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PREDATORS AND PARASITOIDS OF APHIDS (APHIDIDAE: HOMOPTERA) INFESTING TOMATO CROPS IN INDIA

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Abstract: The present article enlists the predators and parasitoids of the aphids (Aphididae: Hemiptera) infesting tomato crops and their distribution in different states and union territories of India. Most of them are found to prey/parasitise *Myzus persicae* (Sulzer) and *Aphis gossypii* Glover. The predators belong to one order of class Arachnida: Araneae (families Anaphaenidae, Araneidae, Lycosidae, Oxyopidae, Tetragnathidae, Thomisidae) and four orders of the class Insecta: Coleoptera (family Coccinellidae), Diptera (family Syrphidae), Hemiptera (Geocoridae) and Neuroptera (family Chrysopidae). A total of 37 species of predators from various taxa were recorded to feed 5 species of tomato aphids distributed in 15 states/union territories of India. The highest number of predators belonged to the families Coccinellidae (19 species) and Syrphidae (7 species). Most of the tri-trophic associations (triplets, predators-preys-host plants) of these predators were reported in Uttar Pradesh (14 triplets), Karnataka (9 triplets), Assam (8 triplets) and Tamil Nadu (7 triplets), and other states/union territories 1-6 triplets. All the parasitoids of tomato aphids belong to two subfamilies Aphelininae (Aphelinidae: Hymenoptera) and Aphidiinae (Braconidae: Hymenoptera) in India. A total of 8 species of parasitoids were observed parasitising these aphids infesting in only 4 states of India. Most of the tri-trophic associations (triplets, parasitoids-hosts-host plants) of these parasitoids are reported from Uttar Pradesh (7 parasitoid species, 7 triplets) followed by Bihar (4 parasitoid species, 6 triplets) and single species each in Himachal Pradesh and Manipur. In fact, there have been very few attempts to document the natural enemies of tomato aphids in India; therefore, a thorough survey plan is necessary to document them in unexplored areas.

Keywords: Aphelinidae, Chrysopidae, Coccinellidae, Parasitoids, Syrphidae, Tomato aphids.

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INTRODUCTION

The tomato (*Solanum lycopersicum* L.) (Family: Solanaceae), also known as 'Red gold of India' is the third most important annual vegetable cash crop in India after potato and onion. India accounts for 11% of global tomato production and is the second-largest producer of tomatoes in the world after China (FAO, 2020). Andhra Pradesh, Bihar, Chattisgarh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal are the major

tomato-producing states in India. These states account for about 90% of total tomato production in the country. In the year 2022, it was cultivated in 8,41,000 hectares of land with production over 20.34 million tonnes (Anamika *et al.*, 2024). Tomatoes are used in a wide range of dishes, such as salad, ketchup, sauces and other processed foods. Lycopene, an antioxidant that lowers the risk of cancer, cardiovascular disease, and other chronic diseases, is more abundant in tomatoes. Additionally, it contains carotene, another antioxidant that gives the fruit its characteristic red colour and is believed to have cancer-preventive qualities (Agarwal and Rao, 2000).

Unfortunately, the tomato plant is highly vulnerable to several insect pests and plant pathogens right from the nursery stage to harvesting. These pests may damage tomato plants by feeding on the foliage and by attacking fruits (Butani, 1977; Shanmugam *et al.*, 2024). Common tomato pests include the bugs, cutworms, hornworms, aphids, loopers, whiteflies, fruit worms, flea beetles, red spider mite, etc. among the sap-feeding insects are aphids, thrips, and whiteflies, which cause severe damage to tomato crops (Khokhar and Kumar, 2024). Aphids are very fascinating insects as they are thelytokous parthenogenetic viviparous, having short generation time and telescopic generation with polymorphism. Many species of aphids display complex life cycles with alternation of sexual and asexual generations and host plant alternation. In India, 794 species of aphids under 208 genera are reported out of which about 385 are endemic (Singh and Singh, 2019). Singh and Singh (2022a) and Singh *et al.* (2023a) listed 21 species of aphids to infest tomato crops in India. Among them, two species, *Aphis gossypii* Glover (Chakraborty, 2011) and *Myzus persicae* (Sulzer) (Khajuria *et al.*, 2008) are notorious pests and damage the crop considerably along with other insect pests. Both of these species are highly polyphagous and pestiferous on several other crops (Singh, 2024a; 2024b). High aphid populations of these species may have considerable direct effects on yield. These aphids produce profuse amounts of honeydew, a sweet and watery anal excretory material that provides a medium on which sooty mould grows that blackens the leaf and reduces the photosynthetic ability of the host plants and the yield of the crops (Singh and Singh, 2021). However, the major concern with aphids is usually their role as virus vectors. Both apterous and alate morphs of the aphids transmit several plant viral diseases which cause significantly greater losses than damage caused by direct sap sucking (Singh and Singh, 2022b). Out of 620 plant viruses known in the biosciences, about one-third are arthropod-borne, and more than 80 per cent are transmitted by aphids (Ghosh *et al.*, 2017; Singh and Singh, 2021). *Aphis gossypii* Glover transmits at least 80 plant viruses (Singh and Singh, 2016) while *Myzus persicae* (Sulzer) transmits 182 plant viruses (Chan *et al.*, 1991).

There are several carnivorous arthropods in nature that keep the population of aphids and other insects under control, however, excessive anthropogenic activities and pollution adversely influence their species richness and population distribution in nature (Prakash and Verma, 2022; Singh *et al.,* 2023b). Therefore, the tri-trophic associations between plants, pest insects and the associated natural enemies provide an essential basis for planning an effective biocontrol method (Del-Claro, 2004). The conservation of the area's natural enemies is currently the global trend in aphid biocontrol strategies. This involves knowledge of the aphid-predator/parasitoid species status of that area, which forms the basis of such a plan (Pons *et al.*, 2018). One can enhance their ability to control the population of their aphid preys/hosts by conserving these readily available biocontrol agents of aphids in the fields. The tri-trophic relationships (predator/parasitoid-aphid-plant) therefore, must be studied. These data, however, are fragmentary records of species, isolated investigations of the life cycles of certain species, and distinct data on the biology and ecology of a small number of species nationwide. The primary purpose of this article is to enlist the natural enemies of tomato aphids in different states/union territories of India. These records indicate that most of the region of India is still unexplored for natural enemies of tomato aphids. Such a checklist provides an invaluable reference for taxonomists, researchers, academicians,

conservation managers, and policymakers for their proper use in natural/biological control programmes against these aphid pests.

MATERIAL AND METHODS

The present checklist is based on the primary data of published literature on parasitoids, e.g., books, book chapters, journals, proceedings of conferences, review articles and a few authentic Ph.D. theses (available on Shodhganga, https://shodhganga.inflibnet.ac.in) up to January 31, 2025. In most of the recent past literature, there are several errors in the scientific names of parasitoids as well as their aphid hosts and food plants because of their modified status and other nomenclatural decisions and clarifications. The names of aphids, as well as plants that were misspelt in the original records have been corrected where we logically ascertain the intended species. In the present checklist, attempts have been made to provide the valid scientific names of the parasitoids following GBIF (2025), aphids following Favret (2025), and the plants following (WFO, 2025). Synonymy of only aphid parasitoids is given, and for the synonymy of aphids and host plants, cited sources may be consulted.

RESULTS AND DISCUSSION

Singh and Singh (2022a) and Singh *et al.* (2023a) listed 21 species of aphids infesting tomatoes in India. However, the literature reveals that only five species are preyed upon by 22 species of predators, and four species are parasitised by 8 species of parasitoids belonging to different taxa in only four states of India.

A. Predators of tomato aphids

The data shown in Table 1 revealed that a total of 37 species of predators are recorded to prey on 5 species of tomato aphids out of 21 species recorded (Singh *et al.*, 2023a). Predators of these species belong to one order of class Arachnida, the order Araneae (families Anyphaenidae, Araneidae, Lycosidae, Oxyopidae, Tetragnathidae, Thomisidae), and 4 orders of class Insecta: Coleoptera (family Coccinellidae), Diptera (family Syrphidae), Hemiptera (family Geocoridae) and Neuroptera (family Chrysopidae). These predatory species are distributed only in 15 states/union territories of India (Table 1). The data show that no predator species were recorded on aphids infesting tomato crops in several tomato-growing states, including Andhra Pradesh, Chhattisgarh, Himachal Pradesh, Odisha, Telangana, Uttarakhand, and West Bengal (Figure 1). The maximum number of predator species was recorded in Uttar Pradesh (12 species, 14 triplets), followed by Jammu and Kashmir (10 species, 10 triplets), Karnataka (7 species, 9 triplets), Assam (7 species, 8 triplets), Meghalaya (6 species, 6 triplets), and less than 6 species in the rest of the states of India (Figure 1). Most of the predators are found to prey on *Aphis gossypii* Glover (20 species in 11 states) and *Myzus persicae* (Sulzer) (19 species in 8 states/union territories) (Table 2).

Table 1: Number of species of predators belonging to different taxa preying on different number of aphid species infesting tomato crop distributed in number of states/states/union territory of India.

Order	Families of predators	Number of			
		Predator species	Prey (aphid) species	Tri-trophic associations	States/Union territories
Araneae	Anyphaenidae	1	1	1	1
	Araneidae	3	1	3	2
	Lycosidae	1	1	1	1
	Oxyopidae	1	1	1	1
	Tetragnathidae	1	1	1	1
	Thomisidae	1	1	1	1
	Unidentified sp.	1	1	1	1
	Subtotal	**9**	**3**	**9**	**4**

Coleoptera	Coccinellidae	19	5	35	17
Diptera	Syrphidae	7	4	7	3
Hemiptera	Geocoridae	1	1	1	1
Neuroptera	Chrysopidae	1	2	2	3
	Total	**37**	**5**	**51**	**15**

Table 2: Number of species of predators belonging to different taxa preying different species of aphid infesting tomato crop distributed in different number of states/union territories of India.

Order	Number of predator species of different taxa						States/ Union territories
	Araneae	Cocci-nellidae	Syrph-idae	Geocor-idae	Chryso-pidae	Total	
Aphis craccivora	2	7	2	-	-	11	3
Aphis gossypii	6	10	1	1	1	20	11
Aphis spiraecola	-	2	-	-	-	2	1
Brevicoryne brassicae	-	1	-	-	-	1	1
Myzus persicae	1	13	4	-	1	19	8
Unidentified aphid	1	-	-	-	-	1	1
Total	9	19	7	1	1	37	15

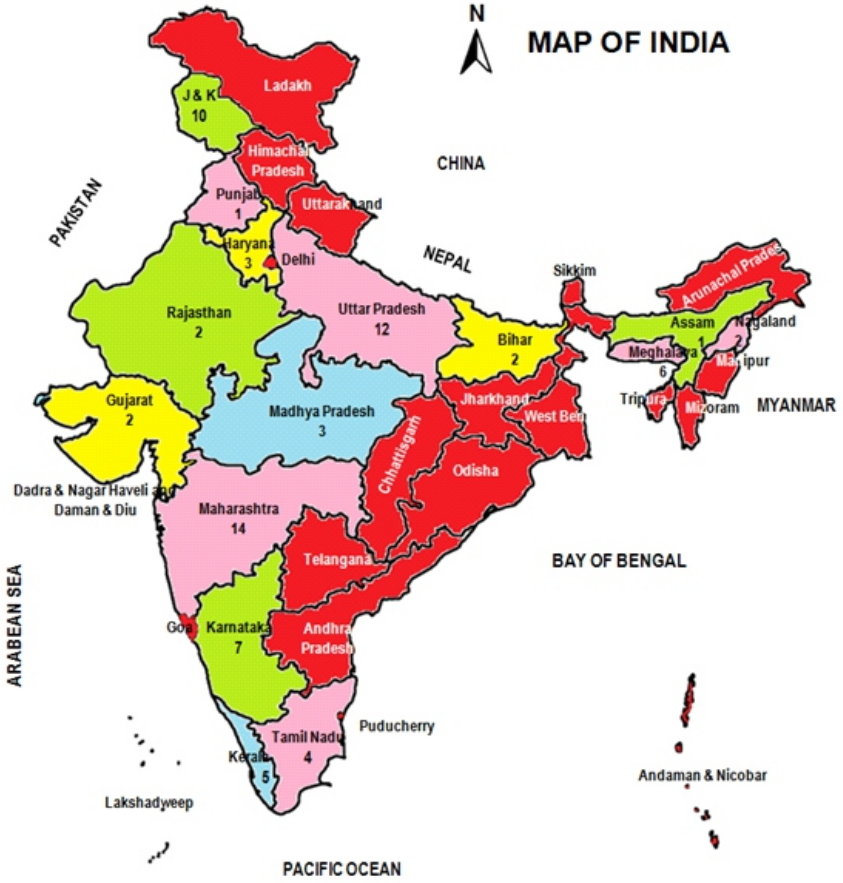

Fig. 1: Map showing the number of species of predators of tomato aphids in different states/union territories of India. No species of the predators was recorded in the red shaded states/union territories of India.

I. Class: Arachnida

Order: Araneae (spiders): The spiders are an extremely precious component of the earth's ecosystem being predatory devouring mostly insects and keeping their population under check. But, unlike insect predators, their potential as biocontrol agents is not exploited (Singh *et al.,* 2023c). Recently, Singh *et al.* (2024a) reported 79 species of aphidophagous spiders in India preying on 53 species of aphids infesting 59 species of plants. Table 1 reveals that 9 species of spiders belonging to 6 families are known to prey on 4 species of aphids, mostly *Aphis gossypii* Glover feeding on tomatoes in India (Table 2), particularly in Karnataka and Assam. Indeed, minimal attempts have been made to record these aphidophagous spiders in India, and an intensive and extensive survey plan is necessary to record them in unexplored areas.

I. Family: Anyphaenidae

1. *Anyphaena accentuata* (Walckenaer, 1802)
   Aphis (Aphis) craccivora Koch, 1854
   - Assam (Bora *et al.*, 2024)

II. Family: Araneidae

1. *Cyrtophora* sp.
   Aphis (Aphis) gossypii Glover, 1977
   - Karnataka (Patil *et al.*, 2023)
2. *Neoscona theisi* (Walckenaer, 1841)
   Aphis (Aphis) gossypii Glover, 1977
   - Madhya Pradesh (Netwal *et al.*, 2023)
3. *Neoscona* sp.
   Aphis (Aphis) gossypii Glover, 1977
   - Karnataka (Patil *et al.*, 2023)

IV. Family: Lycosidae

1. *Lycosa tista* Tikader, 1970
   Aphis (Aphis) craccivora Koch, 1854
   - Assam (Bora *et al.*, 2024)

V. Family: Oxyopidae

1. *Oxyopes* sp.
   Aphis (Aphis) gossypii Glover, 1977
   - Karnataka (Patil *et al.*, 2023)

VI. Family: Tetragnathidae

1. *Tetragnatha* sp.
   Aphis (Aphis) gossypii Glover, 1977
   - Karnataka (Patil *et al.*, 2023)

VII. Family: Thomisidae

1. *Thomisus* sp.
   Aphis (Aphis) gossypii Glover, 1977
   - Karnataka (Patil *et al.*, 2023)

VIII. Unidentified species

Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Rajasthan (Khokhar and Rolania, 2021)

II. Class: Insecta

a. Order: Coleoptera, Family: Coccinellidae (ladybird beetles): Despite several species of this family being pestiferous, more than 260 species are entomophagous, feeding on soft insects like aphids, mealybugs, scale insects, whiteflies, etc., and several species have been utilised as bioagents in the classical and applied biocontrol of aphids and other soft insects (Kumar and Omkar, 2023). Table 1 demonstrates that 19 species of these beetles feed on 5 species of tomato aphids distributed in 13 states/union territories of India with 35 predator-prey-food plant associations (triplets). Most of the species of these ladybird beetles are reported from Maharashtra and Uttar Pradesh (8 species each) followed by Meghalaya and Tamil Nadu (6 species each), Assam and Jammu and Kashmir (5 species each), and less than 5 species in other states. Among the tomato aphids, *Myzus persicae* (Sulzer) and *Aphis gossypii* Glover serve as food for 13 and 10 species of predators, respectively (Table 2). A detail predator-prey records of tomato aphids are given below.

1. *Adalia bipunctata* (Linnaeus, 1758)
   Brevicoryne brassicae (Linnaeus, 1758)
   - Uttar Pradesh (Tiwari *et al.*, 2024a)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari *et al.*, 2024a)
2. *Adalia tetraspilota* (Hope, 1831)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Jammu and Kashmir (Bhat, 2017; Khan and Shah, 2017)
3. *Brumoides suturalis* (Fabricius, 1798) [syn. *Brumus suturalis* (Fabricius, 1798)]
   Aphis (Aphis) craccivora Koch, 1854
   - Maharashtra (Bhandare, 2022a)
   Aphis (Aphis) gossypii Glover, 1977
   - Haryana (Khokhar and Rolania, 2021); Meghalaya (Rahman *et al.*, 2023)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)

- Tamil Nadu (Rekha *et al.*, 2009); Uttar Pradesh (Chaudhary and Singh, 2012)

4. *Cheilomenes propinqua* (Mulsant, 1850)
   Aphis (Aphis) gossypii Glover, 1977
   - Meghalaya (Rahman *et al.*, 2023)
5. *Cheilomenes sexmaculata* (Fabricius, 1781) [syn. *Menochilus sexmaculatus* (Fabricius, 1781)]
   Aphis (Aphis) craccivora Koch, 1854
   - Assam (Bora *et al.*, 2024); Maharashtra (Bhandare, 2022a)
   Aphis (Aphis) gossypii Glover, 1977
   - Gujarat (Wagh *et al.*, 2017); Haryana (Khokhar and Rolania, 2021); Karnataka (Patil *et al.*, 2023); Kerala (Jose, 2003; Thamilvel, 2009); Meghalaya (Rahman *et al.*, 2023); Tamil Nadu (Rekha *et al.*, 2009)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Haryana (Khokhar and Rolania, 2021); Jammu and Kashmir (Bhat, 2017); Kerala (Thamilvel, 2009); Tamil Nadu (Rekha *et al.*, 2009); Uttar Pradesh (Chaudhary and Singh, 2012)
6. *Chilocorus nigritus* (Fabricius, 1798)
   Aphis (Aphis) gossypii Glover, 1977
   - Tamil Nadu (Rekha *et al.*, 2009)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Tamil Nadu (Rekha *et al.*, 2009)
7. *Coccinella septempunctata* Linnaeus, 1758
   Aphis (Aphis) gossypii Glover, 1977
   - Assam (Harshita *et al.*, 2019); Bihar (Ahmad *et al.*, 2020); Gujarat (Wagh *et al.*, 2017); Haryana (Khokhar and Rolania, 2021); Madhya Pradesh (Netwal *et al.*, 2023); Meghalaya (Rahman *et al.*, 2023); Uttar Pradesh (Tiwari *et al.*, 2024a)
   Aphis (Aphis) spiraecola Patch, 1914
   - Nagaland (Pongen *et al.*, 2022)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Haryana (Khokhar and Rolania, 2021); Jammu and Kashmir (Bhat, 2017; Khan and Shah, 2017); Uttar Pradesh (Tiwari *et al.*, 2024a)
8. *Coccinella transversalis* Fabricus, 1781
   Aphis (Aphis) craccivora Koch, 1854
   - Maharashtra (Bhandare, 2022a)
   Aphis (Aphis) gossypii Glover, 1977
   - Assam (Harshita *et al.*, 2019); Karnataka (Patil *et al.*, 2023); Kerala (Thamilvel, 2009); Meghalaya (Rahman *et al.*, 2023); Tamil Nadu (Rekha *et al.*, 2009)
   Aphis (Aphis) spiraecola Patch, 1914
   - Nagaland (Pongen *et al.*, 2022)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Tamil Nadu (Rekha *et al.*, 2009); Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari *et al.*, 2024a)
9. *Coccinella undecimpunctata* Linnaeus, 1758
   Aphis (Aphis) craccivora Koch, 1854
   - Jammu and Kashmir (Bhat, 2017)
10. *Coelophora bissellata* Mulsant, 1850 [syn. *Lemnia bissellata* (Mulsant, 1850)]
    Aphis (Aphis) craccivora Koch, 1854
    - Assam (Saharia, 1980)
11. *Hippodamia variegata* (Goeze, 1777) [syn. *Adonia variegata* (Goeze, 1777)]
    Myzus (Nectarosiphon) persicae (Sulzer, 1776)
    - Jammu and Kashmir (Bhat, 2017; Khan and Shah, 2017)
12. *Hippodamia variegata doubledeayi* (Mulsant, 1850)
    Myzus (Nectarosiphon) persicae (Sulzer, 1776)
    - Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari *et al.*, 2024a)
13. *Illeis cincta* (Fabricius, 1798)
    Aphis (Aphis) gossypii Glover, 1977
    - Karnataka (Patil *et al.*, 2023)
14. *Micraspis discolor* (Fabricius, 1798) [syn. *Verania discolor* (Fabricius, 1798)]
    Aphis (Aphis) craccivora Koch, 1854
    - Assam (Bora *et al.*, 2024)
    Aphis (Aphis) gossypii Glover, 1977
    - Assam (Harshita *et al.*, 2019); Meghalaya (Rahman *et al.*, 2023)
15. *Nephus ancyroides* Pang and Pu, 1988 [syn. *Scymnus (Pullus) latemaculatus* Motschulsky, 1858]
    Aphis (Aphis) gossypii Glover, 1977
    - Kerala (Thamilvel, 2009); Maharashtra (Bhandare, 2022a)
    Myzus (Nectarosiphon) persicae (Sulzer, 1776)
    - Kerala (Thamilvel, 2009); Maharashtra (Bhandare, 2022b)

16. *Oenopia kirbyi* Mulsant, 1850
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Uttar Pradesh (Tiwari *et al.*, 2024a)

17. *Propylea japonica* (Thunberg, 1781)
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Uttar Pradesh (Tiwari *et al.*, 2024a)

18. *Scymnus (Pullus) pyrocheilus* Mulsant, 1853
Aphis (Aphis) gossypii Glover, 1977
- Bihar (Ahmad *et al.*, 2020)

19. *Scymnus* sp.
Aphis (Aphis) craccivora Koch, 1854
- Maharashtra (Bhandare, 2022a)
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Jammu and Kashmir (Bhat, 2017)

b. Order: Diptera, Family: Syrphidae (hover flies): The hover flies, are the most common aphid predators and are globally distributed. Most of them offer twofold service in nature; as adult, they help in crop pollination (Joshi *et al.*, 2023) and as larvae, they feed on many soft-bodied insects, including aphids, mealy bugs, scale insects, whiteflies, thrips etc. As a result, they play a crucial role in the natural control of these insects (Kumar and Omkar, 2023). Table 1 demonstrates that a total of 7 species of hover flies feed on 4 species of tomato aphids (Table 2). Four species are recorded feeding on *Myzus persicae* (Sulzer), mostly in Jammu and Kashmir and Uttar Pradesh. Detail predator-prey records of tomato aphids are given below:

1. *Episyrphus balteatus* (De Geer, 1776) [syn. *Syrphus balteatus* De Geer, 1776]
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Jammu and Kashmir (Bhat and Bhagat, 2017); Uttar Pradesh (Tiwari *et al.*, 2024a)

2. *Eupeodes confrater* (Wiedemann, 1830) [syn. *Metasyrphus confrater* (Wiedemann, 1930)]
Aphis (Aphis) craccivora Koch, 1854
- Jammu and Kashmir (Bhat and Bhagat, 2017)

3. *Ischiodon scutellaris* (Fabricius, 1805) [syn. *Xanthogramma scutellare* (Fabricius, 1805)]
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Uttar Pradesh (Tiwari *et al.*, 2024a)

4. *Paragus serratus* (Fabricius, 1805) [syn. *Serratoparagus serratus* (Fabricius, 1805)]
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Uttar Pradesh (Tiwari *et al.*, 2024a)

5. *Sphaerophoria indiana* Bigot, 1884
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Uttar Pradesh (Tiwari *et al.*, 2024a)

6. *Sphaerophoria philantha* (Meigen, 1822)
Aphis (Aphis) gossypii Glover, 1977
- Madhya Pradesh (Netwal *et al.*, 2023)

7. *Sphaerophoria scripta* (Linnaeus, 1758)
Aphis (Aphis) craccivora Koch, 1854
- Jammu and Kashmir (Bhat and Bhagat, 2017)

c. Order: Hemiptera: Geocoridae: Hemiptera includes at least seven families of predatory bugs preying on soft-bodied insects (Chellappan and Ranjith, 2023). In India, only a single species of predatory bug belonging to the family Geocoridae is reported as a predator of *Aphis gossypii* Glover on tomatoes as mentioned below.

1. *Geocoris jucundus* (Fieber, 1861)
Aphis (Aphis) gossypii Glover, 1977
- Rajasthan (Pal, 1974)

d. Order: Neuroptera, Family: Chrysopidae (lacewings): Both adults and larvae of lacewings are predatory. Singh *et al.* (2024b) enlisted 32 species of aphidophagous neuropterans from India belonging to four families. However, members of only one family Chrysopidae were recorded to prey on tomato aphids in India. Among them, only one species of lacewings was recorded to prey on 2 species of tomato aphids in 3 states/ union territory of India, as mentioned below.

1. *Chrysoperla zastrowi sillemi* (Esben- Petersen, 1935)
Aphis (Aphis) gossypii Glover, 1977
- Karnataka (Patil *et al.*, 2023)
Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Jammu and Kashmir (Khan and Shah, 2017); Punjab (Nair *et al.*, 2020)

B. Parasitoids of tomato aphids

The parasitoids of tomato aphids belong to two

families of the order Hymenoptera, the Aphelinidae (Superfamily: Chalcidoidea) and Braconidae (Superfamily: Ichneumonoidea). A total of 8 species of the parasitoids were recorded parasitising 5 species of tomato aphids in 4 states of India (Table 3). Among the aphids infesting tomato, *Myzus pericae* (Sulzer) was reported parasitised by 7 species of the parasitoids in 3 states of India (Table 4). Most of the tri-trophic associations (triplets, parasitoids-hosts-host plants) of these parasitoids are reported from Uttar Pradesh (7 parasitoid species, 7 triplets) followed by Bihar (4 parasitoid species, 6 triplets) and single species each in Himachal Pradesh and Manipur. Interestingly, no parasitoid species of tomato aphids were recorded in several tomato growing states. Indeed, a comprehensive survey plan is required to document these parasitoids in unexplored states.

Table 3: Number of species of parasitoids belonging to different taxa parasitising on different number of aphid species infesting tomato crop distributed in number of states/states/union territory of India.

Order	Families of Parasitoids	Number of			
		Parasitoid species	Host (aphid) species	Tri-trophic associations	States/Union territories
Hymenoptera	Aphelinidae	2	2	2	2
	Braconidae	6	4	10	3
	Total	**8**	**4**	**12**	**4**

Table 4: Number of species of parasitoids belonging to different taxa parasitising different species of aphid infesting tomato crop distributed in different number of states/union territories of India.

Sl. No.	Aphid species	Parasitoid species	States/Union territories
1.	*Aphis craccivora*	1	1
2.	*Aphis gossypii*	1	2
3.	*Aphis nasturtii*	2	1
4.	*Macrosiphum euphorbiae*	1	1
5.	*Myzus persicae*	7	3
	Total	**8**	**4**

a. Order: Hymenoptera

i. Family: Aphelinidae: The Aphelinidae contains 60 genera and a little over a thousand species (GBIF, 2025) and is a major source of biocontrol agents of economically important insect pest species such as coccoids, aphids and aleyrodids (Homoptera) (Singh and Singh, 2016). The members of its subfamily Aphelininae, tribe Aphelinini are exclusively aphid parasitoids (Starý, 1988). Only 2 species of *Aphelinus* are recorded to parasitise different species of aphids on tomato crops in only 2 states of India (Table 3). Detail checklist is given below.

1. *Aphelinus asychis* Walker, 1839
   Macrosiphum (Macrosiphum) euphorbiae (Thomas, 1878)
   - Himachal Pradesh (Gavkare *et al.*, 2015)
2. *Aphelinus gossypii* Timberlake, 1924
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Bihar (Parween *et al.*, 2023)

ii. Family: Braconidae, Subfamily: Aphidiinae: Das and Chakrabarti (2023) listed 157 aphidiine species parasitising several aphid species in India. Out of these, 6 species are described/recorded from India parasitising 4 species of the aphids infesting tomato crops only in 3 states of India (Table 3). The maximum number of parasitoids is known to parasitise *Myzus periscae* (Sulzer) (7 species of parasitoids) (Table 4). Other species are parasitised by 1-2

species of parasitoids. A total of 10 tri-trophic associations (parasitoid-aphid host-host, triplets) were observed. A detail checklist is given below.

1. *Aphidius colemani* Viereck, 1912
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Uttar Pradesh (Rafi *et al.*, 2010; Tiwari *et al.*, 2024b)
2. *Aphidius matricariae* Haliday, 1834
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
- Bihar (Ahmad and Singh, 1996); Uttar Pradesh (Singh and Tripathi, 1987; Ahmad and Singh, 1993)
3. *Aphidius qadrii* (Shuja-Uddin, 1977) [syn. *Lysaphidus qadrii* Shuja-Uddin, 1976]
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Uttar Pradesh (Rafi *et al.*, 2010)
4. *Aphidius similis* Stary and Carver, 1980
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Manipur (Subhrani *et al.*, 2006)
5. *Binodoxys indicus* (Subba Rao and Sharma, 1958) [syn. *Trioxys indicus* Subba Rao and Sharma, 1958]
   Aphis (Aphis) craccivora Koch, 1854
   - Uttar Pradesh (Singh *et al.*, 1999; Tiwari *et al.*, 2024b)
   Aphis (Aphis) gossypii Glover, 1877
   - Bihar (Ahmad and Singh, 2007; Ahmad *et al.*, 2020); Uttar Pradesh (Singh *et al.*, 1999; Rafi *et al.*, 2010)
   Aphis (Aphis) nasturtii Kaltenbach, 1843
   - Bihar (Ahmad *et al.*, 2020)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Bihar (Parween *et al.*, 2023); Uttar Pradesh (Singh and Tripathi, 1988)
6. *Lipolexis oregmae* (Gahan, 1932) [syn. *Lipolexis pseudoscutellaris* Pramanik and Raychaudhuri, 1984; *Lipolexis scutellaris* Mackauer, 1962]
   Aphis (Aphis) nasturtii Kaltenbach, 1843
   - Bihar (Ahmad *et al.*, 2020)
   Myzus (Nectarosiphon) persicae (Sulzer, 1776)
   - Uttar Pradesh (Singh and Tripathi, 1988).

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