GESA
GLOCAL ENVIRONMENT & SOCIAL ASSOCIATION

International Journal of Biological Innovations
http://ijbi.org.in | http://www.gesa.org.in/journals.php
https://doi.org/10.46505/IJBI.2026.8105
IJBI 8(1): 45-58 **(2026)**
E-ISSN: 2582-1032

A CATALOGUE OF TRI-TROPHIC ASSOCIATION OF APHID PARASITOIDS IN UTTAR PRADESH, INDIA

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Article Info:
Review Article
Received
21.12.2025
Reviewed
15.01.2026
Accepted
02.02.2026

Abstract: A comprehensive synthesis of tri-trophic associations involving aphids, their parasitoids and host plants was compiled for Uttar Pradesh, India, based on published records. The checklist documents parasitoids belonging to two families, Aphelinidae and Braconidae (Aphidiinae), comprising 7 species of Aphelinidae and 21 species of Aphidiinae, associated with a wide diversity of aphid hosts and plant taxa. In total, the associations encompass 33 agriculturally important aphid pests, including *Aphis craccivora*, *Aphis gossypii*, *Aphis fabae*, *Lipaphis erysimi*, *Melanaphis sacchari*, *Myzus persicae*, *Rhopalosiphum maidis*, *Sitobion avenae* and *Sitobion miscanthi*, infesting 74 species of cereals, oilseeds, pulses, vegetables, fruit crops, ornamentals and weeds forming 205 tri-trophic associations. Parasitoid genera such as *Aphelinus*, *Aphidius*, *Binodoxys*, *Diaeretiella*, *Lipolexis*, *Lysiphlebia* and *Ephedrus* emerged as key natural enemies with broad or crop-specific host ranges. The data reveal pronounced host specificity in several parasitoids, particularly within defined host-plant contexts, underscoring the structured and region-specific nature of aphid–parasitoid interactions. This consolidated checklist provides baseline information on species diversity, host associations and trophic linkages, highlighting dominant natural regulators of aphid populations in the region. The synthesis is expected to support biodiversity assessments, ecological studies; development of regionally adapted conservation and biological control strategies within IPM programmes in Uttar Pradesh.

Keywords: Aphelinidae, Aphid parasitoids, Biodiversity, Braconidae, Tri-trophic interaction.

Cite this article as: Singh R., Agrawal R. and Ahmad Md. Equbal (2026). A Catalogue of Tri-trophic association of Aphid parasitoids in Uttar Pradesh, India. *International Journal of Biological Innovations*. 8(1): 45-58. https://doi.org/10.46505/IJBI.2026.8105

INTRODUCTION

Aphids (Hemiptera: Aphididae) are major pests of agricultural and horticultural crops worldwide, causing damage through phloem feeding, plant deformation, honeydew deposition, and the transmission of numerous plant viruses (Blackman and Eastop, 2000; Singh and Singh, 2021). Their high reproductive capacity, telescoping generations, polyphenism, and rapid adaptability often result in sudden population outbreaks and substantial yield losses across diverse agroecosystems (Minks and Harrewijn, 1987; Dixon, 1998; Singh and Singh, 2022). Aphid populations are naturally regulated by a complex network of biotic interactions involving host plants, aphids, and their natural enemies. Among these, tritrophic associations linking host plants, aphids, and parasitoids constitute a key ecological framework governing aphid population dynamics

(Price *et al.*, 1980; Singh, 2003). Parasitoids, particularly Hymenoptera belonging to Braconidae (Aphidiinae) and Aphelinidae, act as major density-dependent mortality agents and play a central role in the natural suppression of aphid infestations (Starý, 1970; Dixon, 1998; Das *et al*., 2023a, b; Singh, 2025a).

The host plants strongly mediate aphid–parasitoid interactions by influencing aphid nutrition, physiology, defensive chemistry, and behaviour, which in turn affect parasitoid host selection, development, survival, and reproductive success (Bhatt and Singh, 1989; Prasad *et al*., 2005; Guerrieri and Digilio, 2008). Consequently, aphid parasitoids often exhibit high host specificity within particular host-plant contexts, rendering these interactions highly structured and region-specific. The effective evaluation of parasitoid performance therefore clearly requires an integrated tritrophic perspective rather than isolated aphid–parasitoid relationships (Schoonhoven *et al*., 2005). Aphidiine parasitoids display diverse behavioural, physiological, chemical and other type of adaptations that enable efficient exploitation of aphid hosts; however, their effectiveness varies with agro-ecological conditions, cropping patterns, host-plant diversity, and climate (Starý, 1988; Singh and Agarwala, 1992; Dixon, 1998). Consequently, region-specific documentation of aphid–host plant–parasitoid associations is essential for understanding their ecological roles and applied potential in biological control programmes (van Lenteren, 2012).

Preparation of regional checklists of aphids and their associated parasitoids provides critical baseline data on species composition, distribution, host range, and trophic linkages. Such inventories are indispensable for biodiversity assessment, detection of invasive species, and monitoring community shifts under changing land-use and climate scenarios (Starý and Ghosh, 1983; Singh and Singh, 2016). In many tropical regions of the globe, including large parts of India, aphid parasitoid diversity remains inadequately documented, limiting their effective incorporation into integrated pest management (IPM) programmes (Singh, 2025a, Singh, 2025b, Singh, 2025c, Singh, 2025d). From an applied standpoint, knowledge of local tri-trophic associations facilitates the selection and conservation of indigenous, well-adapted parasitoid species for sustainable aphid control. Conservation biological control, emphasising reduced pesticide use, habitat manipulation, and preservation of refugia, relies fundamentally on understanding regional parasitoid assemblages and their host relationships (Landis *et al.*, 2000; Gurr *et al.*, 2017). Thus, systematic regional studies of aphid tritrophic associations are essential for linking taxonomy, ecology, and pest management, and for promoting environmentally safe and economically viable aphid control strategies.

The present article presents a comprehensive checklist of tri-trophic associations involving aphid parasitoids, their aphid hosts, and associated host plants in Uttar Pradesh (U.P.). This compilation provides essential baseline data on species diversity, distribution, and host specificity, forming a critical foundation for ecological interpretation and applied pest management. By elucidating key parasitoid – aphid–plant linkages, the study highlights natural regulatory agents of aphid populations and facilitates the identification of locally adapted and ecologically compatible biological control candidates. Such information underpins the development of region-specific IPM strategies, enhances understanding of food-web structure and trophic interactions, and enables detection of changes in species associations arising as a result of climate change, agricultural intensification, and habitat modification. Overall, the checklist serves as a valuable reference for researchers, extension personnel, and policymakers engaged in promoting sustainable and environmentally sound pest management.

MATERIALS AND METHODS

This empirically derived checklist of tri-trophic associations involving aphid parasitoids in U.P. has been compiled from an extensive survey of books, peer-reviewed journals, authenticated theses, and reliable online sources published up to 31 December, 2025. Earlier and even some recent literature contains inaccuracies in the scientific names of predators, aphids, and host plants, largely due to rapid taxonomic revisions and the tendency to rely on seemingly comprehensive but outdated sources.

In addition, continued research has resulted in new host-parasitoid records, changes in taxonomic status, and nomenclatural updates. To address these issues, the present checklist standardises aphid nomenclature following the Aphid Species File (https://aphid.speciesfile.org), and validates host-plant names and parasitoids using World Flora Online (https://www.worldfloraonline.org) and the Global Biodiversity Information Facility (https://www.gbif.org), respectively, thereby ensuring taxonomic accuracy and consistency.

RESULTS AND DISCUSSION

Aphid parasitoid fauna recorded from Uttar Pradesh comprises two hymenopteran families: Aphelinidae

(Subfamily: Aphelininae) and Braconidae (Subfamily: Aphidiinae). In total, 28 parasitoid species were documented, including 7 aphelinid species and 21 aphidiine braconids. Aphelinid parasitoids were associated with 13 aphid species feeding on 20 host plants, forming 31 tri-trophic associations, whereas aphidiine parasitoids attacked 30 aphid species infesting 69 host plants, resulting in 174 associations (Table 1).

Table 1: Number of species of parasitoids belonging to the families Aphelinidae and Aphidiinae parasitising different number of aphid species infesting different number of host plants and number of tritrophic associations (parasitoids-aphids-host plant, triplets) in U.P.

Families	Number of			
	Parasitoid species	Aphid host species	Host plant species	Triplets
Aphelinidae	7	13	20	31
Braconidae	21	30	69	174
Total	**28**	**33**	**74**	**205**

Collectively, these parasitoids were linked to 33 aphid species on 74 host plants, accounting for 205 tri-trophic associations. Among the aphids, *Myzus persicae* showed the highest parasitoid diversity, being associated with eight parasitoid species across 15 host plants, largely agricultural crops, and forming 26 tri-trophic associations. This was followed by *Aphis gossypii*, which attracted six parasitoid species and infested 29 host plants, predominantly crops, yielding 41 tri-trophic associations (Table 2). Several other economically important aphids, *viz. Lipaphis erysimi* (parasitised by six species), *Aphis craccivora*, *Melanaphis sacchari*, and *Rhopalosiphum maidis* (each parasitised by five species), as well as *Aphis fabae*, *Aphis spiraecola*, and *Sitobion miscanthi* (each parasitised by four species), were also recorded infesting major oilseed, cereal, and vegetable crops (Table 2).

Table 2: Number of species of parasitoids belonging to different taxa parasitising different species of aphid species infesting different number of host plants in U.P.

Aphid species	Number of parasitoid species	Number of host plant species	Number of tri-trophic associations
Acyrthosiphon pisum	1	4	5
Acyrthosiphon sp.	1	1	1
Aphis aurantii	1	1	1
Aphis craccivora	5	17	22
Aphis fabae	4	4	4
Aphis gossypii	6	29	41
Aphis nasturtii	2	6	6
Aphis nerii	1	2	2
Aphis solanella	1	2	2
Aphis spiraecola	4	5	5
Brachycaudus helichrysi	1	1	1
Brevicoryne brassicae	1	5	5
Cavariella sp.	1	1	1
Greenidea ficicola	1	1	1
Greenidea psidii	1	1	1
Greenidea sp.	2	1	2

Hayhurstia atriplicis	1	1	1
Hyadaphis coriandri	1	1	1
Hyadaphis sp.	2	1	2
Hyalopterus pruni	1	1	1
Hysteroneura setariae	1	1	1
Lipaphis erysimi	6	6	10
Macrosiphum rosae	1	1	1
Macrosiphum sp.	1	1	1
Melanaphis sacchari	5	4	12
Melanaphis sacchari indosacchari	1	1	1
Metopolophium dirhodum	1	1	1
Mollitrichosiphum sp.	1	1	1
Myzus persicae	8	15	26
Rhopalosiphum maidis	4	6	17
Saltusaphis sp.	1	1	1
Schizaphis graminum	3	4	8
Sitobion avenae	3	2	4
Sitobion miscanthi	4	4	7
Sitobion sp.	1	2	2
Unknown aphid	5	5	7

A. Family: Aphelinidae, Subfamily: Aphelininae

The family Aphelinidae has 43 recognised genera, and about 1120 described species (Noyes, 2019) parasiting not only aphids but also other members of Homoptera (whiteflies, scale insects, etc.) (Starý, 1988; Hayat, 1998). Within these genera, only two are primary parasitoids of aphids: all species of *Aphelinus* (106 species) and *Protaphelinus* (single species). Their biology has been well-studied due to their effectiveness against economically important aphid pests such as *Aphis gossypii*, *Brevicoryne brassicae*, *Myzus persicae*, and *Sitobion avenae*. Several species of *Aphelinus* are important biocontrol agents used against various pest aphids in crops and greenhouses worldwide (Greathead, 1986; Su *et al.*, 2018). A total of 16 species of *Aphelinus* are recorded to parasitise aphids in India (Hayat, 1998). However, only 7 species of them are recorded to parasitise 13 species of aphids feeding on 20 species of food plants with 31 tri-trophic associations in U.P. (Table 3).

Table 3: Number of species of parasitoids belonging to Aphelinidae parasitising on different number of aphid species infesting different number of host plant species and triplets in U.P.

Sl. No.	Parasitoid species	Number of		
		Aphid species	Plant species	Triplets
1.	*Aphelinus albipodus*	1	1	1
2.	*Aphelinus argiope*	1	1	1
3.	*Aphelinus asychis*	2	3	3
4.	*Aphelinus desantisi*	1	1	1
5.	*Aphelinus gossypii*	9	14	23
6.	*Aphelinus humilis*	1	1	1
7.	*Aphelinus varipes*	1	1	1
	Total	**13**	**20**	**31**

The aphelinid parasitoids demonstrated a high degree of host specificity, with most species parasitising only one to two aphid hosts. *Aphelinus gossypii* was the sole exception, exhibiting a comparatively broad host range by parasitising nine aphid species associated with fourteen host plants, resulting in twenty-three tri-trophic associations. Among the aphid hosts, *Lipaphis erysimi*, *Melanaphis sacchari*, and *Myzus persicae* were attacked by two aphelinid parasitoid species, whereas the remaining aphid species were parasitized by only a single parasitoid species. Detail checklist is given below.

1. ***Aphelinus albipodus*** **Hayat and Fatima, 1992**
   - ***Aphis fabae*** **Scopoli, 1763**
     - *Solanum nigrum* L. (Hayat, 1998)

2. ***Aphelinus argiope*** **Walker, 1839 [syn. *Mesidia argiope* (Walker, 1839)]**
   - ***Saltusaphis*** **sp.**
     - Unknown plant (Hayat, 1979)

3. ***Aphelinus asychis*** **Walker, 1839**
   - ***Lipaphis erysimi*** **(Kaltenbach, 1843)**
     - *Brassica* spp. (Hayat, 1998)
   - ***Myzus persicae*** **(Sulzer, 1776)**
     - *Brassica oleracea* L. var. *capitata* (Hayat, 1998)
     - *Solanum tuberosum* L. (Hayat, 1998)

4. ***Aphelinus desantisi*****, Hayat, 1972**
   - ***Melanaphis sacchari*** **(Zehntner, 1897)**
     - *Sorghum bicolor* (L.) Moench (Hayat, 1998)

5. ***Aphelinus gossypii*** **Timberlake, 1924 [syn. *Aphelinus kashmiriensis* Hayat, 1972]**
   - ***Aphis gossypii*** **Glover, 1877**
     - *Cajanus cajan* (L.) Millsp. (Ahmad and Singh, 1993, 1994a, 1995b)
     - *Capsicum frutescens* L. (Singh et al., 1999; Chaudhary and Singh, 2007)
     - *Lagenaria siceraria* (Molina) Standl. (Singh and Tripathi, 1988b; Tripathi and Singh, 1997; Chaudhary and Singh, 2007)
     - *Solanum melongena* L. (Tripathi and Singh, 1997; Chaudhary and Singh, 2007)
     - *Vicia faba* L. (Ahmad and Singh, 1993, 1995b; Tripathi and Singh, 1997)
   - ***Aphis spiraecola*** **Patch, 1914**
     - *Cajanus cajan* (L.) Millsp. (Singh et al., 1999)
     - *Dahlia pinnata* Cav. (Ahmad and Singh, 1995b; Singh et al., 1999)
     - *Dahlia* sp. (Ahmad and Singh, 1992a, 1993; Tripathi and Singh, 1997)
     - *Solanum melongena* L. (Singh et al., 1999; Chaudhary and Singh, 2007)
   - ***Hyadaphis*** **sp.**
     - *Trifolium alexandrinum* L. (Ahmad and Singh, 1992a, 1993, 1995b)
   - ***Lipaphis erysimi*** **(Kaltenbach, 1843)**
     - *Trifolium alexandrinum* L. (Ahmad and Singh, 1992a, 1993, 1995a)
   - ***Melanaphis sacchari*** **(Zehntner, 1897)**
     - *Cenchrus americanus* (L.) Morrone (Ahmad and Singh, 1992a, 1993; Singh et al., 1999)
     - *Sorghum bicolor* (L.) Moench (Tripathi and Singh, 1997)
     - *Zea mays* L. (Tripathi and Singh, 1997)
   - ***Myzus persicae*** **(Sulzer, 1776)**
     - *Delphinium* sp. (Ahmad and Singh, 1992a, 1993, 1995b)
     - *Hemigraphis* sp. (Ahmad and Singh, 1992a, 1993, 1995b; Singh et al., 1999)
     - *Solanum tuberosum* L. (Tripathi and Singh, 1988b; 1997; Chaudhary and Singh, 2007)
   - ***Rhopalosiphum maidis*** **(Fitch, 1856)**
     - *Cenchrus americanus* (L.) Morrone (Ahmad and Singh, 1992a, 1993; Tripathi and Singh, 1997)
     - *Sorghum bicolor* (L.) Moench (Tripathi and Singh, 1997)
     - *Zea mays* L. (Tripathi and Singh, 1997)
   - ***Schizaphis graminum*** **(Rondani, 1852)**
     - *Cenchrus americanus* (L.) Morrone (Tripathi and Singh, 1997)
     - *Zea mays* L. (Tripathi and Singh, 1997)
   - ***Sitobion miscanthi*** **(Takahashi, 1921)**
     - *Phalaris minor* Retz. (Ahmad and Singh, 1992a; 1993, 1995a)

6. ***Aphelinus humilis*** **Mercet, 1927**
   - ***Macrosiphum*** **sp.**
     - *Rosa* sp. (Hayat, 1981)

7. ***Aphelinus varipes*** **(Förster, 1841) [syn. M*yina varipes* Förster, 1840]**
   - **Unknown aphid**
     - Unknown plant (Hayat, 1998)

B. Family: Braconidae, Subfamily: Aphidiinae:

The data presented in Table 4 summarise the diversity and host–plant associations of Aphidiinae (Braconidae) parasitoids recorded in the study area. A

total of 21 parasitoid species were documented, collectively parasitising 30 aphid species infesting 69 host plant species, including cereals, pulses, vegetables, oilseeds, ornamentals, fruit crops, and weeds, and accounting for 174 parasitoid–host–plant (tri-trophic) associations. This reflects a complex trophic network and represents a substantial component of the 157 aphidiine species recorded from India (Das and Chakrabarti, 2023a).

Table 4: Number of species of parasitoids belonging to Aphidiinae (Braconidae) parasitising different number of aphid species infesting different number of host plant species and triplets in U.P.

Sl. No.	Parasitoid species	Number of		
		Aphid species	Plant species	Triplets
1.	*Adialytus ambiguus*	4	5	9
2.	*Aphidius bifurcatus*	1	3	3
3.	*Aphidius colemani*	1	5	5
4.	*Aphidius funebris*	1	1	1
5.	*Aphidius matricariae*	1	2	2
6.	*Aphidius qadrii*	2	3	3
7.	*Aphidius rosae*	1	1	1
8.	*Aphidius smithi*	3	7	7
9.	*Aphidius uzbekistanicus*	4	8	13
10.	*Archaphidus greenideae*	2	1	2
11.	*Binodoxys eutrichosiphi*	1	1	1
12.	*Binodoxys indicus*	13	36	57
13.	*Binodoxys sinensis*	2	1	2
14.	*Diaeretiella rapae*	9	11	17
15.	*Ephedrus plagiator*	2	2	3
16.	*Indaphidus curvicaudatus*	1	1	1
17.	*Lipolexis gracilis*	3	4	4
18.	*Lipolexis oregmae*	6	17	21
19.	*Lysiphlebia japonica*	8	9	18
20.	*Lysiphlebus* sp.	1	1	1
21.	*Praon* sp.	2	2	2
	Total	**30**	**69**	**174**

Marked interspecific variation in host breadth was evident among the parasitoids. Several species, notably *Binodoxys indicus*, *Lipolexis oregmae*, *Lysiphlebia japonica*, *Diaeretiella rapae*, and *Aphidius uzbekistanicus*, exhibited broad host ranges, parasitising multiple aphid species across diverse host plants and contributing substantially to overall tritrophic diversity (Table 4). *Binodoxys indicus* emerged as the most polyphagous species, parasitising 13 aphid species, including *Aphis craccivora, Aphis gossypii*, *Aphis fabae*, *Aphis spiraecola*, *Lipaphis erysimi*, and *Myzus persicae*, across a wide array of cultivated and wild host plants. *Diaeretiella rapae* was predominantly associated with aphids infesting brassicaceous crops, particularly Brevicoryne brassicae, *Lipaphis erysimi*, and *Myzus persicae*. Similarly, *Lysiphlebia japonica* and *Aphidius uzbekistanicus* were frequently recorded from cereal aphids such as *Melanaphis sacchari*, *Rhopalosiphum maidis*, *Schizaphis graminum*, *Sitobion avenae*, and *Sitobion miscanthi*, underscoring their ecological importance in grassland and cereal-based agro-ecosystems.

Overall, the results highlight a highly complex tritrophic network involving aphids, their parasitoids, and host plants, in which only a limited number of polyphagous parasitoids contribute disproportionately to biological regulation across agroecosystems, while a larger number of host-specific species enhance ecological stability through targeted host suppression. The observed diversity of host utilisation patterns underscores the ecological significance of aphid parasitoids in integrated pest management and broader ecosystem functioning. Several species of these parasitoids have been utilised in biological control both in fields and glasshouses (Singh and Rao, 1995; Singh and Singh, 2016).

The detailed account of tri-trophic associations of aphidiine parasitoids are given below.

1. ***Adialytus ambiguus*** **(Haliday, 1834) [syn.** ***Adialytus arvicola*** **(Starý, 1961);** ***Aphidius ambiguus*** **Haliday, 1834;** ***Aphidius delhiensis*** **Subba Rao and Sharma 1960; L*ysiphlebus ambiguus*** **(Haliday, 1834);** ***Lysiphlebus delhiensis*** **(Subba Rao and Sharma 1960)]**
   - ***Melanaphis sacchari*** **(Zehntner, 1897)**
     - *Cenchrus americanus* (L.) Morrone (Ahmad and Singh, 1993, 1995b; Singh *et al*., 1999)
     - *Sorghum bicolor* (L.) Moench (Singh *et al*., 1999)
     - *Zea mays* L. (Singh *et al*., 1999)
   - ***Melanaphis sacchari*** **indosacchari (David, 1956)**
     - *Saccharum officinarum* L. (Varma *et al*., 1978)
   - ***Rhopalosiphum maidis*** **(Fitch, 1856)**
     - *Cenchrus americanus* (L.) Morrone (Singh and Tripathi, 1987; Ahmad and Singh, 1993, 1994b)
     - *Triticum aestivum* L. (Singh *et al*., 1999)
     - *Zea mays* L. (Singh *et al*., 1999; Tiwari *et al*., 2024)
   - ***Schizaphis graminum*** **(Rondani, 1852)**
     - *Cenchrus americanus* (L.) Morrone (Singh *et al*., 1999)
     - *Zea mays* L. (Singh *et al*., 1999)

2. ***Aphidius bifurcatus*** **Rakhshani and Tomanovic, 2012**
   - **Unknown aphid**
     - *Centaurea cineraria* L. (Rakhshani *et al*., 2012)
     - *Salvia* sp. (Rakhshani *et al*., 2012)
     - *Trifolium alexandrinum* L. (Rakhshani *et al*., 2012)

3. ***Aphidius colemani*** **Viereck, 1912**
   - ***Myzus persicae*** **(Sulzer, 1776)**
     - *Brassica oleracea* L. var. botrytis (Ahmad and Singh, 2007)
     - *Brassica oleracea* L. var. capitata (Ahmad and Singh, 1993; Singh *et al*., 1999; Chaudhary and Singh, 2007)
     - *Brssica oleracea* L. (Ahmad and Singh, 1993)
     - *Solanum lycopersicum* L. (Rafi *et al*., 2010)
     - *Solanum nigrum* L. (Rafi *et al*., 2010)

4. ***Aphidius funebris*** **Mackauer, 1961**
   - **Unknown aphid**
     - *Trifolium alexandrinum* L. (Rakhshani *et al*., 2012)

5. ***Aphidius matricariae*** **Haliday, 1834**
   - ***Myzus persicae*** **(Sulzer, 1776)**
     - *Solanum lycopersicum* L. (Ahmad and Singh, 1993; Chaudhary and Singh, 2007)
     - *Triticsum aestivum* L. (Ahmad and Singh, 1995b; Singh *et al*., 1999)

6. ***Aphidius qadrii*** **(Shuja-Uddin, 1977) [syn.** ***Lysaphidus qadrii*** **Shuja-Uddin, 1976]**
   - ***Myzus persicae*** **(Sulzer, 1776)**
     - *Carica papaya* L. (Rafi *et al*., 2010)
     - *Solanum lycopersicum* L. (Rafi *et al*., 2010)
   - **Unknown aphid**
     - *Artocarpus heterophyllus* Lam. (Shuja-Uddin, 1976)

7. ***Aphidius rosae*** **Haliday, 1833**
   - ***Macrosiphum rosae*** **(Linnaeus, 1758)**
     - *Rosa* sp. (Raychaudhuri *et al*., 1979)

8. ***Aphidius smithi*** **Sharma and Subba Rao, 1959**
   - ***Acyrthosiphon pisum*** **(Harris, 1776)**
     - *Lathyrus odoratus* L. (Rao *et al*., 1969; Ahmad and Singh, 1995b)
     - *Medicago sativa* L. (Singh *et al*., 1999)
     - *Pisum sativum* L. (Ahmad and Singh, 1993; Singh *et al*., 1999; Ahmad and Singh, 2007)
     - *Vicia faba* L. (Ahmad and Singh, 1995b; Singh *et al*., 1999)
     - *Vicia lens* (L.) Coss. and Germ. (Ahmad and Singh, 1995b)
   - ***Acyrthosiphon*** **sp.**
     - *Centaurea cineraria* L. (Rakhshani *et al*., 2012)

- **Unknown aphid**
  - *Sinapis arvensis* L. (Rakhshani et al., 2012)

9. *Aphidius uzbekistanicus* Luzhetzki, 1960

- ***Rhopalosiphum maidis* (Fitch, 1856)**
  - *Cenchrus americanus* (L.) Morrone (Ahmad and Singh, 1994b; Tiwari *et al*., 2024)
  - *Hordeum vulgare* L. (Ahmad and Singh, 1993, 1995b; Tiwari *et al*., 2024)
  - *Saccharum officinarum* L. (Tiwari *et al*., 2024)
  - *Sorghum bicolor* (L.) Moench (Ahmad and Singh, 1994b; Tiwari *et al*., 2024)
  - *Triticum aestivum* L. (Tiwari *et al*., 2024)
  - *Zea mays* L. (Ahmad and Singh, 1994b)

- ***Sitobion avenae* (Fabricius, 1775)**
  - *Hordeum vulgare* L. (Singh and Tripathi, 1988a)
  - *Triticum aestivum* L. (Singh and Tripathi, 1987, 1988a)

- ***Sitobion miscanthi* (Takahashi, 1921)**
  - *Cenchrus flaccidus* (Griseb.) Morrone (Akhtar et al., 2011)
  - *Hordeum vulgare* L. (Ahmad and Singh, 1993, 1995a, b)
  - *Triticum aestivum* L. (Ahmad and Singh, 1993; Singh *et al*., 1999; Srivastava *et al*., 2009)

- ***Sitobion* sp.**
  - *Avena sativa* L. (Shuja-Uddin, 1975a)
  - *Triticum aestivum* L. (Shuja-Uddin, 1975a)

10. *Archaphidus greenideae* Starý and Schlinger, 1967

- ***Greenidea ficicola* Takahashi, 1921**
  - *Psidium guajava* L. (Ahmad and Singh, 1993; Ahmad and Singh, 1995b)

- ***Greenidea psidii* van der Goot, 1917**
  - *Psidium guajava* L. (Singh *et al*., 1999)

11. *Binodoxys eutrichosiphi* (Starý, 1975) [syn. *Trioxys (Binodoxys) eutrichosiphi Starý*, 1975]

- ***Lipaphis erysimi* (Kaltenbach, 1843)**
  - *Brassica rapa* L. (Ahmad and Singh, 1995b)

12. *Binodoxys indicus* (Subba Rao and Sharma, 1958) [syn. *Trioxys indicus* Subba Rao and Sharma, 1958]

- ***Aphis craccivora* Koch, 1854**
  - *Ageratum conyzoides* L. (Ahmad and Singh, 1992a, 1993; Ahmad and Singh, 1995b)
  - *Cajanus cajan* (L.) Millsp. (Singh and Sinha, 1979; Singh *et al*., 1987)
  - *Cicer arietinum* L. (Rakhshani *et al*., 2012)
  - *Hibiscus rosasinensis* L. (Ahmad and Singh, 1993, 1995b)
  - *Lablab purpureus* (L.) Sweet ssp. purpureus (Singh and Tripathi, 1987, 1988a; Ahmad and Singh, 1993)
  - *Lagenaria siceraria* (Molino) Standl. (Ahmad and Singh, 1993; Singh et al., 1999; Chaudhary and Singh, 2007)
  - *Luffa aegyptiaca* Mill. (Singh *et al*., 1999; Chaudhary and Singh, 2007)
  - *Solanum lycopersicum* L. (Singh *et al*., 1999; Chaudhary and Singh, 2007)
  - *Solanum melongena* L. (Ahmad and Singh, 1993, 1995b; Chaudhary and Singh, 2007)
  - *Vicia faba* L. (Ferrer-Suay *et al*., 2013)

- ***Aphis fabae* Scopoli, 1763**
  - *Clerodendrum infortunatum* L. (Ahmad and Singh, 1993, 1995b; Singh *et al*., 1999)

- ***Aphis gossypii* Glover, 1877**
  - *Cajanus cajan* (L.) Millsp. (Ahmad and Singh, 1993; Singh *et al*., 1999)
  - *Capsicum frutescens* L. (Singh *et al*., 1999; Singh and Tripathi, 1988a; Chaudhary and Singh, 2007)
  - *Carica papaya* L. (Rafi *et al*., 2010)
  - *Chenopodium album* L. (Rafi *et al*., 2010)
  - *Chrysanthemum* sp., (Shuja-Uddin, 1973)
  - *Cucumis maderaspatanus* L. (Shuja-Uddin, 1973)
  - *Cucumis melo* L. (Singh and Tripathi, 1988b)
  - *Cucurbita maxim*a Duchesne (Singh and Tripathi, 1988a; Chaudhary and Singh, 2007)
  - *Cuscuta reflexa* Roxb. (Shuja-Uddin, 1973)
  - *Duranta* sp. (Shuja-Uddin, 1973)
  - *Gossypium herbaceum* L. (Shuja-Uddin, 1973; Singh *et al*., 1999)
  - *Gossypium hirsutum* L. (Shuja-Uddin, 1973)
  - *Hibiscus rosasinensis* L. (Rafi *et al*., 2010)
  - *Lablab purpureus* (L.) Sweet ssp. purpureus (Singh and Tripathi, 1988a)
  - *Lagenaria siceraria* (Molino) Standl. (Singh and Tripathi, 1988a, b)
  - *Luffa aegyptiaca* Mill. (Singh and Tripathi, 1988a; Singh *et al*., 1999; Chaudhary and Singh, 2007)

- *Momordica charantia* L. (Ahmad and Singh, 1992b, 1993; Chaudhary and Singh, 2007
- *Psidium guajava* L. (Shuja-Uddin, 1973; Ahmad and Singh, 1993, 1994a)
- *Solanum lycopersicum* L. (Singh *et al*., 1999; Rafi *et al*., 2010)
- *Solanum melongena* L. (Singh and Tripathi, 1988a; Singh *et al*., 1999; Rakhshani *et al*., 2012)
- *Solanum nigrum* L. (Rafi *et al*., 2010)
- *Solanum tuberosum* L. (Shuja-Uddin, 1973; Singh *et al*., 1999)
- *Tinospora* sp. (Shuja-Uddin, 1973)
- *Vicia faba* L. (Ahmad and Singh, 1994a; Chaudhary and Singh, 2007)

- ***Aphis nasturtii* Kaltenbach, 1843**
  - *Capsicum frutescens* L. (Singh *et al*., 1999)
  - *Hibiscus rosasinensis* L. (Singh *et al*., 1999)
  - *Psidium guajava* L. (Ahmad and Singh, 1993, 1995b)

- ***Aphis nerii* Boyer de Fonsc., 1841**
  - *Calotropis gigantea* (L.) W.T. Aiton (Singh *et al*., 1999)
  - *Calotropis procera* (Aiton) Dryand. (Shuja-Uddin, 1973; Ahmad and Singh, 1992a, 1993)

- ***Aphis solanella* Theobald, 1914**
  - *Cestrum nocturnum* L. (Rafi *et al*., 2010)
  - *Vicia faba* L. (Chaudhary and Singh, 2007)

- ***Aphis spiraecola* Patch, 1914**
  - *Cajanus cajan* (L.) Millsp. (Ahmad and Singh, 1993, 1995b)
  - *Cestrum diurnum* L. (Ahmad and Singh, 1993, 1995b; Singh *et al*., 1999)
  - *Sonchus* sp. (Ahmad and Singh, 1993, 1995b; Singh *et al*., 1999)

- ***Aphis aurantii* Boyer de Fonsc., 1841**
  - *Bougainvillea spectabilis* Willd. (Singh *et al*., 1999)

- ***Greenidea* sp.**
  - *Psidium guajava* l. (Rakhshani *et al*., 2012)

- ***Hyadaphis* sp.**
  - *Trifolium alexandrinum* L. (Ahmad and Singh, 1993)

- ***Hysteroneura setariae* (Thomas, 1878)**
  - *Cyperus rotundus* L. (Ahmad and Singh, 1993, 1995b)

- ***Lipaphis erysimi* (Kaltenbach, 1843)**
  - *Brassica rapa* L. (Ahmad and Singh, 1993; Ahmad and Singh, 1995a, b)
  - *Calotropis procera* (Aiton) Dryand. (Ahmad and Singh, 1993, 1995b)
  - *Trifolium alexandrinum* L. (Ahmad and Singh, 1993)

- ***Myzus persicae* (Sulzer, 1776)**
  - *Cajanus cajan* (L.) Millsp. (Ahmad and Singh, 1993, 1995b)
  - *Calotropis procera* (Aiton) Dryand. (Ahmad and Singh, 1993, 1995b)
  - *Capsicum frutescens* L. (Singh and Tripathi, 1988a)
  - *Solanum lycopersicum* L. (Singh and Tripathi, 1988a)
  - *Solanum melongena* L. (Ahmad and Singh, 1993; Singh *et al*., 1999; Chaudhary and Singh, 2007)
  - *Solanum tuberosum* L. (Singh and Tripathi, 1987, 1988a; Singh *et al*., 1999)

13. *Binodoxys sinensis* Mackauer, 1962

- ***Aphis gossypii* Glover, 1877**
  - *Cestrum nocturnum* L. (Rao, 1969)

- ***Aphis spiraecola* Patch, 1914**
  - *Cestrum nocturnum* L. (Rao, 1969)

14. *Diaeretiella rapae* (McIntosh, 1855) [syn. *Aphidius rapae* McIntosh, 1855]

- ***Aphis craccivora* Koch, 1854**
  - *Lablab purpureus* (L.) Sweet ssp. purpureus (Halder *et al*., 2014)

- ***Aphis spiraecola* Patch, 1914**
  - *Solanum melongena* L. (Halder *et al*., 2014)

- ***Brachycaudus helichrysi* (Kaltenbach, 1843**
  - *Prunus amygdalus* Batsch (Akhtar *et al*., 2011)

- ***Brevicoryne brassicae* (Linnaeus, 1758)**
  - *Brassica oleracea* L. var. botrytis (Ahmad and Singh, 1995a)
  - *Brassica oleracea* L. var. capitata (Ahmad and Singh, 1993; Pal and Singh, 2012)
  - *Brassica rapa* L. (Ahmad and Singh, 1996a; Rafi *et al*., 2010)
  - *Brassica* sp. (Ahmad and Singh, 1995a)
  - *Raphanus sativus* L. (Singh *et al*., 1999; Rafi *et al*., 2010)

- ***Hayhurstia atriplicis* (Linnaeus, 1761)**
  - *Chenopodium album* L. (Akhtar *et al*., 2011)

- ***Lipaphis erysimi* (Kaltenbach, 1843)**
  - *Brassica oleracea* L. var. botritys (Ahmad and Singh, 1995a, b; Rafi *et al*., 2010)
  - *Brassica rapa* L. (Akhtar *et al*., 2006; Hugar et al., 2008)
  - *Raphanus sativus* L. (Rafi *et al*., 2010)
  - *Trifolium alexandrinum* L. (Rakhshani *et al*., 2012)

- ***Metopolophium dirhodum* (Walker, 1849)**
  - *Grass* (Akhtar *et al*., 2011)

- ***Myzus persicae* (Sulzer, 1776)**
  - *Brassica oleracea* L. var. botrytis (Halder *et al*., 2014)
  - *Brassica* sp. (Akhtar *et al*., 2011)

- ***Sitobion avenae* (Fabricius, 1775)**
  - *Triticum aestivum* L. (Atwal *et al*., 1969)

15. *Ephedrus plagiator* (Nees, 1811)
- ***Aphis fabae* Scopoli, 1763**
  - *Tagetes erecta* L. (Akhtar *et al*., 2011)

- ***Aphis gossypii* Glover, 1877**
  - *Tagetes erecta* L. (Singh *et al*., 1999)
  - *Tagetes* sp. (Ahmad and Singh, 1993, 1994a)

16. *Indaphidius curvicaudatus* Starý, 1979
- ***Mollitrichosiphum* sp.**
  - *Psidium guajava* L. (Rakhshani *et al*., 2012)

17. *Lipolexis gracilis* Forster, 1862
- ***Aphis craccivora* Koch, 1854**
  - *Argimone* sp. (Rafi *et al*., 2010)
  - *Bougainvillea* sp. (Rafi *et al*., 2010)

- ***Hyadaphis coriandri* (Das, 1918)**
  - *Foeniculum vulgare* Mill. (Rafi *et al*., 2010)

- ***Lipaphis erysimi* (Kaltenbach, 1843)**
  - *Brassica rapa* L. (Rafi *et al*., 2010)

18. *Lipolexis oregmae* (Gahan, 1932) [syn. *Lipolexis pseudoscutellaris* Pramanik and Raychaudhuri, 1984; *Lipolexis scutellaris* Mackauer, 1962]
- ***Aphis craccivora* Koch, 1854**
  - *Abelmoschus esculentus* (L.) Moench (Chaudhary and Singh, 2007)
  - *Argimone* sp. (Rafi et al., 2010)
  - *Benincasa hispida* Cogn (Ahmad and Singh, 1993; Singh *et al*., 1999; Chaudhary and Singh, 2007)
  - Bougainvillea sp. (Rafi et al., 2010)
  - *Capsicum frutescens* L. (Singh and Tripathi, 1987)
  - *Cassia fistula* L. (Ahmad and Singh, 1993, 1995b)
  - *Lablab purpureus* (L.) Sweet ssp. purpureus (Ahmad and Singh, 1992b, 1993; Chaudhary and Singh, 2007)
  - *Psidium guajava* L. (Ahmad and Singh, 1995b)
  - *Vigna unguiculata* (L.) Walp. (Rafi *et al*., 2010)

- ***Aphis fabae* Scopoli, 1763**
  - *Chenopodium album* L. (Rafi *et al*., 2010)

- ***Aphis gossypii* Glover, 1877**
  - *Capsicum frutescens* L. (Singh and Tripathi, 1988a)
  - *Momordica charantia* L. (Ahmad and Singh, 1994a)
  - *Psidium guajava* L. (Ahmad and Singh, 1993, 1994a; Singh *et al*., 1999)
  - *Solanum melongena* L. (Singh *et al*., 1999; Chaudhary and Singh, 2007)

- ***Aphis nasturtii* Kaltenbach, 1843**
  - *Cucumis melo* L. (Ahmad and Singh, 1993)
  - *Luffa aegyptiaca* Mill. (Ahmad and Singh, 1992a, 1993; Chaudhary and Singh, 2007)
  - *Tectona grandis* L.f. (Ahmad and Singh, 1993; Singh *et al*., 1999)

- ***Greenidea* sp.**
  - *Psidium gujava* L. (Rakhshani et al., 2012)

- ***Myzus persicae* (Sulzer, 1776)**
  - *Capsicum frutescens* L. (Singh *et al*., 1999; Chaudhary and Singh, 2007)
  - *Solanum lycopersicum* L. (Singh and Tripathi, 1988a)
  - *Solanum melongena* L. (Singh and Tripathi, 1987, 1988a; Singh *et al*., 1999)
  - *Solanum tuberosum* L. (Rafi *et al*., 2010)

19. *Lysiphlebia japonica* (Ashmead, 1906) [syn. *Lysiphlebia mirzai* Shuja-Uddin, 1975]
- ***Aphis craccivora* Koch, 1854**
  - *Cicer arietinum* L. (Rakhshani *et al*., 2012)

- ***Aphis gossypii* Glover, 1877**
  - *Solanum melongena* L. (Rakhshani *et al*., 2012)

- ***Hyalopterus pruni* (Geoffroy, 1762)**
  - *Phragmites karka* (Retz.) Trin. ex Steud. (Singh and Tripathi, 1987; Singh *et al*., 1999; Tripathi and Singh, 1995)

- ***Melanaphis sacchari* (Zehntner, 1897)**
  - *Cenchrus americanus* (L.) Morrone (Ahmad and Singh, 1993, 1995b; Tripathi and Singh, 1995)
  - *Saccharum officinarum* L. (Shuja-Uddin, 1975b; Tripathi and Singh, 1995)
  - *Sorghum bicolor* (L.) Moench (Tripathi and Singh, 1995)
  - *Zea mays* L. (Tripathi and Singh, 1995)
- ***Rhopalosiphum maidis* (Fitch, 1856)**
  - *Cenchrus americanus* (L.) Morrone (Ahmad and Singh, 1993, 1994b; Singh and Tripathi, 1988a)
  - *Hordeum vulgare* L. (Tripathi and Singh, 1995)
  - *Sorghum bicolor* (L.) Moench (Tripathi and Singh, 1995)
  - *Triticum aestivum* L. (Tripathi and Singh, 1995)
  - *Zea mays* L. (Tripathi and Singh, 1995)
- ***Schizaphis graminum* (Rondani, 1852)**
  - *Cenchrus americanus* (L.) Morrone (Singh *et al.*, 1999)
  - *Hordeum vulgare* L. (Tripathi and Singh, 1995)
  - *Triticum aestivum* L. (Tripathi and Singh, 1995)
  - *Zea mays* L. (Singh and Tripathi, 1988b; Singh *et al.*, 1999)
- ***Sitobion miscanthi* (Takahashi, 1921)**
  - *Hordeum vulgare* L. (Tripathi and Singh, 1995)
  - *Triticum aestivum* L. (Tripathi and Singh, 1995)

20. *Lysiphlebus* sp.

- ***Melanaphis sacchari* (Zehntner, 1897)**
  - *Saccharum officinarum* L. (Singh and Shukla, 1966)

21. *Praon* sp.

- ***Sitobion avenae* (Fabricius, 1775)**
  - *Hordeum vulgare* L. (Singh and Tripathi, 1987)
- ***Sitobion miscanthi* (Takahashi, 1921)**
  - *Hordeum vulgare* L. (Ahmad and Singh, 1993, 1994a)

CONCLUSION

The aphid parasitoid fauna of Uttar Pradesh is diverse and ecologically significant, comprising 28 species from the families Aphelinidae and Braconidae (Aphidiinae) and forming 205 aphid-parasitoid-host plant associations. Aphidiine braconids dominated in species richness and trophic linkages, while aphelinids contributed a smaller but important component. Economically important aphids such as *Aphis craccivora*, *Aphis gossypii*, *Lipaphis erysimi*, *Melanaphis sacchari* and *Myzus persicae* supported the highest parasitoid diversity across multiple crops. A few polyphagous parasitoids (e.g. *Binodoxys indicus*, *Diaeretiella rapae*) accounted for a large proportion of associations, whereas numerous host-specific species contributed to targeted regulation. Overall, the complex tritrophic network underscores the crucial role of aphid parasitoids in sustaining agroecosystem stability and their strong potential in integrated pest management in Uttar Pradesh.

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