**Original Research Article**

**Migratory Routes of *Apis mellifera* Apiaries from Himachal Pradesh vis-à-vis Seasonal Floral Availability in North Indian Plains: An Approach for Sustainable Beekeeping**

**ABSTRACT**

**Aims:** To explore the migration routes, floral resources, honey yield, and the economic and ecological challenges faced by beekeepers, along with the market orientation for bee products and economic viability on the basis of apiary size.

**Study design:** A survey of 40 beekeepers was conducted to evaluate floral calendar, migratory patterns and associated challenges.

**Place and duration of study:** Survey was carried out across various agro-climatic zones of Himachal Pradesh during 2023 and 2024.

**Methodology**: We surveyed 40 randomly selected migratory beekeepers across Himachal Pradesh. Data on migratory routes, floral resources and season transitions were collected through farm visits and structured questionnaires. A floral calendar was developed using field observations and weather data. On the bases of apiary size, we classified beekeepers into four groups and profitability was calculated for each group, highlighting variations in income potential with the scale of operation.

**Results**: Data showed that the majority of beekeepers in Himachal Pradesh practice migratory beekeeping, traveling through Haryana, Punjab, Rajasthan, and the plains of Uttar Pradesh to take advantage of region-specific nectar flows. A well-planned floral calendar and flexible migration reduce feed requirements, especially during long dearth periods, and help combat threats like predatory wasps. The study highlights the importance of climate-resilient beekeeping and floral phenology-based management for maintaining sustainable apiculture. Findings support the idea of evidence-based migratory routes, performed cooperatively in most cases, and delineate measures to improve the resilience and profitability of beekeeping in mountainous areas.

**Conclusion:** Migratory beekeeping enhances honey yield and profitability through strategic floral phenology-based movements, supporting sustainable and climate resilient apiculture in Himachal Pradesh.

*Keywords: Floral calendar, dearth period, predatory wasps, climate-resilient, floral phenology.*

**1. INTRODUCTION**

India's apiculture sector plays a pivotal role in rural livelihood, agricultural pollination, and biodiversity maintenance. *Apis mellifera* is widely adopted among domesticated honey bee species for its superior honey yield and adaptability to migratory beekeeping systems (Frunze et al., 2021). Migratory beekeeping with *A. mellifera* was suggested to Himachal Pradesh beekeepers in the early 1980s after aenticating flora-rich niches, especially in Punjab, Haryana, Uttar Pradesh, and Rajasthan. In Himachal Pradesh, a state with diverse agro-climatic zones, stationary beekeeping faces inherent challenges due to extended periods of floral dearth, topographical constraints, and increasing climatic variability (Sharma et al., 2022). These limitations have led to a large-scale transition toward migratory beekeeping, where colonies are transported seasonally to lowland regions with abundant nectar and pollen sources. Planned migration, especially, which in most cases is cooperative among beekeepers, helps them to save on duplicating transport costs and the huge cost of sugar for artificial feed.

Recent research highlights the importance of a synchronized floral calendar to guide migratory movements. Nurnberger et al.,2019 noted that an induced phenology-based approach enhances honey yield and reduces varroa infestation. Additionally, climate induced changes in floral development, pollen and nectar stores have made traditional migratory routes less predictable, necessitating more dynamic and potential routes (Le Conte et al., 2008).

The present study aims to map migratory routes, analyze floral dependencies, and propose a sustainable management calendar to assist beekeepers and practitioners in optimizing resource use and maximizing apicultural productivity. The study also focused on the economic viability of different groups of apiary-sized beekeepers, particularly in terms of transition and bee products.

**2. MATERIALS AND METHODS**

A comprehensive survey was carried out during 2023 and 2024 to reach out to over 100 migratory beekeepers across various agro-climatic zones of Himachal Pradesh. The information was gathered from 40 randomly selected and physically present beekeepers at their farms. Data was recorded on migratory routes and also gathered essential requisite information on floral resources and their transition timings. An apicultural activity calendar was created based on available literature, multidimensional observations of management practices, including direct seasonal factors such as comb condition, brood health, pollen storage, nectar flow, and floral phenology, along with meteorological data like ambient temperature, relative humidity, and rainfall.

To quantitatively assess the beekeeping operations of 40 beekeepers, a structured questionnaire was administered. Data collected included the number of colonies maintained, migratory movements across states, seasonal timelines, and quantities of hive products harvested (honey, beeswax, pollen). Based on apiary sizes, beekeepers were classified into four groups, and profitability was calculated for each group, highlighting variations in income potential with the scale of operation.

**3. RESULTS AND DISCUSSION**

The migratory strategies followed by *A. mellifera* beekeepers in Himachal Pradesh exemplify a finely tuned response to seasonal floral dynamics and ecological pressures. Based on survey studies and long-term apiary management records, a highly structured and temporally phased movement pattern has emerged, designed to maximize nectar availability and minimize feeding costs during dearth periods. Often, small-scale beekeepers, in fact, the beginners, are supported by the established beekeepers to transport their apiaries sharing the same vehicle, hence cutting the cost of transportation manifold. Sharing transport costs is usual among the beekeepers with the apiary size up to 100 colonies. Study envisaged after interacting with apiarists and through literature that there are some well-defined and set migratory routes for specific flora.

**3.1 August to February: Plains Migration for Bajra, Ber, and Mustard**

Migration begins in August-September, targeting regions in Haryana (Rewari, Gurgaon, Hisar) and Rajasthan (Sri Ganganagar, Suratgarh, Hanumangarh). The main floral resource during this period is Bajra (*Pennisetum glaucum*), a summer crop rich in pollen but moderate in nectar (Fig. 1). This is soon followed by Ber (*Ziziphus mauritiana*) blooms in October, which offer substantial nectar suitable for pre-winter colony buildup. As per Chauhan et al., 2017, *Ziziphus* is a critical bridge flora that sustains bee colonies between the monsoon and winter crop cycles in the North Indian plains. It is considered as a minor source of pollen and a secondary source of nectar. Colonies typically remain stationed in these regions till February, capitalizing on the extended bloom of mustard (sarson) (*Brassica juncea*), a major nectar source in the Rabi season. Some apiaries prefer mustard blooms in Kota and Ajmer, Rajasthan, known for their early flowering. This aligns with studies of Hooda and Jain, 2020, who documented a rich diversity of Apidae family members visiting the mustard flora.

**3.2 March-April: A transition of apiaries to Punjab and Mid-Hills**

By early March, beekeepers begin relocating colonies to Punjab (notably Jalandhar, Phagwara, Hoshiarpur, Mukerian), targeting floral flows of shisham (*Dalbergia sissoo*) and other leguminous trees common in riparian agroforests. The nutrient-rich nectar of shisham is vital for pre-summer colony health and expansion. Migratory beekeepers of Himachal have observed that these tree crops in Northern Indian plains offer consistent bloom under varied climatic conditions, thereby serving as a stable resource for migratory cycles.

Following this, by late April or early May, beekeepers either return to their home districts in Himachal Pradesh for multifloral honey harvests or re-enter Punjab for Berseem (*Trifolium alexandrinum*) and Sunflower crops. These forages are particularly high in nectar and support robust colony strength heading into summer.

**3.3 June-August: Return to the Hills for Summer Forage and Specialty Honeys**

In June-July, colonies return to the mid-hill districts of Kangra, Chamba, Solan, and Bilaspur for the Khair honeyflow from *Acacia catechu*. This species blooms during the monsoon onset and offers aunique nectar that contributes to one of the most commercially valued honeys of the region. Some beekeepers, particularly from Chamba, bypass the Khair bloom to access *Plectranthus* in high-elevation zones of Holi, Bharmour, and Salooni. Thakur et al., 2021 highlighted the superior antioxidant and antibacterial profile of *Plectranthus* honey, which has shown increasing demand in urban medicinal markets. An alternative high-elevation route is to Lahaul-Spiti for wild thyme (*Thymus serpyllum*) honey, which blooms in August. The region's dry-temperate climate allows for niche honey production with minimal biotic stress. However, logistical barriers sometimes curtail migration to these regions. Motmayen et al.,2024 observed a sharp loss of apiaries (20-25%) in high-altitude of Himachal Pradesh, primarily due to increased mortality by *Vespa velutina* (Asian hornet) and other dominant wasp species.

**Table 1: Details of the apiaries of farmers surveyed with their respective migration schedules and production of hive products**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name**  | **Block & District** | **No. of colonies** | **Migration state** | **Month of Migration** | **Sites/ Places of Migration** | **Hive Products**  |
| **Product** | **Quantity (kg)** |
| 1. | Sh. Lal Chand  | Nagrota Bagwan,Kangra | 350 | HaryanaPunjabUttar Pradesh | Sept. - Oct. March | Hisar, RewariHoshiarpur, MukerianAligarh, Moradabad, Bareli | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 1300b) 400c) 100d) 13 |
| 2. | Sh. Suresh Kumar  | Nagrota Bagwan,Kangra | 80 | Haryana or Delhi Punjab | Dec. - Jan.March | Hisar, Rewari & Najafgarh Hoshiarpur | a) Honeyb) Bee Wax | a) 600b) 25 |
| 3. | Sh. Sushil Kumar | Nagrota Bagwan,Kangra | 80 | Haryana or DelhiPunjabRajasthan | Oct. - Nov.March | Hisar, Rewari | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 900b) 35c) 2.5d) 3.5 |
| 4. | Sh. Sanjeev Kumar | Nagrota Bagwan,Kangra | 100 | HaryanaPunjabRajasthanUttar Pradesh | March | HisarGanganagarBareli | a) Honeyb) Bee Waxc) Propolis | a) 1000b) 130c) 9 |
| 5. | Sh. Anil Kumar | Nagrota Bagwan,Kangra | 150 | HaryanaPunjabRajasthan | March | Hisar, Rewari | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 2000b) 400c) 3 d) 3 |
| 6.  | Sh. Vinod Kumar | NagrotaBagwan,Kangra | 85 | Rajasthan HaryanaDelhi | Sept. - Oct.Oct. - Nov.Nov. - Dec. | Jind, Rohtak | a) Honeyb) Bee Wax | a) 300b) 55 |
| 7. | Sh. Anshul Kondal  | Nagrota Bagwan, Kangra | 150 | HaryanaPunjab | Oct. - Nov.March | Hisar, Rewari | a) Honeyb) Bee Waxc)Pollen | a) 1200b) 45c) 45 |
| 8. | Sh. Bhupinder Singh | Kangra | 35 | HaryanaPunjab | Nov.Feb.-March | Noonh, JhajjarPathankot | a) Honeyb) Bee Wax | a) 1000b) 5 |
| 9. | Sh. PritamChand | Kangra | 100 | HaryanaRajasthan Punjab | Oct.-Nov.Feb.March | JindVijayanagar, HaripuraPathankot, Hoshiarpur | a) Honeyb) Bee Wax | a) 1000b) 50 |
| 10. | Sh. Nijay Kumar | Panchrukhi, Kangra | 475 | Uttar Pradesh or RajasthanPunjab | Aug. - Oct.Oct. - Dec. Jan. - Feb. | MoradabadHoshiarpurHanumangarh | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 1600b) 100c) 100 d) 50 |
| 11. | Sh. Dhananjay Sharma  | Nagrota Bagwan, Kangra | 50 | Himachal Pradesh | March - April | Ranital, Jawalamukhi | a) Honey | a) 600 |
|  |  |  |  |  |  |  |  |  |
| 12 | Sh. Amar Singh | Kangra | 60 | Haryana Rajasthan Punjab  | Oct. - Nov.Jan.March | Jhajjar, GurgaonSriganganagarHoshiarpur | a) Honeyb) Bee Wax | a) 500b) 25 |
| 13 | Sh. Rishav  | Nagrota Bagwan,Kangra | 120 | Rajasthan Punjab | Sept.Feb. | HoshiarpurGanganagar | a) Honeyb) Bee Wax | a) 1000b) 40 |
| 14 | Sh. Dimple Kumar | Kangra | 110 | HaryanaPunjab | Oct. - Nov.Feb. - March | Jind or SriganganagarHoshiarpur | a) Honeyb) Bee Waxc)Pollend)Propolis | a) 600b) 20c) 4d) 2 |
| 15 | Sh. Vishal Kumar | Nagrota Bagwan,Kangra | 120 | Haryana, Punjab | Oct. - Nov.Feb. - March | Jind or SriganganagarHoshiarpur | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 1000b) 50c) 5d) 1 |
| 16 | Sh. Suresh Kumar | Khundian, Kangra | 36 | Haryana, Punjab | Nov.March  | JhajjarHoshiarpur | a) Honeyb) Bee Waxc) Pollen | a) 200b)3 c) 1 |
| 17 | Sh. Ankur Kumar Sharma | Panchrukhi, Kangra | 30 | HaryanaPunjab  | Nov.Feb. | JindHoshiarpur | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 60b) 3c) 1d) 0.2 |
| 18 | Sh. Jagdev Singh | Khundian, Kangra | 53 | Punjab  | Jan. | Hoshiarpur | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 300b) 5c) 3d) 1 |
| 19 | Sh. Chanchal Kumar | Baba Baroh, Kangra | 46 | Punjab  | Jan. | Hoshiarpur | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 250b) 4c) 2d) 0.5 |
| 20 | Sh. Ravinder Kumar | Kangra | 80 | Haryana PunjabHP | Nov.Feb.March | Jhajjar or HisarHoshiarpurBankhandi | a) Honeyb) Bee Wax | a) 5000b) 50 |
| 21 | Sh. Rakesh Kumar | Nagrota Bagwan,Kangra | 65 | Haryana | Oct. | Rewari or Hisar | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 350b) 20c) 2d) 1 |
| 22 | Sh. Ajeet Kumar  | NagrotaBagwan,Kangra | 120 | Rajasthan Punjab | Aug. - Sept. Feb. - April | SriganganagarHoshiarpur | a) Honeyb) Bee Waxc) Pollen | a) 2000b) 55c) 3 |
| 23 | Sh. Sanjeev Kumar | Nagrota Bagwan, Kangra | 90 | RajasthanPunjab | Sept. - Nov.March - April | Sri GanganagarPathankot | a) Honeyb) Bee Waxc) Pollen | a) 300b) 25c) 1.5 |
| 24 | Sh. Man Chand  | Baba Baroh, Kangra | 100 | Haryana &Punjab | Feb. - MarchFeb. - March | Kernal, HisarHoshiarpur | a) Honeyb) Bee Waxc) Pollen | a) 1200b) 35c) 2 |
| 25 | Sh. Sachin Kumar | Nagrota Bagwan, Kangra | 600 | Rajasthan  | Sep.- Oct. | Sri Ganganagar, Udhampur, Bikaner, Jodhpur, Lal Garh | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 7500b) 180c) 10d) 25 |
| 26 | Sh. Varinder Singh | Nagrota Bagwan,Kangra | 50 | Haryana Punjab | Feb. - MarchFeb. - March | Sri GanganagarMukerian, Hoshiarpur | a) Honeyb) Bee Wax | a) 550b) 45 |
| 27 | Sh. Munish Kumar | Kangra | 100 | HaryanaPunjab  | July - Aug. | JindHoshiarpur, Mukarian, Pathankot | a) Honeyb) Bee Wax | a) 800b) 20 |
| 28 | Sh. Bihari Lal | Nagrota Bagwan,Kangra | 100 | Haryana Rajasthan | Nov. - Feb.Feb. - March | HisarSri Ganganagar | a) Honeyb) Bee Wax | a) 1500b) 55 |
| 29 | Sh. Parveen Kumar | Nagrota Bagwan, Kangra | 280 | PunjabHaryanaDelhi | July - Aug.Sept. - Oct.Nov. - Dec. | Hoshiarpur or JallandharJindNajafgarh | a) Honeyb) Bee Waxc) Propolis | a) 1200b) 600c) 8 |
| 30 | Sh. Ram Krishan  | Jawali, Kangra | 159 | Rajasthan or HaryanaPunjab | Oct. - Nov.Feb.  | Sri GanganagarHisarDasuha | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 1500b) 35c) 4d) 0.5 |
| 31 | Sh. Rakesh Kumar | Nagrota Bagwan,Kangra | 160 | Haryanaor Rajasthan Punjab | Nov. - Feb.Feb. - March | HisarSri GanganagarHoshiarpur | a) Honeyb) Bee Wax | a) 600b) 45 |
| 32 | Sh. Karam Chand | Kangra | 50 | Haryana  | Nov. - Feb. | Sri Ganganagar | a) Honeyb) Bee Waxc) Pollen | a) 300b) 5c) 2.5  |
| 33 | Sh. Satish Kumar | Kangra | 400 | Rajasthan orHaryana Punjab | Sept. - Oct.Hoshiarpur | Vijaya nagarHoshiarpur | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 8000b) 700c) 4d) 15 |
| 34 | Sh. Vishal | Kangra | 500 | Punjab/HaryanaRajasthan | Sept. to March | HoshiarpurHisarVijayanagar | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 5000b) 50c) 6d) 24 |
| 35 | Smt. Saroj Kumari | Nurpur, Kangra | 200 | Rajasthan orHaryanaPunjab,  | Sep.February | Sriganganagar/ RohtakMukerian | a) Honeyb) Bee Waxc) Pollen | a) 1500b) 35c) 8 |
| 36 | Smt. Aruna Kumari | Kangra | 400 | RajasthanPunjab | Sep.February | VijayanagarFeb. | a) Honeyb) Bee Waxc) Pollend) Propolis | a) 2500b) 25c) 25d) 1 |
| 37 | Sh. Kulveer Singh | Nagrota Bagwan,Kangra | 87 | Rajasthan | Oct. | Vijayanagar | a) Honeyb) Bee Waxc) Pollen | a) 400b) 4c) 1 |
| 38 | Sh. Arvind Kumar | Nagrota Bagwan,Kangra | 35 | Rajasthan | Nov. | Sriganganagar/ | a) Honey | a) 150 |
| 39 | Sh. Nagin Chand | Jawali, Kangra | 45 | Punjab | Nov. | Mukerian | a) Honeyb) Bee Wax | a) 150b) 3 |
| 40 | Sh. Suresh Kumar | Hamirpur | 42 | Haryana | Nov. | Ambala | a) Honeyb) Bee Wax | a) 150b) 4 |

The survey included 40 migratory beekeepers mainly from the Kangra district of Himachal Pradesh, aiming to understand the dynamics of migratory beekeeping regarding their routes, seasonal timing, and hive product yields (Table 1). It provides insights into regional beekeeping practices, productivity patterns, and movement trends across North India. This study can serve as a model for migration where a large number of beekeepers work together and stay in clusters at different sites in various states. Therefore, within the country, such routes may help make beekeeping sustainable for all apiary owners. The study found that the number of bee colonies per beekeeper varied widely, from as few as 30 colonies to as many as 600, with larger colonies generally producing more hive products. Migration patterns mainly followed seasonal floral availability, with the most common routes involving Haryana, Punjab, Rajasthan, and Uttar Pradesh, corresponding with peak nectar and pollen flow.

It can be inferred from Table 1 that two principal migratory windows were observed: the post-monsoon period (September-October) and the spring season (February-March). Early migrations, particularly to Rajasthan and Haryana, were often initiated as early as August, while returns or subsequent shifts to Punjab occurred during February to April. Prominent migratory destinations included Hisar, Rewari, Ganganagar, Hoshiarpur, and Moradabad, reflecting established floral belts favourable for bee forage.

It was also recorded and is evident from Table 2 that regarding hive products, honey was universally favoured by beekeepers and regularly harvested, with average yields ranging from 245.5kg/year for apiaries having less than 50 colonies to as much as 3871.42kg/year for more than 200 colonies. High honey production was generally linked to a greater number of colonies and well-coordinated multi-state migrations. Beeswax was the second most common product, with notable variability in average extraction (7.4-293.57 kg/year). Pollen and propolis were less frequently extracted but appeared in significant amounts among larger colonies; the highest recorded outputs were 36.14 kg for pollen and 18.28 kg/year for propolis.

Further stratification of beekeepers based on apiary size revealed that larger apiaries benefit from economies of scale, better migratory management, and possibly greater exposure to diverse floral resources across migration sites. Moreover, the increase in non-honey hive products such as pollen and propolis in larger apiaries reflects a trend toward diversification and value addition, which remains limited in smaller operations.

Beekeepers with less than or equal to 50 colonies earned an average of approximately ₹41,530, predominantly from honey (₹39,280), with only modest contributions from wax (₹1,850) and pollen (₹400). In contrast, those managing 51-100 colonies reported average earnings of ₹1, 81,163, driven by a considerable increase in honey (₹1, 70,460.80) and improved wax yield (₹10,172.50). However, pollen remained a minimal contributor (₹530) (Table 3).

**Table 2: Categorization of beekeepers based on apiary size and corresponding average yields of hive products in 2023**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Apiary size** | **No. of beekeepers** | **Average honey(kg)** | **Average wax(kg)** | **Average pollen(kg)** | **Average propolis (kg)** |
| Less than or equal to 50 | 9 | 245.5 | 7.4 | 0.4 | 0.07 |
| 51-100 | 15 | 1065.38 | 40.69 | 0.53 | 1.03 |
| 101-200 | 9 | 1266.66 | 80.5 | 8 | 0.72 |
| >200 | 7 | 3871.42 | 293.57 | 36.14 | 18.28 |

**Table 3: Estimated economic value of hive products by apiary size category**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Apiary size** | **Honey Value (160/kg)** | **Wax Value (250/kg)** | **Pollen Value (1000/kg)** | **Total Value (approx)** |
| Less than or equal to 50 | 39,280 | 1850 | 400 | 41,530 |
| 51-100 | 1,70,460.8 | 10,172.5 | 530 | 1,81,163 |
| 101-200 | 2,02,665.6 | 20,125 | 8000 | 2,30,791 |
| >200 | 6,19,427.2 | 73,392.5 | 36,140 | 7,28,960 |

Note: Market rates used for calculation—Honey: ₹160/kg, Beeswax: ₹250/kg, Pollen: ₹1000/kg.

The economic leap was even more significant among beekeepers managing 101-200 colonies, with an average product value of ₹2,30,791. This increase was largely attributed to a substantial rise in pollen income (₹8,000), in addition to enhanced honey and wax returns. Notably, the >200 colonies group exhibited the highest profitability, earning nearly ₹7.29 lakh, of which over ₹6.19 lakh came from honey alone. Additionally, this group earned considerable value from wax (₹73,392.50) and pollen (₹36,140), highlighting the potential of larger apiaries to diversify their product and exploit the untapped market. Lack of awareness about other valuable hive products like venom, royal jelly still stands as a hindrance to enhanced profitability among beekeepers.

A unique and handy information in the form of a floral calendar has been devised to help the beekeepers plan and organize their migration routes as per the floral availability. It provides month-wise information on the availability of major flora in different regions. It will serve as a planning tool that enhances colony productivity, health, and profitability by synchronizing beekeeping operations with regional floral (Figure 1).



**Fig 1: Floral calendar**

**4. CONCLUSION**

This study offers a comprehensive insight into the migratory beekeeping practices adopted by *Apis mellifera* beekeepers in Himachal Pradesh, characterized by their organized structure, cooperative planning, and government support. The movement of apiaries is strategically aligned with the seasonal availability of floral resources across the North Indian plains. During transitions between locations, beekeepers remain in clusters, where smaller apiarists receive support from more established ones in terms of transportation. This collaborative approach often results in an increased number of colonies upon return, due to colony division at migratory sites. Economic analysis revealed that larger apiary units achieved substantially higher returns, not only from honey production but also from secondary hive products such as beeswax, pollen, and propolis. The success of such a model suggests its potential for replication in other regions worldwide that encompass diverse agro-ecological zones.

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