

VOLUME 11 ISSUE 2 2025

ISSN 2454 – 3055



**INTERNATIONAL
JOURNAL OF
ZOOLOGICAL
INVESTIGATIONS**

***Forum for Biological and
Environmental Sciences***

Published by Saran Publications, India



An Updated Checklist of Tri-Trophic Associations of Aphidophagous Arthropods in Different Districts of Uttarakhand, India

Singh Rajendra* and Srivastav Ajai K.

Department of Zoology, Deendayal Upadhyay Gorakhpur University, Gorakhpur 273 009, Uttar Pradesh, India

**Corresponding Author*

Received: 22nd September, 2025; **Accepted:** 22nd October, 2025; **Published online:** 30th October, 2025

<https://doi.org/10.33745/ijzi.2025.v11i02.079>

Abstract: Tritrophic associations among plants, aphids, and their natural enemies underpin ecological balance and biological control in agroecosystems. Plants support aphids, which damage hosts through sap feeding and virus transmission, while diverse predators such as coccinellids, lacewings, syrphids, spiders, mites, hemipteran bugs, earwigs, and thrips suppress aphid populations. Cataloguing these associations is essential for understanding biodiversity, food-web structure, and selecting effective natural enemies for integrated pest management. In Uttarakhand, 138 predator species across Arachnida and Insecta are documented preying on 101 aphid species from 101 host plants, forming 760 predator-prey-plant associations. Predatory groups include spiders (18 species), trombidiform mites, coccinellids (41 species), earwigs, dipterans (26 species), hemipteran bugs (14 species), lacewings (25 species), and thrips. The highest diversity is reported in districts of Garhwal, especially Uttarkashi. Key findings highlight the dominance of coccinellids and syrphids as aphid regulators, the overlooked but significant role of spiders and mites, and the ecological importance of lacewings (both Chrysopidae and Hemerobiidae). Earwigs and thrips provide supplementary control, while hemipteran bugs complement specialist predators. The catalogue demonstrates that some aphids such as *Aphis gossypii*, *Lipaphis erysimi*, and *Eriosoma lanigerum* attract the highest number of predators. Overall, the study establishes a regional baseline for predator-aphid-plant interactions in Uttarakhand, offering critical insights for biodiversity conservation, IPM design, and monitoring ecological shifts under climate change and agricultural intensification.

Keywords: Aphids, Biological control, Checklist, Aphidophagous arthropods, Predators, Tri-trophic association

Citation: Singh Rajendra and Srivastav Ajai K.: An updated checklist of tri-trophic associations of Aphidophagous Arthropods in different districts of Uttarakhand, India. Intern. J. Zool. Invest. 11(2): 810-826, 2025.

<https://doi.org/10.33745/ijzi.2025.v11i02.079>



This is an Open Access Article licensed under a Creative Commons License: Attribution 4.0 International (CC-BY). It allows unrestricted use of articles in any medium, reproduction and distribution by providing adequate credit to the author (s) and the source of publication.

Introduction

Tritrophic interactions in aphid systems encompass plants, aphids, and their natural enemies (predators and parasitoids). At the base level, plants act both as habitat and as the primary

food source for aphids, with their structural and chemical features influencing aphid density and distribution. Aphids, in turn, exploit these resources while also modifying plant physiology

through sap extraction and transmission of viral diseases. At the third level, aphidophagous arthropods, including ladybird beetles, lacewings, hoverfly larvae, predatory bugs, spiders, and parasitoid wasps, exert top-down pressure that regulates aphid populations, helping stabilize crop health and productivity (Singh and Singh, 2016). Additionally, plants indirectly influence these dynamics by emitting herbivore-induced volatiles that attract natural enemies, strengthening biological control mechanisms (Singh, 2003). Together, these multilayered interactions underpin natural pest regulation, where diverse predator and parasitoid guilds suppress aphid outbreaks without external interventions.

Aphids (Hemiptera: Aphididae) are small, soft-bodied insects that feed on plant phloem and are among the most damaging pest groups. In India, 794 species have been documented, with around 250 identified as major pests of agricultural and horticultural crops (Singh and Singh, 2016, 2019; Singh *et al.*, 2023a). Their remarkable ecological success is attributed to traits such as wide host adaptability, diverse reproductive modes, plastic developmental patterns, and pronounced polymorphism (Singh and Singh, 2022). Persistent sap feeding weakens plant vigour, distorts young shoots, and hampers overall growth. In addition, aphids are highly effective vectors of over 200 plant viruses, many of which are responsible for substantial yield losses across cropping systems (Singh and Singh, 2021).

Systematic documentation of tritrophic associations among aphidophagous arthropods, their aphid prey, and host plants is fundamental to both ecological research and applied pest management. Such catalogues not only capture the diversity of predators and parasitoids but also provide essential baselines for understanding the structural complexity of agroecosystems and natural habitats. By delineating predator-prey-plant linkages, they clarify ecological networks, identify keystone taxa, and inform the strategic deployment of natural enemies in augmentative and conservation biological control (Singh,

2025a). These inventories also function as critical references for detecting invasive pests, monitoring distributional shifts of natural enemies, and evaluating host-parasite dynamics under global environmental change (Singh, 2025b). Moreover, they contribute to agroecological management by guiding habitat interventions that enhance ecosystem services, while facilitating cross-regional comparisons to uncover biogeographical patterns and climatic drivers. Collectively, such catalogues establish a scientific framework that strengthens sustainable aphid management through integrated insights into biodiversity and ecosystem functioning (Sharma *et al.*, 2025).

This study provides a comprehensive checklist of tritrophic associations involving aphidophagous arthropods, their aphid prey, and host plants in Uttarakhand, India. The compilation establishes critical baseline data on species diversity, distribution, and host specificity, thereby supporting both ecological research and applied pest management. By detailing predator-prey-plant interactions, the checklist underscores key ecological linkages that contribute to the natural regulation of aphid populations. It also facilitates the identification of effective, ecologically compatible natural enemies for biological control, minimizing potential risks from non-native introductions. Furthermore, the resource informs the design of region-specific integrated pest management (IPM) programs and provides a framework for analyzing food-web structure, trophic networks, and biogeographical trends. Importantly, it enables the monitoring of shifts in species associations driven by climate change, agricultural intensification, and habitat alteration. Collectively, this checklist serves as an essential reference for researchers, practitioners, and policymakers committed to advancing sustainable pest management (Sharma *et al.*, 2025).

Materials and Methods

The present checklist of tritrophic associations of aphidophagous arthropods in Uttarakhand has been assembled from recently published books, peer-reviewed journals, authenticated theses, and

curated online databases up to 31 August 2025. Earlier literature, including some recent works, frequently contained inaccuracies in the scientific nomenclature of predators, aphids, and host plants, an issue largely attributable to the rapid pace of taxonomic revisions and the tendency to overlook updated references. Continuous research on predator-prey interactions further contributes new records, nomenclatural changes, and revised species statuses. To address these challenges, the current compilation standardizes aphid taxonomy in accordance with the Aphid Species File (<https://aphid.speciesfile.org>) and harmonizes host plant nomenclature following World Flora Online (<https://www.worldfloraonline.org>) and the Global Biodiversity Information Facility (<https://www.gbif.org>).

Results and Discussion

A review of available literature suggests that Rao (1969) was the first to report tritrophic associations in Uttarakhand, documenting four species of hover flies. This was followed by Agarwala *et al.* (1981), who recorded a ladybird species from Nainital district. Over the subsequent decade, additional records of ladybirds and hover flies preying on diverse aphid species across agricultural and horticultural crops of the Garhwal Himalaya were contributed by Ghosh *et al.* (1985, 1986, 1991), Debnath *et al.* (1988), Chakrabarti *et al.* (1990), and others. The first comprehensive faunistic survey of aphidophagous arthropods, their aphid prey, and host plants was undertaken by Debnath (1991). Subsequent contributions by Bhattacharya and Dey (2001), and Bisht *et al.* (2001, 2006) expanded these records with additional aphidophagous taxa from the region. These studies documented tritrophic associations involving 18 species of spiders, 8 species of mites, 41 species of coccinellids, 24 species of syrphids, 14 species of predatory bugs, 25 species of lacewings, and a single species of thrips, all preying on aphids infesting a wide range of economically important host plants across nearly all districts of Uttarakhand, India.

The data displayed in Table 1 revealed that a total of 135 species of predators are recorded to prey on 101 species of aphids infesting 101 species of host plants with 760 tri-trophic associations (predator-prey-plant, triplets) in all 13 districts of Uttarakhand. All the predators belong to two orders of class Arachnida, the order Araneae (7 families: Araneidae, Cheiracanthiidae, Clubionidae, Philodromidae, Salticidae, Theridiidae, and Thomisidae) and the order Trombidiformes (8 families: Anystidae, Bdellidae, Erythraeidae, Microtrombidiidae, Podothrombidiidae, Smarididae, Tetranychidae, and Trombidiidae); 6 orders of class Insecta: Coleoptera (family Coccinellidae), Dermaptera (family Forficulidae); Diptera (4 families: Anisopodidae, Asilidae, Chamaemyiidae, and Syrphidae); Hemiptera (4 families: Anthocoridae, Miridae, Nabidae, and Pentatomidae); Neuroptera (4 families: Chrysopidae, Coniopterygidae, Dilaridae, and Hemerobiidae); and Thysanoptera (family Phlaeothripidae). The majority of tri-trophic associations (triplets) of these aphid predators were recorded from 8 districts, mostly of Garhwal division of Uttarakhand. The maximum number of triplets were observed in Uttar Kashi (532 triplets) followed by Tehri Garhwal (178 triplets), Chamoli (153 triplets), Pauri Garhwal (114 triplets), Rudraprayag (81 triplets), Dehradun (68 triplets), Udham Singh Nagar (66 triplets), Bageshwar (50 triplets) and less than 50 triplets from rest of 5 districts (Fig. 1). Most the aphidophagous species in different districts are predatory on *Eriosoma lanigerum* on apple, *Lipaphis erysimi* and *Brevicoryne brassicae* on brassica crops, *Sitobion miscanthi* on wheat, *Macrosiphum rosae* and *Sitobion rosaeiformis* on roses and several species of aphids on mugworts and oak trees.

I. Class: Arachnida

A. Order: Araneae

The order Araneae comprises spiders, which are integral components of ecosystems, acting as natural predators that primarily consume insects and thereby regulate their populations (Singh *et*

Table 1: Number of species of predators belonging to different taxa preying on different number of aphid species infesting different number of host plant species and triplets in different number of districts in Uttarakhand

Order/Family of the aphidophagous predators	Number				
	Predator species	Aphid species	Plant species	Triplets	Districts
Arachnida: Araneae	18	28	26	70	5
Arachnida: Trombidiformes	8	18	14	22	7
Total Arachnida	26	42	35	92	9
Insecta: Coleoptera: Coccinellidae	41	66	73	337	13
Dermaptera: Forficulidae	2	13	12	15	3
Diptera: Asilidae	1	7	7	7	1
Diptera: Chamaemyiidae	1	11	10	11	4
Diptera: Syrphidae	24	52	57	194	12
Total Diptera	26	52	57	212	12
Hemiptera: Anthocoridae	9	16	16	33	6
Hemiptera: Miridae	3	4	4	4	1
Hemiptera: Nabidae	1	1	1	1	1
Hemiptera: Pentatomidae	1	1	1	1	1
Total Hemiptera	14	18	18	39	7
Neuroptera: Chrysopidae	19	28	22	51	9
Neuroptera: Coniopterygidae	1	1	1	1	1
Neuroptera: Dilaridae	1	2	2	2	1
Neuroptera: Hemerobiidae	4	9	8	10	5
Total Neuroptera	25	27	23	64	9
Thysanoptera: Phlaeothripidae	1	1	1	1	1
Total predators	135	101	101	760	13

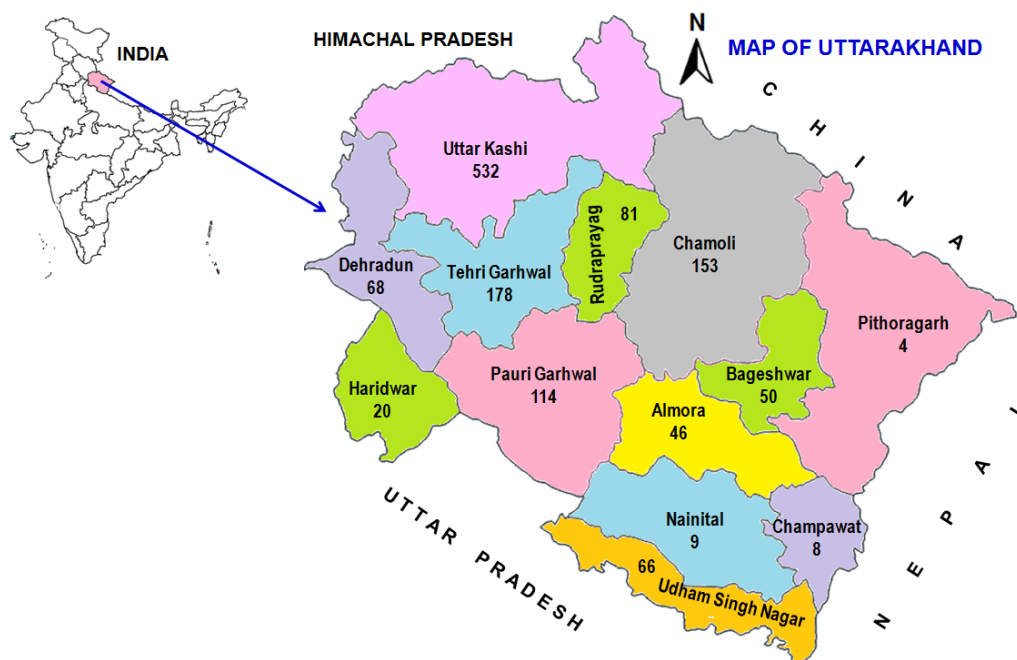


Fig. 1: Number of tri-trophic associations of aphidophagous arthropods in different districts of Uttarakhand.

Table 2: Number of species of araneid arachnid (siders) predators belonging to different families preying on different number of aphid species infesting different number of host plant species and triplets in different number of districts in Uttarakhand

Families	Species of predators	Number			
		Species of aphid	Species of host plant	Triplets	Districts
Araneidae	<i>Araniella nympha</i>	3	3	3	2
	<i>Neoscona elliptica</i>	1	1	1	1
	<i>Neoscona mukerjei</i>	2	2	2	2
	<i>Neoscona</i> spp.	8	8	8	2
Cheiracanthiidae	<i>Cheiracanthium</i> spp.	8	8	8	3
Clubionidae	<i>Clubiona</i> spp.	5	5	6	1
Philodromidae	<i>Tibellus</i> sp.	1	1	1	1
Salticidae	<i>Marpissa</i> spp.	11	9	11	4
	<i>Myrmarachne</i> sp.	2	2	2	1
	<i>Phidippus</i> spp.	1	1	1	1
	<i>Plexippus</i> spp.	2	2	2	1
	<i>Zygoballus</i> spp.	5	5	5	3
Theridiidae	<i>Argyrodes</i> spp.	2	2	2	1
	<i>Theridion</i> spp.	9	9	9	2
Thomisidae	<i>Henriksenia hilaris</i>	1	1	1	1
	<i>Indoxysticus minutus</i>	1	1	1	1
	<i>Xysticus bengalensis</i>	1	1	1	1
	<i>Xysticus</i> spp.	6	6	6	2
Total		28	26	70	5

al., 2023b). Despite their ecological importance, their potential as biological control agents has received comparatively little attention when compared with insect predators. Singh *et al.* (2024) recently documented 79 species of aphidophagous spiders in India, associated with 53 aphid species feeding on 59 host plants. However, as shown in Table 2, 18 species of spiders representing 7 families have thus far been reported as aphid predators in 5 districts of Uttarakhand, mostly in Uttar Kashi district (Debnath, 1991). These spiders were observed preying mostly on *Aphis kurosawai*, *Capitophorus formosartemisiae*, *Eriosoma lanigerum*, *Liosomaphis himalayensis*, *Melanaphis* nr. *arundinariae*, *Myzus dycei*, *Pemphigus mordwilkoii*, *Sitobion miscanthi* on *Artemisia vulgaris*, *Berberis aristata*, *otoneaster bacillaris*, *Lonicera quinquelocularis*, *Malus domestica*, *Populus ciliata*, *Prunus persica*, *Pyrus pashia* and *Triticum aestivum*. This indicates that research on aphidophagous spiders in Uttarakhand remains crop-limited, underscoring the necessity for extensive surveys to document their diversity

across other regions and cropping systems. Following is the tri-trophic associations of aphidophagous spiders in Uttarakhand.

i. Family: Araneidae

1. *Araniella nympha* (Simon, 1889)

- *Acyrtosiphon rubi* Narzikulov, 1957
- *Rubus ellipticus* Sm. - Uttar Kashi (Debnath, 1991)
- *Sitobion miscanthi* (Takahashi, 1921)
- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)
- *Tumoranuraphis indica* (Chakrabarti and Maity, 1984)
- *Prunus cornuta* (Wall. ex Royle) Steud. - Uttar Kashi (Debnath, 1991)

2. *Neoscona elliptica* Tikader and Bal, 1981

- *Myzus dycei* Carver, 1961
- *Urtica dioica* L. - Uttar Kashi (Debnath, 1991)

3. *Neoscona mukerjei* Tikader, 1980

- *Aphis kurosawai* Takahashi, 1921
- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)
- *Sitobion miscanthi* (Takahashi, 1921)
- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)

4. *Neoscona* spp.

- *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus persica* (L.) Batsch - Uttar Kashi (Debnath, 1991)
- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)
- *Liosomaphis himalayensis* Basu, 1964
- *Berberis aristata* DC. - Uttar Kashi (Debnath, 1991)
- *Lipaphis erysimi* (Kaltenbach, 1843)
- *Brassica rapa* L. - Uttar Kashi (Debnath, 1991)
- *Myzus dycei* Carver, 1961
- *Urtica dioica* L. - Uttar Kashi (Debnath, 1991)
- *Prociphilus* sp.
- *Lonicera quinquelocularis* Hardw. - Uttar Kashi (Debnath, 1991)
- *Sappaphis* sp.
- *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991)
- *Sitobion miscanthi* (Takahashi, 1921)
- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)

ii. Family: Cheiracanthiidae

1. *Cheiracanthium* spp.

- *Aphis clematidis* Koch, 1854
- *Clematis buchananiana* Wall. - Champawat (Debnath, 1991)
- *Eriosoma lanigerum* (Hausmann, 1802)

- *Malus domestica* (Suckow) Borkh. - Uttar Kashi (Debnath, 1991)
 - *Liosomaphis himalayensis* Basu, 1964
 - *Berberis aristata* DC. - Uttar Kashi (Debnath, 1991)
 - *Melanaphis nr. arundinariae* (Takahashi, 1937)
 - *Pyrus pashia* Buch.- Ham. ex D. Don - Uttar Kashi (Debnath, 1991)
 - *Pemphigus mordwilkoii* Cholodkovsky, 1912
 - *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)
 - *Prociphilus* sp.
 - *Lonicera quinquelocularis* Hardw. - Uttar Kashi (Debnath, 1991)
 - *Sappaphis* sp.
 - *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991)
 - *Sitobion miscanthi* (Takahashi, 1921)
 - *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)
- #### iii. Family: Clubionidae
- ##### 1. *Clubiona* spp.
- *Aspidophorodon indicum* (David, Rajasingh and Narayanan, 1972)
 - *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991)
 - *Brachycaudus helichrysi* (Kaltenbach, 1843)
 - *Erigeron bonariensis* L. - Uttar Kashi (Debnath, 1991)
 - *Prunus persica* (L.) Batsch - Uttar Kashi (Debnath, 1991)
 - *Prociphilus* sp.
 - *Lonicera quinquelocularis* Hardw. - Uttar Kashi (Debnath, 1991)
 - *Sappaphis* sp.
 - *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991)

- *Tumoranuraphis indica* (Chakrabarti and Maity, 1984)

- *Prunus cornuta* (Wall. ex Royle) Steud. - Uttar Kashi (Debnath, 1991)

iv. Family: Philodromidae

1. *Tibellus* sp.

- *Sitobion rosaeiformis* (Das, 1918)

- *Rosa* sp. - Uttar Kashi (Debnath, 1991)

v. Family: Salticidae

1. *Marpissa* spp.

- *Acyrtosiphon rubi* Narzikulov, 1957

- *Rubus ellipticus* Sm. - Uttar Kashi (Debnath, 1991)

- *Aphis kurosawai* Takahashi, 1921

- *Artemisia* sp. - Uttar Kashi (Debnath, 1991)

- *Chaitophorus kapuri* Hille Ris Lambers, 1966

- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)

- *Epipemphigus imaicus* (Cholodkovsky, 1912)

- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)

- *Eriosoma lanigerum* (Hausmann, 1802)

- *Malus domestica* (Suckow) Borkh. - Uttar Kashi (Debnath, 1991)

- *Liosomaphis himalayensis* Basu, 1964

- *Berberis aristata* DC. - Uttar Kashi (Debnath, 1991)

- *Lipaphis erysimi* (Kaltenbach, 1843)

- *Brassica rapa* L. - Uttar Kashi (Debnath, 1991)

- *Melanaphis* nr. *arundinariae* (Takahashi, 1937)

- *Pyrus pashia* Buch.- Ham. ex D. Don - Uttar Kashi (Debnath, 1991)

- *Mollitrachosiphum* sp.

- *Alnus nepalensis* D. Don - Chamoli (Debnath, 1991); Champawat (Debnath, 1991)

- *Pemphigus mordwilkoii* Cholodkovsky, 1912

- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)

- *Sitobion miscanthi* (Takahashi, 1921)

- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)

2. *Myrmarachne* sp.

- *Brachycaudus helichrysi* (Kaltenbach, 1843)

- *Erigeron bonariensis* L. - Uttar Kashi (Debnath, 1991)

- *Capitophorus formosartemisiae* (Takahashi, 1921)

- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)

3. *Phidippus* spp.

- *Sitobion miscanthi* (Takahashi, 1921)

- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)

4. *Plexippus* spp.

- *Brevicoryne brassicae* (Linnaeus, 1758)

- *Brassica rapa* L. - Uttar Kashi (Debnath, 1991)

- *Eriosoma lanigerum* (Hausmann, 1802)

- *Malus domestica* (Suckow) Borkh. - Uttar Kashi (Debnath, 1991)

5. *Zygoballus* spp.

- *Melanaphis* nr. *arundinariae* (Takahashi, 1937)

- *Pyrus pashia* Buch.- Ham. ex D. Don - Uttar Kashi (Debnath, 1991)

- *Mollitrachosiphum* sp.

- *Alnus nepalensis* D. Don - Chamoli (Debnath, 1991); Champawat (Debnath, 1991)

- *Myzus dycei* Carver, 1961

- *Urtica dioica* L. - Uttar Kashi (Debnath, 1991)

- *Pemphigus mordwilkoii* Cholodkovsky, 1912

- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)

- *Sappaphis* sp.

- *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi

(Debnath, 1991)

vi. Family: Theridiidae

1. *Argyrodus* spp.

- *Aphis verbasci* Schrank, 1801
- *Verbascum thapsus* L. - Uttar Kashi (Debnath, 1991)
- *Macrosiphoniella sanborni* (Gillette, 1908)
- *Chrysanthemum* sp. - Uttar Kashi (Debnath, 1991)

2. *Theridion* spp.

- *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus persica* (L.) Batsch - Uttar Kashi (Debnath, 1991)
- *Hayhurstia atriplicis* (Linnaeus, 1761)
- *Chenopodium album* L. - Uttar Kashi (Debnath, 1991)
- *Liosomaphis himalayensis* Basu, 1964
- *Berberis aristata* DC. - Uttar Kashi (Debnath, 1991)
- *Melanaphis* nr. *arundinariae* (Takahashi, 1937)
- *Pyrus pashia* Buch.- Ham. ex D. Don - Uttar Kashi (Debnath, 1991)
- *Myzus dycei* Carver, 1961
- *Urtica dioica* L. - Uttar Kashi (Debnath, 1991)
- *Pemphigus mordwilkoii* Cholodkovsky, 1912
- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)
- *Prociphilus* sp.
- *Lonicera quinquelocularis* Hardw. - Uttar Kashi (Debnath, 1991)
- *Sappaphis* sp.
- *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991)
- *Sitobion miscanthi* (Takahashi, 1921)
- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)

vii. Family: Thomisidae

1. *Henriksenia hilaris* (Thorell, 1877)

- *Aphis kurosawai* Takahashi, 1921
- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)

2. *Indoxysticus minutus* (Tikader, 1960)

- *Pterocallis affinis* Chakrabarti, 1988
- *Corylus colurna* L. - Uttar Kashi (Debnath, 1991)

3. *Xysticus bengalensis* Tikader and Biswas, 1974

- *Uroleucon sonchi* (Linnaeus, 1767)
- *Sonchus arvensis* L. - Uttar Kashi (Debnath, 1991)

4. *Xysticus* spp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)
- *Cavariella indica* Maity and Chakrabarti, 1982
- *Salix babylonica* L. - Uttar Kashi (Debnath, 1991)
- *Eriosoma lanigerum* (Hausmann, 1802)
- *Malus domestica* (Suckow) Borkh. - Uttar Kashi (Debnath, 1991)
- *Liosomaphis himalayensis* Basu, 1964
- *Berberis aristata* DC. - Uttar Kashi (Debnath, 1991)
- *Prociphilus* sp.
- *Pinus wallichiana* A.B. Jacks. - Uttar Kashi (Debnath, 1991)

• *Sitobion miscanthi* (Takahashi, 1921)

- *Triticum aestivum* L. - Almora (Debnath, 1991); Uttar Kashi (Debnath, 1991)

Unidentified

• *Aphis gossypii* Glover, 1877

- *Abelmoschus esculentus* Moench - Udham Singh Nagar (Bhatt and Karnatak, 2018)

B. Order: Trombidiformes

Aphidophagous Trombidiformes, particularly velvet mites (Trombididae), play a hitherto

Table 3: Number of species of mites (Trombidiformes) belonging to different families preying on different number of aphid species infesting different number of host plant species and triplets in different number of districts in Uttarakhand

Families	Species of predators	Number			
		Species of aphid	Species of host plant	Triplets	Districts
Anystidae	<i>Anystis</i> sp.	4	4	4	2
Bdellidae	<i>Bdella</i> sp.	1	1	1	1
Erythraeidae	<i>Abrolophus</i> sp.	2	1	2	1
Microtrombidiidae	<i>Enemothrombium</i> sp.	2	1	2	1
Podothrombiidae	<i>Podothrombium</i> sp.	9	8	9	6
Smarididae	<i>Fessonina</i> sp.	2	2	2	2
Tetranychidae	<i>Eutetranychus</i> sp.	1	1	1	1
Trombidiidae	<i>Allothrombium</i> sp.	1	1	1	1
Total		18	14	22	7

underappreciated, but real role in natural control of aphids through a combination of larval ectoparasitism and adult predation. They contribute especially during early season population build-up and in less intensively managed or more natural habitats. To leverage their potential in biological control (conservation or augmentative), more focused studies are needed on their taxonomy, biology, ecology, effectiveness in field conditions, and compatibility with other control agents and management practices (Felska *et al.*, 2018). Eight families of these mites parasitise/consume 18 species of aphids in 7 districts of Uttarakhand are reported only by Debnath (1991) and Ghosh *et al.* (1991). All are poorly identified, only upto generic level and very poorly known as aphidophagous. Only *Podothrombium* sp. is polyphagous distributed in 6 districts (Table 3).

Following is the tri-trophic associations of velvet mites in Uttarakhand.

i. Family: Anystidae

1. *Anystis* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)
- *Eriolophium takahashii* (Ghosh, 1969)

- *Rhododendron* sp. - Chamoli (Debnath, 1991)

- *Eumyzus* sp.

- *Gnaphalium* sp. - Uttar Kashi (Debnath, 1991)

- *Mollitrichosiphum nandii* Basu, 1964

- *Alnus nepalensis* D. Don - Chamoli (Debnath, 1991)

ii. Family: Bdellidae

1. *Bdella* sp.

- *Eumyzus* sp.

- *Gnaphalium* sp. - Uttar Kashi (Debnath, 1991)

iii. Family: Erythraeidae

1. *Abrolophus* sp.

- *Mollitrichosiphum montanum* (van der Goot, 1917)

- *Alnus nepalensis* D. Don - Chamoli (Debnath, 1991)

- *Mollitrichosiphum nandii* Basu, 1964

- *Alnus nepalensis* D. Don - Chamoli (Debnath, 1991)

iv. Family: Microtrombidiidae

1. *Enemothrombium* sp.

- *Eutrichosiphum khasyanum* (Ghosh and Raychaudhuri, 1962)

- *Quercus* sp. - Chamoli (Debnath, 1991)
- *Lachnus acutihitsutus* Kumar and Burkhardt, 1970
- *Quercus* sp. - Chamoli (Debnath, 1991)

v. Family: Podothrombiidae

1. *Podothrombium* sp.

- *Aphis* sp.
- *Dipsacus* sp. - Pithoragarh (Debnath, 1991)
- *Aphis verbasci* Schrank, 1801
- *Verbascum thapsus* L. - Tehri Garhwal (Debnath, 1991)
- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Saussurea albescens* Hook.f. and Thoms - Pithoragarh (Debnath, 1991)
- *Macromyzus woodwardiae* (Takahashi, 1921)
- *Cnicus* sp. - Nainital (Debnath, 1991)
- *Macrosiphoniella pseudoartemisiae* Shinji, 1933
- *Artemisia* sp. - Bageshwar (Debnath, 1991)
- *Myzackaia verbasci* (Chowdhuri, Basu, Chakrabarti and Raychaudhuri, 1969)
- *Artemisia* sp. - Uttar Kashi (Debnath, 1991)
- *Myzus* sp.
- *Boenninghausenia albiflora* (Hook.) Rchb. ex Meisn. - Almora (Debnath, 1991)
- *Oedisiphum* sp.
- *Senecio chrysanthemoides* Schrank, 1789 - Pithoragarh (Debnath, 1991)
- *Uroleucon lactucicola* (Strand, 1928)
- *Solidago virgaurea* L. - Tehri Garhwal (Debnath, 1991)

vi. Family: Smarididae

1. *Fessonina* sp.

- *Lachnus acutihitsutus* Kumar and Burkhardt, 1970
- *Quercus* sp. - Chamoli (Debnath, 1991)

- *Lachnus* sp.

- *Salix babylonica* L. - Uttar Kashi (Debnath, 1991)

vii. Family: Tetranychidae

1. *Eutetranychus* sp.

- *Chaitophorus kapuri* Hille Ris Lambers, 1966
- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)

viii. Family: Trombidiidae

1. *Allothrombium* sp.

- *Lachnus* sp.
- *Salix babylonica* L. - Uttar Kashi (Debnath, 1991)

II. Class: Insect

A. Order: Coleoptera

i. Family: Coccinellidae

Coccinellidae, commonly referred to as ladybird beetles, are among the most prominent groups of predatory insects, functioning as key natural enemies of agricultural pests. Both larval and adult stages actively prey upon a variety of soft-bodied insects, particularly aphids, mealybugs, scales, whiteflies, and mites (Singh, 2025a). Through the suppression of these pest populations, coccinellids contribute significantly to the protection of cereals, vegetables, fruits, and oilseed crops. Recently, Singh (2025c) enlisted tri-trophic associations of aphidophagous coccinellids of Uttarakhand and listed 41 species (including those identified up to generic level) of ladybird beetles feeding on 66 aphid species infesting 73 plant species, amounting to 337 predator-prey-host plant associations (triplets) distributed across all districts of Uttarakhand. The highest number of associations has been documented from Uttar Kashi (205 triplets), followed by Udham Singh Nagar (53 triplets), Tehri Garhwal (37 triplets), Dehradun (31 triplets), and Bageshwar (23 triplets), while fewer than 20 triplets were noted in remaining 8 districts (Singh, 2025c).

B. Order: Dermaptera

i. Family: Forficulidae

Members of earwig family Forficulidae, particularly *Forficula auricularia*, are omnivorous insects that feed on plant material, other insects, and soft-bodied arthropods such as aphids. Molecular studies have confirmed their aphid predation in the field, including early-season feeding when aphids are scarce. Field trials in Mediterranean citrus and Spanish apple orchards have shown that augmentative releases of earwigs can reduce aphid colonies, such as *Eriosoma lanigerum*, over successive years (Romeu-Dalmau *et al.*, 2012; Alins *et al.*, 2023). Similarly, in African cowpea fields, earwigs consumed *Aphis craccivora* under laboratory and field conditions, contributing measurably to aphid control. Their generalist diet allows them to persist even at low aphid densities and exert early predation pressure, slowing aphid population growth (Manyuli *et al.*, 2008). While not highly specialised, earwigs can complement other predators and parasitoids within multi-species trophic networks, although interactions with ants may affect their efficiency. Predation levels are moderate compared to specialist enemies, and their effectiveness depends on environmental conditions, prey availability, and release strategies. Additionally, they can occasionally damage plants when prey is scarce, indicating both potential and limitations in their role as biological control agents. Other than Uttarakhand, aphidophagous Forficulidae, particularly, *Forficula auricularia* was observed preying on *Eriosoma lanigerum* in Himachal Pradesh infesting European crab apple, *Malus sylvestris* (Thakur *et al.*, 1988) and *Aphis craccivora* in Odisha (Dwibedy *et al.*, 2018) and Telangana (Latha *et al.*, 2022) feeding on mung bean (*Vigna radiata*) and peanut (*Arachis hypogaea*), respectively. In Uttarakhand, two species of earwigs are recorded as aphidophagous on 13 species of aphids infesting 12 species of plants only in 3 districts of Garhwal Himalaya (Table 1).

Following is the detailed account of tri-trophic associations of aphidophagous earwigs in Uttarakhand.

1. *Forficula auricularia* Linnaeus, 1758

- *Eriosoma lanigerum* (Hausmann, 1802)

- *Malus domestica* (Suckow) Borkh. - Pauri Garhwal (Maurya, 2011)

2. *Forficula beelzebub* (Burr, 1900)

- *Aphis kurosawai* Takahashi, 1921

- *Artemisia vulgaris* L. - Uttar Kashi (Debnath, 1991)

- *Epipemphigus imaicus* (Cholodkovsky, 1912)

- *Populus ciliata* Wall. ex Royle - Tehri Garhwal (Bisht *et al.*, 2001); Uttar Kashi (Debnath, 1991)

- *Hydaphis* sp.

- *Lonicera alpigena* L. - Pauri Garhwal (Debnath, 1991)

- *Lachnus* sp.

- *Quercus* sp. - Chamoli (Debnath, 1991)

- *Liosomaphis himalayensis* Basu, 1964

- *Berberis aristata* DC. - Uttar Kashi (Debnath, 1991)

- *Melanaphis* nr. *arundinariae* (Takahashi, 1937)

- *Pyrus pashia* Buch.- Ham. ex D. Don - Uttar Kashi (Debnath, 1991)

- *Mollitrachosiphum* sp.

- *Alnus nepalensis* D. Don - Uttar Kashi (Debnath, 1991)

- *Pemphigus mordwilkoii* Cholodkovsky, 1912

- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Debnath, 1991)

- *Prociphilus* sp.

- *Lonicera quinquelocularis* Hardw. - Uttar Kashi (Debnath, 1991)

- *Rhopalosiphum maidis* (Fitch, 1856)

- *Triticum aestivum* L. - Uttar Kashi (Debnath, 1991)

- *Zea mays* L. - Uttar Kashi (Debnath, 1991)

- *Sappaphis* sp.

- *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991)

• *Sitobion miscanthi* (Takahashi, 1921)

- *Triticum aestivum* L. - Uttar Kashi (Debnath, 1991)

C. Order: Diptera

Members of four families of Diptera have been recorded as aphidophagous in Uttarakhand: Anisopodidae, Asilidae, Chamaemyiidae and Syrphidae. Sharma *et al.* (2006) recorded *Olbiogaster* sp. of Anisopodidae feeding on *Aphis aurantii* on *Camellia sinensis* in Dehradun. However, the larvae of anisopodids are not aphidophagous, instead, they are saprophagous or detritivorous and their adults are pollen feeder like hover flies (Marchiori, 2023). Hence, the record is excluded from this checklist. A total of 28 species of aphidophagous flies were recorded preying on 52 species of aphids infesting 57 species of plants, mostly agricultural and horticultural crops with 216 tri-trophic associations in 12 districts of Uttarakhand. The tri-trophic associations of these flies are recently listed by Singh and Omkar (2025).

D. Order: Hemiptera

Hemipteran predators, commonly called as bugs, mainly from families such as Anthocoridae, Geocoridae, Miridae, Pentatomidae, Reduviidae, and Nabidae, are important aphidophagous arthropods contributing to natural aphid control. Both nymphs and adults actively prey on aphids using piercing-sucking mouthparts, reducing infestations in cereals, vegetables, legumes, and orchards (Singh and Srivastav, 2024). Their generalist feeding habits, mobility, and ability to act early in infestations make them valuable components of integrated pest management, complementing other predators like coccinellids, lacewings and syrphids (Singh, 2025a; Singh, 2026a, b; Singh *et al.*, 2024). A total of 14 species of aphidophagous bugs belonging to 4 families were recorded preying on 18 species of aphids infesting 18 species of plants, mostly agricultural and horticultural crops with 39 tri-trophic

associations in 7 districts of Uttarakhand (Table 1). A detailed account of aphidophagy of these families is given below.

i. Family: Anthocoridae

The Anthocoridae, or minute pirate bugs, are a globally distributed family of Hemiptera, mostly predatory on soft-bodied arthropods like aphids, thrips, mites, and caterpillars, both as nymphs and adults. Recognized as effective biocontrol agents, several species are commercially used in Europe for pest management in greenhouses and fields (Ballal and Yamada, 2016). In India, research has emphasized documenting anthocorid diversity, their prey range, and evaluating indigenous species. The ICAR-NBAIR, Bangalore, has developed mass-rearing methods and field-tested promising species for use in biological control (Ballal and Yamada, 2016). In Uttarakhand, a total of 9 species of aphidophagous anthocorids were recorded preying on 16 species of aphids infesting 16 species of plants, mostly horticultural crops with 33 tri-trophic associations in 6 districts of Uttarakhand (Table 4). A detailed account of aphidophagy of these bugs is given below.

1. *Anthocoris confusus* Reuter, 1884

• *Brachycaudus helichrysi* (Kaltenbach, 1843)

- *Prunus amygdalus* Batsch - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Eriosoma lanigerum* (Hausmann, 1802)

- *Malus domestica* (Suckow) Borkh. - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Melanaphis nr. arundinariae* (Takahashi, 1937)

- *Pyrus pashia* Buch.- Ham. ex D. Don - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Myzus dycei* Carver, 1961

- *Urtica dioica* L. - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

Table 4: Number of species of aphidophagous Hemiptera belonging to different families preying on different number of aphid species infesting different number of host plant species and triplets in different number of districts in Uttarakhand

Families	Species of predators	Number			
		Species of aphid	Species of host plant	Triplets	Districts
Anthocoridae	<i>Anthocoris confusus</i>	8	8	8	3
	<i>Anthocoris minki pistaciae</i>	5	6	9	4
	<i>Anthocoris</i> nr. <i>pilosus</i>	1	1	1	1
	<i>Anthocoris</i> sp.	1	1	1	1
	<i>Ectemna</i> sp.	1	1	1	2
	<i>Orius bifilarus</i>	2	2	2	1
	<i>Orius niger</i>	4	4	4	1
	<i>Orius</i> spp.	4	4	4	3
	<i>Xylocoris flavipes</i>	3	2	3	2
	Subtotal	16	16	33	6
Miridae	<i>Deraeocoris</i> sp.	1	1	1	1
	<i>Lygus</i> sp.	1	1	1	1
	<i>Psallus</i> sp.	2	2	2	1
Subtotal		4	4	4	1
Nabidae	<i>Nabis capsiformis</i>	1	1	1	1
Pentatomidae	<i>Eocanthecona</i> sp.	1	1	1	1
Total		18	18	39	7

• *Myzus sorbi* Bhattacharya and Chakrabarti, 1982
 - *Sorbaria tomentosa* (Lindl.) Rehder - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Pemphigus mordwilkoii* Cholodkovsky, 1912

- *Populus ciliata* Wall. ex Royle - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Prociphilus* sp.

- *Lonicera quinquelocularis* Hardw. - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Sappaphis* sp.

- *Cotoneaster bacillaris* Wall. ex Lindl. - Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

2. *Anthocoris minki pistaciae* Wagner, 1957

• *Brachycaudus helichrysi* (Kaltenbach, 1843)-
Prunus domestica L. - Uttar Kashi (Debnath, 1991)

- *Prunus persica* (L.) Batsch - Uttar Kashi (Debnath, 1991)

- *Prunus domestica* L. - Bageshwar (Ghosh *et al.*, 1986); Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986)

- *Prunus persica* (L.) Batsch - Bageshwar (Ghosh *et al.*, 1986); Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986)

• *Eumyzus pruni* Chakrabarti and Bhattacharya, 1985

- *Prunus cornuta* (Wall. ex Royle) Steud. - Uttar Kashi (Debnath, 1991); Bageshwar (Ghosh *et al.*, 1986); Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986)

• *Myzus sorbi* Bhattacharya and Chakrabarti, 1982

- *Sorbaria tomentosa* (Lindl.) Rehder - Chamoli (Debnath, 1991); Bageshwar (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Ghosh *et al.*, 1986)

• *Prociphilus* sp.

- *Lonicera quinquelocularis* Hardw. - Uttar Kashi (Debnath, 1991); Bageshwar (Ghosh *et al.*, 1986); Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986)

- *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Debnath, 1991); Bageshwar (Ghosh *et al.*, 1986); Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986)

• *Tumoranuraphis indica* (Chakrabarti and Maity, 1984)

- *Prunus cornuta* (Wall. ex Royle) Steud. - Uttar Kashi (Debnath, 1991); Bageshwar (Ghosh *et al.*, 1986); Chamoli (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986)

3. *Anthocoris* nr. *pilosus* (Jakovlev, 1877)

• *Brachycaudus helichrysi* (Kaltenbach, 1843)

- *Prunus persica* (L.) Batsch - Uttar Kashi (Ghosh *et al.*, 1986)

4. *Anthocoris* sp.

• *Eriosoma lanigerum* (Hausmann, 1802)

- *Malus domestica* (Suckow) Borkh. - Pauri Garhwal (Maurya, 2011)

5. *Ectemna* sp.

• *Epipemphigus imaicus* (Cholodkovsky, 1912)

- *Populus ciliata* Wall. ex Royle - Chamoli (Ghosh *et al.*, 1986; Debnath, 1991); Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

6. *Orius bifilarus* Ghauri, 1972

• *Eumyzus prunicolus* Medda and Chakrabarti, 1986

- *Prunus padus* L. - Bageshwar (Debnath, 1991)

• *Taoia indica* (Ghosh and Raychaudhuri, 1972)

- *Alnus nepalensis* D. Don - Uttar Kashi (Ghosh *et al.*, 1986)

7. *Orius niger* (Wolff, 1811)

• *Capitophorus formosartemisiae* (Takahashi, 1921)

- *Artemisia vulgaris* L. - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

• *Myzus dycei* Carver, 1961

- *Urtica dioica* L. - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

• *Pemphigus mordwilkoii* Cholodkovsky, 1912

- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

• *Sappaphis* sp.

- *Cotoneaster bacillaris* Wall. ex Lindl. - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

8. *Orius* spp.

• *Brachycaudus helichrysi* (Kaltenbach, 1843)

- *Cirsium wallichii* DC. - Bageshwar (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Debnath, 1991)

• *Hayhurstia atriplicis* (Linnaeus, 1761)

- *Chenopodium album* L. - Bageshwar (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Debnath, 1991)

• *Myzus dycei* Carver, 1961

- *Urtica dioica* L. - Bageshwar (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Debnath, 1991)

• *Sappaphis* sp.

- *Cotoneaster bacillaris* Wall. ex Lindl. - Bageshwar (Ghosh *et al.*, 1986); Pauri Garhwal (Ghosh *et al.*, 1986); Uttar Kashi (Debnath, 1991)

9. *Xylocoris flavipes* (Reuter, 1875)

• *Pemphigus dorocola* Matsumura, 1917

- *Populus ciliata* Wall. ex Royle - Almora (Ghosh *et al.*, 1986; Debnath, 1991)

• *Pemphigus mordwilkoii* Cholodkovsky, 1912

- *Populus ciliata* Wall. ex Royle - Almora (Ghosh *et al.*, 1986; Debnath, 1991); Nainital (Ghosh *et al.*, 1986; Debnath, 1991)

• *Sappaphis* sp.

- *Cotoneaster bacillaris* Wall. ex Lindl. - Almora (Ghosh *et al.*, 1986; Debnath, 1991)

ii. Family: Miridae

The Miridae is the largest family of Heteroptera and includes herbivorous, predatory, and zoophytophagous species of major economic importance. Most are generalist predators of soft-bodied insects such as aphids, thrips, mites, and caterpillars, similar to anthocorids (Singh and Srivastav, 2024). While some species have been evaluated for aphid control in crops like sweet pepper abroad (Messelink *et al.*, 2015), no such studies have been conducted in India. So far, only 3 mirid species have been documented preying on 4 aphid species in Uttar Kashi district of Uttarakhand as mentioned below.

1. *Deraeocoris* sp.

- *Pemphigus mordwilko*i Cholodkovsky, 1912
- *Populus ciliata* Wall. ex Royle - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

2. *Lygus* sp.

- *Myzus sorbi* Bhattacharya and Chakrabarti, 1982
- *Artemisia* sp. - Uttarkashi (Debnath, 1991)
- *Sorbaria tomentosa* (Lindl.) Rehder - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

3. *Psallus* sp.

- *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus persica* (L.) Batsch - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)
- *Macrosiphoniella pseudoartemisiae* Shinji, 1933
- *Artemisia vulgaris* L. - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

iii. Family: Nabidae

The family Nabidae, commonly referred to as damsel bugs, represents a small group within the Heteroptera. Members of this family are polyphagous, feeding as herbivores, predators, or both, similar to plant bugs. They mainly attack leafhoppers at all developmental stages and also

prey on various economically significant aphid species (Singh and Srivastav, 2024). However, due to their broad feeding habits, nabids are considered less efficient as specialised natural enemies of particular prey compared to species-specific predators (Lattin, 1989). In India, only one species from this family has been reported as aphidophagous, recorded from Uttar Kashi district in Uttarakhand as follow:

1. *Nabis capsiformis* Germar, 1838

- *Sitobion miscanthi* (Takahashi, 1921)
- *Triticum aestivum* L. - Uttar Kashi (Ghosh *et al.*, 1986; Debnath, 1991)

iv. Family: Pentatomidae

Pentatomidae, commonly known as shield or stink bugs, is a large family in which most species are major crop pests, though some are predatory. In India, only one species, *Eocanthecona furcellata* (Wolff), a generalist predator of many agricultural, horticultural, and forest pests (Halder *et al.*, 2020). In Uttarakhand, only a single species was recorded in Udham Singh Nagar district as follow:

1. *Eocanthecona* sp.

- *Aphis gossypii* Glover, 1877
- *Abelmoschus esculentus* Moench - Udham Singh Nagar (Bhatt and Karnatak, 2018)

E. Order: Neuroptera

Neuroptera, comprising lacewings, mantidflies, and antlions, is a globally distributed order with predominantly carnivorous members, many of which prey on soft-bodied insects such as aphids. In India, aphidophagy has been reported in larvae of four families—Chrysopidae, Coniopterygidae, Dilaridae, and Hemerobiidae. Among these, green lacewings (Chrysopidae) and brown lacewings (Hemerobiidae) are particularly important in agroecosystems, where they contribute to natural pest suppression (Singh *et al.*, 2024). While larval Chrysopidae and both larval and adult Hemerobiidae are effective aphid predators, their ecological role has received comparatively less attention than that of syrphids and coccinellids.

Recently, Singh and Omkar (2025) enlisted tri-trophic associations of a total of 25 species of lacewings preying on 27 species of aphids infesting 23 species of host plants with 59 tri-trophic associations across 9 districts of Uttarakhand.

F. Order: Thysanoptera

i. Family: Phlaeothripidae

The members of the family Phlaeothripidae are primarily phytophages, but few species of the genus *Haplothrips* are aphidophagous on cereal aphids (Lewis, 1973). Although less efficient than syrphids, coccinellids, or lacewings, their presence in wheat and barley ecosystems provides supplementary regulation of aphids, contributing to integrated pest management. In Uttarakhand only an unidentified species of *Haplothrips* was recorded in Tehri Garhwal as mentioned below:

1. *Haplothrips* sp.

- *Epipemphigus imaicus* (Cholodkovsky, 1912)

- *Populus ciliata* Wall. ex Royle - Tehri Garhwal (Bisht *et al.*, 2001)

Ethical Statement

No animal or microbes have been used or sacrificed for this study, hence Ethical Approval not required.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

References

Agarwala BK, Ghosh D, Das SK, Poddar SC and Raychaudhuri DN. (1981) Parasites and predators of aphids (Homoptera: Aphididae) from India. V. New records of two aphidiid parasites, nine arachnids and one dipteran predator from India. Entomon 6(3): 233-238.

Alins G, Lordan J, Rodríguez-Gasol N, Arnó J and

Peñalver-Cruz A. (2023) Earwig releases provide accumulative biological control of the woolly apple aphid over the years. Insects 14(11): 890.

Ballal CR and Yamada K. (2016) Anthocorid predators. In: Ecofriendly Pest Management for Food Security (ed.) Omkar, Academic Press, pp. 183-216.

Bhatt B and Karnatak AK. (2018) Population dynamics of sucking pests and their predators on okra agroecosystem. J Entomol Zool Stud. 6(2): 1289.

Bhattacharya DK and Dey S. (2001) Biodiversity of Neuroptera associated with aphids of western Himalaya. Entomon 26(spl. Issue): 320-325.

Bisht RS, Rana DS and Mishra PN. (2001) Bio-ecology of predators and parasitoids of aphids in Garhwal Hills. J Aphidol. 15: 123-128.

Bisht RS, Sharma RK and Dev P. (2006) Vertical distribution and activity of aphidophagous syrphids (Diptera: Syrphidae) in Garhwal Himalayas. J Aphidol. 20: 25-29.

Chakrabarti S, Ghosh D and Debnath N. (1990) Hymenopteran parasitoids of aphidophagous dipteran in western Himalaya, India. J Aphidol. 4: 1-5.

Debnath N. (1991) Studies on some aphidophagous insects in northwest and western Himalayas. Ph.D. thesis, University of Kalyani, India.

Debnath N, Ghosh D and Chakrabarti S. (1988) Predators and parasites of aphids from northwest and western Himalaya. II. Records of eight aphidophagous neuropterans (Insecta) from India. Entomon 13: 137-139.

Dwibedy SK, Swain T and Pattnaik G. (2018) Entomofauna assessment of *Vigna radiata* agroecosystem of eastern Odisha, India. J Entomol Zool Stud. 6(3): 910-924

Felska M, Wohltmann A and Mąkol J. (2018) A synopsis of host-parasite associations between Trombidioidea (Trombidiformes: Prostigmata, Parasitengona) and arthropod hosts. Syst Appl Acarol. 23: 137501479.

Ghosh D, Debnath N and Chakrabarti S. (1985) Predators and parasites of aphids (Homoptera: Aphididae) from northwest Himalaya: ten species of syrphids (Diptera: Syrphidae) from Garhwal range. Entomon 10: 301-303.

Ghosh D, Debnath N and Chakrabarti S. (1991) Predators and parasites of aphids from north west and western Himalaya III. Twenty five species of coccinellidae (Coleoptera: Insecta) from Garhwal and Kumaon ranges. Rec Zool Surv India 88(2): 177-188.

Ghosh D, Debnath N and Chakrabarti S. (1986) Predators and parasites of aphids from northwest and western Himalaya. IV. Twelve species of

- heteropterans (Heteroptera: Insecta) from Garhwal and Kumaon ranges. *Proc Zool Soc Calcutta* 39: 15.
- Halder J, Rai AB, Chakrabarti S and Dey D. (2020) Distribution, host range and bionomics of *Rhopalosiphum nymphaeae* (Linnaeus, 1761), a polyphagous aphid in aquatic vegetables. *Def Life Sci J*. 5(1): 49-53.
- Latha ES, Prasanna US and Rajan SJ. (2022) Major insect pests and their natural enemy biodiversity in ecological engineering groundnut (*Arachis hypogaea* L.) crop. *Biol Forum – An Int J*. 14(4a): 445-448.
- Lewis T. (1973) Thrips: Their biology, ecology and economic importance. Academic Press, London.
- Manyuli T, Kyamanywa S and Luther GC. (2008) Capability of *Forficula auricularia* Linnaeus (Dermaptera: Forficulidae) to prey on *Aphis craccivora* Koch (Homoptera: Aphididae) in eastern and central Africa. *Agron Afric*. 20(1): 49-58.
- Marchiori CH. (2023) The characteristics of the families Anisopodidae and Mycetophilidae (Insecta: Diptera). *Int J Life Sci Res Arch*. 5(2): 96-108.
- Maurya RP. (2011) Natural enemies of apple woolly aphid, *Eriosoma lanigerum* Hausmann and their population dynamics in a mid hill apple orchard. *Indian J Ent*. 73(1): 15-18.
- Messelink GJ, Bloemhard CMJ, Hoogerbrugge H, Schelt J, Ingegno BL and Tavelle L. (2015) Evaluation of mirid predatory bugs and release strategy for aphid control in sweet pepper. *J Appl Ent*. 139(5): 333-341.
- Rao VP. (1969) Survey of natural enemies of aphids in India. Final Report of the Commonwealth Institute of Biological Control 480: 1-93.
- Romeu-Dalmau C, Piñol J and Agustí N. (2012) Detecting aphid predation by earwigs in organic citrus orchards using molecular markers. *Bull Ent Res*. 102(5): 566-572.
- Sharma A, Acharya S and Singh R. (2025) Checklist of tri-trophic associations of aphidophagous predators of the tribe Chilocorini (Coccinellinae: Coccinellidae: Coleoptera) in India. *Intern J Zool Invest*. 11(1): 803-820.
- Sharma RK, Bisht RS and Sani BC. (2006) Natural enemies of tea aphid *Toxoptera aurantii* (Boyer de Fonscolombe) in Uttaranchal. 9th National Symposium on Recent Advances in Aphidology (November 27-29, 2006) held at Banaras Hindu University, Varanasi. pp. 20-21.
- Singh R. (2003) Tritrophic interactions with referenceto biological control of insect pests: A review. *Biol Mem*. 29(2): 55-70.
- Singh R. (2025a) Species diversity and tri-trophic associations of aphidophagous Coccinellidae (Coleoptera: Insecta) in India. *Uttar Pradesh J Zool* 46(18): 225-241.
- Singh R. (2025b) A catalogue of tri-trophic associations of aphidophagous species of the ladybird beetle *Oenopia Mulsant*, 1850 (Coccinellinae: Coccinellidae: Coleoptera) in different states and union territories of India. *J Fauna Biodiver*. 2(2): 12-44.
- Singh R. (2026a) Tri-trophic associations of aphidophagous hover flies (Syrphidae: Diptera) in different states and union territories of India. *Munis Ent Zool* 21(1): 373-403.
- Singh R. (2026b) An updated checklist of tri-trophic associations of aphidophagous ladybirds (Coccinellidae: Coleoptera) in different districts of Uttarakhand, India. *Munis Ent Zool* 21(1): 537-567.
- Singh R and Omkar (2025) An updated checklist of tri-trophic associations of aphidophagous Diptera and Neuroptera in different districts of Uttarakhand, India. *J Appl Biosci*. 51(2): in press
- Singh R and Singh G. (2016) Aphids and their biocontrol In: *Ecofriendly pest management for food security*, (ed.) Omkar, Academic Press, pp. 63-108.
- Singh R and Singh G. (2019) Species diversity of Indian aphids (Hemiptera: Aphididae). *Int J Biol Innov*. 1(1): 23-29.
- Singh R and Singh G. (2021) Aphids. In: *Polyphagous pests of crops*, (ed.) Omkar, Springer Nature Singapore, pp. 105-182.
- Singh R and Singh G. (2022) Reproductive strategies in aphids. In: *Reproductive strategies in insects* (eds.) Omkar and Mishra G, Taylor and Francis Group, LLC, pp. 259-282.
- Singh R and Srivastav Ajai K. (2024) Checklist of aphidophagous predatory bugs (Heteroptera: Hemiptera: Insecta) in India. *Intern J Biol Environ Invest*. 4(2): 1-11.
- Singh R, Tiwari AK and Tiwari KM. (2024) Checklist of aphidophagous Neuroptera (Insecta: Arthropoda) in India. *Int J Biol Innov*. 6(2): 99-127.
- Singh R, Verma AK and Singh G. (2023a) Food plant catalogue of indian aphids (Homoptera: Aphididae). Asian Biological Research Foundation, Prayagraj, India, Nature Light Publications, Pune, pp. 350.
- Singh R, Verma AK, Singh BB and Singh G. (2023b) Spider fauna of India. Asian Biological Research Foundation, Prayagraj, India, Nature Light Publications, Pune, pp. 567.
- Thakur JN, Pawar AD and Rawat US. (1988) Observations on the correlation between population density of apple woolly aphid and its natural enemies and their effectiveness in Kullu Valley (H.P.). *Plant Prot Bull* 40(2): 13-15.