



Diversity and distribution of predators and parasitoids associated with *Capitophorus* species (Hemiptera: Aphididae) in India: An updated checklist of tri-trophic associations

Rajendra Singh

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

DOI: <https://doi.org/10.66856/ijer.2026.11.4.11375>

Abstract

Capitophorus van der Goot, 1913 species are aphids associated with diverse herbaceous plants in India, but information on their natural enemies remains fragmented. This study presents an updated checklist of their predators and aphidiine parasitoids, emphasising their diversity, host associations, and distribution. A total of 25 predator species belonging to 10 families and six arthropod orders were recorded from six *Capitophorus* species infesting seven identified host plants, forming 36 tri-trophic associations (TTAs) across five States/Union Territories. Coccinellidae predominated (13 species; 63.9% of TTAs), with *Oenopia sauzeti* showing the widest host and geographical range. *Capitophorus formosartemisiae* supported the richest predator assemblage, while *Artemisia vulgaris* was the principal host plant. Uttarakhand accounted for nearly 70% of predator TTAs. The parasitoid complex comprised 16 aphidiine taxa in seven genera, associated with six *Capitophorus* species on 12 identified host plants, forming 33 TTAs across six States/Union Territories. *Aphidius*, particularly *Aphidius matricariae*, was the dominant genus, and parasitoid associations were concentrated on *Artemisia*, *Carduus*, and *Polygonum*. Compared with parasitoids, predators were more species-rich but utilised fewer host plants, whereas parasitoids exhibited broader host plant associations and a more even distribution among *Capitophorus* species. Both predator and parasitoid records were strongly concentrated in Himalayan regions, with numerous single-record associations, indicating considerable geographical and taxonomic knowledge gaps. This checklist provides the first comprehensive synthesis of predator- and parasitoid-mediated tri-trophic interactions of *Capitophorus* species in India and establishes a baseline for future ecological research, biodiversity assessments, and conservation biological control programmes.

Keywords: Aphidiinae, aphidophagous predators, biodiversity, *Capitophorus*, Coccinellidae, conservation biological control, tri-trophic associations

Introduction

India's tribunal system has repeatedly generated the same constitutional anxiety: bodies created to exercise judicial or quasi-judicial power have often remained administratively dependent on the executive departments whose decisions they review. The aphid genus *Capitophorus* van der Goot, 1913 (Hemiptera: Aphididae: Aphidinae: Macrosiphini) comprises 33 recognised species worldwide^[22], occurring predominantly in temperate regions of the Holarctic, with extensions into subtropical and montane areas of Asia, Africa, Europe and the Americas^[6]. In India, 14 *Capitophorus* species are recorded on 63 plant species from 19 families^[48]. Species are closely associated with herbaceous and woody hosts, particularly members of Asteraceae, Convolvulaceae, Elaeagnaceae, Fabaceae, Gentianaceae, Lamiaceae, Melastomaceae, Nyctaginaceae, Polygonaceae, Primulaceae, Rosaceae, Rubiaceae, Salicaceae, Urticaceae, etc.^[6, 48]. In India, the genus is represented mainly in the Himalayan and northeastern regions, where its distribution closely follows temperate habitats and the occurrence of suitable host plants^[2, 9, 33]. Species of *Capitophorus* are distinguished by elongate siphunculi with apical flanges, comparatively long cauda, well-developed antennae and characteristic antennal and cuticular features, with identification based primarily on siphuncular morphology, antennal proportions, chaetotaxy and host association^[6, 28]. Like most Macrosiphini, they exhibit cyclical parthenogenesis, with many species alternating between woody primary hosts (mainly *Elaeagnus*, *Hippophae* and *Shepherdia*) and herbaceous

secondary hosts, while others remain monoecious on herbaceous plants^[6, 21, 44]. As in other temperate aphids, the dispersal and seasonal dynamics of *Capitophorus* species are influenced by temperature, photoperiod, host plant quality, and population density (crowding), which regulate alate production, migration, and seasonal phenology^[21]. *Capitophorus* species are distinguished by elongate siphunculi with apical flanges, comparatively long cauda, well-developed antennae, and characteristic antennal and cuticular features; identification relies primarily on siphuncular morphology, antennal proportions, chaetotaxy, and host association^[6, 48]. In India, infestations are particularly associated with *Artemisia*, *Rumex*, *Polygonum* and other herbaceous hosts, including several medicinal and aromatic plants. Most *Capitophorus* species exhibit a high degree of host specialisation, occurring primarily on *Artemisia vestita* (wormwood), *Artemisia vulgaris* (mugwort), *Carduus edelbergii* (plumeless thistle), *Cirsium wallichii* (Wallich's thistle), *Saussurea albescens* (whitish saw-wort), *Persicaria chinensis* (Chinese knotweed), *Saussurea albescens* (whitish saw-wort) and *Polygonum* sp. (knotweeds), a pattern that has likely driven their evolutionary diversification^[6, 22, 41]. In India, the genus is most diverse in the Himalayan region, particularly in Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Sikkim, Meghalaya, Arunachal Pradesh and the north West Bengal^[2, 9, 33]. Importantly, *Capitophorus* species sustain diverse assemblages of aphidophagous predators and aphidiine parasitoids that play a crucial role in the natural regulation of aphid populations in both natural and managed

ecosystems. Consequently, these aphids represent valuable model systems for investigating tritrophic interactions, biodiversity, conservation biological control and integrated pest management [7, 30, 45, 51]. Host specificity strongly shapes the distribution, phenology and natural enemy assemblages of *Capitophorus* species, resulting in distinct tritrophic associations among aphids, host plants and aphidophagous arthropods. Knowledge of these predator assemblages is fundamental for understanding food-web structure, evaluating predator diversity and distribution, identifying potential biological control agents, and supporting integrated pest management programmes in temperate agroecosystems. Although numerous taxonomic, faunistic and ecological investigations have documented predators/parasitoids associated with *Capitophorus* species in India, the available information remains scattered across research articles, technical bulletins, institutional reports, monographs, dissertations and regional journals, and is further complicated by taxonomic revisions, nomenclatural changes and inconsistencies in historical records. The absence of a consolidated and taxonomically validated checklist hampers accurate assessment of predator diversity, geographical distribution, aphid–predator–host plant relationships and existing knowledge gaps, thereby limiting their effective utilisation in biodiversity research and conservation biological control. Consequently, no comprehensive and critically evaluated synthesis of aphidophagous predators associated with *Capitophorus* species in India is currently available. To address this deficiency, the present study provides an updated checklist of aphidophagous predators/parasitoids associated with *Capitophorus* species infesting diverse host plants in India. The checklist critically compiles validated information on predator taxonomy, aphid–predator–host plant associations, geographical distribution and supporting literature, thereby establishing a reliable baseline for future studies on systematics, ecology, biodiversity, tritrophic interactions and conservation biological control of *Capitophorus* species in India. It also provides a standardised reference for monitoring changes in predator assemblages, identifying poorly explored regions and host associations, and facilitating the development of ecologically based aphid management strategies.

Materials and Methods

A comprehensive checklist of aphidophagous predators associated with *Capitophorus* species in India was compiled from published literature available up to 30 June 2026. Relevant records were

obtained from peer-reviewed journal articles, books, book chapters, conference proceedings, technical bulletins, institutional reports, dissertations, postgraduate theses and other authenticated publications retrieved through Google Scholar, Web of Science, Scopus, CAB Abstracts and institutional repositories, together with pertinent references cited therein. Only records explicitly documenting aphidophagous predators/parasitoids associated with identified *Capitophorus* species in India were included. Records with ambiguous taxonomy, doubtful identifications, duplicate reports or unsupported predator–aphid associations were excluded. For each validated record, data on predator species, associated *Capitophorus* species, host plant, state/union territory and bibliographic source were extracted. Predator/parasitoid nomenclature was validated using the Global Biodiversity Information Facility (<https://www.gbif.org>), aphid taxonomy followed by Favret [22], and host plant names were verified using World Flora Online (<https://www.worldfloraonline.org>). Synonymous and obsolete names were updated to their currently accepted nomenclature while retaining the original biological associations reported in the source literature. The checklist was arranged alphabetically by predator/parasitoid species and included the associated *Capitophorus* species, host plant(s), geographical distribution and literature references. As the study was based exclusively on published qualitative records, no statistical analyses were performed.

Results

Predators of *Capitophorus* species

A total of 25 aphidophagous predator species, representing 10 families, six arthropod orders, and two classes (Arachnida and Insecta), were recorded preying on six *Capitophorus* species infesting seven identified host plant species and one unidentified host plant across five states/union territories of India, forming 36 tri-trophic associations (TTAs) (Table 1). Insect predators predominated, comprising 19 species (76.0%) distributed among five orders, whereas arachnid predators contributed six species (24.0%) belonging to Araneae and Trombidiformes. Coleoptera was the dominant order, represented exclusively by 13 coccinellid species (52.0% of all predators) that collectively accounted for 23 TTAs (63.9%). The remaining predator fauna comprised three dipteran species, one hemipteran species, one neuropteran species, four spider species, and two predatory mite species, each contributing comparatively few associations. Most of the tri-trophic associations were recorded in Uttarakhand (25 TTAs, 69.4%).

Table 1: Species of predators preying on *Capitophorus* species infesting different species of plants and tri-trophic associations (TTAs) in different number of states/union territories (ST/UT) of India.

Order/Family	Species of the predators	Number of			
		Aphid species	Plant species	TTAs	ST/UT
Class: Arachnida					
Order: Araneae					
Araneidae	<i>Araneus</i> sp.	1	1	1	1
	<i>Neoscona</i> sp.	1	1	1	1
Salticidae	<i>Myrmarachne</i> sp.	1	1	1	1
Thomisidae	<i>Xysticus</i> sp.	1	1	1	1
Order: Trombidiformes					
Anystidae	<i>Anystis</i> sp.	1	1	1	1
Podothrombiidae	<i>Podothrombium</i> sp.	1	1	1	1
Class: Insecta					

Order: Coleoptera					
Coccinellidae	<i>Adalia tetraspilota</i>	3	2	3	2
	<i>Calvia punctata</i>	1	1	1	1
	<i>Coccinella septempunctata</i>	2	2	2	2
	<i>Cryptogonus</i> sp.	1	1	1	1
	<i>Halyzia sanscrita</i>	1	1	1	1
	<i>Hippodamia variegata</i>	1	2	2	2
	<i>Micraspis discolor</i>	1	1	1	1
	<i>Oenopia kirbyi</i>	2	3	3	1
	<i>Oenopia sauzeti</i>	3	4	5	3
	<i>Platynaspis saundersii</i>	1	1	1	1
	<i>Propylea luteopustulata</i>	1	1	1	1
	<i>Scymnus pyrocheilus</i>	1	1	1	1
	<i>Scymnus</i> sp.	1	1	1	1
Order: Diptera					
Cecidomyiidae	<i>Aphidoletes aphidimyza</i>	1	1	1	1
Syrphidae	<i>Eupeodes latifasciatus</i>	1	1	1	1
	<i>Ischiodon scutellaris</i>	1	1	1	1
	<i>Paragus tibialis</i>	1	1	1	1
Order: Hemiptera					
Anthocoridae	<i>Orius niger</i>	1	1	1	1
Order: Neuroptera					
Chrysopidae	<i>Chrysoperla zastrowi sillemi</i>	1	3	3	3
	Total	6	7	36	5

Among the individual predators, *Oenopia sauzeti* exhibited the broadest trophic and geographical range, being associated with three *Capitophorus* species infesting four host plant species, resulting in five TTAs across three states/union territories. *Adalia tetraspilota* ranked second, occurring on three aphid species infesting two host plants and forming three TTAs in two states/union territories. *Oenopia kirbyi* and *Chrysoperla zastrowi sillemi* each formed three TTAs, although the former was associated with two aphid species on three host plants within a single state/union territory, whereas the latter preyed on a single aphid species occurring on three host plant species across three states/union territories. *Coccinella septempunctata* and *Hippodamia variegata* each formed two TTAs, while the remaining 19 predator species were each represented by a single recorded association. At the family level, Coccinellidae overwhelmingly dominated the predator complex, contributing more than half of the recorded

predator species and nearly two-thirds of all TTAs, confirming ladybird beetles as the principal predators of *Capitophorus* species in India. The distribution of predator assemblages among *Capitophorus* species was highly uneven. *Capitophorus formosartemisiae* supported by far the richest predator community, with 22 predator species associated with four host plant species, producing 27 TTAs distributed across all four recorded states/union territories (Table 2). This single aphid species accounted for 88.0% of the documented predator fauna and 75.0% of all TTAs compiled in the present review. In comparison, *Capitophorus elaeagni* was associated with five predator species on a single host plant, forming five TTAs confined to one state/union territory. The *Capitophorus carduinus*, *Capitophorus hippophaes*, *Capitophorus hippophaes javanicus*, and an unidentified *Capitophorus* sp., each supported only one predator species, one host plant, and one TTA, all restricted to a single state/union territory.

Table 2: Number of predator species associated with species of *Capitophorus* on different host plant species forming different number of trophic associations (TTAs) and their distribution across states and union territories (ST/UT) of India.

Aphid species	Number of			
	Species of predators	Species of host plant	TTAs	ST/UT
<i>Capitophorus carduinus</i>	1	1	1	1
<i>Capitophorus elaeagni</i>	5	1	5	1
<i>Capitophorus formosartemisiae</i>	22	4	27	4
<i>Capitophorus hippophaes</i>	1	1	1	1
<i>Capitophorus hippophaes javanicus</i>	1	1	1	1
<i>Capitophorus</i> sp.	1	1	1	1
Total	25	7	36	5

The host plant analysis likewise revealed a marked concentration of documented interactions on *Artemisia* species. *Artemisia vulgaris* supported the greatest predator diversity, harbouring 15 predator species associated with *Capitophorus formosartemisiae* and accounting for 15 TTAs, whereas *Artemisia* sp. supported 10 predator species and 10 TTAs across three states/union territories (Table 3). Together, these

two host plant categories contributed 25 TTAs (69.4% of the total), demonstrating the predominance of *Artemisia* as the principal host plant genus sustaining predator-*Capitophorus* associations in India. *Cirsium wallichii* represented the second most important host plant, supporting two *Capitophorus* species, five predator species, and six TTAs, while other host plants supported only a single predator-aphid association.

Table 3: Number of predator species recorded from host plant species infested by *Capitophorus* species, the resulting tri-trophic associations (TTAs), and their distribution across the States and Union Territories (STs/UTs) of India

Plant species	Number of			
	Species of aphids	Species of predators	TTAs	ST/UT
<i>Artemisia vulgaris</i>	1	15	15	1
<i>Artemisia</i> sp.	1	10	10	3
<i>Cajanus cajan</i>	1	1	1	1
<i>Carduus edelbergii</i>	1	1	1	1
<i>Cirsium wallichii</i>	2	5	6	1
<i>Persicaria orientale</i>	1	1	1	1
<i>Saussurea albescens</i>	1	1	1	1
Unidentified plant	1	1	1	1
Total	6	25	36	5

Overall, the compiled evidence indicates that the currently documented tri-trophic associations of predators with *Capitophorus* species in India are taxonomically diverse but strongly skewed towards coccinellid beetles, *Capitophorus formosartemisiae*, and *Artemisia* hosts. Most predator species exhibited narrow recorded host and geographical ranges, with nearly four-fifths of the predators represented by a single TTA. The pronounced concentration of records on one aphid species and one host plant genus, together with the limited geographical coverage of most other associations, suggests that the existing knowledge largely reflects differences in sampling intensity rather than the actual diversity of predator–aphid–host plant interactions. Consequently, comprehensive surveys on poorly studied *Capitophorus* species, non-*Artemisia* host plants, and underexplored agroecological regions are needed to provide a more complete understanding of these tri-trophic associations in India.

Parasitoids

A total of 16 aphidiine parasitoid taxa, belonging to seven genera, were recorded parasitising six *Capitophorus* species infesting 12 identified host plant species and one unidentified host plant across six states/union territories of India, resulting in 33 tri-trophic associations (TTAs) (Table 4). The parasitoid complex was dominated by the genus *Aphidius*,

represented by five taxa (31.3%) that collectively accounted for 13 TTAs (39.4%), followed by *Ephedrus* and *Trioxys* with three taxa each. The remaining genera, *Betuloxys*, *Binodoxys*, *Cristicaudus*, and *Toxares*, were represented by one or two species each, confirming the predominance of *Aphidius* in the parasitoid complex associated with *Capitophorus* species in India. Most of the tritrophic associations were recorded in northwest Himalayan states (Uttarakhand-10 TTAs, Jammu & Kashmir-9 TTAs) and the northeast Himalayan state, Meghalaya (10 TTAs). Among the parasitoids, *Aphidius matricariae* exhibited the broadest host range and geographical distribution, parasitising five *Capitophorus* species infesting five host plant species and forming seven TTAs across four states/union territories. *Betuloxys intermedius* ranked second, being associated with two aphid species on three host plant species, resulting in four TTAs distributed across three states/union territories, whereas *Trioxys rishii* formed three TTAs involving two aphid species and three host plants across two States/Union Territories. Six parasitoid taxa, namely *Aphidius qadrii*, *Aphidius* sp., *Binodoxys centaureae*, *Cristicaudus garhwalensis*, *Ephedrus trichosiphoniellae*, and *Toxares macrosiphophagum*, each contributed two TTAs, while the remaining 10 parasitoid taxa were each represented by a single recorded association (Table 4). Overall, 10 of the 16 parasitoid taxa (62.5%) were confined to a single State/Union Territory, indicating generally restricted geographical distributions.

Table 4: Species of aphidiine parasitoids of *Capitophorus* species infesting different species of plants and tri-trophic associations (TTAs) in different number of states/union territories (ST/UT) of India.

Species of the parasitoids	Number of			
	Aphid species	Plant species	TTAs	ST/UT
<i>Aphidius eglanteriae</i>	1	1	1	1
<i>Aphidius matricariae</i>	5	5	7	4
<i>Aphidius qadrii</i>	1	2	2	1
<i>Aphidius salicis</i>	1	1	1	1
<i>Aphidius</i> sp.	1	2	2	2
<i>Betuloxys intermedius</i>	2	3	4	3
<i>Binodoxys centaureae</i>	1	2	2	1
<i>Binodoxys indicus</i>	1	1	1	1
<i>Cristicaudus garhwalensis</i>	2	1	2	2
<i>Ephedrus lacertosus</i>	1	1	1	3
<i>Ephedrus plagiator</i>	1	1	1	1
<i>Ephedrus trichosiphoniellae</i>	2	2	2	1
<i>Toxares deltiger</i>	1	1	1	1
<i>Toxares macrosiphophagum</i>	2	2	2	1
<i>Trioxys rishii</i>	2	3	3	2
<i>Trioxys</i> sp.	1	1	1	1
Total	6	12	33	6

The distribution of parasitoid associations among *Capitophorus* species was comparatively balanced, although clear differences in parasitoid richness and host utilisation were evident. An unidentified *Capitophorus* sp. exhibited the broadest host plant range, being associated with five parasitoid species on eight host plant species, resulting in nine TTAs across three states/union territories. In contrast, *Capitophorus formosartemisiae* supported the highest parasitoid richness, harbouring six parasitoid species associated with three host plant species, which collectively formed six TTAs distributed across three states/union

territories. *Capitophorus elaeagni* also produced six TTAs, although these involved only four parasitoid species and were restricted to two States/Union Territories. *Capitophorus mitegoni* supported four parasitoid species and five TTAs, whereas *Capitophorus hippophaes* was associated with four parasitoid species on four host plant species, forming four TTAs confined to Meghalaya. The least diverse parasitoid assemblage was recorded from *Capitophorus carduinus*, which supported two parasitoid species and three TTAs across three states/union territories (Table 5).

Table 5: Number of parasitoid species associated with species of *Capitophorus* on different host plant species forming different number of tri-trophic associations (TTAs) and their distribution across states and union territories (ST/UT) of India.

Aphid species	Number of			
	Species of parasitoids	Species of host plant	TTAs	ST/UT
<i>Capitophorus carduinus</i>	2	3	3	3
<i>Capitophorus elaeagni</i>	4	3	6	2
<i>Capitophorus formosartemisiae</i>	6	3	6	3
<i>Capitophorus hippophaes</i>	4	4	4	1
<i>Capitophorus mitegoni</i>	4	3	5	3
<i>Capitophorus</i> sp.	5	8	9	3
Total	16	12	33	6

Host plant analysis revealed that parasitoid diversity was concentrated primarily on members of the genera *Artemisia*, *Carduus*, and *Polygonum*. *Artemisia vulgaris* and *Carduus* sp. each supported the highest number of TTAs (five), although

the former was associated with two aphid species and four parasitoid species across three states/union territories, whereas the latter harboured three aphid species and four parasitoid species in two states/union territories (Table 6).

Table 6: Number of parasitoid species recorded from host plant species infested by *Capitophorus* species, the resulting tri-trophic associations (TTAs), and their distribution across the States and Union Territories (STs/UTs) of India

Plant species	Number of			
	Species of aphids	Species of host parasitoids	TTAs	ST/UT
<i>Anaphalis cinnamomea</i>	1	1	1	1
<i>Anaphalis margaritacea</i>	1	1	1	1
<i>Artemisia vestita</i>	2	1	2	2
<i>Artemisia vulgaris</i>	2	4	5	3
<i>Artemisia</i> sp.	2	3	3	2
<i>Carduus edelbergii</i>	1	2	2	1
<i>Carduus</i> sp.	3	4	5	2
<i>Centaurea iberica</i>	1	1	1	1
<i>Cirsium wallichii</i>	1	1	1	1
<i>Persicaria chinensis</i>	2	2	3	1
<i>Polygonum chiloensis</i>	1	1	1	1
<i>Polygonum</i> sp.	3	4	4	3
Unidentified plant	4	3	4	3
Total	6	16	33	6

Polygonum sp. and the unidentified host plant each accounted for four TTAs, while *Persicaria chinensis* and *Artemisia* sp. each supported three TTAs. *Artemisia vestita* and *Carduus edelbergii* contributed two TTAs each, whereas *Anaphalis cinnamomea*, *Anaphalis margaritacea*, *Centaurea iberica*, *Cirsium wallichii*, and *Polygonum chiloensis* were each represented by a single TTA. Geographically, *Artemisia vulgaris* and *Polygonum* sp. exhibited the widest distribution, each occurring in three states/union territories, whereas most other host plants were represented by records from only one or two regions (Table 6). Collectively, these findings demonstrate that the documented parasitoid–*Capitophorus*–host plant network in India is moderately diverse but unevenly represented across parasitoid taxa, aphid species, and host plants. Although a

few parasitoids, particularly *Aphidius matricariae*, display broad host ranges and extensive geographical distributions, most taxa exhibit narrow ecological amplitudes and localised occurrence. Likewise, parasitoid associations are concentrated on a limited number of *Capitophorus* species and host plant genera, especially *Artemisia*, *Carduus*, and *Polygonum*. The prevalence of single-record associations and the occurrence of incompletely identified host plants indicate that the current knowledge largely reflects unequal sampling intensity rather than the true diversity of parasitoid–aphid–host plant interactions. Consequently, extensive surveys across poorly explored host plants, aphid species, and agroecological regions are required to provide a more comprehensive understanding of aphidiine parasitoid diversity associated with *Capitophorus* species in India.

Discussion

The compiled data indicate distinct ecological patterns in predator and parasitoid assemblages associated with *Capitophorus* species in India. Predators showed higher species richness (25 species) than parasitoids (16 taxa), whereas parasitoids exploited a broader host plant range (12 versus seven identified plant species), reflecting the broader prey spectrum of predators and greater host specialisation of aphidiine parasitoids [23, 29, 53]. Nevertheless, the available records are geographically uneven and likely underestimate actual natural enemy diversity. Coccinellidae dominated the predator community, accounting for more than half of predator species and most tri-trophic associations, consistent with their importance as efficient and polyphagous aphid predators [29, 32]. Parasitoids were mainly represented by *Aphidius*, particularly *Aphidius matricariae*, followed by *Ephedrus* and *Trioxys*, reflecting the prominence of these genera

in temperate aphid ecosystems [42, 51]. This contrast indicates broader prey utilisation by predators and stronger host specificity among parasitoids. Predators were concentrated mainly in Uttarakhand, while parasitoids showed a broader Himalayan distribution, including Uttarakhand, Jammu & Kashmir, and Meghalaya (Figure 1). The predominance of Himalayan records indicates considerable sampling bias and limited information from other regions of India. Most predators were recorded from single associations, likely reflecting insufficient sampling. Overall, predators showed greater diversity but stronger association with *Capitophorus formosartemisiae* and *Artemisia*-based habitats [47], whereas parasitoids displayed wider host plant utilisation and more balanced aphid associations [8, 14, 37, 44, 49]. Further standardised surveys, molecular validation, and long-term ecological studies are required to clarify *Capitophorus* tri-trophic networks and their biological control potential.

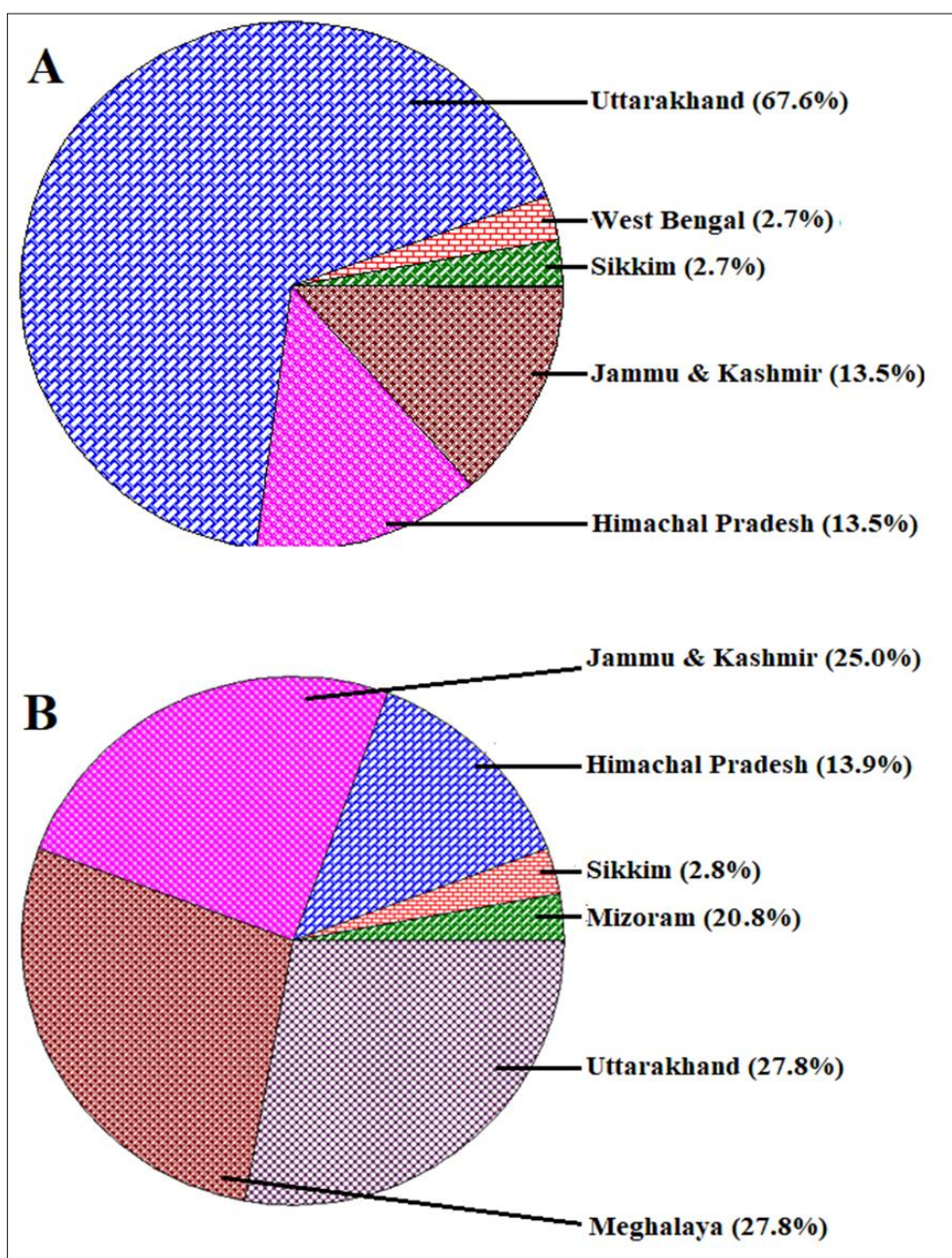


Fig 1: Percentage of tri-trophic associations of predators (A) and parasitoids (B) of different species of the aphid *Capitophorus* in different states and union territories of India.

The detailed account of tri-trophic association of predators and parasitoids of *Capitophorus* species are given below.

Class: Arachnida

Order: Araneae

a. Family: Araneidae

1. *Araneus* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia* sp. - Himachal Pradesh ^[17]

2. *Neoscona* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

b. Family: Salticidae

1. *Myrmarachne* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

c. Family: Thomisidae

1. *Xysticus* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

Order: Trombidiformes

a. Family: Anystidae

1. *Anystis* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

b. Family: Podothrombiidae

1. *Podothrombium* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Saussurea albescens* Hook.f. & Thoms - Uttarakhand ^[18]

Class: INsecta

Order: Coleoptera

a. Family: Coccinellidae

1. *Adalia tetraspilota* (Hope, 1831)

- *Capitophorus carduinus* (Walker, 1850)
- *Cirsium wallichii* DC. - Uttarakhand ^[27]
- *Capitophorus elaeagni* (del Guercio, 1894)
- *Cirsium wallichii* DC. - Uttarakhand ^[27]
- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia* sp. - Jammu & Kashmir ^[31]

2. *Calvia punctata* (Mulsant, 1853)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia* sp. - Jammu & Kashmir ^[31]

3. *Coccinella septempunctata* Linnaeus, 1758

- *Capitophorus elaeagni* (del Guercio, 1894)
- *Cirsium wallichii* DC. - Uttarakhand ^[18]
- *Capitophorus* sp.
- Unidentified plant - Himachal Pradesh ^[1]

4. *Cryptogonus* sp.

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia* sp. - Himachal Pradesh ^[17]

5. *Halyzia sanscrita* Mulsant, 1853

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[27]

6. *Hippodamia variegata* (Goeze, 1777)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[27]
- *Artemisia* sp. - Jammu & Kashmir ^[31]

7. *Micraspis discolor* (Fabricius, 1798)

- *Capitophorus elaeagni* (del Guercio, 1894)
- *Cirsium wallichii* DC. - Uttarakhand ^[27]

8. *Oenopia kirbyi* Mulsant, 1850

- *Capitophorus elaeagni* (del Guercio, 1894)
- *Cirsium wallichii* DC. - Uttarakhand ^[27]
- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[27]
- *Artemisia* sp. - Uttarakhand ^[26]

9. *Oenopia sauzeti* Mulsant, 1866

- *Capitophorus elaeagni* (del Guercio, 1894)
- *Cirsium wallichii* DC. - Uttarakhand ^[27]
- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[27]
- *Artemisia* sp. - Himachal Pradesh ^[17]; Uttarakhand ^[26]
- *Capitophorus hippophaes javanicus* Hille Ris Lambers, 1953
- *Persicaria orientale* (L.) Spatch - Sikkim ^[11]

10. *Platynaspis saundersii* Crotch, 1874

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

11. *Propylea luteopustulata* (Mulsant, 1850)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia* sp. - Uttarakhand ^[26]

12. *Scymnus pyrocheilus* Mulsant, 1853

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia* sp. - Himachal Pradesh ^[17]

13. *Scymnus* sp

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[27]

Order: Diptera

a. Family: Cecidomyiidae

1. *Aphidoletes aphidimyza* Rondani, 1848

- *Capitophorus hippophaes* (Walker, 1852)
- *Carduus edelbergii* Rech.f. - Jammu & Kashmir ^[5]

b. Family: Syrphidae

1. *Eupeodes latifasciatus* (Macquart, 1829)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

2. *Ischiodon scutellaris* (Fabricius, 1805)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[25]

3. *Paragus tibialis* (Fallén, 1817)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[25]

Order: Hemiptera

a. Family: Anthocoridae

1. *Orius niger* (Wolff, 1811)

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[18]

Order: Neuroptera

a. Family: Chrysopidae

1. ***Chrysoperla zastrowi sillemi* (Esben-Petersen, 1935)**
 - *Capitophorus formosartemisiae* (Takahashi, 1921)
 - *Artemisia vulgaris* L. - Uttarakhand ^[19]
 - *Artemisia* sp. - Jammu & Kashmir ^[31]
 - *Cajanus cajan* (L.) Millsp. - West Bengal ^[20]

Class: Insecta

Order: Hymenoptera

Family: Braconidae

Subfamily: Aphidiinae

1. ***Aphidius eglanteriae* Haliday, 1834**
 - *Capitophorus formosartemisiae* (Takahashi, 1921)
 - *Artemisia* sp. - Uttarakhand ^[13]
2. ***Aphidius matricariae* Haliday, 1834**
 - *Capitophorus carduinus* (Walker, 1850)
 - *Cirsium wallichii* DC. - Uttarakhand ^[12, 13]
 - Unidentified plant - Himachal Pradesh ^[36]
 - *Capitophorus elaeagni* (del Guercio, 1894)
 - *Carduus edelbergii* Rech.f. - Jammu & Kashmir ^[3]
 - *Capitophorus formosartemisiae* (Takahashi, 1921)
 - *Artemisia* sp. - Himachal Pradesh ^[36]
 - *Capitophorus hippophaes hippophaes* (Walker, 1852)
 - *Persicaria chinensis* (L.) H. Gross -Meghalaya ^[49]
 - *Capitophorus mitegoni* Eastop, 1956
 - *Persicaria chinensis* (L.) H. Gross -Meghalaya ^[34]
 - Unidentified plant - Meghalaya ^[49]
3. ***Aphidius qadrii* (Shuja-Uddin, 1977)**
 - *Capitophorus* sp.
 - *Anaphalis cinnamomea* (DC.) C.B. Clarke - Uttarakhand ^[14]
 - *Anaphalis margaritacea* (L.) Benth. and Hook.f. - Uttarakhand ^[14]
4. ***Aphidius salicis* Haliday, 1834**
 - *Capitophorus elaeagni* (del Guercio, 1894)
 - *Carduus* sp. - Jammu & Kashmir ^[8]
5. ***Aphidius* sp.**
 - *Capitophorus* sp.
 - *Artemisia vulgaris* L. - India ^[24]
 - *Carduus* sp. - Jammu & Kashmir ^[4]
6. ***Betuloxys intermedius* (Shuja-Uddin, 1975) ^[40]**
 - *Capitophorus formosartemisiae* (Takahashi, 1921)
 - *Artemisia vulgaris* L. - Uttarakhand ^[14, 16]
 - *Capitophorus* sp.
 - *Artemisia* sp. - Uttarakhand ^[14]
 - *Artemisia vulgaris* L. - Uttarakhand ^[10]; Himachal Pradesh ^[8]
 - *Centaurea iberica* Trevir. ex Spreng.- Jammu & Kashmir ^[40]
7. ***Binodoxys centaureae* (Haliday, 1833)**
 - *Capitophorus elaeagni* (del Guercio, 1894)
 - *Carduus* sp. - Jammu & Kashmir ^[35]
 - Unidentified plant - Jammu & Kashmir ^[4]
8. ***Binodoxys indicus* (Subba Rao & Sharma, 1958)**
 - *Capitophorus mitegoni* Eastop, 1956

- *Polygonum* sp. - Meghalaya ^[37]

9. ***Cristicaudus garhwalensis* Das & Chakrabarti, 1991 ^[14, 15]**

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vestita* Wall ex Besser - Himachal Pradesh ^[8]; Uttarakhand ^[15, 16]
- *Capitophorus* sp.
- *Artemisia vestita* Wall ex Besser - Uttarakhand ^[10, 39]

10. ***Ephedrus lacertus* (Haliday, 1833)**

- *Capitophorus mitegoni* Eastop, 1956
- *Polygonum* sp. -Meghalaya ^[37]; Mizoram ^[38]; Sikkim ^[52]

11. ***Ephedrus plagiator* (Nees, 1811)**

- *Capitophorus* sp.
- *Polygonum* sp. - Not mentioned ^[24]

12. ***Ephedrus trichosiphoniellae* Takada, 1968**

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Meghalaya ^[37]
- *Capitophorus hippophaes* (Walker, 1852)
- *Polygonum* sp. - Meghalaya ^[37]

13. ***Toxares deltiger* (Haliday, 1833)**

- *Capitophorus hippophaes* (Walker, 1852)
- *Polygonum chiloensis* Rech.f. - Meghalaya ^[49]

14. ***Toxares macrosiphophagum* Shuja-Uddin, 1974**

- *Capitophorus hippophaes* (Walker, 1852)
- Not mentioned - Meghalaya ^[50]
- *Capitophorus mitegoni* Eastop, 1956
- *Persicaria chinensis* (L.) H. Gross - Meghalaya ^[37]

15. ***Trioxys rishii* Starý & Bhagat, 1978 ^[49]**

- *Capitophorus carduinus* (Walker, 1850)
- *Carduus* sp. - Jammu & Kashmir ^[8]
- *Capitophorus elaeagni* (del Guercio, 1894)
- *Carduus edelbergii* Rech.f.- Jammu & Kashmir ^[3, 8]
- *Carduus* sp. - Jammu & Kashmir ^[4, 35]; Himachal Pradesh ^[8]

16. ***Trioxys* sp.**

- *Capitophorus formosartemisiae* (Takahashi, 1921)
- *Artemisia vulgaris* L. - Uttarakhand ^[8]

References

1. Agarwala B K, Ghosh D, Das S K, Poddar S C, Raychaudhuri D N. 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.
2. Basu R C, Raychaudhuri D N. Studies on the aphids (Homoptera: Aphididae) from eastern India. xxxi. The genus *Capitophorus*. Orient Ins,1976;10:567-572. <https://doi.org/10.1080/00305316.1976.10434527>
3. Bhagat R C. Records and host range of hyperparasitoids (Insecta: Hymenoptera) of aphids (Homoptera: Aphididae) from Kashmir, India. Sci & Cult,1983;49:150-152.
4. Bhagat R C. New records and hosts of aphid parasitoids (Hymenoptera: Aphidiidae) from Kashmir, India. J Bombay Nat Hist Soc,1984;81(1):91-98.

5. Bhagat R C. Diversity and distribution of midge-fauna (Insecta: Diptera) of Jammu, Kashmir and Ladakh Himalaya (India). *Res & Rev BioSci*,2014;9(6):199-206.
6. Blackman R L, Eastop V F, Aphids on the World's Herbaceous Plants & Shrubs. Host List & Keys, John Wiley & Sons, Chichester, UK,2006:1:1460.
7. Brodeur J, Boivin G. Trophic and Guild Interactions in Biological Control. Springer, Dordrecht, The Netherlands, 2006, 249.
8. Chakrabarti S, Debnath M. Diversity of aphidophagous parasitoids (Insecta) of northwest and western Himalayas, India. In: Biodiversitat und Natursausstattung im Himalaya, III (eds. Hartmann, M.& Weipert, J.), Naturkundemuseum Erfurt, 2009, 441-454.
9. Chakrabarti S, Sarkar A. A supplement to the food-plant catalogue of Indian Aphididae. *J Aphidol*,2001;15:9-62.
10. Chakrabarti S, Sarkar S, Das B C. Aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) from western Himalaya. *J Aphidol*,2002;16:45-49.
11. Chakrabarti S, Sarkar S, Debnath M. Diversity, bioecology and biosystematics of aphidophagous predators of eastern Himalaya and northeast India. In: Biodiversitat und Natursausstattung im Himalaya, IV (eds. Hartmann, M, Weipert, J.), Naturkundemuseum Erfurt, 2012, 129-147.
12. Das B C, Chakrabarti C. Seasonal occurrence of *Aphidius matricariae* Haliday (Aphidiidae: Hymenoptera) in Garhwal range of northwest Himalaya. *Indian J Ent*,1988;50:388-389.
13. Das B C, Chakrabarti S. New and little known aphidiid parasitoids (Hymenoptera: Aphidiidae) of gall forming aphids in Western Himalaya, with notes on their seasonal history. *Orient Ins*,1990;24:399-414. <https://doi.org/10.1080/00305316.1990.11835548>
14. Das B C, Chakrabarti S. Aphidiid (Hymenoptera: Aphidiidae) fauna of Garhwal, Western Himalaya. *J Bombay Nat Hist Soc*,1991;88:409-413.
15. Das B C, Chakrabarti S. Two new *Cristicaudus* (Hymenoptera: Aphidiidae) as parasites of aphids in Garhwal range of Himalaya, India. *Entomon*,1991;16:305-309.
16. Das B C, Chakrabarti C. Diversity and distribution of hyperparasitoids of Aphidiinae (Insecta: Braconidae: Hymenoptera) in the Garhwal Himalayas. Hartmann, Barclay. & Weipert: Biodiversität und Natursausstattung im Himalaya VI. – Erfurt, 2018, 565-570.
17. Das S K, Raychaudhuri D. Parasitoids and predators of aphids (Homoptera: Aphididae) from India VI. New records of seven arachnids, one dipteran and neuropteran predators from Himachal Pradesh, India. *Entomon*,1983;8(1): 27-34.
18. Debnath N. Studies on some aphidophagous insects in northwest and western Himalayas. Ph.D. thesis, 1991. University of Kalyani. <http://hdl.handle.net/10603/211339>
19. Dey S R. Seasonal occurrence and altitudinal distribution of Neuroptera (Insecta) in Uttarakhand, India. *The Beats Nat Sci*,2015;2(4):1-13.
20. Dey S R, De M. Report on winter crop plant-aphid-aphidophagous Chrysopidae (Neuroptera: Insecta) association from Murshidabad district, West Bengal, India. *Intern J Exp Res & Rev*,2018;16:7-13. <https://doi.org/10.52756/ijerr.2018.v16.002>
21. Dixon A F G. Aphid Ecology: An Optimization Approach (2nd ed.). Chapman & Hall, London, 1998, 300.
22. Favret C. Aphid Species File: <https://Aphid.SpeciesFile.org>, retrieved on June 30, 2026.
23. Ferrer-Suay M, Barreda M, Rakhshani E, Rodrigo E, Selfa J, Polaszek A. A review of aphid parasitoids, with an identification key to the genera of economic importance. *Insects*,2025;16(7):648. <https://doi.org/10.3390/insects16070648>
24. Ghosh A K, Agarwala B K. A catalogue of aphidiid (Hymenoptera: Aphidiidae) parasites of aphids (Homoptera) of India. *J Bombay Nat Hist Soc*.1982;79:125-134.
25. 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.
26. Ghosh D, Debnath N, Chakrabarti S. Development of three species of *Oenopia* (Coleoptera: Coccinellidae) predating on aphids of Garhwal Himalaya. *Proc III Orient Ent Symp*, Fenruary 21-24, 1984, Trivendrum, 1986, 173-176.
27. Ghosh D, Debnath N, Chakrabarti S. 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*,1991;88(2):177-188. <https://doi.org/10.26515/rzsi/v88/i2/1991/161342>
28. Ghosh A K, Ghosh A K, Chandra K. Fauna of India and the adjacent countries: Homoptera: Aphidoidea, Part 7/2 Subfamily: Aphidinae: Macrosiphini. *Zoological Survey of India*, 2017, 843.
29. Hodek I, Honěk A. Ecology of Coccinellidae. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1996, 480.
30. Hodek I, Van Emden H F, Honek I. Ecology and Behavior of Ladybird Beetles (Coccinellidae). Blackwell Publishing Ltd, 2012, 650. <https://doi.org/10.1002/9781118223208>
31. Khan A A, Shah M A. Records of aphid and their natural enemies in agro-ecosystem with special reference to horticultural ecosystem of Kashmir. *J Ent Zool St*,2017;5(4):189-203.
32. Kumar B, Omkar. Prey-predator relationships in ladybird beetles and biological control of insect pests. *J Appl Biosci*,2025;51(1):1-36. <https://doi.org/10.61081/joab/51v1i101>
33. Raychaudhuri D N. Aphids of North-East India and Bhutan. *Zoological Society, Calcutta*, 1980, 521.
34. Raychaudhuri D N, Poddar S C, Raychaudhuri D. Study of the genus *Aphidius* (Hymenoptera: Aphidiidae) of India. *Entomon*.1982;7(1):11-22.
35. Saha B K. Studies on aphid-aphidiid complex of Jammu and Kashmir. Ph.D. thesis, University of Calcutta, Kolkata, West Bengal, 1988, 497. <http://hdl.handle.net/10603/163506>
36. Saha J L, Poddar S C, Das S K, Agarwala B K, Raychaudhuri D. Studies on the aphid parasites

- (Hymenoptera: Aphidiidae) from Himachal Pradesh, India. *Akitu NS*, 1982:44:1-12.
37. Samanta A K. Studies on aphidiids (Hymenoptera) - aphids (Homoptera) of Meghalaya and Arunachal Pradesh. Ph. D. thesis, University of Calcutta, Kolkata, West Bengal, 1986, 339. <http://hdl.handle.net/10603/163445>
 38. Sarkar S K. Studies on aphid-aphidiid complex of Mizoram. Ph. D. thesis, Culcutta University, Kolkata, 1991, 452. <http://hdl.handle.net/10603/154725>
 39. Sarkar S. Incidence and host association of primary parasitoids (Hymenoptera: Braconidae: Aphidiinae) of aphids infesting economically important plants in Kumaon-Garhwal ranges of western Himalaya. *Intern J Agric Innov & Res*, 2022:10(4):137-142.
 40. Shuja-Uddin. Two new species of Aphidiidae (Hymenoptera) from India. *Rec Zool Surv India*, 1975;68:415-420.
 41. Singh G, Singh R. Updated checklist of food plants of Macrosiphini (Aphididae: Hemiptera) in India - 1. *Intern J Res St Zool*, 2017:3(1):6-33.
 42. Singh R. Distribution and tritrophic associations of aphid parasitoids of the tribe Aphidiini (Aphidiinae: Braconidae: Hymenoptera) in India. *Arthropods*, 2025:14(3):94-149.
 43. Singh R. An updated checklist of aphidiine parasitoids (Hymenoptera: Braconidae) of aphids (Homoptera: Aphididae) infesting *Artemisia* species (Asterales: Asteraceae) in different states/union territories of India. *Asian J Res Zool*, 2026:9(4):95-107. <https://doi.org/10.9734/ajriz/2026/v9i4316>
 44. Singh R, Ghosh S. Sexuales of Aphids (Insecta: Homoptera: Aphididae) in India: Identification Keys, Illustrative Descriptions and Host-Plant Relations. LAP Lambert Academic Publishing, Saarbrücken, Germany, 2012, 412.
 45. Singh R, Singh G. Aphids and their biocontrol. In: *Ecofriendly Pest Management for Food Security* (Ed. Omark), Academic Press, 2016, 63–108. <https://doi.org/10.1016/B978-0-12-803265-7.00003-8>
 46. Singh R, Singh G. Reproductive strategies in aphids. In: *Reproductive strategies in insects* (Eds. Omark & Mishra, G.), Taylor, Francis Group, LLC, 2022, 259-282. <https://doi.org/10.1201/9781003043195-13>
 47. Singh R, Jaiswal G, Chauhan H K. An updated checklist of arthropod predators of aphids (Homoptera: Aphididae) infesting *Artemisia* species (Asteraceae) across India. *J Appl Ent*, 2026:6(3):34–45. <https://doi.org/10.64171/JAE.6.3.34-45>
 48. Singh R, Verma A K, Singh G. Food Plant Catalogue of Indian Aphids (Homoptera: Aphididae). Asian Biological Research Foundation, Prayagraj, India; Nature Light Publications, Pune, 2023, 350.
 49. Starý P, Ghosh A K. Further records of aphid parasitoids (Hymenoptera: Aphidiidae) from Meghalaya, India. *Orient Ins*, 1978:12:77-80. <https://doi.org/10.1080/00305316.1978.10434553>
 50. Starý P, Ghosh A K. Aphid parasitoids of India and adjacent countries (Hymenoptera: Aphidiidae). *Zoological Survey of India. Tech Monogr*, 1983:7: 1-96.
 51. Starý P. Biology of Aphid Parasites (Hymenoptera: Aphidiidae) with Respect to Integrated Control. Dr. W. Junk, B.V, The Hague, 1970, 643.
 52. Tamili H K. Taxonomy of Aphidiids - Aphids of Sikkim and Hilly areas of West Bengal. Ph. D. Thesis. University of Calcutta, Kolkata, West Bengal, 1988:1-370. <http://hdl.handle.net/10603/163376>
 53. Žikić V, Lazarević M, Milošević D. Host range patterning of parasitoid wasps Aphidiinae (Hymenoptera: Braconidae). *Zool Anz*, 2017, 268: 75-83. <https://doi.org/10.1016/j.jcz.2016.10.001>.