Entomology

Annotated checklist of aphidophagous predators associated with *Brachycaudus* species (Hemiptera: Aphididae) and their distribution in India

Rajendra Singh[1*], Suresh Kumar Kol[2] and Yogendra Kumar Payasi[2]

[1] Department of Zoology, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, Uttar Pradesh, India

[2] Department of Zoology, Indira Gandhi National Tribal University, Amarkantak, Madhya Pradesh, India

*Corresponding author: Rajendra Singh

Received 13 May 2025; Accepted 26 Jun 2025; Published 8 Jul 2026

DOI: https://doi.org/10.64171/JAE.6.3.21-31

Abstract

An annotated analysis of the predator complex associated with *Brachycaudus* species in India was conducted based on published records. A total of 47 predator species belonging to five orders and ten families were documented preying on five *Brachycaudus* species (including one unidentified species) infesting 29 host plant species across 11 states of India. These interactions collectively formed 112 tri-trophic associations (TTAs). Coleoptera was the dominant order, represented by 24 species of Coccinellidae, followed by Diptera (9 species), Hemiptera (7 species), Araneae (4 species), and Neuroptera (2 species). *Adalia tetraspilota*, *Coccinella septempunctata*, *Propylea luteopustulata*, and *Hippodamia variegata* were among the most widely distributed predators. *Brachycaudus helichrysi* supported the highest predator diversity, with 41 predator species associated with 24 host plants, forming 95 TTAs across nine states. Among host plants, peach (*Prunus persica*) harboured the richest predator assemblage, supporting 22 predator species, followed by almond (*Prunus amygdalus*) with 12 predator species. The distribution of TTAs exhibited marked geographical variation, with Uttarakhand (34 TTAs), Jammu & Kashmir (25), and Himachal Pradesh (19) together accounting for nearly 70% of all documented associations. The predominance of interactions in the Himalayan region reflects favourable climatic conditions, rich temperate flora, and extensive survey efforts. The study highlights the ecological significance of coccinellids, syrphids, anthocorids, spiders, and lacewings in the natural regulation of *Brachycaudus* populations and provides a comprehensive baseline for future studies on aphid biodiversity, biogeography, and conservation biological control in India.

Keywords: *Brachycaudus*, Aphidophagous predators, Coccinellidae, Tri-trophic associations, Host plants, Biological control, India

Introduction

The genus *Brachycaudus* van der Goot, 1913 (Aphididae: Aphidinae: Macrosiphini) is a moderately diverse aphid genus comprising nine subgenera and approximately 50 valid species worldwide. Members of the genus are distributed predominantly throughout the Palaearctic region, although several species extend into other biogeographic regions, including Asia, Africa, and North America [9, 38].

Brachycaudus species are small- to medium-sized aphids, green to ochreous-red in colour, with weakly developed antennal tubercles and antennae shorter than the body. The terminal process of the last antennal segment is at least three times the length of its basal part. Apterae often possess a dark dorsal sclerotic shield, while marginal tubercles are absent or poorly developed. The siphunculi are short, smooth, cylindrical to tapering, and distinctly flanged, whereas the cauda is short, broad, semicircular to helmet-shaped, and slightly constricted at the base. There is considerable morphological variation associated with host-plant utilisation and life-cycle strategies [9, 20, 29]. Species of *Brachycaudus* exhibit diverse life-history patterns, including holocyclic and anholocyclic reproduction, as well as monoecious and heteroecious life cycles. Many species overwinter as eggs on woody hosts, particularly species of *Prunus* (Rosaceae), while summer generations develop on a wide range of herbaceous plants. Reproduction is predominantly parthenogenetic during the growing season, allowing rapid population growth, whereas sexual forms are produced in autumn and give rise to overwintering eggs [9,26,29].

The genus has attracted considerable evolutionary interest because it includes species representing all major aphid life-cycle strategies: monoecy on woody hosts, monoecy on herbaceous hosts, and heteroecy involving host alternation [44]. Molecular phylogenetic analyses suggest that gains and losses of host alternation have occurred repeatedly within *Brachycaudus*, challenging the traditional hypothesis that once a primary woody host is lost it cannot be regained [29]. Such evolutionary flexibility is believed to have contributed significantly to diversification and speciation within the genus.

In India, *Brachycaudus* is represented by only seven species belonging to five subgenera, e.g. *Brachycaudus (Prunaphis) cardui* (Linnaeus, 1758); *Brachycaudus (Brachycaudus) helichrysi* (Kaltenbach, 1843); *Brachycaudus (Mordvilkomemor) pilosus* (Mordvilko ex Nevsky, 1929); *Brachycaudus (Scrophulaphis) persicae* (Passerini, 1860); *Brachycaudus (Thuleaphis) amygdalinus* (Schouteden, 1905); and *Brachycaudus (Thuleaphis) rumexicolens* (Patch, 1917). These species have been recorded from 185 host plant species, reflecting a broad range of host associations and ecological adaptability within the country [52].

Species of *Brachycaudus* infest a wide range of economically important plants, particularly members of Rosaceae, Asteraceae, Boraginaceae, Caryophyllaceae, Polygonaceae, and other families [41]. Several species are recognised as pests

of fruit crops, ornamental plants, medicinal herbs, and wild vegetation. Among them, *Brachycaudus helichrysi* is highly polyphagous feeding on 184 species of plants [41]. Their feeding activity causes deformation of leaves and shoots, suppression of plant growth, and reduction in crop yield and quality. In addition, some species are known vectors of economically important plant viruses, thereby increasing their agricultural significance [47]. Owing to their broad host range, high reproductive potential, and adaptability to diverse climatic conditions, *Brachycaudus* species frequently attain pest status in both cultivated and natural ecosystems.

Natural enemies play a crucial role in regulating aphid populations and constitute an essential component of sustainable pest management programmes. Aphidophagous predators, including coccinellid beetles, syrphid flies, lacewings, spiders, and predatory bugs exert substantial mortality on aphid populations and contribute significantly to their natural suppression [34]. These natural enemies form the basis of classical, augmentative, and conservation biological control strategies, reducing dependence on chemical insecticides and promoting ecological stability in agroecosystems. Conservation of indigenous predator and parasitoid communities has increasingly been recognised as an effective and environmentally sound approach for aphid management, particularly in integrated pest management programmes.

Knowledge of the diversity, host associations, and geographical distribution of natural enemies is fundamental for understanding aphid–natural enemy interactions and for developing effective biological control strategies. Although numerous records of predators and parasitoids associated with *Brachycaudus* species are scattered throughout taxonomic, ecological, and faunistic literature, no comprehensive checklist is available for India. The absence of a consolidated account hampers assessments of species richness, distribution patterns, and the potential utilisation of natural enemies in biological control programmes.

The preparation of an annotated checklist is therefore necessary to document the diversity and distribution of predators associated with *Brachycaudus* species across different states of India. Such a checklist provides baseline information on species composition, host associations, geographical occurrence, and natural enemy complexes, facilitating future studies on biodiversity, ecology, conservation biological control, and integrated aphid management. The present study aims to compile and critically review all available records of predators associated with *Brachycaudus* species in India and to provide a comprehensive checklist of their natural enemies along with their state-wise distribution.

Materials and Methods

Published records of *Brachycaudus* species and their associated predators in India were compiled through an extensive survey of scientific literature, including research articles, books, monographs, catalogues, review papers, faunistic surveys, and technical reports published up to May 1, 2026. Information on aphid species, natural enemies, host plants, state-wise distribution, and references was extracted and critically examined. The nomenclature and taxonomic status of aphid species were validated using the Aphid Species File (https://Aphid.SpeciesFile.org). Predator and parasitoid names were verified using current taxonomic databases (https://www.gbif.org), while host plant nomenclature was standardised according to World Flora Online (https://www.worldfloraonline.org). Synonyms and obsolete names were updated to their currently accepted valid names.

The checklist is arranged orderwise, familywise and species-wise, providing information on associated predators, host plants, state-wise distribution, and relevant references. Duplicate and doubtful records were carefully evaluated before inclusion.

Results and Discussion

A total of 47 predator species belonging to five orders and ten families were recorded preying on 5 species (one unidentified) of *Brachycaudus* in India infesting 29 host plant species and collectively formed 112 tri-trophic associations (TTAs) distributed across 11 states (Table 1). Coleoptera was the dominant order, represented by 24 species, all belonging to the family Coccinellidae. Among which, *Adalia tetraspilota* exhibited the widest distribution, being associated with only *Brachycaudus helichrysi* on 10 host plants across four states. Other widely distributed predators included *Coccinella septempunctata* and *Propylea luteopustulata*, each associated with nine host plant species, while *Harmonia eucharis* and *Hippodamia variegata* each were recorded from seven host plants. *Cheilomenes sexmaculata*, *Oenopia sauzeti*, and *Calvia punctata* were also associated with more than one aphid species. Diptera constituted the second most diverse order with nine species belonging to Chamaemyiidae and Syrphidae. Among these, *Episyrphus balteatus* and *Eupeodes confrater* were the most important syrphid predators, each recorded from two aphid species and four to six host plants. Hemiptera was represented by seven species belonging to Anthocoridae and Miridae, whereas Araneae comprised four species distributed among Araneidae, Clubionidae, Salticidae, and Theridiidae. Neuroptera was represented by two chrysopid species, namely *Chrysopa* sp. and *Chrysoperla zastrowi sillemi*. The latter showed a comparatively broad host range, being associated with two *Brachycaudus* species on four host plants.

Most predator species exhibited narrow host associations, with 41 species recorded from only a single aphid species, *Brachycaudus helichrysi* and host plant. In contrast, only seven predator species were associated with two *Brachycaudus* species. The results indicate that coccinellid beetles constitute the predominant predator guild of *Brachycaudus* species in India, followed by syrphid flies, anthocorid bugs, spiders, and lacewings. The large number of tri-trophic associations documented highlights the ecological importance of these predators in the natural regulation of *Brachycaudus* populations across diverse agroecosystems and geographical regions of India.

A total of 112 tri-trophic associations (TTAs) involving *Brachycaudus* species, their host plants, and predators were

documented from 11 states of India (Figure 1). The distribution of TTAs showed considerable geographical variation. Uttarakhand recorded the highest number of TTAs (34), accounting for 29.3% of the total associations, followed by Jammu & Kashmir (31 TTAs) and Himachal Pradesh (19 TTAs). Together, these three Himalayan states contributed 84 TTAs, representing 72.4% of all documented associations. Moderate numbers of TTAs were recorded from Uttar Pradesh (13), West Bengal (11), Manipur (6), and Sikkim (6). In contrast, relatively few associations were reported from Nagaland (3), Bihar (1), Madhya Pradesh (1), and Tripura (1).

The predominance of TTAs in the northwestern Himalayan region reflects the greater diversity and abundance of *Brachycaudus* species, their host plants, and associated predator fauna in these areas. Conversely, the lower numbers recorded from several states may be attributable to limited occurrence of host plants, restricted aphid distribution, or inadequate faunistic surveys. Overall, the results indicate that the Himalayan states constitute the principal centres of predator-mediated tri-trophic interactions involving *Brachycaudus* species in India.

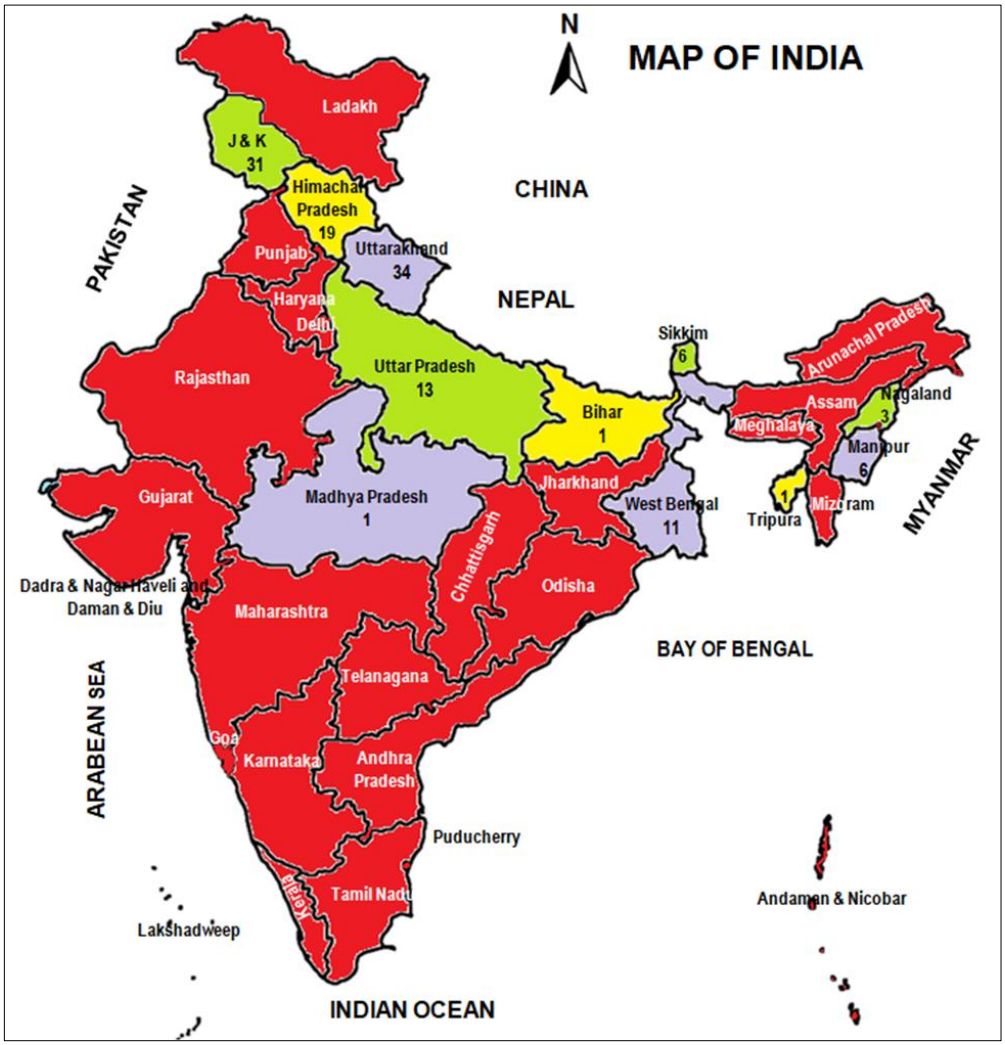

Fig 1: Map showing the number of tri-trophic associations of *Brachycaudus* species in different states/union territories of India. No species of the predator was recorded in the red shaded states/union territories of India

Table 1: Number of species of predators preying on different number of *Brachycaudus* species infesting different number of host plant species and tri-trophic associations (TTAs) in number of states in India

Order/Family	Species of the predators	Number of			
		Aphid species	Plant species	TTAs	States
Order: Araneae					
Araneidae	1. *Neoscona* sp.	1	1	1	1
Clubionidae	2. *Clubiona* sp.	1	2	2	1
Salticidae	3. *Myrmarachne* sp.	1	1	1	1
Theridiidae	4. *Theridion* sp.	1	1	1	1
Order: Coleoptera					
Coccinellidae	5. *Adalia bipunctata*	1	1	1	1

	6. *Adalia tetraspilota*	1	10	10	4
	7. *Ballia* sp.	1	1	1	2
	8. *Brumoides suturalis*	1	1	1	1
	9. *Calvia punctata*	2	2	2	2
	10. *Cheilomenes sexmaculata*	2	5	5	3
	11. *Coccinella septempunctata*	1	9	9	6
	12. *Coccinella transversalis*	1	6	6	4
	13. *Coelophora bissellata*	1	1	1	1
	14. *Harmonia dimidiata*	1	1	1	1
	15. *Harmonia eucharis*	1	7	7	2
	16. *Harmonia* sp.	1	1	1	1
	17. *Hippodamia variegata*	2	7	7	3
	18. *Hippodamia variegata doubledeayi*	1	1	1	1
	19. *Horniolus dispar*	1	1	1	1
	20. *Megalocaria dilatata*	1	1	1	1
	21. *Micraspis discolor*	1	1	1	1
	22. *Oenopia billieti*	1	1	1	1
	23. *Oenopia kirbyi*	1	1	1	2
	24. *Oenopia sauzeti*	2	5	5	4
	25. *Oenopia sexareata*	1	2	2	3
	26. *Propylea luteopustulata*	1	9	9	5
	27. *Rodolia octoguttata*	1	1	1	1
	28. *Scymnus* sp.	1	1	1	1
	29. *Sticholotis binotata*	1	1	1	1
Order*:* Diptera					
Chamaemyiidae	30. *Leucopis* sp.	1	1	1	1
Syrphidae	31. *Betasyrphus serarius*	1	1	1	1
	32. *Episyrphus balteatus*	2	6	6	2
	33. *Eupeodes confrater*	2	4	4	2
	34. *Eupeodes corollae*	1	1	1	1
	35. *Ischiodon scutellaris*	1	1	1	1
	36. *Paragus politus*	1	1	1	1
	37. *Paragus rufocinctus*	1	1	1	1
	38. *Paragus serratus*	1	1	1	1
	39. *Paragus tibialis*	2	2	2	2
	40. *Sphaerophoria indiana*	1	1	1	1
	41. *Sphaerophoria scripta*	1	1	1	1
Order*:* Hemiptera					
Anthocoridae	42. *Anthocoris confusus*	1	1	1	2
	43. *Anthocoris minki pistaciae*	1	2	2	1
	44. *Anthocoris* nr. *pilosus*	1	1	1	1
	45. *Orius lindbergi*	1	1	1	1
	46. *Orius minutus*	1	1	1	1
	47. *Orius* sp.	1	1	1	1
Miridae	48. *Psallus* sp.	1	1	1	1
Order*:* Neuroptera					
Chrysopidae	49. *Chrysopa* sp.	1	1	1	1
	50. *Chrysoperla zastrowi sillemi*	2	4	4	1
Total		**4**	**29**	**116**	**11**

Five species of *Brachycaudus* (including on unidetified) were recorded from different host plants and states of India, supporting varying numbers of predator species. Among them, *Brachycaudus helichrysi* harboured the highest predator diversity, with 41 predator species associated with 24 host plants, forming 99 tri-trophic associations (TTAs) across nine states. In contrast, *Brachycaudus cardui* and *Brachycaudus rumexicolens* each supported five predator species, accounting for five TTAs. The former was recorded from five host plants in four states, whereas the latter occurred on two host plants in

two states. *Brachycaudus persicae* was the least represented species, with only one predator species, one host plant recorded from one state. The relative contribution of different *Brachycaudus* species to the diversity of associated predator species, host plant species infested, and the total number of documented TTAs in India are illustrated in Figure 2.

A total of 29 host plant species belonging to diverse families were recorded as hosts of *Brachycaudus* species and their associated predator assemblages in India (Table 2). Among these, *Prunus persica* (peach) supported the highest predator diversity, harbouring 22 predator species associated exclusively with *Brachycaudus helichrysi* and accounting for 22 tri-trophic associations (TTAs) across four states. *Prunus amygdalus* (almond) ranked second in importance, supporting two *Brachycaudus* species and 12 predator species, resulting in 12 TTAs distributed across three states. Other notable host plants included *Clerodendron* sp., which supported seven predator species, while *Brassica oleracea* var. *capitata*, *Erigeron canadensis*, and *Kleinia grandiflora* each harboured five predator species. The majority of host plants was infested predominantly by *Brachycaudus helichrysi* and supported comparatively low predator richness, generally involving one to five predator species. These findings highlight the prominent role of certain host plants, particularly species of *Prunus*, in sustaining diverse predator communities and facilitating complex tri-trophic interactions involving *Brachycaudus* aphids in India.

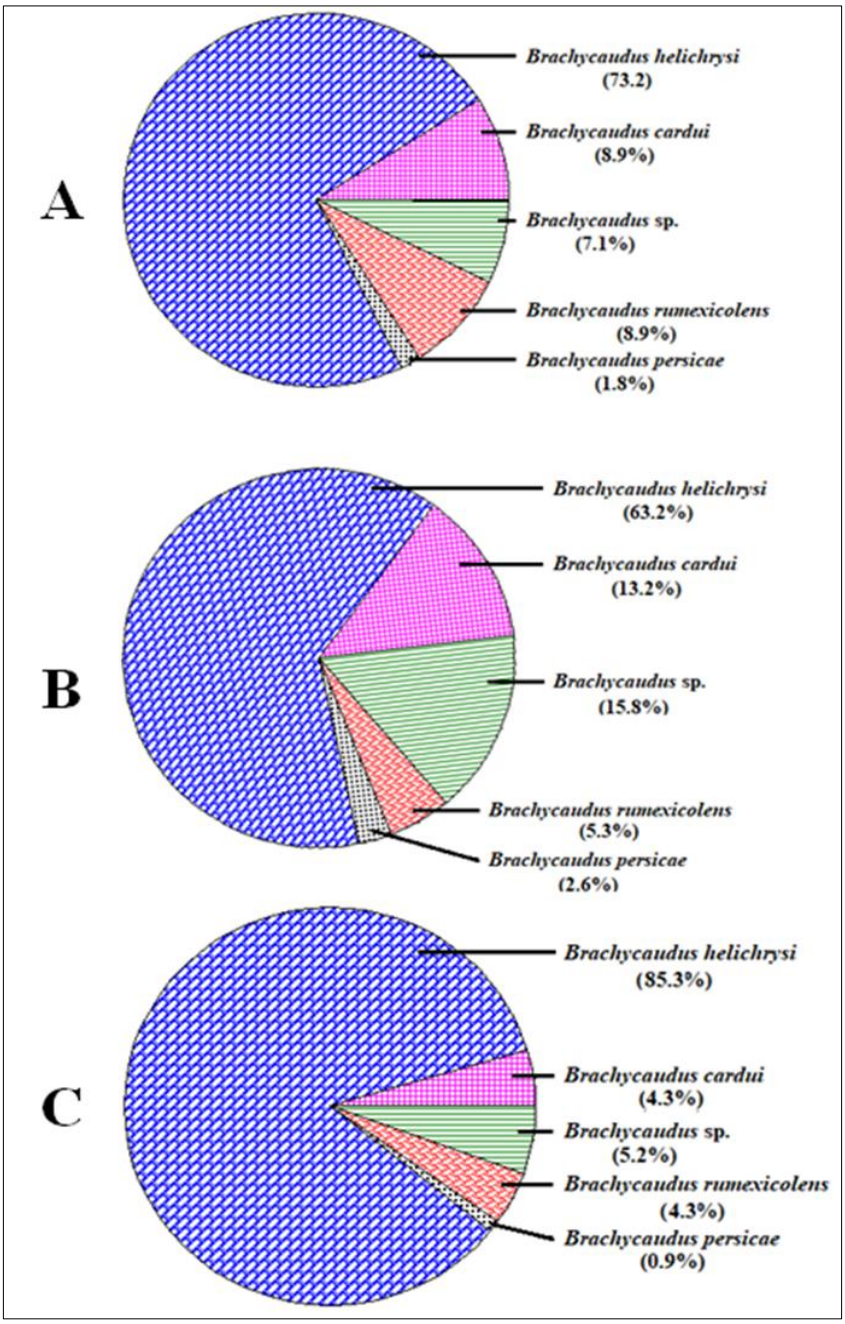

Fig 2: Relative contribution of different *Brachycaudus* species to (A) the diversity of associated predator species, (B) the diversity of host plant species infested, and (C) the total number of documented tri-trophic associations in India

Table 2: Number of species of plants infested by different species of *Brachycaudus* consumed by different numbers of predator species along with TTAs in different number of states in India

Plant species	Number of			
	Aphid species	Predator species	TTAs	States
1. *Ageratum conyzoides*	1	6	6	2
2. *Anaphalis margaritacea*	1	2	2	1
3. *Artemesia* sp.	1	1	1	2
4. *Artemisia vulgaris*	1	4	4	4
5. *Brassica oleracea* var. *botrytis*	1	4	4	1
6. *Brassica oleracea* var. *capitata*	1	5	5	1
7. *Brassica rapa*	1	2	2	2
8. *Carduus edelbergii*	1	1	1	1
9. *Carduus* sp.	1	1	1	1
10. *Chromolaena odorata*	1	3	3	3
11. *Cirsium wallichii*	1	1	1	1
12. *Cirsium* sp.	1	1	1	1
13. *Clerodendron* sp.	1	7	7	3
14. *Crotalaria saltiana*	1	1	1	1
15. *Duranta erecta*	1	1	1	1
16. *Erigeron bonariensis*	1	4	4	1
17. *Erigeron canadensis*	1	5	5	1
18. *Erigeron* sp.	1	1	1	1
19. *Eupatorium* sp.	1	1	1	1
20. *Gynura bicolor*	1	4	4	3
21. *Kleinia grandiflora*	1	5	5	1
22. *Prunus amygdalus*	2	12	12	3
23. *Prunus domestica*	1	2	2	1
24. *Prunus persica*	1	26	26	4
25. *Rumex hastatus*	1	1	1	1
26. *Rumex* sp.	1	4	4	1
27. *Schleichera oleosa*	1	1	1	1
28. *Solanum lycopersicum*	1	4	4	1
29. *Synotis rufinervis*	1	1	1	1
30. Unknown plant	3	5	5	3
Total	5	50	116	11

Discussion

The predominance of coccinellid beetles among the 47 recorded predator species agrees with previous studies identifying ladybird beetles as the principal aphidophagous predators in agroecosystems due to their broad prey range and high consumption capacity [27]. The wide distribution of *Coccinella septempunctata*, *Adalia tetraspilota*, *Propylea luteopustulata*, and *Hippodamia variegata* reflects their ecological adaptability and ability to exploit aphids on diverse host plants [31]. Syrphids, anthocorids, spiders, and chrysopids formed important secondary predator groups, contributing to the natural regulation of *Brachycaudus* populations [42, 46, 49, 51].

The highest predator diversity associated with *Brachycaudus helichrysi* is attributable to its polyphagous nature and extensive distribution on 24 host plant species across nine states of India. Increased host-plant diversity and vegetation complexity are known to promote greater herbivore abundance and support richer assemblages of predators and other natural enemies by providing diverse resources, refugia, and prey habitats [32, 53]. Consequently, the broad host range of *Brachycaudus helichrysi* likely contributes to the high diversity of predator species and tri-trophic associations recorded in the present study.

The concentration of nearly 70% of all tri-trophic associations in Uttarakhand, Jammu & Kashmir, and Himachal Pradesh highlights the importance of the Himalayan region. Its varied topography, altitudinal gradients, temperate climate, and rich flora provide favourable habitats for *Brachycaudus* species and their natural enemies. Moreover, extensive aphidological surveys conducted in these states have likely contributed to the higher number of recorded associations [43, 45, 50]. In contrast, the lower diversity documented from several other states may reflect limited host-plant availability, restricted aphid occurrence, or inadequate survey efforts.

The exceptionally high predator richness recorded on *Prunus persica* and *Prunus amygdalus* further emphasises the importance of host-plant diversity in sustaining predator communities. These plants serve as important reservoirs of *Brachycaudus* populations and their natural enemies, promoting complex tri-trophic interactions and contributing to conservation biological control in Indian ecosystems [9, 32].

The paucity of records of natural enemies of *Brachycaudus* species from western and southern India is primarily attributable to the limited distribution of these temperate aphids and their preferred host plants, particularly *Prunus*, *Artemisia*, and *Rumex* species, which are more abundant in the Himalayan

region [9]. The cooler climatic conditions and rich temperate flora of northern India favour both *Brachycaudus* populations and their associated predator communities. Additionally, extensive aphidological surveys conducted in Himalayan states such as Jammu & Kashmir, Himachal Pradesh, and Uttarakhand have resulted in better documentation of aphid–plant–predator associations, whereas comparable studies are scarce in western and southern India. Thus, the apparent absence of records likely reflects a combination of biogeographical constraints and inadequate survey efforts rather than the true absence of natural enemies.

Following is the detailed account of tri-trophic associations of *Brachycaudus* species in India:

A. Order: Araneae

a. Family: Araneidae

1. *Neoscona* sp.

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Prunus persica* (L.) Batsch - Uttarakhand [18]

b. Family: Clubionidae

1. *Clubiona* sp.

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Erigeron bonariensis* L. - Uttarakhand [18]
- *Prunus persica* (L.) Batsch - Uttarakhand [18]

c. Family: Salticidae

1. *Myrmarachne* sp.

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Erigeron bonariensis* L. - Uttarakhand [18]

d. Family: Theridiidae

1. *Theridion* sp.

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Prunus persica* (L.) Batsch - Uttarakhand [18]

B. Order: Coleoptera

Family: Coccinellidae

1. *Adalia bipunctata* (Linnaeus, 1758)

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- Unknown plant - West Bengal [13]

2. *Adalia tetraspilota* (Hope, 1831)

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Ageratum conyzoides* L. - Uttar Pradesh [48]
- *Artemisia vulgaris* L. - West Bengal [13]
- *Brassica oleracea* L. var. *botrytis* - Jammu & Kashmir [30]
- *Brassica oleracea* L. var. *capitata* - Jammu & Kashmir [30]
- *Clerodendron* sp. - Uttar Pradesh [14]
- *Erigeron canadensis* L. - Jammu & Kashmir [30]
- *Kleinia grandiflora* (Wall. ex DC.) N.Rani - Jammu & Kashmir [30]
- *Prunus amygdalus* Batsch - Himachal Pradesh [8]
- *Prunus persica* (L.) Stokes - Uttarakhand [25]
- *Rumex* sp. - Jammu & Kashmir [30]

3. *Ballia* sp.

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Prunus persica* (L.) Stokes - Himachal Pradesh [55]
- Sikkim [2]

4. *Brumoides suturalis* (Fabricius, 1798)

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Brassica rapa* L. - West Bengal [33]

5. *Calvia punctata* (Mulsant, 1853)

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Prunus amygdalus* Batsch - Himachal Pradesh [8]
- *Rumex* sp. - Jammu & Kashmir [30]

6. *Cheilomenes sexmaculata* (Fabricius, 1781)

• ***Brachycaudus cardui* (Linnaeus, 1758)**

- *Carduus* sp. - Madhya Pradesh [57]
- *Ageratum conyzoides* L. - Uttar Pradesh [48]
- *Artemisia vulgaris* L. - Nagaland [19]
- *Chromolaena odorata* (L.) R.M.King and H.Rob. - Nagaland [13, 36]
- *Clerodendron* sp. - Uttar Pradesh [14]

7. *Coccinella septempunctata* Linnaeus, 1758

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Artemesia* sp. - Sikkim [21, 37]; West Bengal [17]
- *Artemisia vulgaris* L. - Sikkim [13]
- *Brassica oleracea* L. var. *botrytis* - Jammu & Kashmir [30]
- *Brassica oleracea* L. var. *capitata* - Jammu & Kashmir [30]
- *Erigeron canadensis* L. - Jammu & Kashmir [30]
- *Erigeron* sp. - Uttarakhand [25]
- *Kleinia grandiflora* (Wall. ex DC.) N.Rani - Jammu & Kashmir [30]
- *Prunus persica* (L.) Stokes - Himachal Pradesh [56]; Jammu & Kashmir [6]
- Uttarakhand [25]; West Bengal [17]
- Unknown plant - Tripura [5]

8. *Coccinella transversalis* Fabricus, 1781

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Ageratum conyzoides* L. - Uttar Pradesh [48]
- *Artesemia vulgaris* L. - Manipur [19]
- *Clerodendron* sp. - Uttar Pradesh [14]
- *Gynura bicolor* DC. - Manipur [13]; Nagaland [19]
- *Prunus persica* (L.) Stokes - Himachal Pradesh [39]
- *Solanum lycopersicum* L. - Uttar Pradesh [48]

9. *Coelophora bissellata* Mulsant, 1850

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Chromolaena odorata* (L.) R.M.King and H.Rob. - Manipur [19]

10. *Harmonia dimidiata* (Fabricius, 1781)

- *Prunus persica* (L.) Stokes – Jammu & Kashmir [6]

11. *Harmonia eucharis* (Mulsant, 1853)

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Ageratum conyzoides* L. - Uttar Pradesh [48]
- *Anaphalis margaritacea* (L.) Benth. & Hook.f. - Uttarakhand [18, 25]
- *Clerodendron* sp. - Uttar Pradesh [14]
- *Prunus amygdalus* Batsch - Uttarakhand [25]
- *Prunus domestica* L. - Uttarakhand [12, 25]
- *Prunus persica* (L.) Stokes - Uttarakhand [25]
- *Solanum lycopersicum* L. - Uttar Pradesh [48]

12. *Harmonia* sp.

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Gynura bicolor* DC. - Sikkim [13]

13. *Hippodamia variegata* (Goeze, 1777)

• ***Brachycaudus helichrysi* (Kaltenbach, 1843)**

- *Brassica oleracea* L. var. *botrytis* - Jammu & Kashmir [30]

- *Brassica oleracea* L. var. *capitata* - Jammu & Kashmir [30]
- *Erigeron bonariensis* L. - Uttarakhand [25]
- *Erigeron canadensis* L. - Jammu & Kashmir [30]
- *Kleinia grandiflora* (Wall. ex DC.) N.Rani - Jammu & Kashmir [30]
- *Prunus amygdalus* Batsch - Himachal Pradesh [8]

• ***Brachycaudus rumexicolens*** **(Patch, 1917)**
- *Rumex* sp. - Jammu & Kashmir [30]

14. *Hippodamia variegata doubledeayi* (Mulsant, 1850)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Clerodendron* sp. - Uttar Pradesh [14]

15. *Horniolus dispar* Weise, 1900

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Gynura bicolor* DC. - Sikkim [13]

16. *Megalocaria dilatata* (Fabricius, 1775)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Stokes - Himachal Pradesh [39]

17. *Micraspis discolor* (Fabricius, 1798)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Duranta erecta* L. - Manipur [19]

18. *Oenopia billieti* (Mulsant, 1853)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Stokes - Himachal Pradesh [55]

19. *Oenopia kirbyi* Mulsant, 1850

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Stokes - Himachal Pradesh [39]; Uttarakhand [23, 24]

20. *Oenopia sauzeti* Mulsant, 1866

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus amygdalus* Batsch - Himachal Pradesh [8, 15]
- *Prunus persica* (L.) Stokes - Jammu & Kashmir [6]; Uttarakhand [23, 25]

• ***Brachycaudus*** **sp.**
- *Crotalaria saltiana* Andrews - West Bengal [35]
- *Eupatorium* sp. - West Bengal [35]
- *Rumex hastatus* D. Don - Uttarakhand [2]

21. *Oenopia sexareata* (Mulsant, 1853)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Clerodendron* sp. - West Bengal [13]; Manipur [1, 13]
- *Prunus persica* (L.) Stokes - Himachal Pradesh [39]

22. *Propylea luteopustulata* (Mulsant, 1850)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Brassica oleracea* L. var. *botrytis* - Jammu & Kashmir [30]
- *Brassica oleracea* L. var. *capitata* - Jammu & Kashmir [30]
- *Brassica rapa* L. - Uttarakhand [25]
- *Chromolaena odorata* (L.) R.M.King and H.Rob. - Sikkim [28]
- *Clerodendron* sp. - Manipur [1, 13]
- *Erigeron canadensis* L. - Jammu & Kashmir [30]
- *Kleinia grandiflora* (Wall. ex DC.) N.Rani - Jammu & Kashmir [30]
- *Prunus persica* (L.) Stokes - Uttarakhand [24]
- *Solanum lycopersicum* L. - Uttar Pradesh [48]

23. *Rodolia octoguttata* Weise, 1910

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Stokes - Himachal Pradesh [39]

24. *Scymnus* sp

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Stokes - Uttarakhand [25]

25. *Sticholotis binotata* (Gorham, 1894)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Ageratum conyzoides* L. - West Bengal [13]

C. Order: Diptera

a. Family: Chamaemyiidae

1. *Leucopis* sp.

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus amygdalus* Batsch - Uttarakhand [18]

b. Family: Syrphidae

1. *Betasyrphus serarius* (Wiedemann, 1830)

• ***Brachycaudus cardui*** **(Linnaeus, 1758)**
- *Schleichera oleosa* (Lour.) Oken - Bihar [10]

2. *Episyrphus balteatus* (De Geer, 1776)

• ***Brachycaudus cardui*** **(Linnaeus, 1758)**
- Unknown plant - Himachal Pradesh [40]

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Anaphalis margaritacea* (L.) Benth. & Hook.f. - Uttarakhand [22]
- *Erigeron bonariensis* L. - Uttarakhand [22]
- *Prunus amygdalus* Batsch - Uttarakhand [22]
- *Prunus persica* (L.) Stokes - Uttarakhand [22]

• ***Brachycaudus*** **sp.**
- Unknown plant - Himachal Pradesh [40]

3. *Eupeodes confrater* (Wiedemann, 1830)

• ***Brachycaudus cardui*** **(Linnaeus, 1758)**
- *Cirsium* sp. - Himachal Pradesh [40]
- *Prunus amygdalus* Batsch - Uttarakhand [22]
- *Prunus persica* (L.) Batsch - Uttarakhand [22]

• ***Brachycaudus*** **sp.**
- Unknown plant - Himachal Pradesh [40]

4. *Eupeodes corollae* (Fabricius, 1794)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Batsch - West Bengal [11, 22]

5. *Ischiodon scutellaris* (Fabricius, 1805)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Batsch - Jammu & Kashmir [6]

5. *Paragus politus* Wiedemann, 1830

• ***Brachycaudus*** **sp.**
- *Synotis rufinervis* (DC.) C.Jeffrey & Y.L.Chen - Uttarakhand [18]

6. *Paragus rufocinctus* (Brunctti, 1908)

• ***Brachycaudus rumexicolens*** **(Patch, 1917)**
- Unknown plant - Himachal Pradesh [16]

7. *Paragus serratus* (Fabricius, 1805)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Batsch - Jammu & Kashmir [6]

7. *Paragus tibialis* (Fallén, 1817)

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Batsch - Jammu & Kashmir [6]
- *Solanum lycopersicum* L. - Uttar Pradesh [48]

8. *Sphaerophoria indiana* Bigot, 1884

• ***Brachycaudus helichrysi*** **(Kaltenbach, 1843)**
- *Prunus persica* (L.) Batsch - Uttarakhand [18]

9. *Sphaerophoria scripta* (Linnaeus, 1758)
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Ageratum conyzoides* L. - West Bengal [3, 4]

D. Order: Hemiptera
a. Family: Anthocoridae
1. *Anthocoris confusus* Reuter, 1884
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus amygdalus* Batsch - Himachal Pradesh [8]; Uttarakhand [24]
2. *Anthocoris minki pistaciae* Wagner, 1957
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus domestica* L. - Uttarakhand [24]
- *Prunus persica* (L.) Batsch - Uttarakhand [24]
3. *Anthocoris* nr. *pilosus* (Jakovlev, 1877)
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus persica* (L.) Batsch - Uttarakhand [24]
4. *Orius lindbergi* Wagner, 1952
• *Brachycaudus persicae* (Passerini, 1860)
- *Prunus amygdalus* Batsch - Jammu Kashmir [7]
5. *Orius minutus* (Linnaeus, 1758)
• *Brachycaudus cardui* (Linnaeus, 1758)
- *Carduus edelbergii* Rech.fil. - Jammu Kashmir [7]
6. *Orius* sp.
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Cirsium wallichii* DC. - Uttarakhand [18]
b. Family: Miridae
1. *Psallus* sp.
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus persica* (L.) Batsch - Uttarakhand [18]

E. Order: Neuroptera
Family: Chrysopidae
1. *Chrysopa* sp.
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Prunus amygdalus* Batsch - Himachal Pradesh [8]
2. *Chrysoperla zastrowi sillemi* (Esben-Petersen, 1935)
• *Brachycaudus helichrysi* (Kaltenbach, 1843)
- *Brassica oleracea* L. var. *capitata* - Jammu & Kashmir [30]
- *Erigeron canadensis* L. - Jammu & Kashmir [30]
- *Kleinia grandiflora* (Wall. ex DC.) N.Rani - Jammu & Kashmir [30]
• *Brachycaudus rumexicolens* (Patch, 1917)
- *Rumex* sp. - Jammu & Kashmir [30]

Conclusion

This study provides the first comprehensive checklist of predator-mediated tri-trophic associations involving *Brachycaudus* aphids in India. Coccinellids were the dominant predator group, while *Brachycaudus helichrysi* supported the highest diversity of predators, host plants, and tri-trophic associations owing to its broad host range and distribution. The northwestern Himalayan states, particularly Uttarakhand, Jammu & Kashmir, and Himachal Pradesh, emerged as the principal centres of *Brachycaudus*–plant–predator interactions. Host plants of *Prunus*, especially peach (*Prunus persica*) and almond (*Prunus amygdalus*), played a key role in sustaining diverse predator communities. The checklist generated herein provides a valuable baseline for studies on aphid biodiversity, trophic ecology, and conservation biological control, while highlighting the need for further surveys in underexplored regions of India.

References

1. Agarwala BK, Raychaudhuri D, Raychaudhuri DN. Parasites and predators of aphids in Sikkim and Manipur (Northeast India). III. Entomon. 1980;5:39-42.
2. Agarwala BK, Ghosh D, Das SK, Poddar SC, Raychaudhuri DN. 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. 1981;6(3):233-238.
3. Agarwala BK, Dutta S, Raychaudhuri DN. An account of syrphid (Diptera: Syrphidae) predators of aphids (Homoptera: Aphididae) available in Darjeeling district of West Bengal and Sikkim. Pranikee. 1982;3:15-21.
4. Agarwala BK, Laska P, Raychaudhuri DN. Prey records of aphidophagous syrphid flies from India (Diptera: Syrphidae). Acta Entomol Bohemoslov. 1984;81:15-21.
5. Agarwala BK, Das S, Bhaumik AK. Natural food range and feeding habits of aphidophagous insects in northeast India. J Aphidol. 1987;1:18-22.
6. Arora RK, Gupta RK, Bali K. Population dynamics of the leaf curl aphid *Brachycaudus helichrysi* (Kaltenbach) and its natural enemies on subtropical peach *Prunus persica* cv. Flordasun. J Entomol Nematol. 2009;1(3):36-42.
7. Bhagat RC, Lone MA. New records and host range of predators of aphids (Aphididae: Homoptera) in Kashmir Valley, India. Sci Cult. 1984;50:364-366.
8. Bhardwaj SP. Biological management of *Brachycaudus helichrysi* (Kaltenbach) infesting almond in dry temperate region of Himachal Pradesh. J Aphidol. 1991;5(1-2):26-31.
9. Blackman RL, Eastop VF. Aphids on the World's Herbaceous Plants and Shrubs. Host List and Keys. Vol. 1. John Wiley & Sons, 2006.
10. Brunetti E. The Fauna of British India Including Ceylon and Burma. Diptera. Vol. III. Pipunculidae, Syrphidae, Conopidae, Oestridae. Taylor & Francis, 1923. Available from: https://doi.org/10.5962/bhl.title.48423
11. Chakrabarti S, Chakrabarti S. Tritrophic relationship: Aphidophaga, aphid and its host plant: A study on *Brachycaudus helichrysi*. J Aphidol. 2002;16:39-44.
12. Chakrabarti S, Debnath N, Ghosh D. Bioecology of *Harmonia eucharis* (Mulsant) (Coleoptera: Coccinellidae), an aphidophagous predator in western Himalayas. Entomon. 1995;20(3-4):191-196.
13. Chakrabarti S, Sarkar S, Debnath M. Diversity, bioecology and biosystematics of aphidophagous predators of eastern Himalaya and northeast India. In: Hartmann M, Weipert J, editors. Biodiversität und Naturausstattung im Himalaya IV. Naturkundemuseum Erfurt, 2012. p.129-147.

14. Chaudhary HC, Singh R. Records of the predators of aphids (Homoptera: Aphididae) in eastern Uttar Pradesh. J Aphidol. 2012;25-26:13-30.
15. Chauhan N, Singh C, Verma SC, Sharma PL, Chandel RS, Chandel VGS, *et al.* Biology and functional response of *Oenopia sauzeti* (Mulsant) on peach leaf curl aphid *Brachycaudus helichrysi* (Kaltenbach). Phytoparasitica. 2024;52:2. Available from: https://doi.org/10.1007/s12600-023-01114-6
16. Das SK, Raychaudhuri D. Parasitoids and predators of aphids (Homoptera: Aphididae) from India. VI. New records of seven arachnids, one dipteran and one neuropteran predator from Himachal Pradesh, India. Entomon. 1983;8(1):27-34.
17. Debnath M. Aphidophagous predator diversity in Kalimpong district, India. Int J Exp Res Rev. 2020;22:30-36. Available from: https://doi.org/10.52756/ijerr.2020.v22.004
18. Debnath N. Studies on some aphidophagous insects in northwest and western Himalayas. University of Kalyani, 1991. Available from: http://hdl.handle.net/10603/211339
19. Devi SS. Studies on taxonomy and biology of aphidophagous coccinellids (Coleoptera: Coccinellidae) of Manipur and Nagaland. Manipur University, 1989. Available from: http://hdl.handle.net/10603/150284
20. Ghosh AK, Ghosh LK. Fauna of India and the Adjacent Countries: Homoptera: Aphidoidea. Part 7/2. Subfamily Aphidinae: Macrosiphini. Zoological Survey of India, 2017.
21. Ghosh AK, Raychaudhuri DN. Ecology of natural enemy complex of Aphidoidea (Homoptera) in some areas of eastern India. Proc Symp Ecol Anim Popul Zool Surv India. 1982;3:55-69.
22. Ghosh D, Debnath N, Chakrabarti S. Predators and parasites of aphids (Homoptera: Aphididae) from northwest Himalaya: Ten species of syrphids (Diptera: Syrphidae) from Garhwal range. Entomon. 1985;10:301-303.
23. Ghosh D, Debnath N, Chakrabarti S. Development of three species of *Oenopia* (Coleoptera: Coccinellidae) predating on aphids of Garhwal Himalaya. In: Proceedings of III Oriental Entomology Symposium. 1986. p.173-176.
24. Ghosh D, Debnath N, Chakrabarti S. 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. 1986;39:15-19.
25. Ghosh D, Debnath N, Chakrabarti S. Predators and parasites of aphids from northwest and western Himalaya. III. Twenty-five species of Coccinellidae (Coleoptera: Insecta) from Garhwal and Kumaon ranges. Rec Zool Surv India. 1991;88(2):177-188. Available from: https://doi.org/10.26515/rzsi/v88/i2/1991/161342
26. Gupta BP, Thakur JR. Sexual generation and overwintering of the peach leaf curl aphid *Brachycaudus helichrysi* (Kaltenbach) in Himachal Pradesh. Ann Appl Biol. 1993;122(2):215-221.
27. Hodek I, Honěk A. Ecology of Coccinellidae. Kluwer Academic Publishers, 1996.
28. Joshi S, Sangma RHCh. Natural enemies associated with aphids and coccids from Sikkim, India. J Biol Control. 2015;29(1):3-7. Available from: https://doi.org/10.18311/jbc/2015/3231
29. Jousselin E, Genson G, Coeur d'Acier A. Evolutionary lability of a complex life cycle in the aphid genus *Brachycaudus*. BMC Evol Biol. 2010;10:295. Available from: https://doi.org/10.1186/1471-2148-10-295
30. Khan AA, Shah MA. Records of aphids and their natural enemies in agro-ecosystems with special reference to horticultural ecosystem of Kashmir. J Entomol Zool Stud. 2017;5(4):189-203.
31. Kumar B, Omkar. Prey-predator relationships in ladybird beetles and biological control of insect pests. J Appl Biosci. 2025;51(1):1-36. Available from: https://doi.org/10.61081/joab/51v1i101
32. Landis DA, Wratten SD, Gurr GM. Habitat management to conserve natural enemies of arthropod pests in agriculture. Annu Rev Entomol. 2000;45:175-201. Available from: https://doi.org/10.1146/annurev.ento.45.1.175
33. Nath DK, Sen B. Some observations on aphidophagous coccinellid beetles in mustard cultivation. Sci Cult. 1976;42:288-290.
34. Omkar. Insect Predators in Pest Management. CRC Press, 2023. Available from: https://doi.org/10.1201/9781003370864
35. Poorani J. A review of the genus *Oenopia* Mulsant (Coleoptera: Coccinellidae) of the Indian subcontinent with description of a new species. Orient Insects. 2002;36(1):97-116. Available from: https://doi.org/10.1080/00305316.2002.10417328
36. Sharma PL, Chauhan U, Sharma KC. Studies on the diversity of predatory coccinellid beetles (Coleoptera) in different agro-climatic zones of Himachal Pradesh. Bioscan. 2015;10(3):981-985.
37. Siddiqui RK, Krishnaswami S. Diptera: Syrphidae. In: Rao VP, Ghani MA, editors. Studies on predators of Adelges spp. in the Himalaya. Miscellaneous Publication of the Commonwealth Institute of Biological Control No. 3. 1972. p.14-22.
38. Singh G, Singh R. Updated checklist of food plants of Macrosiphini (Aphididae: Hemiptera) in India-1. Int J Res Stud Zool. 2017;3(1):6-33.
39. Singh R. Tri-trophic associations of aphidophagous hover flies (Syrphidae: Diptera) in different states and union territories of India. Munis Ent Zool. 2026;21(1):367-397.
40. Singh R, Bhagat RC, Singh A. An updated checklist of tri-trophic associations of aphidophagous predatory arthropods in Jammu & Kashmir and Ladakh, India. Uttar Pradesh J Zool. 2025;46(21):177-198. Available from: https://doi.org/10.56557/upjoz/2025/v46i215339
41. Singh R, Ghosh S. Sexuales of aphids (Insecta: Homoptera: Aphididae): Identification keys, illustrative

descriptions and host-plant relations. LAP Lambert Academic Publishing, 2012.
42. Singh R, Shukla A. A catalogue of tri-trophic associations of arthropod predators of aphids (Homoptera: Aphididae) in different districts of Himachal Pradesh, India. J Fauna Biodivers. 2026;3(1):1-44.
43. Singh R, Singh BB, Sharma AK. Checklist of aphidophagous spiders (Araneae: Arachnida: Arthropoda) in India. Serket. 2024;20(3):288-310.
44. Singh R, Singh G. Aphids. In: Omkar, editor. Polyphagous Pests of Crops. Springer Nature Singapore, 2021. p.105-182. Available from: https://doi.org/10.1007/978-981-15-8075-8_3
45. Singh R, Singh N. Biodiversity of aphidophagous predators in the southeast districts of Uttar Pradesh, India. Munis Ent Zool. 2026;21(1):181-222.
46. Singh R, Srivastav AK. Checklist of aphidophagous predatory bugs (Heteroptera: Hemiptera: Insecta) in India. Int J Biol Environ Invest. 2024;4(2):1-11. Available from: https://doi.org/10.33745/ijbei.2024.v04i02.001
47. Singh R, Srivastav AK. An updated checklist of tri-trophic associations of aphidophagous arthropods in different districts of Uttarakhand, India. Int J Zool Invest. 2025;11(2):810-826.
48. Singh R, Tiwari AK, Tiwari KM. Checklist of aphidophagous Neuroptera (Insecta: Arthoptera) in India. Int J Biol Innov. 2024;6(2):99-127. Available from: https://doi.org/10.46505/IJBI.2024.6204
49. Singh R, Verma AK, Singh G. Food Plant Catalogue of Indian Aphids (Homoptera: Aphididae). Asian Biological Research Foundation; Nature Light Publications, 2023.
50. Staab M, Schuldt A. The influence of tree diversity on natural enemies: A review of the "enemies" hypothesis in forests. Curr For Rep. 2020;6:243-259.
51. Starý P. Natural enemies: Aphidiidae. In: Minks AK, Harrewijn P, editors. Aphids: Their Biology, Natural Enemies & Control. Vol. 2B. Elsevier, 1988. p.171-184.
52. Verma KL, Chowdhuri AN. Predation on peach leaf curl aphid Brachycaudus helichrysi Kalt. by Coccinella septempunctata L. Indian J Entomol. 1975;37:315-316.
53. Verma KL, Chowdhuri AN. Predaceous coccinellids on peach curl aphid Brachycaudus helichrysi Kalt. from Mashobra (Himachal Pradesh). Himachal J Agric Res. 1975;3:38-39.
54. Verma SN, Gargav VP, Mittal S. Host preference of six-spotted ladybird beetle Menochilus sexmaculatus (Fabricius). Indian J Plant Prot. 1983;11:66-69.