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# Diversity and ecological significance of bee flora supporting honey bees in southern Karnataka

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**Abstract**
A total of 68 bee forage plant species belonging to 34 families were documented across Tumkur, Bangalore North, Bangalore South, and Chikkaballapura districts of southern Karnataka from February to August 2025. Trees dominated with 26 species (38.24%), followed by herbs (18; 26.47%), shrubs (14; 20.59%), crops (6; 8.82%), and climbers (4; 5.88%). Of these, 29 species (42.65%) were nectar sources, 17 (25.00%) pollen sources, and 22 (32.35%) dual sources. Nectar sugar concentration ranged from 18 to 42% (mean 30.8%). Monthly flowering richness peaked in May (52 species) and declined to a minimum in August (15 species). Natural vegetation patches harboured the highest species richness (30; 44.12%). A strong positive correlation was recorded between flowering species richness and honey flow index (r = 0.87). The findings provide baseline data for floral calendar development and apiary management in the region.

**Keywords:** Apis mellifera, Apis dorsata, Apis cerana, bee flora, nectar sugar concentration, pollen morphology, floral calendar, flowering phenology, forage plant diversity, seasonal richness, apiculture management, pollinator conservation, Karnataka

## Introduction

Insect-mediated pollination is a fundamental ecological process that maintains angiosperm reproduction and supports terrestrial ecosystem functioning. Among insect pollinators, honey bees (*Apis* spp.) are regular foragers exploiting a wide range of angiosperms (Free, 1993; Ollerton *et al*., 2011) [18, 24]. Animal pollination enhances productivity in about three-fourths of globally important food crops, with honey bees contributing the largest share of pollination services (Klein *et al*., 2007; FAO, 2018) [7, 14]. The genus *Apis* includes *Apis dorsata* Fabricius, *Apis cerana* Fabricius, and *Apis mellifera* Linnaeus, which differ in nesting habits, foraging range, colony size, and habitat preferences across tropical and subtropical regions (Roubik, 1989; Oldroyd and Wongsiri, 2006) [17, 22]. Flowering plants providing nectar and pollen, collectively termed bee flora, form the primary nutritional resource for honey bee colonies. Nectar supplies carbohydrates for foraging and honey production, while pollen provides protein, lipids, amino acids, and vitamins essential for larval development and adult physiology (Standifer *et al*., 1977; Nicolson, 2011) [16, 23]. Floral attributes such as colour, scent, morphology, and reward quality, together with environmental variables including temperature, humidity, and rainfall, govern foraging activity and colony productivity (Giurfa *et al*., 1995; Corbet *et al*., 1993; Abou-Shaara, 2014) [1, 4, 9].

Habitat loss, pesticide use, climate change, and urbanisation have collectively reduced floral resources for pollinators, causing nutritional stress and declining colony health (Potts *et al*., 2010; Goulson *et al*., 2015; Vanbergen *et al*., 2013) [10, 19, 25]. Systematic documentation of bee flora and flowering phenology is therefore critical for pollinator conservation and sustainable apiculture. Regional floral calendars assist colony migration scheduling, identification of dearth periods, and supplementary feeding decisions (Zamarlicki, 1984; Suryanarayana and Veeresh, 1993) [24, 29]. Southern Karnataka, with its heterogeneous agro-climatic landscape encompassing agricultural, forest, semi-arid, and urban ecosystems, is significant for apiculture, yet detailed scientific documentation of honey bee forage plants across ecological niches remains inadequate (Ramachandra *et al*., 2016) [21]. The present study was undertaken to document the diversity, distribution, and seasonal availability of bee forage plants in Tumkur, Bangalore North, Bangalore South, and Chikkaballapura districts; to characterise species by growth habit, forage type, and nectar sugar concentration; and to develop a regional floral calendar for apiary management.

## Materials and Methods

The study was carried out from February to August 2025 in four districts of southern Karnataka, India. Tumkur district (13.34°N, 77.10°E) has a semi-arid to sub-humid climate with 700–900 mm annual rainfall and red sandy loam and laterite soils, supporting dry deciduous vegetation, scrublands, agriculture, and roadside flora; sampling was conducted along a 12.3 km stretch from Tumkur city to Dodd Sarangi Playa village. Bengaluru South sampling was done within the campus of Bengaluru University (12.56°N, 77.57°E; ~920 m asl), which has semi-evergreen vegetation with gardens, plantations, and weed flora (three sampling points). Bengaluru North comprised GKVK (13.07°N, 77.58°E) and REVA University campus (13.11°N, 77.62°E), receiving ~970 mm annual rainfall with diverse horticulture and ornamental flora. Chikkaballapura district (13.43°N, 77.72°E; ~915 m asl) has a cool, dry climate with rocky scrublands and agricultural fields; sampling was done at G. Cherlopalli and Kotturu roadside locations. Field surveys were conducted during peak bee-foraging hours under favourable weather conditions. All flowering plant species visited by honey bees were recorded; voucher specimens were collected and identified using regional taxonomic keys (Crane, 1990) [5] and classified as nectar sources, pollen sources, or dual sources. For nectar analysis, fresh flowers of each species were sampled and nectar sugar concentration (%) determined as mean of three readings using a handheld Brix refractometer. Pollen morphology and grain diameter were examined at 400× magnification on safranin-stained, DPX-mounted slides using a calibrated ocular micrometer (Erdtman, 1960) [6]. Data were compiled to calculate mean nectar sugar concentration and pollen size per species, and species were categorised by forage type and flowering period to delineate seasonal floral resource availability. A honey flow index based on relative floral abundance and nectar sugar concentration was computed for correlation analysis.

## Results and Discussion

A total of 68 bee forage plant species belonging to 34 families were recorded across the study sites during February–August 2025 (Table 1; Fig. 1). Trees constituted the dominant growth form with 26 species (38.24%), followed by herbs (18; 26.47%), shrubs (14; 20.59%), crops (6; 8.82%), and climbers (4; 5.88%); mean species count across growth categories was 13.60 (SD ± 8.75). The predominance of tree species indicates a strong perennial nectar base in the region, as trees produce large quantities of nectar during synchronised mass-flowering events and are primary contributors to honey flow seasons (Crane, 1990) [5]. Herbaceous flora, comprising more than one-fourth of total species, maintained seasonal continuity of forage supply during inter-peak periods.

**Table 1:** Distribution of bee forage plants by growth habit in southern Karnataka (February–August 2025)

| Growth Habit | Number of Species | Percentage (%) |
|---|---|---|
| Trees | 26 | 38.24 |
| Herbs | 18 | 26.47 |
| Shrubs | 14 | 20.59 |
| Crops | 6 | 8.82 |
| Climbers | 4 | 5.88 |
| Total | 68 | 100.00 |

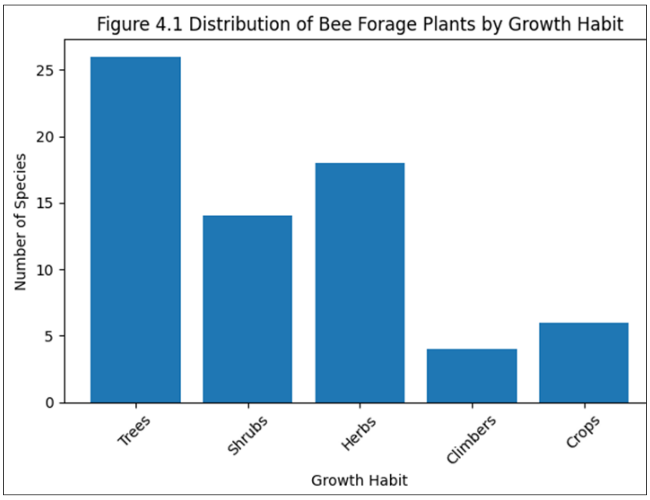


**Fig 1:** Family-wise distribution of honey bee forage flora recorded in southern Karnataka

Resource-based classification showed 29 species (42.65%) as predominantly nectar sources, 17 (25.00%) as pollen sources, and 22 (32.35%) as dual sources. Nectar sugar concentration ranged from 18 to 42% (overall mean 30.8%), with species above 35% categorised as major nectar flow contributors. The high proportion of dual-purpose species indicates a balanced nutritional environment supporting both honey production and brood rearing (Roubik, 1989) [22]. Monthly flowering species richness peaked in May (52 species), declined sharply through July (18) and August (15), and showed a mean of 32.57 (SD ± 13.67) across the study period (Table 2; Fig. 2). The peak in April–May corresponds with the principal honey flow season, while July–August represent potential dearth periods of limited nectar and pollen supply, highlighting the critical importance of seasonal floral calendars for colony management and migratory beekeeping decisions (Zamarlicki, 1984) [29].

**Table 2:** Monthly flowering species richness of bee forage plants in southern Karnataka (2025)

| Month | Number of Species in Bloom |
|---|---|
| February | 28 |
| March | 36 |
| April | 48 |
| May | 52 |
| June | 31 |
| July | 18 |
| August | 15 |

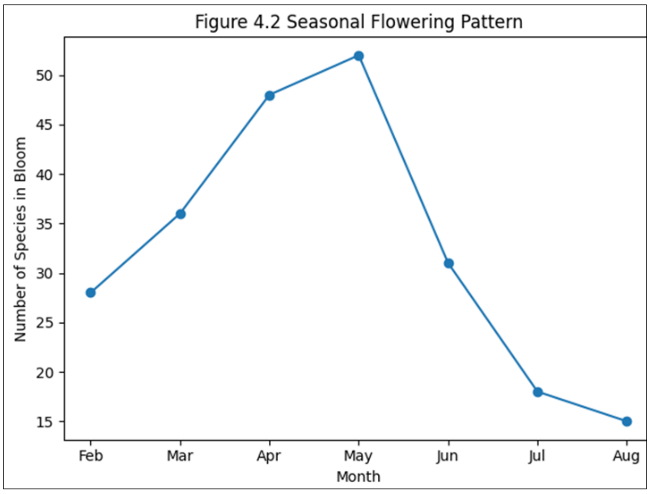


**Fig 2:** Top five dominant plant families supporting honey bee forage in southern Karnataka.

Habitat-wise analysis indicated that natural vegetation patches supported the highest species richness (30; 44.12%), followed by agricultural ecosystems (24; 35.29%) and semi-urban areas (14; 20.59%). Natural habitats provided greater phenological heterogeneity and staggered flowering, ensuring relatively continuous forage across the season. Agricultural systems contributed mass-flowering pulses during crop seasons that significantly enhanced short-duration nectar flows. Correlation analysis revealed a strong positive relationship between flowering species richness and honey flow index ($r = 0.87$), and between nectar sugar concentration and honey yield ($r = 0.81$; Fig. 3), confirming that floral diversity and nectar quality directly govern colony productivity.

Family-wise distribution showed Fabaceae as the most species-rich family with 46 forage records, followed by Asteraceae (24) and Apocynaceae (16) (Table 3; Fig. 1, Fig. 2). The dominance of Fabaceae is consistent with earlier reports recognising leguminous species as abundant nectar and protein-rich pollen sources essential for brood development and colony growth (Free, 1993; Crane, 1990) [5, 8]. Leguminous crops including pigeon pea, green gram, black gram, cowpea, chickpea, and soybean contributed substantially to nectar flow and pollen reserves during peak flowering. The significant representation of Asteraceae confirms the role of composite-flowered plants as dependable, season-extending forage sources; their capitulum-type inflorescences provide readily accessible rewards over prolonged blooming periods attractive to honey bees (Proctor *et al*., 1996) [20].

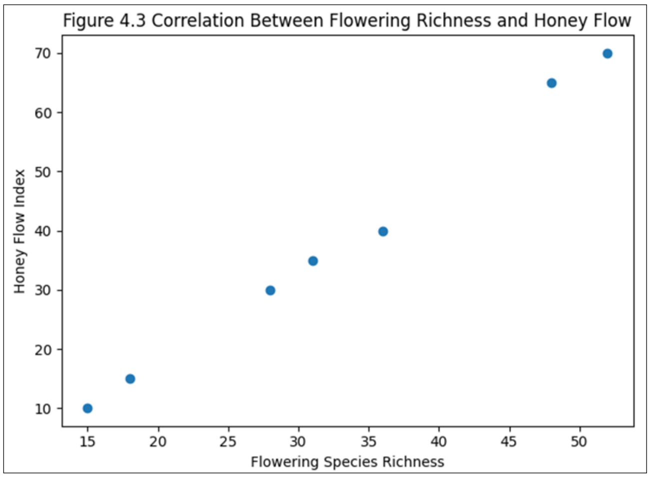


**Fig 3:** Correlation between monthly flowering species richness and honey flow index across study sites in southern Karnataka (r = 0.87)

## Summary and Conclusion

Regional variation in species composition reflected differences in cropping patterns, urbanisation gradients, and vegetation structure. Tumkur and Chikkaballapura districts exhibited higher field-crop and wild-flora diversity characteristic of semi-arid agro-ecosystems, whereas Bengaluru South and North showed greater dominance of ornamental, avenue, and horticultural species associated with urban and peri-urban expansion. Urban landscapes harboured nectar-rich ornamentals such as bougainvillea, allamanda, plumeria, and hummingbird bush that function as bridging forage resources between major seasonal flowering peaks (Baldock *et al*., 2015) [2]. Landscape heterogeneity — the mosaic of agricultural fields, orchards, forest patches, and ornamental gardens — is widely recognised as a key driver of pollinator diversity and resilience (Kremen *et al*., 2007) [12]. Cucurbit crops (pumpkin, cucumber, ridge gourd, and bottle gourd) and oilseed crops (mustard and sunflower) provided important seasonal nectar and simultaneously benefited from pollination services, illustrating the integrated role of apiculture within agro-ecosystems (Klein *et al*., 2007) [12]. Conservation of wild flora, integration of flowering crops into farming systems, promotion of agroforestry, and incorporation of pollinator-friendly ornamental species are recommended to strengthen floral resources and sustain long-term apicultural productivity in southern Karnataka

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## Author Contribution Statement

D K K conceived and designed the study. A B, N G, R and S G L conducted field surveys and laboratory experiments. All authors contributed to data analysis. D K K wrote the manuscript. All authors read and approved the manuscript.

## Conflict Of Interest

The authors declare no conflict of interest.

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