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## THE ROLE OF APICULTURE IN SUSTAINABLE FOREST MANAGEMENT

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**ABSTRACT:** This review gives an overview of apiculture, as an indispensable tool in sustainable forest planning and management. Trees depend on healthy bee colonies to improve the quality and quantity of forest seeds through effective pollination. Raw materials for honey, propolis and wax production are derived from plant nectar, pollen and resins. Trees also serve as sources of shelter and protection for bees. Beekeeping encourages forest conservation and protection. Valuable information about forest archaeology and diversity can be obtained through the scientific analysis of honey, bee pollen and propolis. There is high demand for honey and beeswax in the world market, whereas there is inadequate production and supply, especially in developing countries. The economic and biochemical potentials of bee products and their significance in health and biodiversity management are all underestimated in Nigeria. Woody biomass has potential benefits in apiculture. Honey and beeswax production are important means of income generation for many rural communities. The rural poor people, especially the beekeepers, are motivated to manage and protect the forests when seen as sources of sustainable livelihood. Apiculture establishes the basis why forests should be managed sustainably. This paper aims at examining the possibilities of managing forests sustainably through integration with apicultural practices.

**Keywords:** Symbiotic relationship, Ecosystem, Pollination, Biomass, Biodiversity.

### 1. INTRODUCTION

Apiculture or beekeeping is the maintenance or management of honeybee colonies, commonly in hives of different types, by humans, to procure their valuable by-products (Kachhawaha 2019). It is the management and study of domesticated honeybees; a critically important profession for securing and sustaining the world's food supply (Robertson, 2010). Apiculture is responsible for one third of the world's food supply by pollination of more than 90 to 100 species of flowering

plants (Agera 2011). The modern-day beekeeping is based on movable comb hives, including, top bar and frame hives, placed on iron stands.

Beekeeping is sustainable when there is adequate research and development, participation of the local people, design and fabrication of cost effective equipments; processing, storage and utilization of hive products; sustainable agricultural practices, among others. Sustainable beekeeping contributes to the empowerment of women (Belete and Ayele, 2020).

Beekeeping (apiculture) is a dynamic forest-based industry and played great roles in the economic growth of the producing countries. In Australia, honey is tagged "Liquid gold" because of its contribution to National treasury (Adekola *et al* 2019). Honey production contributes significantly to the GDP of many countries which include the four largest producers of honey, namely, the USA, Mexico, Argentina and Australia (Carroll and Kinsella 2013). According to FAO (2015) US\$3.3 billion is obtained from naturally harvested honey in 2011 alone. In 2017, the honey industry contributed approximately US\$2.1 billion in value added to the US GDP (Banks, 2019).

Trees provide food and habitat for bees, and by pollination, bees enable them to reproduce. Pollinators strongly influence ecological relationships, ecosystem conservation and stability, genetic variation in the plant community, floral diversity, specialization and evolution. This helps in preservation and sustainability of wild species of flowering plants (Robertson, 2010) and ensuring increase in production and quality of tree seeds through cross pollination of trees (Agera 2011). Without bee pollination, about 100,000 species of plants would go into extinction (Agera 2011). In addition to pollen and nectar, bees also collect propolis (resins), honeydew and water, which are used in producing valuable hive products. The quality of these products depends on forest diversity, while forests also depend on strong active colonies of bees for increased yield and quality of fruits and seeds. The more the species of fruit and seed generating within a system, the greater is its biodiversity and life-carrying and life-enhancing capacity (FAO 2019). Bees can help in indicating the natural status of their surrounding ecosystem, by detecting environmental pollution (Lowenstein *et al* 2015). Abrol (2009) reported honeybees to be useful in prospecting and detecting landmines.

## 2. SUSTAINABLE FOREST MANAGEMENT

Sustainable development can be simply described as the attainment of balance between societal increasing demands for forest products and benefits, and the preservation of forest health and diversity (FAO 2016). The concept of sustainability ensures continuous production for both present and oncoming generation: rate of exploitation should be less than regeneration rate of the renewable resource (David-Sarogoro *et al* 2019). Otherwise, the forest which is a renewable resource may become extinct. Integrated benefits are provided to all, through the attainment of a sustainable forest management plan. Such benefits include, safeguarding local livelihoods, protecting the biodiversity and ecosystems provided by the forests reducing rural poverty and mitigating some of the effects of climate

change. Woody forest resources are exploited mainly for fuel wood and charcoal, construction works, and household tools. To achieve the set objectives of sustainable management, a balance must be maintained between the needs of the rural or poor people and management of major forest resources.

In Nigeria, wood wastes are a source of fire explosions and environmental pollution (Owoyemi 2016). In-situ processing of felled log in the forest is common among local wood dealers. A large volume of wood chippings/flitches is generated which eventually ends up as wastes in the forests. Apiculture stimulates thorough forest sanitation and organization. Potential uses abound for forest wastes in apiculture.

In other to protect natural habitats, the local people must be encouraged and involved (The Sustainable Forestry Handbook 1999, Pullin *et al* 2013). The consequence of deforestation is first felt by people living in or near tropical forests and woodlands, who are amongst the poorest in the world, often depending on shifting cultivation for their food, and local wood as their fuel source. Beekeeping offers a sustainable way for rural people to create income from natural resources. This then implies that conserving forests involves considering the sustainable sources of food and income of the rural poor people (FAO 2016). Supporting beekeepers with alternative livelihood and good marketing channels motivate them to support local forest conservation efforts (Gemedra 2014).

## 3. THE UNIQUENESS OF APICULTURE IN SUSTAINABLE FOREST MANAGEMENT

Apiculture is unique in that, it provides an opportunity for food production, income generation with low investment and maintenance cost, low labor requirement and minimal disturbance to the natural ecosystem (Agboola *et al* 2021). Some outstanding benefits of beekeeping include: pollination of flowering plants, thereby maintaining the ecosystem; valuable products well known for their medicinal value and income generation; few resources (land, water, nectar and pollen from forests and cultivated crops, fruits, plant resins, cheap hives, wild colonies, trees for wind and temperature control) are needed, bees are obtained from the wild, equipments can be fabricated locally and feeding is not essential; land ownership is not essential; there are no competitors for nectar and pollen, which are the basic raw materials for honeybees; different sectors and trades benefit from the beekeeping industry (Krell 1996, Robertson 2010, Agera 2011); beekeeping encourages ecological awareness, as beekeepers have the financial reason to conserve the environment ensuring

that flowers are available and bees are protected. Beekeeping cuts across all ages and genders.

### 3.1. Apicultural Products and Potentials in Forest Resources Management

Besides the production of honey, beeswax, bee pollen, royal jelly, bee venom and apitherapy, the maintenance of biodiversity and pollination of crops are among the most valuable services provided by bees (FAO 2009, FAO 2021). The Africanized honeybee (*Apis mellifera*) is a particularly good producer of beeswax and honey (Kachhawaha 2019), and marketing potential seems vast. Beeswax is used in grafting in horticulture; for waterproofing textiles, paper and wood, and as wood preservative (Krell 1996, Abrol 2013). Bee propolis has promising potentials as natural antifungal in wood products (Abanikannda *et al* 2019) and as a raw material for furniture polishes and varnishes. Propolis is used as part of traditional medicines, and as an effective glue to mend or seal containers (wood, metal or clay), and to seal up knots in wood. Propolis has long been used for making wood varnish.

Beehive boxes can be weatherproofed by dipping in wax recipes (Krell 1996, Adriana 2021). Its potency lies in its composition which depends on the diversity of the forest. Old honeycombs, slum gums or remains from absconded hives, are potential sources of wax and resins for wood protection and finishing.

The plant diversity of a natural forest can be studied through palinology (pollen analysis) and propolis analysis. Examined pollen samples collected by bees have been observed to reflect environmental pollution when examined for heavy metals and radioactivity (Oliver 2012, Herrero-Latore 2017)

### 3.2. The Role of Bee Pollination in Rural Livelihoods and Forest Management

The great value of bees as pollinators have been known for many years, but unfortunately this knowledge is not widely appreciated and understood. Of the world's wild flowering plants, it has been estimated that 87.5% (approximately 308,000 species) are pollinated by insects and other animals and most of the remainder use abiotic pollen vectors, mainly wind (FAO 2022). This degree of dependence is thought to be even higher in tropical zones where it is estimated that more than 98% of plants depend on animals for pollen (Bawa 1990 *In: Abrahamczyk et al* 2011).

The value of bee pollination in Western Europe is estimated to be 30-50 times greater than the value of

honey and wax harvests in the region (Pannure 2016). In Africa, bee pollination is estimated to be 100 times the value of the honey harvest, depending on the type of crop. In a country like Denmark, about 3,000 tons of honey are harvested every year. It has a value of 60 million DKK or about €7.6 million. However, the value of pollination is estimated to be between 1,600 and 3,000 million DKK, equivalent to €200 and €400 million (Pannure 2016).

The outstanding benefits of bee pollination in forest livelihoods and management, as highlighted by AgriProFocus (2013) includes:

- Higher number of fruits and seeds,
- Better quality of produce,
- Protection of plant floral parts from pests due to efficient pollination of flowers,
- An increase in fruit weight due to full fertilization, thus leading to an increase in food production and forest productivity,
- Uniform harvest of mature well-formed forest seeds and fruits. The presence of sufficient bees ensures that all trees are pollinated at the same time, thus increasing the income of the forest management.

The benefits of bees and other pollinators have been observed beyond human food production alone, there is an increase in the diversity of forage crops due to pollination, thereby leading to an increase in animals' adaptability to climate change. Pollination has either indirectly or indirectly brought about an increase in medicinal plants, biofuels, fibres and construction materials (FAO 2018).

The effectiveness of honeybees as pollinators is due to their great number, their social life and their ability to pollinate a broad variety of different flowers. Major limitations to the survival and development of pollinators were identified as biodiversity loss and deforestation, intensive farming, monocropping, climate change and excessive use of agrochemicals (FAO 2019).

## 4. WOOD AND APICULTURE

Wood is an outstanding structural material, owing to its advantages over metal, plastics and ceramics. Some of its desirable characteristics such as color, durability, low heat conductivity, dimensional stability at low moisture content, high strength to weight ratio, sound resistance, make wood an excellent structural material in making beehives, smoker bellows and other various items. Even when processed, wood still blends naturally with the environment. It is warm to the touch, being particularly applicable in temperate and cold regions (Lucas, 2017). Unlike metals, wood is not corrosive and doesn't react

with honey, wax, or propolis. Wood does not react sharply to vibrations or radiations. Wood is one of Nigeria's most important natural resources which provide nests for bees and many other living creatures (Aiyelaja and Adedeji 2014). The odor of wood reflects the type of essential oils, resins, and tannins, present in a certain species, and this may influence colonization of the hive by bee colonies. The low thermal conductance of wood at low moisture content is of practical importance in hive construction and bee colony thermoregulation. Dimensional stability of wood is moisture dependent. Dimensional movement (changes) creates unwanted gaps in the hive. The colony responds to this by producing Propolis to seal such spaces. Continuous movement (or gap creation) in the hive may lead to colony absconding.

#### 4.1. Wood Utilization and Protection

Beeswax and Propolis have the potentials to protect wood against both biotic and abiotic deteriorating agents and give a good surface finishing as well. Water (moisture) and air (oxygen) are essential requirements for the development and survival of wood decay fungal organisms (Wood Preservation 2016). Beeswax and its combinations can protect wood by imparting both waterproofing (hydrophobation) and airproofing into wood, so that the major conditions favoring fungal growth in wood are controlled (Hyvonen *et al* 2005, Teaca *et al* 2019).

Hive construction is becoming a viable business because of the increasing awareness of valuable hive products in poverty alleviation. There is competing use of valuable species in constructing beehives. Lesser utilized or lesser-known species are promising sources of hive construction.

The use of woody biomass and fiber sources, such as grasses, rattan cane, palm fronds, raffia palm, basket work hives from split bamboo can help reduce pressure on valuable timber and increase utilization efficiency of forest biomass and sustain rural livelihoods (Gupta 2014). There is potential utilization for certain grasses and sorghum stem in the construction of beehives. It might be problematic using more than one species of wood in the same hive because of their difference in physical and mechanical properties. Wood wastes such as off-cuts, edges, and slabs can be used as alternatives to conventional wood sources. As a sustainable practice, chemically treated wood is not used; rather, recycled and non-durable wood can be treated with wax and rosin, linseed oil or propolis prior to installation as beehives.

#### 4.2. Biomass Utilization in Colony Handling

Smoking is an important procedure during bee colony handling. A cool, thick, soothing (white) smoke is needed to reduce the aggressiveness of bees, using forest biomass as smoker fuels, during colony handling. In selecting bee smoker fuels, wood porosity is more important than its density. Less dense wood with lower extractive content is expected to produce a cool, natural and more soothing smoke, due to its porosity and low toxicity. Natural materials such as grasses and straws, leaves, coconut husk, wood planer shavings and chainsaw chippings, papaya fibres and pine needles, are used as fuel in smoking bees (Kachhawaha 2019). Chemically treated biomass is not used in smoking because of the possibility of contamination. Beeswax is a good source of fuel for burning and lighting, especially at home; this contributes to a reduction in carbon gas emissions.

### 5. FOREST PROTECTION AND MANAGEMENT

Many poor Nigerians are living in areas rich in natural resources, such as tropical forests and woodlands; beekeeping is a feasible way for them to create food and income using the natural resources around them. Surveys from Zambia's Northwest province showed that beekeepers were strong advocates for forest conservation, as they value dense woodland and are keen to avoid damaging late season fires which can scorch the flush and the flower of the most important nectariferous species (FAO, 2009, Lowoore 2020). The nectar rich available habitat for honey production serves as incentives for beekeepers to protect the habitat of bees. As a result, they are interested in the conservation and development of forest woodland.

The presence of beehives was observed to help in scaring firewood and charcoal cutters for the fear of being stung by bees and may also serve as deterrents to elephants (Ngama *et al* 2016), as observed in Laikipia plateau in Kenya, where log hives are used to mine a favorite elephant foraging area of *Acacia xanthophloea* regrowth (Vollrath, 2002). Encouraging beekeeping inside wildlife parks and forest reserves are beneficial for the livelihoods of nearby communities. This social security strategy was adopted in Nyika National Park in Malawi, in which the local people were encouraged to place hives in suitable foraging locations within the park by the Wildlife and National Park Department. The local people develop a vested interest in protecting the park because of the benefits derived therein (Peace Parks 2020). These beekeepers assist in controlling forest fires and serves as security agents in monitoring and controlling poaching.

## 6. THE WAY FORWARD

The following highlights are recommended

1. **Bee** reserves should be created within Nigerian forests and national parks for beekeepers.
2. Strict laws should be enacted against the use of pesticides, coupled with Organic Certification for beekeepers, to encourage sustainable forest management.
3. There should be better interaction between the forestry and beekeeping sectors, by organizing honey hunters and beekeepers into marketing groups, establishing honey councils and collection centers, marketing assistance for beekeepers. There is need for the inclusion of environmental education, pollination, and pollinator education in training manuals for farmers, foresters and extension workers.
4. Establishment of nectariferous multipurpose trees to produce timber, food and nectar for honeybees and livelihood supports.
5. Apicultural practices should focus more on genetics and biotechnology for sustainability of honeybee populations, such as the Sakata Honeybee breeding programme (FAO, 2009).
6. Beekeeping should be considered when planning evaluating the economic importance of forests.

## 7. CONCLUSION

1. Apiculture as an indispensable component, should be included in forest management and planning, especially in developing countries like Nigeria where the level of awareness is low.
2. Through beekeeping, the rural people are able to create income from sustainable management of natural resources.
3. When beekeepers are supported and have access to good markets for their products, they are motivated to support local conservation efforts.

## AUTHORS' CONTRIBUTIONS

AUTHOR A wrote the protocol and first draft of the review and performed intensive literature searches. AUTHOR B and AUTHOR C contributed to the drafting and editing of the manuscript and gave necessary suggestions. All authors read and approved the final manuscript for publishing.

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