs scientifiques et apiculteurs ont eu recours aux produits chimiques. En dépit de leur efficacité, l'utilisation de ces produits doit être limitée et pour éviter la contamination des produits de la ruche. De plus, la répétition de ces pesticides peut causer certains problèmes secondaires comme la toxicité et l'augmentation de la probabilité de la résistance (Milani, 1995). Pour ces raisons, les chercheurs tentent à contrôler cet acarien par des moyens relativement sûrs tels que les produits naturels.

L'objectif de cette étude est d'évaluer l'effet de l'acide formique sur varroa dans les conditions tunisiennes.

Matériel et Méthodes

Traitements appliqués

L'acide formique

Ce travail a été conduit dans un rucher d'Apis mellifera intermissa situé à l'Institut National Agronomique de Tunisie durant la saison 2008-2009. Le rucher contient une trentaine de ruches. Leur état varie entre faible et fort. Cinq colonies ont été utilisées pour chaque traitement.

a. Cinquante ml d'acide formique dilué à 50% dans l'eau, ont été déposés sur des papiers absorbants (un papier par ruche) de dimensions (21,6 cm x 28 cm x 0,25 cm). Les hauts des ruches ont été couverts d'un plastique clair. Tous les trous ont été fermés et les ouvertures ont été réduites à des petites ouvertures de 0,95 cm x 31 cm.
b. Cinquante ml d'acide formique dilué à 30 % dans l'eau ont été déposés sur des papiers absorbants (même méthode di dessus) sans couvrir les ruches ni fermer les ouvertures.

Le traitement de l'acide formique a duré 24 heures.

Traitement à l'Amitraze

Deux bandes d'Apivar® à base d'amitraze ont été placées dans chaque ruche. Il s'agit de lanières de 15g contenant 0,5g d'Amitraze.

Pour le témoin, aucun traitement n'a été appliqué.

Evaluation des effets des traitements
Echantillonnage des adultes.

L'échantillonnage a été fait sur toutes les ruches (traitées et témoin).Cette méthode consiste à recueillir 200 à 300 abeilles/ ruche dans un pot : après avoir vérifié l'absence de la reine, on secoue 2 à 3 cadres de couvain ouvert dans en plastique qu'on transvase dans un pot en verre de 0,5 L. Le récipient est placé à 4°C pendant 5 min. On ajoute par la suite de l'eau chaude dans le pot et on agite vigoureusement. Les abeilles sont retirées après plusieurs agitations et sont comptée. Les varroas tombés au fond du récipient sont également comptés et le pourcentage d'infestation est déterminé comme suit :

(Nombre de varroas/ nombre d'abeilles) x 100

Comptages des chutes journalières

L'essai consiste à placer un lange graissé de la vaseline au fond de la colonie, de telle manière à ce qu'il soit inaccessible aux abeilles tout en recueillant les varroas qui tombent. Le comptage a été fait après 1, 2, 3, 6, 9, 13, 34 et 60 jours après la première application du traitement

Echantillonnage du couvain

Cette méthode consiste à prélever un échantillon de couvain operculé de chaque ruche (traitées et témoin) de dimensions 5cm x 5cm et à désoperculer les cellules une à une. Le nombre de nymphes parasitées ainsi que le nombre de varroas femelles ont été comptés.

Résultats

Infestation sur les abeilles adultes

D'après la figure 1, avant d'appliquer le traitement par l'amitraze (Apivar®), le taux d'infestation moyen des ruches était de 4,58% contre 1,86% chez le témoin. Suite au traitement, ce taux a diminué pour atteindre 0% au mois de mars d'où une efficacité de 100% qui a été noté jusqu'au mois d'avril. Alors que pour le témoin, l'infestation continuait à augmenter pour atteindre 3% au mois de mars et 4,85% au mois d'avril. Cependant, à partir du mois de mai on a noté une ré- invasion par varroa dans les ruches traitées par l'amitraze et le taux d'infestation enregistré était de 0,35% au mois de mai et 1,43% au mois de juin ; cette infestation est toujours restée inférieure au taux enregistré chez le témoin qui était de l'ordre de 6,2% au mois de mai et 13,9% au mois de juin.

Pour les ruches traitées par l'acide formique à 40% (figure 1), le taux d'infestation est passé de 6,59% avant traitement à 1,42% après traitement, c'est-à-dire qu'il a été efficace à plus de 75%. Le taux d'infestation s'est stabilisé dans le temps et il est resté au dessous de 2% jusqu'au mois de juin où l'infestation était de 1,5% ; une valeur presque égale à celle enregistrée durant la même période chez les ruches traitées par l'amitraze. Néanmoins, sur les ruches traitées, 2 sont devenues orphelines. En ce qui concerne le témoin, le taux d'infestation continue à augmenter pour dépasser les 10% au mois de juin.

L'application de l'acide formique à une concentration de 30 % sans fermeture des ouvertures de la ruche a montré que (figure 2) le taux d'infestation tend à augmenter pour atteindre un maximum au mois de juin de 21, 72 % pour le groupe traité t contre 6,35% pour le lot témoin. Le traitement par l'acide formique 30% a réduit l'infestation à 1,55% au mois de juillet d'où une efficacité de plus de 90% sans noter de perte des reines. Alors que pour le témoin, l'infestation a atteint 10,26% au même mois.

Chute journalière

L'évolution quotidienne de la chute est un autre paramètre qui a été mesuré pour évaluer l'efficacité des traitements. Pour les ruches traitées par l'acide formique à 40%, le nombre de varroas chutés et enregistré juste avant le traitement (J0) était de 23 varroas. Au jour J1, le nombre s'est élevé de façon très importante pour arriver à 619 varros et diminuer au 3ème jour à 73 acariens (figure 3). Un effet rebond du 6ème au 9ème jour

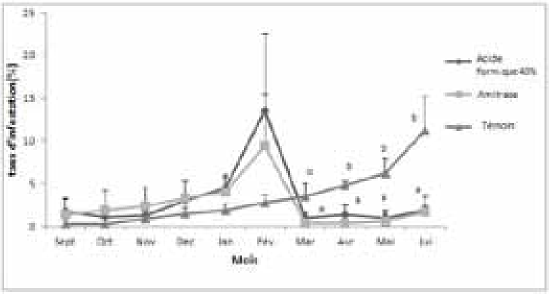

Figure 1: Evolution de l'infestation des abeilles adultes des ruches avant et après traitement par l'acide formique 40%, et par l'amitraze en comparaison avec le témoin. Les valeurs associées à des lettres différentes (a,b) sont significativement différentes selon le test de Student Newman-Keuls à $p<0,05$

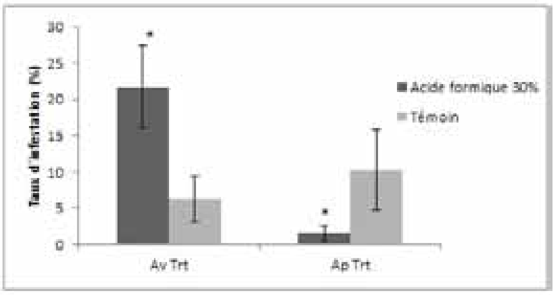

Figure 2. Evolution de l'infestation des abeilles adultes des ruches avant et après traitement à l'acide formique 30%. Les moyennes associées à (*) sont significativement différentes à la probabilité $p<0,05$.
Av Trt : avant traitement
Ap Trt : Après traitement

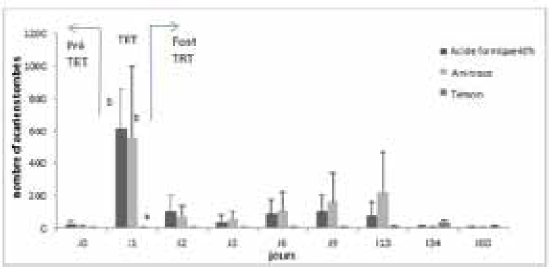

Figure 3: Evolution quotidienne de la chute de varroas avant et après traitement par l'amitraze et par l'acide formique. Les valeurs associées à des lettres différentes (a,b) sont significativement différentes selon le test de Student Newman-Keuls à $p< 0,05$.

est noté et doit correspondre à l'élimination des acariens morts qui étaient à l'intérieur du couvain operculé. Il est à signaler que les acariens trouvés sur les langes enduits de vaseline étaient tous morts.

En ce qui concerne les ruches traitées à l'amitraze, la figure 3 illustre l'importante chute enregistrée dés le premier jour. Elle était de l'ordre de 559 varroas puis elle a diminué le 2ème jour pour atteindre 73 varroas et enfin le 3ème jour elle était de 58 varroas. Le 6ème jour, on a noté une augmentation qui s'est poursuivie jusqu'au 13ème jour et qui doit correspondre à la sortie des varroas des cellules operculées (figure 3).

Infestation du couvain

On a eu recours à l'examen d'une centaine de cellules operculées pour suivre l'effet de l'acide formique et de l'amitraze sur les Varroas localisés à l'intérieur des cellules. L'acide formique a été testé par plusieurs chercheurs, ces derniers ont prouvé son efficacité sur les varroas accrochées sur les abeilles adultes mais également sur les varroas présents à l'intérieur du couvain operculé pouvant atteindre une valeur de plus de 95% (Amrine and Noel, 2006). Afin de confirmer ce fait, on a pris des échantillons de couvain avant et après traitement et on a calculé le taux de mortalité des varroas. L'effet du traitement est très marqué. En effet, avant traitement, le taux de mortalité était de 18,16 % et il a évolué après traitement à 92 ,72% soit une augmentation de 74, 56 % (figure 4).

En ce qui concerne les ruches traitées à l'amitraze, il n'y a pas de différence avant et après traitement avec le témoin. En effet le taux de mortalité était de 16,79 % avant traitement à l'amitraze contre 17,48% chez le témoin et il est passé après traitement à 13,97 % pour le traitement à l'amitraze contre 19,84 chez le témoin (figure 4).

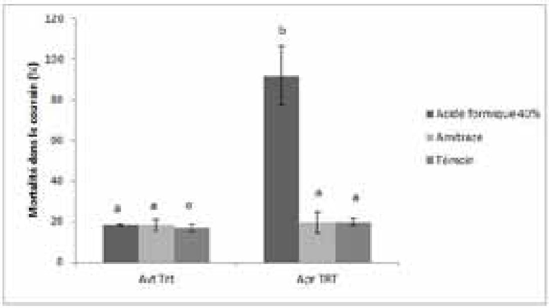

Figure 4 : Taux de mortalité des varroas dans le couvain avant et après traitement. Les histogrammes associés à des lettres différentes (a,b) sont significativement différents selon le test de Student Newman-Keuls à $p<0,05$

> Si l'on veut éviter le dépérissement des colonies, une lutte annuelle contre Varroa est indispenable. Les produits chimiques de lutte contre Varroa ont conduit après peu d'années déjà à une résistance des acariens, de sorte que ces produits ne sont plus suffisamment efficaces dans certaines régions. En raison de l'utilisation de varroacides liposolubles, les résidus ont augmenté en particulier dans la cire et, quoique dans une moindre mesure, également dans le miel. C'est pour cette raison, différentes alternatives de lutte ont été proposées tels que les acides organiques et en particulier l'acide formique. En Europe, l'acide formique est utilisé à des concentrations de 60 à 80% alors que une concentration allant de 30 à 40 % s'est avéré efficace dans les conditions tunisiennes.

Discussion

Le varroa est un véritable fléau auquel ont à faire face tous les apiculteurs, débutants tout autant que les professionnels. L'utilisation des produits chimiques présente plusieurs inconvénients c'est pourquoi le regard a été tourné vers l'application d'autres moyens tels que les acides organiques. Dans cette étude, l'application d'un produit chimique à base d'amitraze a montré une efficacité de 100% sur les varroas phorétiques. Kilani et al. (1981) ont pu montrer que pour une concentration de 0,001 % d'amitraze, 100 % des varroas sont tombés après pulvérisation, et 96,5 % après évaporation du produit. A cette même concentration, 5,2 % et 1,6 % des abeilles ont été tuées respectivement. Cependant, à partir du mois de mai on a noté une ré-invasion par varroa dans les ruches traitées par l'amitraze. Ceci peut être expliqué par le phénomène de dissémination de l'acarien. En effet et selon Kraus (1994) un tiers des varroas sont phorétiques d'abeilles butineuses et ceci constitue un facteur essentiel de dissémination de l'espèce.

L'application de l'acide formique en hiver ou en été en dehors de la période de miellée a été plus efficace que l'amitraze puisque le taux d'infestation dans les ruches traités par l'acide formique est resté inférieur à 2% par rapport aux ruches traités à l'amitraze et ruches témoin. Selon Amrine and Noel (2006), la température ambiante lors de l'application de l'acide formique doit être comprise entre 15 et 35°C. Ceci implique qu'on peut appliquer l'acide formique à n'importe quelle période de l'année sous les conditions tunisiennes où la température est supérieure à 15°C pendant plusieurs jours même en hiver. Fluri et al. (1999) ont recommandé de ne pas appliquer de traitements entre les deux périodes de miellée qu'en cas d'urgence et ils ont conseillé d'utiliser l'acide formique puisqu'il agit sur le couvain operculé et vu que la plupart des acariens se trouvent sur les larves.

Pour la chute journalière, l'acide formique est plus efficace. D'abord, pour les ruches traités à l'amitraze, les varroas trouvés sur les langes enduits de vaseline étaient dans les 80% vivants contrairement aux résultats trouvés par Le conte and Faucon (2002);ceci peut obliger l'apiculteur à augmenter la dose conseillée et par conséquent pourrait entrainer une infestation des produits de la ruche en particulier le miel et la cire. De plus, on n'a pas noté une ré-invasion des varroas comme c'était le cas de l'amitraze.

L'efficacité de l'acide formique a été prouvée également sur les acariens qui se trouvent à l'abri à l'intérieur du couvain operculé. Alors que l'amitraze n'a montré aucun effet sur les varroas à l'intérieur du couvain operculé; l'efficacité de l'acide formique à l'intérieur du couvain operculé été confirmé également par

Hanley and Duval (1995) et par Amrine et al. (2007). En effet, les cellules du couvain ne sont pas hermétiquement fermées, elles ont besoin de respirer l'air: l'oxygène, le CO2, et la vapeur d'eau doivent être capable d'entrer et de sortir à travers les opercules (Amrine *et al.,* 2007). Les cellules du couvain sont formées à partir de la cire mélangée avec le bois, les fibres de plantes, le pollen et les débris de la ruche. Les petites molécules telles que l'eau et la vapeur de l'acide formique peuvent donc accéder à travers les opercules poreux (Amrine *et al.,* 2007)

Cependant, les opercules faites sur les anciens rayons noirs sont plus épaisses et ont plus de cire ; ce qui les rend plus imperméables à la vapeur d'acide formique (Amrine *et al.,* 2007).

Conclusion

Actuellement, il n'existe pas de remède miracle contre Varroa destructor, mais les connaissances acquises peuvent tout de même permettre d'améliorer la stratégie de lutte, afin de limiter la prolifération du parasite et les dégâts qu'il entraine, tout en veillant à réduire au maximum l'utilisation des acaricides chimiques afin d'éviter la pollution et les résidus dans les produits naturels issus de la ruche. Cette étude a permis de montrer l'efficacité de l'acide formique appliqué en hiver ou en été à des concentrations de 30 et 40% et que ce produit peut remplacer les produits chimiques tels que l'amitraze.

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PRELIMINARY OBSERVATIONS ON ENEMIES OF STINGLESS BEES AND HONEYBEE (APIS MELLIFERA ADANSONII L.) COLONIES FROM THE MITI-CIVANGA-TSHIBINDA SECTOR EAST OF KAHUZI BIEGA NATIONAL PARK, SOUTH-KIVU PROVINCE, EASTERN DRCONGO

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Abstract

Beekeeping gives local people an economic incentive for the retention of natural habitats, and is an ideal activity for the local conservation program. A monitoring field survey, aimed at identifying enemies (pests, parasites, diseases) of Apis mellifera adansonii L. in apicultural villages surrounding Kahuzi Biega National park, was conducted for two years (2012-2014) in rural areas surrounding a protected area in South-Kivu province, Eastern DRCongo. . Both wild and domesticated colonies (in apiary) were visited and enemies sampled and or identified (observed) in the field during the rainy and dry seasons. The status, epidemiology and impacts of bee pests and diseases are largely unknown in DRCongo. The preliminary surveys indicated the occurrence of parasites-pests/predators including mammals, birds, reptiles, beetles, ants and wasps and flies. This survey found pests, parasites, predators belonging to Insecta, Mammalia, Reptilia, Arachnida and Gastropoda groups. The frequency of occurrence of enemies (pests, parasites) was higher during dry season than during rainy season. Mites were common during both dry and rainy seasons, but the species is yet to confirmed by a taxonomist. The knowledge of enemies and perceptions of beekeeping challenges by beekeepers, honey hunters, forest honey gatherers was also investigated. Respondents knew predators of honeybees but had little knowledge of the pests, parasites and diseases of honeybees in the region. However, both beekeepers and honey hunters had a good and similar knowledge of bee species (honeybees and stingless bees) and are able to produce good quality honey that is in high at the market and that is highly medicinal. Environmental challenges and the different approaches to management were also recognized by respondents. Efforts are needed to organize landless and marginalized peoples by providing them with the necessary beekeeping technologies and inputs to ensure maximum honey production while promoting rehabilitation and conservation of landscape habitats of eastern DRCongo.

Key words: Diseases, Pests and Parasites, Honeybees, Honey hunters strategies, South-Kivu Province, eastern DRCongo

OBSERVATIONS PRÉLIMINAIRES SUR LES ENNEMIS DES COLONIES D'ABEILLES SANS DARD ET D'ABEILLES MELLIFERES (APIS MELLIFERA ADANSONII L.) DU SECTEUR MITI-CIVANGA-TSHIBINDA A L'EST DU PARC NATIONAL DE KAHUZI BIEGA, EN PROVINCE DU SUD-KIVU, DANS L'EST DE LA REPUBLIQUE DEMOCRATIQUE DU CONGO

Résumé

L'apiculture offre aux populations locales une incitation économique pour la conservation des habitats naturels, et constitue une activité idéale pour le programme de conservation local. Une étude de suivi sur le terrain, visant à identifier les ennemis (ravageurs, parasites, maladies) de l'abeille Apis mellifera adansonii L. dans les villages apicoles situés autour du Parc national de Kahuzi Biega, a été menée pendant

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deux ans (2012-2014) dans les zones rurales entourant une aire protégée dans la province du Sud-Kivu à l'Est de la République démocratique du Congo (RDC). Des colonies sauvages et domestiques (en rucher) ont été visitées ; et les ennemis des abeilles ont été échantillonnés ou identifiés (observés) sur le terrain pendant la saison des pluies et la saison sèche. Le statut, l'épidémiologie et les impacts des parasites et des maladies des abeilles sont largement inconnus en RDC. Les enquêtes préliminaires ont révélé la présence de parasites-ravageurs / prédateurs, y compris les mammifères, les oiseaux, les reptiles, les coléoptères, les fourmis, les guêpes et les mouches. Cette enquête a identifié la présence de ravageurs, parasites, prédateurs appartenant aux groupes Insecta, Mammalia, Reptilia, Arachnida et Gastropoda. La fréquence de l'apparition des ennemis (ravageurs, parasites) était plus élevée pendant la saison sèche par rapport à la saison des pluies. Les acariens étaient communs pendant les saisons sèche et pluvieuse, mais leurs espèces ne sont encore confirmées par un taxonomiste. La connaissance des ennemis des abeilles et les perceptions des défis de l'apiculture par les apiculteurs, les chasseurs de miel, les cueilleurs de miel de forêt ont également fait l'objet d'enquête. Les répondants connaissaient les prédateurs des abeilles, mais savaient peu de choses sur les ravageurs, les parasites et les maladies des abeilles mellifères dans la région. Cependant, les apiculteurs et les chasseurs de miel avaient des connaissances suffisantes et similaires des espèces d'abeilles (abeilles mellifères et abeilles sans dard) et étaient capables de produire du miel de bonne qualité très demandé sur le marché, et qui possède d'importantes propriétés médicinales. Les défis environnementaux et les différentes approches de gestion ont également été reconnus par les répondants. Des efforts sont nécessaires pour organiser les populations sans terre et marginalisées en les dotant de techniques apicoles et d'intrants nécessaires pour assurer une production maximale de miel, tout en favorisant la réhabilitation et la conservation du paysage et des habitats naturels de l'Est de la RDC.

Mots-clés : maladies, ravageurs et parasites, abeilles mellifères, stratégies des chasseurs de miel, Province du Sud-Kivu, Est de la RDC

Introduction

Dependence on subsistence agriculture has depleted the natural vegetation and has been less effective in improving the living standards of communities in DRC. Thus, implementation of livelihood activities through a strategic mix of community participation in conservation is essential. Improved beekeeping is identified as profitable economic activity that can be an incentive to promote conservation and rehabilitation in the face of demand for cultivated land. Beekeeping is factored in when the economic importance of trees is calculated in economic accounts (Gemeda 2014) .

Beekeeping preserves nature, supports agriculture, sustains livelihoods, and provides food security through increasing beekeepers participation in regeneration of different bee foraging ecosystem, sustaining biodiversity, increasing flowering plants and crop pollination. Despite its important roles, the potential of beekeeping is under-exploited and not quantified as an economic incentive in forestry and landscape habitat conservation. Bee products provide healthy, high-nutrient food, safe medicines and raw material for pharmaceutics and cosmetics industries. Beekeeping is a proven reliable source of income generation for small and marginal farmers, women and other vulnerable groups offering a more environmental sustainable option to charcoal production. When beekeepers are supported with improved beekeeping technologies and have access to good markets for their products, they are motivated to support local conservation efforts. Community motivation to conserve and rehabilitate biodiversity increases when households can harness the commercial benefits of beekeeping such as honey and beeswax as part of their livelihood strategies (Ejjgu 2005).

Beekeeping is one of best livelihood activities that has been recognized to improve incomes and well being of poor farming communities without requiring much initial capital and investment. Apart from being consumed as food, bee products, especially honey, propolis and bee pollens, have long been used in traditional medicine. They have bioactive properties, i.e., are antimicrobial, anti-inflammatory, free radical scavenging and have anti-ant proliferation properties, amongst others.

DRCongo has the potential to host a large honeybee population and honey production due to the diversity of suitable ecological and climatic conditions that prevail (Inderer et al.2010; Vandervalk 2013). A high diversity of bee forages exists in different locations of the country. There are also a number of small scale industries that process honey supplied by honey collectors located in rural areas. The majority of honey is from wild populations. However, there are few beekeepers. In South-Kivu Province, beekeepers are concentrated along the Kahuzi Biega National Park which offers opportunity for best breeding of their races with wild races, presumably to acquire resistance to bee diseases and to access floral resources inside the park.

In the vicinity of Kahuzi Biega, several annual weeds, crops and wild plants provide honey flora throughout the year. Beekeeping in the region is still rudimentary and not yet professional, with beekeepers employing traditional production practices, with limited and poor technical skills. Like many other parts of rural DRCongo, there is a lack of scientific documentation to guide sustainable beekeeping in eastern DRCongo, therefore the potential is unrealized. This gap necessitated an investigation to determine how improved beekeeping can be adopted as a competitive option for addressing food security challenges in rural areas. This calls for understanding the challenges and constraints in professionalizing beekeeping. To this end, surveys were conducted in 2012: preliminary observations highlighted a number of constraints including pests and diseases.

The prevailing production constraints in the beekeeping are complex and to a large extent vary between agro-ecological zones and production systems. Variations of production constraints also extend in socio-economic conditions, cultural practices, climate (seasons of the year) and behaviors of the bees The main constraints of apiculture sub sector include: Shortage of bee forage (20%), Pesticides poisoning, Lack of skilled (16%) manpower and training institutions (11%), Low level of technology used, Honeybee pest and diseases, Shortage of bee colony, Marketing problems, Absence of policy in apiculture (12%).

Honeybees plays a vital role in the environment by pollinating both wild flowers and many agricultural crops as they forage for nectars and pollen, in addition to producing honey, beeswax and other bee products. The essential and valuable activities of honeybees depend upon beekeepers maintaining a healthy population of honeybees, because like other insects and livestock, honeybees are subject to many diseases and pests like Varroa mites.

Climate is one of the most important factors that influence productivity in beekeeping: it affects bee floral resources as well as the life of the bee itself. Beekeeping requires an understanding of the seasonal cycle and managing the colonies in such a way as to obtain a large adult colony population to coincide with the major nectar flow in an area. When resources of both pollen and nectar are plentiful, the colony is stimulated to raise more brood and thus the colony population increases. When resources are low, brood-rearing decreases and the colony population decreases (Ejjgu 2005, Adgaba 2002, Homes 2000, Anderson & Trueman 2000). Success in synchronizing colony population with peak forage availability results in the maximum honey production of benefit to the beekeepers. . Honey yield may fluctuate due to locally prevailing climate conditions and availability of floral resources as well the structure of the local landscape.

The average yield from an apiary depends also on the strength of the individual colonies; the incidence of swarming within the apiary (Ejjgu 2005, Adgaba 2002, Homes 2000, Anderson & Trueman 2000) and competition for forage between nectar consumers, especially for wild colonies.

The life of bee colony is based around three periods, that is the buildup season (when nectar flow is increases slowly at the beginning of the dry season); nectar flow season (when plants secrete large amounts of nectar and the middle of dry season) and dearth season (when nectar flow decreases slowly, the beginning of the wet season).

There is an emerging trend of less predation on wild bee colonies, especially in protected areas where the government is discouraging people from gathering honey from the wild. Previously colonies of bees (honey bees and stingless bees) were subject of predation by communities. These unsustainable methods of harvesting honey from inside the park led people to a growing interest in beekeeping, and prompting an increase in artisans crafting of making traditional hives. Even when they have failed with stingless bees (Meliponula bocadeni, Meliponula nebulata and Hypotrigona gribodoi), people are making effort to invest in apiculture based on honeybees. Thus around Kahuzi Biega, wild honeybees are conserved, even though the consumption and demand for honeybee is increasing. In urban areas, there are more consumers of honey instead of sugar due to a high prevalence of non communicable diseases such as diabetes, hypertension, etc. More than seventy percent of the honey purchased from the local market is imported honey; less than thirty percent is supplied by local beekeepers. Thus, there is a great opportunity to increase and to professionalize beekeeping. Value addition would increase revenues of local beekeepers if value chain development is enhanced. The global concerns about bee diseases and pests necessitate mechanisms to prevent and control potential and current diseases and pests and related enemies of honeybees in eastern DRCongo.

Threats to honey bees in DRCongo are many. The population growth driving destruction of natural forests, critical for food and shelter for bees, are the most important. The natural vegetation cover is burnt to open crop land, grazing for animals, for brick making, and forests cut for charcoal. Increased pesticide use poses risks for man and bees in region where cropping especially of cash crops (vegetables) are a growing activity. Many developmental projects in the region recommend and promote the use of insecticides without warning about the risk for pollinating insects. Beekeeping has not been elevated to a level which balances conservation and optimum yields. Most honey is gathered from wild swarms nested in hollow trees, using traditional destructive methods; a mode of collecting honey that threatens sustenance of bee colonies in the wild. The practices is frequently combined with the use of fire to drive out the bees before harvesting is done, smoke, non-target chemicals, felling of trees and wild fire setting. Thus, colonies are killed to harvest honey and wax (Nuru 2002).

If fire has been used to kill the bees, a long time lapses before another bee colony settles at the same place. Where bee colonies are killed by insecticide to harvest the honey and the wax, residues in the products may be toxic to consumers. Where combs containing honey and brood (larval and pupal stages) are taken, the sustenance of the remaining colony is affected negatively due to the loss of honey stores and brood. Honey hunters usually regret having to destroy the colony, but they know no other way to obtain honey or wax. Wild bee colonies are common in many regions of the world and harvesting of honey from them is a common traditional practice across sub-saharan Africa. for many years. The gathering of honey from these colonies is an occasional activity for many local farmers. This often occurs when trees containing bee colonies are felled during the clearing of forest and bush for planting crops.

Honeybee colonies are subject to a number of pests, predators, parasites and diseases (Gemeda 2014, Anderson & Trueman 2000) from different parts of the world. The ectoparasitic mite Varroa destructor is the reported as the most dangerous pest of managed honeybees (Apis mellifera) worldwide (Bradbear 1988, Leonard 1983, Morse & Nowogrodzki 1990, Nixon 1982, Finley et al.1996, Frazier et al. 1994, Harris et al. 2003, Wilkins et al.2007) . It is not clear if it is the same situation in DRCongo.

The objective of this study to reach landless and marginalized people to increase their revenue through making available information about how to improve beekeeping for maximum honey production. The sub-objective is to identify honeybee's pests and parasites in eastern DRCongo. This is an area of investigation that has been neglected and yet holds significant potential for future sustainable forestry-agriculture and landscape habitats management initiatives for the enhancement of ecosystem services deliver.

It is hypothesized in this investigation that Varroa mites are not yet important pests of honeybees in eastern DRCongo.

The sub-objective of this study was to determine the knowledge of bee enemies and perceptions of the problems (challenges) of beekeeping business by interviewed stakeholders (beekeepers, honey hunters or wild honey gatherers). The findings of this study will feed into strategy development for the prevention and management of bee biodiversity and health in the region

Material and Methods

Study area

Tchivanga (28°1'23"E, 1°42'25"S; 1580-1670 m altitude; Figure-1ab)is the sector village located at the entrance of Kahuzi Biega National Park, in Miti Locality, Kabare territory of South-Kivu province. Kabare territory is located in the mountainous zone of eastern DRCongo. .The climate is predominantly tropical-humid with distinct rain and dry seasons with a bimodal type of rainfall i.e. short rains from December to February and long rains between March and May and between September and November. The territory is therefore endowed with two agricultural seasons that receive the annual rainfall of between 1200m and 2200 mm. The distribution of these rains is quite appropriate for agricultural activities and livestock rearing. The soils (ultisols) are relatively fertile, of volcanic origin, well drained dark sandy loams with favorable moisture holding properties. However soil erosion exists in agro-pastoral areas especially in the steeply and hilly zones (villages) along the main road to Bukavu-Goma.

Socio-economic data collection and analysis

Data were collected from three villages in the Tchivanga Sector in which thirty households with beehives from each village participated. A Participatory Rural Appraisal (PRA) was conducted at the beginning of the exercise to get an overview of the study area and to modify the study questions addressed to farmers. PRA tools included wealth ranking, and pair wise and preference ranking. Systematic sampling was adopted so as to include people of different age, gender, and wealth categories, as guided by the PRA results. The second phase involved administration of structured and semi-structured questionnaires... Semi -structured questionnaires were used to interview key informants including district natural resources officers, park rangers, community associations leaders, honey dealers and village leaders.

During the second phase, interviews focused on honey operators (beekeepers, honey hunters and those doing both activities) in the Kabare territory. The operators were randomly selected and surveyed individually to collect socio-demographic characteristics of respondents, their perceptions of beeping challenges and knowledge of enemies of bees. Semi-structured interviews and focused group discussions were organized to understand the role of beekeeping in the selected villages, and observation and triangulation of information done to ensure the veracity of the collected information.

The third phase of data collection involved field surveys aimed at identifying suitable forage species, types of hives, common locations preferred by farmers to hang the hives, bee pests and parasites/predators. Lastly, participant

Figure 1a: Map of DRCongo showing South-Kivu (Sud-Kivu) Province

Figure-1b: Map of South-Kivu (Sud-Kivu) Province showing Kabare territory where the data was collected

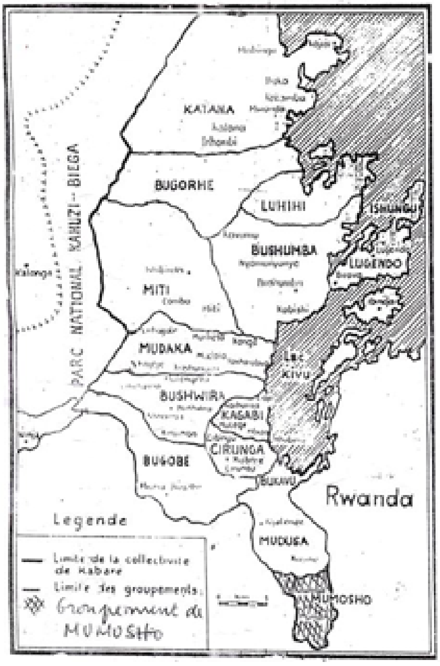

Figure1c: Map showing Miti-Sector, Kabare territory, South-Kivu Province

observation was used to gather information that could not be well explained by respondents during interviews, especially about constraints in beekeeping. In addition, the researchers inspected wild colonies, examining nesting trees and sites of wild colony of honeybees in the villages. Secondary information, village demographic data and previous reports information were also collected from village registries, the territory library, Kahuzi Biega national park and beekeeper and honey gather associations in the region, and from various previous reports in the study area.

Both qualitative and quantitative methods were used to analyze socio-economic data. Qualitative data were analyzed using content analysis and descriptive statistics (percentage, mean, standard errors, etc), whereas quantitative data were analyzed with the aid of MINITAB version 17. Data related to the socio-economic survey will be presented elsewhere in other papers; this paper will focus on pests and parasites of honeybees.

Survey of pests and parasites of bees

The bee farms (apiary) and wild colonies used in this study were selected arbitrary in all three villages (Tchivanga, Combo, Tshibinda) based on landscape and habitat characteristics (grazing plots, forest-fallows, edge of the parks, tea plantations, farmlands, shrubby-grasslands). In addition available wild colonies were surveyed, both those located nearby homesteads and or locations farther away from homesteads. The selected colonies were visited for two consecutive years (2014-2015). Visits to the bee farms were made during both seasons in the company of the owners. Beekeepers who had a good knowledge of the whereabouts of wild colonies were involved in locating them. Each colony or beehive was observed for at least two to four hours from a safe vantage point at each visit, to give adequate time for researches to see whatever was happening around the bee hive and or colony. Samples of bees were taken from both the wild colonies and beehives and analyzed at an entomology laboratory of entomology (using standardized microscopic techniques and tools for identification) to help detect Varroa mites (600 bees/colony), tracheal mites (50 bees/ colony), and Nosema spore counts (100 bees/ colony). Even though in some cases researches weighed honey produced, colony productivity was not purposively measured. Samples of the honeybees, pests and parasites found associated with the honey bee hive in each selected bee farms were collected and preserved in 70% alcohol for taxonomic identifications. Video records (using night camera trapping) were made of the activities of all pests and parasites at the times of visit. Still shot and macrographs were taken to facilitate identification, enumeration and population estimation the Lwiro Research Center Laboratory..

Results

Socio-economic and demographic characteristics of respondents

In eastern DRCongo, beekeeping is a secondary livelihood activity for most of the people involved. However, it is an activity of great importance as it provides a more relatively high and stable income, and financial autonomy than from other agricultural ventures. Beekeeping is one of the strategies for diversification of farmers' income. The sector, however, receives very little attention in terms of agricultural strategies and policies although its contributions cut across sectors i.e., agricultural, social, food, economic, industry and environment.

In the study area, exploitation of honey is exclusively a male activity. Most of the respondents were married and head of households. Four ethnic groups were identified in the sample: the Bashi, Bahavu ,Batembo and Batwa. Most of the respondents were Christians Catholics; more than half of the respondents had never gone to school therefore had no formal education, with only ten to thirty-nine percent literate. The age of respondents ranged from 16 and 73 years, with an average of 27 years.Beekeeping was predominantly a secondary activity except for the pygmies (Batwa) for whom honey gathering in the National Park and in the surrounding wild lands was a primary livelihood activity. Few respondents, five to ten percent, had access to agricultural credit since microfinance companies operating in the region were not interested in supporting beekeeping.

Reasons given for involvement in beekeeping/ honey hunting include income generation (84%),an activity that is complementary and easy to perform in tandem with with other agricultural activities (8%), income to meet different household expenses (3%), inherited the activity from parents (4%) and took it up after training (1%). The level of beekeepers' experience was taken to be the number of years that an individual was continuously engaged in beekeeping,

Beekeepers and honey hunters' perceptions of beekeeping challenges

The study indicated that honey operators in the villages of study, constituted of honey hunters (40.5%), beekeepers (30.5%) and park wild honey gatherers(29%), identified and perceived beekeeping challenges differently (Table 2) . Honey hunters were mostly immigrant's people internally displaced by the epidemic wars in eastern DRCongo. Honey gatherers were predominantly pygmies who are native forest people, most of whom were evicted from living inside the forests when the National Park was gazetted. Beekeepers were predominantly local people who have lived in the villages for a long time.

Wild honey gatherers were most likely to perceive the degradation of the landscape vegetation and land-use changes (disappearance of floral resources) as key challenges in beekeeping. Beekeepers on the other hand perceived that price fluctuation and competition with imported honey were the key challenges alongside the lack of honey processing equipment to help add value to their products. The honey-hunters were more concerned about the welfare of their households and hand little interest in the business aspects of beekeeping.

Knowledge of enemies of bees (stingless bees and honeybees)

Most respondents identified predation as the key problem of beekeeping, with older respondents, with a longer history of beekeeping, having a better knowledge of the key enemies of honeybees than younger beekeepers. Respondents with more intimate experience i.e., the pygmies/hunter-gatherers and beekeepers, were better able to articulate the problems that moneys, chimpanzees, gorillas, snakes, lizards and birds caused for beekeeping (Table-3). Honey hunters, who were less involved in management and observation of hives, did not offer detailed reports such as the fact that birds fed on adult bees both in the wild and near apiaries. However, honey hunters were able to identify climate change and variability in temperature and rainfall as some of the main causes for insufficient honey in their hunting areas in the study area. They noted that rainy periods were not only shorter, but also the total amount of rain received less than what was usually received in the normal rain seasons in the local that used to have abundant rain.

Natural Enemies of honeybees (wild and domesticated colonies)

Incidence and severity of pests and diseases occurred differently in the dry and rainy seasons for the different species (Table 1). It was observed that the occurrence was higher during dry season than during rainy seasons i.e., more pests and parasites were encountered during the dry seasons (June-August) than during the rainy season (March-May). Specimens of mites were detected observed and isolated from honeybees. However, at the first observation (morphologically) it was not clear if the mites collected in the study were the same mites described in the literature; they seemed to belong to different species. Specimens were sent to specialist lab for species confirmation and identification.

Table 1: Seasonal variations of the occurrence of enemies (pests, parasites, predators) of domesticated and wild conies of honeybees (data are means of years 2012-2014): fauna associated with bees

		Long rainy season **March-May** **Mean ± SE**	**Long dry season** **June-August** **Mean ± SE**	**Short-rainy season** **September-November** **Mean ± SE**	**Semi-dry season** **December-February** **Mean ± SE**
Mammals	Bats (Microchiroptera)	12.78 ± 1.27	56.54 ± 5.65	11.34 ± 1.34	6.65 ± 0.665
	Praomis jacksoni (Rodentia)	34.12 ± 6.41	2.66 ± 0.266	5.122 ± 0.56	9.33 ± 0.998
	Rattus rattus (Rodentia)	23.72 ± 2.37	12.34 ± 1.234	7.434 ± 0.74	5.76 ± 0.571
	Mus sp (Rodentia)	1.23±1.651	0.00±0.000	1.78 ± 0.056	0.00±0.000
	Agama agama (Reptilia)	1.89 ± 0.189	6.54 ± 0.654	1.123 ± 0.22	9.765 ± 0.76
	Black slinder snake (Reptilia)	1.76 ± 0.178	0.12 ± 0.012	2.443 ± 0.24	0.78 ± 0.045
	Wild & domestic cats(Mamalia)	1.34 ± 0.132	1.431 ± 0.14	2.76 ± 0.276	2.45 ± 0.245
Birds	Picnonotus barbatus (Piconnotidae)	23.12 ± 2.31	45.12 ± 4.51	12.54 ± 1.254	8.65 ± 0.865
	Ploceus cuculatus (Cuculatidae)	4.34 ± 0.43	2.54 ± 0.254	1.78 ± 0.178	5.45 ± 0.545
Primates	Chimpanzees, Gorilla, Monkeys, civet	2.22 ± 0.22	0.12 ± 0.012	4.78 ± 0.478	1.32 ± 0.112
Molluscs	Archachatina maginata (Mollusca)	1.98 ± 0.198	3.45 ± 0.356	5.123 ± 0.512	1.34 ± 0.123
	Bulinus sp (Mollusca)	1.67 ± 9.167	0.98 ± 0.0123	2.88 ± 0.288	0.92 ± 0.043
Insects	Brachytrypes sp (Insecta)	34.65 ± 3.465	11.76 ± 1.23	45.77 ±4.98	5.76 ± 0.765
	Zonocerus variegatus (Insecta)	2.76 ± 0.276	3.56 ± 0.67	1.84 ± 0.231	5.66 ± 0.567
	Mantis sp .(Blattodea: insecta)	1.88 ± 0.188	0.23 ± 0.034	2.45 ± 0.431	1.34 ± 0.54
Small hive beetles	Aethina tumida (Coleoptera)?	12.48 ±5.21	34.2 ±3.87	67.98 ±23.11	123.4 ±34.12
Black small ants	Formica sp. (Formicidae)	12.98 ± 1.298	23.54 ± 2.65	2.22 ± 0.223	8.54 ± 0.851
	Macrotermis sp (Termitidae)	78.77 ± 7.87	12.11 ± 1.231	124.56 ± 12.76	12.76 ± 1.23
	Formica Sp (Formicidae: Insecta)	34.87 ± 3.41	56.44 ± 5.67	78.87 ± 7.98	134.12 ± 14.5
	Moth (Noctuidae: Lepidoptera)	3.45 ± 0.345	2.11 ± 0.234	1.121 ± 0.123	7.867 ± 0.56

		Long rainy season March-May Mean ± SE	Long dry season June-August Mean ± SE	Short-rainy season September-November Mean ± SE	Semi-dry season December-February Mean ± SE
Parasite	Physocephala sp. (Diptera:Canopidae)?	1.23±3.12	5.45±1.67	0.00±000	0.00±000
	Leucospis sp.(Leucospididae)	1.1±0.87	1.9±1.09	0.00±000	0.00±000
	Melittobia acasta (Eulophidae)	2.1±2.34	3.120.56	2.67±0.67	5.12±3.13
	Paravespula sp (Vespidae)?	12.6±5.87	3.122±2.45	6.76±0.982	1.98±0.56
Predatory Wasps	Vespa sp (Vespidae)	2.13±1.12	5.67±2.12	7.12±2.09	2.56±3.31
Spiders	Lycosa sp (Arenae)	2.54 ± 0.25	2.23 ± 0.234	6.98 ± 0.761	1.56 ± 0.15
	Spiders 1 (Arenae)	12.65 ± 1.26	2.11 ± 0.213	34.78 ± 4.56	12.34 ± 1.54
	Spiders 2 (Arenae)	45.51 ± 4.55	2.45 ± 0.245	11.88 ± 2.312	89.76 ± 8.912
	Tyrolichus sp (Acarina: Acaridae)?	15.21 ± 1.55	1.42 ± 0.241	2.88 ± 2.354	1.761 ± 0.912
Mites	Acarus sp. (Acaridae, Acarina)	2.67±1.334	12.6±4.12	0.00±0.00	0.00±0.00
Tracheal mites	Acarapis sp. (Acari: Tarsonemidae)?	112.65 ±11.26	33.12 ± 3.451	10.38 ± 1.65	13.65 ± 1.51
Varroa mite	Varroa destructor				
(Varroidae, acarina)?	23.12 ± 2.312	321.32 ±31.13	5.12 ± 1.31	66.67 ± 8.87	
	Forficula auricularia L. (Forficulidae, Dermaptera)	2.23±06.2	5.78±1.43	1.11±0.65	2.54±0.87
Beetles	Dermestes sp (Dermestidae, Coleoptera)	1.23±0.87	2.11±0.54	1.43±0.34	1.54±0.112
	Trogoderma sp (Dermestidae ,Coleoptera)	1.11±0.67	0.00±0.00	0.00±0.00	1.23±0.54
	Tribolium sp (Tenebrionidae, Coleoptera)	0.341±0.114	4.23±1.34	2.11±2.1	4.12±1.11
	Musca sp (Muscidae, Diptera)	6.12±3.12	145.5±3.12	234.67±23.65	123.895±8.67
	Galleria sp. (Pyralidae, Lepidoptera)	1.13±0.45	3.56±1.1	29.12 ±3.45	7.45±1.65
Diptera	Braula sp.(Diptera: Braulidae)	7.12 ± 0.912	2.11 ± 0.2312	6.987 ± 0.897	23.67 ± 2.56

Table 2: Perception of problems of beekeeping industry by stakeholders

	Perceived factors	% of Respondents		
		Beekeepers (N= 31)	Farmland honey hunters (N=41)	Forest honey gatherers (N= 28)
Natural-Environmental factors	Climate change (rainfall, temperature),			
	Bad weather (high rain, wind, sunshine)	1.45	5.67	5.57
	Stingless bees & wild honeybees colonies continuously decreasing	0.09	19.65	29.91
	Disappearance of good floral resources			
	(Shortage of bee forage and water due to drought)	34.6	22.5	5.33
	Land-uses changes (nest trees cutting)	1.58	10.43	0.005
	Livestock and Mono-cropping intensifications	1.87	0.05	0.003
	Wars and growing insecurity	4.98	0.65	5.56
	Frequent wild fires	1.45	0.03	4.65
	Wild lands conversion to farmlands	1.04	0.04	1.12
	Absconding honeybee , migration of colonies	3.54	0.45	0.031
	Predators, parasites, pests and Disease	5.67	3.76	12.25
	Death of colony	2.65	7.34	5.67
	Reduction of honey bee colony	1.56	2.67	7.54
Production factors	Lack of modern Beekeeping equipments	1.14	0.03	0.05
	Lack of adequate beekeeping skill & poor management, poor storage and processing facilities	2.76	0.04	0.67
	Lack of modern Beekeeping equipments	1.14	0.03	0.05
	Lack of adequate beekeeping skill & poor management, poor storage and processing facilities	2.76	0.04	0.67

	Perceived factors	% of Respondents Beekeepers (N= 31)	Farmland honey hunters (N=41)	Forest honey gatherers (N= 28)
Market and trade factors	Lack of access to financial credit services and extension services	7.85	0.09	0.03
	Lack of training opportunities in modern beekeeping practices	3.67	2.75	0.02
	Competition of local honey with imported one at local market	2.78	3.36	3.32
	Fluctuation in the price at local markets	6.76	7.65	8.51
	Lack of information of the demand at the local markets	6.78	4.12	1.98
	Trade problems (government taxes, honey quality, packaging)	2.65	1.02	0.04
	Poor linkage consumers-collectors- retailers-processors	3.45	6.65	5.65
	Un-clear and disorganized marketing channels	1.68	1.05	2.12

Discussion

Natural enemies of bees

Varroa mite has been identified incriminated as the leading pest of honeybee globally across seasons and locations (Bradbear 1988, Leonard 1983, Morse & Nowogrodzki 1990, Nixon 1982, Finley et al.1996, Frazier et al. 1994, Harris et al. 2003, Wilkins et al.2007, Vandervalk 2013). There has been no previously published research work on bee health (pests and diseases and related enemies) in DRCongo. Beekeeping as a business is gaining recognition in DRCongo at a time when and that there is a high and growing demand for honey in the country and therefore it is important to identify all constraints to the promotion of the business in the country. This is the first preliminary investigation which helped identify a number of enemies of bees and challenges to beekeeping. It is possible that Varroa mite may exist in DRCongo but this report was not able to conclusively ascertain its existence. Given the potential damage that varroa can inflect, it is an important issue that warrants further investigations.

The frequency of occurrence of pests/ parasites was more in dry season than in the wet season. During the rainy season honeybees are less exposed as they tend to remain in the hives and foraging activity is reduced because of the low temperature and wind storms. The dry season is nectar and honey flow period (usually the honey harvest period) which probably also serves to enhance the infestation of bee colonies with pests and parasites.

Knowledge of enemies of bees and perceptions of beekeeping business challenges

Overall, more than fifty percent of honey producers relied on honey hunting and only thirty percent are involved in traditional beekeeping activities: modern beekeeping is not practiced in the study area. In the wild or stingless bees (Meliponula ferruginea, Meliponula bocandei,

Table- 3: Knowledge of enemies of bees (honeybees and stingless bees) by respondents

Types of Knowledge of enemies of bees	**% of Respondents**		
	Beekeepers (N= 31)	**Farmland honey hunters (N= 41)**	**Forest honey gatherers (N=28)**
Primates (Gorillas, monkey, chimpanzees)	2.17	8.12	34.65
Man (poachers, rangers, charcoal makers, fire makers,...)	8.45	47.6	7.34
Birds (common village species)	17.4	18.4	25.7
Snakes and frogs and lizards	5.67	8.12	6.32
Red ants and some spiders	26.62	12.96	14.25
Honeybees poisoning, feeding on poisonous plant flowers	22.1	0.078	0.34
Unknown diseases (stopping bees to collect pollen/nectar) consistently	2.13	0.067	0.082
Honeybees poisoning by chemicals (pesticides)	1.12	0.023	0.011
Feeding on non nutritious flowers in poor & polluted environment	8.71	5.12	0.021
Magic, witchcraft by traditional healers (stopping bee flights)	7.78	0.054	11.36

Hypotrigona gribodoi, Meliponula nebulata, etc) and honeybees (Apis mellifera adasonii, Apis mellifera scutellata and hybrids of these two sub-species) colonies are mostly exploited both from grasslands-bushlands, forest fallows and from within protected areas. Mostly traditionally made hives are used, with beekeepers strategically siting their hives mostly inside the park or in the vicinity of the park. Few hives were observed within the farmlands as beekeepers perception was that the best floral resources were inside the park. Other farmers felt that there was limited natural vegetation in the villages. This practice exposed hives to increased predation by primates and snakes from the park, and to theft by poachers, medicinal plant harvesters, miners and charcoal makers. The practice has also led to disputes between pygmies and beekeepers, with pygmies who gather honey from inside the park, accused of stealing honey from hives of beekeepers who have been authorized to run their business at the edges of the park.

Honey hunters and wild gatherers from Kahuzi Biega national park therefore, represent the most active actors in honey collection. Thus hives and colonies are exposed to several threats such as hunting and habitat loss both in the forests and in farmland habitats and in grassland habitats. Beekeeping in eastern DRCongo is currently reliant on local bees, and therefore appropriate conservation policies are needed to maintain nesting sites and ensure the persistence of a healthy wild populations in farm-landscape habitats and inside the parks (protected areas). The strategies of the honey hunters, however, put serious pressures on bee populations and will negatively impact on their diversity if the practices are unchecked. Climate change and variability further lead to increased destruction of wild colonies by honey hunters and wild honey gatherers to compensate the economic shortfall because of the reduction of the honey production .

From the point of view of beekeepers, the major constraints to exploitation of the untapped potential of beekeeping in the study areas include lack of beekeeping equipment, environmental/ climatic challenges, shortage and reduction of bee forages, incidence of predators, parasites, pest and diseases, lack of improved beekeeping technologies, poor colony management, poor or traditional harvesting and processing methods to produce honey that is of high quality and therefore competitive on the local market, lack of financial access and incentives/ support from the government.

Knowledge of bee health is poor. Appropriate measures for the promotion of sustainable beekeeping practices are needed, to preserve bee diversity and to enhance sustainable development of the agriculture in the study area as well as in the country. This will result in an improvement of the well-being of beekeepers and the promotion of beekeeping industry in the country. There is a need to put a monitoring programme in place to monitor bee pests and diseases. Training in various aspects of bee health as means to increase honey for additional income generation increase and to realize the potential for enhancing pollination services should be a priority. . There is also a need to train farmers on modern beekeeping; and to introduce honey therapy trials in local medical schools and hospitals.

Beekeeping industry plays a pivotal role in the agricultural, food security, biodiversity and national economies, not only through hive products but most importantly the contribution of honeybees to crop and wild flora pollination. Beekeeping therefore is integral to sustainable agriculture, and can serve to boost the income of the rural and urban poor. Interventions and investments to stop the degradation of land, DRCongo has the potential of becoming a continental and global leader in the bee industry. .

Beekeeping projects are an ideal vehicle for awareness raising and advocacy about the value of forests, and to engage the public on conscious protection, conservation and sustainable resource management. Beekeeping industry has the potential for livelihood improvement and biodiversity conservation and forest conservation, especially in the buffer zones of Kahuzi Biega National Park. Beekeeping can therefore be considered a viable commercial activity that is compatible with natural resource protection and conservation objectives, and should be an integral part of national forest programs and other development strategy plans (Keralem Ejjgu 2005). Improved beekeeping can be an incentive for farmers to invest in wild nature conservation, restoration and improvement since beekeeping also requires the existence of diverse agricultural and wild floral resources in the landscape. The objective will be to promote reforestation with indigenous plants with emphasis on melliferous plants, and eventually to propose that these site be preserved as bee reserves with access only to beekeepers. . Beekeeping can thus have a positive impact on the livelihoods of the population in the vicinity of the park as it is less demanding in terms of investment and is an environmentally friendly activity.

Beekeeping can play a role in the protection and rehabilitation of landscape habitats and vegetation, aspects that can be taught to beekeepers as an integral part of maintaining diverse honeybee floral resources and nesting sites (habitats refugia) to achieve maximum honey production. This integrated approach to improved beekeeping would be a strong economic incentives that merges nature conservation with increased honey and beeswax production. Government efforts are critical for organization of resources-poor, landless and marginalized peoples by providing them with the necessary beekeeping technologies and inputs to realize the benefits of this integrated approach.

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EVALUATION OF TRANSITIONAL AND MODERN HIVES FOR HONEY PRODUCTION IN THE MID RIFT VALLEY OF ETHIOPIA

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Abstract

The study was conducted in Adami Tulu and Arsi Negelle districts from September 2009 to June 2012 to evaluate productivity performance of transitional and modern box bee hives. Based on farmers' capacity, one modern box hive and one transitional hive made from locally available materials were used at each of the experimenting farmer. Traditional hives were used as control. Before actual commencement of this study, theoretical and practical training session was given for a total of 60 beekeepers at the selected sites. After training, the farmers were organized as Farmers' Research Group (FRG) to perform all research activities together. Data related to honey yield were collected and analyzed using the General Linear Model procedure of the statistical Analysis System (2006). The overall average annual honey yield performance clearly revealed that both modern bee hive (23.18 kg/hive and transitional bee hive (13.88 kg/hive were significantly higher ($p < 0.05$) than traditional bee hive (6.08 kg/hive. There was significant difference ($p < 0.05$) among the three representative sites. It is concluded that using improved bee hives with improved management practices can improve honey yield and ensure better quality of honey compared to traditional bee hive. It is recommended that government and non government should intensively focus on scaling up and promoting the adoption of transitional hive for small scale beekeepers and modern bee hive for large scale/commercial beekeepers to improve their' income.

Key words: Transitional hive, modern hive, evaluation, honey, bee colonies, yield

EVALUATION DES RUCHES DE TRANSITION ET DES RUCHES MODERNES POUR LA PRODUCTION DE MIEL DANS LA MID RIFT VALLEY DE L'ETHIOPIE

Résumé

L'étude a été menée dans les districts Adami Tulu et Arsi Negelle, de septembre 2009 à juin 2012, dans le but d'évaluer la productivité des ruches de transition et des ruches modernes. Sur la base de la capacité des apiculteurs, une ruche en blocs (box hive) moderne et une ruche de transition construite avec des matériaux disponibles localement ont été utilisées dans chacune des exploitations apicoles visées par l'expérimentation. Les ruches traditionnelles ont été utilisées comme témoins. Avant le début effectif de cette étude, une session de formation théorique et pratique a été donnée à un total de 60 apiculteurs sur les sites sélectionnés. Après la formation, les apiculteurs ont été organisés en groupe de recherche agricole (RFA : Farmers' Research Group) pour mener ensemble toutes les activités de recherche. Les données relatives au rendement en miel ont été recueillies et analysées en utilisant la procédure du modèle linéaire général du Système d'analyse statistique (2006). Le rendement annuel moyen global en miel a clairement révélé que le rendement de la ruche moderne (23,18 kg / ruche) et de la ruche de transition (13,88 kg / ruche) était significativement plus élevés ($p < 0,05$) que celui de la ruche traditionnelle (6,08 kg / ruche). Une différence significative ($p < 0,05$) a été notée entre les trois sites représentatifs. Il a été conclu que l'utilisation de ruches améliorées combinée avec de meilleures pratiques de gestion peut augmenter le rendement en miel et produire du miel de meilleure qualité par rapport à la ruche traditionnelle. Il est recommandé aux organismes gouvernementaux et non gouvernementaux de se concentrer particulièrement sur l'intensification et la promotion de l'adoption de la ruche de transition pour les apiculteurs artisanaux et la ruche moderne pour les apiculteurs professionnels/commerciaux afin d'améliorer leur revenu.

Mots-clés : ruche de transition, ruche moderne, évaluation, miel, colonies d'abeilles, rendement

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Introduction

Ethiopia is the leading honey producer in Africa and one of the ten largest honey producing countries in the world. Due to its wide climatic and edaphic variability, Ethiopia is home to some of the most diverse flora and fauna in Africa that provide surplus nectar and pollen source to foraging bee colonies (Girma Deffar, 1998).This is assisted for the existence of more than 12 million honey bee colonies in the country (Gezahegn, 2001). Despite the favorable agro-ecology for honey production and the number of bee colonies the country is endowed with, the level of honey production and productivity in the country is remain low. One of the prominent factors for this low honey productivity is traditional hives. According to the study made by Tesfaye K and Tesfaye L. (2008) on the distribution of bee hives, about 98% beekeepers' in mid rift valley of Oromia still use traditional bee hive for honey production. Ethiopia has the potential to produce about 500,000 tonnes of honey per year and 50,000 tonnes of beeswax per annual, but currently production is limited to 43,000 tonnes of honey and 3,000 tonnes of beeswax (MOARD, 2008).The quantity and quality of Ethiopian honey is in generally poor, as 95% of beekeepers follow traditional way of beekeeping practice with no improved techniques or technologies (Oxfam, 2008). As it is true in many beekeeping regions, honey production in mid rift valley area has recurrently been reported to be very low because of poor management of bee colonies and traditional production systems. Low productivity and poor quality of bee products are the major economic impediments for beekeepers (Nuru, 1999).

In Ethiopia in general and in mid rift valley of Oromia Regional state in particular, beekeeping has been practiced since an old age (Tesfaye K and Tesfaye L, 2007). However, the role of this subsector in diversifying income of farmers is very low as compared to the country bee colonies resource base. Beekeeping plays a major role in diversifying farmers' income in developing countries where source of income for farmers is limited. Nuru (2002) stated that honey bee and bee products provide direct cash income for beekeepers especially in the area of other agricultural activity is difficult.

There are three different hives types in Ethiopia by which honey is produced based on their technology level.These are traditional, transitional and modern bee hives (GDS, 2007).The major portion of honey production in Ethiopia is done by using traditional bee hives. Traditional bee hives accounts for more than 95% of honey produced. This way of honey production makes the management of honey bees for better quality and quantity of honey more difficult. Gezahegne (2001) stated that under Ethiopian farmers' management condition, the average amount of crude honey cropped from traditional hive is estimated to be 5 kg /hive per year. Transitional hives, one of the modern hive types being promoted in the country since 1978 and types of hives used are: Kenya Top-bar hives, Tanzania Top-bar hives and mud block hives. Among these Kenya Top-bar hive is widely known and commonly used in many parts of the country (HBRC, 1997). It is also known as intermediate bee hive, has two version are made from a wooden box and the other from locally available material such as bamboo (GDS, 2009). High yield and other quality, ease of inspection and ease of product harvesting are the major relatively advantage of modern hives.Top-bar hive in an ideal condition can yield about 50 kg of honey per year, but under Ethiopian condition, the average amount of crude honey produced would be 7-8 kg/hive per year (Gezahegne, 2001). These hives have been considered as better hives over traditional ones in that the honey yield is relatively high and are easy to inspect the status of colony. So, the importance of this study is to introduce transitional hives made from locally available materials and modern box hives and evaluate their performance in the mid rift valley of Oromia, Ethiopia.

Materials and Methods

The study was conducted in Adami Tulu and Arsi Negelle districts from September

2009 to June 2012 to evaluate the yield performance of transitional and modern hives. Adami Tulu district is situated at latitude of 7° 19' N to 7° 40' N and '35 38° 30' E to 38° 53 'E and an altitude ranges from 1500 to 2000 m.a.s.l (ATARC, 1998). Adami Tulu district is located at 160 km from Addis Ababa to the south of Addis Ababa. The district covers an area of 1403.3 km2 (140,330 hectare) with the total population of 177,492 which more than 79% living in the rural area. The agro ecological zone of the district is semi-arid and sub-humid in which 90% of the area is low land while the remaining 10% is intermediate. The mean annual rain fall ranges from 750 to 1000 mm with the average minimum and maximum of temperature is 25° C and 28° C respectively. Rain fall distribution is highly variable between and within years. Arsi Negelle district is situated at latitude of 7o09' N to 7o41 N and 38o25' E to 38o54' E and an altitude ranges 1500 to 2300 m.a.s.l (Arsi Negelle Agriculture and rural development office, 2013). It is located at 225 km South of Addis Ababa. The average of rain fall ranges from 800 to 1400 mm with the average minimum and maximum of temperature is 15° C and 20° C respectively. The rain fall is bimodal, the long rain occurs from June to September and the short rain fall is from March to April with highest usually record in July and August, respectively (Arsi Negelle Office of Agriculture and Rural Development, unpublished data). Arsi Negelle district is divided in to three major climatic zones on altitude including low, mid and high altitudes. Mixed crop-livestock system is the mode of agriculture in both districts.

Treatments

To evaluate the performance of transitional and modern hives in mid rift valley of Ethiopia, a total of 30 bee colonies which had similar strength were selected and transferred from traditional hives to transitional and modern hives in active season. Based on farmers' capacity, one traditional hive, one modern hive and one transitional hive made from locally available materials were used for the trail at each of the experimental farmer but for those farmers who do not have three hives in the area, two farmers were organized under one experimental group. Traditional hives were used as control during the study time.

Farmers and experimental sites selection

For this study, beekeeping potential sites were purposively selected with the criteria of having large number of participants in beekeeping, beekeepers experience and interest to evaluate transitional and modern hives, potential area for beekeeping, abundance of honey bee colonies in traditional hives, availability bee forage plants, accessibility of the areas to transportation service and socio-economic value of honey. Accordingly, Asebo Peasant Association from Adami Tulu district, Ashoka Lepis Peasant Association from Arsi Negelle district and Adami Tulu research station were purposely selected for this experiment.

Farmers Research Group (FRG) approach followed

After sites and farmers were selected, theoretical and practical training session was given for a total of 30 beekeepers, bee experts and DAs at experimental sites for consecutive five days since transitional and modern hives were new to beekeepers of both districts. Training topics focused on bee biology, beekeeping system, routine honey bee colony management and inspection, procedure of bee colony transferring from traditional hives to transitional and modern hives, honey harvesting and post harvest management system, importance of transitional and modern hives. One transitional bee hive was constructed at each experimental site in mass during the training session and demonstrated to all participants. After training, every farmer was constructed two additional transitional bee hives (Kenya Top-bar) from locally available materials by themselves. The project was provided technical support and materials support such as Modern hives, queen excluder, refine beeswax for the experimental farmers. Farmers were also made to share experience at Holeta Bee Research Center with established well performing FRG members. This was performed before honey bee colony transferring to transitional and modern bee hives.

Honey bee colony management practices

Bee colony transferring

Bee colonies were transferred from traditional hives to transitional and modern hives with the participation of researchers, technical assistance and experimental farmers' at each study site in nectar and pollen flow seasons. During colony transferring, all materials including two combs contain honey, two combs contain pollen and two combs contain bee brood were attached on top-bars and frames and put for the newly transferred bee colonies to maintain and minimize colony absconding but for honey, pollen and brood less colonies, external colony feeding with sugar syrup and bean flour (shiro) was undertaken at each study site.

Bee colony feeding and watering

Seasonal fluctuations in food availability and the ability of bee colonies to stored food are the two most important factors determining whether feeding is necessary. Bee colonies normally obtain pollen, nectar and water from various plant species and natural water sources but during dearth period (both in wet and dry seasons) there is a shortage of pollen, nectar source of plants and water in the study area. To minimize bee colony absconding and maintain during dearth period, various supplementary feed such as bean flour (shiro), sugar syrup and water were undertaken at each study site.

Bee colony inspection

Unlike traditional bee hives, transitional and modern bee hives have movable combs so that the beekeepers easily can open their hives and inspect to follow up bee colonies. Hives were inspected regularly by researchers, technical assistant and farmers at each study site to check the progress of the bee colonies problems, examine the condition of brood, check food store, attachment of top-bar with the wall of hive, honey ripe, pests and predators attack and look for sign of diseases.

Honey harvesting and processing

Honey is considered ripe when the combs sealed with thin wax layer. In traditional beekeeping system, honey quality is poor due to harvesting of unripe honey, excessive using of smoking materials during honey harvesting, mix of honey with beeswax, pollen, bee brood and propolis. The thin wax layer was uncapped by using knife. This is the first step of honey processing. The harvested honey from transitional hives is squeezed or pressed from the combs and strained/ filtered soon as harvested through fine sieve and clothe but harvested honey from modern hives was strained by using honey extractor and stored in sealed containers and put in dry place until marketed. The amount of honey harvested per transitional and modern hive was measured with farmers at each study site in all harvesting seasons by using sensitive balance weigh. In the both district honey was harvested twice. Large honey harvesting season in Adami Tulu district is September to early November, while small amount honey harvesting season is in May. Large honey harvesting season in Arsi Negelle district is January, while small honey harvesting season is in June.

Method of data collection and analysis

Data collection

Honey collection sheets and check lists were developed by the researches at team level for each study site. Data related honey yield per hive were collected for consecutive three years The amount of honey yield was soon measured and recorded on the prepared of honey collection sheets.

Statistical analysis of data

The collected data were statistically analyzed using the General Linear Model analysis of variance procedure of the statistical Analysis System (SAS) programmme (SAS Institute Inc., 2006). Means were separated using least square significant difference whenever they were statistically significant at ($p < 0.05$).

Results and Discussions

Honey yield from transitional and modern hives

The productivity of transitional and modern box hives were evaluated at three sites for consecutive three years and the means values were shown in (Table 1).

The study result indicated that the mean honey yield per hive/year from transitional hive was 13.88 kg, 13.2 kg and 10.45 kg at Adami Tulu Research station, Asebo and Ashoka Lepis site respectively. There was significant difference ($p < 0.05$) between Adami Tulu Research Center and Ashoka Lepis site in honey yield per hive/year from transitional hive but, there is no statistically significant ($p > 0.05$) between Adami Tulu Research Center and Asebo site. Significantly, High and low amount of honey yield from transitional hive were recorded at Adami Tulu Research Center and Ashoka Lepis site respectively. The mean yield obtained from transitional hives are similar with the findings by Workneh et al (2008), which is 10-15 kg per hive/year/but it is significantly higher than the national average yield of traditional hive indicated by Jacobs et al (2006) and Workneh et al (2007), which is 5-6 kg and 5 kg per /hive/year respectively. However, the mean honey yield obtained from transitional hive in this study area is lower than the result reported by Nebiyu and Messele (2013) in districts of Gamo Gofa zone southern Ethiopia, which is 14.07 kg/hive/year. The mean honey yield per hive/year from modern hive was 23.18 kg, 21.93 kg and 18.61 kg at Adami Tulu research station, Asebo and Ashoka Lepis site respectively. There was significant difference ($p < 0.05$) among the three study sites in honey yield/hive/year from modern hive. The mean honey yield from modern hive in this study area is similar to the national average yield indicated by Workneh et al (2008) in Atsib Wonberta district of Tigray region, which is 20-25 kg hive/year but it is above the average yield indicated by Tessega (2009) in Burie district of Amhara region, which is 15.6 kg/hive/year. The mean honey yield per hive/year from traditional hive

Table 1: The mean honey yield of traditional, transitional and modern hives year in study sites

Sites	Transitional hive Mean yield (in kg)	Modern hive Mean yield (in kg)	Traditional hive mean yield (in kg)
ATARC	13.21[a]	23.18[a]	6.08[a]
Asebo	13.88[a]	21.93[b]	5.94[a]
Ashoka Lepis	10. 45[b]	18.61[c]	4.94[a]
LSD (5%)	2.0051	2.17	2.036
SE(±)	0.60	0.79	0.50
CV (%)	9.54	4.57	4.01
Over all mean	12.54	21.02	5.65

Table 2: Mean square error of season, location, hive type and their interaction on honey yield

Source of variation	1st season	2nd season	Av. yield
Hive type	2547.216***	2626.56***	2586.736***
Sites	132.025***	124.561***	124.821***
Year	28.505*	7.68NS	7.972NS
Hive type * sites	9.391NS	8.182NS	8.639*
Hive type * year	3.854NS	22.045*	9.875*
Sites * year	0.185NS	7.207NS	1.784NS
Hive type* Sites * year	8.029NS	1.558NS	3.695NS

**** Significant at α= 0.05,* Significant at α= 0.01, NS-Non-significant*

Table 3: Interaction effects of hive type and site on honey yield at the study area

Hive type	Sites	Av. yield
Modern	Asebo	21.93b
Modern	Ashoka	18.61c
Modern	ATARC	23.18a
Transitional	Asebo	13.88d
Transitional	Ashoka	10.45f
Transitional	ATARC	13.22e
LSD5%		0.424
CV		10.4

Table 4: Interaction effects of hive type and year on honey yield at the study area

Hive type	Year	Av. yield	2nd season
Modern	2009	21.29[ab]	20.27[b]
Modern	2010	20.34[b]	20.62[b]
Modern	2011	22.08[a]	22.76[a]
Transitional	2009	11.27[c]	10.83[c]
Transitional	2010	10.25[c]	10.37[c]
Transitional	2011	10.03[c]	10.03[c]
LSD5%		1.196	1.615
CV		10.4	14

Table 5: Main effect of hive type, site and season on honey yield at the study area

Hive type	Av. yield	2nd season	1st season
Modern	21.24[a]	21.22[a]	21.26[a]
Transitional	10.52[b]	10.41[b]	10.62[b]
SE	0.245	0.331	0.388
LSD5%	0.691	0.932	1.095
Site			
Asebo	16.91[a]	16.48[a]	17.34[a]
Ashoka	13.53[b]	13.53[b]	13.53[b]
ATARC	17.2[a]	17.44[a]	16.96[a]
SE	0.3	0.405	0.476
LSD5%	0.846	1.142	1.341
Year			
2009	16.28[a]	15.55[ab]	17.01[a]
2010	15.3[b]	15.49[b]	15.1[b]
2011	16.06[ab]	16.4[a]	15.72[b]
SE	0.3	0.405	0.476
LSD5%	0.846	1.142	1.341
CV	10.4	14	16.3

Table 6: Presentation of production cost and profitability of modern bee hives

Gross output	Unit	Average yield	Quantity	Unit price	Total
Production	kg	13.88	208.2	110	22,902
Total gross income	Birr				22,902
Cost of production					
Cost of sugar	kg		30	24	720
Cost of bean flour	kg		35	18	630
Total variable cost	Birr				1,350
Gross margin	Birr				20,100
Fixed cost					
Cost of hive	Birr		15	150	2,250
Annual depreciation of hives (25%)	Birr		15	37.5	562.5
Total fixed cost	Birr				2,812.5
Total overall cost	Birr				4,162.5
The net income attribute to farmer	Birr				18,739.8

Table 7: Presentation of production cost and profitability of modern bee hives

Gross output	Unit	Average yield	Quantity	Unit price	Total
Production	kg	23.18		130	347.7
Total gross income	Birr				45,201
Cost of production					
Cost of sugar	kg		30	24	720
Cost of bean floor	kg		35	18	630
Cost of refined beeswax	kg		40	140	5,600
Total variable cost	Birr				6,950
Gross margin	Birr				38,251
Fixed cost					
Cost of hive	Birr		15	850	12,750
Annual depreciation of hives (25%)	Birr		15	212.5	3,187.5
Cost of hive tools	Birr				12,000
Total fixed cost	Birr				29,937.5
Total overall cost	Birr				34,887.5
The net income attribute to farmer	Birr				8,313.5

was 6.08 kg, 5.94 kg and 4.94 at Adami Tulu Research Center, Asebo and Ashoka Lepis site respectively. There was ($p < 0.05$) difference among the three representing sites in honey yield/hive/year from traditional, transitional and modern hives. The significantly higher honey yield from traditional, modern and transitional hives was indicated in Adami Tulu Research station and Asebo site respectively (Table 1). Whereas low honeys yield from traditional, transitional and modern hives was recorded in Ashoka Lepis site.

Location and hive type interaction had significant effect on honey yield per hive at study area. Whereas hive type and season of honey harvesting interaction had no significant effect on honey yield per hive at the study area (Table 3 and 4).Gidey and Mekonen (2010) also reported that environment/location and hive type interaction has an effect on honey yield per hive. This is most probably due to differences on the type and availability of bee forage, bee management practice and environmental factors such as climate changes, pests and predators and disease (Gidey and Mekonen, 2010).

Financial analysis of transitional and modern hives

Conclusions

The study clearly revealed that using improved bee hives can ensure better honey quantity and quality. Significantly higher honey yield from transitional, modern and traditional hives were recorded at Asebo and Adami Tulu research station respectively whereas low honey yield from the three hive types were recorded at Ashoka Lepis site. Location and hive type interaction had significant effect on honey yield per hive in the study area. Hive type and honey harvesting season interaction had no significant effect on honey yield per hive at the study area. Modern hives require more expensive beekeeping equipment and accessories as well as skilled personnel compare to transitional and traditional hives. Hence it is recommended that government should subsidize the cost of modern hives and accessories. Government and non government organization should focus on scaling up and promoting the adoption of transitional bee hives for small scale beekeeper farmers and modern bee hives for large scale and commercial beekeepers.

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SESSION 3: THE BEEKEEPING INDUSTRY IN AFRICA: POLICY, THE INSTITUTIONAL ENVIRONMENT AND LIVELIHOODS, AND POLLINATION SERVICES

THE STATUS AND FUTURE PROSPECTS OF HONEYBEE PRODUCTION IN AFRICA

James Moinde

Abstract

The demand for honey and other hive products in the world market is high compared to the current production. Honey and beeswax production in Africa is estimated to be less than 10 and25 per cent of the potential respectively. The beekeeping sector in Africa is extremely fragmented therefore the actual production and growth levels are difficult to quantify accurately. The actual production is mainly carried at the rural household as part –time income generating activity and food. The production systems and type of hives used vary from fixed comb hives such as bark or log hives to improved movable frame or top bar hives. The introduction of modern technologies and the improvement of the existing indigenous knowledge in beekeeping industry have shown major development in various aspects and beekeeping is now an important component of the Agricultural sector in various countries. However the effective use of these improved production methods is very limited. The current share of production is characterized by low productivity and low quality. The institutional support infrastructure for promoting beekeeping as n economic activity and providing technical and financial services is generally weak and unstructured

The promotion and development of apiculture as a commercial enterprise and the increases in the output of hive products in Africa would require that the agricultural sector policies of most African governments address the uniqueness of the bee industry. Effective use of improved methods of production would contribute to enhanced household food security; increased incomes, and environmental conservation. There are many opportunities for increasing the output of hive products and improving production efficiency and quality. The beekeeping industry provides opportunities to various stakeholders, among them are comparatively low capital investment, no pressure on human settlement and agricultural land, pollination, job creation, high demand for hive products in domestic and export markets, large unexploited natural vegetation and production of organic honey. It does not need sophisticated infrastructure or compete for resources with other agricultural activities. There is need to cultivate for business oriented and well focused approach that will ensure viable beekeeping industry through public-private partnerships. In order to exploit these opportunities, there are technical, financial and administrative constraints that require urgent attention. Development strategies for African apiculture should aim in the first instance at improving the existing technology and progress gradually towards the advanced technologies. The use of transitional steps to improvement would increase output over traditional systems and also be financially beneficial as input costs remain relatively low. Other constraints include inadequate technically trained and committed extension personnel, insufficient research, low adoption of improved technologies, ineffective control of pests and diseases among others. Most African hive products are consumed or used locally but there is a broad range of marketing opportunities for honey and other hive products. In particular, African honey can supply niche markets such as for organic products and value added products. However because of poor market access, poor infrastructure and inadequate products of sufficient quality and quantity and lack of strong organizations representing the interests of beekeepers, market opportunities are not fully utilized.

LA SITUATION ET LES PERSPECTIVES FUTURES DE LA PRODUCTION DES ABEILLES MELLIFERES EN AFRIQUE

Résumé

La demande de miel et des autres produits de la ruche sur le marché mondial est élevée par rapport à la production actuelle. La production du miel et de la cire d'abeille en Afrique est estimée respectivement à moins de 10 et 25 pour cent du potentiel continental. En Afrique, le secteur de l'apiculture

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est extrêmement fragmenté, par conséquent, il est difficile de quantifier avec précision les niveaux réels de production et de croissance. La production est principalement réalisée au niveau du ménage rural, comme activité génératrice de revenu à temps partiel et comme nourriture. Les systèmes de production et le type de ruches utilisé vont des ruches à rayons fixes tels que les ruches constituées d'écorces ou de planches de bois aux ruches à cadres mobiles en passant par les ruches à barres. L'introduction de techniques modernes et l'amélioration des connaissances indigènes existantes dans l'industrie de l'apiculture ont conduit à un développement majeur dans divers aspects, ainsi, l'apiculture est actuellement une composante importante du secteur agricole dans les différents pays. Cependant, l'utilisation efficace de ces méthodes de production améliorées est très limitée. La part actuelle de la production se caractérise par une faible productivité et une faible qualité. L'infrastructure institutionnelle d'appui pour la promotion de l'apiculture en tant qu'activité économique et la fourniture de services techniques et financiers sont généralement faibles et non structurées.

La promotion et le développement de l'apiculture comme entreprise commerciale et les augmentations de la production de produits de la ruche en Afrique exigent que les politiques du secteur agricole de la plupart des gouvernements africains tiennent compte du caractère unique de l'industrie apicole. L'utilisation efficace des méthodes de production améliorées contribuerait à renforcer la sécurité alimentaire des ménages, l'augmentation des revenus, et la conservation de l'environnement. Il existe de nombreuses possibilités d'augmenter les produits de la ruche et d'améliorer l'efficacité et la qualité de la production. L'industrie de l'apiculture présente des opportunités aux différentes parties prenantes, notamment le niveau relativement bas d'investissement financier ; l'inexistence de pression sur les établissements humains et les terres agricoles ; la pollinisation ; la création d'emplois ; la forte demande de produits de la ruche sur les marchés intérieurs et d'exportation ; la grande végétation naturelle inexploitée ; et la production de miel organique. Le secteur n'a pas besoin d'infrastructures sophistiquées et ne concurrence pas les autres activités agricoles pour les ressources. Il est nécessaire de cultiver une approche orientée vers les affaires et bien ciblée, qui assurera la viabilité de l'industrie de l'apiculture grâce à des partenariats public-privé. Pour exploiter ces opportunités, il faudra aborder les contraintes techniques, financières et administratives, lesquelles contraintes nécessitent une attention urgente. Les stratégies de développement de l'apiculture africaine doivent viser en premier lieu à améliorer les méthodes existantes et à progresser graduellement vers des techniques de pointe. L'utilisation de mesures transitoires d'amélioration est susceptible d'augmenter la production par rapport aux systèmes traditionnels, et serait financièrement avantageuse car les coûts des intrants restent relativement faibles. Les autres contraintes comprennent l'insuffisance du personnel de vulgarisation technique formé et dévoué, l'insuffisance des travaux de recherche, la faible adoption de techniques améliorées, l'inefficacité de la lutte contre les parasites et les maladies, entre autres. La plupart des produits de la ruche africains sont consommés ou utilisés localement, mais il existe un large éventail de possibilités de commercialisation du miel et d'autres produits de la ruche. En particulier, le miel africain peut approvisionner les marchés à créneaux, par exemple pour les produits biologiques et les produits à valeur ajoutée. Cependant, en raison du faible accès aux marchés, de l'insuffisance des infrastructures et des produits en qualité et quantité suffisantes et de l'absence d'organisations fortes représentant les intérêts des apiculteurs, les débouchés commerciaux ne sont pas pleinement exploités.

Introduction

Africa is endowed with a diversity of types of wild honeybee found across its agro-ecological zones from the evergreen equatorial rain-forest to the arid desert zones. The diversity is greater in the drier savannah zones than in the wetter forest areas (Adjare, 1990). In many parts of rural Africa, beekeeping has strong cultural traditions and therefore can be used as a development tool to improve the livelihoods of the rural communities. Traditional beekeeping and honey hunting are still being practised among some African communities. Traditional beekeepers use baskets, pots, gourds, logs and barks as beehives. Gathering of wild honey which has predominated where there are low population densities and an abundance of natural bee flora has largely been replaced by beekeeping (Paterson, 2006). The decline in traditional beekeeping in Africa may be attributed partly to increased human population which has led to destruction of natural bee habitats for intensive agriculture, and rapidly growing urban settlements. Charcoal burning and beehive making have resulted in the cutting down of rare indigenous plants and vegetation that are important forage sources for bees, particularly in arid and semi-arid areas (Gikungu,2009). These activities have negative impact on bee forage, honey production and conservation of healthy environments.

Traditional beekeeping is generally characterized by low productivity and low product quality (UNIDO,2003). There are therefore insufficient quantities of other hive products for the market besides honey, and in most cases other valuable hive products such as beeswax, propolis, royal jelly, and pollen go to waste. However the traditional methods of beekeeping have overtime made the management of bee colonies, hives products and their utilization less viable.

The introduction of improved beekeeping technologies (improved beehives and accessories, protective clothing and honey processing equipment as well as bee colony management) with relevant training and expertise, the industry has shown major development in various aspects and is now an important component of the Agricultural sector in many African countries.

Many beekeepers are using both traditional and improved methods. Where some improved methods of beekeeping have not been adopted, it is partly because the technology is in appropriate to that particular area, and/ or is a lack of proper training and expertise. In areas where new technologies have been accepted and adopted beekeeping has succeeded.

Why Apiculture in Africa

Apiculture is comparatively a low-investment and low-input business enterprise that directly generates economic gains for its stakeholders. It is an income generating activity, thereby creating employment opportunities as well as contributing to improved livelihoods of the communities. It does not need sophisticated technology, high capital investment or infrastructure Beekeeping does not compete for resources with other agricultural activities (Bradbear,2004). One does not need to own land to keep bees and can be practiced in areas where other forms of agriculture cannot be effectively sustained. Honey, the most popular hive product has numerous nutritional and medicinal values on which many communities and especially those living in the rural areas rely. Other hive products such as propolis, royal jelly, bee venom and bees wax are known to have invaluable medicinal, cosmetic, pharmaceutical and industrial value. It can be practiced by men, women, and youth making it a crucial avenue towards poverty reduction and enhancing the quality of life. Beekeeping provides the opportunity for poorer households and those with little or no land to diversify production away from direct agriculture. Most parts of Africa have good natural vegetation of various species ranging from equatorial forests to savannah woodlands.

Apiculture in general contributes to environmental conservation, improvement of household food security, increased incomes, and sustainable agriculture. Bees are known to improve agricultural crop yields through their pollination of fruit trees and crops: in Africa crop yields can be increased by more than a third through pollination by bee. Bees are also regarded as important contributors to unquantifiable economic benefits from increased crop yields, maintenance and enhancement of ecosystem biodiversity than that value of the physical outputs (Bradbear et al 2006, Morse and Calderone 2000; Roubik 1995,2000 ;)

There is an opportunity to utilize cultural knowledge of beekeeping to expand and improve current development of apiculture in Africa. In order to achieve this effectively and efficiently, however, factors affecting success in beekeeping development must be addressed.

World honey production

The demand for honey and other hive products in the world market is high compared to the current production (Wilson, 2006). The world top ten honey producing countries in2014 were China, USA,Turkey, Ukraine, Mexico,Russia,India, Argentina, Ethiopia and Spain (Listtoptens.com/top-10-honey-producing-countries-2014). In March, 2015, the top ten honey producing countries were as shown in the (table1).

African production of main hive products

Honey and beeswax are the main hive products from beekeeping in most African countries.Honey and beeswax production in Africa is estimated to be less than 10 and25 per cent of the potential respectively (Wilson, 2006).

Reliable statistics on various aspects of beekeeping in most African countries are difficult to come by. Information on current number of beekeepers, number and type of hives used, number of bee colonies, actual annual production per hive, quantity and quality of products processed and marketed is not readily available.

Ethiopia leads in honey and beeswax producing in Africa with a honey production estimated at 50,000metric tons per annum and is said to represent only 10.7% of the country's production potential.

Production systems

The actual production is mainly carried at the rural household as part –time income generating activity and food. The use of both traditional and improves hives is still being practiced, although improved hives with removable top bars or frames have been promoted intermittently in some countries by government extension services. Improved production has been promoted mainly through externally funded development projects; there has generally been little continuity after cessation of project funding in some countries. However the effective use of frame and top bar hives is limited. Much of the honey and beeswax is therefore produced traditionally from fixed combs leading to low productivity and low quality. There is little support in terms of infrastructure, technical and financial services for promoting beekeeping as an economic activity.

The promotion and development of apiculture as a commercial enterprise and the increases in the output of hive products in Africa would require that the agricultural sector policies of most African governments address the uniqueness of the bee industry. Institutional support and effective use of improved methods of production would contribute to enhanced household food security; increased incomes, and environmental conservation. Some types of the hives used in Africa are shown (figure1, figure 2and figure3).

Policy framework

In most African countries, the operations of the apiculture industry are based on various legal statutes under different administrative mandates. These include Public Health Act, Standards Act, Wild life Act among others. The existing legislation does not adequately address the unique needs of beekeeping industry. For example, indiscriminate use of pesticides in crop and animal husbandry kill bees and contaminate hive products. Promotion of apiculture and increases in the output of hive products would require that most African governments put in place policies and regulatory framework that enhance apiculture development. The policies should seek to improve the household food security raise incomes and stabilizing cash flows through improving the productivity of various agricultural activities.

Opportunities

There are many opportunities for development of Apiculture in African. These are to:

- Increase production and use of appropriate beekeeping equipment;
- Provide quality beekeeping equipment to customers

Table 1: Top 10 Honey Producing Countries

Rank	Area	Production (Int $1000)	Production (MT)
1	China, main land	1,094,110	436,000
2	Turkey	221,236	88,162
3	Argentina	189,461	75,500
4	Ukraine	175,996	70,134
5	United States of America	167,428	66,720
6	Russian Federation	162,856	64,898
7	India	153,075	61,000
8	Mexico	147,057	58,602
9	Iran (Islamic Republic of)	120,452	48,000
10	Ethiopia	115,195	45,905

Source: World maps(2015).

Figure 1. A log hive in croton trees at National Beekeeping Institute, Kenya

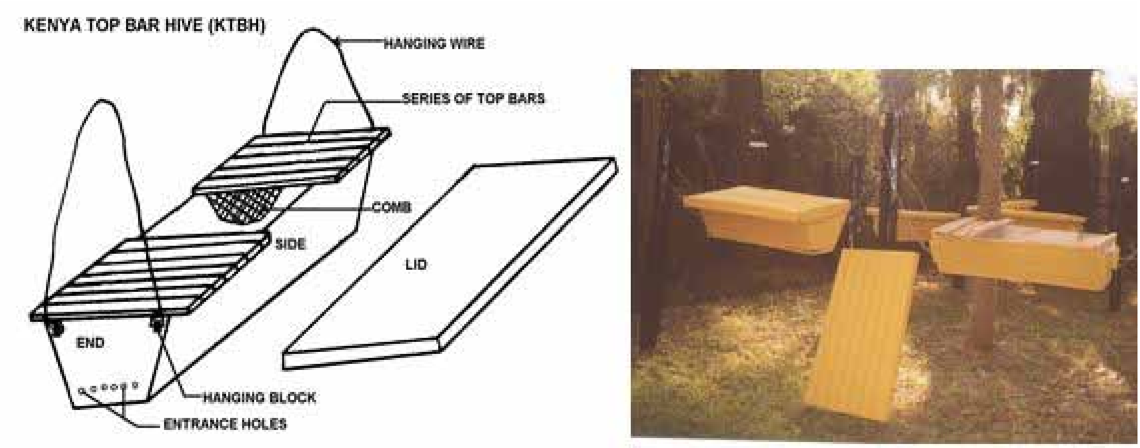

Figure 2: Kenya Top Bar Hives, in Nairobi, Kenya

Figure 3: Langstroth/Frame hive, at National Beekeeping Institute, Kenya

- Establish bee research and demonstration centers;
- Carry out research on common pests and diseases, bee behavior, breeding for docility and productivity and floral calendar, value addition of hive products and appropriate technologies
- Produce queen bees and package bees for sale to beekeepers and researchers
- Provide capacity building through tailor made courses on appropriate beekeeping to extension workers, farmers, equipment manufacturers, processors and packers of hive products.
- Provide extension services
- Intensify production of hive products as there is high demand in domestic and export markets.
- Provide transport services to stakeholders along the value chain
- Provide honey bee colonies on rental basis for pollinating services at a fee
- Add value to hive products
- Provide and market hive products to consumers
- Make credit available and affordable to beekeepers and other players in the industry
- Provide consultancy services in various aspects of beekeeping
- Establish eco-tourism activities such as observation hives, packed comb honey, bee caves and foraging bees are some of the attractions that should be promoted
- Exploit the large natural vegetation
- Produce organic honey

The increasing demand for "organic" products could provide some opportunities for honey from Africa, which is largely free of harmful residues. Much of Africa has an extremely diverse vegetation resource that flowers over different seasons and provides an almost ideal environment for bees. Many plant species of the tropical vegetations are important nectar source for bees. In addition, climatic conditions in certain tropical regions do allow honey production nearly all through the year particularly where seasonal changes have wet and dry periods. The special characteristics of certain natural tropical vegetations or tropical crops such as citrus, coffee offer good nectar supply therefore provide for the development of niche markets for specialty honeys. Honey production in African may be enhanced because beekeeping in some temperate climate countries seems to decline.

Constraints

Increases in the output of hive products in Africa are restrained by a number of factors which include technical, financial and administrative constraints. In particular improvement of apiculture in African may be enhanced by addressing the following limitations:

- Inadequate and inaccessible improved beekeeping equipment
- Environmental degradation(destruction of forests,slow growing indigenous trees) for agriculture, human settlement, charcoal burning and use in making log or bark hives;
- Ineffective control of diseases and pests mechanisms for detecting and controlling especially the spread of Varroa destructor mite and Waxmonth are inadequate.
- Indiscriminate use of unregulated pesticides and insecticides has resulted in the killing of bees and other commercial insects. While not of major concern at the present time the increase in and unregulated use of pesticides on crops may affect honey trade due to uncertainty about the quality status

of honey.

- High aggressiveness of most strains of local bees;
- Bee phobia
- Inadequate technically skilled and committed beekeeping extension personnel
- Poor quality extension services.
- Insufficient research on various aspects of apiculture
- Lack of proper or poor training of farmers ,equipment manufacturers and hive products processors
- Lack of access to, or non- availability of affordable credit facilities for producers, processors, traders and equipment manufacturers.
- Poor honey processing and packaging affecting the potential increase of honey consumption in the formal market
- Unavailability of appropriate processing equipment and diversity of packaging materials
- Lack of proper coordination among the institutional bodies concerned with the various aspects of beekeeping,
- Lack of market research and market network development
- Low adoption of improved technologies
- Poor coordination and lack of linkages between producers and buyers as well as other service providers
- Poor market access,
- Poor infrastructure(roads, transport, clean water, energy and communication)
- Lack of specific policy and regulatory framework for the development and protection of the industry.
- Lack of strong organizations representing the interests of beekeepers
- Inadequate product processing and collecting centres
- Unpredictable climatic changes, most nectar producing vegetation depend on rain and prolonged dry periods lead to high temperatures and bee migration.
- Inadequate quality assurance standards, monitoring and certification of hive products.
- Stringent honey quality standards in importing countries. For example, European Union (EU) now requires that imported honey be certified free from chemical, antibiotic and other residues and that it has a full nutritional analysis. Also “traceability” down to the hive from which the honey has come may soon be a requirement.

Strategies to Improve Apiculture in Africa

The success of apiculture in Africa lies on the ability of the industry to organize and direct the available resources to take action and move the industry to new levels of competiveness and profitability. These resources include: natural, human, physical, social and financial assets. Beekeeping depends upon natural resources such as bees, flowering plants and water which should be adequate and sustainable. Sustainable beekeeping in Africa can be achieved through conservation of bee plants in different areas and developing their seasonal floral calendar.

Most African communities have indigenous knowledge and skills concerning beekeeping, production, processing and trading of hive products that should be taped and enhanced. Successful beekeeping enterprise requires production and processing equipment, infrastructure such as transport, clean water, energy roads, communication systems and buildings. However, lack or inadequate of these resources pose major challenges for the industry. Social networks, producer and marketing associations provide opportunities for beekeepers to advance their skills, lobby for protection of bees, and organize collective processing and marketing of hive products. Access to wider networks would assist beekeepers find opportunities for training, markets and new research findings that can be used to improve their understanding of the industry. Although significant financial resources are not essential to initiate beekeeping activities at subsistence level, they are essential for development of beekeeping enterprises. Successful beekeeping and marketing of hive products depend on adequate supplies of equipment for production, storage, processing and packaging. Availability of affordable credit facility is therefore necessary for beekeepers and beekeeping associations to buy equipment, run collection centres and for traders to buy hive products.

Since apiculture in Africa is at different levels of development, most beekeepers may need, to start with improving on the existing technology and progress gradually to highly sophisticated and advanced technology in the later stages. The use of a transitional hive of the top bar type might be a more appropriate in the early stage intervention. These hives have many of the advantages of movable frame hives but have lower capital cost and minimal management requirements.

To improve the productivity of beekeeping industry in Africa, there is therefore need for effective and efficient organization, funding, research and development, extension progrmme that are market focused.

Suggested strategies in support of improvement of apiculture in Africa

Establish or strengthen national office for Apiculture development

The lead institution charged with apiculture should ensure effective execution and operationalization of its mandate. The operational management team consisting of technically trained committed and with practical beekeeping experience as well as entrepreneurship skills are responsible for the coordination of apiculture activities. The lead institution should have offices at national, regional and county levels in all beekeeping areas.

Carry out a review on the present status of the sub-sector

Beekeeping like other agriculture-based industries has particular strengths and weaknesses that impact the potential growth and development opportunities available to the industry. Before recommending any action plan for improving beekeeping, it is important to conduct an overview of the sub sector for baseline information on the structure of the enterprise, strengths, weaknesses, opportunities and threats (SWOT) so that an appropriate strategy can be developed for its threats and weaknesses, to better manage the risks it faces in the future.

Information on the main players, potential areas, floral patterns, availability of honeybee colonies, capacities and needs of the main institution's profile, existing and access to technologies, competencies ,access to market and commodity prices, current policies, legal and institutional frame work is important.

Carry out value chain analysis (Stakeholder analysis)

The Value Chain Analysis (VCA) should be carried out to inform about the current structure of the beekeeping sub-sector in a given area. It therefore enables one to assess the existing vertical and horizontal linkages within the sub-sector as well as functions and roles of actors from service providers to the final consumers. The analysis will also assist in identifying the opportunities that can benefit the value chain actors, best practices and experiences related to the honey value chain at national, regional and international level which can help in developing appropriate products for the beekeeping sub-sector. Through the stakeholder analysis one is able to identify the existing and missing linkages within the value chain.

Build consensus among major stakeholders on the industry growth strategy and policy recommendations based on the study.

There is need to educate the public and policy makers on the economic contribution made to the country by the honey bees. Create awareness on the: mandate, vision, and mission of the beekeeping office so that the stakeholders can own the process of improving beekeeping industry. The improved productivity of beekeeping industry in Africa will depend on effective and efficient organization, funding, research and development and extension programs that are both stakeholder and market focused.

Develop new or strengthen appropriate legal regulatory framework

The existing legislation, policy and regulatory framework in most African countries do not adequately address the unique needs of beekeeping. It is therefore important to develop new or review the existing legal statutes that have a bearing on beekeeping to make them more responsive to the current beekeeping development activities hence creating an enabling environment.

Establish/Strengthen Institutions providing apiculture training, extension services, quality assurance and certification, financing, and marketing.

Identify training institutions that will provide knowledge and skills in beekeeping and develop activities for collaboration with other relevant institutions. These institutions should have adequate personnel, set quality standards, develop and promote appropriate technologies. Also institutions that ensure quality assurance and certification, provide financial credit and marketing services be identified and strengthened.

Capacity build stakeholders along the value chain on appropriate beekeeping technologies and management practices.

Beekeeping requires specialized training. Therefore training of human resource at all levels of the value chain is important so that the players are equipped with the relevant skill required to transform the beekeeping industry from subsistence into an agribusiness activity. Short term and long term strategy for training in beekeeping and related areas should be formulated and implemented.

The short term strategy should aim at upscaling the technical competence of the existing extension staff and beekeepers as well as creating awareness among stakeholders in agricultural sector and policy makers. The existing beekeepers and artisans should be given first priority in the development programme. The initial training of the group on beekeepers should aim at increasing technical competence for bee colony management, multiplication of colonies and diversification of hive products.

Short courses for stakeholders such as officers in financial institutions, training institutions and other Government departments are important in order for them to understand and appreciate beekeeping as an enterprise.

The long term strategy should aim at creating extension workers, bee-scientists, technicians, researchers and marketing experts. Well trained and experienced personnel will be better placed to take up the responsibilities and changes facing the development of beekeeping industry.

Provision of both technical and support services to specific target groups in the apiculture sector will cause change and promote desired practices at different levels of the industry.

- Train extension personnel in modern beekeeping and technology transfer;
- Train farmers in modern beekeeping, honey processing and marketing;
- Train local small scale equipment manufacturers to construct improved yet simple equipment and make them available for purchase by prospective buyers.
- Train processors, packers and traders in quality control, packaging, labeling and branding and value addition

Enhance entrepreneurship education and skills development.

Apiculture as an enterprise requires some basic business knowledge, business planning, financial literacy, organizational and managerial skills as well as networking. Through entrepreneurship, beekeepers and other stakeholders can increase their revenues and enrich their social capital.

The innovative entrepreneurial behavior will promote improved production conditions in order to maximize the production, together with the reduction of costs. It also influences sustainable development as it entails a better access to certain markets and opportunities. Entrepreneurship as a strategy for the improvement of sustainability should combine the interests of beekeepers and of the environment. Therefore, entrepreneurship in the beekeeping industry is considered to be a factor that influences sustainable development.

Facilitate technology exchange and innovation

Promotion of technology exchange will equip the entrepreneurs with the necessary innovations to improve the efficiency and productivity of their enterprises. Developed innovations will be used to develop new or improve the existing products, services to meet the changing market demand and profitability.

Promote research and development

Research in areas that contribute to higher production such as genetic improvement of more docile bees and superior queens, appropriate equipment, bee plants and floral calendar, value addition and colony management and product development and utilization should be emphasized. In addition, improved conservation of indigenous bees, bee forage and natural bee habitats are other important research areas. Research findings be accessible and be disseminated to relevant stakeholders in the industry.

Identify areas with high population of honey bees and honey bee plants (bee reserves).

These areas should be mapped out and protected to preserve the bees. Establish permanent vegetative cover with bee plants to provide forage for the honey bees. Ensure the area is secure from any damage and vandalism.

Conserve, protect and maintain the existing honey bee colonies

Indiscriminate use of pesticides and insecticides has resulted in the killing of bees and other commercial insects. Destruction of bees would have negative impact not only in honey production but also threatens the future of crop yields and life of plant that depend on bee pollination. It is necessary therefore to regulate use of pesticides and promote measures that ensure agro chemicals used do not harm bees.

Conservation of natural resources such as water and vegetation will ensure the existence of bees. The protection of natural and established bee habitats ensure that indigenous bee species are safe. Use of existing bee colonies should be encouraged because they are better adapted to specific local conditions (Phadke 2008). Imported bees, bee products and bee equipment should be regulated. Importation of any used bee equipment should be highly discouraged at all cost as they are likely to bring in disease and pests. Regular bee disease and pest surveillance is important in detecting any threat at an early stage. There should be in place capacity for detecting diseases, pests and their control. Use of agro chemicals be regulated to ensure the existence of honey bees.

Migratory beekeeping; enables not only colony survival but colony multiplication, honey production and pollination of vegetation since different honey bee plant species flower at different times depending on climatic condition of a particular locality.

Maintain strong bee colonies by ensuring that bees are fed during dearth, colonies have many brood combs before the honey flow and simulative feeding is carried out before the honey flow so that the queen start laying eggs and increase in the number of brood hence large number of workers to collect stores. An old queen may be replaced with a young one and also weak colonies may be combined as a way of strengthening the colonies.

Establish demonstration apiaries

Set up demonstration apiaries in each of the beekeeping potential areas as a training facility, with enough training tools. Hives must be stocked either through wild swarms or deliberate introduction of bee colonies into the hives from the existing colonies, package bees, nucs and division of strong colonies.

Improve production techniques

Increased productivity of the industry may be achieved through the improved techniques. The existing production techniques need to be diversified and improved to ensure proper beekeeping husbandry so as to reach optimal production capacity of any give the area.

Retrain extension officers, researchers, farmers on improved beekeeping production technologies and promote development and fabrication of equipment to acceptable standards using locally available materials. Develop and enforce standards for production equipment.

Promote effective and efficient participatory extension service delivery

Beekeeping extension services are not reaching the intended end users due to lack or inadequate technical and skilled personnel, extension materials, financial support and transport.

An effective and focused extension service involves a partnership between beekeepers, public institutions, private sector and other stakeholders to facilitate the transfer of information necessary to create and maintain a viable and growing apiculture sector.

Extension and training activities should be carried out by public institution and by Non-Governmental Organizations (NGO) in the initial stages of development. As farmers become more proficient and as producer and marketing groups develop, private advisory services provided on a payment basis for services rendered may take over from the public and charitable service providers.

Establish an apex organization

A strong association leads to a strong and proactive apiculture industry. The successful development of apiculture in Africa will depend on the sector's ability to organize and direct the available resources to take action and move to new levels of competitiveness and profitability. Formation of an apex organization will assist in the coordination of stakeholders at various levels namely regional and country. Strong Association is the voice of the sector presenting a unified position on important issues affecting the sector such as policy, regulatory, information and promotion of the apiculture sector. The Association provides opportunities where members can learn new skills, network with other stakeholders and build new business and mentor relationships.

Invest in beekeeping Industry

Resource are required are required for the development of apiculture in Africa. Sustainable development of beekeeping will depend on both public and private sector financing.There is need to sensitize the financial institutions, investors on the business potential and encourage financial institutions to advance affordable credit to in the sector.Conduct local, regional and international investment campaignsto attract potential investor.

Improve infrastructure

Improved infrastructure such as transport, clean water, energy, roads, communication systems and buildings will facilitate delivery of goods and services. It therefore important that these infrastructures are improved to enable apiculture industry develop in Africa.

Develop National Programme for promoting beekeeping,

Prepare an activity plan for the national information system (information network) and floral Calendar. Conduct an awareness and information campaigns for promoting beekeeping especially use of improved practices. Develop a strategy to ensure an adequate and cost-effective supply of hives and beekeeping accessories needed to meet demand generated by the information and market campaigns. Advertise to increase demand for honey and honey products. Develop niche market and brands.

Improve Market access of hive products

Market access promotes production. The demand for honey and other hive products in the world market is high compared to the current production. The beekeeping industry in many African countries is not well organized therefore the production and marketing of hive products are difficult to quantify accurately.

Most African hive products are used within the household or sold in local markets, to neighbors or by the road side. Honey, as the major product of beekeeping, is most commonly consumed within the household and little amounts get into the formal market chain. There are good marketing opportunities for honey and other hive products both in the local and external markets. Value addition to hive products through proper processing, packaging and use of a range of different presentations, is likely to cause arise in demand from niche markets. There are also substantial opportunities on the world market for African honey since most of it could be considered as "organic".

Africa's beeswax is much in demand for use in cosmetics, pharmaceutical, textile and in food technology, in varnishes and polishes. Wax can also be used for making comb foundations, and candles. Other marketable hive products which need to be exploited include propolis, royal jelly, pollen, venom and queens as well as package bees.

However because of poor market access, poor infrastructure and inadequate hive products of sufficient quality and quantity and lack of strong organizations representing the interests of beekeepers, market opportunities are not fully utilized.

Further development of apiculture in Africa will involve market development, product specification for niche marketing and improved linkages between beekeepers, groups, cooperatives, Community Based Organizations(CBOs),Non-Government Organizations(NGOs), traders, processors, packers, and other actors in the value chain. Establishment of collecting centres will assist in increasing volumes of bee products and will make it cost effective for buyers to collect products from specified points. Individual beekeepers working in remote rural areas where most of African beekeeping is done find it difficulty accessing adequate equipment for harvesting and processing good quality products, and transporting products to places with access to traders.

Hive products sold locally generate small and reliable income. External markets are normally larger and require more volumes of products

Marketing Strategies

A sustainable market requires the involvement of major players in the industry. These are, equipment suppliers, bees, beekeepers, traders, transporters, financial institutions, individual or groups, processors and packers, shop keepers and customers. To access markets, the market chain must be strong, at any point where the chain is weak; the whole market system is affected. Hence beekeepers need to have a link to the market chain. Informal traders are unreliable and do not motivate beekeepers. There is therefore necessity to strengthen links in the market chain.

Establish centres for enterprise operations

Collecting and processing centres do assist in increasing volume of bee products. They also provide venues for training of beekeepers, processors and traders on handling and processing of hive products and their by-products techniques, quality and safety controls, packaging and labeling, classifying products to the quality and market opportunities.

Establish Quality control and assurance.

Put in place a functional quality assurance system at all levels of the value chain both in terms of products and services. Institutionalized regulatory mechanisms are necessary for strengthening product traceability/ monitoring and inspection within the industry.

Promote value addition of hive products

Value addition of bee products should carried out at farm, processing and packaging levels.

Improve packaging material

Packaging materials should be of food quality, lightweight and low cost preferably sees through so that customers can see the product. Products may be packed in small amounts ranging from 25 gram to 1Kgforvarious customers.

Labeling and branding

Honey sells depending on its looks and information given on the label. An attractive label will give a new customer confidence to buy the product and will help a satisfied customer to find the same product. Geographical origin of the honey gives the customer confidence in the product. The label should contain at least the following- content, source that is type of flower, country, name and address of beekeeper, weight of product in the container, date of packaging, and give some information on granulation because many customers believe that crystallization is due to added table sugar.

Link beekeepers to the market chain

Strong linkages between beekeepers, processors, packers, traders and consumers as well as with other service providers in the market chain are important for improved performance of the industry. Beekeepers organizations should be encouraged to buy hive products from members and sell to various markets

Improve management and dissemination on market information

Improved collection, analysis and dissemination of information require a database for the apiculture value chain. Such information collected should be refined before being disseminated to targeted groups. There are various promotion campaigns depending on the target group that can promote linkages between the producers and the markets. These include Electronic media, in the form of radio, Website, Direct mail, and Video. Print media such as newspapers and magazine, outdoor advertising -billboards, on public transport, trade fairs, forums and seminars

Enhance the capacity of marketing of hive products

There is plenty of scope for beekeepers to sell honey and beeswax locally, but the type product and the price must reflect the local demand. Beekeepers musttherefore undertake market survey to determine volumes of bee products actually sold in the formal market, value added products in the retail market, domestic market share sizes of existing packers, importers, retail market outlets selling value added products, consumer size in urban regions, export of products if any as well as other relevant information related to the market.

Strong marketing groups are advantageous in that they have greater cash resource and better access to credit. They may also be able to buy large quantities of processing and packaging materials at a more favourable price. They are at same time in a better position to negotiate sales contracts and distribution channels. Entrepreneurs should be encouraged to market and develop local resources that are most likely to benefit the beekeeper in the long term. Local market has lower transaction costs, less stringent quality criteria and small volumes are acceptable hence profitable while export market is large, high prices but the stringent quality criteria is an inhibiting factor . Improved transport and communication infrastructure will greatly enhance provision of goods and services.

Promote value addition of hive products and bi-products

Adding value to hive products play an important role in the enterprise development and employment creation. Currently the main products from beekeeping are honey and beeswax while other products such as bee venom, royal jelly, brood, pollen and propolis have not yet been exploited. Some of the value added hive products are used in pharmaceutical and cosmetics industries, food preservation, brewing and confectionery, candles, textile (batik), polishes and paper. However, adequate knowledge and skills as well as relevant equipment are necessary to be able to fully exploit the huge potential that is available.

Establish marketing infrastructure

A set of business rules and obligations, communication flows are required to ensure free flow of the products and their efficient marketing. Infrastructure such as transport, clean water, energy roads, communication systems and buildings are necessary and therefore should be improved.

Improve access to Finance

Access to an affordable credit is a major factor for many who would like to beekeeping business. Financial instructions should be sensitized to consider beekeeping as a viable enterprise and therefore provide services such as deposits, security and credit to individuals and businesses to buy goods or expand business operations.

Monitoring and evaluation

Apiculture like any other investment would require a monitoring and evaluation mechanism to collect and analyze information based on the targets set and activities planned. It will enable players in the sector to compare the inputs into the work against the expected output. Also it will measure the extent to which set out objectives have been achieved and how they were accomplished.

Conclusions

- African has the potential for increased production of honey and other hive products.
- Output of hive products can be increased by a gradual shift from traditional production to intermediate technology top bar hives and advanced technology.
- Apiculture is in the rural areas, increases household incomes, adds to food security and is beneficial to the environment.
- Africa has an extremely diverse vegetation resource that flowers over different seasons and provides an almost ideal environment for bees
- There are substantial market opportunities for honey, beeswax and other hive products and financial returns can be increased through various methods of adding value and marketing of other products.

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A REVIEW OF AFRICAN HONEYBEES, BEHAVIOUR AND POTENTIAL FOR INCREASED BEEKEEPING PRODUCTION AND FOOD SECURITY:

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Abstract

African honeybees have a higher tendency to swarm, abscond and migrate than their counterparts in Europe and elsewhere, thus making it more difficult to maintain African honeybee colonies over years. They are also labeled as overly defensive, with a high propensity to sting, making their management a challenge. An extensive literature search on honeybee behaviour and management practices was conducted to synthesize available information on African honeybee species and races and behaviour. The aim was to assess potential for options to increase beekeeping production and food security. The review revealed that there are at least twelve different honeybee races in Africa with varied behaviour, and options that can be utilized to proliferate hive colonization, develop more active and productive colonies. A better understanding of African honeybee races and their behaviour can be harnessed for more efficient pollination services critical to improving food security on the African continent, and for increased production of honey and other beehive products.

Key-words: African honeybees, bee behaviour and potential.

UN EXAMEN DU COMPORTEMENT DES ABEILLES MELLIFERES AFRICAINES ET DE LA POSSIBILITE D'AUGMENTER LA PRODUCTION APICOLE ET LA SECURITE ALIMENTAIRE

Résumé

Les abeilles d'Afrique ont une forte tendance à l'essaimage, la fuite et la migration par rapport aux abeilles d'Europe et d'ailleurs, ce qui rend plus difficile le maintien de leurs colonies au fil des années. Les abeilles africaines sont également qualifiées de très défensives, avec une forte propension à la piqure, ce qui rend leur gestion difficile. Une vaste recherche documentaire sur le comportement et les pratiques de gestion des abeilles a été réalisée dans le but de synthétiser les informations disponibles sur les espèces d'abeilles africaines, leurs races et comportements. L'objectif était d'évaluer les options envisageables pour augmenter la production apicole et la sécurité alimentaire. L'étude a révélé l'existence d'au moins douze races différentes d'abeilles en Afrique avec des comportements variés, et d'options susceptibles d'être utilisées pour accroître la colonisation des ruches et développer des colonies plus actives et productives. Une meilleure compréhension des races d'abeilles africaines et de leur comportement peut être exploitée pour mettre en place des services de pollinisation plus efficaces essentiels à l'amélioration de la sécurité alimentaire sur le continent africain, et pour accroître la production de miel et d'autres produits de la ruche.

Mots-clés : abeilles mellifères d'Afrique, comportement et potentiel des abeilles

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Introduction

Africa is home to a diversity of honeybees and forage plants, presenting a huge potential for honey production and pollination services (The Uganda National Apiculture Development Organisation TUNADO, 2014; ApiExpo Africa, 2012; Japan Association for international Collaboration of Agriculture and Forestry JAICAF, 2009; Kebede and Lemma, 2007; Hussein, 2001). Beekeeping is one of the oldest farming practices in Africa, and is suited to a wide range of the ecosystems across tropical Africa (Kebede and Lemma, 2007). However, the beekeeping practices have remained predominantly traditional, characterized by very low production, compounded by poor harvesting, processing and storage techniques, and poor quality honey (Kebede and Lemma, 2007). In the recent past, improved beehive technologies have been introduced into the continent with the accompanying training packages; but these efforts have not yielded much fruit (Butele, 2012; JAICAF, 2009). Active honey and beeswax producing African countries such as Ethiopia, Tanzania, Kenya, and Uganda are still performing well below their production potentials (TUNADO, 2014; JAICAF, 2009; Kebede and Lemma, 2007). Rampant honeybee absconding and migration away from hives including from improved beehives present a pervading challenge for beekeepers around the continent (Butele, 2012; Kebede and Lemma, 2007; Fischer, 1993; McNally and Scheneider, 1992). Indeed, failure to attract or trap and maintain a honeybee colony for a perennial supply of honey is one of the greatest factors contributing to the low honey production on the continent.

For the average African beekeeper there are limited options to manage such undesirable honeybee behaviour associated with African honeybees. There is a paucity of information on whether the honeybees which exist in Africa could be of different species or races (Fischer, 1993). This has served to limit information on the species and race specific bahaviour constraining options for improvement. This study reviewed the available literature and information on different bee species and races around the world, their behaviour related beekeeping systems and management practices with a focus on African honeybees. The study aimed to proffer options for better behaviour manipulation and management of the African honeybee to improve honeybee production and increase the contribution of beekeeping to food security.

Materials and methods:

An extensive literature search on honeybee classification and taxonomy; honeybee morphology and physiology; honeybee biology, behaviour and ecology; and different beekeeping systems and management practices was conducted. Based on information from over forty-five publications, the review on honeybee biodiversity, behaviour and management was published in 2012. This study built on the review of honey bee biodiversity, behaviour and management (Butele, 2012). The information on African honeybee races, their behaviour and management practices, was isolated, updated with additional information from sixteen other references, and analyzed.

Results

There are currently 9 known species of honeybees in the world (Butele, 2012), namely Apis mellifera, A. dorsata, A. laboriosa, A. florae, A. andreniformis, A. cerana, A. nigrocinta, A. koschevnikovi and A. nuluensis. The Western honey bee, Apis mellifera is found in both Europe and Africa, while the other 8 species (Apis dorsata, A. laboriosa, A. florae, A. andreniformis, A. cerana, A. nigrocinta, A. koschevnikovi and A. nuluensis) are all found in Asian countries. Some of the Asian honeybees Apis dorsata, A. laboriosa, A. florae, and A. andreniformis are open-nesting, and still being exploited from mountain cliffs and tree branches in the wild. Others, Apis cerana, A. koschevnikovi, A. nigrocinta and A. nuluensis are cavity-nesting and can be kept in hives.

This review focused on Apis mellifera species to which African honeybees belong. A.

mellifera has 28 sub-species or races; 16 are found in Europe and elsewhere, 12 in Africa; all cavity-nesting, and being kept in hives. The 16 races found in Europe and elsewhere are Apis mellifera mellifera, A. m. sicula, A. m. ligustica, A. m. carnica, A. m. macedonica, A. m. cecropia, A. m. anatoliaca, A. m. adamii, A. m. caucasica, A. m. iberica, A. m. cypria, A. m. syriaca, A. m. meda, A. m. armeniaca, A. m. lihzeni and A. m. ruttneri. The behavioural and morphological description and geographical distribution of the major A. mellifera honeybee races found outside Africa is summarized in Table 1. The 12 African Apis mellifera honeybee races are Apis mellifera scutellata, A. m. adansonii, A. m. litorea, A. m. monticola, A. m. lamarckii, A. m. capensis, A. m. unicolor, A. m. yemenitica, A. m. sahariensis, A. m. intermissa, A. m. abyssinica and A. m. sudanesis. The behavioural and morphological description and geographical distribution of the major African Apis mellifera honeybee races is summarized in Table 2.

Honeybees generally exhibit 2 categories of behaviour and activities; those displayed under normal conditions and the others displayed under conditions of stress or disturbance. Honeybee behaviour and activities displayed under normal conditions include; egg laying by the queen bee; age-specific hive cleaning, nursing of larvae and foraging by worker bees. On the other hand, the behaviour and activities displayed under conditions of stress or disturbance include swarming, absconding, migration and stinging. In both cases, the honeybees are responding to factors or stimuli in their immediate internal and external environments, which are detected by their sensory cells. The bees react to the stimuli in a particular (stereo-typed) way, because their nervous systems are "hard-wired" or "programmed" genetically to react in this manner, hence their behaviour (Butele, 2012).

All honeybees can swarm, abscond, migrate and sting, but the typical European cavity-nesting honeybee, Apis mellifera mellifera is known for being exceptionally gentle, and thus has been so highly researched and developed that it is now a domesticated honeybee race. Unlike the European honeybee, all the African cousins, although cavity-nesting and being amendable to being kept in hives, are still wild, with many retaining a higher propensity to swarm, abscond and migrate than their European counterpart. They are also overly defensive, and are associated with a readiness to sting that has inculcated a fear of African honeybees (Butele, 2012; Waiswa, 1997).

As African honeybees are still wild and yet to be domesticated, they look for their own forage, water and provide their own defense mechanism from invasion (African Organic Agriculture Training Manual, 2011). What are viewed as undesirable behaviours including frequent swarming, absconding and migration, overly aggressive/defensive and stinging behaviour among African honeybees are responses that have evolved over time in the face of pests, diseases and predators such as man, baboons, chimpanzees, honey badger, wasps, ants, bee eater birds, wax moths (Butele, 2012; Hussein, 2001; Fischer, 1993) and harsh environmental conditions such as excessive sun heat and wind, and shortage of food and water (African Organic Agriculture Training Manual, 2011).

Traditional methods developed to manage the African honeybee behaviour overtime include siting of traditional hives high up in tree branches to exclude honeybee pests and predators on the ground. Tall trees along known honeybee swarming routes are targeted to increase chances of colonisation (JAICAF, 2009). Cultural taboos however keep certain segments of the population, especially women who are restricted from climbing trees like in some communities in Uganda, from benefitting from beekeeping (Waiswa, 1997). Women have developed the view that all bees are hostile, and that like with a bull, can only be handled by men. Such gender prohibitive and fear-driven methods and attitudes keep women and other potential beekeepers in the communities out of beekeeping (Carroll, 2006) across Africa as a whole

Table 1: A summary of the major Apis mellifera races outside Africa, their Behavioural and Morphological Description, and Geographical Distribution:

S/No.	Races of Apis mellifera	Behavioral and Morphological Description	Geographical Distribution
1.	*A. m. sicula Montagano*	Referred to as the Sicilian honey bee; dark in color. The hair of the thorax of workers and drones is yellowish. Quiet and gentle during manipulations. Brood rearing occurs almost year round. Resident queen and daughter queens can live together peacefully in the nest prior to departure of the swarm	Sicilia
2.	*A. m. ligustica Spinola*	Referred to as the Italian honey bee. Usually yellow but can be "leather-like". Most popular race world wide. Adapted to mild, wet winter of Mediterranean and therefore continues well into the English winter. Requires large winter structures because of large colony size. Queen starts laying heavily in late winter or early spring. It has low spring build up and requires heavy feeding. Hives easily get congested and so the bee swarms, but is very docile. It uses little propolis. It drifts to other hives and is a robber bee. Requires large to very large hive. An excellent forager and good comb builder.	Italy, Germany, US, Finland
3.	*A. m. carnica Pollmann*	Referred to as the Carniolan honey bee. It is steel grey in colour and slender. Very quiet and gentle (exceptional docility). It has rapid spring build up and is very prone to swarming. Requires medium sized hive. Has beneficial characteristics of longevity, hardiness, foraging ability and wintering ability. But not yet excellent honey producer and comb builder, and not a robber bee.	Switzerland, Upper Carniola, Carinthia, Styria, Yugoslavia, Rumania, Bulgaria, Hungary, Austria, Germany, England, US
4.	*A. m. macedonica Ruttner*	Referred to as the Macedonian honey bee. Very gentle with disinclination to swarm. Builds strong winter population	Macedonia, England
5.	*A. m. cecropia Kiesenwetter*	Referred to as the Greek honey bee. It has varied colours. An excellent forager. It builds strong colonies in terms of population. Good temperament with disinclination to swarm. Gentle and quiet during examination. It has tendency to propolise. Constructs brace-combs. Brood rearing is restricted to a particular month of the year	Greece

S/No.	Races of Apis mellifera	Behavioral and Morphological Description	Geographical Distribution
6.	*A. m. anatoliaca Maa*	Referred to as the central Anatolian honey bee. Small in size with a smudgy orange color which becomes brown on the posterior dorsal and ventral segments. Scutellum is generally dark orange in color. It has disposition to build excessive brace-combs. Uses propolis excessively. Highly susceptible to low temperatures	Anatolia, Turkey
7.	*A. m. adamii Ruttner*	Highly defensive bee when kept in cool climate. Winters without difficulty in a cold-temperate climate. It carries on brood rearing activity during winter	Island of Crete, England
8.	*A. m. caucasica Gorbachev*	Referred to as the gray Caucasian honey bee. It is dark to black in colour with brown spots on the first bands of the abdomen. The hairs of the worker are short and gray. The thoracic hairs of drones are black. Has the longest tongue of any economically important race of honey bees. Gentle and calm on the comb. Can forage at lower temperatures and less favorable climatic conditions. Does not drift to other hives and winters well. Uses large amounts of propolis. Constructs brace-combs	Central Caucasus high valleys, Turkey, Western Europe, US and Russia
9.	*A. m. iberica Goetze*	Referred to as the dark bee of the Iberian Peninsula. It is said to be the link between the African and the northwestern European groups. Appears very closely like the A. m. mellifera, the dark bees. Has quick defense reaction. Shows nervousness on comb. Makes heavy use of propolis. Has propensity to swarm.	Iberia, Argentina, Spain and Portugal
10.	*A. m. mellifera Linnaeus*	Dark brown, almost black with a shiny large, burly body. Some non-selected strains can be defensive. Very winter hardy and goes readily into winter with minimum preparation, minimum winter food stores due to small cluster. Easily stimulated to produce strong foraging colony in April. Starts foraging early in the morning and finishes late. Flies at 6oC, flies in winds and flies in light rain. Has smallish colonies. Does not swarm easily and suitable for the whole of UK. Requires small to medium hives. It is the ideal hobbyist bee-requiring just the basic management.	Ireland, US, France, British Islands, Scotland, Central Europe north of the Alps, Northeastern Europe, the plains of North Poland, USSR and Norway

Source: Butele (2012).

Table 2: A summary of the major African Apis mellifera honeybee races, their Behavioural and Morphological Description, and Geographical Distribution:

S/No.	Races of Apis mellifera	Behavioral and Morphological Description	Geographical Distribution
1.	*Apis mellifera scutellata Lepeletier*	Referred to as the African bee; the most defensive bee race, can attack a human or an animal with 500 to 5000 stings. A small bee with one or two yellow bands on the abdomen and a bright yellow scutellum on the thorax. Nests in cavities in trees, anthills, the ground and houses. A high rate of swarming, absconding and migration or nomadism. In comparison with other races, is a poor honey producer.	Kenya, Uganda, Tanzania, Ethiopia, South Africa and Central Africa
2.	*A. m. adansonii Latreille*	Referred to as the west coast bee: used to be called the common African honey bee. It is aggressive/defensive, prone to swarming, absconding and migrating	West African coast, from Senegal to Congo, including Mali, Benin, Guinea Bissau, Burkina Faso, Ivory Coast (Cote d'ivoire), Nigeria, Togo, Sierra Leone and Ghana
3.	*A. m. litorea Smith*	Similar to A. m. scutellata, except it is more prone to sting but perhaps less migratory due to living in a range with somewhat more predictable rain.	East coast of Africa, from Somalia to Mozambique including Kenya
4.	*A. m. monticola Smith*	Referred to as the black mountain bee is perennial and very gentle and a very good honey producer. It nests in the cool rain forests of mountains at high altitudes. It is able to maintain its racial integrity even though perennial hybridisation takes place with A. m. scutellata in a fluctuating transitory zone	Rain forests of the East African mountains (Ethiopia, Kenya and Tanzania)
5.	*A. m. lamarckii Cockerell*	Referred to as the Egyptian bee	Egypt, Somalia and Sudan
6.	*A. m. capensis Escholtz*	Referred to as the Cape bee. Demonstrates a high rate of female parthenogenesis of worker bees	Southwest coast of South Africa
7.	*A. m. unicolor Latreille*	The darkest honey bee; island honey bee race of Madagascar	Madagascar
8.	*A. m. yemenitica Ruttner*	Inhabitant of arid zones	Kenya, Sudan, Chad, Ethiopia, Eritrea, Somalia and areas of Africa opposite Yemen
9.	*A. m. sahariensis Baldensperger*	Inhabits the western Sahara zone. It is linked to the Central African honey bee, A. m. adansonii, and the western and northern European honey bees, A. m. iberica and A. m. mellifera	Western Sahara and Morocco

S/No.	Races of Apis mellifera	Behavioral and Morphological Description	Geographical Distribution
10.	*A. m. intermissa Buttel-Reepen*	Inhabits the northern Sahara zone; linked to the Central African honey bee, A. m. adansonii, and the western and northern European honey bees, A. m. iberica and A. m. mellifera	Morocco, Tunisia, Algeria and Libya

Source: Butele (2012)

However, Table 2 shows that some of the African honeybee races such as A. mellifera monticola (the black mountain bee) are perennial and very gentle. A report from Kamwenge, a mid-Western District of Uganda, shows families, with young children able to mix with honeybees from colonies kept in huts and toilets without any adverse effects (MAAIF, et al. 2013) In Adjumani District, in the hotter West Nile Region of Uganda, after receiving training, over 20 trainees, were able to handle bee colonies without being stung (MAAIF, 2014a). Some other races such as A. m. scutellata and A. m. adansonii are however more aggressive. Another option for management is to minimize strong smells that can cause honeybees to react readily such as perspiration, alcohol, soap and perfume. Bees also react to pheromones released when a member of the colony is quashed, as well as to rapid movements and noise. Swarming behaviour is a natural phenomenon to increase population.

A honeybee colony will abandon a hive in response to excessive disturbance from intruders or when there is lack of forage or water, or when there is excessive sun heat or wind. Selection of appropriate sites, provision of appropriate foraging areas and supplementation, filling empty hives with new bee colonies, minimizing disturbance from humans and animals, keeping the apiary clean, being gentle and calm during harvesting of honey and during other colony manipulation exercises, leaving some honey to maintain the colony after harvesting, placing hives so that entrance is away from the prevailing winds, and 1cm below the rear bottom board to avoid water entering the hive through the entrances and carrying out proper management of pests, diseases and other nuisances are important management practices that turn around the honeybee behaviours of swarming, absconding, migration and stinging (MAAIF, 2014b; Adgaba, 2012; African Organic Agriculture Training Manual, 2011; Carroll, 2006). However, many beekeepers are unaware of these methods.

Discussion

There are differences in behaviour among African honeybees; some races possess elements of desired traits that make their management easier: the majority of African honeybees however retain the defensive traits. Some African communities are able to recognise the various honeybee races in their localities (JAICAF, 2009), and have named them in their local languages and dialects based on their characteristic behaviour, colour, body size and honey production. Current blanket guidelines and methods being disseminated to African beekeepers do not factor in the variation in behaviour among African honey bee species and races, and therefore do not harness the opportunities in the diversity. Without understanding African honeybee taxonomy and behaviour, the trend of instability and unsustainability of bee colonies will compromise the goals of increased production of honey and other beehive products, and of increased food security and ecosystem benefits from pollination services. This information is particularly critical in the face of climate change that increases the magnitude and frequency of environmental stresses. Mechanisms are needed to institutionalize the process for capturing this kind of tacit information that is largely held within indigenous knowledge systems, for passing it on and training other beekeepers especially women to make beekeeping inclusive. There is also opportunity for harnessing greater understanding of the mechanisms that trigger swarming, absconding and migration among African honeybees for creating new colonies. There is an urgent need for indigenous expertise in African honeybee taxonomy, involving capacity building, extensive field surveys, honeybee identification and characterization, and selection and experiments to develop superior stocks of honeybees from within the races that are available on the continent. This calls for commitment from the concerned indigenous authorities, professional bodies, research institutions and universities, of course with collaboration with relevant international bodies Butele (2012). Continental institutions like the African Union Inter-African Bureau for Animal Resources-AU-IBAR Bee Health Project, Apiculture Platform (AAP), Api-Trade Africa, API, and International Center for Insect Physiology and Ecology (ICIPE) will be instrumental in creating opportunities for sharing information on honeybee taxonomy across the continent.

The differences among African honeybee races offer a highly diverse natural and untapped pool gene that holds advantage for African beekeepers.

Conclusion

Currently, work on African honeybee taxonomy is scanty and country-specific, and there has been no forum for sharing such information among African countries. It is highly likely that the 12 honeybee races are not the exhaustive list; there could be more honeybee species or races on the continent that are yet unknown.

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ANALYSIS OF FARM HOUSEHOLD TECHNICAL EFFICIENCY IN SMALL-SCALE BEEKEEPING ENTERPRISE IN MWINGI AND KITUI, KENYA

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Abstract

Beekeeping generates both socioeconomic and environmental benefits. It is crucial for agricultural well-being owing to the natural biological interdependence that comes from insects and is a useful means of strengthening livelihoods because it uses and creates a range of assets. Beekeeping has been promoted among marginalized rural farmers in Kenya as an alternative source of income generation that improves forest resource management and conserves biodiversity by governments and development agents, for instance, ICIPE's Commercial Insects Programme (CIP). The main objectives of this paper are to measure the technical efficiency levels of Kenyan small-scale beekeeping enterprises and to investigate the degree to which various factors influence efficiency levels in these farms. Data Envelopment Analysis (DEA) was applied to farm-level cross-sectional data collected in mid-2013 after the implementation of CIP activities. Our empirical results indicate that CIP participants and improved farmers (using using both traditional and modern hives) had the highest average levels of technical efficiencies. CIP participants had average technical efficiencies of 0.56, which is higher than non-participants, who achieved average technical efficiencies of 0.26. While improved farmers achieved the highest average levels of technical efficiencies (0.59), the overall level of technical efficiencies in the study area was low (0.35) indicating that a large room for improvement still exists. Participation in CIP had a significant influence on technical efficiency levels of the small-scale farmers. Other important factors influencing the technical efficiencies were found to include farmers' knowledge in honey harvesting and colony transfer, and access to land. Most importantly, gender, age, education and farmers' years of beekeeping experience had no statistically significant influence on the technical efficiencies of small-scale beekeepers in Kenya. The findings of this study can inform the design and the implementation of interventions targeting beekeeping, thereby strengthening beekeeping as an alternative source of income generation.

Keywords: Beekeeping, Beehive, Commercial Insects Programme, Technical Efficiency, Data Envelopment Analysis

ANALYSE DE L'EFFICIENCE TECHNIQUE DES MENAGES AGRICOLES DANS L'ENTREPRISE APICOLE ARTISANALE A MWINGI ET KITUI AU KENYA

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Résumé

L'apiculture génère à la fois des avantages socio-économiques et environnementaux. Elle est cruciale pour le bien-être agricole en raison de l'interdépendance biologique naturelle engendrée par les insectes, et constitue un moyen utile de renforcer les moyens de subsistance, car elle utilise et crée un éventail d'actifs. Les organismes gouvernementaux et les agences de développement, dont le Programme sur l'utilisation commerciale des insectes (CIP) de ICIPE, ont encouragé l'apiculture chez les agriculteurs

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ruraux marginalisés du Kenya comme une source alternative de production de revenus, à même d'améliorer la gestion des ressources forestières et de conserver la biodiversité. Les principaux objectifs de ce document sont de mesurer les niveaux d'efficacité technique des petites entreprises apicoles du Kenya et d'étudier le niveau d'influence exercé par les divers facteurs sur les niveaux d'efficacité dans ces exploitations. L'analyse par enveloppement des données (DEA : Data Envelopment Analysis) a été appliquée aux données transversales recueillies au niveau des exploitations au milieu de 2013, après la mise en œuvre des activités du programme CIP. La lecture de nos résultats empiriques fait ressortir que les participants au programme CIP et les apiculteurs utilisant des ruches (traditionnelles et modernes) améliorées ont enregistré les plus hauts niveaux moyens d'efficacité technique. Les participants au CIP ont montré une efficacité technique moyenne de 0,56, un niveau plus élevé par rapport aux non-participants qui ont atteint une efficacité technique moyenne de 0,26. Alors que les agriculteurs utilisant des méthodes améliorées ont atteint les plus hauts niveaux moyens d'efficacité technique (0.59), le niveau global d'efficacité technique dans la zone d'étude était faible (0,35), une indication que des améliorations sont encore nécessaires. La participation au CIP a eu une influence significative sur les niveaux d'efficacité technique des petits exploitants agricoles. L'on a constaté que les autres facteurs importants influant sur l'efficacité technique comprennent les connaissances des agriculteurs sur le processus de récolte du miel, le transfert des colonies et l'accès à la terre. Plus important encore, le sexe, l'âge, le niveau d'éducation et les années d'expérience des agriculteurs en apiculture n'ont pas eu d'influence statistiquement significative sur les rendements techniques des apiculteurs artisanaux du Kenya. Les résultats de cette étude peuvent éclairer la conception et la mise en œuvre des interventions ciblant l'apiculture, renforçant ainsi ce secteur comme source alternative de génération de revenus.

Mots-clés : apiculture, ruche, Programme « utilisation commerciale des insectes », efficience technique, analyse par enveloppement des données

Introduction

Traditional beekeeping has a long history in Kenya with a variety of tribal/ indigenous beekeeping practices (Nightingale and Crane, 1983). Beekeeping with modern hives is relatively new, having been introduced by the colonial government in the 1950s and further promoted by government and other development actors after independence (Government of Kenya, 2009). As such, two broad beekeeping systems, extensive and intensive systems are used in Kenya (Carroll and Kinsella, 2013). Extensive systems typify traditional beekeeping, using mostly traditional log hives, usually hung high in trees, scattered over large areas away from people and animals, and practiced in Arid and Semi-Arid Lands (ASALs) areas of Kenya. In intensive systems, bees are kept mostly in top bar or frame hives (modern hives) on small to medium scale farms in agriculturally productive parts of Kenya where the majority of people live (Carroll and Kinsella, 2013).

Like in many parts of Africa, the production of honey in Kenya mostly comes from traditional hives whose number is 1.1 million out of a total of 1.3 million hives in the country (Muli *et al.,* 2007). Kenya's honey production potential is estimated to be between 80 - 100,000 metric tons (Carroll and Kinsella, 2013; Muli *et al.,* 2007) with about 80 per cent of the honey being produced in ASALs (Muli *et al.,* 2007). However, the current honey production levels are estimated to be between 6 - 20 per cent of the potential of 100,000 tons per year (Carroll and Kinsella, 2013) because most of the highly productive areas are unexploited (Muli *et al.,* 2007). Carroll and Kinsella (2013) estimated the total honey produced in Kenya in 2007 at 6,839 tons, sold locally and mostly in unrefined form.

Beekeeping, as an enterprise is not devoid of challenges. Habitat loss or degradation is the major threat to bee diversity, whilst invasive species, emerging diseases, pesticide use, and climate change also have the potential to impact bee populations (Brown and Paxton, 2009; Crewe et al. 2009). In Kenya, the important beekeeping zones include West Pokot, Baringo, Mwingi, Tana, North Kinangop, Mbeere, Nandi Hills, Mida Creek, Kakamega and Taita and Kitui

(Kasina *et al.,* 2009; Muli *et al.,* 2007; Ngethe, 1984). Beekeepers in some of these areas are faced with several socio-ecological challenges, for instance, land-use conflict, lack of forage, bee behaviours, predators and pests, unfavourable climatic factors, and social-cultural issues (for instance, certain beliefs), vandalism, lack of modern hives, lack of honey and beeswax harvesting and processing equipment, lack of knowledge on appropriate honey harvesting stages, poor marketing and infrastructure and inadequate labour (Musimba *et al.,* 2001).

Beekeeping generates both socioeconomic and environmental benefits. It is crucial for agricultural well-being owing to the natural biological interdependence that comes from insects (pollination and production of seed), and is a useful means of strengthening livelihoods because it uses and creates a range of assets, for instance financial (cash, savings and access to credit or grants) and social (membership of groups and access to a wider society, market information and research findings) (Bradbear, 2004). In order to promote beekeeping and improve the livelihoods of marginalized rural farmers in Kenyan, improve forest resource management and conserve biodiversity, International Centre of Insect Physiology and Ecology (ICIPE) and the United Nations Development Programme (UNDP) under the CIP (Commercial Insects Programme), promoted beekeeping as an alternative source of income generation through the development of honeybee technologies in Mwingi District, in Kenya. CIP, in collaboration with other partners, for instance, the Ministry Livestock Production, the British High Commission and IFAD, constructed the Mwingi Honey Market Place in 2002. The Marketplaces were meant to create market outlets for the farmers in Mwingi help them attain self-sustainability in the marketing of beekeeping products and improve their household income, and consequently develop strong linkages with the forest conservation process. CIP's package also included training farmers in beekeeping. CIP participants who run the marketplaces received training on processing, packaging and branding of the products.

Having invested approximately US$395,000 into the project with tremendous success noted in terms of the increase in the volume of premium honey produced (ICIPE, 2013), it would be important to clearly outline the extent of productivity gains from CIP activities. The productivity gains could be emanating from increased access to capital and other inputs such as modern hives provided by CIP and increased access to markets, or from increased productivity as a results of the trainings provided by CIP. Outlining the extent of the productivity gains is critical not only in guiding policy formulation, but would also inform future strategic activities for up scaling. Consequently, to fill this knowledge gap, this paper analyses the technical efficiencies of the small-scale beekeeping farms in Mwingi. The general objective of this paper is to assess the technical efficiency gains from participation in CIP among small-scale beekeeping farm households in Eastern Kenya. As a control group, data gathered from small-scale beekeeping farmers, non-participant households in Kitui (an area of comparable ecological conditions) is also analyzed to draw useful inferences about the performance of beekeeping farms under CIP interventions.

Data Envelopment Analysis (DEA) was used to estimate technical efficiency (TE). Further, a general linear model (GLM), with TE estimates as a function of various attributes of the farms and farmers in the sample, was used to analyze the determinants of technical inefficiencies and hence draw strategic action and policy relevant inferences that could contribute to the improvement of the farmers' livelihoods. The paper is organized into three sections. Section 2 discusses the methodological framework used in the analysis. Section 3 presents the empirical results of the DEA analysis along with the results of the GLM model. The discussions, conclusions and implications from the study are presented in section 3.

Method

Analytical Framework

Technical efficiency relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs, or uses a minimum feasible amount of inputs to produce a given level of output (Farrell, 1957). The alternative approaches to measuring productive efficiency suggested in literature are grouped into parametric frontiers and non-parametric frontiers (i.e. techniques where the functional form of the efficient frontier is pre-defined or imposed a priori and those where no functional form is pre-established but one is calculated from the sample observations in an empirical way (Murillo-Zamorano, 2004)). Non-parametric frontiers do not impose a functional form on the production frontiers and do not make assumptions about the error term (Olatomide and Omowumi, 2010).

Parametric approaches, can be subdivided into deterministic ('full frontier' models that envelope all the observations, identifying the distance between the observed production and the maximum production, defined by the frontier and the available technology, as technical inefficiency) and stochastic (model both specification failures and uncontrollable factors independently of the technical inefficiency component by introducing a double-sided random error into the specification of the frontier model) models (Murillo-Zamorano, 2004).

The non-parametric approach has been traditionally assimilated into Data Envelopment Analysis (DEA); a mathematical programming model applied to observed data that provides a way for the construction of production frontiers as well as for the calculus of efficiency scores relative to those constructed frontiers (Murillo-Zamorano, 2004). DEA[1] represents the non-parametric approach for frontier estimation in the sense that it does not require any assumption about any functional form (Mikulás, 2010).

On the other hand, the main disadvantage of non-parametric approaches is their deterministic nature; DEA, for instance, does not distinguish between technical inefficiency and statistical noise effects (Murillo-Zamorano, 2004). On the converse, the main strengths of the stochastic frontier approach are that it deals with stochastic noise and permits statistical tests of hypotheses pertaining to production structure and the degree of inefficiency (Sharma *et al.,* 1999). However, parametric frontier functions require the definition of a specific functional form for the technology and for the inefficiency error term, both specification and estimation problems (Murillo-Zamorano, 2004). The main advantages of the DEA approach are that it avoids parametric specification of technology as well as the distributional assumption for the inefficiency term (Sharma *et al.,* 1999). In this study, a non-parametric DEA method was used because it does not require any assumptions about either production function forms or the distribution of efficiency terms. Moreover, it can easily handle multiple input and output cases.

Data Envelopment Analysis and the Analytical Model

Under the non-parametric approach, DEA is used to derive technical, scale, allocative and economic efficiency measures (Charmes et al, 1978; Fare et al, 1994; Coelli *et al.,* 2002). We constructed the DEA model assuming that each beekeeping farm produces a quantity of output ( ) using multiple inputs ( ), and each farm (i) is allowed to set its own set of weights for both inputs and output. The data for all farms are denoted by the K × N input matrix (X) and M × N output matrix (Y). Using piecewise technology, an input-oriented measure of technical efficiency (TE) can be calculated for the ith farm as the solution to linear programming (LP):

[1]*DEA represents the non-parametric approach for frontier estimation in the sense that it does not require any assumption about any functional form (Mikulás, 2010).*

$$TE_i = Min_{\theta,\lambda}\ \theta$$

$$\text{Subject to: } y_i + y\lambda \geq 0$$

$$\theta x_i + x\lambda \geq 0$$

$$\lambda \geq 0$$

In Equation 1, θ is the TE score having a value . If the value equals 1, the farm is on the frontier. The vector θ is an N × 1vector of weights which defines the linear combination of the peers of the ith farm. The constant returns to scale (CRS) model is only appropriate when the farm is operating at an optimal scale (Coelli *et al.,* 2005) and factors such as imperfect competition and financial constraints may prevent a farm from operating at an optimal scale (Nargis and Lee, 2013). Since apiculture farms in the study area conducted their activities under imperfect competition, Equation 1 was transformed to the variable returns to scale (VRS) technology model by adding the convexity constraint: , where N1 is an N × 1 vector of ones and λ is an N × 1 vector of constant.

The purpose of this study is to investigate the level and sources of technical efficiency differentials in apiculture among farms in Eastern Kenya. The output variables in the DEA analysis include honey, wax, combs and propolis. However, for some farmer categories, for instance traditional producers, the production of other outputs in apiculture, for instance, combs, was found to be negligible, consequently, only three outputs – honey, wax, and propolis - were considered in the analysis. On the other hand, the inputs included: number of hives owned by the households, annual start-up costs, total labour costs, and total feed and other costs. Consequently, except for the aforementioned category, technical efficiency was estimated in a single stage with multi-input and multi-output data envelopment analysis (DEA) framework.

Further, in this study, we assess the factors that influence technical efficiencies of farms. The choice of regression model for the second stage of DEA analysis is not a trivial econometric problem since the standard linear model is not appropriate for such analysis because the predicted values of y may lie outside the unit interval and the implied constant marginal effects of the covariates on y are not compatible with both the bounded nature of DEA scores and the existence of a mass point at unity in their distribution (Ramalho *et al.,* 2010). It is customary to conduct a Tobit model analysis, where the DEA efficiency scores are regressed on the relevant control variables (see for instance, (Chilingerian, 1995; Luoma *et al.,* 1998; Marschall and Flessa, 2011; Nargis and Lee, 2013; Tripathy *et al.,* 2010). Since the dependent variable, efficiency, is a censored variable with an upper limit of one, a Tobit model, which is a censored regression model is applicable in cases where the dependent variable is constrained in some way (Nargis and Lee, 2013). Though Hoff (2007) advocates using tobit and ordinary least squares (OLS) in second stage DEA efficiency analyses, efficiency scores are not generated by a censoring process but are fractional data, hence tobit estimation in this case is inappropriate (McDonald, 2009). Any sensible description of the data-generating process for DEA scores defined on [0,1] requires the use of regression models that are appropriate for dealing with fractional data in the second-stage DEA analysis (Ramalho *et al.,* 2010).

While literature presents an array of studies applying a range of standard regressions to explain DEA scores, for instance (Alexander and Jaforullah, 2004; Armagan, 2008; Kolawole, 2009), Hoff (2007) and McDonald (2009) considered the logit fractional regression model (FRM), proposed by Papke and Wooldridge (2008) which provides a more refined and flexible analyses using the generalized linear model (GLM). Unlike tobit models, FRMs do not require assumptions to be made about the conditional distribution of DEA scores or heteroskedasticity patterns (Ramalho *et al.,* 2010). In addition, a Stata code, fractional logit,”

Table 1: Summary statistics of variables used in the DEA Model, by CIP participation

	Mean for Non Participants (n=331)	Mean for Participants (n=238)	Mean for All (n=569)	T test (567df)	Number of households with non-zero observation
Quantity of honey produced per harvest	35.91 (3.32)	118.09 (11.50)	70.28 (5.45)	-7.82***	557
Quantity of wax produced	1.45 (0.77)	2.35 (0.35)	1.82 (0.47)	-0.94	95
Quantity of combs produced	0.09 (0.06)	0.02 (0.02)	0.06 (0.04)	0.86	4
Quantity of propolis produced	0.01 (0.01)	0.25 (0.08)	0.11 (0.03)	-3.46***	14
Total number of hives owned by the households	20.50 (1.96)	13.63 (1.20)	17.63 (1.25)	2.72***	569
Start-up cost per year (annuitized)	228.87 (17.40)	204.24 (12.44)	218.57 (11.38)	1.07	489
Annual labour cost (in man-days)	18.99 (1.75)	24.8 (5.01)	21.42 (2.33)	-1.23	562
Annual feed costs (operating costs)	70.18 (26.31)	1726.24 (111.79)	762.87 (59.92)	-16.6***	270

Note: 1US$=KES 85 at the time of the survey
**Farmers harvest twice a year, on average (i.e. once a season with two seasons a year)*

or "flogit" was developed and has simplified the implementation of the quasi-MLE with a logistic mean function (Gelan and Muriithi, 2012). Consequently, STATA version 12 was used to conduct the GLM analysis with the efficiency scores (estimated from DEAP version 2.1) as the dependent variable. Care was taken not to include correlated variables in a single model.

Data

The data used in this study were collected from 569 households randomly selected from two counties (Mwingi and Kitui) of Kenya. The sample size was sufficiently large and diverse to represent the households of interest in this study. The selection of the two counties was not random, but rather purposive, aimed at sampling households within CIP intervention area (Mwingi) and non-participant households in Kitui, an area of comparable ecological conditions. In addition to the input and output variables that entered the DEA model (mentioned in section 0) farm characteristics, household head characteristics, household characteristics and other external variables (for instance, market access) were collected and used in the GLM model to analyse factors that explain the observed technical efficiency levels.

Results

Socio-economic Characteristics of beekeeping households

The summary statistics of the variables used in the DEA model are presented in Table 1. As evident from the table, beekeeping households own on average, 18 hives and produce on average 70Kgs of Honey per harvest. However, farmers not participating in CIP activities had a significantly lower production level compared to participant

Table 2: Selected household socio-economic characteristics, by participation in Commercial Insects Program

Household head, household and farm characteristics	Non Participants (n=331)		Participants (n=238)		Pooled (n=569)		T test (567df)
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	
Age of the household head	48.39	0.82	54.73	0.90	51.04	0.62	-5.13***
Household head education (No. of years)	6.44	0.21	4.88	0.26	5.79	0.17	4.76***
Household size	7.15	0.19	6.59	0.18	6.92	0.13	2.08**
Labour force - active persons in the household	3.77	0.13	3.89	0.14	3.82	0.10	-0.60
Dependency ratio	1.12	0.05	1.05	0.07	1.09	0.04	0.75
No. of acres of land owned	14.64	3.74	7.36	0.35	11.59	2.19	1.64
No. of acres of land owned and rented under cultivation	5.57	0.57	4.54	0.18	5.14	0.34	1.49
Total household livestock holding in TLU	3.98	0.21	3.71	0.18	3.87	0.15	0.95
Average household income estimate (KES)	6138.97	398.53	9080.88	569.39	7369.51	337.60	-4.37***
Years of beekeeping experience	19.78	0.68	18.63	0.84	19.30	0.53	1.08
No. of traditional hives with bees (at the time of the survey)	7.00	0.44	10.09	0.86	8.29	0.44	-3.47***
No. of improved hives with bees (at the time of the survey)	0.09	0.06	0.79	0.20	0.38	0.09	-3.89***
Total No. of hives production - with bees	7.09	0.44	10.88	0.88	8.67	0.45	-4.18***
Total honey quantity (KG) per harvest	35.91	3.32	118.09	11.50	70.28	5.45	-7.82***
Total start up costs	656.80	45.30	1666.38	119.61	1079.08	60.22	-8.81***
Total feed and other costs	70.18	26.31	1726.24	111.79	762.87	59.92	-16.61***
Total number of hives owned by the Household	20.50	1.96	13.63	1.20	17.63	1.25	2.72***
Total No. of modern hives owned by the households	0.19	0.10	1.08	0.20	0.56	0.10	-4.24***
Total No. of traditional hives owned by the household	20.31	1.96	12.55	1.19	17.06	1.25	3.07***
Total labour (man days)	19.00	1.75	24.80	5.01	21.42	2.33	-1.23

*Note: *, **, ***indicate significance at 10%, 5% and 1%, respectively*

Table 3: Technical efficiency of farm households (Apiculture) in Mwingi and Kitui, Kenya

Farm household category		Mean technical efficiency	T-Test
Participation in ICIPE's Commercial Insect Programme	Participants (n=238)	0.56	-11.54, 567df***
	Non-participants (n=331)	0.26	
Type of beekeeping	Traditional (exclusively using traditional hives) (n=408)	0.35	-7.80, 567df***
	Improved (using both traditional and modern hives) (n=161)	0.59	
All farmers (pooled) (n=569)		0.35	

**** Significant at 1% level*

Table 4: Participation in CIP by producer type

Producer type	non participants		CIP participants		Total	
	N	%	N	%	N	%
Traditional producers	322	97.28	86	36.13	408	71.7
Mixed producers	9	2.72	152	63.87	161	28.3
Total	331	100	238	100	569	100

farmers. It is surprising, that non-participants had significantly higher number of hives but produced significantly lower amount of honey compared to their participant counterparts. However, participant farmers spent significantly large amounts in terms of operating costs compared to non-participants. In addition, relatively few farmers produced other beekeeping products, for instance, wax, combs and propolis.

Further, from the data obtained in this study, majority of the households were male-headed (72 per cent). In terms of participation in ICIPE's commercial Insect programme (CIP), 42 per cent were participants. While noting that only beekeeping farm households were interviewed, it is expected that households would differ in terms of their socio-economic characteristics. Consequently, we highlight the socio-economic characteristics of beekeeping households in the study area.

Table 2 presents selected household socioeconomic characteristics by participation in icipe's commercial Insect programme (CIP).

From the results shown in Table 2, it is evident that participants of CIP were significantly older[2] and less educated. Moreover, they were more economically endowed since they had significantly higher incomes, lower number of total hives yet they produced much more honey and had more hives in production compared to their non-participants counterparts. Note that the data used in this study was collected after CIP intervention. Consequently, while it is expected that there should be randomness in selection of target and control such that the two samples may be comparable at baseline, after implementation of the intervention in the target area, some differences, especially in form of economic endowment, are expected. The observed difference in age and education is critical since these variables are not influenced by the intervention (short-term) and is therefore dealt with using coarsened exact matching algorithm section 0.

Technical Efficiency in Apiculture households in Mwingi and Kitui Counties of Kenya

[2](Carroll and Kinsella, 2013) found that beekeepers tended to be, on average, older than the general population

The results presented in Table 3 reveals the mean technical efficiency of apiculture farms in Mwingi and Kitui. From the results, it is evident that farms that used modern hives (mixed with traditional hives) and farms participating in CIP had the highest mean technical efficiency. The results show that there was a highly significant difference between technical efficiencies of participants and non-participant (t=-11.54, 567df, p=0.00). Likewise, the results show that there was a highly significant difference between technical efficiencies of traditional producers (producers who use traditional hives) and improved producers (those who use a mix of traditional and modern hives) (t=-7.80, 567df, p=0.00). Improved producers had a significantly higher technical efficiency than traditional producers.

The implication here is that both participation in CIP and the use of modern bee hives have a positive effect on efficiency in honey production. Note that participation in CIP does not exclusively culminate to use of modern hives by the farmers. For instance, as shown in Table 4, thirty six (36) percent of CIP participants were pure traditional producers (use only traditional hives) while the rest (64 percent) use a mix of modern and traditional hives. The implication of this finding is that the relatively higher record of technical efficiency by CIP participants and improved producers did not exclusively derive from ownership of modern hives. Consequently, the results present sufficient evidence that the observed positive impact on farmers' efficiency in beekeeping could be attributed to other components of CIP (for instance capacity building), alongside modern hives, and other farm or farmer characteristics (the results from an estimation of the factors that affect technical efficiency are presented in section 0.)

Factors affecting technical efficiency in Apiculture in Mwingi and Kitui counties

A generalized linear model (GLM) was used to analyse factors that affect the technical efficiency of apiculture farmers in Mwingi and Kitui counties, Kenya. In order to identify policy implications and strategic actions, the selection of the socio-economic variables included in the analysis was guided by the relevance of the variables in eliciting policy implications and strategic actions for the improvement of beekeeping, and consequently, household welfare. Since some significant difference, in general household characteristics, which would normally be exogenous to participation in CIP, for instance household size, age and education of the household head, between CIP participants and non-participants, coarsened exact matching algorithm was used to extract a sample with matching characteristics between CIP participants (target) and non-participants (control) based on the said household characteristics. A total of 431households were found to be matching, with 199 participant and 234 non-participant households. A second GLM model was conducted with the matched dataset. It is worth noting that an initial analysis was conducted using the 2-stage heckmann model. The heckmann model proved that there was no selection bias in terms of farmers participating in CIP activities. In this paper, however, only the GLM results are shown.

From the results of the two GLM regressions, it is evident that the results of the GLM regressions are comparable, with only a few variables changing their significance in the regression with matched dataset. This, therefore, confirms the plausibility of the GLM results and the results of the preceding analyses (the significant differences in technical efficiencies, observed in participant, vis á vis non-participants). The results from the GLM regressions (5) show that participation in ICIPE's CIP project had a strongly significant ($p<0.01$) positive relationship with technical efficiency. This is consistent with the results from technical efficiency estimation (Table 3) implying that farmers participating in the project were more efficient in honey production than non-participant farmers.

In addition, farmers knowledge on colony transfer, access to tap water, owning land, number of acres of land owned, number of mobile phones owned by the household, problems in meeting food requirements, total number of traditional hives owned, total

Table 5: GLM with robust standard errors results: Factors influencing technical efficiency levels of apiculture farms

Dependent variable: technical efficiencies of the apiculture households

Independent variables	Model with Unmatched data (n=567)		Model with Matched data (n= 431)	
	Coefficient	Robust Std. Err.	Coefficient	Robust Std. Err.
Household head's gender – male	0.127	0.161	0.118	0.182
Labour force -active population in the household	-0.072***	0.025	-0.076**	0.031
Household head's total years of education	0.017	0.015	0.007	0.018
Poverty status: household earning above $1.25 a day	-0.264**	0.129	-0.227	0.150
Participation: household participating in ICIPE's CIP	1.182***	0.168	1.130***	0.189
Farmers knowledge on honey harvesting time (score)	-0.477***	0.106	-0.462***	0.120
Farmers knowledge on colony transfer (score)	0.156***	0.051	0.156***	0.056
Access to water and electricity: Household has both	0.172	0.346	0.102	0.355
Access to water and electricity: Household has tap water only	0.692*	0.356	0.583	0.417
Access to water and electricity: has electricity only	-0.964***	0.201	-1.094***	0.222
Land ownership: Household owns land	0.754***	0.203	0.791***	0.249
Number of acres of land owned	0.001***	0.000	-0.005	0.005
Livestock ownership: Household owns livestock	-0.751*	0.423	-0.596	0.488
Number of bikes owned by the household	0.142	0.103	0.061	0.111
Number of mobile phones owned by the household	0.098**	0.048	0.139**	0.056
Problems in meeting food requirement: often	0.141	0.146	0.137	0.172
Problems in meeting food requirement: always	0.760*	0.408	0.332	0.413
Household head's years of beekeeping experience	0.005	0.005	-0.001	0.006
Beekeeping training: Household head attended	0.468	0.317	0.374	0.431
Total number of traditional hives owned	0.007***	0.002	0.008***	0.002

Independent variables	**Model with Unmatched data (n=567)**		**Model with Matched data (n= 431)**	
	Coefficient	**Robust Std. Err.**	**Coefficient**	**Robust Std. Err.**
Number of extension visits in the previous year	0.003	0.002	0.007***	0.002
Children aged 10-14 years' labour (man days) in the household per year	0.136***	0.057	0.179***	0.062
Total adult man days in the household per year	-0.001**	0.001	-0.001	0.001
Constant	-1.244***	0.467	-1.196**	0.548

	Unmatched	**Matched**		**Unmatched**	**Matched**
Log pseudolikelihood	-254.65	-195.46	(1/df) Deviance	0.36	0.37
Residual df	542	406	(1/df) Pearson	0.33	0.34
Deviance	196.17	148.26	Pearson	182.93	137.12
AIC	0.99	1.02	BIC	-3240.30	-2314.58
Variance function	V(u) = u*(1-u/1)		Link function	g(u) = ln(u/(1-u))	
[Binomial] [Logit] Scale parameter=1					

number of Langstroth hives owned and use of child labour, all had positive and significant (P≤0.1) influence on technical efficiency of the farms. On the other hand, poverty status (i.e. household earning above $1.25 a day) had a negative coefficient, implying that, well-off farmers were more technically inefficient in beekeeping compared to poorer farmers. Besides being well-off, having access to electricity only and owning livestock had negative influence on technical efficiencies of the farmers. Clearly, these results imply that poor beekeepers (living below poverty line, having no livestock and no access to electricity) are the more efficient apiculture farmers. This suggests that beekeeping is actually a poor man's trade. The glaring question after this observation would be whether or not, beekeeping is a pathway out of poverty.

Discussion

The mean age of the beekeepers in the study area was found to be 51 years old, with the CIP participants being significantly older than their non-participant counterparts. These results are comparable to the findings by Carroll and Kinsella (2013) that in Nakuru, Kenya, beekeepers tended to be older than the general population with an average age of 56 years in district. On average, the farmers had 8 traditional hives and less than 1 modern hives in production (with bees). This is about 48 and 67 per cent of the total traditional and modern hives owned, respectively. While this reveals a considerable gap between the number of hives owned and those put into productive use, it is also evident that CIP participants made the most use of their hives (80% in production) compared to non-participants (35%).

The results also reveal that CIP farmers had a significantly higher honey production level, lower number of hives and spent significantly large amounts in terms of operating costs compared to non-participants farmers. It follows therefore from the results, that participants had a significantly high technical efficiency. Likewise, improved producers (those using a mix of traditional hives and modern hives) also had a significantly high technical efficiency. Evidently, the source of this significantly higher technical efficiency does not solely derive from ownership of modern hives, as shown by the results in Table 4. While CIP promoted modern hives, the general observation from the study is that CIP participants, whether owning modern hives or not, had significantly higher technical efficiency. This implies that the sources of technical efficiency could have emanated from other factors, but also including ownership of modern hives. Carroll and Kinsella (2013) found that traditional hives were just as good as modern hives in terms of revenue per hive generated

As indicated earlier, production of honey in Kenya mostly comes from traditional hives (Muli *et al.,* 2007). Similarly, the results of this study, majority of farmers still use traditional hives. As described (Carroll and Kinsella, 2013), traditional log hives are usually hung high in trees, scattered over large areas away from people and animals. This signifies the importance of access to land, as is evident in the results from the GLM models. Though it is general knowledge that beekeeping does not require land per se, the GLM model (with unmatched data) results reveal that while mere ownership of land contributes to approximately 15 per cent while the number of acres owned contributes a very minute figure of 0.03 per cent of the observed technical efficiency. Note that honey production in Kenya has traditionally focused on the less-productive agricultural areas, as beekeeping has been seen as an activity that is part of an income generating strategy that is most suited to areas where people are not able to farm the land year round (Maurice, 2004). Since in the said area, land is owned privately, as opposed to communal land, the importance of land ownership can be argued to represent access to forage (production resources) and security from common threats for instance, land-use conflict and vandalism (see Musimba et al. (2001)).

The results from the GLM model confirmed the positive influence of CIP participation on technical efficiency of the beekeeping farms. Alongside participation, which had the highest significant influence on technical efficiency levels, explaining the highest percentage of the observed technical efficiency levels (26%), other factors were also found to have significant influences. These include, for instance, ownership of land, number of acres owned, number of Langstroth hives owned and number of traditional hives owned (accounting for 14, 0.03, 1.4, and 0.15 per cent of the technical efficiency levels, respectively). On the converse, ownership of livestock (a proxy for wealth indicator) had a negative influence, reducing technical efficiency levels by approximately 18 per cent. Likewise, access to electricity was found to reduce technical efficiency by about 17 per cent while the poverty index derived from households' income estimates (falling above the $1.25 a day) would reduce technical efficiency by about 5.9 per cent. These results indicate that the well-off in the society are less efficient in beekeeping while the poor are relatively more efficient. This begs the question on whether beekeeping is a pathway out of poverty or a mere "poor man's trade".

Carroll and Kinsella (2013) found that the gross margin from a ten hive beekeeping enterprise was equivalent to the gross margin from 0.86ha of maize yet in contrast to maize production, beekeeping is far less time- and labour-consuming, has lower variable costs, and requires little land area, and the opportunity cost of diversifying into beekeeping is small since the enterprise takes up very little space in comparison with other farm enterprises such as crop production. This evidence supports the consideration of beekeeping as an effective pathway out of poverty.

Conclusion

Participation in icipe's CIP activities leads to the highest increase in technical efficiency in beekeeping by farm households in Mwingi, Kenya. However, the observed high technical efficiency differences are not being solely attributed to the use of modern hives. The study results of the study undoubtedly reveal that apart from participation in CIP which accounts for the largest proportion of the positive influence on technical efficiencies, there are other factors that significantly influence technical efficiencies in beekeeping farms in the study area. The study also presents an argument that supports the potential of beekeeping as a pathway out of poverty. Consequently, development interventions therefore, should not only aim at replicating CIP activities in other areas (upscaling) but also targeting their interventions for better results by focusing on the socio-economic factors that influence the technical efficiencies. For instance, policies targeting land ownership and strategic development activities targeting increased access to hives for the poor, would go a long way in moving the poor in society out of poverty.

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THE HONEY INDUSTRY IN COMESA: OPPORTUNITIES AND CHALLENGES

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Abstract

Global honey production in 2013 is estimated at 1,663,797.73 tones and the five leading producers in the same year were China, Turkey, Argentina, Ukraine and Russia who contribute 450,300; 94,694; 80,000; 73,713; and 68,446 tones, respectively to the total world production. In terms of trade, only about 31.2 % of global honey production entered international trade in the same year. Whereas, the total natural honey production in Africa in 2013 was only 10.2% (169,306.00 tones) of which, 1.55 % entered international trade.

The total honey production from COMESA Member States in 2013 was estimated at 81,454 tones and the total wax production was 9,811 tones. The four leading Honey producer Member States in the same year in the region were Ethiopia, Kenya, Egypt and Madagascar who contributed 45,000, 12,000, 5100, and 4400 tones, respectively. In terms of trade, only 2.74% of honey produced entered international markets partly being influenced by food quality standard requirements by developed countries. Cognizant of the suitable agro-ecological zones and potential for intensification, honey bee production is potentially one of the most significant resources that Common Market for Eastern and Southern Africa (COMESA) countries can harness for livelihood and economic growth. It serves as a source of income, employment and public revenue.

In COMESA, there is significant potential for production and trade. However, in many Member States, critical challenges to more effective participation in honey bee production and trade include limited technical capacity to implement modern honey bee production, lack of laboratory facilities and operational capacity, poorly defined roles of private and public sector in planning and implementation, lack of market support systems, and inadequate enforcement of quality standards. In addition, poor access to financial service sectors, inefficient cross-border trade facilities and weak organizational capacity of small-scale operators remain major challenges.

The absence of a national policy in most of COMESA Member States on the development of the honey sub-sector appears to be one of the major causes for lack of coherence in the industry; neither do the strategic approaches and interventions by development agencies through various programs appear to be addressing issues affecting the industry on sustainable bases.

In order to overcome the current development challenges and achieve the desired outcomes, significant investments are required especially in the area of production and trade. Establishing intra-regional honey bee product supply chains is essential, and requires significant support to sustain supplies, improve trade efficiencies and enhance the quality of products. It is also important to put in place effective and harmonized regulatory frameworks and enforcement of standard management measures in collaboration with Member States and all concerned stakeholders.

Key words; COMESA, Honey, beeswax, production export

L'INDUSTRIE DU MIEL AU COMESA : OPPORTUNITES ET DEFIS

Résumé

En 2013, la production mondiale de miel était estimée à 1 663 797,73 tonnes, et les cinq principaux producteurs de la même année étaient la Chine, la Turquie, l'Argentine, l'Ukraine et la Russie, qui ont contribué respectivement pour 450 300 tonnes, 94 694 tonnes, 80 000 tonnes, 73 713 tonnes, et 68 446 tonnes à la production mondiale totale. En termes de commerce, seul un pourcentage de 31,2% de

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la production mondiale de miel est entré dans le commerce international au cours de la même année. Considérant que la production de miel naturel total en Afrique en 2013 était seulement de 10,2% (169 306,00 tonnes) du commerce international, seul 1,55% est entré dans le commerce international.

La production totale de miel dans les États membres du COMESA en 2013 a été estimée à 81 454 tonnes et la production de cire totale était de 9 811 tonnes. Les quatre principaux producteurs de miel (États membres du COMESA) au cours de la même année étaient l'Éthiopie, le Kenya, l'Égypte et Madagascar, qui ont contribué respectivement pour 45 000 tonnes, 12 000 tonnes, 5 100 tonnes et 4 400 tonnes. En termes de commerce, un faible pourcentage de 2,74% du miel produit est entré sur les marchés internationaux, dû en partie aux exigences normatives de qualité des aliments imposées par les pays développés. Connaissant les zones agro-écologiques appropriées et le potentiel d'intensification, la production d'abeilles mellifères est potentiellement l'une des ressources les plus importantes que les pays du Marché commun de l'Afrique orientale et australe (COMESA) peuvent exploiter pour la subsistance et la croissance économique. Elle constitue une source de revenu, d'emploi et de recettes publiques.

Au sein du COMESA, il existe un potentiel important pour la production et le commerce de cette denrée. Cependant, dans de nombreux États membres, les défis majeurs à une participation plus efficace à la production et au commerce du miel comprennent : la modicité de la capacité technique à mettre en œuvre un système moderne de production du miel ; le manque d'installations de laboratoire et de capacités opérationnelles ; la définition inadéquate des rôles des secteurs public et privé dans la planification et la mise en œuvre ; le manque de systèmes d'appui aux marchés, et l'application insuffisante des normes de qualité. En outre, le manque d'accès aux services du secteur financier, l'inefficacité des installations commerciales transfrontalières et la faiblesse des capacités d'organisation des petits exploitants demeurent des défis majeurs.

L'absence d'une politique nationale sur le développement du sous-secteur miel dans la plupart des États membres du COMESA semble être l'une des principales causes du manque de cohérence dans l'industrie. De plus, les approches et les interventions stratégiques des organismes de développement, par le biais de divers programmes, semblent ne pas aborder des questions qui touchent l'industrie de manière durable.

Dans la perspective de surmonter les défis de développement actuels et d'atteindre les résultats escomptés, des investissements importants sont nécessaires, en particulier dans le domaine de la production et du commerce. La mise en place de chaînes infrarégionales d'approvisionnement de produits de la ruche est essentielle, et nécessite un soutien important pour maintenir l'approvisionnement, renforcer l'efficacité du commerce et améliorer la qualité des produits. Il est également important de mettre en place des cadres réglementaires efficaces et harmonisés et appliquer des mesures de gestion standard en collaboration avec les États membres et toutes les parties concernées.

Mots-clés : COMESA, miel, cire d'abeille, production, exportation

Introduction

The Common Market for Eastern and Southern Africa (COMESA) was established by treaty in 1994, with the goal of being a fully integrated, internationally competitive regional economic community with high standards of living for its entire people, ready to merge into an African Economic Community. Specifically, by 2025, COMESA plans to be a single trade and investment area in which tariffs, non-tariff barriers and other impediments to the movement of goods, services, capital and people will be removed, while trade in goods and services from the region will have achieved global market competitiveness (COMESA MTSP, 2015).

Within COMESA, the agriculture sector accounts for more than 32 percent of Growth Domestic Product (GDP), supplies 65 percent of raw materials for industry, and employs 80 percent of the region's population. This sector's contribution to GDP ranges from 6 percent in Mauritius to 49 percent in Burundi. Agriculture, therefore, plays a pivotal role in the attainment of increased incomes and improved standards of living of the majority of the people. COMESA region relies heavily on agriculture for employment and economic growth and is well endowed with livestock resources including bee colonies. The livestock sector accounts for more than 35% of agricultural GDP and 30% of foreign exchange earnings (COMESA LPF, 2015).

In COMESA, honey production is an age old practice owing to the various ecological and climatic conditions. There is an ancient tradition for beekeeping in most of MS which stretches back millennia for some of the countries such as Egypt and Ethiopia (Andrew 2000; Vogel, 1867). COMESA MS are home to the most diverse flora and fauna in Africa that provide surplus nectar and pollen to foraging bees. Beekeeping is a well-accepted farming technology and is suited to the varied range of ecosystems of the region. Honey is the major apicultural product in Southern and Eastern African countries (SADC, 2006)

Honey bee keeping is an environmentally friendly activity that integrates well with different farming practices and can be used for conservation of natural resources. It has a low labor requirement, and can contribute considerably to household income and food security. Apiculture has emerged as a strategic sector, attracting regional and governmental support, non-governmental interventions and private sector investments. At the regional level, COMESA has instituted a policy framework which opens up opportunities to enable the sector become a commercial enterprise across the region and hence yield economic, social and environmental benefits (COMESA LPF, 2015). COMESA encourages competitiveness, value addition, trade and investment in the livestock sector which includes apiculture. Under the regional Livestock Policy Framework (LPF, 2015), the COMESA secretariat is embarking on four strategic areas representing the key areas of opportunity in livestock: (i) Attract public and private investments along the different livestock values chains; (ii) Enhance Livestock Production and Animal Health to increase productivity and resilience of livestock production systems; (iii) Enhance innovation, generation and utilization of technologies, capacities and entrepreneurship skills of livestock value chain actors; and (iv) Enhance access to markets, services and value addition. In particular, the secretariats primary role will be to reduce and remove non-tariff barriers that prevent marketing of livestock and livestock products and the private sector from investing in the value chains of livestock subsectors, including apiculture.

The beekeeping industry in COMESA is coming out of the shadow and attracting public and private sector support and is rapidly becoming a promising area where investments can be encouraged. Nevertheless, there has been lack of information on the sub-sector which poses a challenge in demonstrating the true potential of the industry and in accurately assessing and increasing the visibility of the impact of public and private sector interventions.

The objective of this paper is to provide an overview of the honey industry in the region and establish baselines against which the impact of interventions and programmes in the sub-sector could be determined.

The specific objectives are:

- To establish the baseline information on production and trade of the honey sub-sector in COMESA
- To identify key challenges facing the sub-sector and how they could be addressed
- To determine the suitability of the enabling environment of the sub-sector

Materials and Methods

Review of relevant documents: This study involved a detailed review and analysis of relevant information on the honey industry in each Member State (MS). The literature review included international journals, study reports and commentaries on honey production. Data used on honey and bee wax production and trade was retrieved from United Nations Food and Agriculture data base (FOASTAT, 2013)

Findings and Discussion

Overview of Honey Production and Trade Worldwide and in Africa

Global honey production is currently estimated at 1,663,797.73 tones. Asia is the leading honey producing continent globally, with China, India, and republic of Korea being the highest producing countries followed by Europe where Turkey, Ukraine, Russian Federation and Spain as the highest producing countries in descending order. The Americas come third, continentally, with Argentina, USA and Mexico as the leading producers. Africa, Oceania and Caribbean follow in order of decreasing production (Figure 1).

Data on productivity in beekeeping throughout the world shows that production per hive is very high in countries with developed apiculture industries. Worldwide the five leading producers in 2013 were China, Turkey, Argentina, Ukraine and Russia who contributed 450,300; 94,694; 80,000; 73,713; and 68,446 tones, respectively to the total world production. In 2005, the 3 leading producers were China, USA and Argentina who contributed 267,000mt, 110,000mt and 98,000mt respectively to the total world production, however, while production in China and Argentina is increasing that of USA has decreased tremendously mainly due to Colony Collapse Disorder (Dennis et al. 2006) leading to USA becoming one of the major importing countries globally.

Only about 31.2 % of global honey production enters international trade. Globally, the leading exporting countries are China, Argentina, Mexico, and India. The major importers are USA, Germany, Japan and United Kingdom in descending order of volumes. Honey trade is significantly influenced by food quality standards requirements especially in the developed countries. Thus, food safety and quality standards are the determinants of the volume of trade in honey, its by-products and other hive products. The future of honey in international trade is, therefore, tied to the development of good quality organic honey for exports. In addition to honey, products such as propolis, royal jelly, pollens and wax are also significant in world trade. Industrial honey has the largest market in the developed countries (Chauzat et al. 2013). The primary users of industrial honey are bakers, health food and cereal manufacturers

The honey industry is relatively better improved in the developed countries due to the several programs that supported the sub-sector. These include improved beekeeping techniques, technologies, input financing and market support systems, as well as enforcement of quality standards. For instance, the European Union (EU) has set conditions under which beekeepers are given support, in addition to the establishment of quality standards (European Commission 2011; Daberkow et al, 2009).

The total natural honey production in Africa in 2013 was 169,306.00 tones and the leading producers were Ethiopia 45,000.00; Tanzania 30,000.00; Angola 23,300.00 and Central African Republic 16,200.00 tones. Regionally Eastern Africa followed by central Africa registered high production (Figure 2). In terms of trade, only about 1.55 % of Africa's honey production enters international trade. In Africa, in 2012, the leading export countries were Egypt, Ethiopia and Zambia who exported 959.00, 729.00 and 441 tones honey, respectively.

Recognition of the significance of the honey subsector in African countries has been growing. In Africa, though reliable production and trade statistics on honey do not exist, it is believed that the consumption of honey on the continent far outstrips production. Thus there is a huge gap between domestic production and demand which is believed to be complemented by foreign imports of honey. There is therefore huge domestic market for honey on the African continent which needs to be exploited by producing more locally.

Honey production and trade in COMESA

The agro-ecological conditions in COMESA are considered to be suitable for the production of honey in all Member States. The African honeybee, Apis mellifera mellifera and Apis mellifera adansonii are better adapted and performing in COMESA. Since the 1980s, through the interventions of governmental and non-governmental organisations, significant improvements have been made in the sector, notable among them are the introduction of modern beekeeping technologies, training and the provision of beekeeping equipment. As a result, the number of people participating in modern beekeeping has been increasing, leading to an improvement in levels of honey production. In spite of these efforts, traditional honey production (e.g. use of traditional hives made of mud and wattle, clay-pots and tree barks) and wild honey hunting from forest are still dominant.

The most recent United Nations Food and Agriculture Organization data revealed that there are about 8,766,458 beehives in COMESA Member State. The largest number of bee hives was in Ethiopia 59.8% followed by Kenya 20.50% and Egypt 11.41%. Most of the beekeeping activities take place on farmlands.

The total natural honey production in COMESA in 2013 was 81,454 tones. In terms of region over 80% of honey production is in the Eastern African MS as compared to Southern African Countries showing that there are huge gaps and potentials to improve production (Figure 3).

In terms of MS, the census showed that the countries with the highest production were Ethiopia (45,000t), Kenya (23,000t), Egypt (5,100t), and Madagascar (4,400t). The beekeeping industry in COMESA is still in its developmental stage. It requires substantial support if it's full potential for rural income and employment generation is to be exploited for national and regional development. A vibrant honey sector in COMESA would not only contribute to improvement of livelihoods in rural communities through generation of rural employment and increased household incomes; but would also boost export earnings.

In terms of trade, only about 2.74 % of COMESA honey production enters international trade. The leading export countries are Egypt, Ethiopia and Zambia (Table 1). The major export destinations for honey from COMESA are Middle East Countries (United Arab Emirates, Oman, Saudi Arabia and Yemen) and European countries (Germany, United Kingdom, France and Switzerland). There is an increasing level of demand for honey as an ingredient for herbal medicine, pharmaceutical and cosmetic industries. To compete in these markets, exporters need to offer consistent supplies of large volumes at competitive prices. COMESA MS export opportunity lies greatly in supplying niche markets with organic honeys, where they can make premium price for their produce. There are also opportunities in specialized flavor such as honeys from Acacia, Eucalyptus tree, coffee and other flowering plants.

Exporting honey requires a proper understanding of the necessary documentation and procedures, so as to benefit from the different provisions such as quota-free and tax free considerations of different trading partners in COMESA. When exporting to any country within the COMESA region, a COMESA Certificate of Origin issued by the MS is required. Importing countries from Europe request for certificate of analysis of the product issued by a competent laboratory as proof that the product meets the required standards.

COMESA MS do also participate in inter and intra regional trade, and spent $7.8 million USD in 2012 which was close to the amount export of honey generated revenue. The major importing countries were Libya, Mauritius, Rwanda and Kenya.

The total beeswax production in COMESA member states amounted to 9,811 tones in 2013 according to FAO estimate. The leading producers were Ethiopia, Kenya and Uganda (Figure 4). Generally, there is little emphasis on the production of beeswax in the region, largely because the domestic market for beeswax remains underdeveloped. Beeswax in the region is used mainly for baiting bees, candle production and as ingredient for cosmetics production. In terms of trade Ethiopia's beeswax export was highest amounting to 365 tones followed by Egypt 51 and Madagascar 17 tons.

Figure 1: World Honey Production by Continents in 2013 (tones)

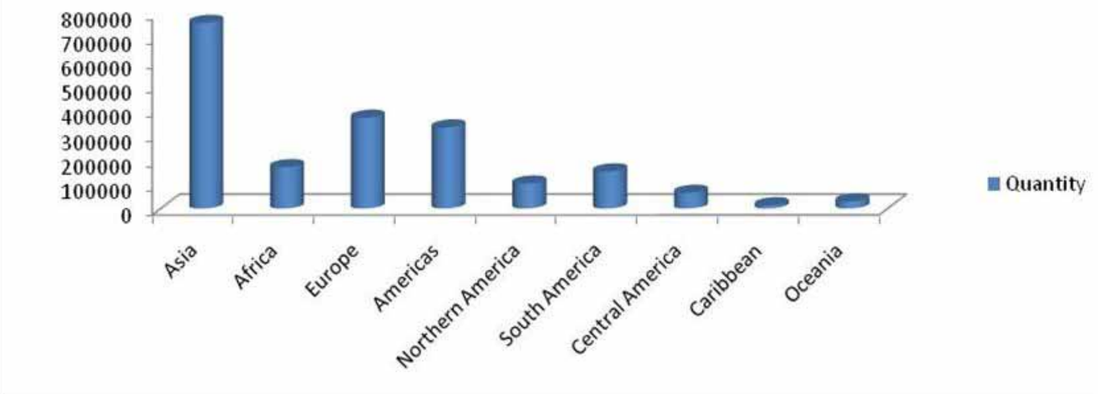


Figure 2: Honey Production in Africa by region in 2013 (tones)

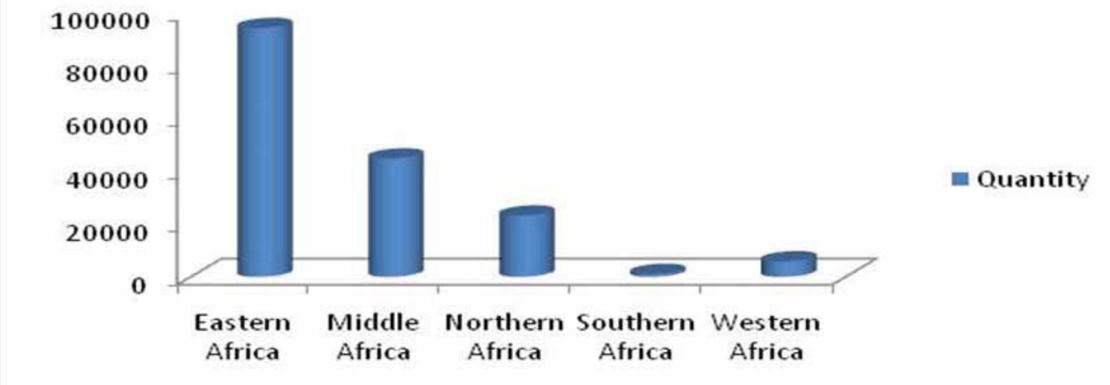


Figure 3: Natural honey production in COMESA MS in 2013

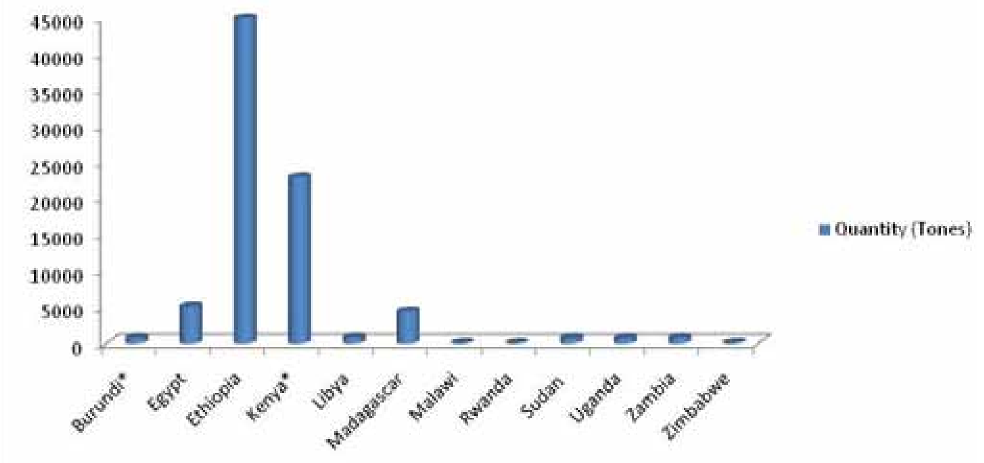
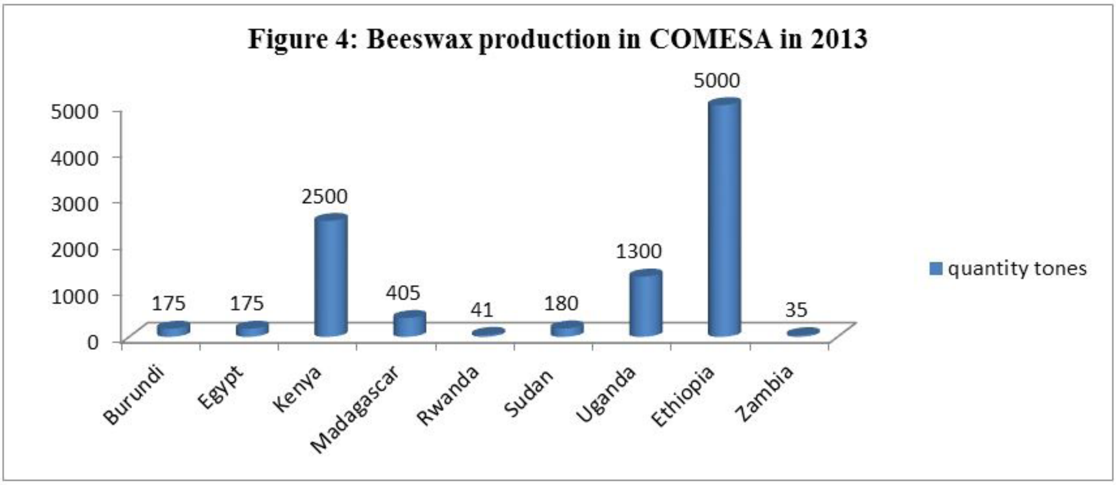


Table 1: Natural Honey Export from COMESA in 2013

Country	Quantity (tones)	Value (1000 USD)
Egypt-**	959	3615
Kenya ***	70	209
Madagascar *	20	50
Malawi **	10	55
Mauritius *	1	5
Rwanda *	1	5
Swaziland **	1	5
Uganda *	2	8
Ethiopia *	729	2718
Zambia *	441	1298
Total	2234	7,968

*Note: * Official Data, ** FAO Estimate, *** Provisional official data*



Opportunities in COMESA for honey industry development

There are tremendous opportunities in the honey industry for the improvement of the livelihoods of people in the MS.

Diverse Agro-Ecological conditions

The prevailing diverse agro-ecological conditions in COMESA region are very conducive for industrial honey production. The regional environments range from cool temperate type environments to tropical ecosystems which are warm to hot and moist all year-round, promotes lush vegetation growth consisting of rainforests, dry deciduous forests, spiny forests and other types of flora which are congenial for beekeeping and honey production.

There are also plenty of marginal lands including arid and semi-arid areas which are considered as lands unable to support permanent or intensive agriculture without significant investment in land. Beehives could be sited on marginal lands since the bees will not directly depend on the land but rather good source of nectar flowers from vegetations on the marginal lands.

Extensive agricultural practices

Crop agriculture is extensively exercised in the region which can be used by forager bee to collect nectar and pollen grain to produce honey. The honeybee in its quest for nectar sources moves between flowers transferring pollen effectively pollinating flowers and increasing crop yields. The smallholder farmers can easily site their beehives near by the farms that will help them generate additional income without increasing labor, also from pollination which boosts their crop production.

The presence of international, regional and national organizations

There are several organizations that, in various ways, provide support and services to the honey industry. Some important stakeholders that could impact the future of the honeybee industry are African Union Interafrican Bureau for Animal Resources (AU-IBAR), International Centre for Insect Physiology and Ecology (ICIPE), Food and Agriculture Organization (FAO), World Organization for Animal Health (OIE), International Livestock Research Institute (ILRI), Regional Economic Community (RECs) (including COMESA, IGAD, SADC, EAC), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASERECA), Agricultural Research and Development for Southern Africa (CCARDESA), Regional farmers or private organizations and national organizations such as Ministry responsible for livestock, national research organizations, Civil Service and Community Based Organizations and Academia.

The presence of supporting institutions in COMESA

The presence of Alliance for Commodity Trade in Eastern and Southern Africa (ACTESA), African Trade Insurance (ATI) is Africa's export credit agency. ACTESA provides insurance against political risk and trade credit risk insurance with the objective of reducing the business risk and cost of doing business in Africa. ACTESA also supports two-way trade flows between Africa and the world facilitating exports and foreign direct investment to enhance trade flows within the continent. COMESA Business Council (CBC) is a Business Member Organization which provides three core services i.e., business support services and linkages, policy advocacy and membership development, with an objective of addressing the pertinent constraints to business and competitiveness in the region, influencing the policy formulation agenda on behalf of the private sector and increasing private sector participation in the regional integration agenda. In COMESA private sector and regional organizations can make use of those organizations for the enhancement of apiculture value chain and in general for the development of the honey industry in the region.

The recently developed COMESA Livestock Policy Framework with the objective of ensuring sustainable livestock production, productivity and competitiveness in the region provides a comprehensive framework for the enhancement of the apiculture industry.

The Developing Cosmetics and Pharmaceutical Industries in the region

Currently the COMESA region is experiencing a rapid development of cosmetic and pharmaceutical industries: honey and its derivatives are widely used inputs for cosmetics and drug manufacturing and formation. Currently almost all the supplies for these industries are derived from imports as the local producers do not meet the quality standard required by the industries. There is a huge opportunity for import substitution.

Challenges Facing the Honey Industry in the region

The honey industry in the COMESA region faces certain key challenges and constraints which need to be resolved if the full potential of apiculture is to be realized.

Limited technical capacity

A major challenge to the development of the industry is limited technical knowhow including lack of materials and ability to prepare improved bee hives, poor hive management skills, limited knowhow in relation to colonization of hives, weak capacity for monitoring beehives for pests and diseases, and limited capacity for finding solutions to problems such as supplemental feed, and management of diseases and pests.

The occurrences of diseases including parasites, bacterial and viral diseases have been indicated as one of the major challenges. In addition the presence of predators and the unlimited use of pesticides and herbicides are some of the major challenges that affect the quality and wholesomeness of honey bee products. Added to that is there is limited knowledge on how to mitigate and reduce the key risks related to apiculture, and how to manage them when they occur. Other environmental and human interference problems such as bush fire are often cited as major problems

Lack of an enabling regulatory and policy framework

A fundamental challenge for the honey industry is lack of an enabling policy framework, strategy and regulatory regime to provide the needed directions and guidelines for the development and growth of the industry both at the regional and national levels. The role of private and public sector in planning and implementation of the development of the industry is poorly defined. This gap has, among others, contributed to less consideration, fragmentation of efforts and lack of support resulting in the under performance of the industry.

Access to financial services

One of the major challenges for the upsurge of the honey industry is access to financial services. Poor access to finance has been a major bottleneck for the development of industrial level production and to establish honey processing and packaging plants. Changing the predominant utilization of traditional methods and equipment by smallholder producers to utilization of modern beehives such as box top bar and others that can double their productivity is a major challenge.

Lack of standardization and quality management system

There is lack of standardization and quality management systems in the industry contributing to the prevalence of poor production, processing, packaging and proper labeling. The lack of standardization and quality management emanates from lack of proper laboratory and facilities necessary for quality assessment. This affects access to regional and international markets and also undercuts production and sale of honey on the local market and across the value chain. In absence of support to address proper handling, packaging and labeling, locally produced honey fails to command good market prices despite the fact that it is organic and free from human interferences, making it inherently a premium product attract to niche markets.

Related with quality standards are unnecessary non-tariff barriers predicated on sanitary and phyto-sanitary requirements which are impediments to intra-regional trade. Although it is critical to aim to improve and uphold the high quality standards of demanding international markets, it is equally important to have regional level quality standards with requirements based on prevailing realities within COMESA.

Limitation in business management

Most beekeepers take beekeeping as a part-time economic activity with minimum labour input. Managing and growing beekeeping as business is one of the major challenges that beekeepers face. Incomes generated from the business are not usually reinvested to raise production and improve quality standards. Processors on the other hand, especially big marketing agents, require a guaranteed supply at a certain quantity and quality. As a result, beekeepers cannot participate in competitive markets from which they could fetch premium price for their product. There is a lack of structured business approaches among beekeepers, with poor linkages between smallholder, medium scale and large scale producers and processors. Beekeepers have limited knowledge on the existence of international, regional and national level support structures for business and entrepreneurship development. Though there has been huge development in the areas of Information

Technology (IT), the use of IT and other communications facility for market information sharing has remained rudimentary. The overall impact of the above challenges manifests in low production, poor yield, limited market access, low incomes and under-utilization of beekeeping for wealth creation.

Conclusions and Recommendations

The honey industry has high growth potential; there is a considerable opportunity to boost production to meet the ever increasing demand for the product. The diverse agro-ecological conditions in COMESA region are highly conducive for industrial honey production. However, there is a need to harmonize policy and supportive structures at the regional and national levels so as to guide the development of the honey industry. It is important to put in place an effective and harmonized regulatory framework and enforcement of standards in collaboration with all concerned stakeholders that can be used to direct the enhancement of the apiculture sector and intra, inter-regional and global trade. Establishing intra-regional honey bee product supply chains are essential, and it requires significant support to sustain supplies, improve trade efficiencies and enhance the quality of products.

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BEEKEEPING TECHNOLOGY ADOPTION IN ARID AND SEMI-ARID LANDS OF SOUTHERN KENYA

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Abstract

This study was conducted in Kibwezi Sub-County, south eastern Kenya. This is a typical semi-arid area and beekeeping is a major economic activity. Although various beekeeping technologies have been available in the study area for many decades, information on the effect of these technologies on the production levels of hive products and on the farmers' social and economic conditions has been lacking. This study was undertaken to establish the factors that determine the adoption of various beekeeping technologies and the impacts of these technologies on the production of hive products. Data were collected through formal interviews using a structured questionnaire. Systematic random sampling was applied to select a sample size of 170 households. Results indicated that 90 out of 170 respondents, representing 52.9% were beekeepers. Of the adopters, 75.6% were found to be using traditional technology while the rest were using modern technology. Descriptive analysis revealed that the major factors that determine the choice of beekeeping technology include the cost, availability and capacity to implement a management regime of a particular type of technology. Analysis using a binary logistic model indicated that the gender of a household head, size of a household, size of land holding, size of a herd and access to extension services significantly influenced the adoption of beekeeping technology. Application of the Cobb-Douglas production function suggested that variable capital items, labour and managerial skills have a significant contribution to output. Recurrent droughts, pests, vandalism, deforestation and inadequate extension services were found to be the main constraints to the adoption of beekeeping technology. The study therefore recommends the provision of more focused extension packages to impart the necessary skills on bee management. The capacity of the existing farmer groups and associations involved in beekeeping activities should also be strengthened in an effort to enhance productivity

Key words: Adoption, beekeeping, technology, productivity, semi-arid

ADOPTION DE LA TECHNOLOGIE DE L'APICULTURE DANS LES ZONES ARIDES ET SEMI-ARIDES AU SUD DU KENYA

Resume

La présente étude a été menée à Kibwezi, dans le sud-est du Kenya. Cette partie du pays est une zone semi-aride typique, et l'apiculture y est une activité économique majeure. Bien que diverses techniques apicoles soient disponibles dans la zone d'étude depuis de nombreuses décennies, il manque des informations concernant l'effet de ces méthodes sur les niveaux de production des produits de la ruche et sur les conditions sociales et économiques des apiculteurs. L'étude a été réalisée dans le but d'établir les facteurs qui déterminent l'adoption de diverses techniques apicoles et l'impact de ces techniques sur la production de produits de la ruche. Les données ont été recueillies au moyen d'entrevues formelles à l'aide d'un questionnaire structuré. Un échantillonnage aléatoire systématique a été appliqué en vue de sélectionner un échantillon de 170 ménages. Les résultats font ressortir que 90 sur 170 répondants, soit 52,9%, étaient des apiculteurs. 75,6% utilisait la méthode traditionnelle tandis que le reste utilisait la technique moderne. Une analyse descriptive a révélé que les principaux facteurs qui déterminent le choix de la technique apicole comprennent le coût, la disponibilité et la capacité à mettre en œuvre un régime de gestion d'un type particulier de technologie. Une analyse utilisant un modèle logistique

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binaire a indiqué que le sexe du chef de ménage, la taille du ménage, la taille de l'exploitation, la taille de la colonie et l'accès aux services de vulgarisation influençaient considérablement l'adoption de la technologie apicole. L'application de la fonction de production Cobb-Douglas porte à croire que la variabilité des éléments de capital, le travail et les compétences de gestion apportent une contribution significative à la production. Il a été constaté que les sécheresses récurrentes, les parasites, le vandalisme, la déforestation et l'inadéquation des services de vulgarisation sont les principaux obstacles à l'adoption de la technologie apicole. L'étude recommande donc la mise en place de programmes de vulgarisation plus ciblées pour conférer les compétences nécessaires à la gestion des abeilles. Il faudrait également renforcer la capacité des groupes et associations impliqués dans les activités apicoles afin d'améliorer la productivité.

Mots-clés : adoption, apiculture, technologie, productivité, semi-aride

Introduction

Beekeeping is an old art in Kenya that has been practiced since time immemorial by most communities. Historically, the production of honey has been a major industry in the African economy and a vital factor in African culture (Nightingale, 1976). Beekeeping gained recognition as a commercial enterprise in the late 1960's (Kigatiira, 1976).Currently, two types of production technologies, traditional and modern beekeeping are widely used in the country.

Traditional beekeeping systems in Kenya are based on the use of local materials for hive construction, the application of indigenous knowledge and the experience of beekeepers. Modern forms of beekeeping entails the use of top bar hives, frame- hives and accessories such as protective clothing, bee smoker, bee brush and hive tool. Bee management and product handling techniques which improve the quantity and quality of hive products are also practiced under this production system.

Although these technologies have been available in the country for many years, what is not clear is their effect on the production levels of hive products and on the farmers' social and economic conditions. As noted by Carroll (2006), some of the technologies have had only limited impact in enhancing production.

The overall aim of this study was to establish the factors that determine the adoption of various beekeeping technologies and the impact of these technologies on the production of hive products. Specifically, the study sought to determine the technical, ecological and socio-economic factors that influence the adoption of beekeeping technologies and the extent of adoption of the various technologies. The study further sought to estimate the benefits in terms of incomes and productivity levels that accrued from adopting the various beekeeping technologies.

Methodology

Study area:

The study was conducted in three locations of the semi-arid Kibwezi Sub-County which is situated about 200km south east of Nairobi. The area receives bimodal rainfall with an average of 600mm annually and an average annual temperature of 230 C. Sixty per cent of the annual rainfall in the study area is received during the short rains from November to early January (Gichuki, 2000).

Vegetation in the area is dominated by Adansonia digitata, Commiphora, Acacia and allied genera, mainly of shrubby habitat (Touber, 1983). Perennial grasses include Cenchrus ciliaris, Enteropogon macrostachyus, Chloris roxburghiana and Pennisetum mezianum.Much of the original vegetation has been modified through cutting of trees, clearing, burning and grazing.

Data collection:

Primary data were collected through formal interviews by way of a structured questionnaire, on- the- spot field observations, key informant interviews and focus group discussions. Secondary data were sourced from literature and relevant government departments.

Sampling technique:

A sample of 170 households was selected for the study from three locations of Utithi, Ngwata and Kikumbulyu each contributing 60, 50 and 60 respondents respectively. The locations were purposively selected based on the presence of adopters of beekeeping technologies. Motorable tracks were used as transects with each location constituting about a 40-50km long transect. Systematic sampling was conducted in every other homestead along the identified transects.

Methods of data analysis:

Data collected through personal interviews and group discussions were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS). Regression analysis was employed to estimate productivity and to establish factors affecting adoption of beekeeping technology. The Cobb-Douglas production function as described by Urama and Mwendera (2005) was used to estimate productivity levels while binary logit model was used for determinants of adoption (Shariff *et al.,* 2009; Aldrich and Nelson, 1984).

Results

More than fifty percent (52.9%), of the respondents were beekeepers. Of the adopters of beekeeping technology, the majority (75%) utilized traditional technology while 25 % had adopted modern technology. Close to half of the adopters (48%) were in the age category of 31-50 years, while 38% were in the age bracket of over 51 years. Only 14% were youth in the 18-30 year bracket. . These findings are consistent with the results of Mwanthi (2009) who found out that the adoption of range resource management technologies in Kibwezi was by those in the age category of 31-50 years. The results also confirm observations that the most youth may have a negative attitude towards beekeeping and are reluctant to take up the practice. The disinclination of youth to join beekeeping has been suggested as one of the reasons why beekeeping is on the decline in many parts of the country.

Size of land holding influenced adoption of beekeeping. Adoption rates in relation to land sizes are presented in Table 1. Individual land parcels ranged from 0.4 hectares to more than 8 hectares. Of the 37.1% who own between 0.4 to 2 hectares, 14.1% and 22.9% are adopters and non adopters of beekeeping technology respectively. Of the farmers sampled, 11.8% own between six and eight hectares of land. Out of this group, 9.4% were found to be adopters and 2.4% were non-adopters. A significant number (16%) of the non-adopters cited small land holdings as one of the reasons for not taking up the technology. These findings are comparable to those of Demeke (2003) who reported that farm size positively and significantly affected farmers' decision to adopt new soil conservation technologies.

Table 2 presents the relationship between some socio-economic variables and the adoption of different beekeeping technologies. Among the adopters, only 30% had received some training in bee management in the previous one year. Of those who had been trained, 7.8% were adopters of traditional technology while a majority (22.2%) had adopted modern technology. This observation is consistent with that of Zegaye et al. (2001) who reported that training contributed positively to farmers' adoption decision. The same trend was also observed as concerned access to extension services whereby among the recipients of extension services, 22.2% were adopters of modern technology while the rest (1.1%) were adopters of traditional technology. This observation closely tallied to that of Ouma et al. (2002) who reported that that access to extension services plays an important role in influencing the adoption of agricultural innovations.

The survey results show that 53.3% of the beekeepers are members of a self-help group. Of the total number of beekeepers who were members of these groups, 36.7% and 16.7% are adopters of traditional and modern technologies respectively. This is an indication that being a member of a Self Help Group (SHG) does not influence the adoption of traditional beekeeping but it may

Table 1: Land Size and Adoption of Beekeeping

Land size (Hectares)	Frequency (n=170)	% Total	% Adopters (n=90)	% Non-adopters (n=80)
0.4 -2.0	63	37.1	14.1	22.9
2.4- 4.0	50	29.4	14.7	14.7
4.4- 6.0	22	12.9	7.6	5.3
6.4- 8.0	20	11.8	9.4	2.4
8.4 and above	15	8.8	7.1	1.8

Table 2: Summary of variable socio-economic factors affecting technology adoption

Variables%	%Total	% of adopters based on technology type	
		Traditional	Modern
Beekeeping Training (%Yes)	30	7.8	22.2
Access to extension (%Yes)	23.3	1.1	22.2
Access to credit (%Yes)	1.1	1.1	0.0
Membership to Self Help Group (%Yes)	53.3	36.7	16.7

Table 3: Maximum Likelihood Estimates for Beekeeping Technology Adoption Model

Variable	B	SE	Wald	Exp(β)
Constant	-4.463	1.440	9.608*	0.012
Age of household head	0.141	0.320	0.195	1.152
Gender of household head	2.171	0.939	5.348*	8.766
Size of household	0.134	0.066	4.077*	1.143
Size of land	0.231	0.068	11.395*	1.260
Livestock holding	0.110	0.052	4.503*	1.117
Off-farm income	-0.551	0.586	0.885	0.576
Membership to SGH	-0.140	0.414	0.115	0.869
Access to extension services	5.028	1.178	18.207*	15.161

*Notes: *Significant at (P<0.05), -2 Log likelihood=151.658, Model Chi-square= 6.575*

Table 4: Estimated Coefficients of Cobb-Douglas Production Function (Adopters n=90)

Variables	B	SE	T
Constant	- 1.804	0.785	- 2.298*
Labour cost (X_1)	0.934	0.089	10.489*
Land size (X_2)	- 0.141	0.125	0.262
Capital cost (X_3)	- 0.298	0.092	-3.232*
Managerial skills (X_4)	0.617	0.281	2.199*
Experience (X_5)	0.130	0.106	1.232

*Notes: *Significant at (P<0.05), F=27.492, R2=0.621, Adj. R2=0.598*

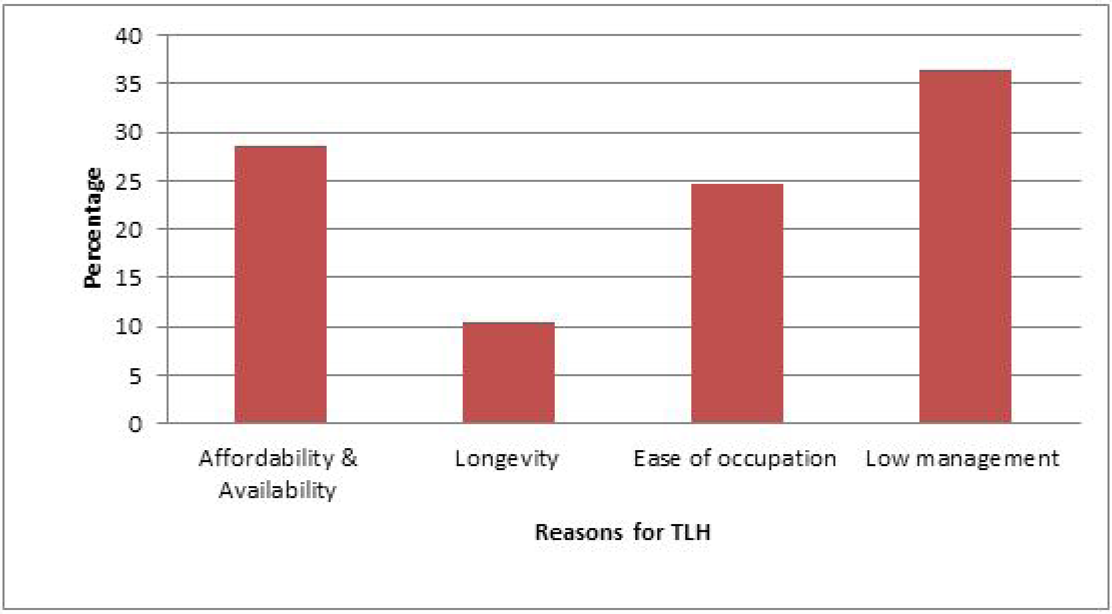

Figure1: Households Reporting Reasons for Choosing Traditional Log Hives (TLH)

have a significant influence on the adoption of modern beekeeping which was introduced in the area through groups as opposed to traditional beekeeping which is passed-on from one generation to the next along family lines.

Preference for a particular technology was based on affordability, availability, management regime, size of land holding, productivity level and quality of the products. Low cost, availability, and ease of occupation by honey bees were the most important considerations for adopters of traditional technology was illustrated in figure 1. Adopters of improved technology cited ease of management, less land requirement and quality of hive products as the major reasons for their choice to invest in modern equipment.

Binary regression analysis was used to test the influence of a number of explanatory variables on household beekeeping technology adoption or non-adoption. As illustrated in Table 3, the gender of a household head, size of a household, size of land holding, size of a herd (a proxy indicator of wealth) and access to extension services had significant($P<0.05$)effect on the adoption of beekeeping technology.

The Cobb-Douglas production function was applied to estimate the influence of labour, size of land holding, capital input, farmers' hands-on experience and managerial skills on honey output.Results of this analysis are given in Table 4 and show that labour, capital and managerial skills as a group had a significant ($P<0.05$)contribution to output.The parameter estimates measure the responsiveness of output to a change in the levels of respective variables (Tan, 2008). The cost of labour and managerial skills had a positive and significant influence on output. This means that a 1% percentage increase in these variables would increase honey output by 0.934% and 0.617% respectively. This shows that it would be profitable to expand investment on these two factors of production.

Discussion

Beekeeping is a suitable farming activity in the study area and has the potential to enhance environmental conservation as well as improve household income and nutrition. The adoption of improved technology is however low as a majority of the beekeepers prefer using traditional technology.The main reasons behind the preference of this technology include low cost, ease of availability and low management requirements. The high cost and unavailability of modern technology are major constraints to its adoption in the area. Reasons for non-adoption was mainly due to lack of skills, capital, small land sizes and cultural inhibitions while the adoption of beekeeping technology was driven by increased income, modest start-up capital and other benefits that accrue from beekeeping such as food and medicine.

The results revealed that adopters of either technology could experience increasing returns to scale implying that the beekeepers in the study area are prone to production inefficiencies.The beekeepers are underutilizing variable inputs compared to the fixed resource outlays and can obtain more output per unit if they increased the level of variable inputs.

Capital costs had a significant but negative influence on output, an indication that more investment on capital costs would not necessarily result in increased output. Only the labour cost was significant across both technologies. This implies that investing more in labour is fundamental to increasing honey productivity for both adopters of modern and traditional beekeeping traditional. This means that more time should be invested on aspects of colony management such as hive inspection, pest control, colony multiplication and colony feeding for increased honey output. While labour in the study area may not be scarce per se, results indicate that farmers allocate very little time to beekeeping activities or do not invest in the correct activities

Although beekeeping is an important livestock enterprise among the agro pastoral households in the study area, there has been a notable decline in production for the last decade. This can be attributed to externalities such as recurrent droughts and deforestation. Factors internal to the beekeeping enterprises also play a major role. These include ineffective control measures for bee pests and predators, vandalism and inefficiency in the allocation and utilization of resources by the farmers. Lack of to bee husbandry skills, poor access to extension services and credit facilities were also found to be major constraints to adoption.

The study therefore recommends the following policy interventions;

- The provision of more focused extension packages to impart the necessary skills on bee management.
- The capacity of the existing farmer groups and associations involved in beekeeping activities should also be strengthened in an effort to enhance productivity.
- There is need for the beekeepers to investment more in better deploying labour in terms of quantity i.e., time allocated to beekeeping and to quality i.e., time allocated to specific activities that are necessary for managing the enterprise.
- Promote youth participation by inculcating business skills and entrepreneurship development
- There is need to preserve the indigenous vegetation in an effort to slow down land degradation and thus ensure sustainability of beekeeping.

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STRENGTHENING THE RESILIENCE OF WOMEN AND YOUTH IN SOMALIA TO ECONOMIC SHOCKS THROUGH BEEKEEPING

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Abstract

Somalia has a huge potential for the production of honey and other hive products. Though traditionally practiced for centuries, apiculture, like many other sectors in the country has suffered from low knowledge and skills and poor perceptions in regard to modern beekeeping technologies. There is a pervading lack of awareness of the high potential for value-addition in processing of hive products and the real opportunity for income generation and investment that beekeeping provides. Capacity development and material support were therefore identified as indispensable incentives for the sustainable production of honey and other hive products. Since 2013, FAO has intervened in apiculture in Somalia with the support of UKaid by forming rural beekeeping village groups and further supporting the groups with beekeeping equipment and tools as well as technical knowledge transfer. The goal of FAO interventions is to diversify households' income and employment opportunities, mainly targeting women and youth. This paper discusses the challenges and impacts of FAO's intervention in Somalia in strengthening the productive capacity of the beekeeping sub-sector. It is evident that technical support and provi¬sion of equipment to beekeepers provides significant alternative income and employment sources for rural households and improves their livelihoods. From the initial lessons learnt during a pilot phase, FAO has replicated beekeeping activities suc¬cessfully in several regions of Somalia by opening opportunity for more women and youth into beekeeping with over 750 households currently benefitting since 2013, with a potential to produce 22.5 Mt of honey annually. Further, the role of women and youth in building sustainable models of rural development has been demonstrated: it is suggested that technical and institutional capacity be strengthened, including establishment of appropriate food safety standards for hive products in the context of Somalia to meet customer needs in local and external markets. Gendered value-chain analysis is also required to delineate relative share of benefits, especially to women and youth.

Keywords: Bee-keeping, Women, Knowledge transfer, Honey

RENFORCEMENT DE LA RESILIENCE DES FEMMES ET DES JEUNES AUX CHOCS ECONOMIQUES PAR LE BIAIS DE L'APICULTURE EN SOMALIE

Résumé

La Somalie dispose d'un énorme potentiel de production de miel et d'autres produits de la ruche. Bien que traditionnellement pratiquée pendant des siècles, l'apiculture, comme beaucoup d'autres secteurs dans le pays, souffre du manque de connaissances et compétences et de perceptions inadéquates en ce qui concerne les technologies modernes de l'apiculture. Il existe un manque omniprésent de conscience de l'important potentiel de valeur ajoutée dans la transformation des produits de la ruche et de l'opportunité réelle de production et d'investissement offerte par l'apiculture. Le développement des capacités et le soutien matériel ont donc été identifiés comme des incitations indispensables pour la production durable de miel et d'autres produits de la ruche. Depuis 2013, la FAO intervient en apiculture en Somalie avec

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le soutien de UKaid en formant des groupes de villages en apiculture en milieu rural et en soutenant ces groupes avec des équipements et instruments utiles pour l'apiculture, et en assurant le transfert des connaissances techniques. L'objectif des interventions de la FAO est de diversifier les revenus des ménages et les opportunités d'emploi, en ciblant principalement les femmes et les jeunes. Ce document examine les défis et les impacts de l'intervention de la FAO en Somalie dans le renforcement de la capacité de production du sous-secteur de l'apiculture. Il est évident que le soutien technique et la fourniture du matériel aux apiculteurs fournit des sources de revenu et d'emploi alternatives importantes pour les ménages ruraux et améliore leurs moyens de subsistance. Dès les premiers enseignements d'une phase pilote, la FAO a reproduit les activités apicoles avec succès dans plusieurs régions de la Somalie en ouvrant des débouchés aux femmes et aux jeunes engagés dans l'apiculture, avec plus de 750 ménages bénéficiaires depuis 2013 et un potentiel de production de 22,5 TM de miel chaque année. En outre, le rôle des femmes et des jeunes dans la construction de modèles durables de développement rural a été démontré : il a été proposée que la capacité technique et institutionnelle soit renforcée, y compris l'établissement de normes appropriées de sécurité sanitaire des aliments pour les produits de la ruche dans le contexte de la Somalie, afin de répondre aux besoins des clients sur les marchés locaux et extérieurs. Une analyse de la filière axée sur le genre est également nécessaire pour délimiter la part relative des bénéfices, en particulier pour les femmes et les jeunes.

Mots-clés : apiculture, femmes, transfert de connaissances, miel

Introduction

Somalia has one of the lowest Gross Domestic Product (GDP) per head, and a population vulnerable to different types of shocks that affect crops and livestock, with related income variability. Recurrent droughts, for instance, experienced in Somalia, in combination with pervasive poverty, means that communities barely recover from one shock before being subjected to the next (FAO, 2013). In addition, without sustainable resource management, it is difficult to increase productivity to reduce the poverty and food insecurity of the pastoral and agropastoral populations. The Resilience Sub-Programme of the Food and Agriculture Organization (FAO) of the United Nations addresses some of the critical dimensions of increasing adaptive capacity and reducing vulnerability to the recurrent shocks at individual, household and community levels. The Programme focuses on livelihood strategy diversification; increasing food production in a sustainable manner including periods after crises and shocks; and improving access to knowledge and better services in order to enhance productivity, among other interventions.

Modern beekeeping has been shown to provide a good alternative livelihood diversification strategy that could stabilize annual household income flows and food security through incomes generated from the sale of honey and other hive products during the meager months in addition to creating employment opportunities for rural communities in several countries including Ethiopia (Abebe, 2011), Nigeria (Fadare *et al.,* 2008), Kenya (Gichora *et al.,* 2011) and Saudi Arabia (Adgabal *et al.,* 2014). Somalia possesses extremely diverse botanical resources which flower throughout the year and provide an almost ideal environment for apiculture but its potential is grossly under-exploited (Musumhi, 2013). Moreover, beekeeping is less affected by erratic rainfall conditions characteristic of Somalia than the growing of annual crops, as honeybees can produce honey following any opportunistic rainfall and subsequent flowerings. While today there is not much documented evidence on the current practice of beekeeping in Somalia, institutional memory points to the fact that there was a positive trend in the industry with high prospects for growth in the early 1980s (Musumhi, 2013). Additionally, no systematic approach has been undertaken to promote the modern beekeeping technologies, consequently the majority of farmers still rely on production from traditional simple log hives. Other challenges to beekeeping in

Somalia include low knowledge and skills for managing hives, increasing production and value-added hive products; poor marketing infrastructure within the communities; and poor business and entrepreneur skills to help bee-keepers tap the vibrant local and export honey markets (Musumhi, 2013; FAO, 2014). Since 2013, FAO, under the UKaid funding has intervened to revitalize the bee-keeping sector by introducing modern apiculture technologies and associated technical support to pastoral and agropastoral communities in Somalia that will improve productivity and profitability. FAO under the support has focused on the formation of women dominated bee-keeping groups, due to women's increased vulnerability and marginalization in agricultural-related activities.

Materials and Methods

Biophysical data collection on apiculture status

A rapid appraisal of households within four villages in Burao District, Togdheer Region of Somalia was carried out in 2013 prior to FAO's intervention. The area was purposively selected since it is traditionally known for apiculture relative to other parts of Somalia. Data were collected from a sample of 118 village members with the sample respondents being stratified according to villages. The respondents were interviewed using semi-structured questionnaires, which was supplemented and validated by the information collected through the group discussion and key informant discussions using a check list, and personal observations. The objectives of this study were to establish the baseline upon which the impact of FAO's interventions would be gauged and identify challenges to beekeeping including causal factors to low honey production. The collected data were managed and analysed using descriptive statistics using computer software-Ms Excel and SPSS. Additional information was collected from secondary sources including available reports and consultations with beekeepers during subsequent technical training of beekeepers organized by FAO.

Formation of beekeeping groups

During the pilot phase, FAO selected three existing beekeeping groups, with a membership of 190 members (109 women; 81 men) in Togdheer region of Somalia. These groups were supported to improve their beekeeping by FAO through the Sustainable Employment and Economic Development (SEED) Programme, funded by UKaid. Through FAO's facilitation, an additional 12 beekeeping groups were formed in other parts of Somalia based on the lessons learnt from the pilot phase. New groups, consisting of a total of 758 members of which 56% were women and youth, were identified through a participatory process involving the local leaders, elders and the community members. The groups were equally supported with honey production and processing equipment. A gender-sensitive selection criterion was maintained throughout the formation of the groups, a process that ensured 425 women and youth were included in the groups. A decisive factor in the selection was the beneficiaries' common interest in the beekeeping technology and capacity to interact with and share information with other members of the group, and their communities. A social-mobilization group approach was considered appropriate since groups have been observed to realize higher rates of adoption of beekeeping enterprise than individuals (Bhusal and Thapa, 2005). Groups walso have the structures to manage assets better, such as equipment and fixed assets including honey processing infrastructure. Farmer-to-farmer sharing of knowledge and skills was encouraged among beneficiary groups' members given that regular extension service is weak. This form of extension had significance not only in terms of injecting greater community ownership of the technology but also creating sustainability mechanisms for scaling-up impacts post-FAO support period.

Beekeeping capacity development

Since the initial pilot phase, FAO continued to support emerging beekeeping groups with material incentives and technical training. The material support included introduction of modern Kenya top-bar hives (KTBH) and Langstroth hives, and related equipment and tools (honey extractors, honey presses, smokers, hive tools, aprons, veils, hand gloves etc.). Group members were trained in all aspects of general bee husbandry ranging from catching bee swarms, colony management, foraging management and pollination, swarming and absconding control, honeybee pest and disease management to quality harvesting and bee-hive products (economic uses and health benefits), processing of honey and beeswax into various value-added products (soaps, body creams, candles etc.). The beekeeping groups were also trained on rural commercialization and record keeping through the use of basic numeracy and literacy skills, with emphasis on improved quality controls for product standards maintenance and financial management. An experiential and participatory mode of training sensitive to different kinds of learning needs aided by use of locally available materials, where possible, was maintained in recognition of the low literacy levels of beneficiaries. Special attention was placed on women members who, like many other women in Africa, largely have little or no rights to property, which infringes on their access to modern technological inputs and credit markets, thus dragging their households towards poverty (Berem *et al.*, 2011). Additional artisanal training to instil basic skills on the construction of hives and related tools was conducted targeting the youth members with above average skills from selected beekeeping groups.

Monitoring and evaluation indicators were established during the group formation stage through a participatory manner to ensure project measurable results were inclusive or relevant to create desired impacts. Some of the indicators included the household incomes and employment opportunities of the modern beekeeping intervention generated for targeted households.

Assessment of the benefits of modern beekeeping technology

Data to quantify the economic potential of modern beekeeping technology was collected through a participatory manner from one of the already existing beekeeping groups supported in 2013 by FAO in the pilot phase. The selected group (Raddin Beekeeping Group) in Togdheer Region of Somalia comprises of 30 men and 27 women. Data collected included the annual mean honey yields and the costs related to the technology (principally hives, honey processor, minor tools, and processing ingredients). The data was used to calculate financial benefits using the Net Returns (NR) analysis method from two case scenarios: Scenario 1, selling of refined honey alone vs. Scenario 2, selling of value-added products from honey and wax. The total revenue represented the honey sales and other hive products, while the total costs include fixed costs (e.g. costs of hives, smokers, bee kits, honey processor and depreciation) and variable costs (labour, storage bottles, sieve cloth, soft brush, detergents, torchlight). The annual mean honey yields were assumed to be 18 and 30 kg per hive from the Langstroth and KTBH hive, respectively as obtained in the group's apiary, sold at a mean value of $ 14 per kg. The yield from local hives was assumed to be 5.2 kg based on the initial survey results.

Results

Status of apiculture in Somalia

The household survey carried out in Burao District, Togdheer region of Somalia indicated that out of 118 households interviewed, only 17% were involved in beekeeping compared to those in meat vending (49%), fodder production (13%), enterprise development (13%) and hides and skins trade (3%). The survey results indicated that there was low participation in apiculture contrary to general perception. It was observed that all beekeepers kept the simple traditional log hives, whose average annual honey yield per hive was estimated to be rather low (average of 5.0 kg). The beekeepers interviewed produced and sold crude (raw) or semi-processed honey directly to consumers on an individual basis, and through personal communication: a pervading practice across Somalia. The demand for honey in surveyed area was high with ready

Table 1: Comparative costs of investment and annual returns per hive type from processed products for Raddin Beekeeping group in Somalia

Scenario case 1: Honey alone	**KTBH**			**Langstroth hive**		
	Amount per year	**Cost per kg, USD**	**Total, USD**	**Amount per year**	**Cost per kg, USD**	**Total, USD**
Total honey yield per hive	18	13	234	30	15	450
Total revenue	-	-	234	-	-	450
Costs of packaging honey & local marketing (500-g bottles)	36	0.05	1.8	60	0.05	3
Unit Costs per beekeeper of hive, honey processors and basic toolsa	-	-	90	-	-	100
Total costs	-	-	91.8	-	-	103
Net returns per hive (beekeeper) from honey and wax			142.20			347
Scenario case 2: Value-added products						
Total honey processed per hive	18	-	-	30	-	-
Amount of waxb	4	-	-	1.0	-	-
Amount of body 100-g body creams (bottles)	200	1	200	50	1	50
Amount of toilet soap (bars)	300	0.5	150	75	0.5	37.50
Total revenue	-	-	550	-	-	87.50
Costs of processing ingredients & packaging & local marketing	-	-	20	-	-	5
Unit Costs per beekeeper of hive and processing equipment and tools & delivery			65			80
Net returns per hive (beekeeper) from soap and body creams			465			2.50

aCost of technology: hives, harvesting gear & minor tools and honey processor with cost of the processing equipment shared among 50 members of the group.
bWax used in preparation of value-added products

market within both the villages and rural urban centres. The price of honey varied ranging between $ 10 and $ 15 per kg. Beekeepers interviewed cited frequent migration of bees and pest (insect) attacks as main reasons for the low honey yields from the local hives, the most prominent pests being the banded bee-pirate and honey-barger (Mellivora spp.) None of the beekeepers had attained education beyond primary level, with nearly half of them having no formal education.

With regard to the modern hives technology, it was found that all members of the formed beekeeping groups fully adopted the hives irrespective of their gender. The members cited the expected high honey yields and the potential for providing an empowering diversification strategy as the main motivating factors to adoption. Furthermore, women and youth were endeared to the modern hives as the technology generally require low capital investment (one-off investment whose costs can be recouped over short period), little requirement for land ownership since modern hives can also be located near or within homesteads and technical requirements generally low enabling women, a majority of whom are illiterate, to manage with minimum basic experiential training.

Honey yield from modern beekeeping technology

Observation of all supported beekeeping groups that adopted modern beekeeping technologies showed that members were able to manage their apiaries, with most of the hives being well colonized by bees. The principal hive product of interest to beekeepers was honey. From a participatory assessment of the yield of honey, from one of the groups supported with modern hives in the pilot phase, it was noted that the average annual honey yield per hive increased from a mean of 5.2 kg observed in the traditional hives to an annual average of 30 and 18 kg for the Langstroth hive and KTBH hive, respectively. The number of annual harvests also increased from 1.8 up to 2-3 harvests for the traditional and modern hives, respectively.

The current scenario analysis demonstrates that either of the two modern beekeeping technologies results in additional incomes to households whether honey alone or value-added products are sold (Table 1). Depending on beekeepers value-added product preference and availability of processing equipment, the KTBH results in high returns than the Langstroth from value-added products due to its relatively higher yield of wax. The net return per beekeeper averaged across the two hive technologies from honey sales alone was USD 244.60 and USD 233.75 for value-added products (Table 1).

Market and value-chain development

Despite the increased honey from the use of modern beekeeping technology and increased local demand, one major challenge cited by honey producers was lack of organized markets for the honey. The majority of rural honey producers had a limited market reach mainly restricted to the local rural centres since they sold their products directly to consumers based on personal communication. This is an indication that the honey market was not efficient or well organized. A proposed scheme for linking to reliable and stable markets was conceptualized for Somalia smallholder beekeepers through various informal discussions with stakeholders (Figure 1).

The major aspects of the proposed scheme are that it will provide better opportunities for the formation of beekeeping production and marketing cooperatives or associations targeting both low- and high-end markets, and evolvement of multiple value-chain actors, promoting private entrepreneurs to provide additional services such as value-addition of hive products, financing of various value-chain segments and promoting platforms for market information exchange along entire beekeeping value-chain. The scheme will allow beekeeping groups benefit from economies of scale along collective bargaining, delivery of inputs and services including business development services (BDS) and a platform for unrelated enterprises to mushroom.

The operationalization of this scheme

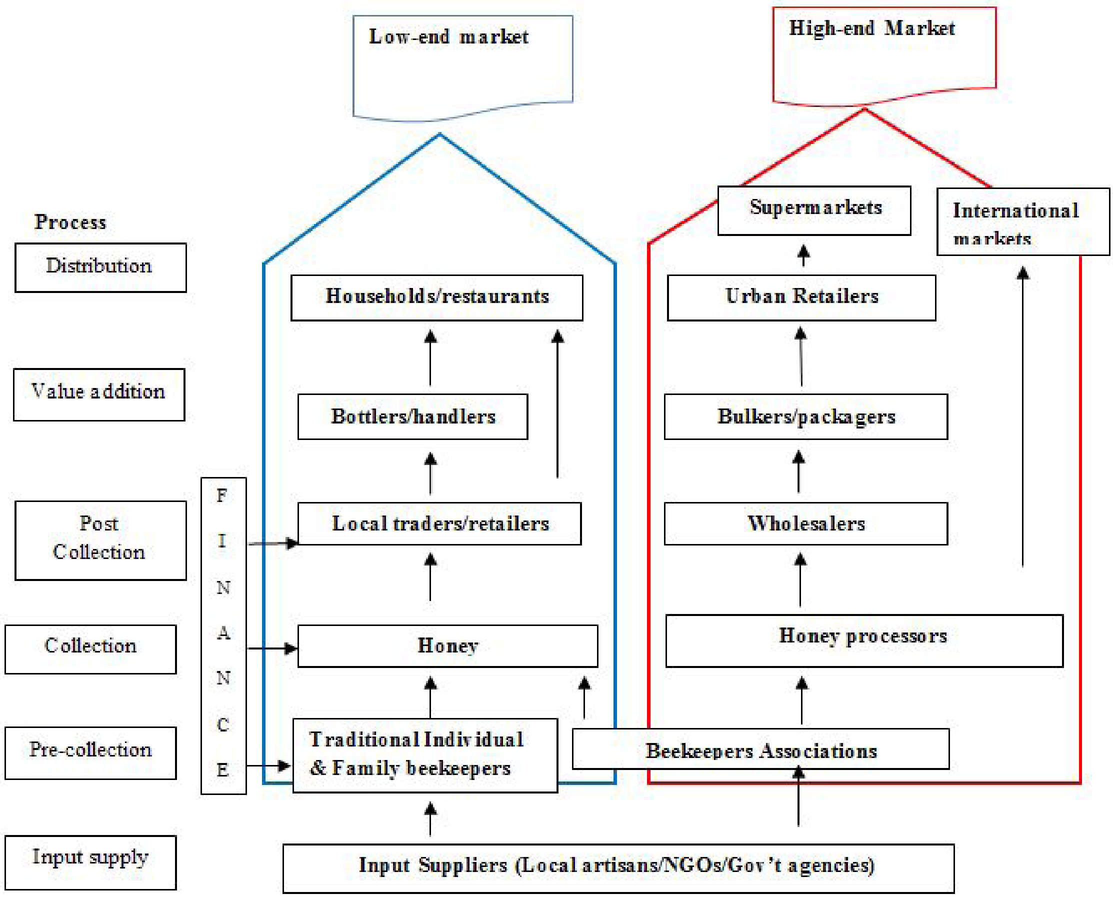

Figure 1: The suggested Honey Value Chain Map for Somalia

will require first a detailed gendered and participatory value-chain analysis and mapping of the beekeeping subsector involving relevant stakeholders as part of a broader implementation strategy. This should be followed by other stakeholders' forums that should provide opportunities not only for identifying main chain actors and bottlenecks along the entire inputs supply-production-marketing-consumption continuum, but also development of linkages to stable and reliable markets. It will, however, be important to stimulate development of an enabling environment for improving investment opportunities and competitiveness of the entire Somali beekeeping sector. Among the critical regulatory instruments required is putting in place credible and cost-effective systems food safety measures and quality certification system. The certification system will allow at least some basic tests of honey quality be available and routinely carried and to the extent possible support the establishment of traceability and recall modalities.

Gender dimensions of the technology

The deliberate and conscious integration by FAO of gender-responsive beekeeping interventions enabled women, youth and men to learn new technical and business skills in beekeeping side by side. Thus the intervention created a platform for a major socio-economic change by shifting a culture where men are considered major decision-makers. Women were therefore able to make decisions freely and on an equal footing with men on the project, their lives, and improved nutrition and food security. Whereas women were not traditionally involved in the beekeeping activities before, they became more active participants besides their household activities while benefitting from a more consistent income flow and increased nutritional security. Apart from the increased economic returns, modern beekeeping interventions opened new opportunities for employment to the beekeeping group members with 263 women, men and youth hitherto unemployed being fully absorbed into the beekeeping activity; this represented about 35% of the total 758 households supported. The perception of farmers towards beekeeping totally changed with the introduction of improved technology with many farmers, especially women citing the technology as less labor-intensive and requiring minimal land, making it an accessible source of income for women as well as vulnerable households with limited access to resources. Further, the technical requirements were generally low and women, majority of who are illiterate, were able to manage with the minimum basic experiential training offered.

Knowledge transfer and sharing

The technical training during the pilot phase formed the initial core of technical information repository, which through further rolling out of training to the other groups formed later greatly increased the critical mass of knowledge and skills bearers, to over 3,000 beneficiaries. The beekeeping groups already formed through FAO intervention are being consolidated into producer cooperatives not only to strengthen the groups' marketing power but also improve knowledge sharing and transfer. It was observed that the additional artisanal training provided to selected youth was applied by some in constructing the KTBH hives. Creating such opportunities will also increase the number of people with decent, socially recognized work, especially women and youth. Currently, the bulk of hives and basic beekeeping tools in Somalia are imported at prices that are prohibitive to many prospective beekeepers.

Discussion

The low honey yield per hive in the current study is consistent with other traditional beekeeping systems that have also exhibited low average annual honey yields per colony: 4.2 kg in Nepal (Bushal and Thapa, 2005); 5.6 kg in Ethiopia (Abebe *et al.,* 2008); 6.7 kg in Nigeria (Fadare *et al.,* 2008); 6.3 kg in Kenya (Gichora *et al.,* 2001); 3.7 kg in Saudi Arabia (Adgabal, *et al.,* 2014) and 4.0 in Pakistan (Muzaffar, 2000, as cited by Bushal and Thapa, 2005). Although it was not clear why there was no refining (value addition) of crude honey given the potential benefits and the available market, the lack of awareness on the economic opportunities provided by value-addition and unavailability of processing equipment are considered to be the main factors.Though honey yield per hive would depend on many factors such as adoption of traditional practices, inadequate technical skills to manage the hives and a poor perception on the economic potentiality of apiculture, the general conclusion is that a low adoption of modern beekeeping technologies in the study area and indeed many parts of Somalia is primarily the major factor limiting honey production. The low productivity may further be compounded by other indirect factors such as the presence of pests such as honey badgers and banded bee pirate, as pointed-out by the Somali beekeepers. Honeybee pests and diseases and death of bee colonies have been ranked high among constraints affecting beekeeping development in Ethiopia (Abebe *et al.,* 2008) and Kenya (Gichora *et al.,* 2001). Honey-badgers, for instance, are considered the most destructive mammalian predators of honeybees causing substantial colony and production losses.in Africa (Hepburn and Radloff, 1998), including Somalia (Musumhi, 2013; FAO, 2014). There are new emerging invasive species of honeybee pests and diseases due to climate change (Abrol, 2011), as well as the rapidly spreading parasitic mite, Varroa destructor that has inflicted massive damage to both commercial and wild honeybee populations almost worldwide (Anonymous) that also require attention. Unfortunately, there is no functional surveillance and research systems in Somalia tailored to the eradication of harmful pests and diseases. It is suggested that partners with a long-term commitment to improving beekeeping in Somalia, including FAO could provide a facilitative role in assisting to strengthen the research capacity, including technical capacity and infrastructure developments to enhance beekeeping pests and diseases surveillance and control.

The study clearly illustrates the positive direct relationship between the adoption of modern hives and increased honey yield per hive, household incomes and potential for employment opportunities. The results concurred with the findings of Berem et al. (2011) and Abebe (2011) who recorded high financial benefits from the adoption of modern hive beekeeping technologies associated with higher honey yields relative to traditional systems. The average yield of honey observed in the current study was also much higher than values reported for the KTBH by Fadare et al. (2008) in Nigeria (12.4 kg) and Adgabal et al. (2014) in Saudi Arabia (6.6 kg), but comparable to the yields reported by Bhusal and Thapa (2008) in Nepal (23.1 kg) and Abebe et al. (2008) in Ethiopia (27 kg). The high economic returns demonstrate a real high potential for sustainable economic development of rural communities in Somalia and scaling-up of the modern technologies should be accelerated. The level of education did not appear to affect the application of the modern beekeeping technology, at least for Somalia despite the low literacy levels; the beekeepers appeared to maintain good management of the apiaries. This contrasts with the findings of other workers who found that education level of household heads positively and significantly influenced adoption and management of improved beekeeping technologies, including value-addition of hive products (Abebe *et al.,* 2008; Berem *et al.,* 2011; Gichora *et al.,* 2001), The observation suggests that enhancing experiential and numeracy literacy skills through training of Somali beekeepers may be more relevant for this technology. Having knowledge of the modern beekeeping technology is crucial for effective and efficient utilization and dissemination of the technology (Abebe, 2011).

The incidence of poverty in Somalia is reportedly high with 43%t of the population living below the extreme poverty line of $1 per day (MNPD, 2012). Therefore beekeeping could have far-reaching impacts in improving rural livelihoods. Some studies have indeed shown strong positive correlations between the household income from honey and poverty reduction (Berem *et al.,* 2011; Rakesh *et al.,* 2011). With 758 households in Somalia supported by FAO since 2013, with a potential to produce 22.5 Mt of honey annually, the economic contribution of modern beekeeping technology to poverty reduction among the rural households is therefore great. More significantly, the introduced modern beekeeping technology in Somalia optimized and unleashed opportunities for women and youth involvement. Marginalization of women worldwide from more productive enterprises and access to productive resources and opportunities greatly reduces their income generating base yet they shoulder responsibilities on children's education, pay for health care, food and clothes (FAO, 2011). Providing an equal opportunities and empowerment to women is now widely recognized as integral and inseparable parts of any sustainable strategy for pro-poor development (Mayoux and Mackie, 2008). Some youth were found to have initiated construction of hives, although not to the expected standards. In addition, the opportunity for alternative source of income demonstrated in this activity could create incentives for communities' investment in reforestation and environment protection ensuring sustainable utilization and management of the natural resources.

Though the conditions of the honey market in Somalia seem encouraging and promise business continuity and sustainability, there is need to streamline market-chain inefficiencies to tap more on both the local and external markets. Adgabal et al. (2014) reported that Somalia honey is a highly valued product in Saudi Arabian culture and religion but local supply cannot satisfy the high demand. A more gendered Value Chain Analysis (VCA) of the beekeeping market value-chain is also suggested that takes cognizance of factors such as market infrastructure and access to credit in order to effectively develop a sustainable market system for the beekeeping sub-sector as recommended by Mayoux and Mackie (2008). The gendered VCA could promote private entrepreneurs to provide additional services especially for specialized value-addition for the high-end markets such as those in the Gulf States, particularly Saudi Arabia. The beekeeping groups would also be better organized to spread the costs of marketing and transportation, improve their ability to negotiate for better prices and increase their market power (Shiferaw, *et al.,* 2006). Social capital (in this case group membership) is a key instrument for knowledge and skills and in essence, farmers benefit both economically and socially if they belong to groups (Berem *et al.,* 2011).

Conclusions and Recommendations

The study has demonstrated that modern beekeeping interventions result in high economic benefits with potential for alleviating rural poverty. The study attributes the observed high economic returns to the introduced modern beekeeping technologies. It is apparent that great effort and initiatives need to be placed on value addition of honey and wax as these guarantees the highest returns. Incorporating gender dimensions as a critical component of the technology provides an equal opportunity to women and youth to benefit from increased incomes and potential employment opportunities. However, to ensure successful upgrading of the technology, it is recommended that stable and reliable market linkages be created and strengthened to enhance market access for products; technical capacity including artisanal skills development continue to be strengthened, including establishment of appropriate food safety standards for hive products in the context of Somalia to meet customer needs in local and external markets. Long-term strategies proposed include establishment of robust research and extension capacity for the transfer of knowledge and adaptation of most appropriate beekeeping technologies.

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TECHNICAL AND SOCIOECONOMIC ASSESSMENT OF HONEY PRODUCTION IN CAMEROON WESTERN HIGHLANDS

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Abstract:

Socio-economic and technical characteristics of 113 beekeepers selected randomly in three Divisions (Bamboutos, Mifi, Menoua) of the Sudano Guinean highlands zone of West Region of Cameroon were assessed through survey using a semi-structural questionnaire, direct interviews and observations from April to July 2014. The main results were as follow: beekeeping is mostly done by men (79.6%) aged between 50-60 years. Many of them are Christians (75.2%), married (88.5%) and taking care of more than 5 persons. 95.6% of the beekeepers have been to school. Some of them have not received a proper training but have been exercising for more than 15 years. The bee colonies, bred through extensive the system, belong to the yellow Apis mellifera adansonii. The number of hives varies from 1 to more than 101, with an average of 40 hives per beekeeper. The fixed (traditional) and mobile (modern) hives are the commonly used. The bait used is mainly wax (91.2%). The interval between hives installation and bee populating as well as hives installation and honey harvest is not evaluated by beekeepers. The products harvested are honey (100.0%), wax (69.9%), propolis (44.2%), pollen (15.9%) and royal jelly (3.5%). The average amount of honey harvest varies from 4 to 7 liters per colony. Honey is kept within the comb or stored in a filtered form. Honey colors were light amber (36.7%). The estimated annual gain from honey production ranged from 16 000 to 16 875 and from 28 125 to 28 625 FCFA per hive, for fixed and mobile hives respectively. Constraints to beekeeping are socio-economic (financial problems), technical (lack or inadequacy of the framework) and pathological (insects). The majority of beekeepers would like to continue the activity and wish to improve and increase the size of the apiary despite these constraints.

Key words: Beekeeping, performances, constraints, perspectives, Western Cameroon.

EVALUATION TECHNIQUE ET SOCIOECONOMIQUE DE LA PRODUCTION DE MIEL DANS LES HAUTES TERRES DE L'OUEST DU CAMEROUN

Résumé

Les caractéristiques socio-économiques et techniques de 113 apiculteurs choisis de manière aléatoire dans trois divisions (Bamboutos, Mifi, Menoua) de la zone soudano-guinéenne des hautes terres de la région ouest du Cameroun ont été évaluées au moyen d'une enquête utilisant un questionnaire semi-structuré, des entrevues et observations directes, d'avril à juillet 2014. Les principaux résultats sont les suivants : l'apiculture est principalement pratiquée par les hommes (79,6%) âgés de 50-60 ans. Beaucoup d'entre eux sont des chrétiens (75,2%), mariés (88,5%) et ont plus de 5 personnes à charge. 95,6% des apiculteurs ont été scolarisés. Certains d'entre eux n'ont pas reçu une formation adéquate, mais ont exercé ce métier pendant plus de 15 ans. Les colonies d'abeilles, élevées en système extensif, appartiennent à l'Apis mellifera adansonii (abeille jaune). Le nombre de ruches varie de 1 à plus de 101, avec une moyenne de 40 ruches par apiculteur. Les ruches fixes (traditionnelles) et les ruches mobiles (modernes) sont communément utilisées. L'appât utilisé est principalement la cire (91,2%). Les apiculteurs n'évaluent pas l'intervalle entre l'installation des ruches et le peuplement des abeilles, ni entre l'installation des ruches et la récolte de miel. Les produits récoltés sont le miel (100,0%), la cire (69,9%), la propolis (44,2%), le pollen (15,9%) et la gelée royale (3,5%). La quantité moyenne de miel récolté varie de 4 à 7 litres par colonie.

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Le miel est maintenu dans le rayon ou stocké sous une forme filtrée. Le miel a une couleur légèrement ambrée (36,7%). Le gain annuel estimatif de la production de miel varie entre 16 000 FCFA et 16 875 FCFA et entre 28 125 et 28 625 FCFA par ruche, respectivement pour les ruches fixes et les ruches mobiles. Les contraintes à l'apiculture sont de nature socio-économique (problèmes financiers), technique (absence ou inadéquation du cadre) et pathologique (insectes). La majorité des apiculteurs souhaite poursuivre l'activité et améliorer et augmenter la taille des ruchers en dépit de ces contraintes.

Mots-clés : apiculture, performances, contraintes, perspectives, Ouest du Cameroun

Introduction:

Recent reports indicate that there is an upward trend in beekeeping in Cameroon over the last decade, mostly attributable to rural communities and dwellers in middle and southern regions (MINEPIA 2011). Current national honey production is not sufficient to meet the fast growing demand (DSCE 2009), and increased domestic production is needed to sustainably meet the demand. .This domestic strategy cannot be implemented without a comprehensive analysis of honey productivity in the country, and an understanding of the whole honey sector, and in particular the production systems. Progress has been made in studying beekeeping in Cameroon, but there remains a paucity of scientific findings, and research is fragmented (Zango 1994, Njia 1999, Abongu 2001, Tchoumboué *et al.,* 2001, Founadoudou 2007, Baimenda, 2010, Tsafack et al, 2011).

The Cameroon western highlands region plays a relatively significant role in honey production being the third region for beekeeping nationwide. Beekeeping is becoming an important economic activity for many households and other stakeholders which needs a proper monitoring system.. The current study aimed at contributing to beekeeping development in order to improve its performances. The objective of the research was to evaluate the relationships between technical and socioeconomic features on one hand and the performances of beekeeping on the other hand. All these being useful for an innovative honeybee sector in Cameroon.

Materials and Methods:

Study area

The study zone constituted of three divisions (Bamboutos, Menoua and Mifi) of the West administrative region (Figure 1). This region is located between 4.79-6.43° Northern and 9.68-11.52° Eastern, between 1,400 and 2,700m above sea level, with an average elevation of 2,000 m above sea level. There are two climatic seasons, the rainy being longer (from March to November) than the dry one (March to November). The predominant natural ecological zones were savannah and marshy forests, but these have been severely modified by human activity. The population density is one of the highest in the country because of relatively rich soils. Agriculture tends to be intensive with use of various technologies. In the dominant mixed-farming systems the main crops are Zea mays, Manihot esculenta, Colocasia esculenta, Xanthosoma sagittifolium, Ipomoea batatas), fruit trees (Persea americana, Mangifera indica, Musa spp, Elaeis guineensis), legumes (Arachis hypogaea, Phaseolus vulgaris, Vigna unguiculata) and some commercial perennials (Coffea arabica, Theobroma cacao, Cola anomala). The commonly reared livestock species are bovine, caprine, ovine, birds (table and layers) and swine (Mbogning et al, 2011).

Data collection

The survey was conducted from April to July 2014. Due to the lack of reliable beekeepers census data, the sampling frame used was "snow ball approach". Data were collected using individual interviews based on a questionnaire and focus group discussions. A total of 30 honey samples were collected according to harvest season for color appraisal

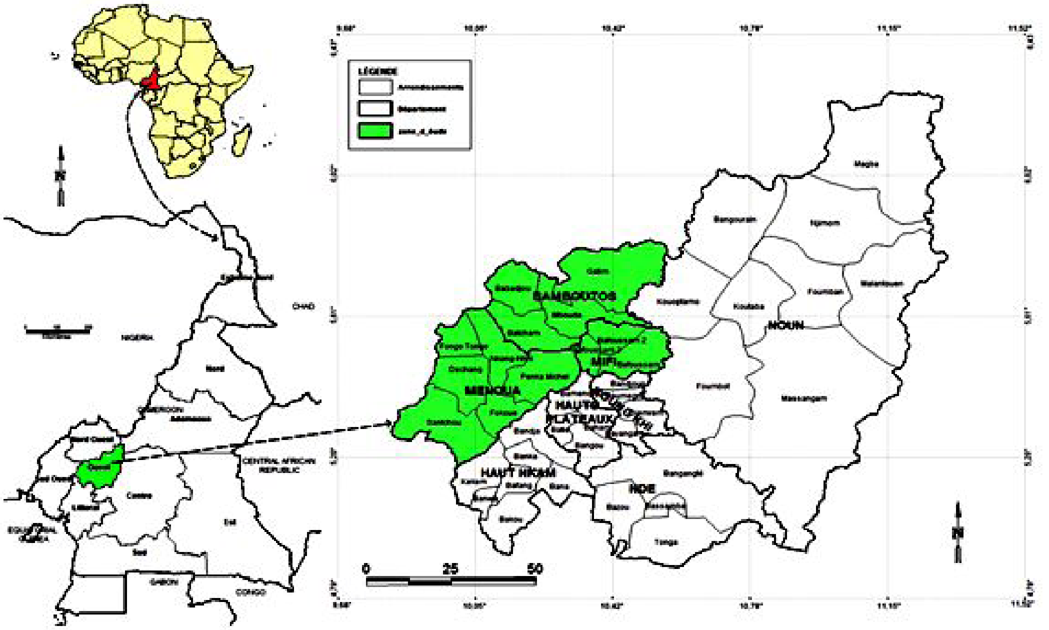

Figure 1 : Study area

later on.

Data analysis

All collected data were keyed using Microsoft Excel 2007 for descriptive statistics. The honey sample color was determined using a visual comparator (lovibone comparator 2000+).Pearson test at 5% was performed to appraiserelationshipamong various socioeconomic and technical parameters using SPSS version 21.0 IBM software.

Results:

Socioeconomic characteristics of beekeepers

Tables 1, 2 and 3 present the major socioeconomic features of beekeepers in the study area. Beekeeping is a predominantly male activity, with only 20% (ranging from 13% in Mifi to 28% in Menoua) being are female. The majority beekeepers in the study fall in 50-60, and 61 and above age brackets. Youth constitute only 2.7% of the beekeepers, and yet youth make up approximately 52 % of the Cameroonian population. Almost all beekeepers interviewed are married (88.5%), with most (80%) having more than five people under their direct care. In the region, close to 90% of beekeepers have a mixed objective (sales and household consumption) but only 2% have purely business objectives for their beekeeping enterprises. Almost all respondents (95.6%) of claimed to have attained at least a primary school education. Only 13% of the respondents cited beekeeping as their main occupation, close to half (47.8%) cited mixed farming (cropping and animal husbandry) as their main occupation. Beekeeping appears to be an important activity among civil servants, retired persons and those in the informal sector. Experience in beekeeping among respondents ranged from 1 to above 15 years. Close to two-thirds (62.8%) of the respondents received oat least one technical training in beekeeping, although most (71.8%) were unable to recall the training topic or highlights of the course content. The majority of respondents (84.1%) started and developed their beekeeping activities by mobilizing their own savings as the main funding source. While over 60% of beekeepers are members of bee

Table 1: Distribution of beekeepers according to sex, age, ethnic group, religion, marital status, number of people under care and motivation

Parameters and characteristics	Division			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Sex				
Male	84.4 (27)	86.7 (26)	72.5 (37)	79.6 (90)
Female	15.6 (5)	13.3 (4)	27.5 (14)	20.4 (23)
Age group (years)				
20 - 30	3.1 (1)	6.7 (2)	0.0 (0)	2.7 (3)
31 - 40	15.6 (5)	3.3 (1)	7.8 (4)	8.8 (10)
41 - 50	28.1 (9)	13.3 (4)	11.8 (6)	16.8 (19)
51 - 60	37.6 (12)	43.4 (13)	37.3 (19)	38.9 (44)
Above 60	15.6 (5)	33.3 (10)	43.1 (22)	32.8 (37)
Marital status				
Bachelor	0.0 (0)	10.0 (3)	2.0 (1)	3.5 (4)
Married	100.0 (32)	90.0 (27)	80.4 (41)	88.5 (100)
Widow	0.0 (0)	0.0 (0)	17.6 (9)	8.0 (9)
Number of people under care				
0	0.0 (0)	10.0 (3)	2.0 (1)	3.5 (4)
1 - 5	18.7 (6)	6.7 (2)	3.9 (2)	8.8 (10) 49.6 (56)
6 - 10	46.9 (15)	43.3 (13)	54.9 (28)	18.6 (21)
11 -15	25.0 (8)	10.0 (3)	19.6 (10)	19.5 (22)
Above 15	9.4 (3)	30.0 (9)	19.6 (10)	
Motivation				
Sales	3.1 (1)	3.3 (1)	0.0 (0)	1.8 (2)
Household consumption	0.0 (0)	6.7 (2)	15.7 (8)	8.8 (10)
Sales and household consumption	96.9 (31)	90.0 (27)	84.3 (43)	89.4 (101)

Table 2: Distribution of respondents according to their main occupations

Main occupations	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Beekeeping	15.6 (5)	30.0 (9)	2.0 (1)	13.3 (15)
Crop-Livestock farming	50.0 (16)	30.0 (9)	56.8 (29)	47.8 (54)
Civil servants	15.6 (5)	10.0 (3)	11.8 (6)	12.4 (14)
Retired		20.0 (6)	9.8 (5)	10.6 (12)
Informal activities	15.7 (5)	6.7 (2)	19.6 (10)	15.0 (17)
Higher education student	0.0 (0)	3.3 (1)	0.0 (0)	0.9 (1)

( ) : Frequency of observations

Table 3: Distribution of respondents according to training received, funding sources, group membership and technical support

Parameters and items	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Training in beekeeping				
Yes	59.4 (19)	66.7 (20)	62.7 (32)	62.8 (71)
No	40.6 (13)	33.3 (10)	37.3 (19)	37.2 (42)
Funding sources				
Owned savings	81.2 (26)	93.3 (28)	80.4 (41)	84.1 (95)
Owned savings and gifts	18.8 (6)	6.7 (2)	19.6 (10)	15.9 (18)
Group membership				
Yes	53.1 (17)	66.7 (20)	62.7 (32)	61.1 (69)
No	46.9 (15)	33.3 (10)	37.3 (19)	38.9 (44)
Technical support				
Yes	28.1 (9)	46.7 (14)	21.6 (11)	30.1 (34)
No	71.9 (23)	53.3 (16)	78.4 (40)	69.9 (79)

( ) : Frequency of observations

Table 4: Distribution of beekeepers according to number, types and form of hives

Parameters and characteristics	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Hive number				
1-10	15.6 (5)	13.3 (4)	60.8 (31)	35.4 (40)
11-30	28.1 (9)	20.0 (6)	9.8 (5)	17.7 (20)
31-50	18.8 (6)	10.0 (3)	11.7 (6)	13.3 (15)
51-100	6.3 (2)	33.4 (10)	11.7 (6)	15.9 (18)
Above 100	15.6 (5)	23,3 (7)	6,2 (2)	12.4 (14)
Non response	15.6 (5)	0.0 (0)	2.0 (1)	5.3 (6)
Type of hive				
Fix hive	50.0 (16)	6.7 (2)	21.6 (11)	25.7 (29)
Hive with mobile bars	18.8 (6)	50.0 (15)	54.9(28)	43.4 (49)
Both types	31.2 (10)	43.3 (13)	23.5 (12)	30.9 (35)
Forms of hive*				
Circular	31.3 (10)	40.0 (12)	33.3 (17)	34.5 (39)
Parallelipipedic	31.3 (10)	23.3 (7)	41.2 (21)	33.6 (38)
Kenyan	40.6 (13)	73.3 (22)	51.0 (26)	54.0 (61)
Cubic	5.7 (2)	6.7 (2)	15.7 (8)	10.6 (12)

*( ) : Frequency of observations; * : the same respondent could give more than one answear*

farming groups, a large percentage (70%) have not received or accessed technical support for their beekeeping activities.

Technico-economic characteristics of beekeepers

Tables 4 to 8 display technico-economic characteristics of beekeepers in Cameroon western highlands region. The number of hive per individual varies from 1 to more than 101, with a mean number of 40 hives. Kenyan Top Bar (KTB) hives are common but the traditional hives and mobile bars type hives (said modern) are predominant in the region, with majority of beekeepers using mobile bars type. Bee hives were installed in two main periods of the year: from January to April and between September and December when perennial crops and coffee flower, and also when natural swarming happens. Beekeepers utilize various strategies and baits to attract bees' swarms: however across the divisions and in all regions beewaxwas the favorite bait that was used to attract bees. About 60% of the hives are populated. The majority of beekeepers visit their hives frequently, and most more than 55% of the respondents, possess either a protective suit or a smoker, with beekeepers from Mifi division being better equipped. Honey and other products are harvested from March to May, extending into July in some years. It appears that in the Western Highlands, beekeepers exploit five beehive products, namely honey, bee wax, propolis, pollen and royal jelly (Table 9), with honey, beewax, and propolis being the predominant products in all divisions. With the exception of Mifi, were 43% beekeepers harvest pollen, and 13% royal jelly, these two products are yet to be exploited in the region. Honey harvested is conserved either in comb or filtered (see table 10). Average honey yield per hive and colony is between 4-10 litres (table 11) in the region. From table 12, irrespective of origins and seasons, the light amber color honey predominates, followed by amber. There is not significant (P=0.265) relationship between division, season and honey color, though Mifi division honey tends to be darker, irrespective of the season. Sales prices per honey litre vary from CFAF 2,000-4,000 (table13). Irrespective of locations, about 37.9% of our interviewees are selling their litre of honey at CFAF 2,500, 79% sale their honey for between 2,000 – 3000 CFA per litre. The average gross margin per individual is between CFA F 448,000-472,500 (for fix bars hives) and CFA F 787,500-801,500 (for mobile bars hives) (Table 14), based on the assumption that parameters used in calculating the gross margin are representative.

Table 5: Distribution of beekeepers according to the attractive bees' baits utilized

Parameters and items	Divisions			
	Bamboutos (32)	**Mifi (30)**	**Menoua (51)**	**Total (113)**
Bee wax	90.6 (29)	96.7 (29)	88.2 (45)	91.2 (103)
Palm oil+ sodium chloride (salt)	3.1 (1)	0.0 (0)	3.9 (2)	2.7 (3)
Cane sugar	3.1 (1)	0.0 (0)	5.9 (3)	3.5 (4)
Honey	3.1 (1)	3.3 (1)	3.9 (2)	3.5 (4)
Raphia palm wine	0.0 (0)	3.3 (1)	9.8 (5)	5.3 (6)
Citronnella and/or palm oil	0.0 (0)	13.3 (4)	3.9 (2)	5.3 (6)
Bees' charm	0.0 (0)	10.0 (3)	0.0 (0)	2.7 (3)
Other types	0.0 (0)	0.0 (0)	7.8 (4)	3.5 (4)

*( ) : Frequency of observations; * : the same respondent could give more than one answear*

Table 6: Rate of hive colonized per division

Total number of hives	Divisions			
	Bamboutos	Mifi	Menoua	Total
Visited	1409	2046	1116	4571
Colonized	918	1465	862	3245
Rate of hive colonized(%)	65.1	71.6	77.2	71.0

Table 7: Distribution of beekeepers according to beehive visit frequency

Beehive visit frequency	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Once per week	46.9 (15)	20.0 (6)	74.5 (38)	52.2 (59)
Once per month	34.4 (11)	60.0 (18)	19.6 (10)	34.5 (39)
Twice per month	6.2 (2)	3.3 (1)	5.9 (3)	5.3 (6)
Thrice per month	3.1 (1)	0.0 (0)	0.0 (0)	0.9 (1)
Once every three months	3.1 (1)	3.3 (1)	0.0 (0)	1.8 (2)
Non response	6.3 (2)	6.7 (2)	0.0 (0)	3.5 (4)

( ) : Frequency of observations;

Table 8: Distribution of beekeepers according to equipment

Equipements apicoles*	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Protecting suits	59.8 (19)	90.0 (27)	45.1 (23)	61.1 (69)
Smoker	56.3 (18)	93.3 (28)	39.2 (20)	58.4 (66)
Knife	100.0 (32)	100.0 (30)	100.0 (51)	100.0 (113)
Gloves	100.0 (32)	100.0 (30)	100.0 (51)	100.0 (113)
Comb cutter	0.0 (0)	3.3 (1)	2.0 (1)	1.8 (2)
Buckets	100.0 (32)	100.0 (30)	100.0 (51)	100.0 (113)
Extractor	3.1 (1)1	10.0 (3)2	5.9 (3)2	6.2 (7)
Maturing tank	6.3 (2)	3.3 (2)	2.0 (1)	4.4 (5)

*( ) : Frequency of observations; * : the same respondent could give more than one answer ; 1 : not utilized, 2 : utilized by one of the three*

Table 9: Distribution of beefarmers according the nature of the products exploited

Nature of products exploited by beefarmers *	Divisions			
	Bamboutos	Mifi	Menoua	Total
Honey	100.0 (32)	100.0 (30)	100.0 (51)	100.0 (113)
Bee wax	84.4 (27)	90.0 (27)	49.0 (25)	69.9 (79)
Propolis	40.6 (13)	83.3 (25)	23,5 (12)	44.2 (50)
Pollen	12.5 (4)	43.3 (13)	2.0 (1)	15.9 (18)
Royal jelly	0.0 (0)	13.3 (4)	0.0 (0)	3.5 (4)

*( ) : Frequency of observations; * : the same respondent could give more than one answer*

Table 10: Distribution of bee farmers according to honey conservation mode

Parameters and items	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Filtered	62.5 (20)	56.7 (17)	82.4 (42)	69.9 (79)
In combs	3.1 (1)	0.0 (0)	0.0 (0)	0.9 (1)
Filtered or in combs	34.4 (11)	43.3 (13)	17.6 (9)	29.2 (33)

( ) : Frequency of observations

Table 11: Distribution of bee farmers according to their honey production performance

Honey production performance (l/hive)	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
<4	3.1 (1)	13.3 (4)	23.5 (12)	15.0 (17)
4-7	53.2 (17)	26.7 (8)	43.1 (22)	41.6 (47)
8-10	28.1 (9)	56.7 (17)	21.6 (11)	32.8 (37)
Non response	15.6 (5)	3.3 (1)	11.8 (6)	10.6 (12)

( ) : Frequency of observations

Table 12: Distribution of honeys according to color by area of origin and season

Divisions and seasons	Colors (n)				
	Extra light amber	Light amber	Amber	Dark amber	Total %
Bamboutos					
Rainy season (6)	16% (1)	66% (4)	16% (1)	0.0 (0)	100
Dry season (4)	50.0% (2)	25.0% (1)	25.0% (1)	0.0 (0)	100
Menoua					
Rainy season (8)		50.0% (4)	50.0% (4)	0.0 (0)	100
Mifi					
Rainy season (10)		10.0% (1)	40.0% (4)	50.0% (5)	100
Dry season (2)		50.0% (1)	0.0 (0)	50.0% (1)	100
Total					
Rainy season (24)		37.5% (9)	37.5% (9)	20.8% (5)	100
Dry season (6)		33.3% (2)	16.7% (1)	16.7% (1)	100

Table 13: Distribution of bee farmers according to the honey unit sales price

Parameters	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Sales price per litre (CFA francs)				
2000	53.1 (17)	17.8 (5)	0.0 (0)	21.4 (22)
2500	43.8 (14)	75.0 (21)	9.3 (4)	37.9 (39)
3000	3.1 (1)	3.6 (1)	44.2 (19)	20.4 (21)
3500	0.0 (0)	0.0 (0)	44.2 (19)	18.4 (19)
4000	0.0 (0)	3.6 (1)	2.3 (1)	1.9 (2)

Table 14 : Beekeeping balance sheet

Economicparameters	Traditional hives	Mobile bars hives
Hivepurchase (CFA F)	2 500-6 000	11 000-15 000
Life span (year)	4-8	8-11
Annual installment/hive (CFA F)	625-1 500	1 375-1 875
Annual honey yield (litre/hive/yield)	7	12
Honey sales/hive/an (CFA F)	7×2 500	12×2 500
Gross margin/hive/year (CFA F)	16 875-16 000	28 625-28 125

Table 15: Constraints and perspectives of bee farmers

Parameters and modalities	Divisions			
	Bamboutos (32)	Mifi (30)	Menoua (51)	Total (113)
Constraints*				
Socioeconomic				
Financial problems	71.9 (23)	93.3 (28)	72.5 (37)	77.9 (88)
Lack of markets	12.5 (4)	20.0 (6)	2.0 (1)	9.7 (11)
Lack of promotion	6.3 (2)	16.7 (5)	2.0 (1)	9.7 (11)
Technical				
Lack or insufficient support	78.1 (25)	63.3 (19)	98.0 (50)	83.2 (94)
Low rate of colonization	34.4 (11)	16.7 (5)	35.3 (18)	30.1 (34)
Pesticides contaminations	0.0 (0)	3.1 (1)	23.5 (12)	11.5 (13)
Predators and diseases				
Insects	75.0 (24)	76.7 (23)	13.7 (7)	47.8 (54)
Theft and destruction	50.0 (16)	63.3 (19)	21.6 (11)	40.7 (46)
Wild bush fire	28.1 (9)	56.7 (17)	21.6 (11)	32.7 (37)
Spider "Araneus sp"	12.5 (4)	6.7 (2)	11.8 (6)	10.6 (12)
Otherpredators	15.6 (5)	26.7 (8)	25.5 (13)	23.0 (26)
Dysentery	3.1 (1)	0.0 (0)	0.0 (0)	0.9 (1)
Perspectives*				
Resign	6.2 (2)	10.0 (3)	0.0 (0)	4.4 (5)
Becomeprofessional	75.0 (24)	73.3 (22)	39.2 (20)	58.4 (66)
Increase and improve hive number	81.3 (26)	93.3 (28)	70.6 (36)	79.6 (90)
Processingbeehiveproducts	28.1 (9)	16.7 (5)	7.8 (4)	15.9 (18)
Exploitation of otherproducts	21.9 (7)	33.3 (10)	7.8 (4)	18.6 (21)
Intensification of honey production	21.9 (7)	16.7 (5)	5.9 (3)	13.3 (15)
Queenrearing	0.0 (0)	3.3 (1)	3.9 (2)	2.7 (3)

*( ) : Frequency of observations; * : the same respondent could give more than one answer*

Correlation tests (at 5%) reveal that sex does not influence (P=0.624) the honey yield, and thus gender is not a limitating factor for beekeeping. Experience (P=0.208) also does not influence the production of honey: older beekeepers tend to maintain their habits and skills and are not amendable to changing them or improving on their skills. It was instructive that the data indicated that training received was not adding value to total honey yield (P=0.939). The most plausible reasons are that training sessions focus on provision of subsidies rather than improving technical capacity. Many of the trainings are facilitated by consultants with inadequate practical skills rather than by an experienced practitioner. The number of hive does not influence the final honey production (P=0.634). Massive utilization of mobile bars hive is not obviously giving promising yields as expected.

Constraints and perspectives of beekeeping

The core beekeepers' constraints are socioeconomic, technical and epidemiological (table 15). Financial problems/ lack of finance to improve beekeeping were the most frequently raised issue by respondents. Lack of technical support (extension services, training and capacity building)was another frequently mentioned constraint. Pests and theft and destruction of apiaries were other constraints that over 40% of beekeeper cited. There were strong perspectives among beekeepers towards growing their enterprises through increasing and improving hives, with almost 60% of beekeepers aspiring to become a professional beekeeper, earning only from honey production. In general, majority of beekeepers surveyed are motivated to maintain their profession, articulating specific actions to improve their beekeeping.

Discussion:

Concerning gender, the findings revealed that fewer women are involved in beekeeping in the region. Women proportion in the western highlands are below by 16.9% to results produced in Oku area (Sanglier 2013). Most of beekeepers are above 50years, Youth, below 30 years are not as involved in beekeeping; this finding differs from the findings from previous studies in Adamaoua plateaux (Founadoudou, 2007), and in western highlands (Njia, 1999; Abongu, 2001 and Tchoumboué et al, 2001). Almost all beekeepers sampled are married, similar to the findings of Abongu (2001) and Founadoudou (2007) respectively in Adamaoua and Nord West regions, who also had similar data for size of beekeeping households in their respective study areas. The study found that most beekeepers are in the venture for both family consumption and sale, similar to the findings reported by Founadoudou (2007) in Adamaoua soudano-guinean region. Education trends in beekeepers we obtained are comparable to results found by Njia (1999) and Tchoumboue et al, (2001). For most respondents, beekeeping is secondary or supplementary to either farming or livestock keeping; a trend evident in the Western Highlands Zango (1994), Njia (1999), Abongu (2001) and Tchoumboue et al, (2001) Founadoudou (2007) in Adamaoua region and Sanglier (2013) in Oku mountainous area and other regions of the country.

This study found that there was greater experience in beekeeping, which is different to findings by Founadoudou (2007) in Adamoua, and in western highlands by Njia (1999), Abongu (2001), Tchoumboue et al, (2001) and Tsafack (2006). Founadoudou (2007) revealed that more than 80% of beekeepers he surveyed had received no training: it is apparent that over the last decade or so there has been progress in beekeeping training, as the findings in this study are more than 10% higher than those reported successively by Njia (1999) and Tchoumboue et al, (2001) in the same region. Funding sources in our study are similar to those described by Founadoudou (2007), but less by 26.8% in Adamaoua region.

The average number of beehive per individual in our findings is higher than figure obtained in Adamoua region (Founadoudou, 2007) and in this study area (Njia, 1999; Tchoumboue et al, 2001 and Tsafack, 2006), suggesting therefore an increasing interest and substantial investment. Findings that the KTB type of hive are predominant are consistent with Njia (1999) and Tsafack (2006) observations in the region, but deviates from Founadoudou findings depicting the predominance of circular type in Adamaouaplateaux. Zango (1994), Njia (1999), Tchoumboue et al, (2001) and Founadoudou (2007) reported the similar patterns of installation of beehives as in this study. The use of a variety of baits to attract colonies was also mentioned by Zango (1994), Njia (1999) and Tchoumboue et al, (2001).

The rate of beehive colonized is slightly higher (3.7-6.6%) than the rate reported respectively by Founadoudou (2007) in Adamaoua and Tchoumboue et al, (2001) in western highlands region. This study observed a greater frequency of visitsd to beehives in this study by 4.6 and 5% than results reported by Founadoudou (2007) and Njia (1999) and Tchoumboue et al, (2001), respectively in Adamaoua and western highlands region. The harvesting period is comparable to previous study findings (Zango, 1994; Njia, 1999; Tchoumboue et al, 2001 and Founadoudou, 2007). The level of personal use of basic equipment (protective suit and smoker) reported in Adamaoua region was significantly low (3.8%) compared to the results of this study (Founadoudou, 2007). Njia (1999) and Tchoumboue et al, (2001) reported the same five products beekeepers derive from bee hives inventoried in these findings. Methods of conserving harvested honey in either combs or filtered was also reported by previous authors (Njia, 1999; Tchoumboue et al, 2001; Founadoudou, 2007). The average honey production per colony reported for this study is lower than the 11-15 litres per colony found by Founadoudou (2007) in Adamaoua, but remains close to figures reported by Njia (1999) and Tchoumboue et al, (2001) in Cameroon Western region. Sanglier (2013) reported the same non significant correlation between gender, beehive number and annual honey yieldin Oku area as in these findings. Concerning honey color, Founadoudou (2007) noted that contrary to the findings of this study, dark amber honey was the predominant chromotype in Adamaoua. Sales price in in this study are much higher than figures reported by Founadoudou (2007) in Adamaoua where sales price per honey litre varied between CFAF 300-700 in 2007, however, the gross margin per individual obtained in this study is similar to estimates by Abongu (2001) and Tsafack (2006) in North West and Tchoumboue et al, (2001) in West regions.

All issues inventoried as key constraints by bee keepers in this study were reported previously by Founadoudou (2007) and Tchoumboue et al, (2001), similar perspectives on aspirations of respondents on beekeeping were reported by Founadoudou, (2007) for beekeepers in Adamaoua region.

Conclusion:

This study presents the main socioeconomic, technical features as as well as challenges and future of beekeeping in the Cameroon western highlands region. In the region, beekeeping remains a male dominated enterprise, although women are involved in supportive professional roles. The majority of beekeepers are mature persons, with very few youth involved in the enterprise. Most beekeepers are educated with several years of experience, and are mostly involved in beekeeping as a secondary or supplementary occupation with honey production for sales and trade as the main objective. Investment in beehives was moderate, with the majority owning between 1 and 101; about 12% had a significant investment owing over one hundreds hives of mostly the modern type (with mobile bars). Beehive installation and honey harvesting are influenced by the agricultural calendar and season of flowering of species that provide foraging for bees.The major constraints encountered in beekeeping were biological, technical and financial. One key aspect for immediate improvement identified was the opportunity to improve accessibility and quality of technical training for beekeepers: this will serve to improve yield and productivity. To achieve this, there is need for integration of beekeeping in educational curricula, and to incentives.

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HONEY BEEKEEPING AND LIVELIHOODS PROSPECTS RELATED TO FAIR TRADE IN OKU REGION – NORTH WEST CAMEROON

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Abstract:

Oku's White Honey has been produced for generations in the Kilum-Ijim forest, North-West region of Cameroon. Its white colour and creamy texture are bestowed by special mountainous plants, especially Schefflera abyssinica and Nuxia congesta. This honey is produced in a remote rural area where beekeeping is an important activity for the local economy. However, the trade channel needs to be improved in order to expand the market opportunities. Fair Trade might suit Oku's White Honey and open up new market opportunities. Fair Trade standards have been internationally defined by Fair Trade Labelling Organizations (FLO) to homogenise certification processes. Athree-month survey (2012-2013) provided a deep analysis of the Oku's White Honey production system. The social analysis revealed women empowerment and the state of child labour in Oku's honey production system. The technical analysis highlighted the nature of traditional beekeeping in Oku. The environmental analysis underlined actions undertaken by beekeepers to protect the Kilum-Ijim forest. A description of honey drink and beeswax processing illustrates the diversification of bees-products realised in Oku. The economic analysis provides information on quantities produced, benefits and means of commercialisation. Results coming from this deep analysis are referenced at FLO's standards and requirements in order to assess if such certification would be possible and appropriate for this production system. Investments to improve production and certification of Oku white honey may have potential benefits for the ecosystem as well as for the communities living in this particular highlands environment and some ways forward given.

Key words: Honey, Oku, Fair-trade, household income

PERSPECTIVES POUR L'ELEVAGE DES ABEILLES MELLIFERES ET LES MOYENS D'EXISTENCE EN RAPPORT AVEC LE COMMERCE EQUITABLE DANS LA REGION D'OKU AU NORD-OUEST DU CAMEROUN

Résumé

Le miel blanc de la région Oku est produit depuis des générations dans la forêt Kilum-Ijim, au Nord-Ouest du Cameroun. Ce miel doit sa couleur blanche et sa texture crémeuse aux plantes montagneuses spéciales, en particulier Schefflera abyssinica et Nuxia congesta. Il est produit dans une région rurale éloignée où l'apiculture est une activité importante pour l'économie locale. Cependant, il est nécessaire d'améliorer son circuit de commercialisation afin accroître ses débouchés. Le Fairtrade (commerce équitable) peut être convenable pour le miel blanc d'Oku et ouvrir de nouveaux débouchés. Les normes du Fairtrade ont été définies à l'échelle internationale par l'Organisation d'étiquetage du Fairtrade (FLO ; Fair Trade Labelling Organisations) pour uniformiser les processus de certification. Une enquête de trois mois (2012-2013) a effectué une analyse en profondeur du système de production du miel blanc de la région Oku. L'analyse sociale a évoqué l'autonomisation des femmes et le travail des enfants dans le système de production de miel d'Oku. L'analyse technique a mis en évidence le caractère traditionnel de l'apiculture à Oku. L'analyse environnementale a souligné les actions entreprises par les apiculteurs pour protéger la forêt Kilum-Ijim. Une description de la boisson de miel et du traitement de la cire d'abeille est une illustration de la diversification des produits de la ruche réalisée à Oku. L'analyse économique

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fournit des informations sur les quantités produites, les bénéfices et les moyens de commercialisation. Les résultats produits par cette analyse approfondie sont référencés à des normes et exigences du Fairtrade FLO afin d'évaluer si une telle certification serait possible et appropriée pour ce système de production. Les investissements destinés à améliorer la production et la certification du miel blanc d'Oku peuvent avoir des avantages potentiels pour l'écosystème ainsi que pour les communautés vivant dans cet environnement de hautes terres ; et des mesures à prendre pour aller de l'avant ont été données.

Mots-clés : miel, Oku, commerce équitable, revenu familial

Introduction:

Honey is a substance rich in simple sugar; with a high energetic power; both food and medicine; with a high cultural value and characteristics specific to the ecological zone and the nectar and pollen floral origin (Bradbear, 2010). The West African honeybee in Cameroon is known as Apis mellifera adansonii. This species has two main particularities; it is very defensive and has a tendency to abscond, to abandon the hive if disturbed either by man or other intruders (Atabe, 2009). The traditional beekeeper is focused on meeting the subsistence needs of the household, to earn supplementary income (Fisher, 1993). Production techniques have been evolving, from harvesting to keeping, with traditionally made hives or more efficient bee hives in most of African countries (Fisher, 1993; Howard, 2005; Atabe, 2009; El Agrebi, 2010). In addition to honey, beekeeping provides several other interesting by products for multiple usages (Erasmus *et al.,* 2006; Fonadoudou, 2007; Atabe, 2009).

In Africa, The main honey producers in Africa are Ethiopia, Tanzania, Angola and Kenya: Cameroon where the production represents only 2% of African total production (Founadoudou, 2007). Honey production is still largely a traditional and small scale activity in Cameroon context (Ingram, 2009a). During the last decade, beekeeping sector has been encouraged for its potential in preserving natural resources and developing activities with better rewards for producers. Several organizations involved in beekeeping development in Cameroun, especially in Adamawa and North-West regions.

White Honey has been produced for generations in the Afro montane-forest of the Kilum-Ijim, in the North-West region of Cameroon, mainly in Oku. Contrary to other honey types which are dark, brown or pale gold (Ingram, 2009b; Guiding Hope, 2011), Oku's honey texture and colour is exceptional. White honey lacks new markets outside the North-West province, which the second largest production area in Cameroon (Erasmus *et al.,* 2006), even though beekeeping is an important activity in Oku forest villages, both economically and traditionally (Fisher, 1993; Matsop, 2011). The 20,000 ha forest is at an altitude ranging from 1,600 to 3,011 metres, although most of it occurs above 2,000 metres. This zone represents the largest montane-forest of West zone in Central Africa with numerous endemic flora and fauna species (Bah, 2005). Around half of this forest is montane-forest and the rest montane-grasslands, various types of scrubland, and a small area of afro-subalpine grassland at the summit (Forbosehe*t al.,* 2003). The forest boasts of a diversity of treespeciess including Carapa procera, Schefflera abyssinica, Schefflera mannii and Syzygium guineense bamendae. Podocarpus latifolius is dominant at high altitudes (Asanga, 2001; Fotso, 2001). These trees are associated with mountain bamboos Trundinaria alpina (MINEFI, 2001). The canopy of the forest is usually rather open and there are extensive shrubberies of Acanthaceae in the under-storey. The forest also includes montane Sporobolus grassland, Gnidia woodland and montane Hypericum–Adenocarpus shrub-land together with a few swamps. Lake Oku with a 2km diameter, at the 2,200 altitude meters, is in a basin entirely surrounded by forest (Fotso*et al.,* 2001).

Poverty incidence poverty among rural populations, and particularly in the mountains, which are some of the most populated areas, is high i.e., 36% of the poor, nationally, with poverty increased by the decline of coffee sales is (MINEFI, 2001). In such a context, the environmental imbalance is a real challenge. Populations were forced to identify new opportunities for livelihood, leading to overexploitation of local natural resources, through unsustainable practices. Besides the main staple or cash crops: arabica coffee, irish potato and sweet potato, maize, beans, bananas, cocoyam, plantain, cowpeas, beekeeping seems to have the highest potential for income generation (Londi, 2004; Bradbear, 2005 and 2010). The Oku's white honey has been selected by the OAPI(Organisation Africaine de la Proprieté Intetellectuelle) to be a product for Geographic Indication (GI) certification because it meets the prerequisite set out criteria (Bridier and Chabrol , 2009; Chabrol and Niba, 2010). Geographic Indication (GI) label has a very interesting potential for new urban markets (AFD and FFEM, 2010). Even better still, fair trade prospects in a larger horizon may bring more benefits for people living in remote regions of Cameroon (Ebong, 2010).Fair-Trade certification systems promote better relationships between the producers and customers within a framework of social, economic, governance and environmental values (FLO, 2011). The objective of Fair-Trade is to empower marginal producers for alternative and better access to international market avenues. This certification may constitute an opportunity for Oku's white honey, and therefore a possible sustainable system towards more robust production practices for Oku natural ecosystems (Ebong, 2010).

The purpose of this study was to assess the feasibility of fair trade certification for the Oku's white honey produced in the

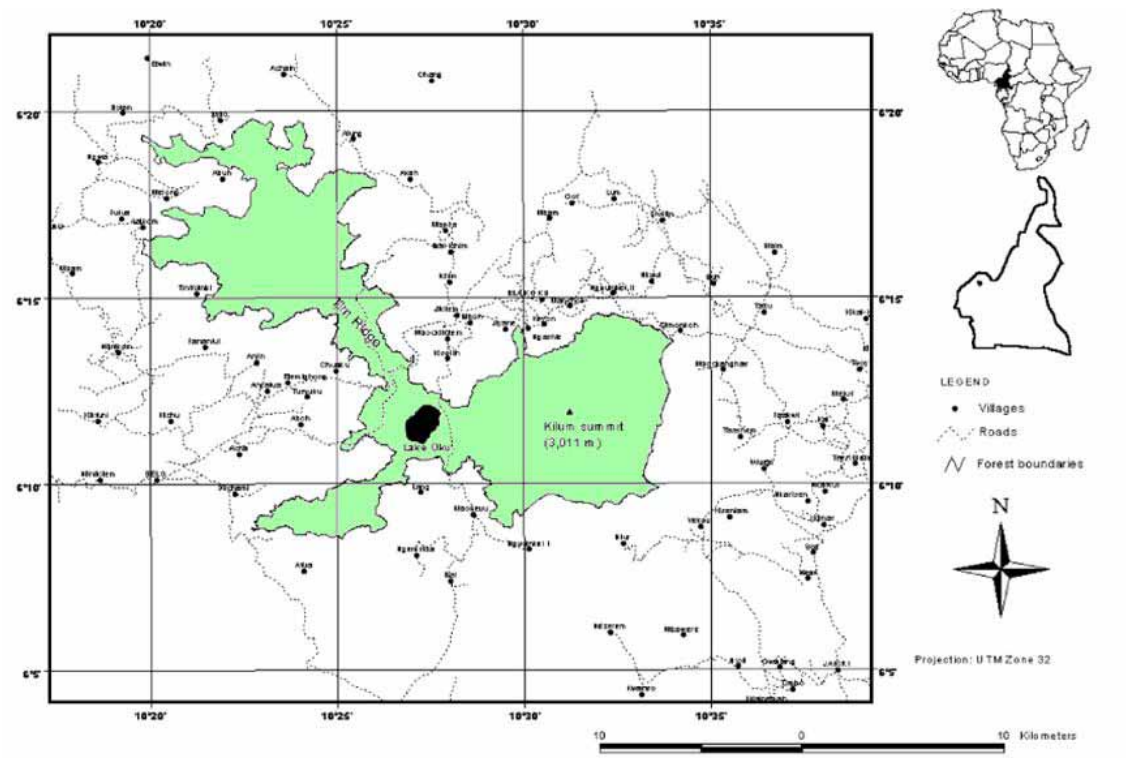

Figure 1: Study area

Kilum-Ijim forest, in North-West Cameroun. The objectives were to perform socio-economic and technical analysis of Oku's white honey production system, describe the current Oku's white honey production system and to compare this situation with the requirements and conditions necessary for the Fair-Trade certification in order to draw a conclusion on the feasibility of this certification system as far as Oku's white honey is concerned.

Materials and Methods:

The study site

The study was conducted in Oku mountain forest region (Figure 1), in the North West region, Cameroon.

Data collection and analysis

A total of 77 beekeepers based in Oku area and immediate surroundings were randomly interviewed based on a tested FLO baseline survey questionnaire (details in table 1).Focus groups were also organized and direct observations made. Data analysis was using the Statistical Package for Social Sciences software (SPSS) version 12.0 for Windows (Microsoft, 2011). Pearson Chi-square at 5% test was done for correlation between several factors where applicable.

Results:

Social analysis

Age and education main trends are summarized in Figure 2 which shows that beekeeping activity in Oku region is mainly by adults between 30 and 50 years and that majority of beekeepers are literate i.e., have received over Class 7 education. Concerning gender as shown in Table 2, only 12% of beekeepers interviewed were female i.e. nine out of the seventy-seven interviewed beekeepers. Among these nine women, six are crop farmers. As shown in Table 3, when considering other related honey activities, women are more or less represented within beekeeper's groups. Jikijem Zonal Beekeepers' group (zone 2) and Kilum Bee Farmers group (zone 1) have the two highest percentages of women, with respectively 44% (24/55) and 25% (7/28). Women perform a variety of tasks besides honey harvesting or collection. Generally, there is no distinction between men and women tasks. However, in majority of groups women are in charge of honey filtration; they are responsible of honey sales in the Common Initiative Group's (CIG) shop or are responsible of the daily administration of the group. These administrative tasks might be attributed to women due to their relatively higher level of education. Among the nine beekeeping farmer's groups interviewed, six give equal salaries to women and men.

Beekeeping is a shared household activity with 87% beekeepers revealing they share tasks with other household members. About 30% of the interviewees work with their spouse, meanwhile children are the main labour source in beekeeping (67%). However, it is important to stress that "children" concept is locally ambiguous. Some beekeepers (38%) revealed that they worked with children below the age of 15. Among these 29 beekeepers 25 (or 86%) assert that when their children work with them, it is during school holidays and/ or on weekends; and 27 (or 93%) supervise children as they work.

Organizational analysis:

The majority (75 %) of respondents sampled are members of a beekeeper group. Figure 3 highlights their perceptions of advantages attached to group membership including benefits from technical aspects as well social networking for beekeepers. By selling smaller quantities, beekeepers manage to have regular customers, but individually they are limited in capacity to supply larger quantities, and packaging price might be higher. In the interviews, it appears implementing group constitutions, particularly decision-making by regular consultation/ consensus building, in transparency with minutes, are in most cases difficult to implement because of lack of funds. Regular meeting seems to be a common challenge in various groups (Figure 4). Partnering is an important option for

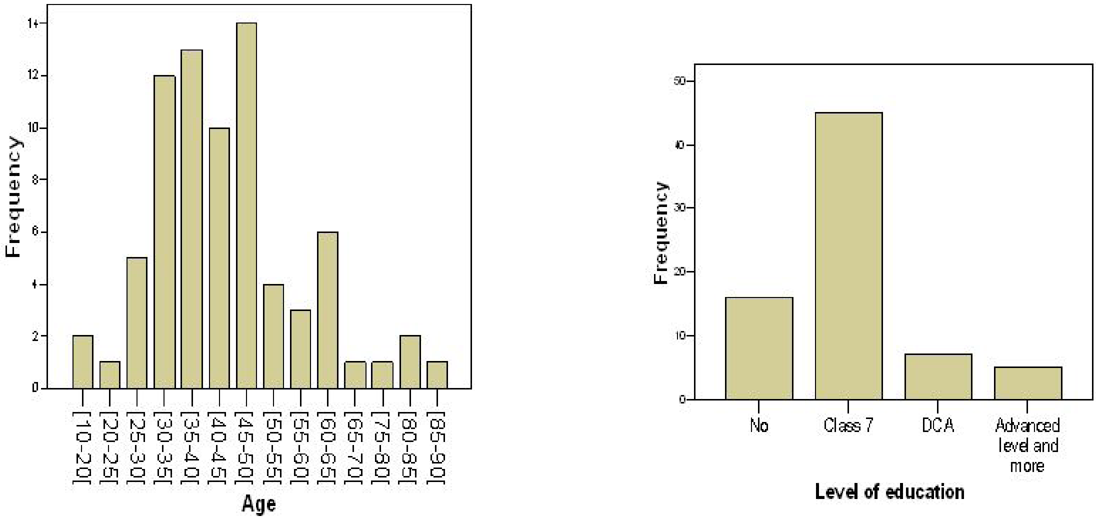

Figure 2: Distribution bars of respondents according to age and education level

Table 1: Respondent distribution in Oku region and surroundings

Zone	Frequency	Percentage
1.Oku centre	42	54
2.Oku close periphery	23	30
3.Belo/Fundong area	9	12
4.Jakiri/Kumbo area	3	4
Total	77	100

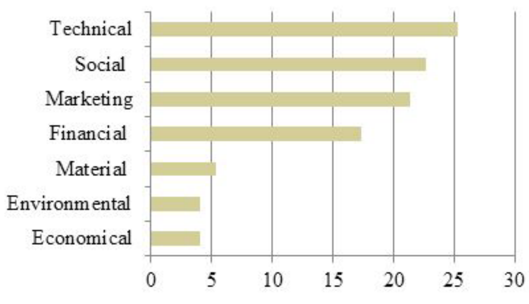

Figure 3: Respondent perception of the advantages attached to group membership.

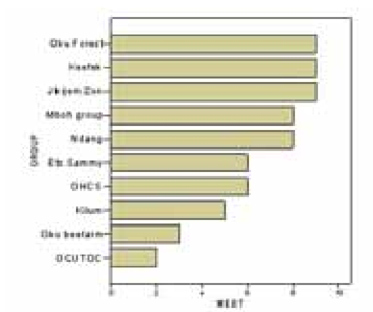

Figure 4: Regular meetings in beekeepers organization on an annual basis

beekeeping organizations (Table 4). The Oku Honey Cooperative Society (OHCS) is the most advanced in terms of building strategic partnerships: it has received strong support from numerous partners, including the Dutch NGO SNV; financial support from the French embassy and United Nations for Development Program (UNDP); and has a commercial partnership with the (Common Initiative Group) CIG Guiding Hope located in the capital city, Yaoundé.

Technical analysis:

On average beekeepers reported 19 years of continuous honeybee production of white honey activity; but with a large standard of deviation (16 years) among beekeepers, indicating experience with beekeeping varies a

Table 2: Sex frequency of respondents

Sex	Frequency	Percentage
Male	68	88
Female	9	12
Total	77	100

Table 3: Women representation and women groups within beekeepers' groups

Zone	Beekeepers' Group	Percentage of women employed	Women's tasks
1.	Oku Honey Cooperative Society	3%	Administrative tasks, educational tasks, honey sales
	Ets Sammy Sammy	3%	Honey filtration
	Oku Forest Honey	NA	Honey filtration and sales
	Kilum Bee Farmers	25%	Hives construction, honey harvesting
	Oku Beefarmer's CIG	6%	Same tasks as men
	OCUTOC CIG	NA	Administrative tasks
	NdangBeefarmer's Group	0%	Not applicable
2.	Jikijem Zonal Beekeeper's group	44%	Honey harvesting, Administrative tasks
	Snang Beekeepers	NA	Same tasks as men
	Keefek	13%	Hives construction
	MbohBeefarming group	6%	Same tasks as men
3.	FERUDEC	0%	Not applicable
	Telaw Mixed Farming group	NA	Clean containers, carry honey from the bush

Table 4: Beekeeping groups' various partners

Technical Partners	Financial Partners	Commercial Partners
OHCS (3)	OHCS (2)	OHCS (2)
SNV (3)	Manchok Credit Union (2)	Guiding Hope (1)
Ministries :Forestry, Agriculture, Livestock (3)	UNDP (1)	Shop NowimbaBamenda (1)
CAMGEW (1)	French embassy (1)	
Guiding Hope (1)		

lot among the beekeepers interviewed (Figure 5). It appears also that beekeepers in the study area possess a very diverse number of hives, with the majority owning less than 50 units (Figure 6). In some communities, the majority of beekeeping farmers use only traditional hives (Figure7) with only a few using Kenyan Top Bar hives (KTB). This latter group are considered as "elite" and are found close to urbanized sites located towards Belo/Fundong area. Oku's beekeepers are reluctant to use KTB hives mostly because of lack of skills and knowledge about these hives. However, "improved indigenous" hives might be a solution to combine the advantages of Oku's traditional hives (light and made with bamboo available in the forest) and the advantages of the KTB hives (no destruction of the brood nest, harvesting of ripe honey only, cleaner honey harvested). In relation to harvesting technique most beekeepers in Oku (87%) use the traditional smoker which is risky for bush fire and bestows a strong smoky taste to the final product. In Oku close periphery, most of beekeepers (65%) drain their honey by themselves (Figure 8).Among the 44 beekeepers that drain their honey individually, 37 reported that they cover the combs during filtration and 39 report doing this in a closed room. These two elements are important for preserving honey quality. It is important to cover combs during filtration in order prevent higher final moisture thus reducing water content during the processing since honey is hygroscopic. Most of beekeepers (64%) said they drink homemade honey based beverages and process beeswax. The final residues remaining after beeswax processing are also used: they are mixed with corn to feed animals. The technical problem is that these residues need first to be dried, and during the rainy season it is difficult to get them completely dry especially since if the waste has to be used to feed animals, they need to be dried within 3 days after beeswax processing, otherwise they rot. Packaging was identified as a major constraint by almost all the interviewees. . The most accessible and commonly used containers are not suitable and labelling is very poor (Figure 9), and very expensive for majority of beekeepers. Such products are not attractive to urban customers and fermentation happens very regularly.

Economic analysis:

The majority of beekeepers surveyed have other activities besides beekeeping. Only 10% reported beekeeping as their main source of earning a livelihood. Among the 69 beekeepers that have other activities, most of them are involved in agriculture with 48% in crop farming and 28% in livestock keeping. The average honey production per hive is 4.3 kg/

Table 5: Beekeeping benefits for household in Oku

Importance	Income	Education	Health	Food	Medicine	Tradition
Answer collected during interviews	Important source of income Income to buy food for family	School fees	Hospital bills	Honey as food product	Medicinal interest	Inherited from old father
	Pay electricity					
	Add to business capital					
	Buy clothes for children					
	Fight poverty					
	Care for family					
	Easy source of income					

year. The high standard deviation of 3.8 kg/hives shows that there exist several factors explaining this diversity as the range of production varies from 0.3 to 15 kg of honey per hive (Figure 10). There is a significant correlation between the honey yield per hive and the total number of hives. Honey benefits are used in many ways for household wellbeing (Table 5).

Environmental analysis:

None of beekeepers in the region treats bees with antibiotics. As Table 6 displays, beekeepers have very clear perceptions of the forest and its benefits for their communities, and take specific related actions as summarized in Table 6. .The majority of beekeepers (61%) undertake conservative measures for forest preservation including taking care of young bee-loving trees, avoiding cutting of wet trees, preventing bush fires, doing fire-tracing (burn under control a band of vegetation in such that the fire cannot propagate if a bush fire occurs), throwing away the smokers in the river after harvest and avoiding grazing and browsing of domestic animals around hives. These preventive actions are undertaken mostly by men (98%). Over half (55%) of respondents from Oku centre zone and Belo/Fundong zone undertake measures to protect the forest. The beekeepers that appear the most involved in these preventive actions are those from Oku close periphery, with 78% of respondents are engaged in preventive actions. About 27% of beekeepers claim to plant trees in order to preserve/restore the forest. They plant species that bees are attracted to, trees, or flowering shrubs, and select mostly species resistant or tolerant to wild bush fire. Beekeepers from the periphery of Oku seem more concerned (39%) compared to those living in Oku Centre (24%). This effort of replacing tree plantations is not as effective as it should be because of a weak regeneration due to poor follow up by the entire communities living from forest products. At last, 5% of beekeepers interviewed, practice environmental education by raising awareness of the benefits of forests and forest preservation. Advice is also given on how to use protected smokers; and instructions protection of the forest, particularly to women who traditionally burn crops residues or weeds around the forest. Education avenues are villages or community and local specific meetings, where bad practices are highlighted, and shared and corrections sought together. It was also noticed that there was no correlation between the forest protection actions and level of education.

FLO certification opportunity for Oku's white honey

In general, the production system of Oku's White Honey fits well with the Fair Trade philosophy and the demands and expectations of discerning customers. The White Honey is traditionally produced by marginalised producers who are also committed to contributing to natural environment preservation, especially by taking care of the Kilum-Ijim forest, the largest montane-forest in the West part of Central Africa. Thus, Oku's area might have opportunities to develop ecotourism to attract tourists in addition to the traditional activity of beekeeping. The main direct concern could have been the child labour. According to the core requirement3.3.7 (FLO, 2011), in the case of fair-trade certification for a Small Producer Organisation (SPO), children below the age of 15 should not be employed in the SPO activities. The prohibition also applies to children who are employed indirectly in the SPO, for example when children are working with their parents. However in the following core requirement 3.3.8 (FLO, 2011), it is mentioned that the members' children below 15 years of age are allowed to help on their household farms under strict conditions: with assurance that they only work after school or during holidays, the work they do is age appropriate, they do not work for long hours and/or under dangerous or exploitative conditions and their parents supervise and guide them.

The level of Oku white honey that is exported outside the North-West region is unknown. When it happens, it is most of the time mediated through middlemen. In this context, FLO's minimum price would not be so much higher than the local price. As shown in table 7, if Oku's white honey would achieve

Table 6: Actions undertaken per beekeepers to protect the forest

Education	**Conservation**		**Plantation**
	Preventive	**Curative**	
Teach farmers on forest benefits (7)	Take care of young bee loving trees (2)	Stop bush fire to protect hives (10)	Plant bee loving trees (1)
Advise farmers to use protected smokers (8)	Prevent wet tree cutting (4)	Stop people who are destroying the forest (15)	Plant flowers (3)
Seminar attendance to learn more about it (9)	Prevent bush fire (5)		Plant trees that do not dry up the soil (19)
Give instructions to protect the forest (16)	Fire tracing (6)		
Advise women to not burn crops along the forest (18)	Smoker thrown in the river after harvest (11)		
Regular meetings to discuss mistakes and correct them (20)	Avoid that domestic animals destroy trees around hives (12)		
	Care during harvest that fire does not drop out the traditional smoker (13)		
	During harvest, spread water around hives (14)		
	Back burning (17)		

Figures into brackets correspond to number of respondents engaged in the action

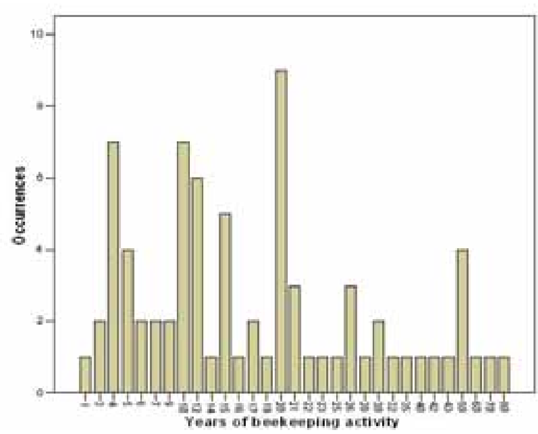

Figure 5: Years of involvement in beekeeping

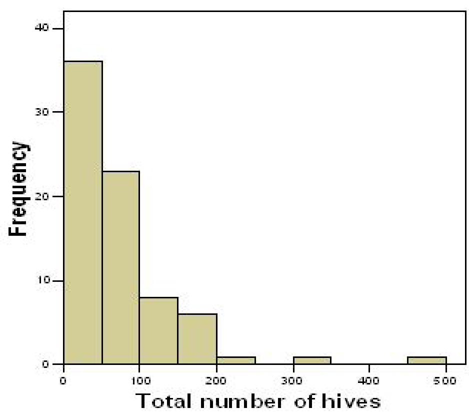

Figure 6: Number of hives per beekeeper in Oku region

the A quality level (based on humidity and HMF rates); it would be paid by Fair Trade buyers at US$2.55/kg which means FCFA 1887 for one honey litre. Calculation with 1 US$ = 0.759 €; 1€ = 650 FCFA and 1.5 honey kg=1honey litre. 2.55US$/kg*0.759€/US$*1.5kg/L*650FCFA/€ = 1,887 FCFA/honey litre (Fair Trade A quality). When the certification costs are compared to the annual benefit earned in each beekeepers' groups in Zone 1, the new fair trade association would have to pay 39% of their honey sales benefits in certification costs in the first year and still 26% of it in the following years (Table 7). These percentages have been calculated in the best case where the annual benefit would be FCFA 6,461,500. In order to decrease the ratio certification fee/benefits, the ficticious association FTOWHO would need to produce at least 55,000 kg of honey (almost 3 times more comparing to the better year production) to pay 10% of their annual benefits in certification fee the first year and 6.7% the following years. This means if the association produces 55,000 kg, it is equal to 36,666 litres. The benefit per litre has been estimated on average at FCFA 684, thus the benefit estimated for 55,000 kg is 36,666*684 or FCFA 25,080,000. The certification fee has been estimated to be FCFA 2,531,750 the first year and 1,696,500 the following years. The certification fees have been estimated in the best case where the average number of members per group affiliated is considered below 50 members. Additional cost might be be warranted for follow-up audit fees to verify non-compliance with Fair Trade Standards identified during an initial, surveillance or renewal audit. These audits are charged in addition to the respective initial or annual certification fee. The invoiced amount is 350 € per day (FLO, 2012) which equals FCFA 227,500 per additional day. The auditors' travel expenses must also be covered and although FLO claims to have local auditors; these are still few in Africa, with the possibility that the closest auditor would be sourced from Kenya. Some groups have kept their production and sales balance sheets, and annual reports, however, these may not be upto to international standard practice. Computer literacy and abilities may become a challenge in a context of very poor telecommunication infrastructures with low internet connectivity is very low. Beekeepers willing to start and maintain a Fair Trade process will need more reliable communication skills and equipment.

Discussion:

Concerning the social characteristics of beekeepers in Oku region, our results are similar to those to Founadoudou (2007) who also found, that the majority of beekeepers were 30 to 50 years in Adamaoua region. The highest the general level of education among beekeeper, the faster the rate of adoption of innovation will be (Londi, 2004). That is why the level of education is quite important to take into consideration as a fair trade certification system would be an innovation in Oku's white honey production and commercialization system. In Adamoua region, beekeeping is predominantly a male activity (Founadoudou, 2007). Ingram (2013) noted that of the estimated 447 honey traders in Kumbo's and Bamenda's markets in the Northwest, 66% were women. But it seems that women are not only involved at the end of the honey value chain anymore, as they also play a role in the production side. In this study, women were found to be involved directly from the initial stage opening ways for direct empowerment. It was also found in other studies that twice as many beekeepers in the Northwest (41%) are members of associations whereas in Adamaoua only 21% of beekeepers belong to a group (Ingram, 2013). The higher percentage of beekeepers in associations in this study is probably due to a sampling strategy that was focused on beekeeper groups. This study found that few beekeepers have additional agricultural activities (crops or livestock) besides beekeeping: the percentage are lower than the findings determined by Londi (2004) who found that 90% of Oku people are involved in agriculture. Consequently, it seems that even if most of beekeepers are farmers, beekeeping is an activity also practiced by diverse professional classes. Only few beekeepers used bee-suit: indeed, in Oku, 99%

Table 7: Certification fee calculation in fictive case of the association FTOWHO (in euro and dollar)

		First year		Following year		Comments
		€	**FCFA**	**€**	**FCFA**	
Application Fee		525	341,250	Not applicable		Not refundable, plus €160 per new/additional product, plus €160 per application for new group members in a 2nd grade organisation
Initial Certification Fee	Central Structure	1,530	994,500	Not applicable		Has to be paid once and before any service is delivered, has to pay €120 per additional product
	Affiliated Organisations	1,840	1,196,000			
Annual Certification Fee	Central Structure	Not applicable		1,170	760,500	Has to pay €180 per additional product
	Affiliated Organisations			1,440	936,000	
Sum	3,895	2,531,750	2,610	1,696,500		

(*) Central Structure is the central (umbrella) organization of a 2nd or 3rd grade organisation which is audited by FLO-CERT (FLO, 2007).

Figure 7: A typical indigenous beehive made of local material in Oku region

Figure 8: A common locally made honey filter machine in Oku

Figure 9: Oku's White Honey in various adapted containers

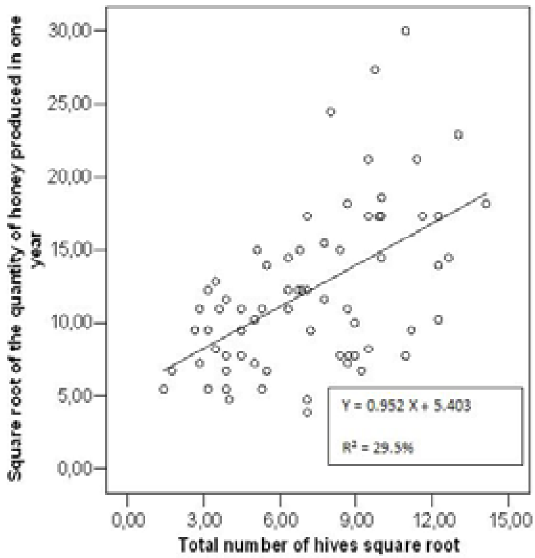

Figure 10: Regression plot between number of hive and annual honey yield in Oku region

of beekeepers do not use bee-suits (Baimenda, 2010). One reason given was that the suit disturbs beekeepers when they need to climb trees to harvest honey; the other reason might be the price. However, without bee-suit, honey quality is affected as no effective hive's examination can be done before harvest to control the health of the colony and because the harvest is stressful without bee-suits, bees are often mixed inside honey (Baimenda, 2010). Besides,Apismellifera's venom is dangerous, and in the case of certification implementation, bee-suits would need to be introduced for better producer safety. Of the respondents who use indigenous hives, 35%base their choice on tradition; they chose to use this type of hives because their father has used it.Tsafack Matsop et al,(2011) showed that there is a significant difference (level 5%) in terms of annual honey yield per hives between traditional and KTB. These latest produce more (4.5 litres or 6.75 kg) compared to traditional hives (3.75 litres or 5.60 kg). Honey yield per traditional hives in Oku is 1kg lower than in the North-West average in 2005 (Tsafack-Matsop et al, 2011). In this study beekeepers claimed to be more comfortable with their local equipment. KTB hives were tried in Oku, especially by the OHCS, but there was low colonization rates which prompted beekeepers to reject them, claiming that the KTB hives were not warm enough to get colonised. A previous socio-economic analysis of beekeeping in Oku (Baimenda, 2010) concluded that the major problems with indigenous hives were challenges for conducting proper examination, difficulties with examining combs for selection of ripe honey combs. Harvesting in this type of hives destroys larvae that critical to the growth of the colony; that might explain the low rate of colonisation. Concerning the harvesting techniques, it seems that the honey smoke taste is not really appreciated by western or other urban consumers although it is a proof of authenticity for local consumers (Chabrol, 2010). In the literature 81% of beekeepers do not add value to their honey through clarification (Baimenda, 2010). The filtration is thus done by the manager of the group or beekeepers who have skills in honey filtration. In this way, honey is more homogenised as it is drained with the same technique. For environmental aspects, as mentioned in the literature, hives are installed in the forest; bee transhumance practices mean that they also feed on crops, particularly coffee. Chemicals are widely used on coffee and are not well controlled. This affects bee health, honey quality and poses problems for potential organic certification of Oku white honey (Ingram, 2013). There is a relatively high population density around the forest as around 200,000 persons live within one hour's walk from the forest (Londi, 2004). Besides, between 1958 and 2001, 56% of the total original forest area was lost by fire or clearance for agriculture. The practice of shifting cultivation implies that the forest was steadily being cleared for farm land. Because clearing the forest properly was difficult, the indiscriminate practice of slash-and-burn clearing destroyed many species. Grazing in the forest, and the indiscriminate harvesting of forest products, as wet wood for carving also contributed to forest destruction (Londi, 2004). This study found that all the respondents are not involved in any way in direct destruction of the forest.

The annual yield of honey will depend on the sustainable maintenance of trees whose flowers provide the peculiar characteristics to Oku's honey, especially Schefflera abyssinica and Nuxia congesta (Asanga, 2001). No GMOs are used or sold commercially as GMO seed is forbidden in Cameroun (PANAPRESS, 2005). Certification procedure and costs may be a constraint for Oku white honey producers. The percentages estimated are quite high by comparison with some examples met in labelled Fair Trade movement Schmelzer (2006). In a British supermarket it was found that on the price of fair-trade bananas (four times the conventional banana price) only 6% of the final price was paid to the producers, 20% to the middlemen and importers and the rest (75%) to the supermarkets. Besides, although Fair Trade labelling companies claim the guarantee of a minimum price and a social premium paid to the cooperative, there is limited transparency on how much these companies earn which raises questions on the fairness of these minimum and premium prices. Indeed, an investigation on fair trade cocoa realised in different African countries showed that the Max Havelaar, (Dutch Fair Trade certifying institution) made more than €400,000 from license fees (paid to them by chocolate companies for the right to use the Fair Trade logo) in 2009 and less than half of that amount (€175,000) was paid to Fair Trade cocoa cooperatives in that year. Despite these substantial certification fees, FLO disclaims any responsibility for finding buyers for organizations that get the certification. Ebong (2010), Moity-Maizy and Sautier (2006) already mentioned the challenges for agricultural products for certification from western and central Africa. However, five Cameroonian organisations are certified by FLO. All of them are smallholders' organisations. The Konye Area Farmers Cooperative Society Ltd (certified since 2007) commercialises cocoa, coffee, plantains and palm-oil. The Mamfe Central Farmers' Cooperative Society Ltd (MACEFCOOP) is FLO certified since 2012 and commercialises robusta coffee (100 tons/year) and cocoa (200 tons/year). Mayo Kabba certified since 2011 commercialises cotton seeds. The organisation Plantations du Haut Penja (PHP) is recently FLO certified (2013) and commercialized bananas. GIC TerrEspoir Cameroun, certified since 2010, commercialises bananas (2.9 tons per week of fresh fruits; 170 kg of dried fruits per week between April and October), mangoes (2.5 tons per week in June of fresh fruits; 350 kg of dried fruits per week between April and June fruits).

In regard to honey standards, the A quality level would be difficult to achieve, because of the technical analysis showing that humidity rate is naturally high for Oku's white honey. To achieve the A quality; if the humidity rate is between 18.6 and 19%, the HMF content should be between 5.1 and 9.9 ppm (FLO, 2012). Although the Code of Conduct of Oku's White Honey recommends 8.9 HMFmg/kg; it authorises quantities up to 40 HMFmg/kg (KIWHA, 2011). This Fair Trade price is actually lower than the current price paid by local trade companies. Guiding Hope (GIC specialised in Cameroonian wax and honey commercialisation, mostly in the country but also outside) buys one white honey litre at FCFA 2,000 when the normal market price is FCFA 2,500 for instance. In this case, Fair Trade minimum price would be lower than the local price paid to producers.

Conclusion:

Beekeeping is a traditional activity in Oku region, employing various types of people, mainly adults, literate with affordable skills and means. Technically, there are gaps and improvement potential for the whole system, from beehive design to hive products processing and packaging. White honey production in the area is contributing directly and indirectly to a conservative and responsible management of the forest and thus to the ecosystem preservation. Although Oku's White Honey is produced according to the Fair Trade philosophy and might fit consumers' expectations, it is currently not possible to fund locally FLO certification for Oku's White Honey production. The minimum price guaranteed by FLO for Fair Trade honey is below the current price paid to producers by local buyers. The production would need a substantial increase of at least 3 folders the present yield to reduce the incidence of labelling costs on benefits for the following years. The Geographical Indication certification is an opportunity for Oku's White Honey for entry into discerning and more lucrative domestic and regional markets. For Oku's White Honey urban consumers in major cities in Cameroon represent a major, largely unexplored opportunity. There is then a need to setup good networks and selling channels. Urban neighbouring cities markets in Central Africa, where less honey is produced, might also be good opportunities. By developing a local market through big cities in Cameroon and Central Africa; Oku's White Honey production system would be enforced and better rewarded.

Acknowledgments:

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SHORT COMMUNICATIONS FROM THE POSTER SESSION

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MAJOR CHALLENGES OF BEEKEEPING IN CHIRON WORDE OF WEST HARANGUE ZONE, EAST ROOMIER, ETHIOPIA

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Abstract

The study was conducted in Chiron District of West Harangue Zone, Ethiopia to identify the major challenges to bee-keeping activities so as to indicate the priority intervention areas for Government and non-governmental beekeeping development organizations. The average traditional and modern hives possessed per respondent was 6.87and 0.38 respectively. Occupancy rates stood at 58.8% for traditional hives and 46.7% for the modern hives. The main reason for these low occupancy rates was the fact that most of the modern hives were distributed at no cost to receipients by NGOs without training on how to operate them as well as the shortage of bee colonies and operational accessories. Out of 119 respondents, only eight (6.7%) were women and this could be due to enduring traditional perceptions that beekeeping was the domain of men only. According to respondents the main sources of the foundation colony were catching swarm, gifting by family members and purchase of colonies. Respondents indicated that the three sources were unreliable because of different factors. The respondents kept their colonies both in and out door, but with no internal hive inspection. The major challenges in the region were shortage of bee colonies, high price of the modern hives and its accessories making them inaccessible for many, low extension service, and lack of awareness of the farmers. Some of these were also factors in keeping women's participation in beekeeping low. Ants and wax moth pest problems were also reported.

PRINCIPAUX DEFIS DE L'APICULTURE A CHIRON WORDE DANS LA ZONE OCCIDENTALE DE HARANGUE - ROOMIER ORIENTAL (ETHIOPIE)

Résumé

L'étude a été menée dans le District Chiron de la Zone occidentale de Harangue en Éthiopie, dans le but d'identifier les principaux défis liés aux activités apicoles, en vue d'indiquer les zones d'intervention prioritaires pour les organismes gouvernementaux et non gouvernementaux de développement de l'apiculture. Les ruches traditionnelles et modernes moyennes détenues en moyenne par les répondants étaient respectivement 6.87 et 0,38. Les taux d'occupation étaient 58,8% pour les ruches traditionnelles et 46,7% pour les ruches modernes. Les principales raisons de ces faibles taux d'occupation résident dans le fait que la plupart des ruches modernes ont été distribuées gratuitement aux bénéficiaires par les ONG sans formation de ces derniers à la façon de les utiliser, ainsi que la pénurie de colonies d'abeilles et d'accessoires opérationnels. Sur 119 personnes interrogées, seules huit (6,7%) étaient des femmes, et ceci pourrait être dû à la persistance des perceptions traditionnelles que l'apiculture était le domaine exclusif des hommes. Selon les répondants, les principales sources des colonies souches étaient : la capture d'essaims, les dons des membres de la famille, et l'achat de colonies. Les répondants ont indiqué que les trois sources étaient peu fiables en raison de différents facteurs. Les répondants gardaient leurs colonies à la fois à l'intérieur et à l'extérieur d leurs habitations, mais sans inspection de la ruche interne. Les principaux défis rencontrés dans la région étaient la pénurie de colonies d'abeilles, le prix élevé des ruches modernes et des accessoires - d'où leur inaccessibilité pour beaucoup d'apiculteurs, la faiblesse des services de vulgarisation, et le manque de sensibilisation des apiculteurs. Quelques-uns de ces défis ont contribué à la minimisation de la participation des

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femmes dans l'apiculture. Des problèmes liés aux fourmis, aux fausses teignes et aux parasites ont également été signalés.

Beekeeping, also called apiculture, is management of honey bee colonies for pollination of crops and for honey and other products. Beekeeping is one of the more universal agricultural activities. It contributes to peoples' livelihoods in almost every country on earth. Honey and other products obtained from beekeeping have been known by every society (Nicola, 2009). Adequate forage availability coupled with the favorable and diversified agro-climatic conditions of Ethiopia creates environmental conditions conducive for the growth of over 7000 species of flowering plants which have supported the existence of large number of bee colonies in the country (Been and David, 2007). These create favorable conditions to undertake beekeeping activities and make the country one of the potential country for apiculture sub-sector. Despite the long tradition of beekeeping and its potentials in Ethiopia, the share of the sub-sector in the GDP has never been commensurate with the huge numbers of honey bee colonies and the country's potential for beekeeping. Additionally low productivity and poor quality of bee products are the major economic impediments for beekeepers (NURU, 1999). Thus the beekeepers in particular and the country in general are not benefiting from the sub-sector (Nauru, 2002). This study was conducted to identify the major challenges of beekeeping and honey production of in Chiron.

Six Peasant Associations (PA) were selected through purposive sampling. Twenty beekeeper farmers were selected and interviewed from each Peasant Association by using pre-tested semi-structured questionnaires. Primary and Secondary data such as the potential of the area for beekeeping, beekeeping constraints, participation of women in beekeeping management practices was collected. Data was analyzed using SPSS software and descriptive statistics. Of 119 respondents, only eight (6.7%) were women. According to male beekeepers, in a few cases men accompany their wives and/or daughters during hive management. As shown in the Table 1, most of the bee hive management practices were male dominated.

Most of the respondents (89%) keep their bees for income generation, the remaining 11% for home consumption. According to the respondents the main sources of the foundation colony were catching swarm (44.5%), gifts from family (41.2%) and through purchase (14.3%). Even though obtaining colonies through gifting by family and catching swarms were indicated as the most important sources of obtaining bee colonies for start-ups, these were not considered as reliable sources of bee colonies. In the study area bee colony buying and selling was practiced in five of the six Peasant Associations. However, the type of bee colony purchased were not good since almost all (99.2%) of the sellers only offered weak colonies that have been not productive. The price of bee colonies ranged from 1300-2000 ETB with the mean price of 1385 ETB. The continued reliance on the three sources of bee colonies in the study area underscores the absence of reliable bee colony sources and bee colony multiplication.

There was also evidence of poor selection of beekeeping sites in study area, and citing of beehives for . Of the respondents interviewed, 53.4% of the respondents kept the bee hives under the roof of their house, 30.7% kept hives on the ground in their gardens (Fig 1), 15.1% in the inside the house, and the 0.8 % kept on trees. As indicated above most of the respondents keep their hives under the roof and inside the house (68.5%) due to fear of theft and for easy access by the household members. Keeping bees in the house and under the roof of the house could have great risk on children and domestic animals especially during hive inspection and honey harvesting.

Very few respondents (3.2 %) visit their bees on a daily basis, while 30.2% of them visit their bees once every few weeks. The rest

Table1: Participation of women in apiculture in sampled peasant associations

Activities	Hive possession and participation in hive management	No of respondents	Male		Female	
			Frequency	**%**	**Frequency**	**%**
Gender participation in ownership of hives	Traditional	119	111	93.3	8	6.7
	Transitional	119	0	0	0	0
	Modern	119	18	15.2	0	0
	Hive management activity	**No of male respondents**	**Frequency**	**%**	**Frequency**	**%**
Degree of accompanying women in bee hives management	Preparation of bee hives	111	111	100	0	0
	Preparation of fresh cow dung for smearing the hive	111	13	11.7	98	88.3
	Hanging or siting bee hives	111	111	100	0	0
	Inspection of bee hives	111	111	100	0	0
	Cleaning apiary	111	46	41.4	65	58.6
	Preparation of materials for harvesting honey	111	0	0	111	100
	Harvesting honey	111	111	100	0	0
	Selling honey	111	89	80.2	22	19.8

(65.6%) only occasionally visit their bees to check if the hive was occupied with bees and at least during honey harvesting seasons. Internal hive inspection is not practiced: respondents reported that they respondents: they do not promote production of additional queen to encourage swarming, and do not rotinuely check the level of production of brood, nor due they assess for the presence of pests and diseases. The major reason for absence of internal hive inspection was lack of knowledge and awareness. Over half of the respondents (52.7%) cleaned their apiaries and put ash under the hive stand to deter ant infestations: 47.3% of respondents indicated that they do not clean their apiary areas (Fig 1).

Most of the respondents (74.3%) who have modern beehives did not manage them properly. Only 25.7% of the respondents had hives hive stands and carried out better managements practices. The majority kept their hives on the ground and this together with failure to rountinely clean apiaries affected bee entry and exit from hives leading to wastage of pollen as bees struggled to enter and exit the hives and reduced the foraging trips. There was also poor harvesting practices: all respondents reported that honey was harvested on expectation that the hive was ready for harvesting, without an inspection to verify the state of the hive. Only 1.7% of the respondents used a modern smoker due to lack of awareness the value and benefits of the modern smoker. Studies in different part of the country also indicated that most of the local beekeepers lack the basic tool such as bee veils, hand gloves, smokers, chisels, and beekeepers suits.

Figure 1: Traditional hives invaded by weeds increasing exposure to pest attack

Beekeepers involved in the study was requested to prioritize the challenges mentioned: the top six challenges identified in the area include lack of knowledge, lack of beekeeping accessories due to high prices, shortage of bee colonies, poor extension service, pests and predators, and low participation of women.

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PROGRESS AND CHALLENGES TOWARDS LISTING OF KENYA IN EUROPEAN UNION MARKET FOR EXPORT OF HONEY AND HIVE PRODUCTS

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The European Union (EU) market for honey and hive products offers an opportunity for innovative business and capital investment with good returns to traders in honey and beeswax. However, EU stringent regulations and standards for foods of animal origin have made it difficult for many third world countries to secure and sustain this lucrative market. Kenya was delisted from exporting honey and hive products in the year 2006. This was after failure to develop a comprehensive Residue Monitoring Plan as required by various EU Council Directives (96/23/EC) and Regulations that outline requirements for promoting the export of honey and hive products from Kenya. Kenya could therefore not guarantee that there would be no introduction or contamination with substances and pests that can cause adverse health effects or economic losses of concern to the European Union.

Most of honey and hive products are from the small scale farmers who practice traditional beekeeping and use traditional log and modern hives. Approximate 80% of honey is from traditional log hives with the rest from Langstroth and Kenya Top Bar (Government of Kenya, 2008; Director of Livestock Production, 2014). There are 1,106,950 log hives, 201,257 Kenya Top Bar Hives and 116,585 Langstroth hives (Director Livestock Production, 2014).

The rangelands of Kenya are main producing areas of honey due to the diverse flowering plants. The honey production stood at 17,259 tonnes in the year 1994, rose to 19,071 in the year 1996, 22,803 in the year 2000, before declining to 14,653 tonnes in 2008(Food and Agriculture Organisation (FAO), 2015). In the year 2014 the production figures for honey and wax rose to stand at 29,742 and 2900 tons respectively (Director Livestock Production, 2014). The estimated potential for honey production is 100,000 and 10,000 tons of beeswax annually (Government of Kenya, 2008).

Investigations on the pests and diseases of bees have shown that varroa mites and beetles are some of the main pests of the honeybees in Kenya. Towards this, the Government of Kenya has gazetted six main diseases and pests; Varroosis, Tropilaelaps, Small hive beetle (Aethina tumida), Ascorosis, American Foulbrood and European Foulbrood bacterial diseases (Kenya Gazette, 2009). The investigations also involve profiling of the viruses in different ecological zones, an undertaking being carried out by Director of Veterinary Services in collaborations with research institutions and universities.

Most of Kenyan honey is consumed locally with the main outlets being supermarket chains in the major towns. Several organized groups and individual entrepreneurs package their products ready for distribution to the outlets. Kenya used to export to European Union market until the year 2006 when it was unable to fulfil one of the export requirements of submitting a Residue Monitoring Plan (RMP). The RMP is a mandatory requirement set out in European Union Council Directives and is supposed to indicate the level of compliance on Maximun Residue Limits (MRLs) for Veterinary Medicinal products, pesticides and other environmental contaminants and the Maximum Limits (MLs) for heavy metals.

Since December 2014, Kenya has been engaged in putting up some measures that would see it listed again to export in the European Union market. Some of the measures are intended to address bee health, safety and quality standards. So far significant progress has been made though with some challenges.

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One of the first steps that the Government of Kenya has taken is to put into place mechanisms for review of the legislation on bees and bees' product. The current regulations relating to honey and beekeeping are quite outdated. The East African Custom Management Act of 1952(Act No.12 of 1952) and The Animal Diseases (CAP 364), Kenya Subsidiary legislation of 2002 provide for the prohibition of importation of honey, queen bees, pupae, larve or eggs, used bee cages and accessories or wax from areas infested with Foul Brood Diseases or Nosema Disease that have been detected in the last two years. Currently a new Beekeeping Bill has been drafted and is now being subjected to stakeholders before enactment as a law by the parliament.

The Director of Veterinary Services has trained personnel on bee health and investigations in the field and laboratory. This would help mapping the infected areas and characterization of the pests and pathogens. A bee health and chemical analysis laboratory for diagnosis and confirmatory testing is being set up. The diagnosis will be complimented by external laboratories and institutions that have been designated by the Director of Veterinary Services: these include the Chemical Laboratory of the School of Veterinary Science at the University of Nairobi, the International Livestock Research Institute laboratory (ILRI), the International Centre for Insect Physiology and Ecology (icipe) laboratory, the Kenya Plant Inspectorate Services (KEPHIS) and Kenya Bureau of Standard laboratory. The laboratories are approved for analysis based on the assessment for compliance as per ISO 17025:2005 requirements and their capability and competency to test residues and contaminants as per EU requirements outlined in Commission Decision 2002/657/EC, and other specific Community Legislation like Document No. SANCO/12495/2011, Commission Regulation (EC) No 836/2011, Commission Regulation 5EC° No 401/2006 Commission Regulation (EC) No 252/2012 (CBI, 2012; Director of Veterinary Services, 2015).

Sentinel Apiaries are in process of being established within different ecological zones in the country where samples will be collected from and tested for diseases and pests. The sentinel Apiaries will also be used to train the animal health staff in the County Governments on the procedures for monitoring the diseases and pests of honeybees.

So far two premises for export of beeswax to European Union Market have been approved under third country listing. A total of beeswax worth US$ 190,000 has been exported. More exports of the beeswax are expected to be made with this new achievement.

The stringent rules on imports of the food products from third world countries make it difficult for most of potential exporters to exploit the European Union market especially for honey. The requirement on traceability of the products up to farm level is a challenge to the exporters who depend on small scale farmers for their supply. There is also a challenge to maintain the market once an exporting company is listed.

The farmers lack adequate skills on production and handling of the honey and hive products. Most of them do not take beekeeping as a commercial venture that demands adequate attention. They also have limited knowledge on regulations for exporting their honeybee products and lack protective gear. There is therefore a need to train the farmers and organized groups on production issues, health, group management and accountability.

Drastic weather conditions such as prolonged drought and cold spells have affected the production. Poor flowering, lack of water and limited or loss of plant diversity are some of challenges faced by most of beekeeping farmers especially in rangelands.

Honey production is expanding in Kenya. However the non availability of crucial data on production trends and processing and marketing is an impediment to potential clients and exporters.

Acknowledgement

The acknowledgement is extended to Director of Veterinary Services, Kenya who

made it possible to collect information and come up with regulatory roadmap geared towards facilitating trade on hive products.

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ENABLING POLICIES AND LEGAL FRAMEWORK TO SUPPORT THE GROWTH OF HONEY INDUSTRY IN SUB SAHARAN AFRICA: A CASE OF RWANDA.

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The honey industry has been identified as one of the important agricultural activities in Rwanda due to multiple contributions made in terms of biodiversity conservation, employment opportunities and overall sustainable development (PSTA III, 2013). Rwanda is estimated to be producing 156,641 Kg of honey annually from seventeen high potential districts across the country. According to a baseline survey carried out by SNV Rwanda across these high potential honey production districts in Rwanda, there are an estimated 30,293 beekeepers of whom 18,430 are men (60.8%), 7,233 women (23.8%) and 4,630 are youth (15.2%). The total number of hives was estimated to be 92,971 with 84,255 (90.6 %) being traditional log, mud and other indigenous hives while the modern hives were estimated to be approximately 8,716 (9.4%) (SNV, 2009).

Due to the growing local and export market demand for quality honey and bee products and pro-poor potential of beekeeping, the sector attracted the interest of policy makers to put in place an enabling legal framework to support and boost production of honey and other bee hives products. After the approval of the residue monitoring plan in 2014, Rwanda is among the developing countries allowed to export honey into the European Union (EU). This paper sought to review in detail the policy and legal framework put in place by Rwanda and other African countries to modernize the beekeeping sector.

Rwanda has a number of different policy frameworks governing/guiding the apiculture sector. The National Beekeeping Strategy (2007-2011) was formulated as a policy document to guide the efforts aimed at modernizing the Beekeeping sector. Apiculture is also governed by a set of laws i.e., Law N° 25/2013 of 10/05/2013 regulating beekeeping activities; Law N° 54/2008 of 10/09/2008 determining the prevention and fight against contagious diseases for domestic animals in Rwanda (Control of bee diseases). Other legal instruments include the Prime Ministerial Order establishing the organization and functioning of the National Forum of Beekeeping in Rwanda. The forum shall include all beekeepers eligible to practice the profession in the Republic of Rwanda, processors and traders of honey and bee products. The A Ministerial Order was adopted by the Cabinet in 2015 determining the exploitation modalities for beekeeping sector in Rwanda and to enforce the orderly conduct of beekeeping. Article Two states that any public or private person, organization or cooperative who wishes to practice beekeeping must have a registration certificate issued by Rwanda Agriculture Board.

Law N° 25/2013 of 10/05/2013 regulating beekeeping activities provides for the regulation of beekeeping activities including bee hiving, honey harvesting, processing and marketing of other beekeeping products. The Law consists of five chapters: General provisions (I); Management and development of beekeeping (II); Conservation of beekeeping resources (III); Hygiene and prohibition in beekeeping (IV); Final provisions (V). The main provisions are that standards for raising bees are set by the instructions of Minister under Article Six. Article Nine states that ownership of hives, colonies, swarms and beekeeping products shall be the beekeeper's private property. Article Fifteen requires the beekeeping service to destroy a colony or a swarm of bees in following circumstances: The colony of bees is infected with pathogens difficult to treat; the colony or swarm of bees may cause inevitable damage to the population; and the colony of bees or the place where bees

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are raised is neglected or abandoned; 4° the colony consists of sick or dead bees. Other provisions of this law outline modalities for the use of toxic substances employed in agriculture and for the prevention of contamination in beekeeping activities, granting and withdrawal of beekeeper's certificate and loss of the right to practice the beekeeping profession, inspections, and regulation-making powers of the Minister.

Law N° 54/2008 of 10/09/2008 determining the prevention and fight against contagious diseases of domestic animals in Rwanda introduces measures to prevent the spread of a disease affecting bees.Article 139 of the law determines preventive and quarantine measures for curbing bee diseases including Varroasis, Acariosis, American and European loche and bee nosemosis. The law sets out powers of authorized officers in case of the need to manage an outbreak.

Within the East African Community region, Tanzania has formulating apiculture polices and enacted supportive laws. The Tanzanian National Beekeeping Policy was formulated in 1998 and the Beekeeping Act enacted in 2002. The available legal framework on beekeeping in Uganda is Rules on Control of Bee Diseases 2004 in line with the Animal Diseases Control Act while in Kenya the Animal Disease Act, 2012 made mention of bees as animals. Elsewhere in Africa, the FAO legislative database shows that very few African Countries have in place the laws and policies on apiculture and bee industry.Those countries are Nigeria, Botswana and Zimbabwe.

The Nigeria Bees (import control and management) Act, 1970, makes provision for the control of importation of bees and apicultural material and the spread of diseases and pests among bees. Importation into Nigeria of any bees, or any apicultural material for use in connection with bees or bee-keeping requires a permit from the Minister of Agriculture. It also states that Importers shall, with the application for a permit, undertake to do anything considered by the Minister necessary for the prevention of diseases or parasites among bees.

In Botswana, the Importation of Bees Act (Chapter 49:02) introduces measures to prevent the spread of a disease affecting bees. It prohibits the importation of bees without the written permission of the President and prohibits the importation of specified material relating to bees altogether. The Act sets out powers of authorized officers in relation with inspection of consignments, apiaries or places where honey or beeswax is sold and defines the regulation-making powers of the President.

In Zimbabwe, the Bees Act [Chapter 19:02], provides for the control of diseases in bees and the conservation of bees found in the wild; regulation of bee-keeping; and provides for matters incidental to or connected with the foregoing. In this act, the Minister may authorize an apiculturist to destroy bees and it requires a beekeeper to notify an apiculturist regarding the occurrence of infectious diseases. The act places restriction on removal or disturbance of bees, etc., found in natural hives. Sale of bee products found in the wild is declared to be an offence. The act makes it compulsory for notification of use of insecticides or herbicides.

Impact

This paper has highlighted the progress made by some African countries in setting policy and legal frameworks to support the growth of bee and honey industry in Africa. It underscores the need for African countries to adopt policy measures aimed at overcoming challenges in quality improvement and access to a remunerative market, management of honeybee diseases and pests, apiculture value chain development like access to finance and adequate training.

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AFRICAN UNION - INTERAFRICAN BUREAU FOR ANIMAL RESOURCES (AU-IBAR)

Bulletin of Animal Health and Production in Africa
Guide for Preparation of Papers
Notes to Authors

The Editor in Chief
January 2013

Aims and scope

The Bulletin of Animal Health and Production in Africa (BAHPA) of the African Union Interafrican Bureau for Animal Resources (AU-IBAR) is a scientific journal which publishes articles on research relevant to animal health and production including wildlife and fisheries contributing to the human wellbeing, food security, poverty alleviation and sustainable development in Africa. The bulletin disseminates technical recommendations on animal health and production to stakeholders, including policy makers, researchers and scientists in member states. The Bulletin is the African voice on animal resources issues specific to Africa.

The Bulletin of Animal Health and Production publishes articles on original research on all aspects of animal health and production, biotechnology and socio-economic disciplines that may lead to the improvement animal resources. Readers can expect a range of papers covering well-structured field studies, manipulative experiments, analytical and modeling studies of the animal resources industry in Africa and to better utilization of animal resources.

The BAHPA encourages submission of papers on all major themes of animal health and production, wildlife management and conservation, including:

- Veterinary microbiology, epidemiology
- Marketing, economics
- Infectious and non infectious disease
- Parasitology
- Genetic improvement and biotechnology
- Animal production, nutrition and welfare
- Science and policy in animal health and production
- Beekeeping and honey bees
- Ecology and climate change impacts on animal resources in Africa
- wildlife management
- Fisheries and aquaculture development
- Food safety and food hygiene
- One health
- Emerging and re-emerging issues in animal resources
- Biosecurity
- Animal resources trade and value chain
- Socio economics and economics of animal resources development

Language

The language of submission should be either in U.K. English or Standard French. The abstract is translated to the other three languages of the African Union (Arabic, English, French and Portuguese), by the editors, after acceptance. Full articles submitted in French will also be published in English.

Manuscripts Submission

Authors are invited to submit electronically their manuscripts via attachment only at bahpa@au-ibar.org in a secured PDF and word format. Manuscript can be sent by post in case of unavailability of internet services (authors should be aware that in this case it will take longer time to be published).

Authors submitting articles to the BAHPA must follow the guidelines in this document. Submissions that deviate from these guidelines will be returned to the corresponding authors for changes and compliance.

To be considered for publication in the BAHPA, any given manuscript must satisfy the following criteria:

- Originality. BAHPA does not accept manuscripts that have already been published elsewhere. However, studies that replicate results that are already in the literature may be considered for publication, as the independent confirmation of results can often be valuable, as can the presentation of a new dataset.
- Audience. Manuscripts submitted must be of broad interest to animal health and production professionals in general, they must capture and hold readers' attention.
- Usefulness. Manuscripts submitted must help researchers, trainers, educators and policy makers in all regions of Africa improve their effectiveness.
- Rigorous methodology. Manuscripts submitted must be based on valid and reliable information, documentation or sound concepts, empirically, logically and theoretically supported.
- Well written to ensure clear and effective presentation of the work and key findings. The BAHPA editorial staff does not copyedit the text of accepted manuscripts, it is therefore important for the work, as presented, to be intelligible. Perfect, stylish language is not essential but it must be clear and unambiguous. If the language of a paper is not clear, Academic Editors should recommend that authors seek independent editorial help before submission of a revision. Poor presentation and language is a justifiable reason for rejection.
- Experiments, statistics, and other analyses performed are described in sufficient detail. The research must have been performed to a technical standard to allow robust conclusions to be drawn from the data. Methods and reagents must also be described in sufficient detail so that another researcher is able to reproduce the experiments described.
- Conclusions are presented in an appropriate fashion and are supported by the data. The results must be interpreted appropriately, such that all conclusions are justified. However, authors may discuss possible explanations for their results as long as these are clearly identified as speculations or hypotheses, rather than as firm conclusions. Inappropriate interpretation of results is a justifiable reason for rejection.
- The research meets all applicable standards for the ethics of experimentation and research integrity. Research to be published must have been conducted to the highest ethical standards. A brief description of the most common of these is described in our Editorial and Publishing Policies.
- Because the guidelines are updated as appropriate, authors should check them again before they submit their articles. Manuscripts submitted for publication will be considered for acceptance on the understanding that they present original work which has not been published or submitted for publication elsewhere and that they are subject to peer review.

Types of contribution

Full papers providing accounts of original work: Research containing significant new findings. The material presented should be original and not have been published elsewhere, except in a preliminary form. Papers will be reviewed by three referees familiar with the subject matter of the paper.

Short Communications: are intended to provide quick publication of highly relevant and interesting information. Manuscripts will be peer reviewed by two reviewers and the Editor.

Review Articles: should cover subjects falling within the scope of the bulletin, which are of active current interest. Papers need not contain original work or ideas. They will be reviewed for completeness, accuracy, style and suitability of content by referees familiar with the subject and the Editor-in-Chief..

Editorial: articles are short articles describing news about the bulletin or the opinion of the editor-in-chief, the publisher or a guest editor of a thematic series.

Letters to the Editor: the bulletin welcomes letters to the editor. The purpose of Letters to the Editor is to provide a forum for positive and constructive views on articles and matters published in the bulletin. Letters to the Editor must not exceed 300 words. Letters to the editors include technical reports from countries or projects.

Key notes and special calls: The editor will, from time, invite selected key figures in the field of animal health and production for key notes on specific topics. Book Reviews: are accepted and should provide an overview of the work's contents and a critique of the work's value. Book reviews should be limited to 1000 words.

Conference Proceedings: Special Issues of the bulletin may be dedicated to publication of proceedings of key meetings/ conferences

Obituary articles to honor prominent African scientists that have made significant contribution to animal resources research and development

News and announcements: BAHPA is pleased to publish information on animal health and production activities/meetings. Please send the following information to the Editor: Date of the event, title, organization offering the event, location and contact information.

Submission Guidelines

Full papers of original research

All manuscripts submitted to BAHPA should include the following features:

1. On cover page of the manuscript, the following should be clearly written/inserted: the corresponding author, name of the institution, , title of the manuscript, names of the authors, the addresses of the authors and the e-mail address of the corresponding author. The corresponding author should ensure that all the other authors consent to their names being included. The consent should be sent directly by co-authors to the editor via email.
2. Each original article should be divided into Abstract and Keywords, Introduction, Materials and Methods, Results, Discussion, conclusion, Acknowledgments and References. A textbox containing a public brief on the study for the benefit of policy makers should also be provided. This textbox will not be included in the published article but will be compiled and published in a separate edition at the end of the year.
3. Title, which should be concise, preferably not more than 15 words long, followed by the author(s) name(s) and institution(s) to which work should be attributed and address for correspondence, if different.
4. The Abstract should not be longer than 300 words giving a synopsis of the work and should contain the objectives, briefs description of materials and methods, highlights of significant results, conclusions and recommendations. Up to six keywords should be provided..
5. The Introduction should contain the problem statement, the hypothesis and the objective of the work and cite recent important work undertaken by others.
6. Materials and Methods should describe materials, methods, apparatus, experimental procedure and statistical methods (experimental design, data collection and data analysis) in sufficient detail to allow other authors to reproduce the results. This part may have subheadings. The experimental methods and treatments applied shall conform to the most recent guidelines on the animal's treatment and care. For manuscripts that report complex statistics, the Editor recommends statistical consultation (or at least expertise); a biostatistician may review such manuscripts during the review process. Cite only textbooks and published article references to support your choices of tests. Indicate any statistics software used.
7. Results should be presented clearly and concisely, in a non-repetitive way. Subheadings may be accepted.
8. Discussion of significance should be focused on in the interpretation of results. Subheadings are not accepted in this section.
9. Acknowledgements. Where necessary acknowledgements of grants and technical assistance should be included under this heading. . Please also include any potential conflict of interests if appropriate. Suppliers of materials should be named and their location (town, state/county, country) included.
10. State the conclusions, and any implications that may be drawn from the study.

Short Communications: Manuscripts should contain original data and be limited to 1500 words. The number of tables and figures are limited to two. A limited number of references should be included. Headings are not allowed in short communications.

Sequence of Preparation

1. The data files must be PC/Windows-compatible. The text should be prepared using standard software (Microsoft Word) format; do not use automated or manual hyphenation. Please do not include footnotes.
2. Use Times New Roman 12 point font for all text except for tables and figures where Times New Roman 10 font should be used.
3. Use 1 inch margins on top, bottom, left and right margins,
4. Every line on the text should be numbered.
5. Use double line spacing for body of text. For Abstract, Figures, Tables and References use single line spacing.
6. Place page numbers in the lower right hand corner of your manuscript.
7. Run "the spell check" and "grammar check" on the entire file before submission using either the UK English or French standard.
8. Avoid using abbreviations for the names of concepts. Use ordinary words for variable names – not code names or other abbreviations. Use the same name for a variable throughout your text, tables, figures and appendices. Names of organizations and research instruments may be abbreviated, but give the full name (with abbreviation in brackets) the first time you mention one of these.
9. References should take the following form: In the text, a reference identified by means of an author's name should be followed by the date of the reference in parentheses. When there are more than two authors, only the first author's name should be mentioned, followed by '*et al.,*'. In the event that an author cited has had two or more works published during the same year, the reference, both in the text and in the reference list, should be identified by a lower case letter like 'a' and 'b' after the date to distinguish the works. Examples: Abayomi (2000), Agindotan *et al.,*. (2003), (Kelebeni, 1983), (Usman and Smith, 1992), (Chege, 1998; Chukwura, 1987a,b; Tijani, 1995,1993), (Kumasi *et al.,* 2001)

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- *Books:* Durbin R, Eddy SR, Krogh A, Mitchison G, 1999. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. London, Cambridge University Press.

- *Chapter in a Book:* Leach J, 1993. Impacts of the Zebra Mussel (Dreissena polymorpha) on water quality and fish spawning reefs of Western Lake Erie. In Zebra Mussels: Biology, Impacts and Control, Eds., Nalepa T, Schloesser D, Ann Arbor, MI: Lewis Publishers, pp: 381-397.
- *Reports:* Makarewicz JC, Lewis T, Bertram P, 1995. Epilimnetic phytoplankton and zooplankton biomass and species composition in Lake Michigan, 1983-1992. US EPA Great Lakes National Program, Chicago, IL. EPA 905-R-95-009.
- *Conference Proceedings:* Stock A, 2004. Signal Transduction in Bacteria. In the Proceedings of the 2004 Markey Scholars Conference, pp: 80-89.
- *Thesis:* Strunk JL, 1991. The extraction of mercury from sediment and the geochemical partitioning of mercury in sediments from Lake Superior, Unpublished PhD thesis, Michigan State University, East Lansing, MI.
- *Web links:* Cerón-Muñoz M F, Tonhati H, Costa C N, Rojas-Sarmiento D and Solarte Portilla C 2004 Variance heterogeneity for milk yield in Brazilian and Colombian Holstein herds. Livestock Research for Rural Development. Volume 16, Article #20 Visited June 1, 2005, from http://www.lrrd.org/lrrd16/4/cero16020.htm

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