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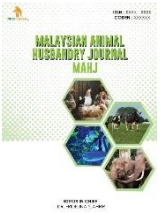

REVIEW ARTICLE

STATUS OF BEEKEEPING AND QUEEN REARING IN NEPAL: A REVIEW

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ABSTRACT

Beekeeping is a traditional practice in Nepal that has evolved to a profit-making industry over time. This review highlights the status of beekeeping and queen production in Nepal shedding lights on the journey of transformation of beekeeping practice from the very beginning to the present. Beekeeping is a source of income for rural communities and a vital component of sustainable agriculture as it enhances pollination and food security. It also highlights the immense potential of beekeeping in Nepal and suggests room to future developments with few human interventions like use of quality queen and good beekeeping practices. Ensuring a quality queen in a hive is crucial for maximum productivity and has emerged as strong hope for the boom of this sector in Nepal. There are several challenges including issues related to infrastructure, quality control and the knowledge gap among beekeepers. However, necessary steps have been taken by different government and non-government bodies relating to this sector and is slowing paving its way to becoming a strong sub-sector contributing to the national economy. The article suggests need for improved infrastructure, regular trainings, and awareness to bring beekeeping and queen rearing to its full potential. With the right support and guidance, these practices could not only boost the income of beekeepers but also contribute to the conservation of biodiversity and the growth of a sustainable beekeeping industry in the country.

KEYWORDS

Queen bee production, Beekeeping in Nepal, Honey production, History, Training

1. INTRODUCTION

Beekeeping is the domestication of bees for honey. For eons, people have been gathering many bee products in addition to honey. To boost profits, humans began domesticating bees into hives. Beekeeping became more profitable and easier as hive monitoring and honey collecting became more efficient with the introduction of modern hives. There is now greater space for more lucrative beekeeping methods due to the diversification of bee products. It has been made feasible by the discovery of the therapeutic qualities of several bee products and their applications in a range of contexts. Bee venom, propolis, bee wax, royal jelly, beehive air, and other products are now sold on the market (Aryal et al., 2015; FNBK, 2015). As a result, beekeeping now offers a wider range of applications and more opportunities for significant financial gain.

For Nepalese people, beekeeping is a traditional activity. Nepal is able to support one million bee colonies that produce over 10,000 metric tons of honey annually (Devkota, 2020; FNBK, 2018). Nepal exported 19 million worth of raw natural honey in 2022 and imported 222 million (MoICS, 2023). Beekeepers benefit from the availability of natural pasture, a favorable environment, a diversity of flowers, etc. (ADC, 2023). The rising popularity is a result of low input and high output, which offers several advantages like income generation, employment opportunities, wholesome food, and the advancement of sustainable agriculture through pollination services.

A vital component of the rural economy is beekeeping. Beehives are a common feature of the agriculture and livestock based rural lifestyle, providing both extra money and food security. Honey, the main bee product, is nutrient-rich and contributes to a balanced diet (MoICS, 2023). When sold, honey generates a substantial profit and enjoys strong market demand. For poor farmers, this is a helpful way to support their livelihood. It is not only nutritionally and economically significant, but also medicinally and religiously significant. If traditional farmers acquire the necessary training and beekeeping abilities to become contemporary beekeepers, it can be a significant source of revenue.

Bees are excellent pollinators. They preserve biological variety and the ecology (Manandhar and Khanal, 2021). They ensure efficient pollination and increase agricultural yield. When it comes to cross-pollinators, bees are crucial. Pollinators have been shown to boost yield by up to 30% even in the case of self-pollinators (Thapa, 2006). About 80% of all insect pollinators come from bees alone. Bees make 143 times more money as pollinators than as producers of honey. Bee pollinated plants provide around one third of the food that humans eat (Thapa, 2006). Its existence is therefore essential to human existence.

In recent years, there has been a rise in both the consumption and demand for honey, particularly in cities and metropolitan regions (Devkota, 2020). The various bee species in Nepal are supported by the floral diversity that has resulted from climatic variability. Farmers may become beekeepers because of the possibility of making additional money from beeswax, pollen, royal jelly, and queen bees, in addition to selling honey. From a business perspective, there is a constant need for honey on the global market. Nepalese government has designated honey as a high-value product and given priority to its growth, realizing the significance of the commodity in both domestic and foreign markets (Srivaram, 2021).

In addition to this enormous potential, there are numerous difficulties too. The production and marketing sides of beekeeping in Nepal face numerous challenges. Domestic honey has not been able to meet the honey demand of the country. Low honey production in Nepal can be attributed

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to several factors, including inadequate government assistance, a lack of infrastructure and skilled labor, limited research on hive management, and inadequate training programs (Manandhar and Khanal, 2021). Similarly, Nepalese honey cannot compete with international honey because there is no guarantee of quality production or certification (Bhattarai et al., 2020). Another significant impediment to Nepal's beekeeping business is the current divide between the parties involved in the production and marketing aspects of the honey supply chain.

Conventional hives are still widely used by beekeepers. Because of Nepalese people's low socioeconomic status, the beekeeping business has not seen the expected level of investment or productivity. Additionally, those that use modern hives are not well-versed in hive management techniques. Furthermore, farmers do not view beekeeping as a lucrative business or bee products as a marketable commodity. Similar to this, the beekeeping sector in Nepal has been impacted by inadequate data on current bee flora, declining floral diversity as a result of increased deforestation, inadequate programs for bee research, and lack of product quality testing and control body (Aryal et al., 2015). Beekeepers are unaware about supplement diet, mite attack being minimum in managed hives, continuous selection of best colonies required to reduce absconding, swarming and robbing tendencies in bees, etc. that are important for economic beekeeping. These days, the frequency of chemical poisoning and the prevalence of diseases and pests are rising, which has an additional negative impact on production and quality. However, there is little information needed to manage and prevent disease and pest attacks in beekeeping. Although, Nepalese government and numerous NGOs/INGOs are actively distributing bee colonies, honey buckets, and various hive tools in an effort to reduce poverty, the necessary trainings have not been provided (Thapa et al., 2018).

A beekeeping industry's ability to succeed depends on the production of superior queens. The queen, the most significant member of the hive, influences the production and health of the colony (ADC, 2022b; Güneşdoğdu and Şekeroğlu, 2020), which in turn affects income. Since the queen is the only reproductive individual in the hive, other colony members can be seen to exhibit traits associated with the queen. A quality queen is one who possesses exceptional qualities such as a higher genetic potential, resistance to sickness, and non-violent nature. South Asia has a lot of room to produce and market high-quality queens (Srivaram, 2021). A high-quality queen increases honey yield and produces a colony that is easy to manage, disease-resistant, and stress-tolerant. Thus, beekeepers ought to receive training to produce superior quality queens.

2. Beekeeping in Nepal

Both traditional and modern hives are employed for beekeeping in Nepal. The most common types of hives under traditional hives are wall and log hives. Traditional hives are built using materials that are readily available locally. They therefore require little maintenance and are affordable. Nonetheless, their low honey-yielding quality is a big disadvantage. Moreover, because there is a greater chance of ant invasion in traditional hives, undesired behaviors such swarming and fleeing are frequent (Allen, 1995).

Alternatively, bee colony management and shipping are simplified by modern hives. The rectangular frames that make up the hive box are suspended parallel to the necessary bee area. It is possible to examine the frames for parasites, disease symptoms, and hive function. As a result, it is easy to carry out the necessary hive tasks and to avoid or manage unwanted colony behaviors. Thus, Nepal has seen a rise in the popularity of the recently introduced modern beehives (Bhusal et al., 2011).

Nepal produces honey from five different species of Apis: *A. mellifera, A. cerana, A. laboriosa, A. dorsata*, and *A. florea*. Except for *A. mellifera*, often known as the European bee, all honeybee species are indigenous to the nation. *A. mellifera* became more well-known because of its easy-to-handle nature and capability for higher honey production compared to other bees. Thus, it is believed that commercial beekeeping began in Nepal with the arrival of *A. mellifera*. Prior to this, native bees were only raised in traditional hives, and gathering honey from the wild was rather usual. Nevertheless, the Gurung tribe of Nepal engages in the perilous activity of gathering honey from cliffs, particularly that produced by *A. dorsata* (Manandhar and Khanal, 2021). This has the potential to grow as a tourism industry and a way to make foreign exchange.

According to Bhattarai et al. (2020), *A. mellifera* and *A. cerana*, which are found in the Terai and Hills, respectively, are the main producers of honey in Nepal. *A. mellifera* and *A. cerana*, in contrast to other bee species, can be raised in hives that facilitate efficient and easy honey gathering. Despite being a common species of bee in Nepal, *A. mellifera* is vulnerable to nosema disease and wasp invasions. In contrast, farmers prefer *A. cerena* because it is less vulnerable to disease infestation (Theisen-Jones and Bienefeld, 2016). The other species is *A. florea*, also referred to as dwarf honeybees, which are indigenous to milder mountain valleys and the Terai region and can be found below an elevation of 1000 meters (Thapa et al., 2018). Below 1350 meters, *A. dorsata* is observed creating honeycombs on the undersides of heavy tree branches, man-made buildings, or rock walls. The Himalayan giant honeybee, *A. laboriosa*, makes its home in Nepal between 1500 and 4000 meters above sea level, where it builds nests on precipitous rock sides (Allen, 1995; Manandhar and Khanal, 2021). In a similar vein, Meliponid stingless bees are found in Nepal. They contribute very little to honey production, but they are extremely important to the preservation of the ecology and biodiversity (FNBK, 2018).

Beekeeping is generally done for the purpose of producing bee products for domestic use, even if it has grown to be one of the major businesses contributing to the nation's agricultural GDP. The switch by beekeepers from traditional to modern hives has increased the amount of honey produced in Nepal. As beekeepers have multiplied throughout time, so too have the amount of hives and honey produced. The trajectory for honey production reveals a slow increase until 2013–14, a sharp spike between 2013–14 and 2016–17, and then a gradual increase.

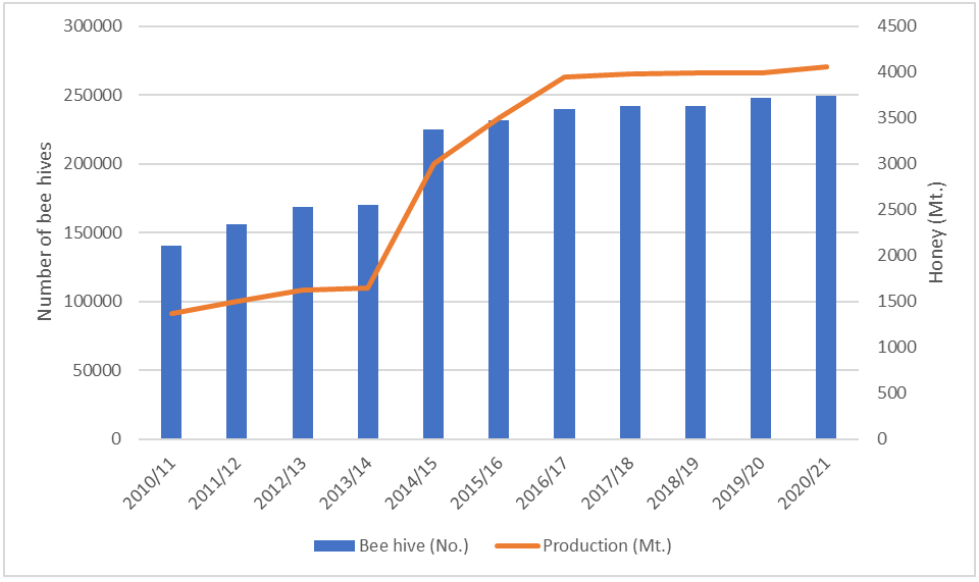

Figure 1: honey production and bee hives number in different years in Nepal

3. Queen Rearing

Beekeepers in Nepal are aware of the significance of keeping healthy queens in their colonies as they are essential to the well-being and productivity of honeybee colonies. According to Shrestha et al. (2017), during a study conducted in the Lamjung district, they learned of a

beekeeper named Mr. Lalit Gurung who was grafting queen bees and selling them for Rs. 700 each to other local producers and clients. However, information about the quantity of beekeepers engaged in high-quality queen production in Nepal or the state of queen production has not been discovered.

Owing to variations in the country's geology and climate, pollen and nectar supply varies throughout Nepal. Queen production can take place in the Spring (Falgun-Chaitra), Summer (Baishakh-Jestha), Autumn (Ashoj-Kartik), and Winter (Mangsir-Poush) depending on the availability of nectar and pollen. However, the optimal time to produce queens is either before the honey flow phase is reached or shortly after flowers begin to bloom, as most workers are occupied with foraging during this period (ADC, 2022b).

However, several issues that impede the industry's expansion and development characterize Nepal's current state of queen production. Among these are the scarcity of superior breeding stock, beekeepers' lack of technical expertise and training, inadequate infrastructure and marketing, and government support (ADC, 2022a).

The scarcity of excellent breeding stock is one of the main issues facing beekeepers in Nepal. Many beekeepers raise queens using conventional techniques, which can produce queens of lesser quality and having less desired qualities. Additionally, beekeepers frequently struggle to obtain the best breeding material and must rely on traditional inbred queens due to limited access to improved genetic stock caused by a lack of infrastructure and resources (Bhandari and Kattel, 2020).

One such issue hindering Nepal's queen production is the lack of technical expertise and training among beekeepers. The inability of many beekeepers to raise queens correctly results in lower-quality queens and decreased productivity. Additionally, Nepal lacks established procedures for raising queens, which can result in uneven outcomes and a variation in the caliber of queens that are produced.

In addition to these difficulties, infrastructure, and marketing concerns trouble beekeepers in Nepal. Queen bees are not transported or stored properly, which might result in a decline in production and quality. Moreover, Nepal's queen bee market is underdeveloped, which restricts beekeepers' ability to make money from their production.

4. Genesis of Beekeeping and Beekeeper's Training

In Nepal, beekeeping is a traditional occupation. Since the beginning of time, people have been raising bees. At first, bees were raised in traditional hives made of wood and walls, and searching for wild honey was a regular activity. Beekeeping became more popular after the introduction of Modern hives. However, traditional hives such wall and log hives are still common (ADC, 2022a).

The introduction of *A. mellifera* in 1994 led to the development of commercial beekeeping in Nepal. Moveable hives for *A. cerena* were introduced in 1989, marking the beginning of scientific beekeeping in Nepal (Devkota, 2020). The Thai sack brood, which first emerged from Nepal's eastern border in 2038 BS, had a negative impact on the beekeeping business up until 1985–1986 (ADC, 2023).

In the beginning, the Department of Cottage Industry provided contemporary beehives to several areas and ran beekeeping training courses. Records from 1968–1969 show that the local development committee conducted beekeeping trainings for farmers of their areas. Beekeepers were receiving technical and advising assistance from the Department of Agriculture's Entomology Branch in the interim.

Beekeeping initiatives have been operated under the commercial entomology project from 1975–1976 (FNBK, 2015). The Department of Agriculture launched a specific beekeeping program in conjunction with the creation of a commercial entomology initiative. Through the organization of farmer-level trainings in the districts of Kavrepalanchok, Lalitpur, and Nuwakot, 250 modern beehives were delivered as part of this program.

Additionally, the districts of Sindhupalchok, Dolakha, Ramechhap, Sindhuli, Makwanpur, Chitwan, Dhading, Kaski, Lamjung, Palpa, Rolpa, Solukhumbu, etc. received modern beehives from the District Agricultural Development Offices. In the meantime, the Chepangs were scheduled for beekeeping training. In the meantime, the Praja Bikas Samiti provided modern hives and beekeeping training to the Chepangs of Dhading, Chitwan, and Makwanpur as well as in Kaski and Surkhet districts under the women's training program.

The Nepal Rehabilitation Company sent modern beehives to the districts of Kanchanpur, Kailali, Banke, Bardiya, Nawalparasi, Sarlahi, etc. in 1978–1979 and conducted beekeeping trainings using funds from its own budget (ADC, 2023).

To advance and grow apiculture and conduct research in various areas of applied entomology, the Beekeeping Development Center was founded in 1980 as a division of NARC (Thapa, 2006). Similar to this, starting in 1980–1981 a unique beekeeping program was run in 16 different small farmer development projects across the nation under the Small Farmer Development Program, with technical assistance from the Agricultural Development Bank and UNICEF's Economic and Commercial Entomology Project.

Both sericulture and beekeeping programs were run under the commercial entomology project at the same location in Khopasi, Kavrepalanchok. In 1987/88, the beekeeping program changed into a beekeeping project at the central level under the Department of Agriculture in Godavari, according to the instruction box left by the late King Birendra. From 1987–1988 until 1992–1993 the "Beekeeping Center" was a stand-alone entity, and the Beekeeping and Extension Service Project was run (with funding from the Dutch Government). The Beekeeping Development Branch was founded in 1994–1995 (FNBK, 2015).

To create an entrepreneurial beekeeper, CTEVT created a curriculum for beekeepers. In 2012, ICIMOD produced a resource manual titled "Beekeeping Training for Farmers in the Himalayas: Resource Manual for Trainers" for use by trainers and field extension personnel. (Ashwin and Sharma, 2012). Similarly, FNBK created the "Advanced Beekeeping Manual" in 2018 with assistance from GIZ.

Currently, general, and advanced beekeeping trainings are regularly conducted by the Apiculture Development Center in Lalitpur and the Beekeeping Development Program in Chitwan run by the Nepalese government. Bee Zones in various districts have also performed quality queen production training. This type of training falls under the category of advance beekeeping training. To create new opportunities for the beekeeping business in Nepal, an instrumental insemination training program was held at the Beekeeping Development Program in Chitwan from April 26 to May 2, 2023 (CIED, 2023). Likewise, beekeeping and pollination-related initiatives have been carried out in Nepal by several national and international non-governmental organizations and projects (FNBK, 2015).

5. Knowledge on Quality Queen Production

Keeping healthy and productive bee colonies is the main goal of beekeepers. Assuring the presence of a high-quality queen is one method of reaching this goal. Every hive requires a youthful, healthy, and active queen since these traits affect the colony's performance (Sharma et al., 2014).

A single fertile laying queen, female worker bees, and fertile haploid male drones make up a bee colony. However, each colony caste plays a vital part in raising the queen. Drones are necessary for fertilizing the queen, and nurse bees (younger worker bees) feed the larvae of the queen (Hailu and Atsbeha, 2016).

The solitary reproductive female in the colony, the honeybee queen is clearly identifiable from other members due to its bigger stature and extended abdomen. The queen's unique queen pheromone aids in controlling the other bees inside the colony. According to Rekwot et al. (2001), the presence of a queen suppresses oogenesis in workers, hinders the rearing of other queens, and draws drones during the nuptial flight. A queen can produce up to 1000 eggs every day and has approximately 200 ovarioles per ovary (Cristino et al., 2006). Since the queen is the lone worker in the hive, her characteristics are passed on to the offspring. Therefore, a queen controls the behavior and output of her offspring.

The worker and queen develop from the same egg. However, the development is not the same as the larval stage, when the queen emerges through differential feeding of royal jelly (Hailu and Tadesse, 2016). Furthermore, unlike the larvae of other classes, the larvae of the queen develop in bigger vertical compartments. A female can become a queen from any female egg and any female larva that is younger than three days (Anton and Grozinger, 2022). Beekeepers can use this potential to raise queens based on their needs.

It is the nurse bees' job to produce new queens. They start the process of producing a queen from existing eggs and larvae as soon as they sense the

absence of the queen pheromone. On the other hand, introducing particular larvae with the desired genetic origin to the queen cell is one way that humans can intervene. The transferred larva is fed royal jelly by the workers, and it grows into a queen with the required traits (ADC, 2022). Grafting is the term for this procedure, which involves transferring larvae to queen cells using grafting needle which is referred as high-quality queen production technology in Nepal.

Queen rearing is one of the most important components of successful beekeeping, according to commercial beekeepers. Beekeepers rear queens in order to keep a healthy supply on hand for either starting new colonies or replacing aging or unwanted queens. Beekeepers have two options for obtaining new queens: buying or rearing them (Hailu and Tadesse, 2016). Rearing queens in a self-apiary is the recommended method due to factors such as cost, time, availability, quality, illnesses, and mites (Bush, 2007). Bringing an outside queen bee to their Apiary, is not sustainable for many beekeepers, and more importantly, it is contributing to the spread of parasites and diseases and negatively impacting biodiversity through genetic mixing (FAO, IZSLT, Apimondia and CAAS, 2021).

Beekeepers can select and multiply colonies from their stock by raising queens. Although such exceptional traits are less likely to be maintained and passed down for generations under natural mating, where there is no control over the several drones that met with a queen, queens can be raised from colonies that have demonstrated better performances among the stock (Hailu and Tadesse, 2016). Thus, the process of raising exceptional queens can lead to both genetic variety and improvement.

The process of producing better drones through quality queen production technology includes choosing a robust and healthy colony for grafting, selecting a nursery colony, and transferring it to a mating unit or nucleus hive. A high-quality queen is essential to raising the caliber of bee products, dividing colonies for commercial purposes, replacing old queens from underperforming colonies or installing new ones in hives, and boosting pollination activity to improve crop yield (ADC, 2022).

A quality queen should appear large and robust, with a well-developed belly and perfect symmetry along the longitudinal axis. She should also have unharmed wings, legs, and tarsi, and be surrounded by workers after two to three weeks from the start of laying. The pattern of a brood is a crucial sign of quality.

6. Queen Replacement

Beekeepers need to replace their queen bee as it becomes old or unhealthy, or if the colony is not thriving. The mating of queen takes place once in a lifetime and a queen remains economically productive for 1-2 years (Okuyan and Akyol, 2018). Queen can live upto 5 years but its productivity reduces after the first year (Anton and Grozinger, 2022). Replacing queen every 1.5 years at the beginning of spring is a good beekeeping practice. Changing hive-queen at the beginning of spring results a stronger colony during the honey flow season. The swarming behaviour and drone burden can be reduced to great extent by introducing young queens every three breeding seasons (Sharma et al., 2014). According to Okuyan and Akyol (2018), in Turkey, replacing queens older than 3 years was reported to have improved honey yield by 150%.

The queen replacement rate is different in different countries. Ethopian beekeeping doesnot practice queen replacement (Okuyan and Akyol, 2018). Similarly, more than 90% of the Polish beekeepers replace old queens (Bieńkowska et al., 2020). However, in case of Nepal most of the beekeepers are unaware about the benefits of annual queen replacement and those aware also barely practice. A key determinant of a queen's quality is her brood pattern. A proper laying pattern is exceptionally uniform and compact, with no empty cells throughout the capped stage of development (holes in the capped stage may be the result of significant inbreeding). It is spiral-like in terms of the several uncapped phases of the larvae (FAO, IZSLT, Apimondia and CAAS, 2021).

Queen bee quality is influenced by a number of parameters, including genetic selection, the queen's age, the quality of her mating, nutrition, and environmental stresses (Güneşdoğdu and Şekeroğlu, 2020). The author comes to the conclusion that paying close attention to these variables can raise the caliber of queen bees produced, which will increase beekeeping operations' chances of success.

According to Kezić's (2011) research, colonies exhibiting greater genetic variety demonstrated superior fitness and greater resilience against environmental stressors and diseases. To protect the wellbeing and survival of honeybee colonies, the author suggested putting in place breeding strategies that give priority to genetic variety and selection for desired features.

7. Future Prospects

The future prospects for beekeeping and queen rearing in Nepal hold immense promise and potential. With the right investments in infrastructure, training, and research, the beekeeping industry in Nepal can thrive and significantly contribute to the country's economy. The expansion of modern beehives and the adoption of best practices can lead to increased honey production and higher-quality bee products. Additionally, the emphasis on queen rearing can enhance the genetic diversity and health of bee colonies, resulting in more robust and productive hives. This can have a cascading effect on crop pollination, thereby supporting agriculture and food security. Furthermore, the growing global demand for honey and other bee products presents a unique opportunity for Nepal to tap into international markets. In the context of sustainable agriculture and ecological conservation, beekeeping and queen rearing are poised to play a crucial role. However, realizing this potential requires concerted efforts in terms of government support, improved training programs, and fostering awareness among beekeepers. With these steps, Nepal can secure a brighter and more prosperous future for its beekeeping and queen rearing industry.

8. Conclusion

The status of beekeeping and queen rearing in Nepal is a tale of tradition, promise, and challenges. Beekeeping has long been an integral part of the rural economy by offering a source of income, food security and pollination services. With the required support and investments, it has the potential to grow into a big industry that benefits both beekeepers and the nation's agricultural sector. The diversification of bee products, the increasing demand for honey,and the ecological importance of bees all contribute to the promise of this industry.

However, there are plenty of challenges from the lack of infrastructure to the quality control issues and the need for greater knowledge and training. Adequate attention is essential to bring the full potential of beekeeping and queen rearing in Nepal. The importance of queen rearing in ensuring healthy and productive colonies cannot be overstated. It is through which beekeepers can improve their stocks, enhance genetic diversity and contribute to the overall health of the beekeeping industry.

The future prospects for beekeeping and queen rearing in Nepal are bright with collaborations between stakeholders, including the government, organizations, and beekeepers themselves to address the challenges and seize the opportunities. By promoting modern practices, quality control and awareness, Nepal can not only bolster its beekeeping industry but also play a vital role in ecological conservation and sustainable agriculture. The journey ahead involves investment, education, and innovation, and with these steps, Nepal can look forward to a thriving and prosperous future for its beekeeping and queen rearing sector.

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