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Checklist of Tri-trophic Associations of Aphid Parasitoids in Karnataka, India

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Abstract: The present study documents the diversity and host associations of aphid parasitoids belonging to Aphelinidae and Aphidiinae (Braconidae) in Karnataka, India. Aphelinidae was represented by seven species of *Aphelinus* and a single species of *Encarsia*, with most aphelinids exhibiting high host specificity. *Aphelinus mali* was the only species with a broader host range, parasitising *Aphis gossypii* on three host plants, while *Encarsia flavoscutellum* was strictly associated with *Ceratovacuna lanigera* on sugarcane. Among aphids, *Aphis craccivora* and *Aphis gossypii* were the most frequently parasitised. Aphidiinae comprised 19 species exploiting 40 aphid species across 57 parasitoid–host–plant associations, indicating a complex trophic structure. *Aphidius* was the most species-rich genus. *Lipolexis oregmae* exhibited the highest ecological amplitude, parasitising ten aphid species on 13 host plants. Most other aphidiines were highly host-specific. Overall, the findings highlight a predominance of host specificity among aphid parasitoids in Karnataka, alongside a few polyphagous species that may play a key role in natural aphid regulation across diverse agroecosystems.

Keywords: Aphid parasitoids, Aphelinidae, Aphidiinae, Biological control, Karnataka, Tri-trophic associations

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Introduction

Parasitoids associated with aphids are a specialized group of hymenopteran insects that exert a profound influence on both the population dynamics of aphids and the structure of terrestrial food webs (Singh and Singh, 2016). These organisms, primarily belonging to the subfamily Aphidiinae (family Braconidae) and the family Aphelinidae (superfamily: Chalcidoidea), are solitary endoparasitoids that lay their eggs within aphid hosts. Following oviposition, the parasitoid larva consumes host tissues, ultimately killing and mummifying the aphid, a characteristic trait that differentiates parasitoids from predators and parasites in ecological function and life history strategies (Starý, 1988a, b; Singh, 2001; Boivin *et al.*, 2012).

Aphid parasitoids occupy the third trophic level in classical tritrophic systems involving plants, aphid herbivores, and parasitoid wasps (Singh, 2003). Through direct exploitation of

aphid populations, parasitoids regulate herbivore abundance, reducing herbivory pressure on host plants and influencing community interactions. Many aphidiine and aphelinid species exhibit high levels of host specificity, often attacking only a narrow range of aphid hosts, which can lead to complex and dynamic host–parasitoid networks within both natural and agricultural ecosystems (Singh, 2025a, b, c, d). The foraging behaviour and efficacy of parasitoids are influenced by host availability, plant cues, and landscape context. Herbivore-induced plant volatiles play a crucial role in mediating parasitoid attraction to aphid-infested plants; these plant emissions act as synomones that enhance parasitoid host-location efficiency. Such chemically mediated interactions underscore the interdependence of plant physiological responses and parasitoid foraging behaviour in trophic regulation (Bhatt and Singh, 1989; Turlings *et al.*, 1990; Vet and Dicke, 1992; Tripathi and Singh, 1994, 1995; Murali-Baskaran *et al.*, 2018).

Global assessments of aphid parasitoid communities reveal that hundreds of species across multiple genera and families contribute to biological regulation of aphids (Singh and Singh, 2016). By exerting top-down pressure on aphid populations, parasitoids contribute significantly to the stability and resilience of plant communities. Their regulatory functions help maintain aphid densities below economic thresholds in agricultural systems and enhance plant fitness in natural ecosystems. As such, aphid parasitoids are integral to biological control programs, reducing reliance on chemical insecticides and promoting sustainable pest management practices (Alhmedi *et al.*, 2025; Ferrer-Suay *et al.*, 2025).

The preparation of a checklist of tri-trophic associations of aphid parasitoids is significant for understanding the ecological linkages among parasitoids, aphids, and host plants. Such checklists provide baseline data on host specificity, parasitoid diversity, and plant associations, which are essential for assessing natural biological control potential (Singh, 2025a, b). They support the selection and conservation of effective parasitoids in integrated pest management programmes, help predict parasitoid performance across cropping systems, and aid in monitoring changes in biodiversity and ecosystem stability under varying agricultural and environmental conditions. Collectively, this checklist serves as an essential reference for researchers, practitioners, and policymakers committed to advancing sustainable pest management (Singh, 2025a). This study presents a detailed checklist of tri-trophic associations among parasitoids, their aphid hosts, and associated plants in Karnataka, India. The compilation provides essential baseline information on species diversity, distribution patterns, and host specificity, serving as a valuable resource for ecological studies and pest management applications. By documenting parasitoid–aphid–plant relationships, the checklist highlights important ecological interactions underlying natural aphid regulation and aids in identifying suitable indigenous natural enemies for biological control, thereby reducing risks associated with the introduction of exotic species.

Materials and Methods

The present checklist of tri-trophic associations involving aphidophagous arthropods in Karnataka was compiled using information from recently published books, peer-reviewed journals, authenticated theses, and reliable online databases available up to 31 December 2025. Earlier literature, including some relatively recent publications, often contained taxonomic inconsistencies in the nomenclature of predators, aphids, and host plants, largely due to rapid advances in taxonomic research and the limited adoption of updated classification systems. With the continued expansion of studies on predator–prey–plant interactions, new species records, nomenclatural revisions, and taxonomic updates are frequently generated. To ensure accuracy and uniformity, aphid nomenclature was standardized following the Aphid Species File (https://Aphid.SpeciesFile.org), host plant names

were verified using World Flora Online (https://www.worldfloraonline.org), and arthropod taxonomy was aligned with the Global Biodiversity Information Facility (https://www.gbif.org).

Results and Discussion

Table 1 display a rich assemblage of aphid parasitoids associated with diverse aphid species and host plants in Karnataka. Overall, the records document a broad parasitoid complex comprising members of Aphelinidae and Braconidae (Aphidiinae), parasitising a wide spectrum of aphids infesting agricultural crops, horticultural plants, ornamentals, plantation crops, and wild hosts.

(A) Family: Aphelinidae, Superfamily: Chalcidoidea, Order: Hymenoptera

The earliest documented aphelinid parasitoid in India is *Aphelinus mali*, introduced from England in 1937 for the biological control of the woolly apple aphid, *Eriosoma lanigerum*. The species successfully established in major apple-growing regions, including the Kullu and Shimla hills, Kashmir Valley, Coonoor, and Shillong, and is now widespread across India's apple belts, with greater control efficacy in valley ecosystems than on mountain slopes (Chacko, 1967). By the 1960s, it was also reported parasitising *Aphis gossypii* on *Bacopa monnieri* and *Rotala rosea* in Karnataka (Sankaran, 1967). Overall, five decades of research document a diverse and progressively expanding *Aphelinus*–aphid–plant association in India, primarily involving aphid species of the tribes Aphidini and Macrosiphini infesting cereals, pulses, vegetables, oilseeds, spices, fruit crops, ornamentals, and associated wild flora. So far, a total of 21 aphelinid species are known from India, forming 164 tritrophic associations that link 32 aphid species and 77 host plants across 21 states (Singh and Shukla, 2026).

In Karnataka, a total of 9 species of aphelinid parasitoids were recorded parasitising 10 species of aphids infesting 16 species of host plants forming 17 tri-trophic associations (Table 1). Within the family Aphelinidae, the genus *Aphelinus* was represented by 7 identified species, each characterised by well-defined host associations while the genus *Encarsia* is represented by only one species (Table 1). The aphelinid parasitoids exhibited a high degree of host specificity, with most species parasitising a single aphid host. *Aphelinus mali* was the only exception, displaying a comparatively broader host range by parasitising *Aphis gossypii* and *Aphis spiraecola* across 4 host plants. *Aphelinus asychis* and *Aphelinus mali* are important biocontrol agents used against various pest aphids in crops and greenhouses worldwide (Greathead, 1986). In addition, the encyrtid parasitoid *Encarsia flavoscutellum* showed strict host specificity, being exclusively associated with the sugarcane woolly aphid *Ceratovacuna lanigera* on *Saccharum officinarum*. It has been successfully released and manage the sugarcane wooly aphid in Kerala, India (Jandhyala *et al.*, 2021). Among the aphid hosts, *Aphis gossypii* was the most frequently parasitised, being attacked by 3 aphelinid parasitoid species, followed by *Aphis spiraecola*, which supported 2 aphelinid species. In contrast, the remaining aphid species were each parasitized by only a single aphelinid parasitoid species.

The detailed account of tri-trophic associations of aphelinid parasitoids are given below:

1. *Aphelinus albipodus* Hayat and Fatima, 1992

• *Sipha elegans* Del Guercio, 1905

- *Arachis hypogaea* L. (Hayat, 1998)

2. *Aphelinus ancer* Hayat, 1990

• *Greenidea artocarpi* (Westwood, 1890)

- *Artocarpus heterophyllus* Lam. (Hayat, 1998)

3. *Aphelinus asychis* Walker, 1839

• *Brevicoryne brassicae* (Linnaeus, 1758)

- *Brassica oleracea* L. var. *capitata* (Hayat, 1998)

4. *Aphelinus basilicus* Fatima and Hayat, 1998

• *Aphis gossypii* Glover, 1877

Table 1: Number of species of parasitoids belonging to different families preying on different number of aphid species infesting different number of host plant species and triplets in Karnataka

Families/Parasitoid species	Number of			
	Aphid species	Plant species	Triplets	States/union territories
Aphelinidae				
1. *Aphelinus albipodus*	1	1	1	5
2. *Aphelinus ancer*	1	1	1	2
3. *Aphelinus asychis*	1	1	1	8
4. *Aphelinus basilicus*	1	1	1	7
5. *Aphelinus gossypii*	2	2	2	10
6. *Aphelinus lankaensis*	1	1	1	1
7. *Aphelinus mali*	2	4	4	10
8. *Aphelinus* sp.	3	5	5	10
9. *Encarsia flavoscutellum*	1	1	1	5
Total Aphelinidae	**10**	**16**	**17**	**21**
Aphidiinae (Braconidae)				
1. *Aphidius asteris*	1	1	1	
2. *Aphidius colemani*	3	4	4	
3. *Aphidius matricariae*	1	1	1	
4. *Aphidius platensis*	1	2	2	
5. *Aphidius smithi*	1	1	1	
6. *Aphidius transcaspicus*	1	2	2	
7. *Aphidius* sp.	8	10	10	
8. *Binodoxys acalephae*	1	2	2	
9. *Binodoxys basicurvus*	1	1	1	
10. *Binodoxys brevicornis*	1	1	1	
11. *Binodoxys indicus*	3	4	4	
12. *Binodoxys* sp.	1	1	1	
13. *Diaeretiella rapae*	3	3	4	
14. *Lipolexis oregmae*	10	13	17	
15. *Lysiphlebus fabarum*	1	1	1	
16. *Lysiphlebus testaceipes*	2	2	2	
17. *Lysiphlebus*	1	1	1	
18. *Praon abjectum*	1	1	1	
19. *Trioxys* sp.	1	1	1	
Total Aphidiinae	**19**	**40**	**57**	
Total	**23**	**45**	**69**	

- *Gossypium hirsutum* L. (Lokeshwari *et al.*, 2014)

5. *Aphelinus gossypii* Timberlake, 1924

• *Aphis spiraecola* Patch, 1914

- *Chromolaena odorata* (L.) R.M.King & H.Rob. - Karnataka (Ramaseshiah, 1979)

• *Brachycaudus helichrysi* (Kaltenbach, 1843)

- *Prunus persica* (L.) Stokes (Hayat, 1998)

6. *Aphelinus lankaensis* Hayat, 1994

• Unknown aphid

- Unknown plant (Hayat, 1994)

7. *Aphelinus mali* (Haldeman, 1851)

• *Aphis gossypii* Glover, 1877

- *Bacopa monnieri* (L.) Pennell (Sankaran, 1967)

- *Gossypium hirsutum* L. (Hayat, 1998)

- *Rotala rosea* (Poir.) C.D.K.Cook (Sankaran, 1967)

• *Aphis spiraecola* Patch, 1914

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

8. *Aphelinus* sp.

• *Aphis gossypii* Glover, 1877

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

- *Solanum melongena* L. (Rao *et al.*, 1969)

• *Aphis punicae* Passerini, 1863

- *Punica granatum* L. (Mani and Krishnamoorthy, 1995)

• *Myzus persicae* (Sulzer, 1776)

- *Brassica oleracea* L. var. *botrytis* (Rao *et al.*, 1969)

- *Capsicum annuum* L. (Mani and Krishnamoorthy, 1994)

9. *Encarsia flavoscutellum* Zehntner, 1900

• *Ceratovacuna lanigera* Zehntner, 1897

- *Saccharum officinarum* L. (Sharanabasappa *et al.*, 2008)

(B) Subfamily: Aphidiinae, Family: Braconidae, Superfamily: Ichneumonoidea, Order: Hymenoptera

The data displayed in Table 1 summarise the diversity and host–plant associations of Aphidiinae (Braconidae) parasitoids recorded in the study area. In total, 19 parasitoid species were documented, collectively exploiting 40 aphid host species across 57 parasitoid–host–plant triplets, indicating a complex trophic network out of 157 species recorded in India (Das and Chakrabarti, 2023). Among the recorded taxa, *Aphidius* was the most species-rich genus, represented by 7 species. *Aphidius* sp. (it may contain more than one species) showed the widest host and plant associations within the genus, parasitising eight aphid species on 10 host plants, accounting for 10 triplets. In contrast, *Aphidius asteris*, *Aphidius matricariae*, *Aphidius smithi*, and *Aphidius transcaspicus* exhibited narrow host ranges, each being associated with a single aphid species and one or two plant species. *Aphidius colemani* demonstrated moderate host breadth, parasitising 3 aphid species on 4 plant species in Karnataka. The genus *Binodoxys* is represented by 5 taxa, of which *Binodoxys indicus* showed relatively broader associations, parasitising 3 aphid species on 4 plant species. The remaining *Binodoxys* species were highly host-specific, each forming a single parasitoid–host–plant association. *Diaeretiella rapae* parasitised 3 aphid species on 3 different host plants, resulting in 4 triplets, reflecting its known affinity with aphids on brassica crops. Among all recorded parasitoids, *Lipolexis oregmae* exhibited the highest ecological amplitude, parasitising 10 aphid species across 13 host plants, and contributing 17 triplets, thereby representing the most polyphagous parasitoid in the assemblage. The remaining genera, including *Lysiphlebus*, *Praon*, and *Trioxys*, are represented by one or two species each and showed limited host and plant associations, typically restricted to a single aphid–plant combination in Karnataka. Overall, the results indicate that while most aphidiine parasitoids in Karnataka exhibit a high degree of host specificity, a few species, particularly *Lipolexis oregmae*, *Aphidius colemani*, and *Binodoxys indicus*, display broader host and plant utilisation, highlighting their potential importance in the natural regulation of aphid populations across diverse agroecosystems in Karnataka. All 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. *Aphidius asteris* Haliday, 1834

• *Macrosiphoniella pseudoartemisiae* Shinji, 1933

- Unknown plant (Dharmadhikari and Ramaseshiah, 1970)

2. *Aphidius colemani* Viereck, 1912

• *Aphis aurantii* Boyer de Fonsc., 1841

- *Camellia sinensis* (L.) Kuntze (Muraleedharan *et al.*, 1988; Radhakrishnan and Muraaledharan, 1992)

• *Aphis gossypii* Glover, 1877

- *Lantana camara* L. (Radhakrishnan and Muraleedharan, 1991)

- *Nicotiana* sp. (Krishnamurthi and Usman, 1954)

• *Rhopalosiphum maidis* (Fitch, 1856)

- Unknown plant (Viswanathan, 1972; Raychaudhuri *et al.*, 1982)

3. *Aphidius matricariae* Haliday, 1834

• *Aulacorthum solani* (Kaltenbach, 1843)

- *Brugmansia suaveolens* (Humb. and Bonpl. ex Willd.) Bercht. and Presl. (Chinnu *et al.*, 2023)

4. *Aphidius platensis* Brethes, 1913

• *Aphis gossypii* Glover, 1877

- *Cucurbita pepo* L. (Lokeshwari *et al.*, 2015)

- *Gossypium hirsutum* L. (Lokeshwari *et al.*, 2015)

5. *Aphidius smithi* Sharma and Subba Rao, 1959

• *Acyrthosiphon pisum* (Harris, 1776)

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

6. *Aphidius transcaspicus* Telenga, 1958

• *Rhopalosiphum maidis* (Fitch, 1856)

- *Coffea arabica* L. (Viswanathan, 1972)

- *Zea mays* L. (Viswanathan, 1972)

7. *Aphidius* sp.

• *Acyrthosiphon pisum* (Harris, 1776)

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

• *Aphis craccivora* Koch, 1854

- *Lablab purpureus* (L.) Sweet ssp. *purpureus* (Dharmadhikari and Ramaseshiah, 1970)

• *Aphis gossypii* Glover, 1877

- *Abelmoschus esculentus* Moench (Raja Rau, 1954)

- *Solanum melongena* L. (Raja Rau, 1954)

• *Aphis punicae* Passerini, 1863

- *Punica granatum* L. (Mani and Krishnamoorthy, 1995)

• *Lipaphis pseudobrassicae* (Davis, 1914)

- *Brassica oleracea* L. var. *capitata* (Chinnu *et al.*, 2023)

• *Macrosiphoniella sanborni* (Gillette, 1908)

- *Chrysanthemum indicum* L. (Chinnu *et al.*, 2023)

• *Macrosiphum rosae* (Linnaeus, 1758)

- *Rosa* sp. (Chinnu *et al.*, 2023)

• *Myzus persicae* (Sulzer, 1776)

- *Brassica juncea* (L.) Czern (Chinnu *et al.*, 2023)

- *Capsicum annuum* L. (Mani and Krishnamoorthy, 1994)

8. *Binodoxys acalephae* (Marshall, 1896)

• *Aphis gossypii* Glover, 1877

- *Cyanotis axillaris* (L.) D. Don (Dharmadhikari and Ramaseshiah, 1970)

- *Gossypium hirsutum* L. (Lokeshwari *et al.*, 2015)

9. *Binodoxys basicurvus* (Shuja- Uddin, 1973)

• *Aphis gossypii* Glover, 1877

- *Cucumis sativus* L. (Vignesh and Patil, 2020)

10. *Binodoxys brevicornis* (Haliday, 1833)

• *Lipaphis erysimi* (Kaltenbach, 1843)

- *Brassica* sp.? (Starý and Ghosh, 1983)

11. *Binodoxys indicus* (Subba Rao and Sharma, 1958)

• *Aphis aurantii* Boyer de Fonsc., 1841

- *Camellia sinensis* (L.) Kuntze (Muraleedharan *et al.*, 1988)

• *Lipaphis erysimi* (Kaltenbach, 1843)

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

• *Myzus persicae* (Sulzer, 1776)

- *Nicotiana tabacum* (Rao *et al.*, 1969)

- *Solanum tuberosum* L. (Rao *et al.*, 1969)

12. *Binodoxys* sp.

• *Aphis gossypii* Glover, 1877

- *Duranta* sp. (Chinnu *et al.*, 2023)

13. *Diaeretiella rapae* (McIntosh, 1855)

• *Aphis fabae* Scopoli, 1763

- *Cestrum fasciculatum* (Schltdl.) Miers (Rao *et al.*,

1969)

• *Lipaphis erysimi* (Kaltenbach, 1843)

- *Brassica nigra* (L.) K. Koch (Rao *et al.*, 1969)

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

• *Myzus persicae* (Sulzer, 1776)

- *Brassica* sp. (Sethumadhavan and Dharmadhikari, 1969)

14. *Lipolexis oregmae* (Gahan, 1932)

• *Aphis aurantii* Boyer de Fonsc., 1841

- *Camellia sinensis* (L.) Kuntze (Radhakrishnan and Muraaledharan, 1992)

- *Citrus ×limon* (L.) Osbeck (Muraleedharan *et al.*, 1988)

- *Schima wallichii* (DC.) Korth. (Dharmadhikari and Ramaseshiah, 1970)

• *Aphis craccivora* Koch, 1854

- *Lablab purpureus* (L.) Sweet ssp. *purpureus* (Dharmadhikari and Ramaseshiah, 1970)

• *Aphis citricidus* (Kirkaldy, 1907)

- *Citrus* sp. (Dharmadhikari and Ramaseshiah, 1970)

• *Aphis fabae* Scopoli, 1763

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

• *Aphis gossypii* Glover, 1877

- *Capsicum frutesence* L. (Lokeshwari *et al.*, 2015)

- *Chromolaena odorata* (L.) R.M.King and H.Rob. (Radhakrishnan and Muraleedharan, 1991)

- Unknown plant (Dharmadhikari and Ramaseshiah, 1970)

• *Aphis nerii* Boyer de Fonsc., 1841

- *Calotropis gigantea* (L.) W.T. Aiton (Dharmadhikari and Ramaseshiah, 1970)

• *Aphis solanella* Theobald, 1914

- *Solanum* sp. (Rao *et al.*, 1969)

• *Aphis spiraecola* Patch, 1914

- *Bidens pilosa* L. (Dharmadhikari and Ramaseshiah, 1970)

- *Chromolaena odorata* (L.) R.M.King and H.Rob. (Ramaseshiah, 1979)

- *Mikania cordata* (Burm.fil.) B.L.Rob., (Dharmadhikari and Ramaseshiah, 1970)

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

• *Greenidea psidii* van der Goot, 1917

- *Psidium guajava* L. (Dharmadhikari and Ramaseshiah, 1970)

• *Rhopalosiphum maidis* (Fitch, 1856)

- Unknown plant (Dharmadhikari and Ramaseshiah, 1970)

15. *Lysiphlebus fabarum* (Marshall, 1896)

• *Aphis craccivora* Koch, 1854

- *Vigna unguiculata* (L.) Walp. (Udayakumar *et al.*, 2024)

16. *Lysiphlebus testaceipes* (Cresson, 1880)

• *Aphis craccivora* Koch, 1854

- *Lablab purpureus* (L.) Sweet (Ramaseshiah *et al.*, 1969)

• *Lipaphis erysimi* (Kaltenbach, 1843)

- *Brassica* sp. (Ramaseshiah *et al.*, 1969)

17. *Lysiphlebus* sp.

• *Aphis craccivora* Koch, 1854

- *Arachis hypogaea* L. (Chinnu *et al.*, 2023)

18. *Praon abjectum* (Haliday, 1833)

• *Aphis craccivora* Koch, 1854

- *Lablab purpureus* (L.) Sweet ssp. *purpureus* (Dharmadhikari and Ramaseshiah, 1970)

19. *Trioxys* sp.

• *Aphis craccivora* Koch, 1854

- *Cyamopsis tetragonoloba* (L.) Taub. (Chinnu *et al.*, 2023)

Conclusion

The present study highlights substantial diversity in aphid parasitoids and their tri-trophic associations in Karnataka, with clear contrasts in host specificity and ecological breadth among taxa. Most aphelinid and aphidiine parasitoids exhibited narrow host ranges, reflecting strong host specificity, whereas a few species, particularly *Lipolexis oregmae*, *Aphidius colemani*, and *Binodoxys indicus*, demonstrated broader host and plant associations. The complex parasitoid–aphid–plant networks documented here underscore the ecological significance of indigenous parasitoids in regulating aphid populations and emphasise their potential role in sustainable, region-specific biological control and integrated pest management strategies in Karnataka.

Ethical Statement

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

Author Contributions

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

Conflict of Interest

The authors declare no conflicts of interest.

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