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Review Paper

Apicultural practice in Nigeria: an exploitative potential for rural dwellers development - A review

Luke Chukwudi Ali*, Nnanna Ephraim Ikeh, Chukwudubem Charles Onah and Ndubuisi Samuel Machebe
Department of Animal Science, Faculty of Agricultural Sciences, University of Nigeria, 410001 Nsukka, Enugu State, Nigeria
aliluke230@gmail.com

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Abstract

Awareness creation on the income generating activities of rural dwellers in developing countries like Nigeria has been a recent topic. Apiculture as an aspect of agriculture stands as an unexploited area of farming, which is capable of sustaining the rural dwellers in Nigeria and other parts of the world. Based on the importance of honeybee and its product, it appears a means of improving the standard of living among rural dwellers. However, most people resident in the rural areas are quite often discouraged from engaging in apiculture due to several observable challenges; such as the aggressiveness of the bees and pains emanating from bee venom/sting. The government and non-governmental organizations (NGOs) have an active role to play in tackling these challenges by educating rural dwellers on the importance and most efficient ways of keeping honeybees. This review concludes that, proper training, research and awareness creation on the principles and practice of apiculture should be encouraged to ensure a sustainable livelihood among rural dwellers in Nigeria and all over the world.

Keywords: *Apis mellifera*, beekeeping, challenges, honeybees, Nigeria, sustainable livelihood.

Introduction

Agriculture is one of Nigeria's most important economic sectors, which play a significant impact on the wealth creation of any country. The agricultural sector produces around 80% of the food for the country's growing population, employs 75% of the labor force, generates over 60% of non-oil foreign profits, and provides raw materials for the country's based industries[1].

According to Oyaniran[2], agriculture provides about 22% to a country's Gross Domestic Product (GDP). Agriculture is composed of different specialized subsectors, which includes; animal science, plant protection, agronomy, agricultural entomology, horticulture, agricultural engineering, agricultural economics etc.[3,4]. However, apiculture belongs to agricultural entomology, which is the study of insects and their relationship to the immediate environment[5]. The science of beekeeping is known as apiculture, and it is the art of controlling, raising and breeding of honeybee colonies in an artificial hive for commercial purposes. According to Amssalu[6], apiculture is the employment of contemporary technology to produce honey and other products including bee venom, wax, royal jelly, propolis and other substances.

It can be learned and practiced as a pleasure, part-time or a full-time occupation. Bees are agitated by noise, therefore, they thrive in a natural, undisturbed forests and on integrated farms with plenty of water and flowering plants[7].

The primary goal of beekeeping practice is to obtain the needed hive products for various needs that arise over the season[8]. According to Beetsma *et al.*[9], it is a unique agricultural enterprise that generates foreign exchange for several African countries. Numerous wild-bees are inherent in Africa; and Nigeria is among countries with huge honey production potentials owing to its varied ecological, climatic and diverse plant species which provide surplus nectar and pollen to foraging bees[10].

Historical Perspective of Beekeeping

Honeybee colonies have historically offered a supply of honey for human use throughout history. The first confirmed record of men targeting bees has been found in a cave picture in Spain dated to around 8,000 years before the modern period. The organized method of maintaining honeybee colonies for commercial honey production on the other hand, is relatively a new invention[11].

At least 2,500 years before the present age, the Ancient Egyptians kept bees exclusively for the production of honey. The maintenance of bees in a moveable comb hive is a legacy of the father of commercial bee farming's ingenuity in modern times. The invention of Langstroth wooden hive in 1862 is widely attributed to the father of modern day apiculture[12]. Between 1,000 and 1,500 AD, Arab honey traders travelled through West Africa, including what is now Nigeria's northern area.

The use of honey was one of the valued goods of commerce recorded, and the presence of it in those regions indicated the presence of bee hives, from which honey was produced[13]. This discovery in Nigeria led to the establishment of apiculture. This practice has gradually spread across different locations, and farmers have utilized various ways in its management. Many states in Nigeria are now engaged in the deliberate process of apiculture and while it is still a virgin subject in the agricultural system; its practice is gradually gaining attention based on the value of honey[11].

Despite Nigeria's honey producing potential due to its diverse flora and fauna, Ojeleye[14] noted that commercial beekeeping was virtually non-existent in Nigeria until recent time. To meet the expanding domestic demand for honey, the country had to rely on imported honey. Because of the risk of being stung by honeybees, many rural residents shun this practice. Nevertheless, honey is produced locally by a few honey hunters and traditional bee farmers who use traditional methods, which typically results in low-quality honey[15].

Beekeeping Start-ups/benefits

Apiculture involves less capital, simple to learn, takes less time, and may be used for small-scale sustainable farming because only small portion of land is required[8]. Honey has been scientifically proven to be beneficial in the treatment of various diseases, including asthma, diabetes, high blood pressure, ulcer, infertility, skin infections, burns, sore throat, snake bites and so on[6]. Honeybees are extremely important since they produce honey and also serves as major pollinators for varieties of agricultural and horticultural crops. Consequently, this has led to the exploitation of heterosis and improvement in yield and quality of seed and fruit. The study and practice of apiculture can play an important role in long-term agricultural growth since it enhance resources while preserving environmental biodiversity[16]. Increasing rate of unemployment has called for the need for alternative means of acquiring a living especially among rural dwellers. As a result, the government is promoting projects that encourage self-sufficiency in order to reduce unemployment and improve sustainable livelihood[7].

Irrespective of the inherent benefits from apiculture, it has been identified as an underutilized area of practice that can save people from starvation and poverty and can also help to alleviate Nigeria's endemic poverty problems, particularly among the rural dwellers[17]. Honey is super beneficial and there is a huge demand for it and as a result may be considered a money spinner[18]. Due to the various advantages attached to apiculture compared to other forms of agricultural practices, it has been identified as a strategy of economically empowering the rural populations leading to a sustainable means of living especially among the youth[19].
Therefore, the aim of the present review is on apicultural practices in Nigeria towards the sustainability and development of the rural dwellers.

The Honeybees (*Apis mellifera*)

All honeybee species are categorized within seven families and the major family among them is Apidae. Three subfamilies of Apidae are Apinea, Nomadinae and Xylocopinae. Nineteen tribes exist under the subfamily Apineabut three are noted; honeybees (Apini), stingless bees (Meliponini) and bumblebees (Bombini). Only one species; *Apis*, belongs to the Apini tribe, and these are the actual honeybees; that are social bees building long-term colonies[20]. Meliponini bees are stingless bees that are found in tropical and southern subtropical climates all over the world. Based on their social behaviour and ability to store large volume of honey, they have attracted human exploit for their honey stores[21]. Bombinibees belongs to the Bombus genus with large and robust body size. They produce and store honey in small volume, thus are impractical for commercial honey production, but are good pollinators of plants[22]. However, with respect to clade, three bees exist: *Apis* (honeybees), *Megapis* (giant honeybees) and *Micrapis* (dwarf honeybees)[23].

According to most beekeeping publications, honeybees exist in a limited number of species, namely; *Apis mellifera*, *Apis cerana*, *Apis florea*, and *Apis dorsata* (Table-1)[24]. Honeybee is one of the most researched insect species, however most of the research has focused on the European honeybee: *Apis mellifera*.

Apis mellifera intermissa, *adansonii* or *scutellata* are honeybee subspecies native to Africa and the Middle East. They are the most extensively employed for bee farming in Africa[21,25] and these subspecies are slightly smaller and have a distinct biology and behavior than the Western honeybees. They can easily migrate off the comb when disturbed in order to protect themselves. As an effective management practices, the apiculturist is expected to have a good number of hives with the knowledge that, some of them might probably be empty over time[24,26].

Table-1: Scientific classification of honeybees.

Kingdom	Animalia
Phylum	Arthropda
Class	Insecta
Order	Hymenoptera
Family	Apidea
Tribe	Apini
Genus	Apis
Species	*Apismellifera, Apiscerana, Apisflorea, Apisdorsata*

In every colony, there are three castes of honeybees namely; worker bees, queen bee and drone bees (Figure-1). Bees undergo complete metamorphosis by developing through 4 stages; egg, larva, pupa and adult. The worker bees are the smallest in size followed by the queen and then, the largest drone bees. The comb in the hive is made up of many small, hexagonal cells that are stacked side by side. The cell floor is shaped like a three-sided pyramid facing away from the cell doorway and slopes slightly downward to the bottom. This little slope is required to prevent substances from slipping out of the cell. There are three cell sizes which include the giant drone bee cells, the smallest worker cells which contains worker bees at different stages of development and the queen cells. Worker bees have a maximum lifespan of 6 weeks (42 days) unlike the queen bee that can live up to 3 years; although fertilized egg laying period last up to 2 years. Most drone bees are short-lived because once mating of the queen bee is achieved, they die off[27,28]. The developmental duration of the queen, drone and worker bees ranges from 15 - 17 days, 23 - 25 days and 20 - 22 days, respectively. The queen lays the eggs and coordinate the activities of the colony with the help of pheromone while the drones mate the queen and the worker bees carry out domestic duties such as feeding the queen, building of comb, cleaning, ventilating the hive, guarding the hive, making honey, nectar and pollen collection[27,29,30].

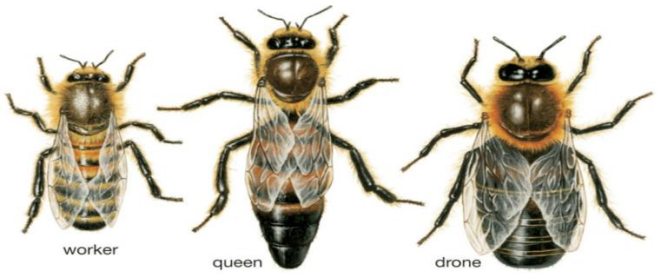

Figure-1: Three kinds of *Apismellifera*[31].

The queen is possibly the most important caste in the bee colony because she is responsible for reproducing other castes leading to the colony's survival[32]. The rapid development of the queen bee and worker bees are important because; (i) when the colony loses her queen, its focus and coordination are disrupted, and thus, the colony as a whole is thrown into disarray. In order for the colony to preserve its social behavior, the lost queen must be replaced as soon as possible by a new virile queen. (ii) For the worker bees, there is a need for rapid generation turnover, and a short developmental time may be advantageous in this regard[33,34].

Equipment for Apicultural Practices

Apiary is the term defining a place where honeybees and their hives are kept. In the apiary, different types of equipment or tools are kept for a successful production of honey and other bee products. The hive (Figure-2) is essentially a space in form of a container provided for honeybees to nest in. It can be constructed out of wood, clay pot, calabash, gourds or woven grasses. Hives can be classified into a traditional and high technology movable frame hives[7]. Other necessary equipment includes protective suit with a veil, hand gloves, smoker, honey extractors, rubber containers, cutlass, knife, baiting agent, storage bottles, funnel/sieves etc.

Figure-2: (a) Modern movable frame hive; (b) Clay pot hive; (c) Kenyan top bar hive.

Honeybee Products and Their Uses

Honey, bee venom, beeswax, propolis, royal jelly and pollen are the product of honeybees, and their success in the animal kingdom is largely due to the chemistry and application of these products. Bee venom, royal jelly and beeswax, are chemically manufactured by bees, whereas the other three are sourced from plants; modified and developed by the bees for their own purpose[35]. Bee products (Figure-3) are also well-known for their anticancer, antiviral, antiparasitic and antibacterial properties, which in certain circumstances exceed conventional medications[36]. The active biologically components of honeybee products include proteins[37], carbohydrates[38], vitamins[39], lipids[40], minerals[41], polyphenols, flavonoids[42] coupled with smaller amount of other compounds. The nutrient base of their chemical component unquestionably enhances health and physiological function in the body system[39]. Several investigations have also found that the active chemicals in bee products have excellent antimicrobial, antioxidant, anti-inflammatory, antimicrobial, anti-proliferative, anticarcinogenic and anti-allergic effects[43-45].

Honey: This is the beehive juice, which is delicious and thick. It can be discovered in the honeybee comb cells. Ripe honey is normally preserved in sealed combs and can last for years. Honey that is in unsealed comb is not yet mature, thus it ferments soon after harvest[46]. Honey is utilized as a raw material in the pharmaceutical, food, brewing, and cosmetic sectors to make products like lip balm, confectioneries, body creams, and medications, among other things. Honey can also be used in place of sugar as a sweetener in food preparation[7].

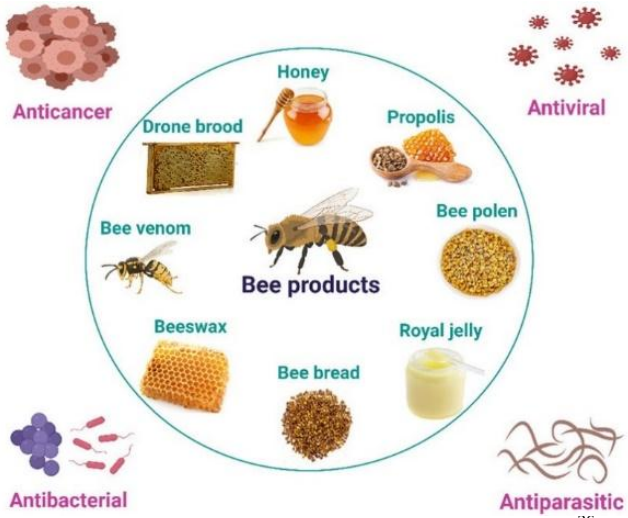

Figure-3: Honeybee products and their anti-effects[36].

Royal Jelly: This product is called the bee milk in the sense that the queen and the 3 days old larvae feed on it. The glands of 1-5 day old worker bees secret this product. It is also a good source of vitamin B with good medicinal value in wound dressing and treatment of infertility in humans[7,46].

Beeswax: During the warm period of the day, the bees produce bee wax from their body which is used in erecting the comb cells. These comb cells contain the honey, pollen and the brood stock. For each 1kg of bee wax produced, a bee will need to consume up to 5kg of honey. Beeswax collection is unknown in most places because people are unaware of their value. It is used in the production and manufacturing of candle, polish, cream, gum, tooth filler, water proof agent etc.[46].

Propolis: This is often known as a bee glue. It is a sticky-brown substance used by bees for a variety of reasons, including covering the inside walls of the hive, keeping down the hive lid, connecting frames, sealing holes, strengthening comb, and narrowing the entrance. Propolis is collected by honeybees from various plant buds, as well as sticky substances such as pitch from pine trees[27]. This product is used in making skin soap, cough syrup, lotion, skin oil, toothpaste etc.

Bee Venom: Bees are naturally blessed with this venom as a defensive weapon for guarding their territory. Mostly, it is important in the treatment of rheumatism, skin and eye diseases[46].

Pollen: This is a source of protein for bees which is also high in fat. It is a crucial diet for the larvae growing in the brood cell areas. Pollen in the form of minute pellets is collected by scavenging bees from flowers and transported back to the hive in little, basketlike pouches on their hind legs. The colour of this pollen varies depending on the type of flower from which it was collected. This product is mostly utilized in the production of perfumes[27].

Sustainable Benefit Attached to Apicultural Practices

Precisely in Nigeria, it has been reported that apiculture represent one of the untapped natural renewable resources[47]. In other study, it was also reported that, beekeeping as a commercial venture is still largely unexplored in Nigeria. As a wild insect, honeybee thrives under a natural vegetation[9]. They live in an environment yet to be damaged by man's activities and where there are abundant foraging plants[48]. Aside employment and income generation, the practice of apiculture is beneficial in many aspects. According to Oyerinde and Omara-Achong[49], the availability of high-quality honey on the domestic market, as well as greater processing capacity, drives the creation of more jobs domestically, resulting in increased revenue for the Nigerian economy. In other study, it was opined that agriculture, particularly apiculture, provides untapped resources capable of rescuing people from abject hunger, unemployment, and poverty[17]. Ayansola[50] also stated that beekeeping can help in reducing unemployment in Nigeria, particularly among rural dwellers. Economically, Adediji and Omoba[51] reported that in Nigeria, the price of honey ranges from 100 - 120 thousand naira per tonne. Therefore, Nigeria is bound to gain 200 - 240 million naira annually when she exports 2,000 tonnes of honey.

Apiculture is a field that can be practiced by either gender because it has traditionally been a male-dominated activity in most African countries due to a combination of societal and cultural factors, as well as practical limitations that affect women's participation[52]. Fortunately, there is no cultural barrier that prevents a certain gender or age from engaging in apiculture and honeybees do not require daily care for them to thrive[53]. Approximately, 80% of Nigerians reside in rural areas and engage in subsistence agriculture[54]. According to Ajamu *et al*.[55], women make up about half of Nigeria's adult population, with 77% of them dwelling in rural areas. Agriculture and associated activities are the primary occupations of rural women and thus, they have actively participated in crop and livestock farming. Conversely, due to the emergence of stingless bees and Langstroth hives, which are economical and easy to start, women are becoming active in apiculture[56]. On this note, there should be a call on more women incorporation into apicultural practices by the government and NGOs.

Apiculture being an environmentally friendly activity, has contributed much ecologically[57]. In the tropics, apiculture through pollination reinforces forestation, good forest management and provides an alternative livelihood to activities such as hunting. This has led to the promotion of bee farming as a conservative positive activity[58,59]. The biodiversity of crops are aided by honeybees since *Apis mellifera* L. has been found to pollinate vegetables, flowers and horticultural crops worldwide[60]. Popo-ola[53] reported that honeybees pollinate flowering plants and this activity is vital in maintaining the yield of many important crops and plants.

In Nigeria, promoting apicultural practices could significantly enhance environmental stability. The contribution of honeybee pollination to crop production and quality has been estimated to be more than the value of honey and wax production[61]. For many crops, pollination may be one of the best ways of improving crop production[62]. In Ethiopian studies, pollination by honeybees had increased seed yield of Onion (*Allium cepa*) by twofold[63] and Niger (*Guizotia abyssinica*) by about 43%[64]. Therefore, honeybees' pollination has brought about significant economic contribution in crop production[65] and human feeding as well[66].

Apiculture as a sustainable means of livelihood can also benefit the civil servants and retirees. Civil servants are employees whose activities are aimed at the implementation of the state's functions and tasks in government agencies within their powers[67]; whereas retirees are individuals who have withdrawn from a paid occupation or business in order to enjoy more leisure and freedom after achieving competence or earning a pension[68]. In a Nigerian study carried out by Ahmad *et al.*[69], they found out that 16% of respondents who engage in apiculture were civil servants and this emphasizes the notion of Folayan and Bifarin[70] which states that, crop farmers and civil servants diversify into apiculture to ensure an optimal and constant supply of revenue. According to Absher[71], retirees or veterans who participated in apiculture demonstrated enhanced social relationships, which resulted in a decrease in symptoms of depression and post-traumatic stress, resulting in a lower need for medical and therapy appointments.

Honey, as a fundamental ingredient in most food recipes, would benefit the food industry from rural dweller's efforts in developing all-natural, organic, low-sugar, low-calorie foods and beverages[72]. Honey is widely utilized in bread, dairy, confectionery, dressings and sauces, meat, frozen foods, candy bars, ice creams, marmalades, industrial nonalcoholic beverages, and many preserved foods, both on a small and large scale[73]. The vast majority of honey's dry weight (95-98%) is made up of carbohydrates, primarily glucose and fructose, but also sucrose, maltose, and other oligosaccharides. A little amount (2-5%) is composed of secondary metabolites such as polyphenols, minerals, amino acids, organic acids, enzymes, minerals, fatty acids, vitamins, pollen, and other solid particles derived from the honey-making processes[74,75].

Honey is most typically used in its raw form. However, honey's antioxidant, antibacterial, and antifungal qualities make it suitable for use in food technology[73]. Honey has recently gained attention as an antioxidant leading to an increased demand for antioxidant supply in the food industries[76]. Because of the increased generation of free radicals, oxidative stress caused cellular damage and genetic structural alteration. Honey's principal antioxidants are phenols such quercetin, chyrsin, hesperetin, and melanoidins[77]. According to Hagberg *et al.*[78], the phenol quercetin directly binds to and significantly inhibits the activities of cellular transcription factors.

Thus, Sousa *et al.*[79] reported that several researches on honey has shown a high association between total phenolic content and the antioxidant activity of honey extracts.

In Nigeria, there is a better environment (mostly rural areas) for establishment of bee colonies as the environment is not as polluted as the environment in the industrialized areas. According to United Nations Conference on Trade and Development: UNCTAD[80], it has been certified that honey from the tropics are enriched with special attractive aroma superior to the one from non-tropical regions of the world. A typical colony of bees can produce 36 - 54 liters of surplus honey and 4kg of pollen in a year depending on the country and environmental factors[81]. Since a colony of bees can produce this quantity of honey, high demand for it in the international market makes an excellent opportunity for the business[7].

The level of social and economic development of any rural dweller determines the concept of social security. Health care, pension funds and insurance policies provide people with a sense of security in the developed world. Social security in developing countries means different things to different persons and groups. Rural dwellers rely on livestock, a piece of land, or their beehives in the surrounding forest which gives them a sense of social and economic security because income flow is unpredictable and often unavailable. In this condition, apicultural development has been included into rural development programmes[82].

It is paramount to know that, apiculture is less expensive to engage because bees are freely available. Hives and equipment can also be constructed locally at the initial phase of the practice. Beekeeping does not use up land that could be used for crops; and bees can visit flowers in bushes, farms, protected areas and other natural habitats. Apiculture is sustainable because beekeepers are friends of natural environment that are willing to conserve forests and vegetation where bees live and forage. In displaced communities for instance, rural dwellers can make a living in relatively short period without necessarily owning a land[53].

Prevailing Challenges and Way Forward in Apicultural Practice among Rural Dwellers

The sole subspecies of bees found in Nigeria is *Apis mellifera adansonii*, which is mostly domesticated in local artificial hives such as clay pot and drum hives for honey and beeswax production by a few traditional bee farmers[83]. However, the bee itself is the most important concern linked with beekeeping in West Africa, particularly Nigeria[32]. There are complications that all beekeepers may face, and they are especially hard to cope with since these drivers may interact with one another, forming a positive feedback loop that is detrimental to a bee colony's health or its production[84]. Some of these challenges and possible ways for enhancing apiculture practice are discussed below:

Aggressiveness of Honeybees: Because of its proclivity to swarm, *A. mellifera adansonii* specie of bee is extremely aggressive and difficult to handle[30]. Colony management and queen rearing in Kenyan honeybees (*A. mellifera scutellata*) has been investigated by some researches and they reported that, grafting procedure utilized for queen rearing in European races of *A. mellifera* can also be employed for *A. mellifera scutellata*[33]. They also recommended that, the indigenous specie of bees may be used for colony development and queen raising if their behaviour could be modified and managed. Kostarelou-Damianidou *et al*.[85] reported that, understanding the life cycle of *A. mellifera macedonica* improves requeening of the species' colony every 2 - 3 years. It is easier to construct an artificial hive in order to manipulate the colony and improve honey production, and because stingless bees do not sting, they are easy to handle[86]. Consequently, Khairunnisa[87] was of the opinion that, stingless bees are less difficult to manage than honeybees, which are susceptible to diseases and swarms frequently. Rasmussen and Cameron[88] reported that approximately 500 species within the stingless bee genus exist in Africa, Latin America, Mainland of Australia, Eastern and Southern Asia, which will foster their use in apicultural practices. Bee sting can also be reduced by wearing a protective suit with a veil and by visiting the hives mostly when the sun has set; this is in agreement with Shackleton *et al*.[89]. In cases of bee stings, the actual region should be washed with water and soap to prevent secondary infection. Also, the amount of swelling, pain and venom uptake are usually reduced when ice packs or baking soda in water paste is applied. Under mild and serious allergic reactions, antihistamine and epinephrine injections, respectively can be used[22].

Paucity of Information in Apiculture: Apiculture in Nigeria is gaining attention via intensive research to improve the production of honeybee products. In respect to honey and beeswax production and management in Nigeria, there is relatively little published information on the biology of *A. mellifera adansonii*. The majority of literature on apiculture in Nigeria focused on the commercial uses of honey, beeswax, and other bee products[83,90]. Furthermore, it has been reported that, the majority of papers on reproductive biology and bio-ecology of honeybees are found in developed countries and some part of Africa (e.g. Ghana and East Africa)[32]. Most individuals are in shadows over how to efficiently manage bees economically. Most of the marketing information regarding beekeeping are limited among rural dwellers because of inadequate infrastructure like road networks connecting different markets. Due to all these, they are unaware of the eventual market information regarding apiculture[7].

In overpowering these challenges, the government and NGOs are faced with the task of sensitizing the rural dwellers through awareness creation on the importance and principles of practicing apiculture. Notwithstanding, credit facilities with reduced or no interest rate should be made available for those showing interest in this area of specialization.

Animal scientists, biologist, entomologist or other researchers are encouraged in engaging researches related to beekeeping, thereby bridging the gap and enriching the literature with scientific information as regards apiculture.

The Use of Agrochemicals in Crop Farming: Honeybees are exposed to various agrochemical (pesticides, herbicides or fungicides) poisonings while foraging on flowers (collecting nectar and pollen) already exposed with these chemicals[91]. They are also exposed to pesticides and herbicides used by the beekeepers themselves aiming to control weed and pest problems within the apiary[92]. Because honeybee larvae are fed by worker bees for their development; larvae, drones and even the queen bee may be exposed to these contaminated nectars and pollen[93].

According to Mengistu and Beyene[94], almost three-quarters of beekeepers have lost their colonies as a result of agrochemicals. Hladik *et al*.[95] discovered 19 pesticides and degradates in 54 samples of native bees taken from wheat fields and grasslands, whereas Mullin *et al*.[96] discovered 121 pesticides and metabolites in beehives and associated hive materials.

Several recent studies have also connected physiological alterations in bees at the molecular and genetic levels to agrochemical exposure[97,98]. In laboratory and semi-field research, the effects of agrochemical exposure on lethal and sub-lethal toxicity to various species of managed bees have been observed[99,100]. On this note, the toxicity of several agrochemicals to honeybees must be addressed[101].

Even though it is difficult to completely avoid the effects of chemicals on honeybees, their impact can be reduced by strengthening integrated pest management programs, using agrochemicals with low toxicity and residual effects on honeybees, limiting application when crops are flowering, and employing proper application methods[102]. Other scientific reports recommended that, crop producers should be aware of the location of honeybee hives before applying chemicals[103,104]. Guesh *et al*.[105] opined that positive communication is of essence during chemical application between beekeepers and crop farmers.

Effect of Pest and Diseases: Honeybees, like all living organisms, are susceptible to infection or attack by natural predators. Diseases, parasites, and other harmful insects may pose a threat to honeybee colonies, despite their innate defense mechanisms[106]. One of the key biotic elements affecting successful beekeeping has been discovered as honeybee pests[107] and their presence poses significant threat to honeybees and beekeepers. Wax moths, spiders, lizards, bee eating birds, ants, honey badgers, and small hive beetles, as well as various viruses, microsporidia and fungi (*Ascosphaera apis*) are serious threats[71,108]. Regular and timely monitoring of any element that endangers honeybee and threatens their products is required for a successful beekeeping[109].

According to Labe[7], pests and predators should be controlled by the beekeeper and application of good management practices that enhances good hygiene and biosecurity is paramount. Apiarists use various preventative strategies to combat pests and predators of honeybees (Table-2). Against these invaders, they employ a variety of traditional control measures[110].

Table-2: Honeybee pests and predators control measures[11,112].

Pests and Predators	Traditional Control Measures
Birds	Use of scarecrow
Honey badger	Use of chasing dogs, fencing the apiary, hanging hives with ropes on long trees.
Wasps	Cleaning the hive.
Hive beetles	Scavenge poultry, narrow the hive entrance, cleaning, seasonal management.
Bee lice	Making the colony strong, smoking, fumigating hives with tobacco, dung, grass
Mites	Burning, killing, removing their home.
Lizard	Removing their nesting site.
Spider	Removal spiders' web, cleaning, follow up.
Wax moth	Remove old comb, strengthen the colony, seasonal management, daily supervision.
Ants	Frequent smoking, using eucalyptus leaf for fumigation, follow up, hot water/ ash.

Land-use and Climate Change: Apiarists or beekeepers have a unique issue when land use changes result in the loss of natural habitat. This results in a loss of foraging/floral resources, which is capable of reducing yields of managed hives[113]. When floral resources around a colony are scarce, bees must work significantly harder to collect pollen and nectar, burning more energy than they acquire and eventually diminishing foraging and food storage inside the hive[114]. Apiarists in places with considerable environmental degradation and scarce floral resources may expect less honey in addition to struggling to retain healthy and productive hives[113,114]. For these reasons, the government needs to checkmate land-use management precisely in the rural areas where apiculture is being practiced in other to foster apicultural development and production.

Climate change is an emerging worldwide phenomena that has potentially affected all aspects of agricultural ecosystems and has been documented to have an impact on bees on a variety of levels, including pollination efficiency[115]. Onabe *et al*.[116] opined that, the certainty of increased food demand (including honey) to feed the growing population, as well as the unpredictability of climate change's short and long-term effects on agricultural production systems, has become a systemic issue. The loss of honeybees as a result of extreme climate change might be challenging to apiculture. For instance, in temperate regions, winter has also altered nectar secretion as reported by Singh *et al*.[117]. Climate change will undoubtedly have an impact on the survival of these honeybee which are intimately linked to their surroundings. Also, migration as well as changes in their lifecycle and behavior, may aid their survival in unfamiliar biotopes[118]. The intergovernmental panel on climate change stated that extreme climate-related occurrences put the livelihoods of rural beekeepers in jeopardy[119]. Similarly, the findings of Howden[120]; IPCC[121] and Gbenga[122] support the argument that climate change causes extreme weather events such as heat waves, droughts, high winds, and heavy rains, among other things, which have a negative impact on apiculture. Therefore, Onabe *et al*.[116] as serted that rural beekeepers need education and training in order to minimize climate change effects on honeybee production and also to avoid ecological practices like deforestation, biomass burning, soil tillage, and clean clearing, which all contribute to climate change.

In order to alleviate the negative effect of climate change on bee production, bee farmers have come up with indigenous adaptation strategies to enhance honeybee production. Dimelu and Nwuba[123] reported that in Nigeria, small-scale beekeepers adapted their practices by shifting the timing of their practices to more climate appropriate times, moving their hives, planting trees to provide shade from the sun or locating hives closer to trees, and supplementary feeding of bees by providing grain powder, sugar solutions and water. Reddy *et al*.[124] reported that in mitigating climatic variability impacts, beekeepers resort to planning ahead for important resources before and after crop flowering, enhancing non-crop flowering resources like growing hedgerows cover crops as bee's supplementary forage and decreasing farmland fragmentation to ensure the ability to move ranges in response to climate change.

Table-3: Reason for decreasing trend of hive product and colony[125].

Problems	Percentage (%)
Poor management	9.2
Lack of bee forage	17.6
Bad weather	11.8
Lack of water	10.9
Lack of credit	2.5
Drought	16.0
Increased cost of production	8.0
Migration of bees	4.2
Increased price of honey	1.7
Death of colony	4.2
Disease	3.4
Pest and predator	5.9
Pesticide and herbicide application	11.8
Total	100.0

In summary, Chigbo *et al.*[125] outlined in a tabular form (Table-3) the challenges or reasons for a decrease in hive product in Nigeria on profitability of honey production, and this is in tandem with the report of Gratzer *et al.*[126]; Oyerinde and Omara-Achong[49].

Conclusion

Apiculture is a goldmine which will lead the rural dwellers off poverty and bring about sustainable livelihood. Government and NGOs should engage in organizing workshops and seminars for appropriate awareness creation on new innovations in beekeeping. Also, to boost production, the country needs an efficient and successful marketing structure for bee products. Honesty is a major key in honey business in other to avoid the incidence of adulteration of any form. In many regions of the world, apiculture is one of the most profitable businesses. It is a lucrative enterprise with no negative environmental impact. It is a successful and practical business that takes very little capital, making it a feasible means of making a living for Nigerians in rural areas.

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