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Stingless bee flora in foothills of Nagaland

Rumki H Ch. Sangma, Arensungla Pongen, Bendangsenla and HK Singh

Abstract
The stingless bees were found to forage on a total of 80 plant species collecting food in the form of nectar and pollen. Out of these, 23 species were vegetables, 2 were cereals, 20 were fruits, 4 were oilseed crops, 18 were flower and ornamental crops and other 13 weed plants. The peak periods of honeybee foraging activity were recorded during January-June of as maximum bee flora were in bloom during this time. Hence, January-June was identified as honey-flow period and July-November was identified as floral-dearth period as minimum bee flora was in bloom during this time.

Keywords: Floral resources, honey-flow period, nectar, pollen, stingless bees

1. Introduction
Beekeeping and meliponiculture forms an integral part in the lives of the rural people of Nagaland. Meliponiculture has been practiced by the people of Nagaland mainly for the purpose of harvesting honey and its hive products. A number of stingless bee species viz., *Tetragonula iridipennis*, *Lepidotrigona ventralis*, *Tetragonula laeviceps Lophotrigona canifrons* and *Tetragonula gressitti* have been reported from Nagaland, India (Singh, 2016; Chauhan and Singh, 2019; Chauhan and Singh, 2021; Sangma *et al*., 2022) [25, 6, 7, 23] iridipennis, and *Lepidotrigona ventralis* were found to be most dominant. Honey is a natural product which is collected and processed by honeybees. Bees (Hymenoptera: Apoidea: Anthophila), as a monophyletic group of 20000 species (Danforth *et al*., 2013) [10], depend entirely on nutrition derived from floral resources (obtained from diverse plant species (Michener, 2007) [19]. Honey bees are polylectic insects which are able to forage on diverse species of plants in order to supply enough abundant and diverse food; nectar and pollen for the colony. Adults and larvae of nearly all bee species depend on nutrients obtained from floral resources for development, reproduction, and health. Bees require nectar and pollen floral resources that provide necessary carbohydrates, proteins, lipids, and micronutrients for survival, reproduction, and resilience to stress. Bees' flora is important for sustaining beekeeping. The flowering plants of an area having good value as bee pasture are necessary to maintain bee colonies (Baptist and Punchihewa, 1980) [3]. Honey bees and their foraging plants have a mutual symbiotic relationship. The plants visited by the honey bees in turn gets benefitted by an important service carried out by them called pollination which is essential for reproduction of the plants and for sustaining and maintaining ecological plant diversity. Usually, high volume and higher sugar concentration nectar is preferred by bees within their flight ranges so as to avoid wasting more energy and time. However, all foraging plant species do not contribute equal amount of food source: nectar and pollen nutritional quality, the amount produced varies widely among host-plant species (Vaudo *et al*., 2015, Singh *et al*., 2016) [27, 24]. Some supply both nectar and pollen abundantly and some produce plenty of nectar but little or no pollen and they are called honey plants. Some floras produce plenty of pollen but only a trace amount or no nectar are known as pollen plants. In order to survive, prosper and be productive, honeybee colonies must have a supply of both nectar and pollen in adequate quantities (Singh *et al*., 2016) [24]. Bees may therefore experience nutritional stress when limited in their choices of host-plant species or when only suboptimal floral resources are available, both of which could result in reduced population sizes and pollination efficiency (Brodschneider and Crailsheim, 2010) [5]. Plant species and their blooming period differ from one place to other due to variation in topography, climate and other cultural practices (Harugade and Chaphalkar, 2013) [11]. Bee floras and their pollinators are greatly affected by environmental variables (Kearns and Inouye 1993) [15]. The importance of flora in bee keeping has been observed worldwide as well as India; the directory of world honey sources (Crane *et al*., 1984) [8], honey plant resources of Hindu Kush-Himalayan region (Verma, 1990; Partap,

1997) [29, 21] and bee flora of India (Kaur and Sihag, 1994) [14] was accomplished in the Himalayan region of north India. Bee keepers' usually try to place their bees' colony in the niche where sufficient quantity of bee flora exists throughout the year, within the economical flight range of honeybee (Singh *et al*., 2016) [24]. For successful bee keeping every beekeeper must be aware of the local floral resources available to the bees near/ or around his/her apiary and also to be benefitted from the service of the bees as pollinators which greatly increase the fruit set and yield of crops and get abundant hive rewards as well. Thus, here we have studied and documented the availability of local bee flora and their blooming period which serve as nectar and pollen sources for stingless and honey bees and their blooming period.

2. Materials and Methods

The studies were carried out at SASRD, Medziphema, Nagaland which is located at an altitude of 310 msl situated at 25º45"45" N latitude and 93º55"04" E longitude. The place is located in the foot hills of Pauna hills of Himalayan range. The visual observations were made on the basis of collection of nectar or pollen or both from flowers by the stingless bees. The observations were recorded at weekly interval during the period from January, 2019 to June, 2021. Observations were recorded on plants' blooming period, by visual observations of the bees visiting the flowers. The floras were categorized into nectar producing flora or pollen producing flora or both nectar and pollen producing flora. The bees found inserting labium and collecting nectar by its lapping after sitting calmly on the flower was classified as nectar yielding crop/tree. Most of the plants observed were exclusively rich in pollen. On such plant flowers, the bees remain hyperactive while collecting pollen. Thereafter, the volume of nectar and pollen produced were visually observed and categorized in three categories; N1, N2 and P1, P2as per volume of nectar secretion, pollen and numbers of anther/flower as described by Singh *et al*. (2016) [24].

3. Results and Discussion

3.1 Crops and wild plants distributed in the study area

The plants that were foraged by stingless bees found in the region were divided into different categories based on the type of crop and its usage. The lists of floral resources to stingless bees are given in Table 1-6. Among cereals, the crops included rice and maize; vegetables included brinjal, chilli, cucurbits like ash gourd, bitter gourd, bottle gourd, cucumber, drumstick, pointed gourd, pumpkin, etc., radish, mustard, tomatoes and a number of leguminous vegetables like cow pea, pigeon pea and winged beans that were commonly grown in that area. Among the fruit crops the commonly foraged plants were cashew, Khasi mandarin, Indian gooseberry, guava, litchi, lemon, mango, mulberry, papaya, passion fruit, pomelo, Singapore cherry and watermelon. A number of ornamental trees and flowering plants that provided a food source to the bees included Christ thorn, Coreopsis, False sun flower, Geraniums, Impatiens, Jasmine, Peacock flower, Portulaca, bitter plant (*Phlogacanthus thyrsiformis*) and Singapore Daisy. Oilseed crops like mustard and sunflower were a rich source of nectar and pollens to the bees. Besides these, the bees sustained on the pollens and nectars of many weed plants which were a great source of food to them., *viz*., Beggars tick weed (*Bidens pilosa*), Touch me not plant (*Mimosa pudica*), Goat weed (*Ageratum conyzoides*), *Portulaca* sp., Leucas (*Leucas aspera*) and many others. Amongst these, the stingless bees collected only pollen from guava (*Psidium guajava*), *Maize* (*Zea mays*), *Rice* (*Oryza sativa*), *Goat weed* (*Ageratum conyzoides*) and *Touch me not plant* (*Mimosa pudica*). *Major nectar-rich plants included plants Brassica rapa*, *Cajanus cajan*, *Hibiscus mutabilis*, *Lablab purpureus*, *Leucas aspera*, *Mangifera indica*, *Momordica charantia*, *Phlogacanthus thyrsiformis*, *Vigna unguiculata*, *Vigna spp.* Both nectar and pollen rich plants included, *Abelmoschus esculentus*, *Benincasa hispida*, *Brassica campestris*, *Carica papaya*, *Citrus limon*, *Citrus reticulate*, *Cucumis sativus*, *Cucurbita pepo*, *Geranium sp.*, *Helianthus annuus*, *Heliopsis helianthoides*, *Hibiscus sabdariffa*, *Litchi chinensis*, *Lagenaria siceraria*, *Lagenaria vulgaris*, *Luffa acutangula*, *Moringa oleifera*, *Melia azedarach*, *Muntingia calabura*, *Musa* sp., *Perilla frutescens*, *Petunia spp.*, *Phyllanthus emblica*, *Prunus persica*, *Prunus* sp., *Psidium guajava*, *Ricinus communis*, *Sesamum indicum*, *Trichosanthes dioica*, *Ziziphus jujube.* Pollen rich plants included *Capsicum* sp., *Ageratum conyzoides*, *Arachis hypogaea*, *Citrullus lanatus*, *Lycopersicon esculentum*, *Mimosa pudica*, *Oryza sativa*, *Parthenium hysterophorus*, *Pyrus* sp., *Solanum melongena* and *Zea mays*. The percent abundance of bee flora during different months were 6, 6, 10, 11,12, 12, 9, 9, 8, 8, 5 and 6 in January, February, March, April, May, June, July, August, September, October, November and December respectively, presented in (Fig.1). The perusal of data reveals that the floral calendar, highest bee flora's flowering was recorded during January to June, therefore, this period was considered as honey flow period. The minimum stingless bee flora blooms during July to November, therefore, this period was considered as floral dearth period.

Many of these findings are in conformity with the findings of Singh *et al.* (2016) [24], who recorded 64 foraging plants for stingless bees and 69 for Indian Honey bee under Medziphema Nagaland. They recorded honey flow period during January to May, due to the availability of maximum blooming floras and favorable climatic condition. Similar honey flow period was reported by Akum *et al.* (2012) [2]. Month of December bloomed abundant bee forage plants, despite of that stingless bee foraging was low, because stingless bees are stenothermal insect (Roubik, 2006) [22]. Hosamani *et al*. (2020) [12] reported 75 plant species as forage plants of honey bees in Haveri district of Karnataka. They too reported *Abelmoschus esculentus*, *Lagenaria siceraria*, *Lagenaria vulgaris*, *Luffa acutangula*, *Moringa oleifera*, *Brassica campestris*, *Carica papaya*, *Cucumis sativus* as nectar and pollen rich plants; *Lablab purpureus*, *Mangifera indica*, *Momordica charantia*, *Vigna unguiculata*, *Vigna* spp. as nectar rich plants and *Lycopersicon esculentum*, *Solanum melongena*, *Zea mays*, *Capsicum* sp. as pollen rich plants. Similar flowering period existed in literatures viz., that *Peltophorum* spp., *Eucalyptus* spp. and *Mimosa pudica* (Kalpana *et al*., 1997) [13]; *Citrus sinensis*, *Abelmoschus esculentus*, *Ageratum conyzoides*, *Cucumis* spp., *Litchi sinensis*, *Prunus* spp. (Noor *et al*., 2009) [20]; *Litchi chinensis* by Kitroo and Abrol (1996) [16]. The dearth period of bees' flora reported; Mid-May to mid-August (Waykar and Baviskar, 2015) [30] and June to July in Nepal (Adhikari and Ranabhat, 2011) [1]. The major source of both nectar and pollen reported; *Citrus* spp., *Litchi chinensis*, *Delonix regia* as major source of both nectar and pollen (Adhikari and Ranabhat, 2011) [1]. However, *Peltophorum* spp., *Tamarindus indica*, *Eucalyptus* spp, *Citrus* spp. was reported as major

source of both pollen and nectar to the bees (Kumari, 2004) [18].

During periods of honey dearth when agro-horticultural crops are not in blooming, then weeds and wild flowering plants provided alternate food source to the bees (Dalio, 2012 [9]; Kumar *et. al.*, 2013 [17]). Similarly Venkatachalapathi *et al.* (2015) [28] documented 66 species of medicinal plants which are potential forages of honey bees in Walayar Valley of Coimbatore district in Western Ghats. Present findings are also in conformity with the records of Sivaram (2001) [26].

3.2 Key bees' flora

On the basis of productivity of nectar and pollen, floral dearth, honey flow period, agro climatic area based crops and their importance, twenty four bees' flora were identified to overcome floral dearth (Table 7). All these plants provide nectar and pollen to honey bees before, during and after floral dearth for their colony development. Many of the flowering plants like *Caesalpinia pulcherrima*, *Jasminum sambac*, *Heliopsis helianthoides*, *Phlogacanthus thyrsiformis*, *Sphagneticola trilobata* being perennial in nature can be easily grown around the houses. Cucurbits, leguminous, fruit and oilseed crops in addition to providing food source to the bees, supply us with food also. A number of weed plants identified here can also be kept within the vicinity of the apiaries in order to supply them with food and help in conservation of the bees especially when floral source from other crops are not available.

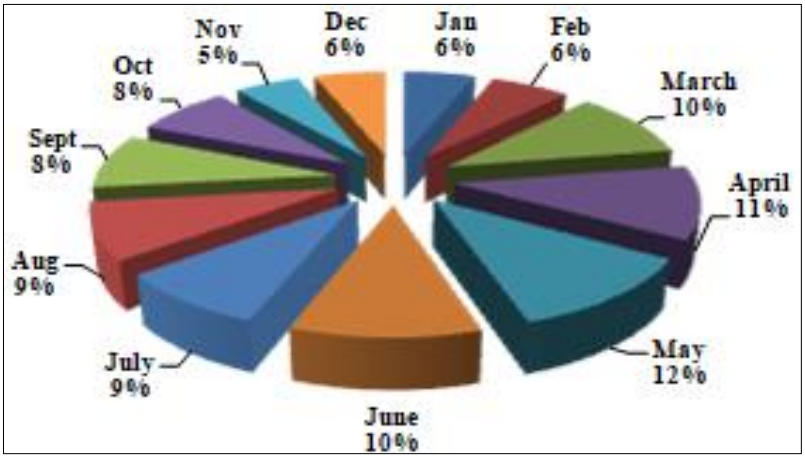


Fig 1: Percent foraging plants available during different months

Table 1: Cereal crops foraged by stingless bees for food

Sl. No.	Common name	Scientific name	Family	Flowering period (Months/ Duration)	Food source
1.	Maize	*Zea mays*	Poaceae	May-June	P1
2.	Rice	*Oryza sativa*	Poaceae	March-April, September-October	P2

Table 2: Vegetable crops and other food crops foraged by stingless bees for nectar and pollen

Sl. No.	Common name	Scientific name	Family	Flowering period (Months/ Duration)	Food source
1.	Ash Gourd	*Benincasa hispida*	Cucurbitaceae	April-June	N1P1
2.	Bitter gourd	*Momordica charantia*	Cucurbitaceae	March- September	N2P2
3.	Brinjal	*Solanum melongena*	Solanaceae	April-August	P1
4.	Bottle gourd	*Lagenaria vulgaris*	Cucurbitaceae	May- November	N1P1
5.	Chilli	*Capsicum annum*	Solanaceae	April-August	P2
6.	Chow-Chow	*Sechium edule*	Cucurbitaceae	March-April	N1P2
7.	Coccinea	*Coccinea grandis*	Cucurbitaceae	March-June	N1P2
8.	Cowpea	*Vigna unguiculata*	Fabaceae	May-August	N1
9.	Cucumber	*Cucumis sativus*	Cucurbitaceae	March-May	N1P1
10.	Dolichos Beans	*Lablab purpureus*	Fabaceae	May-September	N1
11.	Drumstick	*Moringa oleifera*	Moringaceae	January-March	N1P1
12.	Lady's Finger	*Abelmoschus esculentus*	Malvaceae	March- August	P2
13.	Mustard	*Brassica* sp.	Brassicaceae	November-March	N1P1
14.	Pigeon pea	*Cajanus cajan*	Fabaceae	November- January	N2
15.	Pointed Gourd	*Trichosanthes dioica*	Cucurbitaceae	March-August	N1P1
16.	Pumpkin	*Cucurbita moschata*	Cucurbitaceae	July- October	N2P2
17.	Radish	*Raphanus sativus*	Brassicaceae	November-March	N2P2
18.	Ridge gourd	*Luffa acutangula*	Cucurbitaceae	March-August	N1P1
19.	Rosselle	*Hibiscus sabdariffa*	Malvaceae	September-October	N1P1
20.	Sponge gourd	*Luffa cylindrica*	Cucurbitaceae	March-August	N1P1
21.	Tomato	*Lycopersicon esculentum*	Solanaceae	November-March	P1
22.	Soybean	*Glycine max*	Fabaceae	September-October	NP
23.	French Bean	*Phaseolus vulgaris*	Fabaceae	July- December	P3N3

Table 3: Fruit crops foraged by stingless bees for nectar and pollen

Sl. No.	Common name	Scientific name	Family	Flowering period (Months/ Duration)	Food source
1.	Banana	*Musa paradisiaca*	Muscidae	January - December	N1P2
2.	Ber	*Ziziphus jujube*	Rhamnaceae	August-October	P2N2
3.	Cashew	*Anacardium occidentale*	Anacardiaceae	April- May	N2
4.	Khasi mandarin	*Citrus reticulata*	Rutaceae	February-March	N1P1
5.	Guava	*Psidium guajava*	Myrtaceae	February-April	N1P1
6.	Indian Gooseberry/Aonla	*Phyllanthus emblica*	Phyllanthaceae	March- April	N1P1
7.	Jamiaca/Panama/Singapore Cherry	*Muntingia calabura*	Muntingiaceae	Throughout the year	N1P1
8.	Lemon	*Citrus limon*	Rutaceae	April	N1P1
9.	Litchi	*Litchi chinensis*	Sapindaceae	February-April	N1P1
10.	Mango	*Mangifera indica*	Anacardiaceae	January-March	N2P2
11.	Mulberry	*Morus alba/M. serrata* L.	Moraceae	April- May	N2P2
12.	Papaya	*Carica papaya*	Caricaceae	January - December	N2 P2
13.	Passion fruit	*Passiflora edulis*	Passifloraceae	January - June	N2 P2
14.	Peach	*Prunus persica*	Rosaceae	December - January	N1 P1
15.	Pear	*Pyrus* sp.	Rosaceae	December - January	N2 P1
16.	Plum	*Prunus* sp.	Rosaceae	December - January	N1 P1
17.	Pomegranate	*Punica granatum*	Punicaceae	June-July, September-October	N2 P2
18.	Pumelo	*Citrus grandis*	Rutaceae	December-January, June-July	N2 P2
19.	Star fruit	*Averrhoa carambola*	Oxalidaceae	January- March & September-October	N1P2
20.	Water melon	*Citrullus lanatus*	Cucurbitaceae	April- May	N1P1

Table 4: Ornamental crops foraged by stingless bees for nectar and pollen

Sl. No.	Common name	Scientific name	Family	Flowering period (Months/ Duration)	Food source
1.	Christ thorn	*Euphorbia* sp.	Euphorbiaceae	Throughout the year	P2N2
2.	Confederate rose	*Hibiscus mutabilis*	Malvaceae	November-January	P2 N1
3.	Coreopsis	*Coreopsis lanceolata*	Compositae	April-June	N2P1
4.	Cosmos	*Cosmos bipinnatus*	Compositae	September-November	N2P1
5.	False sunflower	*Heliopsis helianthoides*	Asteraceae	October-March	N1P1
6.	Garden balsam	*Impatiens balsamina* L.	Balsaminaceae	May-October	N1P2
7.	Geranium	*Geranium* sp.	Geraniaceae	Throughout the year	N1P1
8.	Gul Mohor	*Delonix regia*	Fabaceae	April- May	P2 N2
9.	Impatiens	*Impatiens balsamina*	Balsaminaceae	March-May	N1P1
10.	Jasmine	*Jasminum sambac*	Oleaceae	March-June	N1
11.	Melia	*Melia azedarach*	Meliaceae	February-March	P2
12.	Nine O'clock	*Portulaca* sp.	Portulacaceae	March - October	P1N1
13.	Nongmangka/Alot	*Phlogacanthus thyrsiformis*	Acanthaceae	February-March	N1P2
14.	Peacock flower	*Caesalpinia pulcherrima*	Fabaceae	March-May	N2P2
15.	Petunia	*Petunia* sp.	Solanaceae	February-April	N1P2
16.	Singapore Daisy	*Sphagneticola trilobata*	Asteraceae	April-September	N2P1
17.	Sweet william	*Dianthus* sp.	Caryophyllaceae	March-October	N1P2
18.	Zinnia	*Zinnia elegans*	Asteraceae	April-October	N2P2

Table 5: Oilseed crops foraged by stingless bees for nectar and pollen

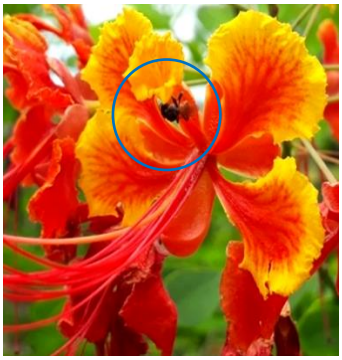
Sl. No.	Common name	Scientific name	Family	Flowering period (Months/ Duration)	Food source
1.	Mustard	*Brassica campestris*	Brassicaceae	November-February	N1P1
2.	Perilla	*Perilla frutescens*	Labiatae	August-September	N1P1
3.	Sesamum	*Sesamum orientale*	Pedaliaceae	September-October	N1P2
4.	Sunflower	*Helianthus annuus*	Asteraceae	January-March/May-June	N2P1

Table 6: Weeds foraged by stingless bees for nectar and pollen

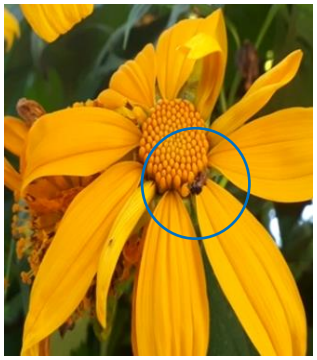
Sl. No.	Common name	Scientific name	Family	Flowering period (Months/ Duration)	Food source
1.	Lemon basil	*Ocimum africanum*	Lamiaceae	April-October	N2P2
2.	Tulsi	*Ocimum tenuiflorum*	Lamiaceae	April-October	N2P2
3.	Chenopodium	*Chenopodium album*	Chenopodiaceae	March-October	P2
4.	Congress grass	*Parthenium hysterophorus*	Asteraceae	May-June	P1
5.	Siam weed	*Chromolaena odorata*	Compositae	October-December	P2
6.	Touch-me-not	*Mimosa pudica*	Leguminaceae	November-March	P1
7.	Goat weed plant	*Ageratum conyzoides*	Compositae	October- April	N2P2
8.	Beggar's Tick	*Bidens pilosa*	Compositae	May-October	P2
9.	Oxalis	*Oxalis corniculata*	Oxalidaceae	February-October	N2 P2
10.	Ipomoea	*Ipomoea purpurea*	Convolvulaceae	May-September	P2
11.	Leucas	*Leucas aspera*	Lamiaceae	September-February	N1
12.	Night shade	*Solanum nigrum*	Solanaceae	June-September	P2
13.	Climbing hemb vine	*Mikania micrantha*	Asteraceae	Throughout the year	N2P2

Table 7: Recommended plants grow to overcome from floral dearth and enhance beehive productivity

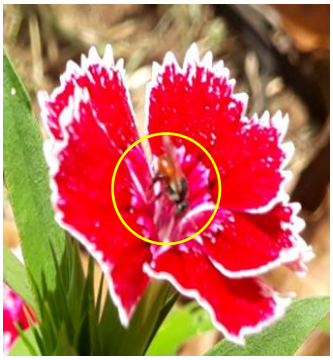
Sl. No.	Common Name	Scientific name	Family	Blooming Period	Food Source
1.	Indian Goose berry	*Phyllanthus emblica*	Phyllanthaceae	March- April	
2.	Ash Gourd	*Benincasa hispida*	Cucurbitaceae	April-June	N1P1
3.	Bitter gourd	*Momordica charantia*	Cucurbitaceae	March-September	N2P2
4.	Bottle gourd	*Lagenaria vulgaris*	Cucurbitaceae	May- November	N1P1
5.	Confederate rose	*Hibiscus mutabilis*	Malvaceae	November- January	P2 N1 N+P
6.	Cowpea	*Vigna unguiculata*	Fabaceae	May-August	N1
7.	Cucumber	*Cucumis sativus*	Cucurbitaceae	March-May	N1P1
8.	Drumstick tree	*Moringa oleifera*	Moringaceae	February - April	P1 N3
9.	False sunflower	*Heliopsis helianthoides*	Asteraceae	October-March	N1P1
10.	Gul Mohor	*Delonix regia*	Fabaceae	April- May	P2 N2
11.	Nongmangka/Alot	*Phlogacanthus thyrsiformis*	Acanthaceae	February-March	N1P2
12.	Jamiaca/Panama/Singapore Cherry	*Muntingia calabura*	Muntingiaceae	Throughout the year	N1P1
13.	Jasmine	*Jasminum sambac*	Oleaceae	March-June	N1
14.	Khasi mandarin	*Citrus reticulata*	Rutaceae	February-March	N1P1
15.	Lemon	*Citrus limon*	Rutaceae	April	N1P1
16.	Litchi	*Litchi chinensis*	Sapindaceae	February-April	N1P1
17.	Maize	*Zea mays*	Poaceae	May-June	P1
18.	Mustard	*Brassica campestris*	Brassicaceae	November-February	N1P1
19.	Passion fruit	*Passiflora edulis*	Passifloraceae	January - June	N2 P2
20.	Peacock flower	*Caesalpinia pulcherrima*	Fabaceae	March-May	N2P2
21.	Perilla	*Perilla frutescens*	Labiatae	August-September	N1P1
22.	Sesamum	*Sesamum orientale*	Pedaliaceae	September-October	N1P2
23.	Singapore Daisy	*Sphagneticola trilobata*	Asteraceae	April-September	N2P1
24.	Sun Flower	*Helianthus annuus*	Asteraceae	January-March/May-June	N2P1



(a) *Caesalpinia pulcherrina*



(b) *Heliopsis helianthoides*



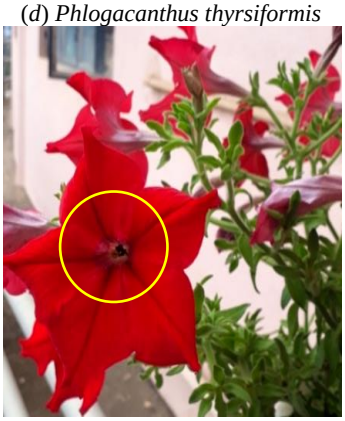
(c) *Dianthus* sp.

(*d*) *Phlogacanthus thyrsiformis*

(e) *Sphagneticola trilobata*

(f) *Portulaca* sp.

(g) *Euphorbia* sp.



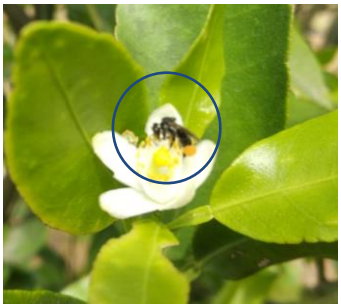
(h) *Petunia* sp.

(i) *Geranium* sp.

(j) *Geranium* sp.

(k) *Impatiens balsamina*

(l) *Zinnia elegans*


(m) *Citrus reticulate*


(n) *Cucumis sativus*


(o) *Bidens pilosa*


(p) *Ageratum conyzoides*

Fig 2: Stingless bees foraging in some forage plants

4. Conclusion

Hence, a total of 80 plants were identified as foraged plants that provided food sources to the stingless bees of Medziphema area. The common bee forage plants included rice, maize, cucurbits, litchi, citrus, mango, mulberry, Singapore Cherry, rapeseed and mustard. The highest bee flora's flowering was recorded during January to June, therefore, this period was considered as honey flow period. The minimum stingless bee flora blooms during July to November, therefore, this period was considered as floral dearth period. A total of 24 plants have been recommended to be grown for providing continuous supply of pollen and nectar to the bees. The information generated here will help the farmers to plan and carry out manage pollination of cross-pollinated crops with stingless bees especially the domesticated ones *viz.*, *Tetragonula iridipennis* and *Lepidotrigona ventralis* by placing bee boxes in crop area/orchards during flowering period.

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