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Hang around flora- the pollination enhancers of apple, of Kashmir Himalaya

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Abstract

Fruit industry is the back bone of Jammu and Kashmir's economy. Prosperity and growth of this industry depends upon number of factors including pollination in three componential apple orchards. Proper pollination demands enhanced population of pollinators which in turn depends upon availability of food and congenial atmosphere. Kashmir valley abounds in rich floristic diversity of herbaceous and arboreal taxa including food providing plants for pollinators. Twenty six species of hang around flora, acting as food source before apple bloom, for twelve species of pollinators, which bio-spin to apple orchards are documented in this paper. *Prunus domestica*, *P. armeniaca* and *Astragalus grahamianus*, exhibited highest hang around capacity. *Apis* was most generalized pollinator genus. *Salix caprea* reflected maximum magnetic power. Highest nectar content was recorded in *Eriobotrya japonica*.

Keywords: hang around flora, apple, Kashmir, pollinator fauna, magnet power

Introduction

Intermontane Kashmir valley forming geologically younger part of Himalaya, covering an area of 158898 sq. km., harbour in holarctic flora in natural and manmade ecosystems. The flora directly and indirectly provides resource base for livelihood of the people and accounts for economy of the state and is equally important for sustenance of fauna of the area. Angiospermic component of the flora, accounting for 2000 species (Dar *et al.*, 2002) [5] bloom in different seasons of the year and provide food for insects including pollinators which frame out the maintenance and substance of both wild as agricultural ecosystems (Buchmann and Nabhan, 1996) [4]. Some species flower before apple blooms and attract pollinators and gather them around, depending upon their advertising efficacies and potential rewards. Such species constitute the Hang-around flora and this type of flora plays pivotal role in enhancing pollination in apple indirectly, if present within or in the vicinity of apple orchards. As diversity, population, health and reproduction success of pollinators - cost less pollen carriers in apple orchard system, is determined by the availability of their food, the documentation of food resource is essential. Though, lot of references are available on different aspects of flora of Kashmir (Dar and Khuroo, 2013 [6]; Ara, 2011 [2]; Anzar *et al.*, 2007 [1]; Dar *et al.*, 2002 [5]) no work has been done till date on hang around flora of Kashmir. Hence the present study which qualifies the documentation of diversity, hang around potential, advertisement and reward efficacy of hang around flora.

Materials and Methods

The field surveys were carried out in Kashmir Himalaya during 2012-16 to study the hang around floristic diversity, acting as food resource for pollinators before apple bloom. Field observations were taken and plant specimens were collected and processed using standard herbarium methodology (Bridson and Forman, 1998) [3] and identified on the basis of relevant taxonomic literature (Hook, 1872 [8]; Nasir and Ali, 1970 [12]) and further validated with expert determination. The pollinators collected by nets were killed in ethyl acetate solution, stretched and pinned. Labels containing field information were appended to each sample. The labeled samples were placed in the boxes specially designed for the purpose and identified following Michener (2007) [11] and further validated with expert determination by Ghorpede Dharwad Agricultural University Bangalore and Alain Pauly Royle Belgian Institute, Belgium. Reward type was ocularised on the basis of foraging behaviour of pollinators on the flower or inflorescence. Flowers about to bloom were bagged to avoid pollinator visit and nectar robbery. After 24 hours nectar content of the foraging plant was determined by Calibrated Micro capillary method. All the samples of plants and identified insect pollinators have been housed in Research and Training Centre for Pollinators, Pollinizers and Pollination Management, Sher-e- Kashmir University of Agricultural Science and Technology of

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Results and Discussions

Hang-around floral diversity

Present study displays the natural endowed pre-apple blooming flora of Kashmir valley, most important for sustenance of pollinators. Analysis of the flora depicted 26 species of flowering plants pertaining to 21 genera and 16

families (Table 1). Rosaceae was the largest represented family with 08 species, followed by Liliaceae with 03 species. Brassicaceae was represented by 02 species while as rest of the families were represented by 01 species each. Documented flora includes 13 herbs, 12 trees and 01 shrub. 16 plant species are exotic in origin where as 10 are native to this valley.

Table 1: Diversity of Hang-around flora

S. No.	Plant Species	Family	Habit	Origin	Pollinators
1	<i>Viburnum grandiflorum</i> Wall. Ex DC.	Adoxaceae	Shrub	Native	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Eristalis tenax</i> , <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
2	<i>Sternbergia lutea</i> Spreng.	Liliaceae	Herb	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> and <i>Pieris brassicae</i>
3	<i>Colchicum luteum</i> L.	Colchicaceae	Herb	Native	<i>Apis cerana</i> , <i>A. mellifera</i> and <i>Halictus</i> spp.
4	<i>Salix caprea</i> L.	Salicaceae	Tree	Exotic	<i>Apis cerana</i> and <i>A. mellifera</i>
5	<i>Narcissus poeticus</i> L.	Liliaceae	Herb	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> and <i>Eristalis tenax</i>
6	<i>Viola odorata</i> L.	Violaceae	Herb	Native	<i>Halictus</i> spp. <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
7	<i>Veronica persica</i> Poir.	Scrophulariaceae	Herb	Native	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Pieris brassicae</i> , <i>Vanessa cashmiriensis</i> , <i>Lasioglossum nursi</i> and <i>L. himalenyse</i> .
8	<i>Stellaria media</i> L.	Caryophyllaceae	Herb	Native	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Lasioglossum nursi</i> , <i>L. himalenyse</i> , <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
9	<i>Magnolia grandiflora</i> L.	Magnoliaceae	Tree	Exotic	<i>Apis cerana</i> and <i>A. mellifera</i>
10	<i>Alliaria petiolata</i> (M.Bieb.) Cavara & Gande	Brassicaceae	Herb	Native	<i>Apis cerana</i> and <i>A. mellifera</i>
11	<i>Forsythia suspense</i> Lindl.	Oleraceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> <i>Xylocopa valga</i> and <i>X. violacea</i>
12	<i>Eriobotrya japonica</i> Lindl.	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Pieris brassicae</i> , <i>Vanessa cashmiriensis</i> , <i>Xylocopa valga</i> and <i>X. violacea</i>
13	<i>Astragalus grahamianus</i> Benth.	Fabaceae	Herb	Native	<i>Apis cerana</i> , <i>A. mellifera</i> <i>Xylocopa valga</i> , <i>X. violacea</i> , <i>Andrena patella</i> , <i>A. flavipes</i> and <i>Eristalis tenax</i> .
14	<i>Thymus linearis</i> Benth.	Lamiaceae	Herb	Native	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
15	<i>Raphanus sativus</i> L.	Brassicaceae	Herb	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> <i>Xylocopa valga</i> and <i>X. violacea</i>
16	<i>Parrotiopsis jacquemontiana</i> (Decne) Rehder	Hamamelidaceae	Tree	Native	<i>Apis cerana</i> , <i>A. mellifera</i> and <i>Lasioglossum nursi</i> , <i>L. himalenyse</i>
17	<i>Fritillaria cirrhosa</i> D. Don.	Liliaceae	Herb	Exotic	<i>Apis cerana</i> and <i>A. mellifera</i>
18	<i>Prunus amygdalus</i> Batsch	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> <i>Xylocopa valga</i> , <i>X. violacea</i> , <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
19	<i>P. domestica</i> L.	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> <i>Xylocopa valga</i> , <i>X. violacea</i> , <i>Eristalis tenax</i> , <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
20	<i>P. armeniaca</i> L.	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> <i>Xylocopa valga</i> , <i>X. violacea</i> , <i>Eristalis tenax</i> <i>Pieris brassicae</i> and <i>Vanessa cashmiriensis</i>
21	<i>P. persica</i> Batsch	Rosaceae	Tree	Exotic	<i>Apis cerana</i> and <i>A. mellifera</i> , <i>Xylocopa valga</i> and <i>X. violacea</i>
22	<i>P. avium</i> L.	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Lasioglossum nursi</i> and <i>L. himalenyse</i> .
23	<i>Iris hookeriana</i> Foster	Iridaceae	Herb	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Xylocopa valga</i> and <i>X. violacea</i>
24	<i>Pyrus communis</i> L.	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Xylocopa valga</i> and <i>X. violacea</i>
25	<i>Pyrus pyrifolia</i> Nakai	Rosaceae	Tree	Exotic	<i>Apis cerana</i> , <i>A. mellifera</i> , <i>Xylocopa valga</i> and <i>X. violacea</i>
26	<i>Ranunculus sceleratus</i> L.	Ranunculaceae	Herb	Native	<i>Apis cerana</i> and <i>A. mellifera</i> ,

Hang-around capacity

Hang around capacity is the ability of foraging plants to keep pollinators adhere to its reward either pollen, nectar or both. *Prunus domestica*, *P. armeniaca* and *Astragalus grahamianus* each hang-arounded 07 species of pollinators followed by *Veronica persica*, *Stellaria media*, *Eriobotrya japonica* and *Prunus amygdalus* each one of which hang-arounded 06 pollinator species. *Viburnum grandiflorum* hang arounded 05

species of pollinators followed by *Forsythia viridissima*, *Thymus linearis*, *Raphanus sativus*, *Parrotiopsis jacquemontiana*, *Prunus persica*, *P. avium*, *Iris hookeriana*, *Pyrus communis* and *P. pyrifolia* (04). *Sternbergia lutea*, *Colchicum luteum*, *Narcissus poeticus*, *Viola odorata* hang arounded 03 and rest of the plant species hang-arounded 02 species of pollinators, depicting the range of flower-pollinator generalization in descending manner (Fig. 1)

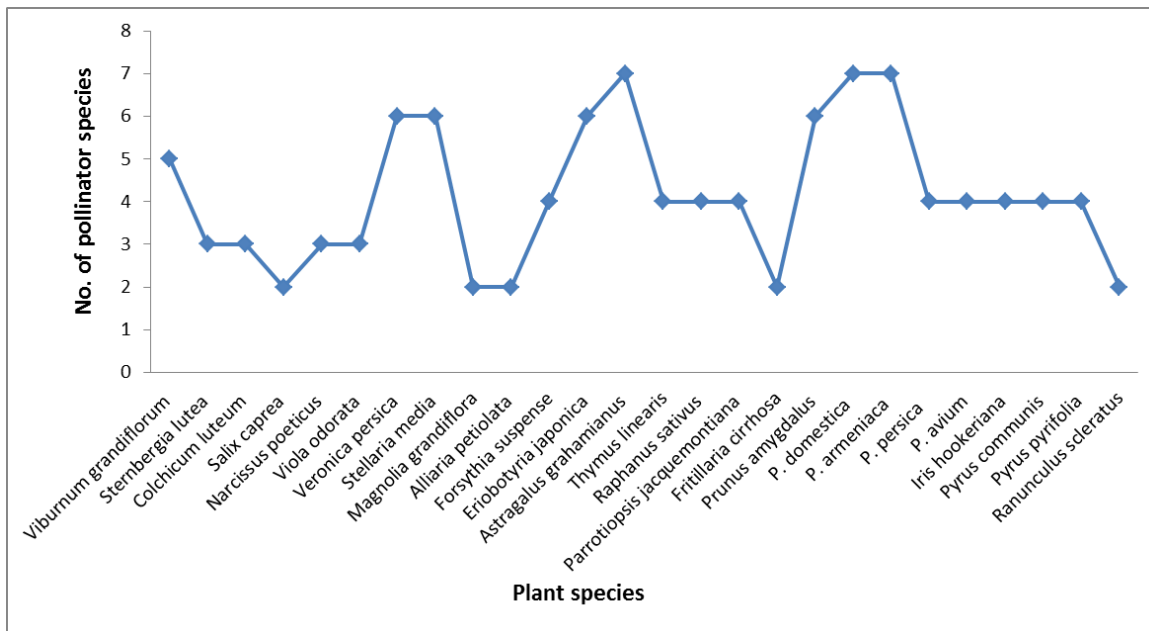


Fig 1: Hang-around capacity of flora

Hang-around pollinator fauna

Hang-around pollinator fauna reflect group of pollinator species, which are adhered to hang around flora for floral reward. Sum total of 12 species of pollinators pertaining to 08 genera and 06 families were found hang-arounded by

documented flora. *Apis* was most generalized pollinator genus, visiting 25 plant species followed by *Xylocopa* visiting 11, *Pieris* (10), *Vanessa* (06 each) *Eristalis* (05), *Lasioglossum* (04), *Halictus* (02) and *Andrena* (01), among documented plant species (Fig. II).

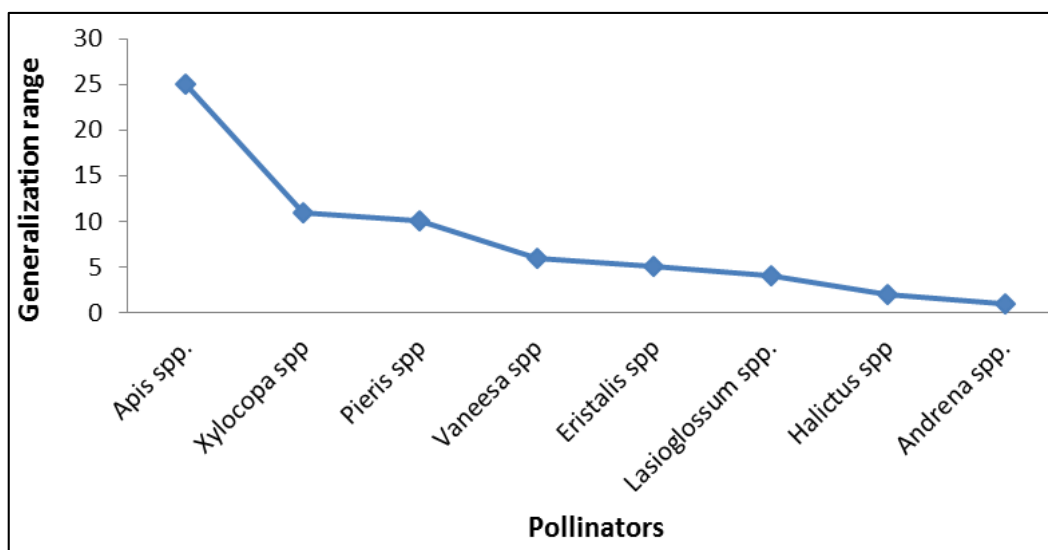


Fig 2: Hang around pollinator fauna

Magnet power of hang-around flora

Floral magnetic power is the intensity of pollinator attraction per unit time and is directly proportional to flower visitation rate. Majority of hang-around plant species behave as magnet flora for most of pollinators due to non-availability of food from any other source. *Salix caprea* exhibited maximum magnetic power with 08 visitations per 05 minutes, followed by *Prunus amygdalus* (05), *Eriobotrya japonica* (04), *Sternbergia lutea*, *Colchicum luteum*, *Forsythia suspensa*,

Prunus armeniaca, *Viburnum grandiflorum*, *Astragalus grahamianus*, *Iris hookeriana*, *Pyrus communis*, *P. pyrifolia*, (03), *Magnolia grandiflora*, *Raphanus sativus*, *Prunus domestica*, *P. persica*, *P. avium*, *Parrotiopsis jacquemontiana*, *Veronica persica*, *Narcissus poeticus* (02), *Stellaria media*, *Alliaria petiolata*, *Fritillaria cirrhosa*, *Viola odorata*, *Thymus linearis*, *Ranunculus sceleratus* L. (01) (Fig 3).

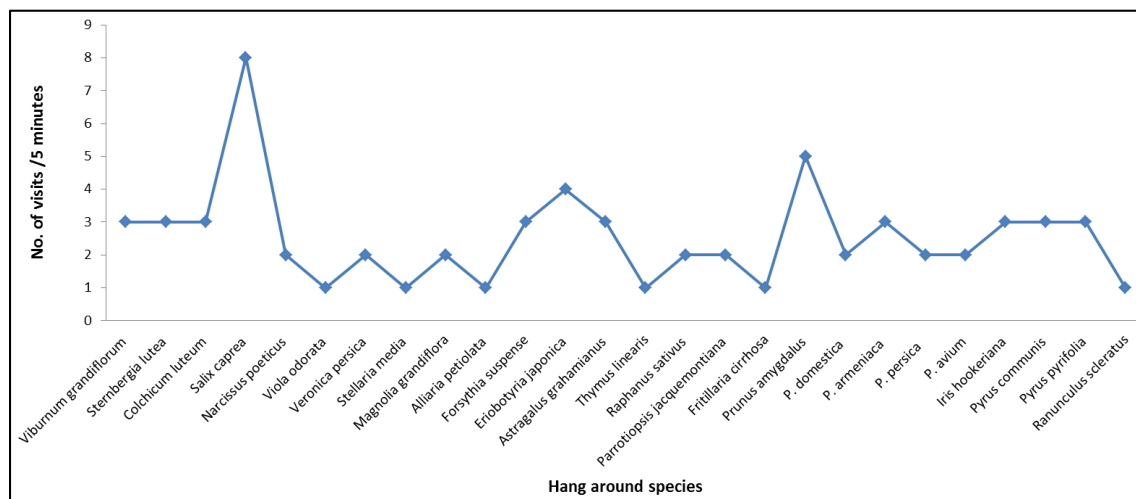


Fig 3: Magnet power of Hang-around flora

Floral traits of hang-around flora

Floral traits include advertisement attributes and reward features (Table 2). 13 hang-around plant species advertise white floral display for attraction of pollinators, 08 yellow, 2 blue, 2 purple and one red (Fig VI). Among studied plants 14 displayed bowl shaped corolla, 3 bilabiate, 2 rotate, 2 cruciform and one each species depicted papilionaceous, trumpet, coronate and campanulate corolla (Table 2). *Salix caprea* being incomplete flower lacks corolla. 11 species were

found to have numerous (> 10) stamens (Table 3), however all were found to provide pollen as well as nectar. 22 plant species exhibited open nectar access for pollinators where as 04 species were found to have closed nectar access for pollinators. *Eriobotryia japonica* recorded highest nectar content (13.50 μ l) followed by *Prunus amygdalus* (11.50 μ l), *Pyrus communis* (10.00 μ l) and rest of the species showed less than 10 μ l nectar content (Fig. 4).

Table 2: Floral traits of Hang-around flora

S. No.	Plant Species	Flower Colour	Flower Shape	Nectar access	Nectar content/flower (μ l)
1	<i>Viburnum grandiflorum</i> Wall. Ex DC.	White	Trumpet	Closed access	0.50
2	<i>Sternbergia lutea</i> Spreng.	Yellow	Rotate	Open access	02.70
3	<i>Colchicum luteum</i> L.	Yellow	Rotate	Open access	01.70
4	<i>Salix caprea</i> L.	Yellow		Open access	06.50
5	<i>Narcissus poeticus</i> L.	Yellow	Coronate	Closed access	01.30
6	<i>Viola odorata</i> L.	Blue	Bowl	Closed access	01.60
7	<i>Veronica persica</i> Poir.	Blue	Bowl	Open access	0.60
8	<i>Stellaria media</i> L.	White	Bowl	Open access	01.30
9	<i>Magnolia grandiflora</i> L.	White	Bowl	Open access	02.50
10	<i>Alliaria petiolata</i> (M.Bieb.) Cavara & Gande	White	Cruciform	Open access	0.40
11	<i>Forsythia suspense</i> Lindl.	Yellow	Bilabiate	Open access	02.35
12	<i>Eriobotryia japonica</i> Lindl.	White	Bowl	Open access	13.50
13	<i>Astragalus grahamianus</i> Benth.	Yellow	Papilionaceous	Closed access	01.84
14	<i>Thymus linearis</i> Benth.	Purple	Bilabiate	Open access	0.10
15	<i>Raphanus sativus</i> L.	Purple	Bilabiate	Open access	02.00
16	<i>Parrotiopsis jacquemontiana</i> (Decne) Rehder	Yellow	Bowl	Open access	02.60
17	<i>Fritillaria cirrhosa</i> D. Don.	White	Cruciform	Open access	04.70
18	<i>Prunus amygdalus</i> Batsch	Red	Companulate	Open access	8.00
19	<i>P. domestica</i> L.	White	Bowl	Open access	11.50
20	<i>P. armeniaca</i> L.	White	Bowl	Open access	05.50
21	<i>P. persica</i> Batsch	White	Bowl	Open access	04.00
22	<i>P. avium</i> L.	White	Bowl	Open access	07.00
23	<i>Iris hookeriana</i> Foster	White	Bowl	Open access	8.00
24	<i>Pyrus communis</i> L.	White	Bowl	Open access	10.50
25	<i>Pyrus pyrifolia</i> Nakai	White	Bowl	Open access	07.90
26	<i>Ranunculus sceleratus</i> L.	Yellow	Bowl	Open access	01.30

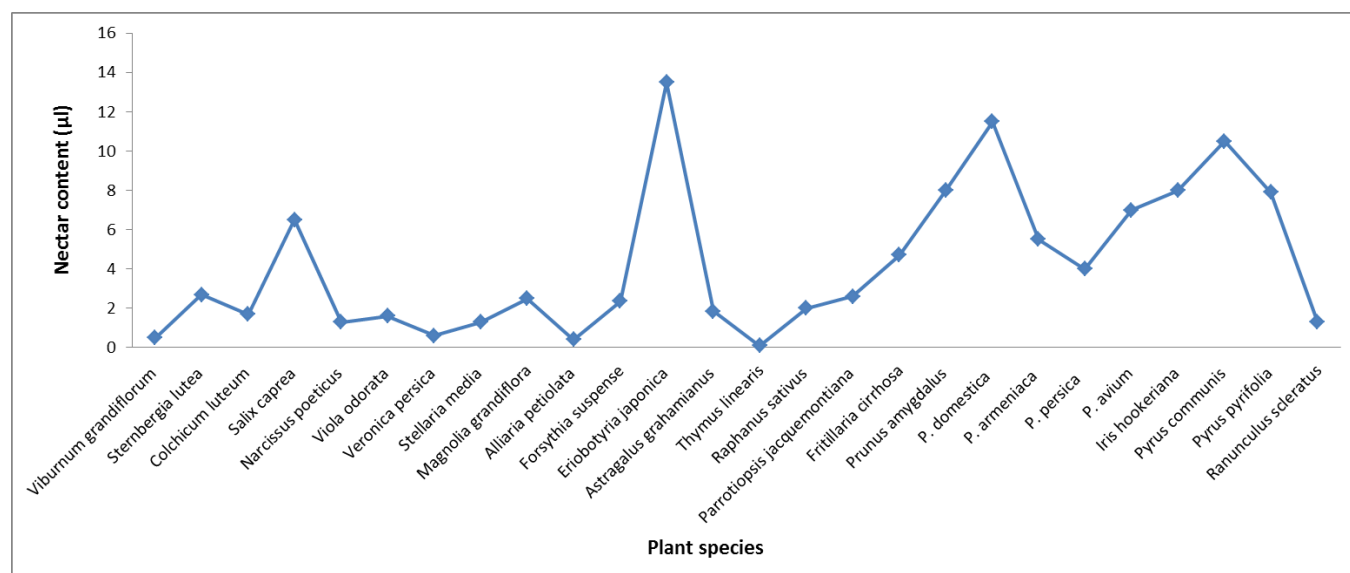


Fig 4: Nectar content of Hang-around flora

Table 3: Floral traits of Hang-around flora

S. No.	Plant Species	No. of flowers in inflorescence	Inflorescence type	No. of Stamens
1	<i>Viburnum grandiflorum</i> Wall. Ex DC.	Many	Terminal corymbs	5
2	<i>Sternbergia lutea</i> Spreng.	Solitary	Scapegerous	6
3	<i>Colchicum luteum</i> L.	Solitary	Scapegerous	
4	<i>Salix caprea</i> L.	Numerous	Catkin	2
5	<i>Narcissus poeticus</i> L.	Few	Umbellate	6
6	<i>Viola odorata</i> L.	Solitary	Solitary	5
7	<i>Veronica persica</i> Poir.	Solitary	Solitary axillary	2
8	<i>Stellaria media</i> L.	Solitary	Solitary axillary	5
9	<i>Magnolia grandiflora</i> L.	Solitary	Solitary terminal	Numerous
10	<i>Alliaria petiolata</i> (M.Bieb.) Cavara & Gande	Few	Racemose	6
11	<i>Forsythia suspense</i> Lindl.	Solitary axillary or in fascicles	Racemose	2
12	<i>Eriobotryia japonica</i> Lindl.	Many	Panicle	Numerous
13	<i>Astragalus grahamianus</i> Benth.	Usually 2 in leaf axils	Condensed Raceme	10
14	<i>Thymus linearis</i> Benth.	Numerous	Dense terminal clusters	4
15	<i>Raphanus sativus</i> L.	Few	Racemose	6
16	<i>Parrotiopsis jacquemontiana</i> (Decne) Rehder	Many	Capitate	Numerous (15)
17	<i>Fritillaria cirrhosa</i> D. Don.	Solitary	Scapegerous	6
18	<i>Prunus amygdalus</i> Batsch	Solitary or 2	Determinate	Numerous
19	<i>P. domestica</i> L.	Solitary or 2	Determinate	Numerous
20	<i>P. armeniaca</i> L.	Solitary or 2	Determinate	Numerous
21	<i>P. persica</i> Batsch	Solitary or 2	Determinate	Numerous
22	<i>P. avium</i> L.	Solitary or 2	Determinate	Numerous
23	<i>Iris hookeriana</i> Foster	Few	Racemose	3
24	<i>Pyrus communis</i> L.	1-5	Determinate	Numerous
25	<i>Pyrus pyrifolia</i> Nakai	1-5	Determinate	Numerous
26	<i>Ranunculus sceleratus</i> L.	Solitary	Lax cymes	Numerous

Flowers act as advertisement units for attraction of pollinators. However, advertisement efficacy varies with variation in floral traits, is in alliance with the study of Raguso, 2004 [13]. Advertisement worth is evident from pollinators preference of light colour corolla (white >yellow> blue> purple>red) and open assess flowers than dark colour and closed assess flowers, as found in the present study. Number and arrangement of anthers and arrangement of flowers on rachis (inflorescence) endow more for pollinator attraction. Plant species having maximum number of stamens (anthers) were found to attract more pollinators, hence Rosaceae is the largest represented family of hang around flora as members of this family possess numerous stamens. Similar trend was exhibited by the flowers having grouped

(diadelphous) arrangement of stamens (*Astragalus*). Since pollen grains are available in plenty at same platform such species reflect highest hang around capacity. Maximum magnetic power exhibited by *Salix caprea* is attributed to arrangement of flowers in catkins facilitating availability of pollen in bulk, coupled with nectar content of the species. The observation is further strengthened by the fact that *Eriobotryia japonica* having highest nectar content (13.50ul) exhibited only 04 visitations as compared to 08 of *Salix caprea*. Though advertisement traits guide the pollinators towards the ultimate reward that is in the form of pollen and nectar (Waser, 1983) [14], however study on reward traits also revealed diversity and is in accordance with Faegri and Van der Pijl, 1979 [7]. Despite recorded observations, the verity

that during food scarcity, pollinators are behind the floral reward by presence, not by preference is clear from the finding that *Veronica persica* having blue corolla hanged around 06 species of pollinators and *Astragalus* and *Viburnum*, even though specific plants for pollinators behave in generalized approach. *Apis* was most generalized pollinator genus, visiting 25 plant species.

Conclusion

Owing different advertising efficacies and potential rewards, pre-apple blooming flora known as Hang-around flora or Welcome flora, gathers around pollinators, until apple blooms. These taxa bio-spin pollinators to apple orchard system for proper pollination service - obligatory for improving quality and quantity of apple. Kashmir the "Apple Bowl" of India having 140156 out of 158898 hectares, under apple cultivation, accounts for 67 percent of total apple production of the country (Masoodi, 2003) ^[10]. Despite ample area under the crop cultivation, adequate nutrient inputs and protection measures and use of pollinizers in these special ecosystems the crop yield is insufficient and quality is decreasing throughout the valley, probably due to inadequate pollination due to inadequacy of pollinators. As population and reproduction success of pollinators is determined to greater extent by the availability of their food, the hang-around flora can prove helpful. Moreover, the hang-around flora ensures availability of food at crucial period when pollinator queens especially bumblebee and other bees of synchronizing period need food for their brood. Developing hang-around flora on orchard boundaries or hedgerows and on waste places in the vicinity of apple orchards shall produce positive effects on quantity and quality of apple.

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