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Research Article

Diversity study and development of bee floral calendar for Kavrepalanchowk district, Nepal

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ABSTRACT
A purposive survey was carried out at Mandandeupur, Jyamdi, and Novobudda of Kavrepalanchowk for two consecutive years (January 2022-December 2023) to identify diversity of bee floral resources and to establish the floral calendar of honey bees in the district. A total of 153 plant species of 50 families were identified as floral resources in the district. Recorded flora was categorized into four groups; trees, shrubs, herbs and climbers. The highest category of bee flora grouped into tree (72 flora) followed by herbs (41), shrubs (30) and climbers (10 flora), respectively. The highest (104 plants) and the lowest (11 plants) number of flowering plants were observed during April and December, respectively. A sufficient number of flowering plants was noticed in March (93 plants), May (68 plants) and February (53 plants) of the spring season as well as during September (49 plants), October (44 plants) and November (41 plants) of the autumn season. From the total available flowering plants in the Kavrepalanchowk district, 90.84% of plants were sources of both nectar and pollen, while only 5.88% as pollen and the remaining 3.26% as sources of nectar only. To ensure sustainability, it is crucial to maintain the existing bee flora and so the floral calendar is important for effective honey production.
Keywords: Bee flora, honey flow period, dearth period, floral calendar

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INTRODUCTION
Beekeeping is an agro-horticultural and forest-based industry with enormous potential in Nepal. The current productivity of honeybees in Nepal is just 25 to 30 kg/colony/year, despite the considerable potential for honey production (70 to 80 kg/colony/year) (Pokhrel *et al.*, 2014). A number of issues, including diseases, insect pests, and inadequate knowledge of bee-flora resources, are major contributors to Nepal's low honeybee productivity. Flowering plants are the mainstay of honeybees' life from which they acquire major colony constituents such as nectar, pollen, and propolis. Beekeeping is a cultural heritage in Nepal with enormous potential and has been practiced since time immemorial owing to the dispersion of diverse bee flora (Adhikari & Ranabhat, 2014; Aryal *et al.*, 2015; Bista & Shivakoti, 2019) and favorable climatic conditions for bee diversity (Thapa, 2012). Among the five species of

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honeybees (*Apis florea*, *Apis cerana*, *Apis mellifera*, *Apis dorsata*, and *Apis laboriosa* present in the country), *A. cerana* and *A. mellifera* are the only domesticated species (Devkota, 2020). Currently, the country possesses about 248037 colonies (including estimated natural honeybee colonies) with 3997 mt of annual honey production (MoALD, 2020). The honey productivity at the national level is very low (25 to 30 kg and 8 to 10 kg per colony per annum for *A. mellifera* and *A. cerana* respectively) from its production potential (70 to 80 kg per colony per annum) (Kafle, 2012; Singh, 2012). A study has estimated that Nepal could produce more than 10,000 mt of honey annually from one million honeybee colonies (Pokhrel *et al.*, 2014).

Within its short north-to-south span, Nepal possesses high variation in climate, landscapes, and biological habitats. The floral diversity comprises more than 7,000 species (MoFE, 2018) along with about 12,300 species of insects (Arthropoda: Insecta) (Thapa, 2015). Honeybee plants are species that provide bees with food sources in the form of nectar and pollen or both (Fitchl & Admassu, 1994; Admassu *et al.*, 2014). Not all bee plants are equally important to bees and honey production (Nuru *et al.*, 2017). Only about 16% of the world's flowering plant species contribute to honeybees as food sources (Crane, 1990). Some supply both nectar and pollen abundantly, while others only provide nectar or pollen (Singh *et al.*, 2016; Shubharani *et al.*, 2012). Flowering plants and their flowering duration differ from one place to another due to variations in topography, climate, and other cultural and farming practices (Alemtsehay, 2011). The extensive knowledge of type, density, and quality of bee flora resources enables beekeepers to utilize the resources at a maximum level so that they can harvest a good yield of honey and other honeybee products in addition to effective pollination which enhances crop yield (Admassu *et al.*, 2014). Thus, the study helps to explore the type, density, and quality of honeybee floral resources available in two hilly districts namely Dhading and Kavre of Bagmati province.

Every region has its own honey flow and dearth periods of short and long duration. Beekeepers must know the time and duration of the blooming season of every major honey plant including the environmental factors affecting them and the carrying capacity of the area, which includes the number of colonies that can be put for maximum production (Rajan, 1980). Floral paucity is the period of time when bee flora blossoms are absent, leaving honeybees with insufficient nectar and pollen (Singh *et al.*, 2016). Production of honey and other products depends on the availability of floral resources (bee forage) and is a very important field for most beekeepers in the world (Rucker *et al.*, 2002). Most of the methods for obtaining information about plants utilized in an area are based on direct field observations of foraging honeybees on flowers. The analysis of bee plants, pollen loads, and melissopalynological analysis of honey samples can give a true picture of the honeybee flora of the area (Shakoori *et al.*, 2023). The microscopic examination of pollen grain in honeybee is termed melissopalynology or pollen analysis. Identification of pollen in honey helps in the identification of the honey sources and analysis of the pollen loads reveals the pollen sources of an area. Not all plant species are equally good for beekeeping. Some supply both nectar and pollen abundantly when in bloom and these are often called honey plants because they are best suited for honey production. Plants producing nectar but little or no pollen are also considered to be honey plants. Other plants, however, may yield pollen but little or no nectar. These pollen plants are also important in beekeeping, especially at the time of colony build-up when the bees need a large amount of the protein contained in pollen for their brood-rearing.

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Plant varieties and flowering times vary depending on location owing to differences in terrain, climate, and other cultural and agricultural activities. Knowledge of bee flora enables beekeepers to maximize their use, resulting in a high supply of honey and other bee products, as well as successful pollination, which increases agricultural yields. This region has brief and long-term floral dearth and honey flows. Such an understanding of bee flora aids in the efficient management of bee colonies during such seasons. A season-specific bee floral calendar was created based on accessible flora, main properties of these plant species, pollen and nectar availability, and flowering time. To preserve these floras, efforts must be made to sustain and expand the present flora. Given these facts, the current study is carried out to build an inventory of existing bee flora and develop a floral calendar for that specific location.

METHODOLOGY

Study Site

Survey study sites were identified from Kavrepalanchowk districts' three honey bee pockets; namely Mandandeupur, Jyamdi and Namobuddha (**Figure 1**) falling around 1500 m asl, 27º32'44"N and 83º38'0" E.

Figure 1: Bee flora survey sites of Kavrepalanchowk district; Mandandeupur, Jyamdi and Namobouddha, represented by dark round spots

Weather Record of the Study Sites

The weather records of the study sites were generously acquired from Agriculture Knowledge Center (AKC), Kavrepalanchwok. Two year weather data were summarized as average of the minimum and maximum temperature and average precipitation throughout the year (**Figure 2**).

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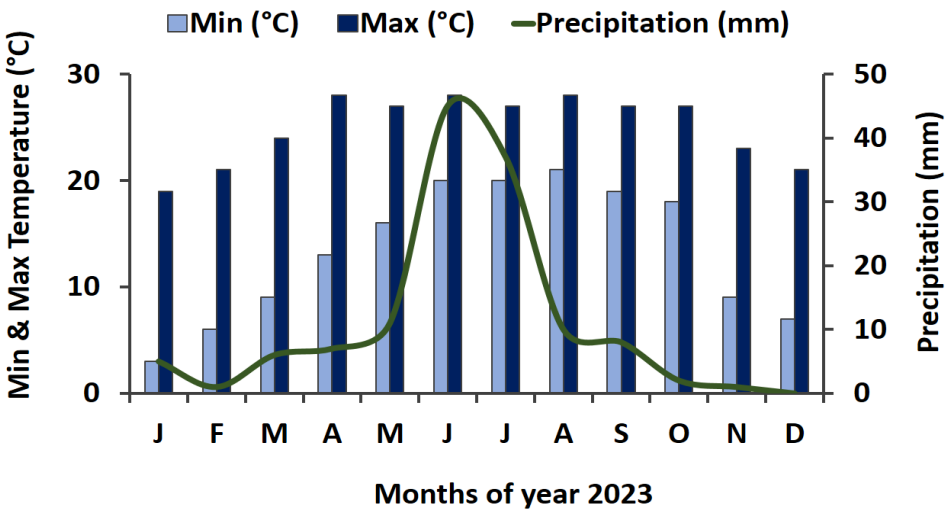

Figure 2: Climatic parameters (minimum and maximum temperature, and precipitation) of study sites during 2023
J-D = January - December of the year 2023.

Data Recording

Focus group discussion

Focus group discussion (GFD) was organized during each season for two study years (January 2022 - December 2023) with concerned personnel. FGD was mainly focused on the availability of plants, their types, their flowering season/ period and others were carried out once at every study site based on which the list of plants were prepared for direct observation.

Direct observation

Following FGDs, the recorded plants (vegetable crops, fruit crops, agronomic crops, ornamental plants and wild plants) were observed once a month that are visited by worker bees. At least one visit was made to study areas in each season for two years (January 2022 - December 2023). The activities of honeybees on flowers of each flowering plants were observed for three minutes. The flowers will be confirmed as a source of nectar if the honeybees stay steadily for some time extending their proboscis into flowers. Whereas, honey bee working with their hind legs to collect pollen was determined as pollen sources. The status of flowering plants as major or minor sources was established with the number and frequency of visits made by honeybees. Likewise, the abundance of floral plants was determined based on their distribution. During the study, only the abundant plants covering 70% of study sites with major sources of nectar or pollen were considered as these plants contribute to beekeeping.

Collection and identification of the plant samples

The plant samples (leaf, flowers, and other aerial parts) visited by honeybees were collected and the herbarium was prepared following a standard protocol and was subjected to an expert at National Herbarium and Plant Laboratories, Godabari, Lalitpur, Nepal for proper identification. The status of flowering plants as a source of nectar or pollen or both was further confirmed by comparing with the published reports. Throughout the study, a detailed chronological record of the plant species' flowering seasons was kept. The data obtained in field notebooks was

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integrated into an annual floral calendar and utilized to construct honey flow and dearth periods.

Data Analysis and Presentation

The data on the available bee flora at the study sites of Kavrepalanchowk district were analyzed for their species by plant types (tree, shrubs, herbs or climbers), by plant families, or by plant utilization (agronomical, pomological, ornamental, vegetable or wild plants), or by the bee diets (nectar source, pollen source or nectar + pollen source). The list of the plants falling under first four categories (tree, shrubs, herbs or climbers) were placed into an annual chart based on their flowering period with the purpose to develop a bee floral calendar for Kavrepalanchowk district, Nepal.

RESULTS

Identified Bee Forage Plants

In the mid-hill areas of the Kavrepalanchowk district, a total of 153 plants were recorded to frequently be visited by the honeybees (**Figure 3**). Among them, 12 were agronomical crops, 26 pomological crops, 11 ornamental crops, 24 vegetable crops and 80 were wild plants.

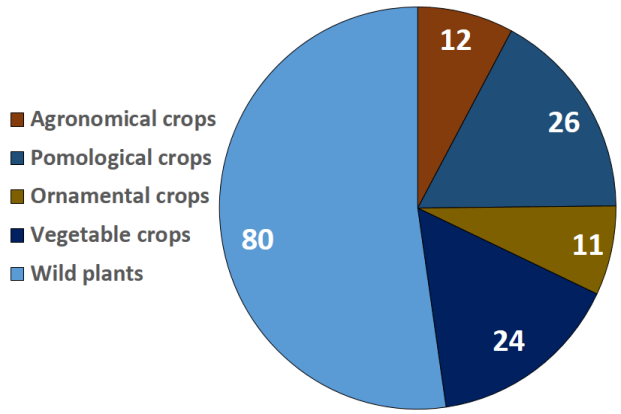

Figure 3: Number of bee flora by crop or wild types at Kavrepalanchowk district, Nepal surveyed during 2023

The recorded bee forage plants were categorized under 50 families (**Table 1**). The highest number of plant species (15) were recorded under Leguminosae followed by Compositae (13), Cucurbitace (10), Rosaceae (10), Lamiaceae (10) Rutaceae (8), Myrtaceae (6) and so on. Similarly, the lowest number of plant species (1) was recorded under families Theaceae, Elaeocarpaceae, Scrophulariaceae, Sapotaceae, Rubiaceae, Rhamnaceae, Proteaceae, Primulaceae, Polygonaceae, Poaceae, Pentaphylacaceae, Pedaliaceae, Oxalidaceae, Musaceae, Lauraceae, Juglandaceae, Ericaceae, Ebenaceae, Dipterocarpaceae, Convolvulaceae, Caricaceae, Bignoniaceae, Betulaceae, Berberidaceae, and Balsaminaceae, respectively (**Table 1**).

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Table 1: Number of bee floral species recorded during survey at Kavrepalanchowk district, Nepal in during January 2022 to December 2023 and categorized under plant families

SN	Families	Species (No.)	SN	Families	Species (No.)
1	Acanthaceae	2	26	Leguminosae	15
2	Amaranthaceae	2	27	Lythraceae	2
3	Anacardiaceae	3	28	Malvaceae	5
4	Apiaceae	2	29	Moraceae	2
5	Asparagaceae	2	30	Musaceae	1
6	Balsaminaceae	1	31	Myricaceae	2
7	Berberidaceae	1	32	Myrtaceae	6
8	Betulaceae	1	33	Oleaceae	2
9	Bignoniaceae	1	34	Oxalidaceae	1
10	Brassicaceae	9	35	Pedaliaceae	1
11	Capparaceae	2	36	Pentaphylacaceae	1
12	Caricaceae	1	37	Phyllanthaceae	2
13	Combretaceae	2	38	Poaceae	1
14	Compositae	13	39	Polygonaceae	1
15	Convolvulaceae	1	40	Primulaceae	1
16	Cucurbitaceae	10	41	Proteaceae	1
17	Dipterocarpaceae	1	42	Rhamnaceae	1
18	Ebenaceae	1	43	Rosaceae	10
19	Elaeocarpaceae	1	44	Rubiaceae	1
20	Ericaceae	1	45	Rutaceae	8
21	Euphorbiaceae	3	46	Sapindaceae	3
22	Fagaceae	2	47	Sapotaceae	1
23	Juglandaceae	1	48	Scrophulariaceae	1
24	Lamiaceae	10	49	Simaroubaceae	2
25	Lauraceae	1	50	Theaceae	1

Availability of Bee Forage Blooms by Months

These plants bloom during different months of the year, with the maximum number of flowering plant species (104) in April, whereas the minimum plants flower during December (**Figure 4**). The availability of an abundant number of flowering plants was also observed during March followed by May, February, September, etc. while during January, July and August the flowering plants were lower in number (**Figure 4**).

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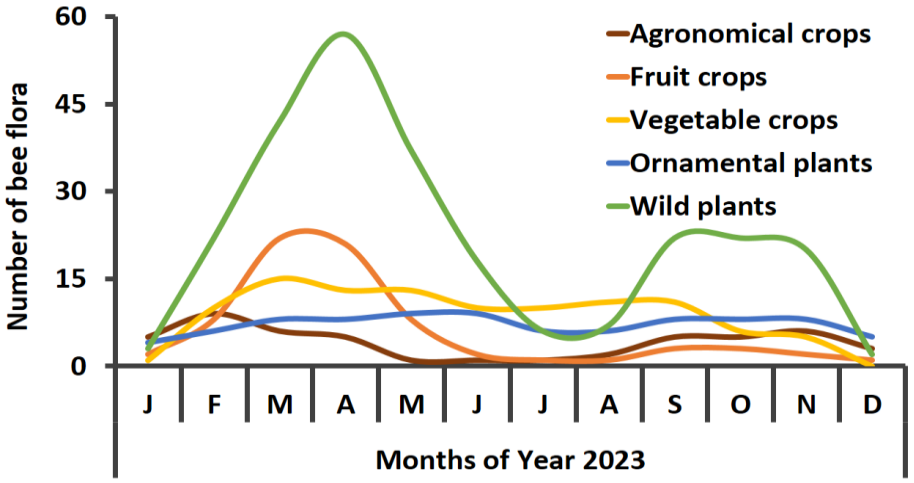

Figure 4: Monthly availability of bee flora by crop or wild types at Kavrepalanchowk district, Nepal surveyed during 2023. J-D in X-axis are for January-December of the year

The maximum number of agricultural plants flowered during the spring season (February and March) and also during October and November, whereas the fruit trees were dominant in flowering in March and April. A higher number of wild plants were observed blooming during April, March, and May, and also in February, September, October and November (**Figure 4)**

Types of Bee Forage Plants

During survey, 153 plants were recorded and categorized into four groups; tree type flora, shrubs type, herbs and climbers type flora. The highest plant groups (69 plant type) could be categorized under tree type flora followed by herbs type flora (43), shrubs type flora (31) and climber types (10), respectively in the study sites of Kavrepalanchowk district (**Figure 5, Table 2, 3,4 and 5**).

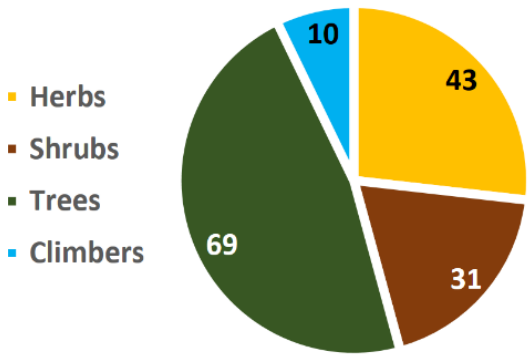

Figure 5: Number of bee flora at Kavrepalanchowk district, Nepal in 2023 by plant types; herbs, shrubs, trees or climbers

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Table 2: Tree-type bee floral species identified during survey at Kavrepalanchowk district, Nepal during 2023

SN	Binomial name	Common name	Nepali Name	Family	Use	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
1	*Prunus persica* (L.) Batsch	Peach	Aaru	Rosaceae	N, P	■	■	■									
2	*Prunus domestica* L.	Plum	Aru bakhada	Rosaceae	N, P		■	■									
3	*Pyrus communis* L.	Pear	Naspati	Rosaceae	N, P		■	■									
4	*Citrus aurantifolia* (Christm.) Swingle	Lime	Kagati	Rutaceae	N, P		■	■	■								
5	*Eriobotrya elliptica* Lindl.	Nepal loquat	Loquat	Rosaceae	N, P		■	■	■								
6	*Litchi chinensis* Sonn.	Litchi	Litchi	Sapindaceae	N, P		■	■	■								
7	*Juglans regia* L.	Walnut	Dante okhar	Juglandaceae	P		■	■	■	■							
8	*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill	Hog plum	Lapsi	Anacardiaceae	N, P			■	■								
9	*Citrus grandis* (L.) Osbeck	Pumelo	Bhogate	Rutaceae	N, P			■	■								
10	*Citrus jambhiri* Lush.	Citrus	Kathe Jyamir	Rutaceae	N, P			■	■								
11	*Citrus limon* (L.) Osbeck	Lemon	Nibuwa	Rutaceae	N, P			■	■								
12	*Citrus medica* L.	Citron	Bimiro	Rutaceae	N, P			■	■								
13	*Citrus reticulate* Blanco	Mandarin orange	Suntala	Rutaceae	N, P			■	■								
14	*Diospros virginiana* L.	Persimmon	Haluwabed	Ebenaceae	N, P			■	■								
15	*Malus domestica* Borkh.	Apple	Syawu	Rosaceae	N, P			■	■								
16	*Mangifera indica* L.	Mango	Aamp	Anacardiaceae	N, P			■	■								
17	*Emblica officinalis* Gaertn.	Gooseberry	Aamala	Phyllanthaceae	N, P			■	■	■							
18	*Psidium guajava* L.	Guava	Aamba	Myrtaceae	N, P			■	■	■							
19	*Punica granatum* L.	Pomogranate	Anar	Lythraceae	N, P			■	■	■							
20	*Syzygium cumini* (L.) Skeels	Jambolan	Jamun	Myrtaceae	P, N			■	■	■							
21	*Phyllanthus emblica* L.	Goose berry	Aamala	Phyllanthaceae	N, P			■	■	■	■						
22	*Ziziphus* spp.	Jujube	Bayer	Rhamnaceae	N, P									■	■		
23	*Castanopsis indica*(Roxb. ex Lindl.) A.DC.	Chesnut	Dhale katus	Fagaceae	N, P									■	■	■	

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SN	Binomial name	Common name	Nepali Name	Family	Use	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
24	*Nyctanthes arbor-tristis* L.	Night jasmine	Parijat	Oleaceae	N, P												
25	*Rhododendron arboreum* Sm.	Rhododendron	Laligurans	Ericaceae	N, P												
26	*Callistemon citrinus* (Curtis) Skeels	Bottle brush	Kalki phul	Myrtaceae	N, P												
27	*Ficus* spp.	Fig	Bar	Moraceae	N, P												
28	*Morus alba* L.	Mulberry	Kimbu	Moraceae	N, P												
29	*Myrica esculenta* Buch.-Ham. ex D. Don	Bayberry	Kafal	Myricaceae	N, P												
30	*Pyrus pashia* Buch.-Ham. ex D.Don	Wild pear	Mayal	Rosaceae	N, P												
31	*Spondias pinnata* (L. f.) Kurz	Hog plum	Amaro	Anacardiaceae	N												
32	*Sapium* spp.	Tallow	Khirro	Euphorbiaceae	N, P												
33	*Alnus nepalensis* D. Don.	Alder	Uttis	Betulaceae	N, P												
34	*Bauhinia purpurea* L.	Pink bahunia	Tanki	Leguminosae	N, P												
35	*Cleistocalyx operculatus* (Roxb.) Merr. & L.M.Perry	Water banyan	Kyamuna	Myrtaceae	N, P												
36	*Cinnamomum zeylanicum* Blume	Cinnamon leaf	Tejpat	Lauraceae	N												
37	*Melia azedarach* L.	Persean lilac	Bakaino	Meliaceae	N, P												
38	*Sapindus mukorossi* Gaertn.	Soap nut	Rittha	Sapindaceae	N, P												
39	*Shorea robusta* Gaertn.	Sal	Sal	Dipterocarpaceae	N, P												
40	*Aegle marmelos* (L.) Corrêa	Bael tree	Bel	Rutaceae	N												
41	*Crateva* sp.	Three leaved caper	Sipligan	Capparaceae	N, P												
42	*Grevillea robusta* A.Cunn. ex R.Br.	Silky oak	Kangiyo	Proteaceae	N, P												
43	*Quercus* spp.	Oak	Baanjh	Fagaceae	P												
44	*Elaeocarpus sphaericus* (Gaertn.) K.Schum.	Bead tree	Rudrakhsha	Elaeocarpaceae	N, P												
45	*Albizia* spp.	Albizia	Siris	Leguminosae	N, P												
46	*Premna integrifolia* Willd.	Headache tree	Gideri	Lamiaceae	N, P												

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SN	Binomial name	Common name	Nepali Name	Family	Use	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
47	*Fraxinus floribunda* Wall	Himalayan ash	Lankuri	Oleaceae	N, P												
48	*Cedrela toona* Roxb. ex Rottler	Cedrela	Tooni	Meliaceae	N, P												
49	*Tamarindus indica* L.	Tamarind	Imili	Legumnosae	N, P												
50	*Terminalia bellirica* (Gaertn.) Roxb.	Myrobolon	Barro	Combretaceae	N, P												
51	*Terminalia chebula* Retz.	Myrobalan	Harro	Combretaceae	N, P												
52	*Toona ciliata* M.Roem.	Red cedar	Tooni	Meliaceae	N, P												
53	*Acacia arabica* (Lam.) Willd.	Gum arabic tree	Khayer	Leguminosae	N, P												
54	*Schima wallichii* Choisy	Needle wood	Chilaune	Theaceae	N, P												
55	*Eucalyptus* spp.	Eucalyptus	Masala	Myrtaceae	N, P												
56	*Grewia optiva* J.R.Drumm. ex Burret	Grewia	Syal phusro	Malvaceae	N, P												
57	*Jacaranda mimosifolia* D.Don	Jacaranda	Nilmohar	Bignoniaceae	N, P												
58	*Aesculus indica* (Wall. ex Cambess.) Hook.	Horse chestnut	Lekhpangra	Sapindaceae	N, P												
59	*Desmodium oojeinense* (Roxb.) H.Ohashi	Tick clover	Bakhre ghans	Leguminosae	N, P												
60	*Lagerstroemia indica* L.	Crape myrtle	Asare phul	Lathyraceae	N, P												
61	*Myrica esculenta* Buch.-Ham. ex D. Don	Bayberry	Kafal	Myricaceae	N, P												
62	*Callistemon* sp.	Bottle brush	Kalki phul	Myrtaceae	N, P												
63	*Bauhinia variegata* (L.) Benth.	Mountain ebony	Koiralo	Leguminosae	N, P												
64	*Leucaena leucocephala* (Lam.) de Wit	Ipil ipil	Ipil ipil	Leguminosae	N, P												
65	*Prunus cerasoides* Buch.-Ham. ex D.Don	Himalayan cherry	Painyu	Rosaceae	N, P												
66	*Rhus javanica* L.	Sumac	Dudhe bhalayo	Simaroubaceae	N, P												
67	*Rhus* spp.	Nepal sumac	Bhalayo	Simaroubaceae	N, P												
68	*Bassia butyracea* Roxb.	Butter tree	Chiuri	Sapotaceae	N, P												
69	*Calliandra calothyrsus* Meisn.	Calliandral	Gunyalo	Leguminosae	N, P												

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J-D in the table heads are for January-December of the year; N-Plant species visited by bees to collect nectar; P-Plant species visited by bees to collect pollen; NP- Plant species visited by bees to collect both pollen and nectar; The shaded part is for the availability of plant species as the bee flora during specified months of the year.

A total of 69 tree-type bee floral plants were recorded during 2022-2023. While plotting them on a calendar, bee floral blooms were available throughout the seasons and year (**Table 2**). Similarly, the shrub-type (**Table 3**) and herb-type (**Table 4**) bee floral plants also bloomed throughout the year.

Table 3: Shrub-type bee floral species identified during survey at Kavrepalanchowk district, Nepal during 2023

SN	Scientific name	Common name	Nepali name	Family	Source	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
1	*Helianthus annuus* L.	Sunflower	Suryamukhi	Compositae	N, P								■	■	■	■	
2	*Cajanus cajan* (L.) Millsp.	Piegon pea	Rahar	Leguminosae	N, P	■	■							■	■	■	■
3	*Zea mays* L.	Maize	Makai	Poaceae	P	■	■	■	■	■	■	■	■	■	■	■	■
4	*Coffea arabica* L.	Coffee	Coffee	Rubiaceae	N, P			■	■								
5	*Hibiscus rosa-sinensis* L.	Chinese rose	Ghanti phool	Malvaceae	N, P			■	■	■							
6	*Tecoma stans* (L.) Juss. ex Kunth.	Tecoma		Bignoniaceae	P	■	■	■	■	■	■			■	■	■	■
7	*Malvaviscus arboreus* Cav.	Chinese lantern	Ghante phul	Malvaceae	N, P	■	■	■	■	■	■	■	■	■	■	■	■
8	*Vicia faba* L.	Broad bean	Bakulla	Leguminosae	N, P	■	■	■	■								
9	*Vigna unguiculata* (L.) Walp.	Beans	Bodi	Leguminosae	P			■	■	■	■	■	■	■			
10	*Phaseolus vulgaris* L.	Kidney bean	Ghui simi	Leguminosae	N, P					■	■						
11	*Ipomoea aquatic* Forssk.	Sweet potato	Karmi sag	Convolvulaceae	P							■	■	■			
12	*Mentha viridis* (L.) L.	Mint	Babari	Lamiaceae	N, P							■	■	■	■	■	
13	*Caryopetris odorata* (D.Don) B.L.Rob.	Caryopteris	Ghusere	Lamiaceae	N, P		■	■	■								
14	*Leucosceptrum canum* Sm.	Leucosceptrum	Bhusure	Lamiaceae	N, P		■	■	■								
15	*Maesa macrophylla* C.B.Clarke	Maesa	Bhagate	Primulaceae	N, P		■	■	■								

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SN	Scientific name	Common name	Nepali name	Family	Source	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
16	*Pogostemon glaber* Benth.	Pogostemon	Rudilo	Lamiaceae	N, P												
17	*Rubus ellipticus* Sm.	Raspberry	Ainselu	Rosaceae	N, P												
18	*Adhatoda vasica* Nees	Basak	Asuro	Acanthaceae	N, P												
19	*Woodfordia fruitcosa* (L.) Kurz	Fire flame bush	Dhaiyaro	Lythraceae	N, P												
20	*Berberis asiatica* Roxb. ex DC.	Barberry	Chutro	Berberidaceae	N, P												
21	*Justicia adhatoda* L.	Malabar nut	Aasuro	Acanthaceae	N, P												
22	*Yucca smalliana* Fernald	Adam's needle	Ketuki	Asparagaceae	P												
23	*Zanthoxylum armatumi* DC.	Nepal pepper	Timbur	Rutaceae	N, P												
24	*Crateva unilocularis* Buch.-Ham	Garlic pear	Siplikan	Capparaceae	N, P												
25	*Vitex negundo* L.	Privet	Simali	Lamiaceae	N, P												
26	*Jatropha curcas* L.	Physic nut	Sajiban	Euphorbiaceae	N, P												
27	*Ricinus communis* L.	Castor oil	Ander	Euphorbiaceae	N, P												
28	*Crotalaria juncea* L.	Sunhemp	Sanai	Leguminosae	N, P												
29	*Agave americana* L.	Century plant	Ketuki	Asparagaceae	N, P												
30	*Eurya chinensis* R.Br.	Osmanthus	Jhingani	Pentaphylacaceae	N, P												
31	*Buddleja asiatica* Lour.	Butterfly bush	Bhimsen pati	Scrophulariaceae	N, P												

J-D in the table heads are for January-December of the year; N-Plant species visited by bees to collect nectar; P-Plant species visited by bees to collect pollen; NP- Plant species visited by bees to collect both pollen and nectar; The shaded part is for the availability of plant species as the bee flora during specified months of the year.

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Table 4: Herb-type bee floral species identified during survey at Kavrepalanchowk district, Nepal during 2023

SN	Scientific name	Common name	Nepali name	Family	Source	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
1	*Brassica napus* var. *toria* L.	Rape	Tori	Brassicaceae	N, P	■	■										
2	*Brassica campestris* var. *sarson* Prain	Sarson	Sarson	Brassicaceae	N, P	■	■	■									
3	*Brassica juncea* (L.) Czern.	Mustard	Rayo	Brassicaceae	N, P		■	■	■								
4	*Fagopyrum esculentum* Moench	Buckwheat	Phapar	Polygonaceae	N, P		■	■	■								
5	*Pisum sativum* L.	Pea	Kerau	Leguminosae	N, P		■	■	■								
6	*Sesamum orientale* L.	Sesame	Til	Pedaliaceae	N, P		■	■	■								
7	*Guizotia abyssinica* (L.f.) Cass.	Niger	Jhuse til	Compositae	N, P									■	■	■	■
8	*Brassica nigra* (L.) K.Koch	Black mustard	Kalo tori	Brassicaceae	N, P									■	■	■	■
9	*Brassica campestris* var. *dichotoma* (Roxb.) Watt	Brown sarson	Sarson	Brassicaceae	N, P	■	■									■	■
10	*Calendula officinalis* L.	Marigold	Asarphi ful	Compositae	N, P		■	■	■	■	■						
11	*Cuphea hyssopifolia* Kunth.	Cuphea		Lythraceae	N, P		■	■	■	■	■	■	■	■	■	■	
12	*Celosia cristata* L.	Cock's comb	Latte phul	Amaranthaceae	N, P			■	■	■	■						
13	*Impatiens* sp.	Balsam	Tiwuri	Balsaminaceae	N, P					■	■	■	■	■	■	■	
14	*Chrysanthemum segetum* L.	Chrysanthemum	Godavari	Compositae	N, P						■	■	■	■	■	■	■
15	*Dahlia* spp.	Dahlia	Lhure phul	Compositae	P	■	■	■	■					■	■	■	■
16	*Tagetes erecta* L.	Marigold	Sayapatri	Compositae	N, P	■	■	■	■	■	■	■	■	■	■	■	■
17	*Brassica oleracea* var *capitata* L.	Cabbage	Banda gobi	Brassicaceae	N, P		■	■									
18	*Raphanus sativus* L.	Radish	Mula	Brassicaceae	N, P		■	■									
19	*Brassica oleracea* var. *botrytis* L.	Cauliflower	Kauli	Brassicaceae	N, P		■	■	■								
20	*Brassica rapa* var. *rapa* L.	Turnip	Salgam	Brassicaceae	N, P		■	■	■								
21	*Trigonella foenum-graecum* L.	Fenugreek	Methi	Leguminosae	N		■	■	■								
22	*Coriandrum sativum* L.	Coriander	Dhaniya	Apiaceae	N, P		■	■	■	■							
23	*Dacus carota* L.	Carrot	Gajar	Apiaceae	N, P		■	■	■	■							
24	*Abelmoschus esculentus* (L.) Moench	Lady's finger	Bhindi	Malvaceae	N, P			■	■	■	■						

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SN	Scientific name	Common name	Nepali name	Family	Source	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
25	*Mentha spicata* L.	Mint	Pudina	Lamiaceae	N								■	■	■	■	
26	*Trifolium repens* L.	Clover	Tinpate	Leguminosae	N, P	■	■	■	■	■	■						
27	*Senecio densiflorus* Wall.	Ragwort	Bakhra kane	Compositae	P		■	■									
28	*Fragaria vesca* L.	Strawberry	Ainselu	Rosaceae	N, P		■	■	■	■							
29	*Chenopodium album* L.	Goose foot	Bethe	Amaranthaceae	N, P		■	■	■	■							
30	*Oxalis corniculata* L.	Creeping sorrel	Chari amilo	Oxalidaceae	N, P		■	■	■	■	■	■					
31	*Echinops echinatus* Roxb.	Globe thistle	Kande	Compositae	N, P		■	■	■	■	■	■	■	■	■	■	
32	*Eupatorium glandulosum* Michx.	Through wort	Seto banmara	Compositae	N, P			■	■								
33	*Cirsium verutum* (D.Don) Spreng.	Field thistles	Dhade kanda	Compositae	N, P			■	■	■	■						
34	*Eupatorium odoratum* L.	Through wort	Nilo banmara	Compositae	N, P				■	■	■						
35	*Ocimum basilicum* L.	Basil	Tulsi	Lamiaceae	N, P								■	■	■	■	
36	*Gossypium* sp.	Cotton	Kapas	Malvaceae	N, P								■	■	■	■	
37	*Artemisia indica* Willd.	Mugwort	Titepati	Compositae	N, P									■	■	■	
38	*Elsholtzia spp*	Elsholtzia	Ban silam	Lamiaceae	N, P									■	■	■	
39	*Inula cappa* (Buch.-Ham. ex D.Don) DC.	Samphire	Kan pake	Compositae	N, P									■	■	■	
40	*Perilla frutescens* (L.) Britton	Perilla	Silam	Lamiaceae	N, P									■	■	■	
41	*Prinsepia utilis* Royle	Prinsepia	Dhatelo	Rosaceae	N, P									■	■	■	
42	*Musa paradisiaca* L.	Banana	Kera	Musaceae	N, P	■	■	■	■	■	■	■	■	■	■	■	
43	*Carica papaya* L.	Papaya	Mewa	Caricaceae	N, P			■	■	■							

J-D in the table heads are for January-December of the year; N-Plant species visited by bees to collect nectar; P-Plant species visited by bees to collect pollen; NP- Plant species visited by bees to collect both pollen and nectar; The shaded part is for the availability of plant species as the bee flora during specified months of the year.

Unlike other types, climber-type bee flora (**Table 5**) were not in enough numbers in terms of their blooming period. December and January were the months during which climber-type bee flora did not bloom. This suggests to consider all types of bee floral plants while constructing a bee floral calendar for the study sites of Kavrepalanchowk district of Nepal.

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Table 5: Climber-type bee floral species identified during survey at Kavrepalanchowk district, Nepal during 2023

SN	Scientific name	Common name	Nepali name	Family	Source	Months, 2023											
						J	F	M	A	M	J	J	A	S	O	N	D
1	*Momordica balsamina* L.	Gourd	Barela	Cucurbitaceae	N, P		■	■									
2	*Momordica cochinchinensis* (Lour.) Spreng.	Gourd	Chaattel	Cucurbitaceae	N, P		■	■	■	■							
3	*Cucurbita moschata* Duchesne	Pumpkin	Pharsi	Cucurbitaceae	N, P			■	■	■	■	■	■	■			
4	*Cucurbita pepo* L.	Barse squash	Pharsi	Cucurbitaceae	N, P			■	■	■							
5	*Cucumis sativus* L.	Cucumber	Kankro	Cucurbitaceae	N, P				■	■	■	■	■	■			
6	*Momordica charantia* L.	Bitter Gourd	Karela	Cucurbitaceae	N, P					■	■	■	■	■			
7	*Luffa cylindrica* (L.) M.Roem.	Sponge gourd	Ghirounla	Cucurbitaceae	N, P					■	■	■	■	■	■		
8	*Lagenaria siceraria* (Molina) Standl.	Bottle gourd	Lauka	Cucurbitaceae	N, P					■	■	■	■	■	■	■	
9	*Trichosanthes anguina* L.	Snake gourd	Chichindo	Cucurbitaceae	N, P					■	■	■	■	■	■	■	
10	*Sechium edule* (Jacq.) Sw.	Chayote	Iskush	Cucurbitaceae	N, P						■	■	■	■	■	■	

Different species of brassica [brown sarson, {*Brassica campestris* var. *dichotoma* (Roxb.) Watt}, sarson (*Brassica campestris* var. *sarson* Prain), mustard {*Brassica juncea* (L.) Czern.}, rape (*Brassica napus* var. *toria*), black mustard {*Brassica nigra* (L.) K.Koch}], buckwheat (*Fagopyrom esculentum* Moench.), maize (*Zea mays* Lin.), and niger {*Guizotia abyssinica* (L.f.) Cass.} as agricultural crops; hog plum {*Choerospondias axillaris* (Roxb.) B.L.Burtt& A.W.Hill}, different citrus [lime {*Citrus aurantifolia* (Christm.) Swingle}, pumelo {*Citrus grandis* (L.) Osbeck}, citrus (*Citrus jambhiri* Lush.), lemon {*Citrus limon* (L.) Osbeck}, citron (*Citrus medica* L.), mandarin orange (*Citrus reticulate* Blanco)] species, banana (*Musa paradisiaca* Lin.), peach {*Prunus persica* (L.) Batsch}, pear (*Pyrus communis* Lin.), plum (*Prunus domestica* Lin.), and persimmon (*Diospros* spp.) as fruit trees and chayote {*Sechium edule* (Jacq.) Sw.}, different Cucurbitaceae crops [cucumber (*Cucumis sativus* L.), pumpkin (*Cucurbita moschata* Duc.), sponge-gourd {*Luffa cylindrica* (L.) M.Roem.}, gourd (*Momordica balsamina* L.), bitter gourd (*M. charantia* L.)], radish (*Raphanus sativus* Lin.), broad bean (*Vicia faba* L.) as vegetable crops were found in abundance as cultivated plants (**Table 5**).

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Similarly, the ornamental plants, such as cuphea (*Cuphea hyssopifolia* Kunth) and Tecoma {*Tecoma stans* (L.) Juss. ex Kunth} and the wild plants like albizia (*Albizia* spp.), butter tree (*Bassia butyracea* Roxb.), mountain ebony {*Bauhinia variegata* (L.) Benth.}, barberry (*Berberis asiatica* Roxb. ex DC.), butterfly bush (*Buddleja asiatica* Lour.), bottle brush{*Callistemon citrinus*(Curtis) Skeels and *Callistemon* sp.}, elsholtzia (*Elsholtzia* spp.), through wort (*Eupatorium glandulosum* Michx. and *Eupatorium odoratum* L.), crape myrtle (*Lagerstroemia indica* L.),maesa(*Maesa macrophylla* C.B.Clarke), mahonia (*Mahonia napaulensis* DC.), persean lilac (*Melia azedarach* L.), bayberry (*Myrica esculenta* Buch.-Ham. ex D. Don), Himalayan cherry (*Prunus cerasoides*Buch.-Ham. ex D.Don), raspberry (*Rubus ellipticus* Sm.), needle wood (*Schima wallichii* Choisy) and clover (*Trifolium repens* L.) were the major source of foraging for honeybees at Kavrepalanchowk locations (**Table 2, 3, 4 and 5**).
The cultivated plants, such as maize (*Z. mays*, agricultural crops), banana (*M. paradisiaca*, fruit crop), Chinese lantern (*Malvaviscus arboreus* Cav., ornamental plant), marigold (*Tagetes erecta* Lin., ornamental plant) and wild plant calliandral (*Calliandra calothyrsus* Meisn.) were considered as important flora because of their nature of flowering throughout the year.

Types of Flora Based on Diet-specific Bee Visits

All the 153 flora recorded were categorized into nectar, pollen and nectar + pollen types based on the diet-specific visits by the bees. Accordingly, five were nectar-type, nine were pollen-type and majority (139) were visited by the bees for both nectar and pollen (**Figure 6**). This showed that the majority of the forage plants were nectar + pollen types sufficiently available throughout the year for bee husbandry at the study sites.

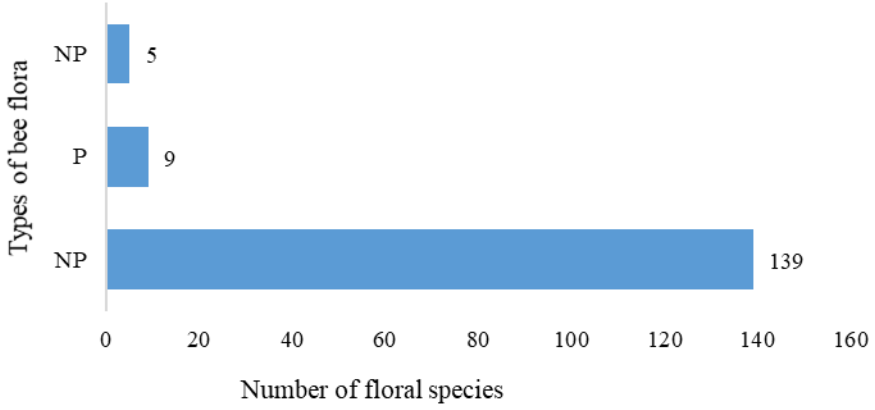

Figure 6: Number of bee flora at Kavrepalanchowk district, Nepal in 2023 by types used by bees; N-Nectar, P-Pollen, NP-Both nectar and pollen

Relating Bee Foraging Efficiency with Respect to Climatic Parameters of the Study Sites

The existing weather condition is one of the most important factors for honeybee foraging activities. Honeybees during minimum temperature and high rainfall periods avoid nectar and pollen collection. At mid-hill areas of Kavrepalanchowk, December, January, and February were the coldest months with minimum temperatures of 6.65^0C, 3.06^0C and 5.93^0C, respectively whereas the highest rainfall occurred during June (44.91 mm) and July (37.28 mm) (**Figure 2**). Also, the number of beneficial flowering for honeybees was lowest during December (11 plants)

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and January (15 plants). On the other hand, during the spring (March, April, and May) and autumn seasons (September, October, and November), mild temperatures and little or no rainfall were observed with the highest number of flowering plants. During February, although the presence of flowering plants was sufficient in number (55 plants) but still the temperature was observed lower (5.93 ^{0}C).

With the weather information and availability of major flowering plants in the study area of Kavrepalanchowk district, it was concluded that the spring (March, April, and May) and autumn (September, October, and November) seasons were the major honey flow periods. Similarly, the winter season (December and January) with the lowest number of flowering plants and temperature was the dearth period for honeybees. Although some flowering plants were observed during June (40 plants) and July (24 plants), with high rainfall, these months were also regarded as a dearth period. After the winter season, during February, the occurrence of flowering plants increased (55 plants) but still, the minimum temperature was low, so this month was assumed as colony development period. Similarly, during August the rainfall began to decrease (9.70 mm) and the number of flowering plants increased (29 plants) compared to July (24 plants). This month could also be considered as a colony development period.

DISCUSSION

Nepal within its short north-to-south span possesses high variations in altitude, climate, and biological habitats. The floral diversity comprises more than 7,000 flowering plant species (MoFE, 2018) along with about 12,300 species of insects (Arthropoda: Insecta) (Thapa, 2015). The relation between these two is eminent where the insects are dependent on flowering plants for food and shelter and in return pollinate the flowering plants for their perpetuation. The honeybees, one of the constant flower visitors, acquire their basic requirements, nectar, and pollen from these flowers. So, for the successful beekeeping development in an area prevalence of quality floral plants is necessary. In this regard, a sufficient number of plants were observed blooming during different months at both study areas, among these 153 plants in mid-hill areas of Kavrepalanchowk were regarded as major flowering plants (Table 2, 3, 4 and 5) utilized by honeybees based upon their abundance and source richness.

From the identified floral plants in Kavrepalanchowk district, the brown sarson {*Brassica campestris* var. *dichotoma* (Roxb.) Watt}, sarson (*Brassica campestris* var. *sarson* Prain), mustard {*Brassica juncea* (L.) Czern.}, rape (*Brassica napus* var. *toria*), black mustard {*Brassica nigra* (L.) K.Koch}, buckwheat (*Fagopyrum esculentum* Moench), and niger {*Guizotia abyssinica* (L.f.) Cass.}, maize (*Zea mays* L.) as agricultural crops; hog plum {*Choerospondias axillaris* (Roxb.) B.L.Burtt& A.W.Hill}, lime {*Citrus aurantifolia* (Christm.) Swingle}, pumelo {*Citrus grandis* (L.) Osbeck}, citrus (*Citrus jambhiri* Lush.), lemon {*Citrus limon* (L.) Osbeck}, citron (*Citrus medica* L.); mandarin orange (*Citrus reticulate* Blanco), persimmon (*Diospros virginiana* L.), banana (*Musaparadisiaca* L.), plum (*Prunus domestica* L.), peach {*Prunus persica* (L.) Batsch} and pear (*Pyrus communis* L.) as fruit trees; cuphea (*Cuphea hyssopifolia* Kunth) and tecoma {*Tecoma stans* (L.) Juss. ex Kunth} as ornamental plants and cucumber (*Cucumis sativus* L.), pumpkin (*Cucurbita moschata* Duchesne), sponge gourd {*Luffa cylindrica* (L.) M.Roem.}, gourd (*Momordica balsamina* L.), bitter gourd (*Momordica charantia* L.), radish (*Raphanus sativus* L.), chayote {*Sechium edule* (Jacq.) Sw.} and broad bean (*Vicia*

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faba L.) as vegetable crops were found important flowering plants useful for honeybees and beekeeping.

Similarly, in the wild plants' group, albizia (*Albizia* spp.), butter tree (*Bassia butyracea* Roxb.), mountain ebony {*Bauhinia variegata* (L.) Benth.}, barberry (*Berberis asiatica* Roxb. ex DC.), butterfly bush (*Buddleja asiatica* Lour.), bottle brush {*Callistemon* sp.}, elsholtzia (*Elsholtzia* spp.), thoroughwort(*Eupatorium glandulosum* Michx. and *Eupatorium odoratum*L.), crape myrtle (*Lagerstroemia indica* L.), maesa (*Maesa macrophylla* C.B.Clarke), mahonia (*Mahonia napaulensis* DC.), Persian lilac (*Melia azedarach* L.), bayberry (*Myrica esculenta* Buch.-Ham. ex D. Don), Himalayan cherry (*Prunus cerasoides*Buch.-Ham. ex D.Don), raspberry (*Rubus ellipticus* Sm.), needle wood (*Schima wallichii* Choisy) and clover (*Trifolium repens* L.) were the major plants visited by the honeybees.

Kafle (1984) listed 156 bee flora plants from Kathmandu Valley and later Maskey (1992) added some more plants to the list and reported 178 useful honeybee plants flowering during different months. Most of the reported plants match the current findings, however some existing flowering plants not reported during those times were observed in abundance. Vegetable plants, like gourd (*Barela*) (*M. balsamina*) and chayote (*S. edule*) nowadays are cultivated profusely with commercial significance, and also flower for longer periods. Also, the commercial plantations of hog plum (*Lapsi*) (*C. axillaris*) for marmalade preparation have increased serving good source for honeybee forage.

Most of the flowering plants reported by Bista and Shivakoti (2001) and Neupane (2001) from the Dolakha district, Adhikari and Ranabhat (2014) from the Kaski district, and Bista (2001) and Joshi *et al.* (2004) from far-western Nepal were similar to this study with some variations. The different amaranth (*Amaranthus* spp.) species are reported from almost all hilly regions blooming during rainy and early autumn seasons but during our study, its abundance was very low and not mentioned. Similar is in the case of soap nut trees (*S. mukorossi*) and toona (*T. ciliatea*), where these plants are mentioned with considerable importance as honeybee flora in western hill areas. The shrubs, such as firethorn (*Ghangru*) {*Pyracantha crenulata*(Roxb. ex D.Don) M.Roem.} and yellow flax (*Pyawali*) (*Reinwardtia indica* Dumort.) flowering for long period (September to May) were also stated as significant plant sources for honeybees by many authors, which were present in few numbers at mid-hill areas of Lalitpur district. The ornamental plants such as cuphea (*C. hyssopifolia*) and Tacoma (*T. stans*) that flower for longer periods (cuphea from February to November and Tecoma from September to June) and serves as good sources for honeybees were observed in abundance at the study areas, but these floral plants were not reported earlier.

Most of the flowering plants visited by honeybees in studied areas yielded both pollen and nectar (91.3% at Kavrepalanchowk) which was evident in the statement given by Pratap (1997) on bee floral plants in the Hindu-Kush Himalayan region. This fact was noticeable in all floral studies carried out at different parts of Nepal. The mint (*M. spicata*), fenugreek (*T. foenum-graecum*), bael tree (*A. marmelos*), cinnamon leaf (*Cinnamomum* spp.) and hog plum (*S. pinnata*) were observed as nectar yielding plants at both study areas whereas maize (*Z. mays*), dahlia (*Dahlia* spp.), bean (*V. unguiculata*) and Adam's needle (*Y. smalliana*) as source of pollen to the honeybees. The maize crop is regarded as an important source of pollen that flower throughout

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the year and thus helps to fulfill pollen requirements (Pratap, 1997; Bista & Shivakoti, 2001; Neupane, 2001; Devkota, 2000; Thapa & Pokhrel, 2007; Rijal *et al.*, 2018).

The spring and autumn seasons in both studied areas were regarded as honey flow periods with the availability of more flowering plants and mild weather. In mid-hill areas of Kavrepalanchowk district, the maximum number of plants flower during April (104), March (93), and May (68 plants) and also in September (49), October (44), and November (41 plants) with no or little rainfall. Also at both locations, winter and rainy seasons were mentioned as dearth periods for honeybees with few flowering plants as well as low ambient temperature or high rainfall. The months of December (11 plants with a minimum temperature of 6.65°C) and January (15 plants with a minimum temperature of 3.06°C) along with June (40 plants with 44.91 mm of rainfall) and July (24 plants with 37.28 mm rainfall) were identified as dearth period at Kavrepalanchowk district. Similarly, the months of February and August are referred to as the colony development period. The findings of the study are in line with the similar investigations carried out inthe Dolakha district (1,740 masl) and mid-hills of Kaski districts by Bista and Shivakoti (2001) and Adhikari and Ranabhat (2014) respectively. As per the available number of flowering plants and existing weather conditions, they identified spring (mid-February to May at Dolakha and March to May at Kaski districts) and autumn seasons (mid-August to October at Dolakha and August to October at Kaski districts) as the honey flow period. Also the months of mid-November to January inthe Kaski district and mid-November to February inthe Dolakha district as winter season and from June to July inthe Kaski district and June to August in the Dolakha district as rainy season were regarded as dearth periods. Bista and Shivakoti (2001) further mentioned mid-February to mid-March and from mid-August to mid-September as colony development periods for honeybee colonies.

The dearth period management for sustenance and later rapid colony development for honey production has been discussed by different authors as providing nectar and pollen substitutes in winter and rainy seasons (Kafle, 1992; Shukla, 2000; Thapa & Pokhrel, 2007), migration of the colonies at bee floral rich areas (Shukla, 2000; Bista & Shivakoti, 2001; Thapa and Pokhrel, 2007) and plantation of bee floral plants (Kafle,1992; Pratap, 1997; Joshi, 1999; Bista & Shivakoti, 2001; Shukla, 2000; Thapa & Pokhrel, 2007; Rijal *et al.*, 2018).

CONCLUSION

The study discovered 153 plant species beneficial to honeybees in the Kavreplanchowk district, including 12 agronomical crops, 26 pomological crops, 11 ornamentals, 24 vegetables, and 80 wild plants. The detected flora was further classified as pollen, nectar, or both pollen and nectar-producing plants. Out of 153 crops, five were nectar supplying, nine were pollen supplying and 139 were pollen + nectar supplying plants. Honeybees and plants have a peculiar symbiotic interaction. Bee flora is essential for sustaining a beekeeping sector. It is critical to raise awareness about the need to preserve current bee flora and multiply plant species for the sake of sustainability.

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Authors' Contributions

Neupane, B. P., Chiluwal, K., & Shrestha, J conceptualized and executed the experiment, collected, analyzed data and wrote this paper.

Conflict of interest

The author declares no conflicts of interest regarding publication of this manuscript.

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