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Insect pollinator flora of the almond growing Karewas of Kashmir valley

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Abstract
The conservation of native insect pollinators provides pollination insurance against the loss of managed honeybees. In order to conserve native insect pollinators, it is imperative to identify and augment the sources of pollen and nectar in the natural habitats. This study was carried out in Kashmir Karewas that act as refugia for native insect pollinators with an aim to identify the sources of sustenance for native insect pollinators. A total of 36 flora species belonging to 34 genera and 19 families of kingdom Plantae were identified as potential sustenance sources and preferred by different native insect pollinators, in addition to honeybees. The flora was available from the month of February till November. The knowledge about the flora preferred by native insect pollinators will help to augment the availability of nectar and pollen to native insect pollinators and safeguard the population of insect pollinators in the area.

Keywords: Almond, insect pollinator flora, Karewas, pollinator, sustenance

Introduction
Pollination is one of the most vital ecosystem functions and is provided by moving current of air, water, birds, bats, in addition to insects (Ashman *et al.* 2004) [4]. Insects represent the largest class and the pollinators belong especially to order Hymenoptera, Diptera, Lepidoptera and Coleoptera. Pollinators rely on angiosperms for the sustenance in the form of nectar and pollen and in return pollinate the flowers and ensure survival of cross pollinated flowering plants (IBPES 2016) [8]. Insect pollinators are facing tremendous pressures due to changing land use pattern, increasing urbanisation, other anthropogenic activities and the indiscriminate use of pesticides (Winfree *et al.*, 2009) [14]. One of the less documented factors is the loss of flora that sustain the insect pollinator population. The dwindling population of native insect pollinators make it necessary to analyse the flora that provide sustenance in the form of pollen and nectar (Potts *et al.*, 2010) [11]. The native insect pollinators also ensure pollination insurance and safeguard the pollination process against the loss of managed honeybee colonies due to various biotic and abiotic factors (Mandelika and Roll, 2009) [10]. The almond in Kashmir valley is completely reliant on native insect pollinators and due to the phenomenon of self-incompatibility is unable to set fruit on its own. To ensure the survival of insect pollinators in the almond Karewas, the flora supporting insect pollinators need to be present before and after the almond bloom. This study was undertaken to document the insect pollinator flora of the Kashmir Karewas and know what provides sustenance to insect pollinators other than almond pollen and nectar.

Material and Methods
This study was carried out in major almond growing belt of agricultural zone Newa and Nagam of agricultural sub-division Pulwama and Chadoora, respectively during the year 2020 and 2021. The Karewas act as refugia, safeguarding the remnant population of native insect pollinators against the different stressors, especially the pesticides as the almond crop receives only one spray of copper fungicide and no insecticidal spray. The almond orchards were visited fortnightly and the flora in bloom, visited by different insect pollinators was recorded. The flora in bloom was observed for 10 minutes and if it received a minimum of 3 visits by any insect pollinator, was categorised as insect pollinator flora with sustenance potential to insect pollinators.

The foraging behaviour of the insect pollinators, visiting the flora was particularly observed and the flora was categorised into different reward categories such as Pollen (P), Nectar (N) and both pollen and nectar (PN) for the pollinators. The extension of proboscis in the direction of the nectary of flower qualified the flora as providing the reward of nectar to the pollinators. The landing of insect pollinators on anthers and working on the male flower parts of the flower categorised as pollen providing plant. If an insect pollinator or a group showed both the behaviours towards the flora, it qualified for the reward of both pollen as well as nectar. The reward was confirmed from the available literature (Ara *et al*., 2018; 2019) [2, 3] as well. Flora specimens were collected and identified with expert taxonomic determination at Centre for Biodiversity and Taxonomy (formerly Centre of Plant Taxonomy), University of Kashmir, Jammu & Kashmir.

Results and Discussion

The data on the prevalence of source of sustenance for insect pollinators in addition to almond, in and around the almond orchards is presented in table 1. A total number of 36 different species of flora were present in the orchards. The flora represented 34 genera and belonged to 19 families of kingdom Plantae. The flora could be classified broadly into 08 species of trees, 07 species of shrubs and 21 herbaceous species.

The different flora species present were *Ailanthus altissima*, *Aesculus indica*, *Anemone tschernjaewii*, *Anthimus cotula*, *Artimisia absinthum*, *Astragalus grahamianus*, *Berberis lyceum*, *Capsella bursa pastorus*, *Chenopodium album*, *Cichorium intybus*, *Cirsium arvense*, *Colchicum lutuem*, *Convulvulus arvensis*, *Dacus carota*, *Fumaria indica*, *Gagea elegans*, *Galinsoga parviflora*, *Hypericum perforatum*, *Indigofera heteriantha*, *Juglans regia*, *Malus domestica*, *Medicago sativa*, *Myosotis arvensis*, *Nepeta salvifolia*, *Plantago lanceolata*, *Prunus domestica*, *Prunus persicae*, *Pyrus communis*, *Ranunculus arvensis*, *Robinia pseudoacacia*, *Rosa moschata*, *Salvia moorcraftiana*, *Taraxacum officinale*, *Trifolium pratense*, *Trifolium rapens* and *Veronica persicae* (Plate 1-7). The family Fabaceae and Asteracea were represented by 06 species of the flora each and had a collective share of 35 per cent. The family Rosaceae was represented by 05 species and had a share of 14 per cent in the flora. Ranunculaceae, Schrophulariaceae and Lamiacea families had a share of 6 per cent and were represented by 02 species, each. The family Sapindaceae, Brassicaceae, Amaranthaceae, Berberidaceae, Colchicaceae, Convulvulaceae, Apiaceae, Fumariaceae, Liliaceae, Hypericaceae, Juglandacea, Boraginaceae and Plantaginaceae were represented by single species each and had a share of 03 per cent each (Figure 1).

The data present in the table further reveals that with the onset of early spring, the flora started to bloom as early as the month of February. The species blooming in the month of February were *Anemone tschernjaewii*, *Colchicum lutuem* and *Gagea elegans*. This was followed by almond bloom in the month of march, and the species blooming in parallel were *Capsella bursa pastorus*, *Prunus domestica*, *Prunus persicae*, *Pyrus communis*, *Taraxacum officinale* and *Veronica persicae* also came into bloom. In the month of April, the species that started to bloom were *Astragalus grahamianus*, *Berberis lyceum*, *Cichorium intybus*, *Dacus carota*, *Galinsoga parviflora*, *Juglans regia*, *Malus domestica*, *Ranunculus arvensis* and *Rosa moschata*. The flora that began to flower in the month of May included *Ailanthus altissima*, *Aesculus indica*, *Anthimus cotula*, *Chenopodium album*, *Cirsium arvense*, *Convulvulus arvensis*, *Fumaria indica*, *Hypericum perforatum*, *Indigofera heteriantha*, *Myosotis arvensis*, *Nepeta salvifolia*, *Plantago lanceolata*, *Robinia pseudoacacia*, *Trifolium pratense* and *Trifolium rapens*. *Artimisia absinthum*, *Salvia moorcraftiana* and *Medicago sativa* started to flower in the month of June. The data further revealed that in the months of November, December and January, there was complete absence of any plant species in bloom in the almond orchards. The floral reward in the plant species included pollen as well as nectar and were visited by *Lasioglossum* bees, *Apis* bees, *Andrena* bees, bee flies as well as Syrphids.

Similar work has also been done by Adhikari and Ranabhat (2011) [1], Toopchi-Khosroshahi and Lotfalizadeh (2011) [13], Bhalchandra *et al*. (2014) [6], Degaga (2017) [7], Rijal *et al.* (2018) [12] and Jaiswal *et al.* (2018) [9] who have documented bee flora from different parts of world and India. Ara *et al.* (2019) [3] have documented bee flora from the Kashmir valley and the key difference between their work and the present work lies in the fact that present work tried to extend the flora from visited by honeybees only to visited by all insect pollinators. The present work focussed on arriving at the conclusion of sustenance available to insect pollinators before and after the almond bloom in Kashmir Karewas. Behera *et al*. (2014) [5] have carried out a unique study of documenting flora available to honey bees in dearth period so that it could be properly propagated and planted in extensive areas to help honeybees tide over unfavourable period of the year. Similarly, the identification of flora that sustain native insect pollinator populations is important in the fact that it can be further used to propagate, plant and conserve the plant species for sustaining dwindling populations of native insect pollinators.

Table 1: Insect pollinator flora available in and around almond orchards during 2020 and 2021

S. No.	*Scientific name*	English name/ Common name	Family	Period of Bloom	Award	Pollinator associated
1.	*Ailanthus altissima*	Tree of Heaven/Bohda	Scrophulariaceae	May-July	Pollen, Nectar	*Lasioglossum, Apis*
2.	*Aesculus indica Hook.*	Horse chestnut/Hani Doun	Sapindaceae	May-July	Pollen, Nectar	*Lasioglossum*, Syrphids, *Apis*
3.	*Anemone tschernjaewii*	Turkistan Anemone/ Tank-e-Bateyn	Ranunculaceae	February - March	Pollen, Nectar	*Lasioglossum, Apis, Andrena*
4.	*Anthimus cotula*	May weed Chamomile/Fukh gass	Asteraceae	May-October	Pollen	*Lasioglossum, Apis*
5.	*Artimisia absinthum*	Wormwood/Tethwen	Asteraceae	June- September	Pollen	*Lasioglossum*
6.	*Astragalus grahamianus*	Graham's Milk/Drabi kaeind/ Gagar kond/Kokar panji	Fabaceae	April-June	Nectar	*Anthophora*, Beeflies
7.	*Berberis lyceum*	Indian barberry/Kawdachh	Berberidaceae	April-May	Pollen, Nectar	*Apis*, Beeflies
8.	*Capsella bursa pastorus*	Shepherd's purse/Kralmund	Brassicaceae	March-June, September-October	Pollen, Nectar	*Andrena, Lasioglossum*
9.	*Chenopodium album*	Lamb's quarters/Kunah	Amaranthaceae	May-July, September –October	Pollen	*Lasioglossum, Apis*
10.	*Cichorium intybus*	Cichory/Kasni hand	Asteraceae	April-September	Pollen, Nectar	*Apis, Lasioglossum*
11.	*Cirsium arvense*	Creeping thistle/Kandij	Asteraceae	May-October	Nectar	*Apis*
12.	*Colchicum lutuem*	Yellow Colchicum/Virkim	Colchicaceae	February-April	Pollen, Nectar	*Apis*
13.	*Convulvulus arvensis*	Field bindweed/Threer	Convolvulaceae	May-October	Nectar	*Apis*, Syrphids
14.	*Dacus carota*	Wild carrot/Gazri gassa	Apiaceae	April-August	Pollen, Nectar	*Apis, Andrena,*
15.	*Fumaria indica*	Fumitory/ Shahteer	Fumariaceae	May-Oct	Pollen, Nectar	*Apis*, Syrphids
16.	*Gagea elegans*	Yellow Star of Bethlehem/ Ker gawl	Liliacea	February-March	Pollen, Nectar	*Apis, Andrena*
17.	*Galinsoga parviflora*	Quick weed/Gallant Soldier	Asteraceae	April-June, August-October	Pollen	*Apis, Lasioglossum*
18.	*Hypericum perforatum*	St. John's wort/Chai Ghaas	Hypericaceae	May-July	Pollen	*Apis, Lasioglossum*
19.	*Indigofera heteriantha*	Himalayan Indigo/Kaich	Fabaceae	May-September	Pollen, Nectar	*Apis, Anthophora*
20.	*Juglans regia*	Walnut/Doon	Juglandaceae	April	Pollen	*Lasioglossum*
21.	*Malus domestica*	Apple/Tschunth	Rosaceae	April-May	Pollen, Nectar	*Lasioglossum, Apis, Andrena,* Syrphids
22.	*Medicago sativa*	Lucerne/Alfalfa	Fabaceae	June- October	Pollen, Nectar	*Apis*
23.	*Myosotis arvensis*	Field forget me not/Tse'r gass	Boraginaceae	May-July	Pollen, Nectar	*Apis*
24.	*Nepeta salvifolia*	Salvia-Leaved Catmint/ Braid pudina	Lamiaceae	May-July	Pollen, Nectar	*Andrena, Apis*, Syrphids
25.	*Plantago lanceolata*	English plantain/ Lakut guli	Plantaginaceae	May-June, September-October	Pollen	*Lasioglossum*
26.	*Prunus domestica*	Plum/Aaer	Rosaceae	March-April	Pollen, Nectar	*Lasioglossum, Apis, Andrena,* Syrphids
27.	*Prunus persica*	Peach/Tschenan	Rosaceae	March-April	Pollen, Nectar	*Lasioglossum, Apis, Andrena,* Syrphids
28.	*Pyrus communis*	Pear/Tang	Rosaceae	March-April	Pollen, Nectar	*Lasioglossum, Apis, Andrena,* Syrphids
29.	*Ranunculus arvensis*	Buttercup/Chrim	Ranunculaceae	April-July, September-October	Pollen, Nectar	*Apis, Anthophora*
30.	*Robinia pseudoacacia*	Black Locust/Kikkar	Fabaceae	May	Nectar	*Apis*
31.	*Rosa moschata*	Musk Rose/Ban gulab	Rosaceae	April-June	Pollen, Nectar	*Apis*, Syrphids, *Lasioglossum*
32.	*Salvia moorcraftiana*	Kashmir salvia	Lamiaceae	June-October	Pollen, Nectar	*Apis, Anthophora*
33.	*Taraxacum officinale*	Common dandelion/Hand	Asteraceae	March-June, September-October	Pollen, Nectar	*Apis, Pieris*
34.	*Trifolium pratense*	Pink clover/ Bud'nej	Fabaceae	May-October	Pollen, Nectar	*Apis*, Syrphids
35.	*Trifolium rapens*	White clover/Tri'patur	Fabaceae	May-October	Pollen, Nectar	*Apis*, Syrphids
36.	*Veronica persicae*	Birds eye speedwell/Tsari gasa	Schrophulariaceae	March-June	Pollen, Nectar	*Apis, Lasioglossum*

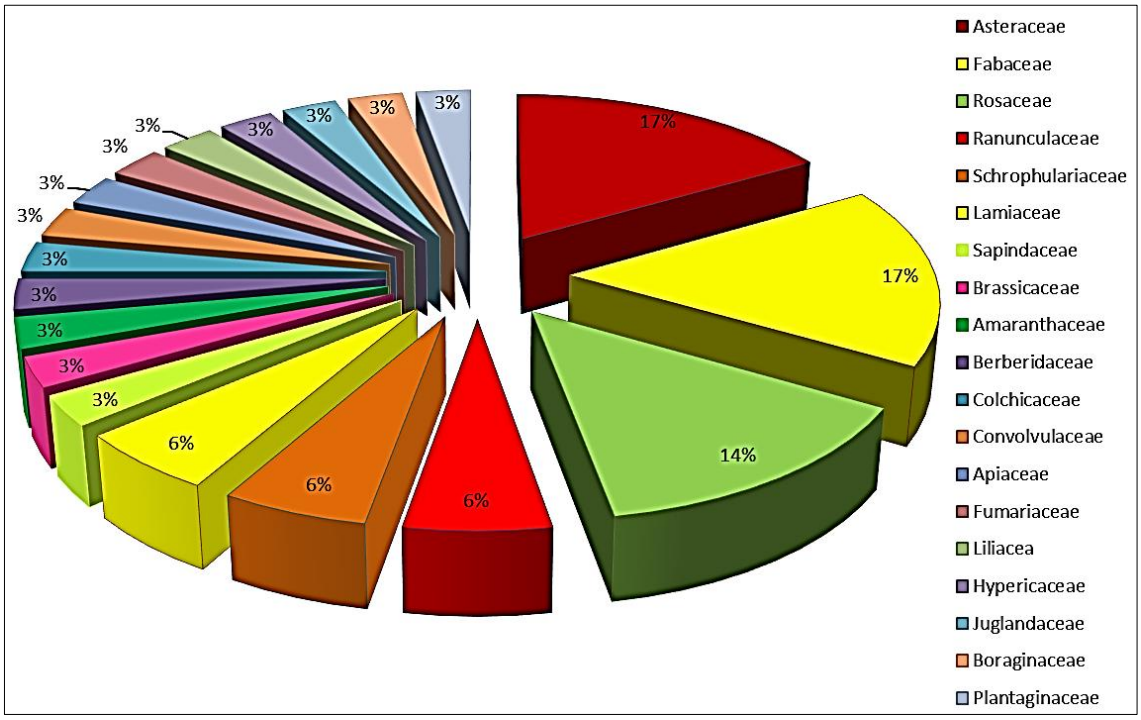

Fig 1: Relative percentage of families represented by the flora in almond orchards during 2020 and 2022

Plate 1: (a) & (c) *Anemone tschernjaewii* (b) & (d) *Colchicum lutuem*

Plate 2: (a) *Gagea elegans* (b) *Capsella bursa pastorus* (c) *Taraxacum officinale* (d) *Berberis lyceum* (e) *Cichorium intybus* (f) *Dacus carota*

Plate 3: (a) *Veronica persicae* (b) *Astragalus grahamianus* (c) *Juglans regia*

Plate 11: (a) *Galinsoga parviflora* (b) *Ailanthus altissima* (c) *Anthimus cotula*

Plate 12: (a) *Ranunculus arvensis* (b) *Chenopodium album* (c) *Rosa moschata* (d) *Cirsium arvense* (e) *Convulvulus arvensis* (f) *Fumaria indica*

Plate 13: (a) *Indigofera heteriantha* (b) *Myosotis arvensis* (c) *Medicago sativa*

Plate 14: (a) *Nepeta salvifolia* (b) *Plantago lanceolata* (c) *Artimisia absinthum* (d) *Trifolium rapens* (e) *Hypericum perforatum* (f) *Salvia moorcraftiana*

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