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Annotated checklist of natural enemies of tea aphid, *Aphis aurantii* Boyer de Fonscolombe (Homoptera: *Aphididae*) in India

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Abstract
The tea aphid, *Aphis aurantii* Boyer de Fonscolombe, is a major pest of tea (*Camellia sinensis*) in India. A review of published records documented 58 aphidophagous predator species belonging to 6 orders and 10 families, and 8 parasitoid species belonging to Aphelinidae and Braconidae (*Aphidiinae*). Predators were dominated by Coccinellidae (31 species) and Syrphidae (19 species), highlighting their importance in the natural regulation of tea aphid populations. *Coccinella septempunctata* was the most widely distributed predator, occurring in eight states. Predator diversity was highest in Tamil Nadu, Assam, and Karnataka. Among parasitoids, aphidiine braconids predominated, with *Lipolexis oregmae*, *Binodoxys indicus*, and *Aphidius colemani* showing the widest distribution across major tea-growing regions. Assam supported the highest parasitoid richness. The study demonstrates that coccinellid beetles, syrphid flies, and aphidiine parasitoids constitute the principal natural enemy complex of *Aphis aurantii* in India and represent valuable biological control agents for sustainable tea pest management.

Keywords: *Aphis aurantii*, tea aphid, *Camellia sinensis*, aphidophagous predators, parasitoids, Coccinellidae, *Aphidiinae*, biological control, biodiversity, India

Introduction

Tea, *Camellia sinensis* (L.) O. Kuntze, is one of the most important plantation crops and the most widely consumed non-alcoholic beverage in the world. India is the second-largest producer and one of the leading consumers of tea globally, contributing substantially to the national economy through employment generation, foreign exchange earnings, and rural development. Tea is cultivated across diverse agro-climatic regions of the country, including the northeastern states of Assam, West Bengal, Tripura and Manipur, the southern states of Tamil Nadu, Kerala and Karnataka, and the northwestern Himalayan regions of Himachal Pradesh, Uttarakhand and Sikkim. The diverse climatic conditions prevailing in these tea-growing regions support a rich assemblage of insect pests and their natural enemies [5, 18].

More than one thousand arthropod species have been reported from tea ecosystems worldwide, of which nearly 300 species are considered pests of economic importance [4, 18]. Among these, aphids constitute an important group of sap-feeding insects causing significant damage to tea plants. The aphid, *Aphis (Toxoptera) aurantii* Boyer de Fonscolombe, 1841 [=*Toxoptera aurantii* Boyer de Fonscolombe, 1841], is a highly polyphagous feeding on almost 176 species/subspecies of plants in India belonging to 134 genera grouped into 57 families among which several species are of economic importance, e.g. lemon, coffee, tea, mango etc. Its life cycle is anholocyclic. Both nymphs and adults feed by extracting phloem sap from tender shoots, young leaves and developing buds, resulting in leaf curling, shoot deformation, reduced vigour and diminished yield [41]. However, it is one of the most widely distributed and economically important aphid pests of tea in India and abroad. Heavy infestations may adversely affect the quality and market value of processed tea. In addition, the excretion of honeydew promotes the growth of sooty mould, which interferes with photosynthesis and further reduces plant productivity [39, 40]. It also transmits viral disease such as tea rose yellow mosaic virus [2].

The management of tea aphids has traditionally relied on chemical insecticides. However, frequent pesticide applications can lead to the development of resistance, resurgence of pest populations, environmental contamination, disruption of ecological balance and the elimination of naturally controlling population of beneficial organisms. Furthermore, concerns regarding pesticide residues in made tea have increased the need for environmentally sustainable pest management strategies [17, 18, 20]. Consequently, biological control through the conservation and utilisation of natural enemies has emerged as an important component of integrated pest management in tea plantations [5].

A diverse complex of predators and parasitoids is known to regulate aphid populations in tea ecosystems. Predatory groups include coccinellid beetles, syrphid flies, chrysopids, hemerobiids, anthocorids, geocorids, spiders and earwigs, while parasitoids are represented mainly by aphidiine braconids and aphelinids [22, 32]. These natural enemies play a crucial role in suppressing aphid populations and maintaining ecological stability within tea plantations. The effectiveness and distribution of these beneficial organisms are influenced by climatic conditions, vegetation diversity, plantation management practices and regional biogeographic factors.

Although numerous studies have documented individual records of predators and parasitoids associated with *Aphis*

aurantii from different parts of India, the available information remains scattered in taxonomic, ecological and faunistic literature. A comprehensive synthesis of these records is lacking, thereby limiting our understanding of the diversity, distribution and potential role of natural enemies in the biological control of tea aphids. Therefore, the present study was undertaken to compile and analyse the available information on the natural enemies of *Aphis aurantii* in the tea-growing states of India, with special reference to their taxonomic diversity, geographical distribution and significance in the natural regulation of tea aphid populations.

Materials and Methods

The present checklist was compiled through a comprehensive review of published literature on the natural enemies of the tea aphid, *Aphis aurantii* in India. Information was collected from research articles, review papers, books, monographs, catalogues, checklists, conference proceedings, dissertations, and technical reports. Published records of predators and parasitoids associated with *Aphis aurantii* on tea (*Camellia sinensis*) were critically examined, and relevant information on species identity, taxonomy, distribution, and source references was extracted. Records lacking reliable host association or adequate taxonomic information were excluded. The nomenclature and taxonomic status of all species were verified and updated using recent taxonomic literature and authoritative databases. Synonyms and obsolete names were corrected, and only valid species names were retained.

Results & Discussion

Predators of tea aphids in India

A comprehensive analysis of the predator complex associated with *Aphis aurantii* infesting tea (*Camelia sinensis*) revealed the occurrence of 58 aphidophagous predator species distributed among 6 orders and 10 families across 9 states of India (Table 1). The predator assemblage was dominated by members of the order Coleoptera, which accounted for 31 species, all belonging to the family Coccinellidae (ladybirds), thereby representing more than half (56.4%) of the total predator diversity recorded on this aphid species (Figure 1). The predominance of coccinellid beetles underscores their significant role in the natural regulation of tea aphid populations in diverse agroecosystems. The order Diptera constituted the second most diverse group, comprising 20 species (34.8%) belonging mainly to the family Syrphidae (hover flies) (Figure 1), with a single species representing Anisopodidae. Syrphid larvae are well-known aphid predators and formed an important component of the predator guild associated with *Aphis aurantii*. Predators belonging to Hemiptera were represented by five species distributed between the families Anthocoridae and Geocoridae, whereas Araneae and Dermaptera were each represented by a single species belonging to the families Oxyopidae (lynx spiders) and Forficulidae (earwigs), respectively. Within Neuroptera, two families were recorded, namely Chrysopidae (green lacewings) and Hemerobiidae (brown lacewings), each represented by a single species (Table 1).

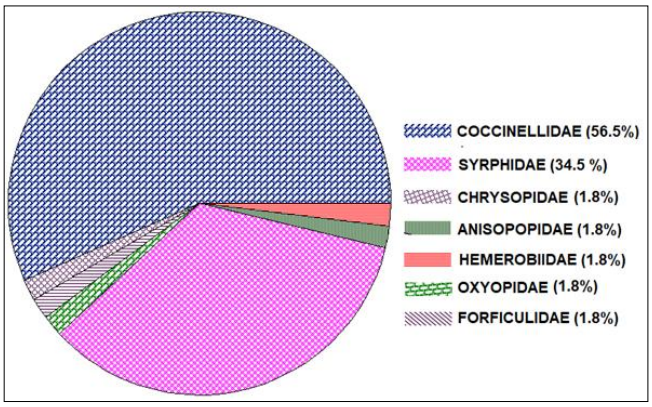

Fig 1: Relative diversity (%) of different families of predators associated with the tea aphid, *Aphis aurantia*

Among the predators, the coccinellid *Coccinella septempunctata* exhibited the widest distribution, being recorded from eight states, followed by the syrphids *Episyrphus balteatus* and *Ischiodon scutellaris*, each reported from six states. The coccinellids *Coelophora biplagiata* and *Pseudaspidimerus trinotata*, the syrphid *Betasyrphus serarius*, and the hemerobiid *Micromus timidus* were each documented from *five states*. *Cheilomenes sexmaculata* and *Paragus tibialis* were recorded from four states. Several predators showed moderate distributions, being reported from three states, including *Coelophora saucia*, *Cryptogonus lepidus*, *Cryptogonus orbiculus*, *Jauravia opaca*, *Jauravia pubescens*, *Jauravia simplex*, *Jauravia soror*, *Scymnus pyrocheilus*, *Asiobaccha nubilipennis*, and *Dideopsis aegrota*. In contrast, the majority of predator species (34 species) were recorded from only a single state, indicating a high proportion of geographically restricted or infrequently reported predators associated with tea aphid populations in India (Table 1).

The distribution of aphidophagous predators associated with *Aphis aurantii* Boyer de Fonscolombe infesting exhibited considerable variation among the tea-growing states of India. The highest predator diversity was recorded from Tamil Nadu, where 22 species were documented, followed closely by Assam with 21 species and Karnataka with 20 species. Substantial predator richness was also observed in Kerala and West Bengal, which supported 19 and 18 species, respectively. These states collectively accounted for the majority of the predator fauna associated with the tea aphid, reflecting the extensive documentation and ecological diversity of tea ecosystems in these regions (Figure 2).

Moderate predator diversity was recorded from Manipur and Uttarakhand, with 9 and 8 species, respectively. In contrast, relatively few predator species were reported from Himachal Pradesh (2 species) and Sikkim (1 species). The observed variation in species richness among states may be attributable to differences in tea cultivation area, climatic conditions, habitat heterogeneity, and the intensity of faunistic surveys conducted in different regions.

Collectively, these findings reveal a diverse and geographically widespread assemblage of aphidophagous predators associated with *Aphis aurantii* in India. Predator richness was particularly pronounced in the major tea-growing states of southern and northeastern India, notably Tamil Nadu, Assam, Karnataka, Kerala, and West Bengal. The predator community was overwhelmingly dominated by coccinellid beetles and syrphid flies, which together constituted the principal natural enemy complex of the tea aphid. Among the recorded species, *Coccinella septempunctata* exhibited the broadest geographical

distribution, occurring across the largest number of states, and thus appears to be one of the most important and widely established predators contributing to the natural suppression of *Aphis aurantii* populations in Indian tea ecosystems.

The observed variation in the diversity and distribution of aphidophagous predators of *Aphis aurantii* across Indian tea-growing states appears to be largely influenced by climatic conditions. The high predator richness recorded in Tamil Nadu, Assam, Karnataka, Kerala, and West Bengal may be attributed to their warm and humid climates, which favour continuous tea growth and sustain aphid populations throughout much of the year, thereby providing stable resources for predators [18]. Such conditions are particularly favourable for coccinellids and syrphids, the dominant predator groups recorded in the present study [37, 38].

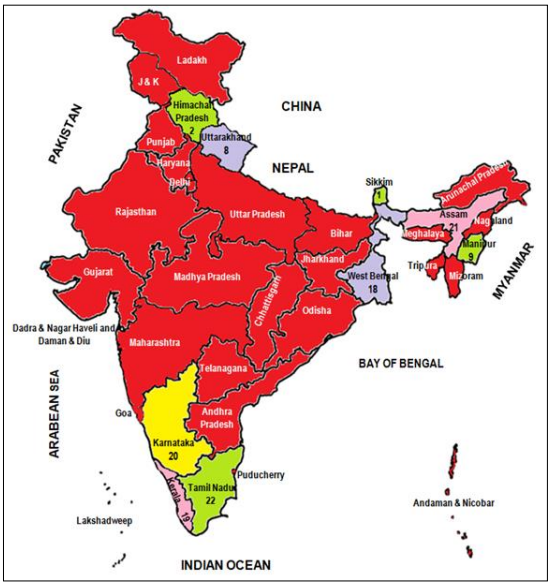

Fig 2: Map showing the number of predator species of tea aphid *Aphis aurantii* in different states/union territories of India. No species of the predator was recorded in the red shaded states/union territories of India

The widespread occurrence of *Coccinella septempunctata*, *Episyrphus balteatus*, and *Ischiodon scutellaris* suggests broad ecological tolerance and adaptability to diverse climatic conditions. In contrast, the lower predator diversity observed in Uttarakhand, Himachal Pradesh, and Sikkim may be associated with cooler temperatures, higher elevations, and comparatively restricted tea-growing areas, which can limit predator establishment and activity [15]. The predominance of species recorded from only a single state further indicates the influence of local climatic conditions, habitat characteristics, and regional biogeography on predator distribution. Overall, the warm and humid tea-growing regions of southern and northeastern India appear to provide the most favourable environments for sustaining diverse predator communities and enhancing the natural biological control of *Aphis aurantii* [18].

Table 1: Species composition of aphidophagous predators belonging to different taxa recorded preying on the tea aphid, *Aphis aurantii*, in number of states of India

Orders/Families/Species of predators	Number of states
Araneae: Oxyopidae	
1. *Oxyopes* sp.	1
Coleoptera: Coccinellidae	
2. *Afidentula manderstjernae*	1
3. *Cheilomenes sexmaculata*	4
4. *Chilocorus circumdatus*	1
5. *Coccinella repanda*	2
6. *Coccinella septempunctata*	8
7. *Coccinella transversalis*	1
8. *Coelophora biplagiata*	5
9. *Coelophora saucia*	3
10. *Cryptogonus bimaculatus*	1
11. *Cryptogonus lepidus*	3
12. *Cryptogonus orbiculus*	3
13. *Cryptogonus quadriguttatus*	1
14. *Harmonia dimidiata*	1
15. *Harmonia sedecimnotata*	1
16. *Henosepilachna septima*	1
17. *Jauravia opaca*	3
18. *Jauravia pubescens*	3
19. *Jauravia quadrinotata*	2
20. *Jauravia simplex*	3
21. *Jauravia soror*	3
22. *Micraspis discolor*	2
23. *Micraspis vincta*	1
24. *Oenopia kirbyi*	1
25. *Oenopia quadripunctata*	1
26. *Oenopia sexareata*	1
27. *Ola* sp.	1
28. *Phrynocaria unicolor*	1
29. *Propylea luteopustulata*	1
30. *Pseudaspidimerus trinotata*	5
31. *Scymnus pyrocheilus*	3
32. *Scymnus* sp.	2
Dermaptera: Forficulidae	
33. *Forficula auricularia*	1
Diptera: Anisopodidae	
34. *Olbiogaster* sp.	1
Syrphidae	
35. *Asiobaccha nubilipennis*	3
36. *Betasyrphus isaaci*	1
37. *Betasyrphus serarius*	5
38. *Dideopsis aegrota*	3
39. *Episyrphus balteatus*	6
40. *Eristalis tenax*	1
41. *Eupeodes confrater*	2
42. *Ischiodon scutellaris*	6
43. *Paragus atratus*	1
44. *Paragus brachycerus*	1
45. *Paragus crenulatus*	1
46. *Paragus indicus*	1
47. *Paragus politus*	1
48. *Paragus rufocinctus*	2
49. *Paragus serratus*	1
50. *Paragus tibialis*	4
51. *Paragus yerburiensis*	1
52. *Paratus indicus*	1
53. *Syrphus fulvifacies*	1
Hemiptera: Anthocoridae	
54. *Cardiastethus exiguus*	1
55. *Orius maxidentex*	1
Geocoridae	
56. *Geocoris ochropterus*	1
Neuroptera: Chrysopidae	
57. *Chrysoperla zastrowi sillemi*	1
Hemerobiidae	
58. *Micromus timidus*	5

The detailed account of distribution of predatory arthropods of tea aphid is given below.

a. Order: Araneae, Family: Oxyopidae

1. *Oxyopes* sp.
   - Himachal Pradesh [35]

b. Order: Coleoptera, Family: Coccinellidae

1. *Afidentula manderstjernae* (Mulsant, 1853)

- West Bengal [31]

2. *Cheilomenes sexmaculata* (Fabricius, 1781
- Assam [8, 9, 10, 30], Karnataka [24, 28], Kerala [24, 28], Tamil Nadu [27]

3. *Chilocorus circumdatus* (Gyllenhal, 1808)
- West Bengal [11, 31]

4. *Coccinella repanda* Thunberg, 1781
- Assam [8, 9], West Bengal [31]

5. *Coccinella septempunctata* Linnaeus, 1758
- Assam [8, 9], Himachal Pradesh [35], Karnataka [24], Kerala [24], Manipur [13], Tamil Nadu [27], Uttarakhand [36], West Bengal [11]

6. *Coccinella transversalis* Fabricus, 1781
- West Bengal [11]

7. *Coelophora biplagiata* (Schönherr, 1808)
- Assam [8, 9], Karnataka [24], Kerala [24], Manipur [13], Tamil Nadu [27]

8. *Coelophora saucia* (Mulsant, 1850)
- Karnataka [24], Kerala [28], Manipur [14]

9. *Cryptogonus bimaculatus* Kapur, 1948
- Assam [8, 9]

10. *Cryptogonus lepidus (Weise, 1885*
- Karnataka [27], Kerala [27], Tamil Nadu [27]

11. *Cryptogonus orbiculus* (Gyllenhal, 1808)
- Karnataka [24], Kerala [28], Tamil Nadu [27]

12. *Cryptogonus quadriguttatus* Weise, 1895
- West Bengal [31]

13. *Harmonia dimidiata* (Fabricius, 1781)
- Assam [8, 9]

14. *Harmonia sedecimnotata* (Fabricius, 1801)
- West Bengal [31]

15. *Henosepilachna septima* (Dieke, 1947)
- West Bengal [31]

16. *Jauravia opaca* (Weise, 1900
- Karnataka [23], Kerala [23], Tamil Nadu [23]

17. *Jauravia pubescens*
- Karnataka [24, 28], Kerala [24, 28]

18. *Jauravia pubescens* (Fabricius, 1798)
- Tamil Nadu [27]

19. *Jauravia quadrinotata* Kapur, 1946
- Assam [8, 9], West Bengal [31]

20. *Jauravia simplex* (Walker, 1859
- Karnataka [23], Kerala [23]

21. *Jauravia simplex* (Walker, 1859
- Tamil Nadu [23]

22. *Jauravia soror* (Weise, 1892
- Karnataka [23], Kerala [23], Tamil Nadu [23]

23. *Micraspis discolor* (Fabricius, 1798)
- Assam [11, 30], West Bengal [11]

24. *Micraspis vincta* (Gorham, 1895)
- Assam [8, 9]

25. *Oenopia kirbyi* Mulsant, 1850
- West Bengal [31]

26. *Oenopia quadripunctata* Kapur, 1963
- Sikkim [1]

27. *Oenopia sexareata* (Mulsant, 1853)
- West Bengal [11, 31]

28. *Ola* sp.
- West Bengal [11]

29. *Phrynocaria unicolor* (Fabricius, 1792)
- West Bengal [31]

30. *Propylea luteopustulata* (Mulsant, 1850)
- West Bengal [31]

31. *Pseudaspidimerus trinotata* (Thunberg, 1781)
- Assam [8, 9], Karnataka [28, 24], Kerala [24, 28], Tamil Nadu [24, 27], West Bengal [11, 34]

32. *Scymnus pyrocheilus* Mulsant, 1853
- Karnataka [28], Kerala [28], Tamil Nadu [27]

33. *Scymnus* sp.
- Assam [8, 9], West Bengal [11]

c. Order: Dermaptera, Family: Forficulidae

1. *Forficula auricularia* Linnaeus 1758
- India [6]

d. Order: Diptera

Family: Anisopodidae

1. *Olbiogaster* sp.
- Uttarakhand [36]

Family: Syrphidae

2. *Asiobaccha nubilipennis* (Austen, 1893)
- Karnataka [24], Kerala [24], Tamil Nadu [21, 26]

3. *Betasyrphus isaaci* (Bhatia, 1933)
- Uttarakhand [36]

4. *Betasyrphus serarius* (Wiedemann, 1830)
- Assam [8, 9], Karnataka [24], Kerala [24], Manipur [13], Tamil Nadu [21, 26]

5. *Dideopsis aegrota* (Fabricius, 1805)
- Karnataka [24], Kerala [24], Tamil Nadu [26, 27]

6. *Episyrphus balteatus* (De Geer, 1776) [
- Assam [8, 9], Karnataka [24, 27], Kerala [24], Manipur [12, 13], Tamil Nadu [21, 26], Uttarakhand [3, 36]

7. *Eristalis tenax* (Linnaeus, 1758)
- Uttarakhand [36]

8. *Eupeodes confrater* (Wiedemann, 1830)
- Manipur [13], Uttarakhand [36]

9. *Ischiodon scutellaris* (Fabricius, 1805)
- Assam [8, 9], Karnataka [24, 27], Kerala [24, 27], Manipur [12, 13], Tamil Nadu [21, 22, 26], Uttarakhand [36]

10. *Paragus atratus* Meijere, 1906
- India [29]

11. *Paragus brachycerus* Thompson, 1992
- Tamil Nadu [43]

12. *Paragus crenulatus Thomson, 1869*
- Tamil Nadu [43]

13. *Paragus indicus* (Brunetti, 1908)
- Assam [8, 9]

14. *Paragus politus* Wiedemann, 1830
- India [43]

15. *Paragus rufocinctus* (Brunctti, 1908)
- Tamil Nadu [43], Tamil Nadu [43]

16. *Paragus serratus* (Fabricius, 1805)
- Manipur [13]

17. *Paragus tibialis* (Fallén, 1817)
- Assam [8], Karnataka [24, 1995], Kerala [24], Tamil Nadu [21, 26]

18. *Paragus yerburiensis* Stuckenberg, 1954
- Assam [8, 9]

19. *Paratus indicus* Marusik, Zheng & Li, 2008
- Assam [8, 9]

20. *Syrphus fulvifacies* Brunetti, 1913
- Uttarakhand [36]

e. Order: Hemiptera

Family: Anthocoridae

1. *Cardiastethus exiguus* Poppius, 1913
- Karnataka [33]

2. *Orius maxidentex* Ghauri, 1972
- Assam [17]

Family: Geocoridae
1. *Geocoris ochropterus* (Fieber, 1844)
- West Bengal [11, 19]

f. Order: Neuroptera
Family: Chrysopidae
1. *Chrysoperla zastrowi sillemi* (Esben-Petersen, 1935)
- Assam [7, 16]

Family: Hemerobiidae
1. *Micromus timidus* Hagen, 1853
- Assam [8, 9], Karnataka [24], Kerala [24], Manipur [13], Tamil Nadu [25]

Parasitoids of Tea Aphids in India

A total of eight parasitoid species belonging to the families Aphelinidae and Braconidae (*Aphidiinae*) were recorded in association with tea aphid, *Aphis aurantii* from different tea-growing regions of India. The family Braconidae (*Aphidiinae*) predominated, accounting for seven species, whereas Aphelinidae was represented by a single species, *Aphelinus* sp.

Among the recorded pa rasitoids, *Lipolexis oregmae* exhibited the widest geographical distribution, being reported from Karnataka, Kerala, Tamil Nadu, and South India, followed by *Binodoxys indicus*, which was recorded from Assam, Karnataka, Kerala, and Tamil Nadu. *Aphidius colemani* was documented from Karnataka, Kerala, and Tamil Nadu, indicating its widespread occurrence in southern Indian tea plantations.

In contrast, *Adialytus ambiguus*, *Aphidius matricariae*, *Lipolexis gracilis*, and *Trioxys* sp. were each recorded exclusively from Assam**,** suggesting a more restricted distribution or limited documentation in other tea-growing regions. Assam harboured the highest parasitoid diversity, with six species recorded from the state, whereas Karnataka, Kerala, and Tamil Nadu each supported three parasitoid species.

The parasitoid fauna associated with *Aphis aurantii* in India was dominated by aphidiine braconids, a pattern consistent with aphid parasitoid communities worldwide [42]. The wide distribution of *Lipolexis oregmae*, *Binodoxys indicus*, and *Aphidius colemani* across major tea-growing regions indicates their broad ecological adaptability and potential importance in regulating tea aphid populations. *Lipolexis oregmae* is one of the most widely distributed aphidiine parasitoids associated with tea aphids in India and has been reported as an important natural enemy of *Aphis aurantii* in South Indian tea plantations, where it contributes significantly to the natural suppression of aphid populations [22, 25].

The detailed account of distribution of parasitoids of tea aphid is given below.

a. Family: Aphelinidae
1. *Aphelinus* sp.
- Assam [17]

b. Family: Braconidae (*Aphidiinae*)
1. *Adialytus ambiguus* (Haliday, 1834)
- Assam [17]

2. *Aphidius colemani* Viereck, 1912
- Karnataka [22, 25], Kerala [22, 25], Tamil Nadu [22, 25]

3. *Aphidius matricariae* Haliday, 1834
- Assam [17]

4. *Binodoxys indicus* (Subba Rao & Sharma, 1958)
- Assam [17], Karnataka [22], Kerala [22], Tamil Nadu [22; 27]

5. *Lipolexis gracilis* Forster, 1862
- Assam [17]

6. *Lipolexis oregmae* (Gahan, 1932)
- Karnataka [25], Kerala [25], Tamil Nadu [25, 27]

7. *Trioxys* sp.
- Assam [17]

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