J. Appl. Biosci., 50(2): 73-87, December, 2024
doi: 10.61081/joab/50v2i102

ISSN (Print) 0975-685X
ISSN (Online) 0975-864X

REVIEW ARTICLE

Tetratrophic Associations of Hyperparasitoids of Aphids (Aphididae: Hemiptera) and their Distribution in India

Rajendra Singh* **and Omkar[1]**
Department of Zoology, Deen Dayal Upadhyay University of Gorakhpur, Gorakhpur, UP, India
[1]Department of Zoology, Lucknow University, Lucknow, UP, India

ABSTRACT

Aphid hyperparasitoids are secondary parasitoids constituting fourth trophic level which develop on primary parasitoids of aphids. Based on oviposition and feeding behaviour, they may be endophagous (develop in the larvae of primary parasitoids) or ectophagous (feed externally on the larvae of primary parasitoids when aphids are killed or mummified). Hyperparasitism has traditionally been considered harmful to the parasitoids and hence is excluded in biological control programmes. Their detailed biology and ecology are less known than their primary parasitoids. The present article provides a tetratrophic association of aphid hyperparasitoids of India. A total of 27 species of aphid hyperparasitoids belonging to 3 superfamilies of Hymenoptera are recorded in 11 states/union territories of India. These hyperparasitoids parasitise 36 species of primary parasitoids parasitising 51 species of aphids infesting 81 species of food plants. The Calcidoidea is the largest superfamily and comprises 15 species of aphid hyperparasitoids belonging to 5 families followed by Cynipoidea (9 species of aphid hyperparasitoids belonging to a single family) and Ceraphronoidea (3 species of aphid hyperparasitoids in two families). Among them, *Alloxysta* spp. are highly polyphagous and hyperparasitise 16 species of parasitoids that parasitise 26 species of aphids on 45 food plants in 9 states/union territories of India followed by *Syrphophagus* (14 species of parasitoids that parasitise 14 species of aphids on 17 food plants in 9 states/union territories), *Pachyneuron* (12 species of parasitoids that parasitise 16 species of aphids on 17 food plants in 4 states/union territories), *Asaphes* (8 species of parasitoids that parasitise 16 species of aphids on 17 food plants in 4 states/union territories). *Binodoxys indicus* (Subba Rao & Sharma), parasitising 7 species of aphids infesting 28 species of host plants was observed to serve as host for 14 species of hyperparasitoids while *Lipolexisoregmae* parasitises 9 species of aphids infesting 17 species of host plants serving as host for 6 species of hyperparasitoids. Indeed, no investigation was conducted in most of the states and union territories of India regarding the tetratrophic associations of aphid hyperparasitoids and hence, it requires an extensive survey in these areas to record them particularly in the agroecosystems to establish their relationship with aphid hosts and their parasitoids on different crops.

KEY WORDS: Aphid hyperparasitoids, Aphids, checklist, parasitoids, tetratrophic association.

INTRODUCTION

Fiske (1910) first used the term hyperparasitoid to mean the development of one parasitoid (fourth trophic level) upon another parasitoid (third trophic level) of herbivore host (second trophic level). However, the term is a misnomer, as the prefix "hyper" means over or excess and does not accurately describe the adaptation of one parasitoid for the development on another parasitoid, yet is used in the sense of Fiske (1910). The lifestyle of hyperparasitoids evolved from primary parasitoids potentially by frequent encounters with parasitised hosts and facultative parasitisation of the secondary host (Godfray,1994). In the absence of primary parasitoids, some hyperparasitoids transform into primary parasitoids (Sullivan, 1987; Sullivan & Völkl, 1999). Sometimes, primary, secondary, tertiary and quaternary parasitisms are frequently used in the literature to denote the trophic relationships between a parasitoid and its host to clarify

*Corresponding author email: rsinghgpu@gmail.com

the host-parasitoid relationship (Gutierrez & van den Bosch, 1970; Matejko & Sullivan,1984). Thus, primary parasitism is parasitism on herbivore host; secondary parasitism is parasitism on a primary parasitoid; tertiary parasitism is parasitism on a secondary parasitoid (of the same species or on different species). Intraspecific tertiary parasitism or autohyperparastism occurs when secondary parasitism is on its species and interspecific tertiary parasitism or allohyperparasitism occurs when the secondary parasitoid attacks different species of hyperparasitoids and so on. Quaternary parasitism is rare and very difficult to determine in the field.

Hyperparasitoids are known from various agricultural systems, including greenhouse vegetables, annual field crops, orchard fruits and cultivated forests (Cusumano *et al.*, 2020). Hassell & Waage (1984) reviewed the multispecies interaction of parasitoids and hyper-parasitoids and noted that there had been relatively few attempts to assess the ecological impact of obligate hyperparasitoids which influence the parasitoid population but the parasitoids also play an important role in the reduction of hyperparasitisation through the modification of behaviour of the hosts. There is a disagreement over the importance of hyperparasitoids in the biological control of insect pests. Naturally occurring hyperparasitism is traditionally thought to disrupt biological control by primary parasitoids on target pests because hyperparasitoids develop at the expense of parasitoids and are thus likely to limit the control of herbivore hosts by the following parasitoid generations (Sullivan & Völkl,1999). The extent of hyperparasitism in the field population varied from 3 to 88% in different tetratrophic relationships (Singh & Tripathi,1991). Among the detrimental effects on the primary parasitoids, hyperparasitoids may affect their establishment, occurrence and abundance not only through direct parasitism but also by acting intraguild competitors (*i.e.* facultative hyperparasitoids that exploit herbivores and primary parasitoids) (Poelman *et al.*, 2022). Obligate hyperparasitoids generally hinder the effect of primary parasitoids but may circumstantially play a role in stabilising host-parasitoid interaction through density-dependent effects (Hassell & Waage, 1984) and may thus in some cases enhance biological control by primary parasitoids (Sullivan & Völkl, 1999). The hyperparasitism may benefit biological control (Luck *et al.*, 1981) by maintaining the proper balance between the parasitoid and its hosts by checking the excessive build-up of the parasitoid population. *Aphidencyrtus aphidivorous* seemed to enhance the control of walnut aphid by helping to prevent extreme fluctuation in the parasitoid and host aphid population (Frazer & van den Bosch, 1973). The efficacy of biological control may also be influenced by the indirect effects of hyperparasitoids, *Aphidius uzbekistanicus* is less efficient in host utilization in the presence of *Alloxysta victrix* because it attacks fewer hosts and makes more flight attempts compared to controlled conditions without it (Holler *et al.*, 1994).

Aphid hyperparasitoids belong to only one insect order, Hymenoptera in three superfamilies, Chalcidoidea (families Aphelinidae -*Encarsia*, Encyrtidae -*Prionomitus*, *Syrphophagus*, *Tassonia*, Eulophidae -*Tetrostichus*, Pteromalidae -*Asaphes*, *Coruna*, *Euneura*, *Pachyneuron*, Signiphoridae -*Chartocerus*), Ceraphronoidea (families Ceraphronidae -*Aphanogmus*,*Ceraphron*, Megaspilidae-*Dendrocerus*) and Cynipoidea (family Figitidae -*Alloxysta*, *Lytoxysta*, *Phaenoglyphis*) (Sullivan, 1987; Singh & Tripathi, 1991).

Based on their biology and host utilisation, the hyperparasitoids may be *obligate hyperparasitoids*, which are always secondary parasitoids. They always lay eggs in/on primary parasitoids and may be "true hyperparasitoids" which parasitise primary parasitoids through the herbivore host insect, e.g., *Alloxysta* or "pseudohyperparasitoids" which parasitise in the pupal stage of the parasitoids inside cocoon stage when it has come out from the herbivore host. Pseudohyperparasitoid associated with aphids are often called mummy hyperparasitoids because they attack parasitised aphids once they become mummified (Sullivan & Völkl, 1999). The hyperparasitoids may be *facultative hyperparasitoids* which lay eggs in/on the herbivore host and develop as primary parasitoids or lay eggs in/on primary parasitoids and develop as secondary parasitoids, e.g. *Aphidencyrtus*. Facultative hyperparasitism can occur through autoparasitism (heteronymous parasitism) in which female offspring develop as primary parasitoids but male offspring develop at the expense of conspecifics as hyperparasitoids of fourth trophic level specifically in aphelinid parasitoids (Viggiani, 1984). Based on place of egg deposition, the hyperparasitoids may be *endophagous* or *endohyper-parasitoids* that lay eggs and their larvae develop inside the living aphid host, e.g., *Alloxysta*, *Phaenoglyphis*, *Lytoxysta* and *Tetrastichus*; or *ectophagous* or *ectohyper parasitoids* that lay eggs on the host and their larvae feed externally, e.g., *Asaphes*, *Dendrocerus*, *Pachyneuron*. The hyperparasitoids may be *koinobiont hyperparasitoids* which allow their hosts to continue development after oviposition, e.g., *Alloxysta*, *Phaenoglyphis*, *Lytoxysta* and *Tetrastichus*; or *idiobiont hyperparasitoids* that paralyse or kill their hosts during oviposition, e.g., *Asaphes*, *Dendrocerus*, *Pachyneuron*. The hyperparasitoids may either be *direct hyperparasitoids* which directly parasitise the primary parasitoids as endo- or ectohyperparasitoids, or *indirect hyperparasitoids* which oviposit herbivore hosts of primary parasitoids whether it is parasitised

or not and their larvae feed the parasitoids larvae indirectly.

Longback, Singh & Tripathi (1991) listed 17 species belonging to 15 genera of the aphid hyperparasitoids hyperparasitising 32 species of aphid parasitoids (3 species of Aphelinidae and 29 species of Braconidae) parasitising 33 species of aphids in India.Since then, several new tetratrophic associations have been recorded by several workers, but this information is scattered. Several areas have either not yet been surveyed or little survey works have been conducted to understand the faunal distribution of aphid hyperparasitoids. This article aims to bring together all information and prepare a tetratrophic association among hyperparasitoids-parasitoids-host aphids-host plants recorded in India.

MATERIALS & METHODS

The present study is based on the primary data of published literature on aphid hyperparasitoidsup to October 31, 2024. In most of the recent-past literature, there are several errors in the scientific names of the hyperparasitoids, parasitoids, aphid hosts and the food plants because of their modified status and other nomenclatural decisions and clarification. The names of all taxa that were misspelt in the original records have been corrected where we logically ascertain the intended species. In present study, attempts have been made to provide the valid scientific names of the parasitois, hyperparasitoids following GBIF (2024), aphids following Favret (2024), and of the plants following WFO (2024). For detailed synonymy of the valid species, the above references should be consulted. If a species is identified only up to a generic level, it was considered as species only if no other species of that genus is reported within that state.

RESULTS & DISCUSSION

Table 1 displays that a total of 27 species of hyperparasitoids belonging to 3 superfamilies of Hymenoptera are recorded in 11 states/union territories of India. The Calcidoidea is the largest superfamily containing 15 species of aphid hyperparasitoids belonging to 5 families followed by Cynipoidea which contains 8 species of aphid hyperparasitoids belonging to a single family and Ceraphronoidea having 3 species of aphid hyperparasitoids in two families.

Among all hyperparasitoids, *Alloxysta* spp. hyperparasitise 16 species of parasitoids that parasitise 26 species of aphids on 45 food plants in 9 states/union territories of India followed by *Syrphophagus* (14 species of parasitoids that parasitise14 species of aphids on 17 food plants in 9 states/union territories), *Pachyneuron* (12 species of parasitoids that parasitise 16 species of aphids on 17 food plants in 4 states/union territories), *Asaphes* (8 species of parasitoids that parasitise 16 species of aphids on 17 food plants in 4 states/union territories) (Table 2). It implies that both koinobiont endohyperparasitoids (*Alloxysta*, *Phaenoglyphis*, *Syrphophagus*) and idiobiontectohyperparasitoids (*Asaphes*, *Pachyneuron*) have a broad host range and diversity. *Binodoxys indicus*, parasitising 7 species of aphids infesting 28 species of host plants was observed to serve as host for 14 species of hyperparasitoids while *Lipolexis oregmae* parasitises 9 species of aphids infesting 19 species of host plants serving as host for 6 species of hyperparasitoids (Table 3).

Table 1: Number of families of hyperparasitoids, number of species of parasitoids, aphid host, host plant, number of quadruplets (hyperparasitoids-parasitoids-aphid host-host plant) and their distribution in India

Superfamily	Families	Number of species				Total number of quadruplets	States/Union Territories
		Hyper-parasitoids	Parasitoids	Aphids	Plants		
Calcidoidea	Aphelinidae	1	1	1	1	1	1
	Encyrtidae	6	14	16	21	33	9
	Eulophidae	1	3	4	4	4	2
	Pteromalidae	6	19	27	31	56	7
	Signiphoridae	1	1	2	3	3	2
	Subtotal	15	32	38	52	95	10
Ceraphronoidea	Ceraphronidae	2	1	1	1	2	1
	Megaspilidae	1	4	8	8	8	4
	Subtotal	3	4	8	8	10	4
Cynipoidea	Figitidae	9	18	26	46	107	9
Total		27	36	51	81	191	11

Following is the detailed list of these hyperparasitoids along with their tetratrophic associations recorded from different states/union territories of India. Each hyperparasitoid was followed by primary parasitoids, host aphids, host plants and their distribution in different states/union territories of India in successive rows.

Superfamily 1: Chalcidoidea

The Chalcidoidea is a large superfamily containing more than 27,000 described species. Most species are parasitoids/hyperparasitoids, but many species in several families are herbivorous and some pestiferous. They are either ectoparasitoids or endoparasitoids of herbivore hosts and their parasitoids and hyperparasitoids belong to 15 different orders of insects and even arachnids (Heraty & Woolley, 2024). As parasitoids, they play a major role in biological/natural control of insect pests of economic importance. The members of the aphid hyperparasitoids belong to five families: Aphelinidae, Encyrtidae Eulophidae, Pteromalidae and Signiphoridae.

Family 1: Aphelinidae

The Aphelinidae are a small family containing little over a thousand species and being parasitic are a major source of biocontrol agents of economically important insect pest species such as coccids, aphids and aleyrodids. However, few species may be facultative hyperparasitoids. Only a single species of this family is recorded as hyperparasitoid in West Bengal as follows:

1. *Prospeltella* sp.

Aphelinus flavipes (Forster, 1841)

Aphis (*Aphis*) *gossypii* (Glover, 1877)

Gossypium sp.-West Bengal (Rao *et al.*, 1969)

Family 2: Encyrtidae

Encyrtidae is a large family of parasitic wasps having some 3700 species. They are usually primary parasitoids on mostly bugs. However, some are hyperparasites. In India, 6 species of the family are recorded as aphid hyperparasitoids parasitising 14 species of parasitoids of 16 species of aphids infesting 21 species of plants distributed in 8 states/union territories. *Syrphophagus* spp. are polyphagous parasitising 14 species of parasitoids. Detail tetratrophic associations are given below.

1. *Copidosoma* sp. (syn. *Litomastix* sp.)

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

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Millsp. - Uttar Pradesh (Singh *et al.*, 1982)

2. *Prionomitus* sp.

Aphidius sp.

Aphis (*Aphis*) *farinosa* Gmelin, 1790

Salix alba L. - Jammu & Kashmir (Bhagat, 1983)

Chaetosiphon (Pentatrichopus) tetrarhodum (Walker, 1849)

Rosa canina L. - Jammu & Kashmir (Bhagat, 1987)

Rosa sp. - Jammu & Kashmir (Bhagat, 1983)

Binodoxys indicus (Subba Rao & Sharma,1958)

Unknown aphid

Mentha longifolia (L.) L.- Jammu & Kashmir (Bhagat, 1983)

Praon lepelleyi Waterston, 1926 [syn. *Areopraon lepelleyi* (Waterston, 1926)]

Schizoneurella indica Hille Ris Lambers, 1973

Ulmus wallichiana Planch. - Jammu & Kashmir (Bhagat, 1983)

Table 2: Some polyphagous aphid hyperparasitoids along with number of species of their parasitoid hosts, aphid hosts, host plants and distribution in India

Hyperparasitoids genera	Number of species			States/ Union Territories
	Species of parasitoids	Species of aphid host	Species of host plants	
Alloxysta	16	26	45	9
Asaphes	8	17	17	4
Dendrocerus	4	8	8	4
Pachyneuron	12	16	17	7
Phaenoglyphis	5	5	12	5
Syrphophagus	14	14	17	9

Table 3: Some primary parasitoids along with number of species of their hyperparasitoids, aphid hosts, host plants and distribution in India

Parasitoid species	Number of species			States/
	Species of hyperparasitoids	Species of aphid host	Species of host plants	Union Territories
Aphidius asteris	3	1	3	1
Aphidius matricariae	4	6	8	2
Binodoxys indicus	14	7	28	6
Diaeretiella rapae	4	4	5	8
Lipolexis oregmae	6	9	19	5
Praon volucre	4	4	3	2

3. *Syrphophagus aphidivorus* (Mayr, 1876) [syn. *Aphidencyrtus aphidivorus* (Mayr, 1876)]

Aphelinus kurdjumovi Mercet, 1930

Myzus (*Nectarosiphon*) *persicae* (Sulzer, 1776)

Brassica sp. - Tamil Nadu (Nagalingam, 1988)

Capsicum frutescens L.-Tamil Nadu (Nagalingam, 1988)

Solanum melongena L. - Tamil Nadu (Nagalingam, 1988)

Aphidius asteris Haliday, 1834 [syn. *Aphidius absinthii* Marshall, 1896; *Aphidius commodus* Gahan, 1926]

Myzus (*Nectarosiphon*) *persicae* (Sulzer, 1776)

Capsicum frutescens L.-Tamil Nadu (Nagalingam, 1988)

Solanum melongena L. - Tamil Nadu (Nagalingam, 1988)

Aphidius sp.

Ovatus (*Ovatus*) *crataegarius* (Walker, 1850)

Mentha longifolia (L.) L.- Jammu & Kashmir (Bhagat, 1983)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (*Aphis*) *gossypii* Glover, 1877

Momordica charantia L. - Uttar Pradesh (Ahmad & Singh, 1996a)

Lipolexis oregmae (Gahan, 1932) [syn. *Lipolexis pseudoscutellaris* Pramanik & Raychaudhuri, 1984; *Lipolexis scutellaris* Mackauer, 1962]

Aphis (*Aphis*) *gossypii* Glover, 1877

Momordica charantia L. - Uttar Pradesh (Ahmad & Singh, 1994)

Lysiphlebia japonica (Ashmead, 1906) [syn. *Lysiphlebia mirzai* Shuja -Uddin, 1975]

Hyalopterus pruni (Geoffroy, 1762)

Phragmites karka (Retz.) Trin. ex Steud. - Uttar Pradesh (Singh & Tripathi, 1988a)

Praon necans Mackauer, 1959 [syn. *Praon nympheae* Subba Rao, Sarup & Sharma, 1963]

Rhopalosiphum nymphaeae (Linnaeus, 1761)

Nymphaea alba L. - Jammu & Kashmir (Bhagat, 1983)

Praon orientale Starý & Schlinger,1967

Uroleucon (*Uroleucon*) *sonchi* (Linnaeus, 1767)

Sonchus arvensis L. - Uttarakhand (Das & Chakrabarti, 2018)

Protaphelinus nikolskajae (Yasnosh, 1963)

Pemphigus (*Pemphigus*) *immunis* Buckton, 1896

Populus ciliata Wall. ex Royle - Jammu & Kashmir (Bhagat, 1982)

Pemphigus (*Pemphigus*) *napaeus* Buckton, 1896

Populus alba L.- Jammu & Kashmir (Bhagat, 1982)

4. *Syrphophagus hofferi* (Hayat, 1973)

Adialytus ambiguus (Haliday, 1834) [syn. *Adialytus arvicola* (Starý, 1961); *Aphidius ambiguus* Haliday, 1834; *Aphidius delhiensis* Subba Rao & Sharma 1960; *Lysiphlebus ambiguus* (Haliday, 1834); *Lysiphlebus delhiensis* (Subba Rao & Sharma 1960)]

Rhopalosiphum maidis (Fitch, 1856)

Cenchrus americanus (L.) Morrone- Uttar Pradesh (Singh & Tripathi, 1988a)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (*Aphis*) *gossypii* Glover, 1877

Lagenaria siceraria (Molino) Standl. - Uttar Pradesh (Singh & Tripathi, 1988a)

Momordica charantia L. - Uttar Pradesh (Ahmad & Singh, 1992; Ahmad & Singh, 1994)

Lipolexis oregmae (Gahan, 1932)

Aphis (*Aphis*) *craccivora* Koch, 1854

Lablab purpureus (L.) Sweet ssp. *purpureus*- Uttar Pradesh (Ahmad & Singh, 1992; 1996b)

Myzus (*Nectarosiphon*) *persicae* (Sulzer, 1776)

Capsicum frutescens L. - Uttar Pradesh (Singh & Tripathi, 1988a)

5. *Syrphophagustachikawai* (Hoffer, 1970)

Aphidius colemani Viereck, 1912

Myzus (*Nectarosiphon*) *persicae* (Sulzer, 1776)

Solanum tuberosum L. - Himachal Pradesh (Trivedi & Rajagopal, 1988)

6. *Syrphophagus* sp.

Aphidius smithi Sharma & Subba Rao, 1959

Acyrthosiphon (*Acyrthosiphon*) *pisum* (Harris, 1776)

Pisum sativum L. - Karnataka (Rao *et al.*, 1969)

Binodoxys indicus (Subba Rao & Sharma, 1958)

Aphis (*Aphis*) *gossypii* Glover, 1877

Momordica charantia L. - Bihar (Ahmad *et al.,* 2009)

Diaeretiella rapae (McIntosh, 1855)

Brevicoryne brassicae (Linnaeus, 1758)

Brassica sp. - Punjab (Sethumadhavan & Dharmadhikari, 1969)

Ephedrus nacheri Quilis, 1934

Hayhurstia atriplicis (Linnaeus, 1761)

Chenopodium album L. - Uttarakhand (Das & Chakrabarti, 1990; Das & Chakrabarti, 2018)

Lipolexis oregmae (Gahan,1932)

Aphis (*Aphis*) *fabae* Scopoli, 1763

Bidens pilosa L. - Karnataka (Rao *et al.*, 1969)

Aphis (*Aphis*) *gossypii* Glover, 1877

Unidentified plant - West Bengal (Rao *et al.*, 1969)

7. *Tassonia* sp.

Adialytus ambiguus (Haliday, 1834)

Rhopalosiphum maidis (Fitch, 1856)

Cenchrus americanus (L.) Morrone- Uttar Pradesh (Singh & Tripathi, 1988a)

Lipolexis oregmae (Gahan,1932)

Myzus (Nectarosiphon) persicae (Sulzer, 1776)

Capsicum frutescens L. - Uttar Pradesh (Singh & Tripathi, 1988a)

Family 3: Eulophidae

The Eulophidae is also a large family with over 4,300 species. Majority of the species are insect parasitoids,exceptionall, few are recorded as aphid hyperparasitoids. In India, only a single species is recorded as aphid hyperparasitoids parasitising 3 species of parasitoids as mentioned below.

1. *Tetrastichus* sp.

Aphidius matricariae Haliday, 1834

Aphis (*Aphis*) *nasturtii* Kaltenbach, 1843

Datura stramonium L. - Uttarakhand (Das & Chakrabarti, 1990)

Myzus (*Myzus*) *dycei* Carver, 1961

Urtica dioica L.- Uttarakhand (Das & Chakrabarti, 2018)

Cristicaudus garhwalensis Das & Chakrabarti, 1991

Capitophorus formosartemisiae (Takahashi, 1921)

Artemisia vestita Wall ex Besser - Himachal Pradesh (Chakrabarti & Debnath, 2009; Das & Chakrabarti, 2018)

Lipolexis oregmae (Gahan, 1932)

Aphis (*Aphis*) *gossypii* Glover, 1877

Rumex sp. - Uttarakhand (Das & Chakrabarti, 2018)

Family 4: Pteromalidae

The Pteromalidae is a large family of calcidoid wasps and the majority are insect parasitoids. Few species are aphid hyperparasitoids. They are usually ectohyper-parasitoidor endohyperparasitoid, mostly idiobiont-hyperparasitoids. In India, 6 species of the family are recorded as aphid hyperparasitoids parasitising 19 species of parasitoids of 26 species of aphids infesting 31 species of plants distributed in 7 states/union territories. Detail tetratrophic associations of these hyperparasitoids are given below:

1. *Asaphes suspensus* (Nees, 1834)

Aphidius areolatus Ashmead,1906

Periphyllus aesculi Hille Ris Lambers,1933

Aesculus indica (Wall. ex Cambess.) Hook.- Jammu & Kashmir (Bhagat, 1983)

Aphidius avenae Haliday, 1834

Chaetosiphon (Chaetosiphon) chaetosiphon (Nevsky, 1928)

Rosa macrophylla Lindl.- Jammu & Kashmir (Bhagat, 1987)

Macrosiphum (*Macrosiphum*) *rosae* (Linnaeus, 1758)

Rosa indica L. - Jammu & Kashmir (Bhagat, 1982; Chakrabarti & Debnath, 2009)

Aphidius colemani Viereck, 1912

Hyalopterus pruni (Geoffroy, 1762)

Prunus persica (L.) Stokes- Uttarakhand (Das & Chakrabarti, 1990)

Aphidius matricariae Haliday, 1834

Aphis (*Aphis*) *nasturtii* Kaltenbach, 1843

Datura stramonium L. - Uttarakhand (Das & Chakrabarti, 2018)

Brachycaudus (Brachycaudus) helichrysi (Kaltenbach, 1843)

Lablab purpureus (L.) Sweet ssp. *purpureus*- Uttarakhand (Das & Chakrabarti, 2018)

Prunus amygdalus Batsch - Uttarakhand (Das & Chakrabarti, 1990)

Capitophorus carduinus (Walker, 1850)

Cirsium wallichii DC.- Uttarakhand (Das & Chakrabarti, 2018)

Capitophorus elaeagni (del Guercio, 1894)

Carduus edelbergii Rech.f. - Jammu & Kashmir (Bhagat, 1983)

Myzus (Myzus) dycei Carver,1961

Urtica dioica L.- Uttarakhand (Das & Chakrabarti, 2018)

Myzus siegesbeckicola Strand, 1929 *Urtica dioica* L. - Uttarakhand (Das & Chakrabarti, 2018)

Phorodon (*Diphorodon*) *cannabis* Passerini, 1860

Cannabis sativa L. - Uttarakhand (Das & Chakrabarti, 2018)

Aphidius rosae Haliday, 1833

Macrosiphum (*Macrosiphum*) *rosae* (Linnaeus, 1758)

Rosa sp. - Uttarakhand (Das & Chakrabarti, 2018)

Macrosiphum sp.

Rosa macrophylla Lindl.- Jammu & Kashmir (Bhagat, 1987)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (*Aphis*) *affinis* del Guercio,1911

Mentha longifolia (L.) L.- Jammu & Kashmir (Bhagat, 1983)

Diaeretiella rapae (McIntosh, 1855)

Brevicoryne brassicae (Linnaeus, 1758)

Brassica oleracea L.-Jammu & Kashmir (Bhagat, 1983)

Brassica juncea (L.) Czern.- Uttarakhand (Das & Chakrabarti, 2018)

Hayhurstia atriplicis (Linnaeus, 1761)

Chenopodium album L. - Uttarakhand (Das & Chakrabarti, 2018)

Lipaphis (*Lipaphis*) *erysimi* (Kaltenbach, 1843)

Brassicarapa L. - Jammu & Kashmir (Bhagat, 1983)

Praon volucre (Haliday, 1833) [syn. *Praon myzophagum* Mackauer, 1959]

Macrosiphum sp.

Rosa sp. - Jammu & Kashmir (Bhagat, 1983)

2. *Asaphes vulgaris* Walker, 1834

Diaeretiella rapae (McIntosh, 1855)

Brevicoryne brassicae (Linnaeus, 1758)

Brassica sp. - West Bengal (Rao *et al.*, 1969)

Lipaphis (Lipaphis) erysimi (Kaltenbach, 1843)

Brassica sp. - Karnataka (Rao *et al.*, 1969)

3. *Asaphes* sp.

Praon volucre (Haliday, 1833)

Aphis (*Aphis*) *gossypii* Glover, 1877

Solanum betaceum Cav. - West Bengal (Rao *et al.*, 1969)

4. *Coruna clavata* Walker, 1833

Pauesia orientalis Das & Chakrabarti, 1989

Cinara (Cinara) maculipes Hille Ris Lambers, 1966

Pinus wallichiana A.B. Jacks. - Uttarakhand (Das & Chakrabarti, 2018)

5. *Coruna* sp.

*Aphidius areolatus*Ashmead,1906

Chaetosiphon sp.

Rosa sp. - Jammu & Kashmir (Bhagat, 1987)

Aphidius sp.

Macrosiphum (Macrosiphum) rosae (Linnaeus, 1758)

Rosa sp. - Jammu & Kashmir (Bhagat, 1983)

Macrosiphum sp.

Rosa indica L. - Jammu & Kashmir (Bhagat, 1987)

Unknown aphid

Aesculus indica (Wall. ex Cambess.) Hook. - Jammu & Kashmir (Bhagat, 1983)

Ephedrus srinagarensis Starý & Bhagat, 1978

Prociphilus sp.

Loniceraquin quelocularis Hardw. - Jammu & Kashmir (Bhagat, 1982)

Kashmiria aphidis Starý & Bhagat,1978

Prociphilus sp.

Lonicera quinquelocularis Hardw. - Jammu & Kashmir (Bhagat, 1982)

Praon volucre (Haliday, 1833)

Hyalopterus pruni (Geoffroy, 1762)

Prunus domestica L.-Jammu & Kashmir (Bhagat, 1983)

Praon sp.

Chaetosiphon sp.

Rosa macrophylla Lindl.- Jammu & Kashmir (Bhagat, 1983.)

6. *Euneura lachni* (Ashmead, 1887)

Pauesia lachniella Das & Chakrabarti, 1989

Lachnus tropicalis (van der Goot, 1916)

Lithocarpusde albatus Rehder - Uttarakhand (Das & Chakrabarti, 1989, 2018)

Pauesia orientalis Das & Chakrabarti,1989

Cinara (Cinara) maculipes Hille Ris Lamb.,1966

Pinus wallichiana A.B. Jacks.- Uttarakhand (Das & Chakrabarti, 2018)

7. *Pachyneuron aphidis* (Bouché, 1834)

Aphidius eglanteriae Haliday, 1834

Aphis sp.

Veronica persica Poir.- Jammu & Kashmir (Chakrabarti & Debnath, 2009)

Capitophorus formosartemisiae (Takahashi, 1921)

Artemisia sp. - Uttarakhand (Das & Chakrabarti, 1990)

Macrosiphoniella (Macrosiphoniella) pseudoartemisiae Shinji, 1933

Artemisia vulgaris L. - Uttarakhand (Das & Chakrabarti, 1990)

Myzus (Myzus) sorbi Bhattacharya & Chakrabarti,1982

Sorbaria tomentosa (Lindl.) Rehder- Uttarakhand (Das & Chakrabarti, 2018)

Aphidius gifuensis Ashmead,1906

Aphis (Aphis) fabae Scopoli, 1763

Capsella bursapastoris (L.) Medik - Jammu & Kashmir (Bhagat, 1983)

Aphidius matricariae Haliday, 1834

Capitophorus elaeagni (del Guercio, 1894)

Carduus edelbergii Rech.f. - Jammu & Kashmir (Bhagat, 1983)

Aphidius rhopalosiphi de Stefani -Perez, 1902 [syn. *Aphidius equiseticola* Starý, 1963]

Sitobion (Sitobion) miscanthi (Takahashi,1921)

Triticum aestivum L.- Uttarakhand (Das & Chakrabarti, 2018)

Aphidius uzbekistanicus Luzhetzki, 1960

Sitobion (Sitobion) avenae (Fabricius, 1775)

Sorghum halepanse (L.) Pers. - Jammu & Kashmir (Bhagat, 1983)

Aphidius sp.

Aphis (Aphis) farinosa Gmelin, 1790

Salix aegyptiaca L. - Jammu & Kashmir (Bhagat, 1983)

Aphis (Aphis) punicae Passerini, 1863

Punica granatum L. - Karnataka (Mani & Krishna-moorthy, 1995)

Betuloxys intermedius (Shuja -Uddin, 1975)

Capitophorus formosartemisiae (Takahashi, 1921)

Artemisia vulgaris L. - Uttarakhand (Das & Chakrabarti, 2018)

Binodoxys acalephae (Marshall, 1896) [syn. *Binodoxys rietscheli* (Mackauer, 1959); *Trioxys acalephae* (Marshall, 1896)]

Macrosiphum (Macrosiphum) rosae (Linnaeus, 1758)

Rosa webbiana Wall. ex Royle - Jammu & Kashmir (Bhagat, 1983)

Diaeretiella rapae (McIntosh, 1855)

Brachycaudus (Brachycaudus) helichrysi (Kaltenbach, 1843

Prunus amygdalus Batsch - Uttarakhand (Das & Chakrabarti, 1990; Sarkar, 2022)

Brevicoryne brassicae (Linnaeus, 1758)

Brassica juncea (L.) Czern.- Uttarakhand (Das & Chakrabarti, 2018)

*Brassica oleracea*L. - Himachal Pradesh (Thakur *et al.*, 1989); Uttar Pradesh (Ahmad & Singh, 1995a)

Lipaphis (Lipaphis) erysimi (Kaltenbach, 1843)

Brassica juncea (L.) Czern. -Delhi (Pramanik, 2011)

Brassica rapa L.- Jammu & Kashmir (Ahmad & Ahmad, 2013); Uttar Pradesh (Pandey *et al.*, 1985)

Kashmiria aphidis Starý & Bhagat, 1978

Prociphilus (Stagona) himalayaensis Chakrabarti, 1976

Lonicera quinquelocularis Hardw. - Uttarakhand (Das & Chakrabarti, 2018)

Prociphilus sp.

Lonicera quinquelocularis Hardw. - Uttarakhand (Das & Chakrabarti, 1990)

Praon volucre (Haliday, 1833)

Hyalopterus pruni (Geoffroy, 1762)

Prunus domestica L. - Jammu & Kashmir (Bhagat, 1983)

8. *Pachyneuron groenlandicum* (Holmgren, 1872) [syn. *Pachyneuron karnalensis* Mani, 1939]

Trioxys rishii Starý & Bhagat,1978

Capitophorus elaeagni (del Guercio, 1894)

Carduus edelbergii Rech.f. - Jammu & Kashmir (Bhagat, 1983)

9. *Pachyneuron* sp.

Binodoxys indicus (Subba Rao & Sharma, 1958)

Aphis (Aphis) gossypii Glover, 1877

Gossypium sp. - West Bengal (Rao *et al.*, 1969)

Diaeretiella rapae (McIntosh, 1855)

Brevicoryne brassicae (Linnaeus, 1758)

Brassica sp. - West Bengal (Rao *et al.*, 1969)

Family 5: Signiphoridae

Signiphoridae is a small family of chalcidoid wasps containing less than 100 species. Like other chalcids, these wasps are usually parasitic but few are hyperparasitic on aphids. Only a single species *Chartocerus walkeri* is recorded as hyperparasitoid from India as mentioned below:

1. *Chartocerus walkeri* Hayat, 1970

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) gossypii Glover, 1877

Cucumis melo L. - Uttar Pradesh (Singh & Tripathi, 1988a)

Solanum melongena L. - Uttar Pradesh (Singh & Tripathi, 1988a)

Aphis (Aphis) nerii Boyer de Fonsc., 1841

Calotropis procera (Aiton) Dryand. -Bihar (Ahmad & Singh, 2005); Uttar Pradesh (Ahmad & Singh, 1992)

Superfamily 2: Ceraphronoidea

Ceraphronoidea is a little known group of very small parasitic wasps that consists of two extant families, Ceraphronidae and Megaspilidae. Most ceraphronoids are known to have highly diverse ecological roles from primary to quaternary parasitism with an exceptionally large host range (at least eight insect orders including Hemiptera, Thysanoptera, Diptera, Hymenoptera, Coleoptera, Mecoptera, Trichoptera and Neuroptera (Miko *et al.*, 2011).

Family 1: Ceraphronidae

The Ceraphronidae is also a small family with about 360 species, are mostly parasitoids of flies, and a few are hyperparasitoids. Only two species are known as aphid hyperparasitoids in India as given below:

1. *Aphanogmus* sp

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Millsp. - Uttar Pradesh (Singh *et al.*, 1982)

2. *Ceraphron* sp.

Binodoxys indicus (Subba Rao & Sharma, 1958)

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Millsp. - Uttar Pradesh (Singh *et al.*, 1982)

Family 2: Megaspilidae

The Megaspilidae is also a small parasitic wasp family with some 450 species, most of them are parasitoids of bugs and a few are hyperparasitoids. Only one species is recorded as aphid hyperparasitoid parasitising 4 species of aphid parasitoids as given below.

1. *Dendrocerus carpenteri* (Curtis, 1829)

Aphidius avenae Haliday, 1834

Macrosiphum (Macrosiphum) rosae (Linnaeus, 1758)

Rosa webbiana Wall. ex Royle - Jammu & Kashmir (Bhagat, 1983)

Aphidius sp.

Uroleucon (Uroleucon) sonchi (Linnaeus, 1767)

Sonchus sp. - Jammu & Kashmir (Bhagat, 1983)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Mill sp. - Uttar Pradesh (Singh *et al.*, 1987)

Praon dorsale (Haliday, 1833)

Amphicercidus tuberculatus David, Narayanan & Rajasingh, 1971

Lonicera quinquelocularis Hardw. - Jammu & Kashmir (Bhagat, 1984)

Praon abjectum (Haliday, 1833)

Aphis (Bursaphis) grossulariae Kaltenbach, 1843

Epilobium hirsutum L. - Jammu & Kashmir (Bhagat, 1983)

2. *Dendrocerus* sp.

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) fabae Scopoli, 1763

Solanum nigrum L. - Uttarakhand (Das & Chakrabarti, 1990)

Aphis (Aphis) gossypii Glover, 1877

Solanum melongena L. Delhi (Subba Rao & Sharma, 1962)

Brachycaudus sp.

*Pyrus*sp.- Uttarakhand (Das & Chakrabarti, 2018)

Superfamily 3: Cynipoidea

Family 1: Figitidae

Figitidae is a large family of cynipoid wasps including about 1400 species. One of its subfamily,Charipinae with about 168 species which are widely distributed (Ferrer-Suay*et al.*, 2013), are biologically characterisedas aphid hyperparasitoids parasitising Aphidiinae and Aphelininae. In India, 9 species of this family are known to hyperparasitise 26 species aphids through 18 species of parasitoids. The detail tetratrophic associations recorded in 9 states/union territories of India are mentioned below:

1. *Alloxysta bhagyae* Bijoy & Rajmohana, 2013

Hosts unonown - Kerala (Bijoy & Rajmohana, 2013)

2. *Alloxysta brevis* (Thomson, 1862) [syn. *Alloxysta ochracea* Bijoy & Rajmohana, 2013]

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) craccivora Koch, 1854

Vicia faba L. - Uttar Pradesh (Ferrer-Suay*et al.*, 2013)

Hosts unknown - Kerala (Bijoy & Rajmohana, 2013)

3. *Alloxysta consobrina* (Zetterstedt, 1838)

Lysiphlebia japonica (Ashmead,1906)

Aphis (Aphis) gossypii Glover, 1877

Unknown plant - Jammu & Kashmir (Ferrer Suay *et al.*, 2013)

4. *Alloxysta indica* Bijoy & Rajmohana, 2013

Hosts unknown - Kerala (Bijoy & Rajmohana, 2013)

5. *Alloxysta pleuralis* (Cameron, 1879)

Adialytusam biguus (Haliday, 1834)

Rhopalosiphum maidis (Fitch, 1856)

Cenchrus americanus (L.) Morrone- Uttar Pradesh (Singh & Tripathi, 1988b)

Aphelinus albipodus Hayat & Fatima, 1992

Aphis (Aphis) gossypii Glover, 1877

Solanum melongena L.- Bihar (Ahmad *et al.,* 2009)

Aphelinus gossypii Timberlake, 1924

Aphis (Aphis) gossypii Glover, 1877

Cajanus cajan (L.) Millsp. - Bihar (Ahmad *et al.,* 2009)

Lablab purpureus (L.) Sweet ssp. *purpureus* - Bihar (Ahmad *et al.,* 2009)

Luffa aegyptiaca Mill. -Bihar (Ahmad *et al.,* 2009)

Momordica charantia L. - Bihar (Ahmad *et al.,* 2009)

Ocimumtenui florum L. - Bihar (Ahmad *et al.,* 2009)

Tagetes sp.- Bihar (Ahmad *et al.,* 2009)

Aphis (Aphis) gossypii Glover, 1877

Impatiens balsamina L.- Bihar (Ahmad *et al.,* 2009)

Aphidius colemani Viereck, 1912

Myzus (Nectarosiphon) persicae (Sulzer, 1776)

Calendulla sp.-Bihar (Kumar, 2013)

Aphidius uzbekistanicus Luzhetzki, 1960

Sitobion (Sitobion) avenae (Fabricius, 1775)

Hordeum vulgare L. - Uttar Pradesh (Singh & Tripathi, 1988b)

Triticum aestivum L. - Uttar Pradesh (Singh & Tripathi, 1988b)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Millsp.- Bihar (Ahmad & Singh, 1996a); Uttar Pradesh (Singh & Sinha, 1979; Ahmad & Singh, 1996b)

Lablab purpureus (L.) Sweet ssp. *purpureus* Bihar (Ahmad & Kumar, 2007); Uttar Pradesh (Singh & Tripathi, 1988b)

Lagenaria siceraria (Molino) Standl. -Bihar (Ahmad & Singh, 1997); Uttar Pradesh (Singh & Tripathi, 1988b; Ahmad & Singh, 1996b)

Solanum melongena L.- Bihar(Ahmad & Singh, 1996a); Uttar Pradesh (Singh & Tripathi, 1988b; Ahmad & Singh, 1996b)

Aphis (Aphis) fabae Scopoli, 1763

Clerodendrum infortunatum L.-Bihar (Ahmad & Singh, 2005); Uttar Pradesh (Singh *et al.*, 1999; Ahmad & Singh, 1996a)

Aphis (Aphis) gossypii Glover, 1877

Benincasa hispida (Thunb.) Cogn. - Bihar (Ahmad *et al.,* 2009)

Cajanus cajan (L.) Millsp. -Bihar (Ahmad & Singh, 1997); Uttar Pradesh (Singh & Tripathi, 1988b; Ahmad & Singh, 1994)

Capsicum frutescens L.-Bihar (Ahmad *et al.,* 2009); Uttar Pradesh (Singh. & Tripathi, 1987; Singh & Tripathi, 1988b)

Coccinia grandis (L.) Voigt- Bihar (Ahmad *et al.,* 2009)

Cucumis melo L. - Uttar Pradesh (Singh & Tripathi, 1987; Singh & Tripathi, 1988b)

Cucurbita maxima Duchesne - Uttar Pradesh (Singh & Tripathi, 1988b)

Hordeum vulgare L. - Bihar (Ahmad *et al.,* 2009)

Lablab purpureus (L.) Sweet ssp. *purpureus*- Uttar Pradesh (Singh & Tripathi, 1988b)

Lagenaria siceraria (Molino) Standl.-Bihar (Ahmad *et al.,* 2009); Uttar Pradesh (Singh & Tripathi, 1988b)

Lawsonia inermis L. - Bihar (Ahmad *et al.,* 2009)

Psidium guajava L. - Uttar Pradesh (Ahmad & Singh, 1994)

Rosa sp. - Bihar (Ahmad *et al.,* 2009)

Solanum melongena L. - Uttar Pradesh (Singh & Tripathi, 1987; Singh & Tripathi, 1988b)

Solanum tuberosum L. - Bihar (Ahmad *et al.,* 2009)

Aphis (Aphis) nerii Boyer de Fonsc., 1841

Calotropis procera (Aiton) Dryand. -Bihar (Ahmad & Singh, 1997; Ahmad & Singh, 2005); Uttar Pradesh (Ahmad & Singh, 1995b)

Myzus (Nectarosiphon) persicae (Sulzer, 1776)

Calendulla sp.-Bihar (Kumar, 2013)

Capsicum frutescens L. - Uttar Pradesh (Singh & Tripathi, 1988b)

Solanum lycopersicum L.- Uttar Pradesh (Singh & Tripathi, 1988b)

Solanum tuberosum L.- Uttar Pradesh (Singh & Tripathi, 1988b)

Lipolexis oregmae (Gahan, 1932)

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Millsp.-Bihar (Ahmad & Kumar, 2007)

Hibiscus sabdariffa L.-Bihar (Ahmad & Kumar, 2007)

Phaseolus vulgaris L.-Bihar (Ahmad & Kumar, 2007)

Aphis (Aphis) gossypii Glover, 1877

Capsicum frutescens L. - Uttar Pradesh (Singh & Tripathi, 1988b)

Clerodendrum infortunatum L. - Bihar (Ahmad *et al.,* 2009)

Coccinia grandis (L.) Voigt- Bihar (Ahmad *et al.,* 2009)

Aphis (Aphis) nasturtii Kaltenbach, 1843

Cucumis melo L. - Uttar Pradesh (Ahmad & Singh, 1996a)

Luffa aegyptiaca Mill. -Bihar (Ahmad & Singh, 2005); Uttar Pradesh (Ahmad & Singh, 1991)

Myzus (Nectarosiphon) persicae (Sulzer, 1776)

Solanum lycopersicum L.- Uttar Pradesh (Singh & Tripathi, 1988b)

Solanum melongena L. - Uttar Pradesh (Singh & Tripathi, 1988b)

Lysiphlebia japonica (Ashmead,1906)

Hyalopterus pruni (Geoffroy, 1762)

Phragmites karka (Retz.) Trin. ex Steud. - Uttar Pradesh (Singh & Tripathi, 1987; 1988b)

Melanaphis sacchari (Zehntner, 1897)

Cenchrus americanus (L.) Morrone- Uttar Pradesh (Singh & Tripathi, 1988c)

Rhopalosiphum maidis (Fitch, 1856)

Cenchrus americanus (L.) Morrone- Uttar Pradesh (Singh & Tripathi, 1988b,c)

6. *Alloxysta sholicola* Bijoy & Rajmohana, 2013

Hosts unknown - Kerala (Bijoy & Rajmohana, 2013)

7. *Alloxysta* sp.

Adialytus ambiguus (Haliday, 1834)

Sipha (Rungsia) maydis Passerini, 1860

Poa angustifolia L. - Jammu & Kashmir (Bhagat, 1983; Chakrabarti & Debnath, 2009)

Aphelinus sp.

Aphis (*Toxoptera*) *aurantii* Boyer de Fonsc., 1841

Citrus×*limon* (L.) Osbeck -Bihar (Kumar, 2012)

Aphidius asteris Haliday, 1834

Myzus (Nectarosiphon) persicae (Sulzer, 1776)

Brassica sp. - Tamil Nadu (Nagalingam, 1988)

Capsicum frutescens L. - Tamil Nadu (Nagalingam, 1988)

Solanum melongena L. - Tamil Nadu (Nagalingam, 1988)

Aphidius eglanteriae Haliday, 1834

Chaetosiphon (Pentatrichopus) tetrarhodum (Walker, 1849)

Rosa webbiana Wall. ex Royle - Jammu & Kashmir (Bhagat, 1987)

Aphidius matricariae Haliday, 1834

Brachycaudus (Brachycaudus) helichrysi (Kaltenbach, 1843)

Lablab purpureus (L.) Sweet ssp. *purpureus*- Uttarakhand (Das & Chakrabarti, 2018)

Prunus persica (L.) Batsch- Uttarakhand (Das & Chakrabarti, 1990)

Myzus (Myzus) dycei Carver, 1961

Urtica dioica L. - Uttarakhand (Das & Chakrabarti, 2018)

Phorodon (Diphorodon) cannabis Passerini, 1860

Cannabis sativa L. - Uttarakhand (Das & Chakrabarti, 2018)

Aphidius rhopalosiphi de Stefani -Perez,1902

Sitobion (Sitobion) miscanthi (Takahashi, 1921)

Triticum aestivum L. - Uttarakhand (Das & Chakrabarti, 2018; Sarkar, 2022)

Aphidius uzbekistanicus Luzhetzki, 1960

Impatientinum (Impatientinum)asiaticum dalhousiensis Verma,1969

Cenchrus flaccidus (Griseb.) Morrone- Jammu & Kashmir (Bhagat, 1983)

Impatiens sp. - Jammu & Kashmir (Bhagat, 1983)

Sitobion (Sitobion) avenae (Fabricius, 1775)

Cenchrus flaccidus (Griseb.) Morrone- Jammu & Kashmir (Bhagat, 1983)

Aphidius sp.

Chaetosiphon sp.

Rosa sp. - Jammu & Kashmir (Bhagat, 1983)

Macrosiphum sp.

Rosa brunonii Lindl.- Jammu & Kashmir (Bhagat, 1983)

Myzaphis rosarum (Kaltenbach, 1843) *Rosa webbiana* Wall. ex Royle - Jammu & Kashmir (Bhagat, 1983)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) gossypii Glover, 1877

Gossypium sp. - West Bengal (Rao *et al.*, 1969)

Solanum melongena L. - Delhi (Subba Rao & Sharma, 1962)

Kashmiria aphidis Starý & Bhagat,1978

Prociphilus (Stagona) himalayaensis Chakrabarti, 1976

Lonicera quinquelocularis Hardw. - Uttarakhand (Das & Chakrabarti, 2018)

Prociphilus sp.

Lonicera quinquelocularis Hardw. - Uttarakhand (Das & Chakrabarti, 1990)

Lipolexis oregmae (Gahan,1932)

Aphis (Aphis) gossypii Glover, 1877

Unknown plant - Karnataka (Dharmadhikari & Ramaseshiah, 1970)

Aphis (Aphis) spiraecola Patch, 1914

Bidens pilosa L. - Karnataka (Dharmadhikari & Ramaseshiah, 1970)

Mikania cordata (Burm.fil.) B.L.Rob.,- Karnataka (Dharmadhikari &Ramaseshiah, 1970)

Spiraea betulifolia var. *corymbosa* (Raf.) Voss- Karnataka (Dharmadhikari & Ramaseshiah, 1970)

Aphis (*Toxoptera*) *aurantii* Boyer de Fonsc., 1841

Citrus sp. - Karnataka (Dharmadhikari & Ramaseshiah, 1970)

Schima wallichii (DC.) Korth. - Karnataka (Dharmadhikari & Ramaseshiah, 1970)

Greenidea (Trichosiphum) psidii van der Goot, 1917

Psidium guajava L.- Karnataka (Dharmadhikari & Ramaseshiah, 1970)

Praon volucre (Haliday, 1833)

Myzaphis rosarum (Kaltenbach, 1843)

Rosa webbiana Wall. - Jammu & Kashmir (Bhagat, 1987)

Rosa sp. - Jammu & Kashmir (Bhagat, 1983)

Toxares deltiger (Haliday, 1833)

Betacallis sp.

Conium maculatum L. - Jammu & Kashmir (Bhagat, 1983)

Toxares zakai Shuja -Uddin,1974

Microlophium sp.

Urtica dioica L. - Jammu & Kashmir (Bhagat, 1983)

8. *Phaenoglyphis indica* Ferrer-Suay & Pujade-Villar, 2013

Hosts unknown - Jammu & Kashmir (Ferrer-Suay *et al.*, 2013)

9. *Phaenoglyphis longicornis* (Hartig, 1840)

Hosts unknown- Jammu & Kashmir (Ferrer-Suay *et al.*, 2013)

10. *Phaenoglyphis villosa* (Hartig, 1841)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) craccivora Koch, 1854

Vicia fabae L. - India (Ferrer-Suay *et al.*, 2013)

11. *Phaenoglyphis* sp.

Aphidius asteris Haliday, 1834

Myzus (Nectarosiphon) persicae (Sulzer, 1776)

Brassica sp. - Tamil Nadu (Nagalingam, 1988)

Capsicum frutescens L. - Tamil Nadu (Nagalingam, 1988)

Solanum melongena L. - Tamil Nadu (Nagalingam, 1988)

Aphidius ervi Haliday, 1834

Microlophiumcarnosum (Buckton, 1876)

Urtica dioica L. - Jammu & Kashmir (Bhagat, 1983)

Aphidius gifuensis Ashmead, 1906

Aphis sp.

Nepeta racemosa racemosa Lam. - Jammu & Kashmir (Bhagat, 1983)

Binodoxys indicus (Subba Rao & Sharma,1958)

Aphis (Aphis) craccivora Koch, 1854

Ageratum conyzoides L. - Uttar Pradesh (Ahmad & Singh, 1991; Ahmad & Singh, 1995b)

Aphis (Aphis) craccivora Koch, 1854

Ageratum conyzoides L. -Bihar (Ahmad *et al.*, 2020)

Cajanus cajan (L.) Millsp. -Bihar (Ahmad & Singh, 1997); Uttar Pradesh (Singh *et al.*, 1982)

Lablab purpureus (L.) Sweet ssp. *purpureus* West Bengal (Poddar, 1982)

Solanum melongena L. - Uttar Pradesh (Ahmad & Singh, 1996b)

Aphis (Aphis) gossypii Glover, 1877

Cajanus cajan (L.) Millsp. - Bihar (Ahmad *et al.,* 2009)

Lagenaria siceraria (Molino) Standl. - Bihar (Ahmad *et al.,* 2009)

Luffa aegyptiaca Mill. - Bihar (Ahmad *et al.,* 2009)

Gossypium sp. - West Bengal (Rao *et al.*, 1969) *Momordica charantia* L.– Bihar (Ahmad *et al.,* 2009)

Ocimum tenuiflorum L. - Bihar (Ahmad *et al.,* 2009)

Tagetes sp. - Bihar (Ahmad *et al.,* 2009)

Aphis (Aphis) nerii Boyer de Fonsc., 1841

Calotropis procera (Aiton) Dryand. -Bihar (Ahmad & Singh, 1997); Uttar Pradesh (Ahmad & Singh, 1991; Ahmad & Singh, 1995b)

Lipolexis oregmae (Gahan, 1932)

Aphis (Aphis) craccivora Koch, 1854

Cajanus cajan (L.) Millsp.-Bihar (Ahmad & Kumar, 2007)

Aphis (Aphis) craccivora Koch, 1854

Hibiscus sabdariffa L.-Bihar (Ahmad & Kumar, 2007)

Aphis (Aphis) gossypii Glover, 1877

Capsicum frutescens L. – Bihar (Ahmad *et al.,* 2009)

REFERENCES

Ahmad, M.J. & Ahmad, S.B. (2013). Dynamics of *Diaeretiella rapae* (M'Intosh) (Braconidae: Aphidiidae) and its hyperparasitoid on mustard aphid, *Lipaphis erysimi* Kalt infesting brown mustard, *Brassica campestris* Linn. in Kashmir, India. *J. Biol. Cont.*, 27(4): 247-252.

Ahmad, M.E. & Kumar, K.M. (2007). Food plants and natural enemies of *Aphis craccivora* Koch (Homoptera: Aphididae) in northeast Bihar. *J.Aphidol.*, 21: 97-102.

Ahmad, M.E. & Singh, R. (1991). New host association of alloxystid hyperparasitoid. *Newsl. Aphidol. Soc.*, *India*, 9(2): 8-10.

Ahmad, M.E. & Singh, R. (1992). New host association of chalcidoid hyperparasitoids. *J. Adv. Zool.*, 13: 66-67.

Ahmad, M.E. & Singh, R. (1994). *Aphis gossypii* Glover on different food plants and its association with parasitoids and hyperparasitoids in Northeastern Uttar Pradesh. *Ann. Entomol.*, 12: 63-67.

Ahmad, M.E. & Singh, R. (1995a). Records of Macrosiphini of north eastern Uttar Pradesh and its relationship with food plants and natural enemies. *J. Aphidol.*, 9: 80-86.

Ahmad, M.E. & Singh, R. (1995b). Survey of parasitoids of aphids in north-eastern Uttar Pradesh for possible use in biological control. *Ann.Entomol.*, 13: 87-96.

Ahmad, M.E. & Singh, R. (1996a). Trophic relations of aphid hyperparasitoids in north-eastern Uttar Pradesh. *Entomon.*, 21: 37-42.

Ahmad, M.E. & Singh, R. (1996b). Tetratrophic interaction of *Aphis craccivora* Koch in Northeastern Uttar Pradesh. *IPM & Sustainable Agriculture- an Appraisal*, 6: 143-146.

Ahmad, M.E. & Singh, R. (1997). Records of aphids and their food plants, parasitoids and hyperparasitoids from north Bihar. *J. Adv. Zool.*, 18(1): 54-61.

Ahmad, M.E. & Singh, R. (2005). Food plants associations, seasonal occurrence and parasitoids/hyperparasitoids of few species of *Aphis* Linnaeus from northeastern Uttar Pradesh and Bihar. *J. Adv. Zool*., 26: 41-46.

Ahmad, M.E., Kumar, K.M., Parween, N. & Kumar, S. (2009). Tetratrophic associations of *Aphis gossypii* Glover with its food plants and natural enemies in northeast Bihar. In: Ecofriendly Insect Pest Management (Ed. Ignacimaithu, S. & David, B.V.), Elite Publication House, pp. 144-152.

Ahmad, M.E., Kumar, S., Parween N. & Rakhshan (2020). Bio-ecological study of few species of *Aphis* Linn. in northeast Bihar and their association with food plants and natural enemies for possible use in the biological control. *J. Adv. Zool*., 41(1&2): 103-116.

Bhagat, R.C. (1982). Aphid-galls and their parasitoids from Kashmir, India. *Entomon.*, 7: 103-105.

Bhagat, R.C. (1983). Records and host range of hyperparasitoids (Insecta: Hymenoptera) of aphids (Homoptera: Aphididae) from Kashmir, India. *Sci. & Cult*., 49: 150-152.

Bhagat, R.C. (1984). New records and hosts of aphid parasitoids (Hymenoptera: Aphidiidae) from Kashmir, India. *J. Bombay Nat. Hist. Soc*., 81(1): 91-98.

Bhagat, R.C. (1987). Field Observations on hyperparasites of aphid pests infesting *Rosa* spp. in Kashmir valley, India. *J. Biol. Cont.*, 1(2): 104-105.

Bijoy, C. & Rajmohana, K. (2013) Descriptions of four new species of the genus *Alloxysta* Förster (Hymenoptera: Cynipoidea: Figitidae: Charipinae) from India. *Biosystem.*, 7(1): 59-66.

Chakrabarti, S. & Debnath, M. (2009). Diversity of aphidophagous parasitoids (Insecta) of northwest and western Himalayas, India. In: Biodiversitat und Naturausstattungim Himalaya, III (eds. Hartmann, M. & Weipert, J.), Naturkundemuseum Erfurt, pp. 441-454.

Cusumano, A., Harvey, J.A., Bourne, M.E., Poelmana, E.H. & de Boerb, J.G. (2020). Exploiting chemical ecology to manage hyperparasitoids in biological control of arthropod pests. *Pest Manag. Sci.*, 76: 432-443.

Das, B.C. & Chakrabarti, S. (1989). *Praon himalayensis*, a new walnut aphid parasitoid (Hymenoptera: Aphidiidae) in Garhwal range of Western Himalaya. *Entomon*, 14: 345-347.

Das, B.C. & Chakrabarti, S. (1990). New and little known aphidiid parasitoids (Hymenoptera; Aphidiidae) of gall forming aphids in Western Himalaya, with notes on their seasonal history. *Orient. Ins.*, 24: 399-414.

Das, B.C. & Chakrabarti, C. (2018). Diversity and distribution of hyperparasitoids of Aphidiinae (Insecta: Braconidae: Hymenoptera) in the Garhwal Himalayas. Hartmann, Barclay. & Weipert: Biodiversität und Naturausstattungim Himalaya VI.- Erfurt, pp. 565-570.

Dharmadhikari, P.R. & Ramaseshiah, G. (1970). Recent records of aphidiids (Hymenoptera: Aphidiidae) in India. *Tech. Bull.Commonw. Inst. Biol. Cont.*, 13: 83-89.

Favret, C. (2024). Aphid Species File: https://Aphid.SpeciesFile.org, retrieved on October 31, 2024.

Ferrer-Suay, M.,Selfa, J. & Pujade-Villar, J. (2013). Charipinae fauna (Hymenoptera: Figitidae) from Asia, with description of eleven new species. *Zool.Stud.* 52(41): 1-26.

Fiske. W.E. (1910). Superparastism: an important factor in the natural control of insects. *J. Econ.Entomol.*, 3: 88-97.

Frazer, B.D. & van den Bosch, R. (1973). Biological control of the walnut aphid in California: the interrelationship of the aphid and its parasite. *Environ.Entomol.*, 2(4): 561-568

GBIF (2024). The Global Biodiversity Information Facility, retrieved on October 31, 2024, https://www.gbif.org

Godfray, H.C.J. (1994). Parasitoids: Behavioral and Evolutionary Ecology. Princeton, NJ: Princeton Univ. Press, pp. 473.

Gutierrez, A.P. & van den Bosch, R. (1970). Studies on the host selection and host specifity of the aphid hyperparasite *Charips victrix* (Hymenoptera: Cynipidae). 2. The bionomics of *Charips victrix. Ann. Entomol. Soc. Amer*., 63: 1355-1360.

Hassell, M.P. & Waage, J. K. (1984). Host-parasitoid population interactions. *Annu. Rev. Entomol*., 29: 89-114.

Heraty, J. &Woolley, J. (2024). Chalcidoidea of the World. CABI Publication, pp. 480.

Holler, C., Micha, S.G., Schulz, S., Francke, W. & Pickett, J.A. (1994). Enemy-induced dispersal in a parasitic wasp. *Experientia*, 50:182-185.

Kumar, K.M. (2012). Species of genus *Toxoptera* Koch (Homoptera: Aphididae) in northeast Bihar. *J. Aphidol.*, 25&26: 31-38.

Kumar, K.S. (2013). Seasonal abundance of *Myzus persicae* (Sulzer) and its association with food plants and natural enemies in Northeast Bihar. *Biolife*, 1: 195-194.

Luck, R.F. Messenger, P.S. &Barbieri, J.F. (1981). The influence

of hyperparasitism on the performance of biological control agents, pp. 34-42. In. The role of hyperparasitism in biological control: a symposium (ed. Rosen, D.). Division of Agricultural Sciences, University of California, Berkeley, CA.

Matejko, I. & Sullivan, D.J. (1984). Interspecific tertiary parasitoidism between two aphid hyperparasitoids: *Dendrocerus carpenteri* and *Alloxysta megourae* (Hymenoptera: Megaspilidae and Cynipidae). *J. Wash. Acad. Sci*., 74:31-38.

Miko, I., Yoder, M.J. & A.R. Deans (2011). Order. Hymenoptera, Family Megaspilidae, Genus *Dendrocerus*. *Arthropod families of the UAE*, 4: 353-374.

Nagalingam, B. (1988). Studies on the ecology and biocontrol agents of *Myzuspersicae* (Sulzer). *Newsl. Aphidol. Soc. India*, 7 (1): 14-15.

Pandey, K.P., Kumar, A., Shanker, S. & Tripathi, C.P.M. (1985). First record of *Pachyneuron aphidis* (Bouche) (Pteromalidae: Hymenoptera), a hyperparasitoid of *Diaeretiella rapae* (M'Intosh) (Aphidiidae: Hymenoptera) from India. *Curr. Sci*., 54: 710.

Poddar, S.C. (1982). Studies on *Aphis craccivora* Koch and its natural enemies in some parts of India. Ph.D. thesis, Calcutta University, Kolkata, West Bengal, pp. 245. http://hdl.handle.net/10603/162498

Poelman, E.H., Cusumano, A. & de Boer, J.G. (2022). The ecology of hyperparasitoids. *Annu. Rev. Entomol*., 67: 143-161.

Rao, V.P., Dharmadhikari, P.R., Ramaseshiah, G., Phalak, V.R. & Madhavan, T.V.S. (1969). Study of natural enemies of aphids (for the U.S.A.). *Rep.Commonw. Inst. Biol. Cont*., 1968: 45-47.

Sarkar, S. (2022). Incidence and host association of primary parasitoids (Hymenoptera: Braconidae: Aphidiinae) of aphids infesting economically important plants in Kumaon-Garhwal ranges of western Himalaya. *Internat. J. Agric. Innov. & Res.*, 10(4): 137-142.

Sethumadhavan, T.V. & Dharmadhikari, P.R. (1969). Notes on *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Aphidiidae) parasitic on aphids on crucifers in India. *Tech. Bull. Commonw. Inst. Biol. Cont.*, 11: 173-177.

Singh, R. & Sinha, (1979). First record of *Alloxysta* sp., a hyperparasitoid of *Trioxys (Binodoxys) indicus* Subba Rao and Sharma (Aphidiidae: Hymenoptera). *Curr. Sci.*, 48: 1008-1009.

Singh, R. & Tripathi, R.N. (1987). First record of hyperparasitism in two species of aphid parasitoid by *Alloxysta pleuralis* (Cameron) (Hymenoptera: Alloxystidae*). Newsl. Aphidol. Soc.*, *India*, 6(1): 11-12.

Singh, R. & Tripathi, R.N. (1988a). New host associations of the parasitoid and hyperparasitoid of aphids from India. *Newsl. Aphidol. Soc. India*, 7(2): 6-8.

Singh, R. & Tripathi, R.N. (1988b). New host associations of *Alloxysta pleuralis* (Cameron) (Hymenoptera: Alloxystidae*). Newsl. Aphidol. Soc. India*, 7(1): 11-12.

Singh, R. & Tripathi, R.N. (1988c). New host records of the parasitoid *Lysiphlebus delhiensis* (Subba Rao & Sharma) and the hyperparasitoid *Alloxysta pleuralis* (Cameron). *Curr. Sci.*, 57: 397.

Singh, R. & Tripathi, R.N. (1991). Records of aphid hyperparasitoids in India. *Bioved*, 1(2); 141-150.

Singh, R., Pandey, R.K., Kumar, A. & Sinha, T.B. (1982). First record of three hyperparasitoids of *Trioxys (Binodoxys) indicus* Subba Rao Sharma (Hym: Aphidiidae) from India. *Entomon*, 8(3): 329-330.

Singh, R., Srivastava, M. & Srivastava, P.N. (1987). New aphidiid host record of aphid hyperparasitoid Hymenoptera) form India. *Entomon.*, 12: 115-116.

Singh, R., Upadhyaya, B.S., Singh, D. & Chaudhary, H.C. (1999). Aphids (Homoptera: Aphididae) and their parasitoids in north-eastern Uttar Pradesh. *J. Aphidol.*, 13: 49-62.

Sullivan, D.J. & Völkl, W. (1999). Hyperparasitism: multitrophic ecology and behavior. *Annu. Rev. Entomol*., 44: 291-315.

Sullivan, D.J. (1987). Insect hyperparasitism. *Annu. Rev. Entomol*., 32: 49-70

Thakur, J.N., Rawat, U.S., Pawar, A.D. & Sidhu, S.S. (1989). Natural enemy complex of the cabbage aphid *Brevicoryne brassicae* L. (Homoptera: Aphididae) in Kullu Valley, Himachal Pradesh. *J. Biol. Cont.*, 3(1): 69.

Trivedi, T.P. & Rajagopal, D. (1988). Natural enemies of potato aphids, *Myzuspersicae* (Sulzer) and *Aphis gossypii* Glover (Homoptera: Aphididae) in India. *Biocovas*, 1: 173-177.

Viggiani, G. (1984). Bionomics of the Aphelinidae. *Annu. Rev. Entomol*., 29: 257-276.

WFO (2024). The World Flora Online. https://www.worldfloraonline.org, retrieved on October 31, 2024.