

Tri-trophic associations of aphidophagous species of six genera of tribe Coccinellini (Coccinellinae: Coccinellidae: Coleoptera) in India

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Abstract

The article presents a checklist of tri-trophic interactions involving eight aphidophagous species from six genera of the tribe Coccinellini (*Microcaria*, *Palaeoneda*, *Phrynocaria*, *Protothea*, *Psyllobora*, and *Synonycha*) across 12 Indian states, with the highest number of associations reported from Manipur. These ladybird beetles prey on 20 aphid species infesting 23 host plants, resulting in 43 tri-trophic associations. Two previously misidentified species have been excluded. The major aphid genera involved include *Aphis*, *Brevicoryne*, *Ceratovacuna*, *Lipaphis*, *Myzus*, *Pseudoregma*, *Rhopalosiphum*, *Schizoneuraphis*, *Tuberculatus* and others that affect various crops such as fruits, cereals, pulses, oilseeds, and vegetables. The study highlights significant knowledge gaps in tri-trophic interactions across many regions and emphasizes the importance of this checklist as a resource for researchers, conservationists, and policymakers involved in biological pest control.

Keywords: Aphids, Aphidophagous predators, Biological control, Checklist, Coccinellidae, Ladybirds, Tri-trophic associations

Introduction

The insect family Coccinellidae (order Coleoptera), commonly known as ladybird beetles, comprises around 6,000 species found in diverse habitats worldwide. In India, roughly 550 species are reported, distributed across 90 genera and 16 tribes [1]. These beetles are significant natural predators of several insect pests such as aphids, scale insects, thrips, and other soft-bodied arthropods, making them essential players in biological pest control [2-4]. Traditionally, the Coccinellidae were divided into seven subfamilies with varying tribe numbers [5]. However, a revised classification by Che *et al.* [6], based on phylogenetic studies, recognises only three subfamilies: Microweiseinae (3 tribes), Monocoryninae (1 tribe), and Coccinellinae (26 tribes). The Coccinellinae includes 26 tribes, of which 8 tribes (Aspidimerini, Chilacorini, Coccidulini, Coccinellini, Hyperaspidini, Noviini, Platynaspidini and Sticholotidini) consist of aphidophagous species. Poorani [7-12] has given detailed, illustrated accounts of their morphology, host plant associations and distribution in the Indian subcontinent. These ladybird beetles are key predators of aphids, scales, thrips, and similar pests, making them crucial components of pest management strategies [4]. They play a vital role in protecting crops susceptible to aphid infestations in Indian agriculture. However, various anthropogenic pressures, including pollution, habitat loss, land-use change, and climate change, are negatively affecting global insect populations, despite their ecological importance [13]. Addressing these challenges requires an integrated conservation approach focused on maintaining and supporting aphidophagous Coccinellini in agricultural landscapes to help regulate aphid outbreaks [3]. Of these tribes, the tri-trophic associations of aphidophagous

species of 7 tribes, Aspidimerini, Chilacorini, Coccidulini, Hyperaspidini, Noviini, Platynaspidini and Sticholotidini have recently been catalogued by us [14-17]. The aphidophagous Coccinellini includes 23 aphidophagous genera; of them, tri-trophic associations of species of 17 genera have recently been catalogued [18-27]. The present article catalogues the tri-trophic associations of the remaining 6 genera of Coccinellini.

Aphids (Hemiptera: Aphididae) are sap-sucking, soft-bodied insects, with around 250 species posing major threats to agriculture and horticulture in India [28]. Their rapid reproductive strategy allows them to exceed economic threshold levels under favourable conditions [29]. In addition to nutrient loss, aphids also transmit plant viruses [30]. In nature, their populations are regulated by various arthropod predators and parasitoids, with ladybird beetles, hover flies, and lacewings being particularly effective. These natural enemies are widely used as biological control agents against aphid infestations [31].

Plant-aphid-coccinellid interactions serve as the basis of biological control, and documenting them is vital for identifying which coccinellid species regulate particular aphid pests on specific host plants. Such insights support farmers and researchers in developing precise, eco-friendly pest management strategies. Knowledge of these tri-trophic relationships also aids in forecasting pest outbreaks and maintaining predator populations for effective suppression, while contributing to the conservation of native coccinellid diversity. The current article addresses the tri-trophic relationships involving species of six aphidophagous genera of the tribe Coccinellini: viz., *Microcaria* Crotch, *Palaeoneda* Crotch, *Phrynocaria* Timberlake, *Protothea* Weise, *Psyllobora*

Chevrolat and *Synonycha* Chevrolat in different states/union territories of India. From this information, it is clear that the tri-trophic relationship of these aphidophagous predators is still mostly unclear in many regions of India. Moreover, this checklist acts as a vital resource for taxonomists, researchers, academics, conservation managers, and policymakers to ensure that these natural enemies are utilised in the natural or biological management approaches for these aphids.

Material and Methods

This checklist is based on the primary data from existing literature regarding aphidophagous predators of the above genera, including books, book chapters, journals, conference proceedings, review articles, and various reliable theses and websites up to June 15, 2025. The misspelt names of aphids, their predators and the plants in the original documents have been corrected where we accurately identify the intended species [14, 15].

Results and Discussion

In the present compilation, tri-trophic associations of aphidophagous species of six genera, viz., *Microcaria* Crotch, *Palaeoneda* Crotch, *Phrynocaria* Timberlake, *Protothea* Weise, *Psyllobora* Chevrolat and *Synonycha* Chevrolat, comprising 8 species, were observed preying on 20 species of aphids infesting 23 species of plants with 43 tri-trophic associations (triplets) in 12 states of India, mostly in Manipur (15 triplets) (Table 1). Two species, *Olla v-nigrum* (Mulsant, 1866) and *Synona melanopepla* (Mulsant, 1850), reported as aphid predators in Chhattisgarh [32], Kerala [33], and West Bengal [34], appear to have been misidentified and are excluded from this checklist. The aphid species, *Aphis*, *Astegopteryx*, *Brevicoryne*, *Ceratovacuna*, *Cervaphis*, *Cinara*, *Eulachnus*, *Hyadaphis*, *Lipaphis*, *Myzus*, *Pseudoregma*, *Rhopalosiphum*, *Schizoneuraphis*, *Taoia*, and *Tuberculatus* are the predominant genera of prey of these ladybirds that infest several fruit trees, cereals, pulses, oil seeds, and vegetable crops, primarily in the northwest and northeastern states of India.

Table 1: Number of species of six genera of aphidophagous Coccinellini preying on aphids infesting different number of host plants in different states/union territories of India

Predator species	Aphid species	Host plant species	Triples	States
<i>Microcaria albolineata</i>	1	1	1	3
<i>Microcaria lewisii</i>	2	1	2	2
<i>Palaeoneda auriculata</i>	1	1	1	1
<i>Phrynocaria perrotteti</i>	1	1	1	1
<i>Phrynocaria unicolor</i>	8	9	12	4
<i>Protothea quadripunctata</i>	1	1	1	3
<i>Psyllobora bisoctonotata</i>	6	5	9	2
<i>Synonycha grandis</i>	10	9	16	4
Total	20	23	43	12

Following is the detailed list of these aphidophagous ladybirds along with their aphid preys and food plants recorded from different states/union territories of India.

A) *Microcaria albolineata* (Gyllenhal, 1808) [syn. *Coccinella albolineata* Gyllenhal, 1808; *Calvia albolineata* (Gyllenhal, 1808); *Bothrocalvia albolineata* (Gyllenhal, 1808)]



Fig 1: Photograph of *Microcaria albolineata* showing elytral colour variation. Courtesy: <https://www.inaturalist.org>

Microcaria albolineata measures 4.7-6.5 mm in length and 3.8-5.0 mm in width. The body is dull brown to brown, oval with strongly convex and glabrous dorsum. It can be identified by the elytral marking including an elongated, cylindrical mark extending from the base to about two-thirds of the length near

the sutural line; a wider band along the outer edge from the humeral callus to about halfway down the elytron; and a thin line running from the humeral callus to the tip of the elytron, interrupted by two brown spots, one at the humeral callus and another just before the apex (Figure 1).

It is distributed in Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland, Sikkim, West Bengal associated with aphids and adelgids feeding on pine, spruce and other coniferous trees [9]. However, it was only recorded to prey on a single species of aphid feeding on pinus in three states of northeastern India as mentioned below.

➤ ***Eulachnus thunbergii* (Wilson, 1919)**

Pinus kesiya Royle ex Gordon - Manipur [35]; Meghalaya [36]; Nagaland [35]

B) *Microcaria lewisii* (Crotch, 1874) [syn. *Bothrocalvia lewisii* Crotch, 1874; *Calvia lewisi* (Crotch, 1874)]

Microcaria lewisii measures 5.8-6.5 mm in length and 5.0-5.5 mm in width. The body is similar to *Microcaria albolineata* but the ground colour is creamy whitish to yellowish. The A roughly M-shaped reddish-brown marking is present on the pronotum. The markings on elytra are characteristic in pattern with variation (Figure 2).



Fig 2: Photograph of *Microcaria lewisii* showing variation in elytral pattern. Courtesy: <https://www.inaturalist.org>

In India, it was recorded from Manipur and Nagaland consuming two species of aphids infesting pinus trees as mentioned below.

- ***Cinara orientalis* (Takahashi, 1924)**
Pinus kesiya Royle ex Gordon - Manipur ^[35]
- ***Eulachnus thunbergii* (Wilson, 1919)**
Pinus kesiya Royle ex Gordon - Nagaland ^[35]

C) *Palaeoneda auriculata* (Mulsant, 1850) [syn. *Coccinella miniata* Hope, 1831; *Neda auriculata* Mulsant, 1866; *Neda miniata* (Hope, 1831); *Palaeoneda miniata* (Hope, 1831); *Palaeoneda miniata* ab. *auriculata*]

Palaeoneda auriculata is a large ladybird measuring 11.9-13.5 mm in length and 10.5-12.5 mm in width. The head is black. A large, median subtrapezoidal, medially slightly narrowed black marking present on the pronotum. Elytra yellowish brown or ochreous or orange or reddish testaceous with a narrow black sutural stripe (Figure 3).



Fig 3: Photograph of *Palaeoneda auriculata* showing elytral colour variation. Courtesy: <https://www.inaturalist.org>

It is recorded from Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttarakhand, Uttar Pradesh and West Bengal preying on adelgids infesting oak and salix. However, only one species of aphid was recorded as its prey feeding on cabbage in Uttarakhand as mentioned below.

- ***Brevicoryne brassicae* (Linnaeus, 1758)**
Brassica oleracea L. var. *capitata* - Uttarakhand ^[37]

D) *Phrynocaria perrotteti* (Mulsant, 1850) [syn. *Coelophora perrotteti* Mulsant, 1850; *Anegleis* (*Pseudanegleis*) *perrotteti* (Mulsant, 1850)]

Phrynocaria perrotteti measures 4.0-4.7 mm in length and 3.6-

4.2 mm in width. The body is round with strongly convex dorsum, pale creamy yellow to brighter yellow, with black maculae on pronotum. The elytral pattern is highly variable (Figure 4).



Fig 4: Photograph of *Phrynocaria perrotteti* showing elytral colour variation. Courtesy: <https://www.inaturalist.org>

It is recorded from Delhi, Himachal Pradesh, Karnataka, Madhya Pradesh, Mizoram, Odisha, Pondicherry, Punjab, Tamil Nadu, Uttarakhand, mostly feeding on whiteflies ^[9]. However, only one species of aphid was recorded as it preys in Kerala as mentioned below.

- ***Aphis gossypii* Glover, 1977**
Capsicum annuum L. - Kerala ^[33]

E) *Phrynocaria unicolor* (Fabricius, 1792) [syn. *Coccinella congener* Billberg, 1808; *Coccinella unicolor* Fabricius, 1792; *Coelophora caliginosa* Mulsant, 1850; *Coelophora dumortieri* Mulsant, 1866; *Coelophora dupasquieri* Mulsant, 1866; *Coelophora petrequini* Mulsant, 1866; *Coelophora romani* Mulsant, 1866; *Coelophora unicolor* (Fabricius, 1792); *Coelophora versipellis* Crotch, 1874; *Dysis saundersii* Crotch, 1874; *Lemnia* (*Microlemnia*) *unicolor* (Fabricius, 1792); *Phrynocaria congener* (Billberg, 1808); *Phrynocaria nigrilimbata* Jing, 1986]

Phrynocaria unicolor is a comparatively small ladybird beetle, measuring 3.4-4.6 mm long and 3.1-4.2 mm wide, with a round to hemispherical body shape. It exhibits high polymorphism, especially in elytral pattern variations (Figure 5), which has led to the existence of multiple synonyms for the species.



Fig 5: Photograph of *Phrynocaria unicolor* showing variation in elytral pattern. Courtesy: <https://www.inaturalist.org>

It is recorded in Assam, Bihar, Delhi, Himachal Pradesh, Puducherry, Jharkhand, Odisha, Uttar Pradesh and Andaman &

Nicobar feeding on aphids and whiteflies [9]. However, its aphidophagy was recorded only in 4 states, mainly Manipur and West Bengal feeding on 8 species of aphids infesting 9 species of plants (Table 1), particularly brinjal, oak and som (host plant of muga silkworm) as mentioned below.

- ***Aphis aurantii* Boyer de Fonsc., 1841**
Camellia sinensis (L.) Kuntze - West Bengal [38]
- ***Aphis citricidus* (Kirkaldy, 1907)**
Citrus sp. - Manipur [35]
- ***Aphis craccivora* Koch, 1854**
Solanum melongena L. - West Bengal [39]
- ***Aphis gossypii* Glover, 1977**
Solanum melongena L. - West Bengal [39]
- ***Myzus persicae* (Sulzer, 1776)**
Machilus gambeli King ex Hook.f. - Assam [40]
Sesamum indicum L. - Manipur [35]
Solanum melongena L. - West Bengal [39]
Sonchus sp. - Sikkim [41]
- ***Schizoneuraphis himalayensis* (Ghosh & Raychaudhuri, 1973)**
Machilus gambeli King ex Hook.fil. - Assam [42]
- ***Taoia indica* (Ghosh & Raychaudhuri, 1972)**
Alnus sp. - Manipur [41]
- ***Tuberculatus indicus* Ghosh, 1972**
Quercus acutissima Carruth. - Manipur [43]
Quercus serrata Murray - West Bengal [41]

F) *Protothea quadripunctata* Mulsant, 1853 [syn. *Nedina mirabilis* Hoang, 1984; *Protothea indica* Weise, 1910; *Thea quadripunctata* Mulsant, 1853]

Protothea quadripunctata is a small ladybird measuring 2.85-3.25 mm long and 2.45-2.70 mm wide. The body is yellowish, oval with moderately convex and glabrous dorsum. Each elytron has four black spots, the spots fused to form larger maculae or totally absent (Figure 6).



Fig 6: Photograph of *Protothea quadripunctata* showing variation in elytral pattern. Courtesy: Poorani [9]

It is recorded only from Assam, Nagaland and Sikkim feeding on a single species of wooly aphid feeding on sugarcane as documented below.

- ***Ceratovacuna lanigera* Zehntner, 1897**
Saccharum officinarum L. - Assam [44]; Nagaland [44]; Sikkim [44]

G) *Psyllobora bisoetonotata* (Mulsant, 1850) [syn. *Vibidia bisoetonotata* Mulsant, 1850; *Thea bisoetonotata* (Mulsant, 1850)]

Psyllobora bisoetonotata is a small ladybird measuring 3.2-3.5 mm long and 2.2-2.5 mm wide. The body is pale creamy yellow, elongate oval and narrow with convex and glabrous

dorsum. The elytra have 18 black spots, arranged in a 2-3-3-1 pattern (Figure 7).



Fig 7: Photograph of *Psyllobora bisoetonotata* showing elytral colour variation. Courtesy: <https://www.inaturalist.org>

Its presence has been documented in various Indian states, including Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Punjab, Tamil Nadu, Uttarakhand, and Uttar Pradesh. It primarily feeds on powdery mildew fungi found on plants like shisham, purple bauhinia, sunflower, mulberry, and *Clerodendron* species and reports of its aphid predation in literature appear to be inaccurate [9]. However, six aphid species have been noted as its prey on five host plants in Punjab and Uttar Pradesh (Table 1), as detailed below.

- ***Aphis aurantii* (Boyer de Fonscolombe, 1841)**
Citrus ×sinensis (L.) Osbeck - Punjab [45]
Citrus reticulata Blanco - Punjab [45]
- ***Aphis gossypii* Glover, 1877**
Citrus ×sinensis (L.) Osbeck - Punjab [45]
Citrus reticulata Blanco - Punjab [45]
- ***Brevicoryne brassicae* (Linnaeus, 1758)**
Brassica oleracea L. var. *capitata* - Uttar Pradesh [46]
- ***Hyadaphis coriandri* (Das, 1918)**
Coriandrum sativum L. - Uttar Pradesh [46]
- ***Lipaphis erysimi* (Kaltenbach, 1843)**
Brassica juncea L. - Uttar Pradesh [46]
- ***Myzus persicae* (Sulzer, 1776)**
Citrus ×sinensis (L.) Osbeck - Punjab [45]
Citrus reticulata Blanco - Punjab [45]

H) *Synonycha grandis* (Thunberg, 1781) [syn. *Coccinella grandis* Thunberg, 1781]

Synonycha grandis, commonly referred to as the giant bamboo ladybird, is a relatively large species, measuring between 10.5-15.0 mm in length and 9.0-11.5 mm in width. It has a rounded body with a highly convex, smooth, and shiny upper surface. The base color of the beetle ranges from bright red to orange or yellow. A prominent black, trapezoid-shaped mark is found in the centre of the pronotum. The elytra feature 13 black spots, three along the suture and the remaining arranged in a 1-2-2 pattern on each elytron (Figure 8).



Fig 8: Photograph of *Synonycha grandis* showing elytral colour variation. Courtesy: <https://www.inaturalist.org>

Synonymy grandis is widely distributed across the Andaman & Nicobar Islands, Karnataka, Manipur, Sikkim, Tamil Nadu, and West Bengal, where it is commonly found on bamboo and only occasionally in agricultural ecosystems. Its life cycle, development, and feeding behaviour have been extensively studied [47-50]. Records of its aphid predation exist from four Indian states, primarily Karnataka and Manipur, where it preys on 10 aphid species found on 8 plant species, resulting in 16 documented tri-trophic associations (Table 1), mainly involving bamboo, bean, oak, and sugarcane as mentioned below.

- ***Aphis craccivora* Koch**
Lablab purpureus (L.) Sweet - Manipur [51]
- ***Aphis gossypii* Glover, 1877**
Lablab purpureus (L.) Sweet ssp. *purpureus* - West Bengal [41]
Saccharum officinarum L. - Maharashtra [52]
Solanum melongena L. - Manipur [35]
- ***Astegopteryx bambusae* (Buckton, 1893)**
Bambusa bambos (L.) Voss - Karnataka [49]
- ***Ceratovacuna lanigera* Zehntner, 1897**
Saccharum officinarum L. - Karnataka [48]; Manipur [35]
- ***Ceratovacuna silvestrii* (Takahashi, 1927)**
Bambusa bambos (L.) Voss - Karnataka [47]
Bambusa sp. - Manipur [35]
- ***Cervaphis rappardi indica* Basu, 1961**
Cajanus cajan (L.) Millsp. - Manipur [35]
- ***Pseudoregma alexanderi* (Takahashi, 1924)**
Bambusa bambos (L.) Voss - Manipur [50]
Bambusa sp. - West Bengal [53]; Manipur [35]
- ***Pseudoregma bambucicola* (Takahashi, 1921)**
Bambusa bambos (L.) Voss - Karnataka [47, 48]
Bambusa sp. - Karnataka [54]
- ***Rhopalosiphum maidis* (Fitch, 1856)**
Zea mays L. - Manipur [35]
- ***Tuberculatus indicus* Ghosh, 1972**
Quercus serrata Murray - Manipur [41, 51]

Conclusion

The present study expands knowledge on the tri-trophic associations of six aphidophagous genera of Coccinellini in India, documenting 43 associations involving 8 species of ladybird beetles, 20 aphid species, and 23 host plants across 12 states. These findings highlight the ecological importance and regional specificity of aphidophagous Coccinellini, while also revealing gaps in our understanding of their prey-host interactions. Misidentifications noted in earlier reports further underscore the necessity of accurate taxonomic studies to ensure reliable data for biological control programs. By cataloguing these associations, the study provides a valuable resource for researchers, conservationists, and policymakers, contributing to the development of eco-friendly pest management strategies. Strengthening research on tri-trophic interactions and integrating conservation measures will be crucial to sustaining native coccinellid diversity and enhancing their role as natural enemies in Indian agriculture.

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