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Myrmecophilous association between ants and aphids – an overview

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ABSTRACT

Ant-aphid mutualism is considered as a beneficial, reciprocal and myrmecophilous association. Ants farm aphids, harvesting honeydew or flesh, in return protect the aphids from their natural foe i.e. predators and parasites and perhaps for other benefits like acceleration of aphid's growth and reproductive rate and in the establishment of aphid colony. And finally aphid could get a pest status. Some of the aphid species are better adapted to profit from the presence of ants than others and benefits are more marked in small populations than in large ones (Saha & Raychaudhuri, 1998). Therefore, it seems essential to know about the interacting ants, their relationship with aphids in any agroecosystem for a better management strategy. The present paper attempts to document the aphids and aphidocolous ants against different host plants. Our investigation during August, 2017 – July, 2018 results a total of 40 aphid infested host plants along with 7 species of aphidocolous ants. Out of 10 aphid species recorded *Aphis gossypii* (Glover) is tended by more no. of ant species (5) followed by *Rhopalosiphum maidis* (Fitch) by four (4) species of ants. Aphidocolous ants demand serious attention as their attendance promotes aphids to reach pest status as well as ant populations need a check so that they may take care of fewer aphid individuals.

Keywords: Myrmecophily, Ants-aphids, *Aphis gossypii*, *Rhopalosiphum maidis*

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1. ANT-APHID RELATIONSHIP : A BRIEF RETROSPECT

Ants and aphids share a well-documented symbiotic relationship, i.e. they both benefit mutually from their working relationship. Aphids produce a sugary food for the ants, in exchange ants care for and protect the aphids from predators and parasites. This ant-aphid association is called Myrmecophily. It is the term applied to positive interspecies associations between ants and a variety of other organisms such as plants, other arthropods, and fungi. A myrmecophile is an organism that lives in association with ants. Some of the most well-studied myrmecophilous interactions involve ants and hemipterans (earlier grouped in the order Homoptera which included the Auchenorrhyncha and Sternorrhyncha), especially aphids.

Ants are eusocial Insects of the family Formicidae and along with the related wasps and bees, belonging to the order Hymenoptera. Ants evolved from wasp-like ancestors in the Cretaceous period, about 99 million years ago, and diversified after the rise of flowering plants. More than 14,000 of an estimated total of 22,000 species have been classified. They are easily identified by their elbowed antennae and distinctive node-like structure that forms their slender waist. In most terrestrial ecosystems ants are ecologically and numerically dominant, being the main invertebrate predators. As a result, ants play a key role in controlling arthropod richness, abundance, and community structure (Fiedler *et al.*, 1996). There is evidence that the evolution of myrmecophilous interactions has contributed to the abundance and ecological success of ants (Holldobler & Wilson, 1994) by ensuring a dependable and energy-rich food supply and thus providing a competitive advantage for ants over other invertebrate predators (Bluthgen *et al*., 2004).

There are around 4000 described species of aphids, and they are the most abundant myrmecophilous organisms in the northern temperate zones (Stadler & Dixon, 2008). Aphid also called plant louse, greenfly, or ant cow, are a group of sap-sucking, soft-bodied insects that are about the size of a pinhead, most species of which have a pair of tube like projections (cornicles) on the abdomen. Aphids can be serious plant pests and may stunt plant growth, produce plant galls, transmit plant viral diseases, and cause deformation of leaves, buds and flowers.

Some species of ants farm aphids, protecting them on the plants they eat, consuming the honeydew the aphids release from the terminations of their alimentary canals. This is a mutualistic relationship. These dairying ants milk the aphids by stroking them with their antennae (Hooper-Bui, 2008). Aphids feed on the phloem sap of plants and as they feed they excrete honeydew droplets from their anus.

The tending ants ingest these honeydew droplets then return to their nest to regurgitate the fluid for their nestmates. Aphid honeydew can provide an abundant food source for ants (aphids in the genus *Tuberolachnus* can secrete more honeydew droplets per hour than their body weight) and for some ants, aphids may be their only source of food. In these circumstances, ants may supplement their honeydew intake by preying on the aphids once the aphid populations have reached certain densities. In this way ants can gain extra protein and ensure efficient resource extraction by maintaining honeydew flow rates that do not exceed the ants' collection capabilities (Holldobler & Wilson, 1994).

Ants use a drug on herds of aphids to make them move more slowly so that they do not scatter and can be more easily “milked”. Chemicals on ants feet tranquilize and subdue colonies of aphids, keeping them close-by as a ready source of food. Even with some predation by ants, aphid colonies can reach larger densities with tending ants than colonies without. Ants have been observed to tend large "herds" of aphids, protecting them from predators and parasitoids. Aphid species that are associated with ants often have reduced structural and behavioral defense mechanisms, and are less able to defend themselves from attack than aphid species that are not associated with ants. Some farming ant species gather and store the aphid eggs in their nests over the winter. In spring, the ants carry the newly hatched aphids back to the plants. Some species of dairying ants (such as the European yellow meadow ant, *Lasius flavus*) manage large herds of aphids that feed on roots of plants in the ant colony (Wootton, 1998).

Queens leaving to start a new colony take an aphid egg to new herd of underground aphids. These farming ants protect the aphids by fighting off aphid predators (Hooper-Bui, 2008). An interesting variation in ant–aphid relationships involves lycaenid butterflies and *Myrmica* ants. For example, *Niphanda fusca* butterflies lay eggs on plants where ants tend herds of aphids. The eggs hatch as caterpillars which feed on the aphids. The ants do not defend the aphids from the caterpillars (this is due to the caterpillar producing a pheromone the ants detect making them think the caterpillar is actually one of them), but carry the caterpillars to their nest. In the nest, the ants feed the caterpillars, who in return produce honeydew for the ants. When the caterpillars reach full size, they crawl to the colony entrance and form cocoons. After two weeks, butterflies emerge and take flight. At this point the ants will attack the butterfly but the butterfly has sticky wool like substance on their wings that disable the ants' jaws, i.e. it can take flight without being ripped apart by the ants (Insects and Spiders, Time-Life Books, 1977).

Honeydew is a sugar-rich sticky liquid, secreted continually by aphids as they feed on plant sap.

Honeydew excretions by hemipterans are the result of feeding on the phloem sap, which has very high sugar content and osmotic pressure. Sucrose-transglucosidase activity in their gut transforms excess ingested sugar into long-chain oligosaccharides that are voided via honeydew excretion. When their mouthpart penetrates the phloem, the sugary, high-pressure liquid is forced out of the anus of the aphid. A black fungus (sooty mould) grows on the honeydew, coating leaves, branches and fruit with a black powder. In plant–ant–aphid interactions, ants visit plants to consume the honeydew produced by phloem-feeding aphids. Aphid's honeydew composition can be determined by the host plant genotype or species (Mittler 1958; Hendrix *et al*. 1992; Fischer *et al*. 2005).

The honeydew produced by clonal *Aphis nerii* feeding on two milkweed congeners, *Asclepias curassavica* plants is chemically distinct from the honeydew the aphids produce on *A. incarnate* plants (Pringle *et al*., 2014). Concentrations of cardenolides (type of steroid, many plants contain in the form of cardenolide glycosides groups derived from sugars) and of two of the most abundant sugars, glucose and sucrose, were higher in the honeydew derived from *A. curassavica*, whereas concentrations of xylose and of two of the four essential amino acids were higher in the honeydew derived from *A. incarnate* (Sternberg *et al.* 2012). Ants respond most intensively to honeydew containing high amounts of melezitose (Schmidt 1938; Kiss 1981; Völkl *et al*. 1999). This trisaccharide is synthesized in the aphid's gut from two units of glucose and one unit of fructose (Bacon & Dickinson 1957; Ashford *et al.*, 2000). Aphids may produce different honeydews on the two plant species because they selectively metabolize or sequester phloem compounds or because differences in phloem flow or viscosity between the two species creates osmotic differences in the aphid guts that result in different excreted compounds (Fisher *et al.* 1984). The differences in honeydew composition can be derived from genetic differences between host plant species and that such differences can affect ant colony performance and behaviors. Further differences are initiated and synthesized following aphid attack.

The presence of cardenolides in *A. curassavica* - derived honeydew could negatively affect ant metabolism and thereby decrease ant weight (or larval growth) and survival. Cardenolides can have acutely toxic effects on the consuming animal or they can slow the animal's growth rate (Cohen 1983; Fukuyama *et al.* 1993; Agrawal *et al*. 2012).

With this fascinating back drop, we initiated a study to observe the toing and froing of ant-aphid against different host plants and to document the aphids and aphid tending ants against the same.

1. 1. Study Area

The survey is conducted since August, 2017 till July, 2018 within Ramakrishna Mission Vivekananda University Campus, Narendrapur, South- 24 Parganas (primarily surrounded by agricultural experimental plots) (Fig. 1).

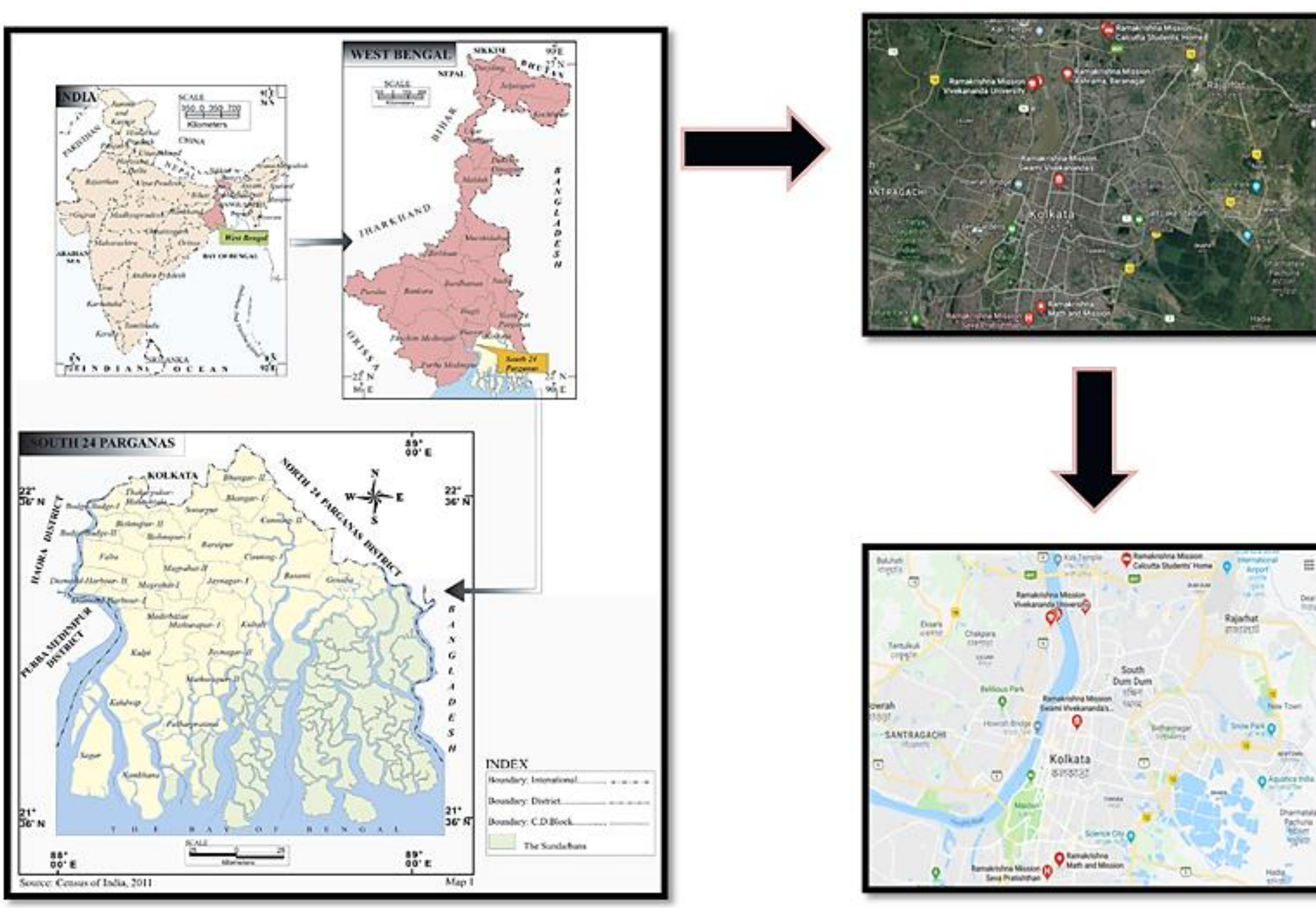

Fig. 1. Study Area

2. MATERIALS & METHODS

Survey is conducted once a week for both ants and aphids from available host plants. Specimens are collected in a plastic container with the help of a fine camel hair brush and forceps and preserved in 70% alcohol as per recommendation of Raychaudhuri & Saha (2014). The materials are studied using Stereo Zoom Binocular Microscope, model Olympus SZX-16. Aphid samples are identified following Raychaudhuri (1980); Raychaudhuri & Saha (2014). Identification of ants are based on Datta (1988); Bhattacharjee (2009). Specimens are in the deposition of Post Graduate Department of Zoology, Barasat Government College, Barasat, Kolkata (Fig. 2).

Fig. 2. Field & Laboratory Work

3. RESULTS

A total of 40 aphid infested host plants along with seven (7) species of aphidocolous ants are collected (Table 1). Out of 10 aphid species recorded *Aphis gossypii* (Glover) is tended by more no. of ant species (5) followed by *Rhopalosiphum maidis* (Fitch) by four (4) species of ants (Figs. 3A-D).

Table 1. List of Aphid-Ant collected from different host plants

Host Plant			Aphid	Aphidocolous Ants
Common Name	**Scientific Name**	**Family**		
Chinarose	*Hibiscus rosa-sinensis* L.	Malvaceae	i) *Aphis gossypii* (Glover) ii) *Myzus persicae* (Sulzer)	i) *Camponotus (Tanymyrmex) compressus* (Fabricius), ii) *Camponotus (Myrmotursus) misturus* (Smith), iii) *Tetraponera rufonigra* (Jerdon)
Jungle geranium	*Ixora coccinea* L.	Rubiaceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Lantana	*Lantana camera* L.	Verbenaceae	*Aphis gossypii* (Glover)	*i) Camponotu (Myrmotursus) misturus (Smith),* *ii) C. (Tanymyrmex) compressus (Fabricius),* *iii) Myrmicaria brunnea Saunders,* *iv) Pheidole nietneri Emery*
Oleander	*Nerium oleander* L.	Apocynaceae	*Aphis nerii* Boyer de Fonscolombe	*Pseudoneoponera rufipes* (Jerdon)
Gigantic Swallow wort	*Calotropis gigantea* (L.)	Apocynaceae	*Aphis nerii* Boyer de Fonscolombe	*Camponotus (Tanymyrmex) compressus (Fabricius)*

Bengal Arum	*Typhonium trilobatum* (L.)	Araceae	*Aphis nerii* Boyer de Fonscolombe	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Chrysanthemum	*Chrysanthemum indicum* L.	Asteraceae	*Macrosiphoniella sanborni* (Gillette)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Browntop millet	*Brachiaria ramosa* (L.)	*Poaceae*	*Rhopalosiphium maidis* (Fitch)	*i) Camponotus (Tanymyrmex) compressus (Fabricius), ii) Pheidole nietneri Emery*
Jobi	*Coix lachryma* L.	Panacea	*Rhopalosiphium maidis* (Fitch)	i) *Camponotus (Myrmoturscus) misturus* (Smith), ii) *Dolichoderus (Hypoclinea) affinis* Emery
Field Marigold	*Calendula arvensis* L.	Asteraceae	*i) Lipaphis erysimi* (Kaltenbach), *ii) Myzus persicae* (Sulzer)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Dahlia	*Dahlia* sp.	Asteraceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Sulfur cosmos	*Cosmos sulphureus* Cav.	Asteraceae	*Aphid gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Madagascar periwinkle/Rose periwinkle	*Catharanthus roseus* (L.)	Apocynaceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Indian Wormwood) (in Bengali Nagadana)	*Artemisia nilagica* (C.B.Clarke)	Asteraceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)

African Marigold	*Tagetes erecta* L.	Asteraceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Pea	*Pisum sativum* L.	Fabaceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Banana	*Musa* sp.	Musaceae	*Pentalonia nigronervosa* (Coquerel)	*Pheidole nietneri* Emey
Sweet pepper	*Capsicum* sp.	Solanaceae	*Acyrthosiphon pisum* Harris	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Carrot	*Daucus carota* L.	Apiaceae	*Lipaphis erysimi* (Kaltenbach)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Radish	*Raphanus raphanistrum sativus* (L.)	Brassicaceae	i) *Aphis gossypii* (Glover), ii) *Lipaphis erysimi* (Kaltenbach)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Beet root	*Beta vulgaris* L.	Amaranthaceae	*Rhopalosiphum maidis* (Fitch)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Kohlrabi	*Brassica oleracea* L.	Brassicaceae	*Lipaphis erysimi* (Kaltenbach)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Cabbage	*Brassica oleracea* L.	Brassicaceae	i) *Lipaphis erysimi* (Kaltenbach), *ii) Neomyzus circumflexus* (Buckton)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Cauliflower	*Brassica oleracea* L.	Brassicaceae	i) *Lipaphis erysimi* (Kaltenbach) *ii) Myzus persicae* (Sulzer)	*Camponotus (Tanymyrmex) compressus* (Fabricius)

Brocoli	*Brassica oleracea* L.	Brassicaceae	*Myzus persicae* (Sulzer)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Mustard	*Brassica nigra* L.	Brassicaceae	*Lipaphis erysimi* (Kaltenbach)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Brinjal	*Solanum melongena* L.	Solanaceae	*Neomyzus circumflexus* (Buckton)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Chilli	*Capsicum annuum* L.	Solaneceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Paddy	*Oryza sativa* L.	Poaceae	*Rhopalosiphium maidis* (Fitch)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Okra	*Abelmodchus esculentus* (L.) Moench	Malvaceae	*Aphis gossypii* (Glover)	*Camponotus (Tanymyrmex) compressus* (Fabricius)
Weeds : Alternate hosts (10)			*Aphis gossypii* (Glover) / *Lipaphis erysimi* (Kaltenbach)/*Myzus persicae* (Sulzer) / *Neomyzus circumflexus* (Buckton) / *Toxoptera aurantii* (Boyer de Fonscolombe)	*Camponotus (Tanymyrmex) compressus* (Fabricius) / *Camponotus* (*Myrmotarsus*) *misturus* (Smith)/ *Dolichodesus* (*Hypoclinea*) *affinis* Emery / *Pheidole nietneri* Emery

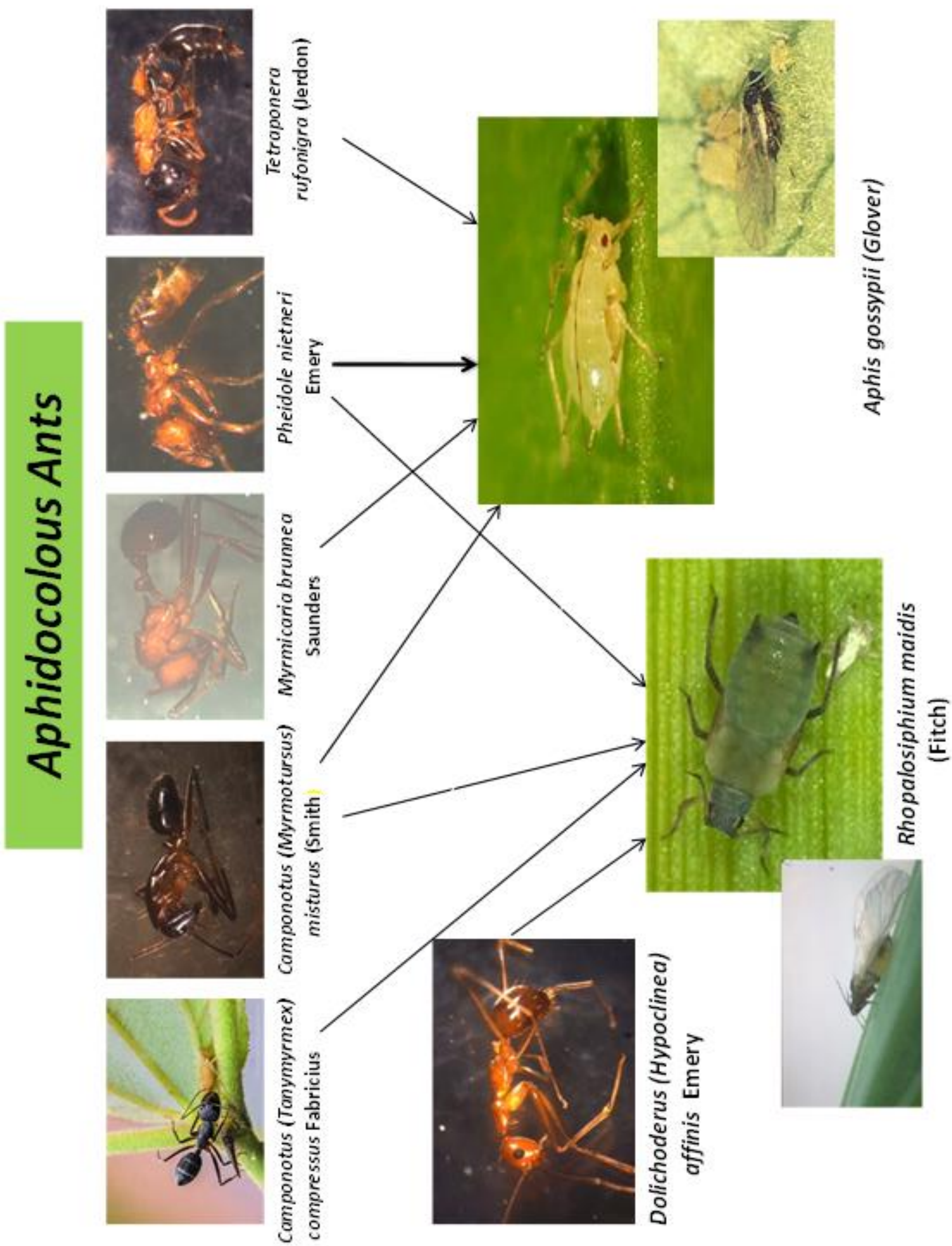
Aphidocolous Ants
Tetraponera rufonigra (Jerdon)
Pheidole nietneri Emery
Myrmicaria brunnea Saunders
Camponotus (Myrmotursus) misturus (Smith)
Camponotus (Tanymyrmex) compressus Fabricius
Dolichoderus (Hypoclinea) affinis Emery
Aphis gossypii (Glover)
Rhopalosiphium maidis (Fitch)

Fig. 3A

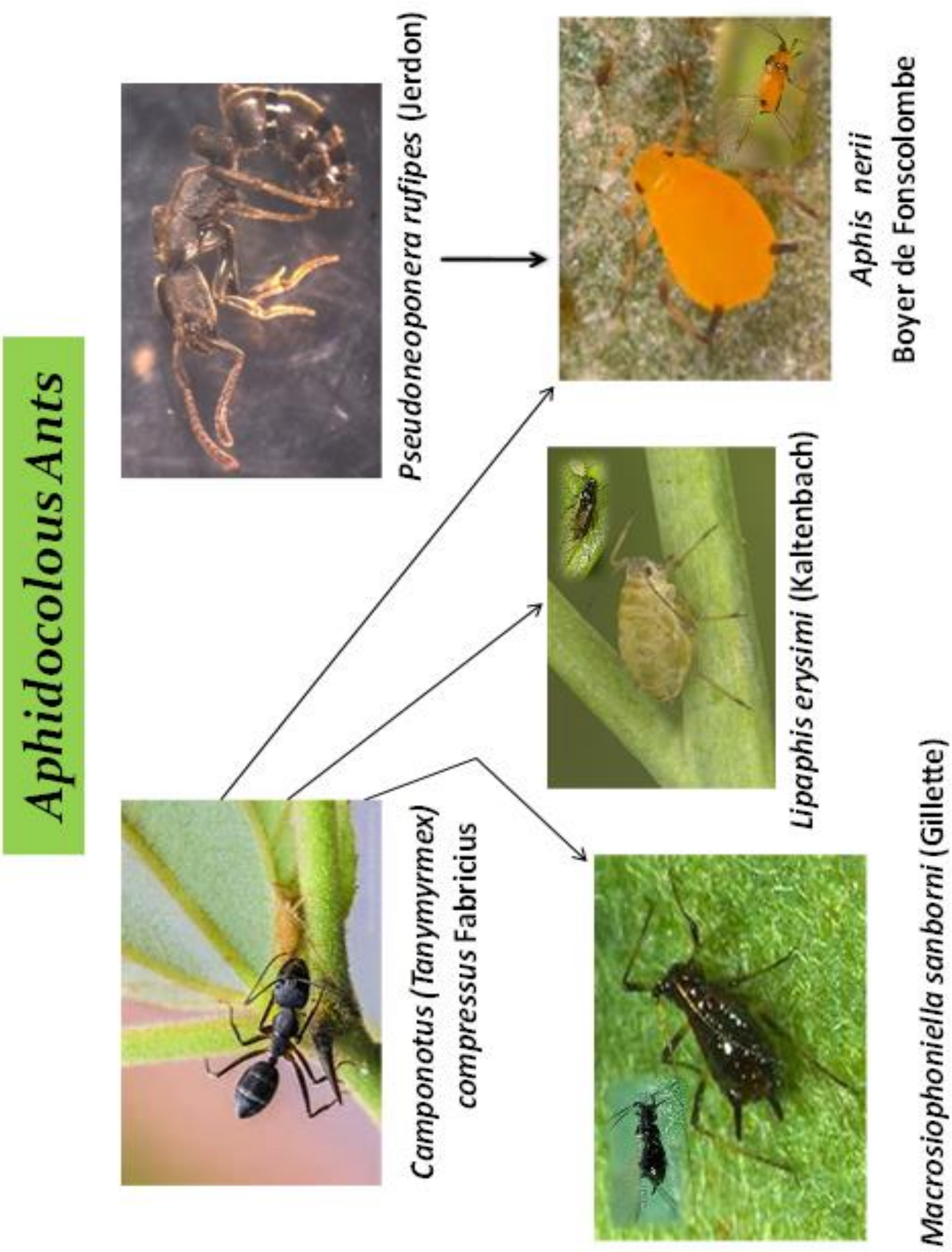
Aphidocolous Ants
Pseudoneoponera rufipes (Jerdon)
Camponotus (Tanymyrmex) compressus Fabricius
Aphis nerii Boyer de Fonscolombe
Lipaphis erysimi (Kaltenbach)
Macrosiphoniella sanborni (Gillette)

Fig. 3B

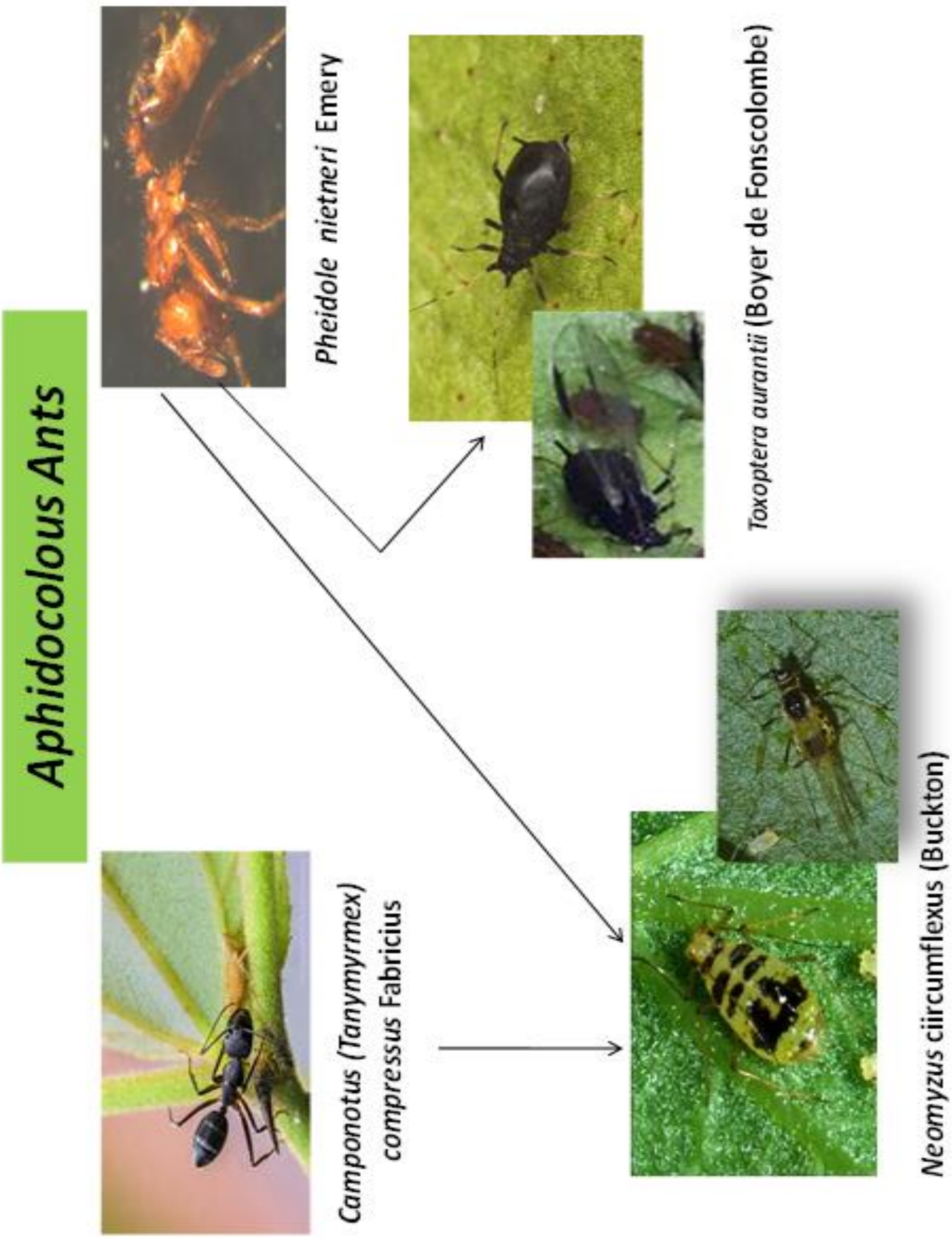
Aphidocolous Ants
Pheidole nietneri Emery
Toxoptera aurantii (Boyer de Fonscolombe)
Camponotus (Tanymyrmex) compressus Fabricius
Neomyzus ciircumflexus (Buckton)

Fig. 3C

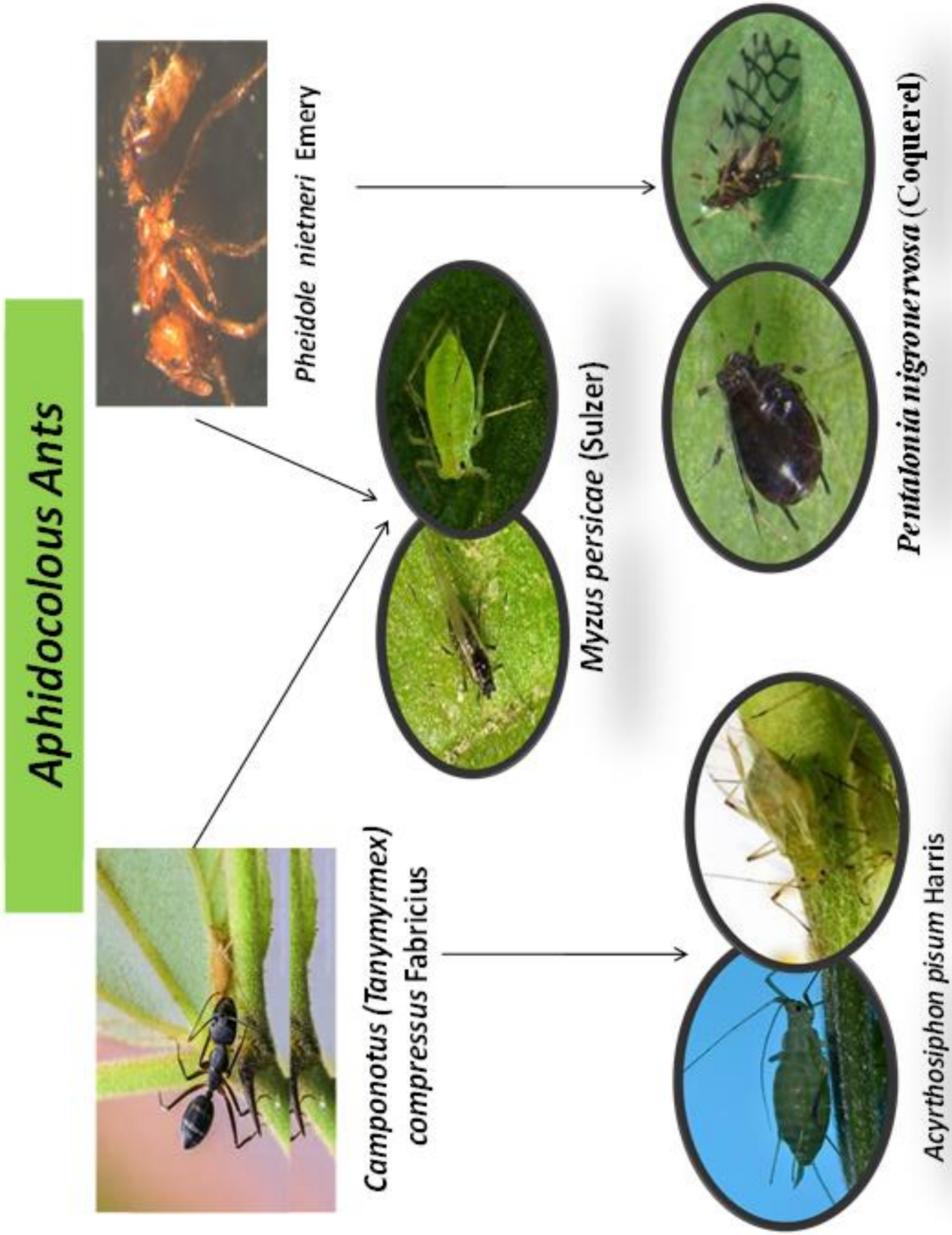
Aphidocolous Ants
Pheidole nietneri Emery
Camponotus (Tanymyrmex) compressus Fabricius
Myzus persicae (Sulzer)
Pentalonia nigronervosa (Coquerel)
Acyrthosiphon pisum Harris

Fig. 3D

4. SUMMARY

In ant-aphid beneficial association, the population and fitness of aphids affected by ant attendance and the outcome of this relationship affects the host plant of the aphid. The main hypothesis is that ant tending decreases aphid developmental time and/or increases reproduction per capita, which seriously reduces host plant fitness. And finally aphid could get a pest status. Ants can affect the fitness of the aphids' host plant as long as the requirements of the colony are satisfied. Thus, the ant-aphid relationship can enhance the dynamics of ecological communities (Hosseini *et al*., 2017).

5. CONCLUSION

Aphidocolous ants demand serious attention while developing management strategy for the control of aphids. It is noteworthy to mention that ants' attendance promote aphids to reach pest status. Ant populations need a check so that they may take care of fewer aphid individuals.

ACKNOWLEDGEMENTS

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