



# Ecological Association of Diversity of Cow Bugs-Ants and Aphids-Ants Species in Pigeonpea and Safflower Ecosystems

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**Abstract:** In pigeonpea, three cow bug species were recorded namely, *Oxyrhachis apicalis* (Anantasubramanian), *Leptocentrus* sp. and *Otinotus* sp. of which, *Otinotus* sp. was the most dominant species (relative abundance=76.48%). All cow bugs were actively tended by one species of ant, *Camponotus compressus* Fab. In safflower, two aphid species were recorded viz., *Urolecon compositae* (Theobald) and *Aphis* sp. *U. compositae* was the most dominant species (relative abundance=93.98%), *Aphis* sp. was found in only tiny patches of field feeding only on leaves. Three ants species found collecting honeydew from aphids by indirect method of tending (i.e. by collecting honeydew fell on plant parts) viz., *C. compressus*, *Tapinoma melanocephalum* Fab. and *Polyrachis* sp. The different species of cow bug and their associated ants on other host plants viz., *Leptocentrus* sp. on brinjal and almond, *Oxyrhachis* sp. on acacia, *Otinotus* sp. on parthenium and were attended by the ant, *C. compressus*. On black nightshade plant (*Solanum nigrum* L.), the cow bug, *Leptocentrus* sp. was found to be tended by the Hunchbacked ant, *Myrmica riabrunnea* Saunders. The aphids, *Pentalonia nigronervosa* Coquerel on banana, *Aphis croccivora* Koch on pigeonpea and *Aphis punicae* Passarini on pomegranate were tended by the ant, *C. compressus*. *Aphis spiraeicola* Patch on Siam weed and *Hysteroneura setariae* Thomas on deer tongue grass were tended by *Camponotus* sp. In finger millet, the aphid, *H. setariae* Thomas was tended by *T. melanocephalum* Fab. *Aphis croccivora* on cowpea, *A. spiraeicola* on Parthenium and *Aphis gossypii* Glover on chilly were tended by *Myrmica riabrunnea* Saunders.

**Keywords:** Honeydew, Cow bugs, Aphids, Ants, Relative Abundance

In the tropics, membracids species injure a variety of crop plants, including avocado, legumes, coffee, cacao, grape, and papaya. Cow bugs may injure plants, not only through feeding, but also through laying their eggs in host plant tissue by making slits. Treehoppers (Membracidae) provide some of the best studied examples of parenting in insects by frequent maternal eggs guarding. The Membracinae exhibit the full range of social behaviour found among treehoppers, ranging from solitary asocial individuals, aggregations of nymph or adult, to highly developed maternal care in the form of offspring- maternal communication (Lin 2006). All the life stages (egg, nymph and adult) of cow bugs are associated with their host plants. Female insert eggs into different parts of host plant tissues with their strong ovipositor. They may also lay eggs on the surface of the plant tissues. Egg masses are frequently coated with waxy substances derived from accessory glands. Ant mutualism is prevalent among membracine treehoppers and may play an important role in the evolutionary development of sub social behaviour (Lin 2006). Many aphid species like *Dactynotus carthami* (H.R.L.), *Uroleucon compositae*, *Dactynotus orientalis* sp., *Dactyonotus jaceae* (Linn.), *Macrosiphum sonchi* (H.R.L.), *Macrosiphum sonchi* (Linn.), *Macrosiphum compositae* (Theobald), *Macrosiphum* spp. (jaceae), *Myzus persicae*

(Sulz), *Aphis fafia* (Scop), *Capitophorus eleagni* (Del. Guer), *Aphis gossypii* Glover, *Aphis nerii* Boyer, *Pleotrichophorus glandulosus* Kalt., *Brachycaudus helichrysi* Kalt. are recorded on safflower (Mallapur et al 2002).

The direct interactions between ants and Homopterans are diverse. A wide range of ant species prey on Homopterans, particularly on coccids and aphids. Some ants prey on one homopteran and tend another: *Formica rufa* (L.), for example, preys on *Drepanosiphum platanoidis* (Schrank) but tends *Periphyllus testudinaceus* (Ferne) (Skinner and Whittaker 1981). Mutualism between ants and sap sucking insects is a well-studied interaction, in which ants stroke cow bugs with their antennae to make them excrete a sugary liquid, called honeydew, which they later consume. *Camponotus compressus* (Fabricius) is a common ant species in Southeast and South Asia, and this ant species is found to interact with many plants sap-sucking hemipterans like aphids and cow bugs. Although *C. compressus* is common and widespread ant, ecology of this ant has been poorly studied. While aspects of the *C. compressus*-aphid mutualism has been reported, the *C. compressus*-cow bugs interaction has not been studied, except for natural history descriptions. Nettimi and Iyer (2015) conducted a preliminary study exploring the foraging strategies of *C. compressus* and its interaction with *Oxyrhachis tarandus*

Fab., a species of cow bug. *C. compressus* ants are reported to follow non-random patterns of searching while foraging on aphid honeydew in cashew inflorescences (Veena and Ganeshiah 1991), by abandoning poor-quality branches and continuing to forage in richer branches.

Aphids (Aphidoidea: Homoptera) and ants (Formicidae: Hymenoptera) are the best examples of most researched models of mutualistic- relationships in the animal kingdom (Detrain et al 2010). This association of aphid and ants has strong interaction with various host plants. Aphids are one of the major pests of the economically important crops like cotton, castor, pigeonpea, cow pea, etc. Razaq et al (2011) reported 10 to 90 per cent yield loss to the economically important crops in India depending upon crop stage and severity of damage by aphids. It is a well-known fact that an ant colony simultaneously tends numerous aphid species, thus there may be intra or interspecific competition amongst aphid groups for the services provided by the ants. Carbohydrate and nitrogen rich excreta produced by aphids honeydew, which is collected by ants species; in return the ants provide protection and hygiene to aphids. Natural history studies of cow bugs were highly biased toward the New World fauna. Most of the Old-World treehoppers (cow bugs) are still poorly studied except for some species in India (Ananthasubramanian 1996), South East Asia (Lin 2006) and China (Yuan and Chou 2002). The objective of this study is to know the species diversity of cow bugs-associated ants and aphids-associated ants in pigeon pea and safflower ecosystem.

## MATERIAL AND METHODS

### Sampling and identification of cow bugs, aphids and ants:

Cow bugs and their associated ant species were collected from the infested parts of plants at weekly interval. The cow bug and ant population were collected manually with the help of camel hair brush and smaller ant species were collected by using aspirator. The collected cow bugs samples were sorted by observing few differentiating characters like length of horns, color, size and solitary or gregarious feeding nature. Apart from pigeonpea, the population of cow bugs and associated ants were collected from other host plants viz. weed plants, horticultural and other field crops. Collected specimens were sent to Biosystematics laboratory, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, (GKVK) Bengaluru, India and National Bureau of Agricultural Insect Resources, NBAIR, Bengaluru, India for their taxonomic identification.

**Relative abundance:** To measure the percentage of individuals of a particular species of cow bug among all the species, following formula was used:

$$RA = \frac{ni}{N}$$

Where, RA= Relative Abundance,  $n_i$  = Total number of individuals in the particular sample / species, N = Total population of all the species

**Species diversity of aphids-ants in safflower:** The different aphid infested plant parts of safflower like leaf stem, flower head collected from the field collection of aphids and ants done by hand as well as by using camel hair brush. The samples were preserved in 70 per cent ethyl alcohol and sent for identification. Apart from safflower, the population of aphid and associated ants were collected from other host plants viz. weed plants, horticultural, other field crops etc. Relative abundance of different species of aphids and ants was calculated by using relative abundance formula mentioned in earlier case with cow bugs.

## RESULTS AND DISCUSSION

**Species diversity of cow bugs -ants in pigeon pea:** Three species of cow bugs recorded from the pigeonpea crop in Vijayapur district, Karnataka, India namely, *Oxyrhachis apicalis* (Ananthasubramanian), *Leptocentrus* sp. and all *Otinotus* sp; all three species were active from flowering to harvesting stage of the crop (Plate 2).

**Field observation:** Out of three species recorded, *Otinotus* sp. was the predominant, contributing to more than three fourth of cow bugs population. *Otinotus* sp. and *O. apicalis* fed gregariously both as nymph as well as adults, and were greatly attended by ants. *Leptocentrus* sp. was a solitary and most active form. These membracid's presence was easily located by noticing the ant's activity in most of the cases. Adults body color was brown, whereas nymphs were found in both green and brown forms. In adults, pronotum was very well developed, with two horns and pronotum was found to cover most of head region from top and it extended backward.

**Biology of cow bugs:** Eggs of all three species were elongate in shape and inserted into pigeonpea stem in the ovipositional slits made by female with strong ovipositor. Only part of egg was inserted inside the slits and remaining half was easily visible on bark. *Otinotus* sp. inserted eggs in multiple rows, each row containing 2- 10 eggs, each batch having 25 to 45 eggs and all the rows of eggs were randomly arranged in proximity to each other. *O. apicalis* laid eggs in groups in palmate pattern with densely packed rows and each egg batch was consisting of 45 to 100 eggs. Frequent egg guarding behaviour was observed in these cow bugs. Especially in *O. apicalis*, the brooding female found sitting on her egg mass so firmly that eggs remain well concealed. The brooding female was not disturbed even after external stimulus by hand touching (Plate 2). In *Otinotus* sp., the eggs were guarded by more than one brooding female, as the

adults were also found more gregarious and deposit eggs masses in proximity to each other. Unfortunately, the brooding behaviour or egg laying pattern of *Leptocentrus* sp. could not be observed in field condition and in *Leptocentrus* sp., there was no such frequent egg guarding behaviour observed. Individual nymphs of *Leptocentrus* sp. were found among gregarious *Otinotus* sp. or *Oxyrhachis apicalis*. The nymphs in all three membracid species observed to be actively attended by ants. In *Leptocentrus* sp., the nymphs were attended more by ants than the adult cow bugs. There was difference in time of hatching even for individuals from the single egg mass. So nymphs of different instars in the same group were hatched from same egg mass. The females of *O. rufescens*, *O. brevicornutus*, *O. uncatu*s, *O. minusculus* and *O. krusadiensis* guarding the egg masses till the eggs hatch and thereafter the nymphal instars remain very close to the parent females in a gregarious manner, invariably attended by ants. Lin (2006) reported that, membracinae exhibit the full range of social behaviour found among treehoppers, ranging from solitary asocial individuals, aggregations of nymph or adult, to highly developed maternal care in the form of offspring- maternal communication. The antennae were short, filiform and located beneath the eyes, and their structure was identical in all three species. Terminal abdominal segment of both nymphs and adults of all the three species found to possess eversible anal tube which excretes honey dew. The male and female genitalia in all the three species was similar in structure and genital organs were found below the anal tube. Male genitalia have parameres, a U- shaped aedeagus and sternal plate. Female genitalia represented by a strong ovipositor with valvifers (Plate 3).

**Relative abundance:** Among three species of cow bugs recorded, *Otinotus* sp. was the most abundant species found throughout the experimental period with relative abundance 76.48 per cent, making the most dominant cow bug species in the study area. Relative abundance of second most abundant species, *Oxyrhachis apicalis* was 19.84 percent and *Leptocentrus* sp. was the least abundant species contributing only 3.68 per cent to the total cow bug population. Seni (2021) documented *O. oneratus* as the more abundant cow bug species than *L. taurus* in pigeonpea. Ananthasubramanian (1996) also observed *Oxyrhachis rufescens* (Walker), *O. taranda*, *O. tuberculus* (Walker), *Otinotus oneratus* (Walker), *Leptocentrus tourus* (Fab.) and *Gargara mixta* (Buckton). Khajuria et al. (2015) recorded two species of cow bugs, *Otinotus oneratus* W. and *O. tarandus* as sporadic pests of pigeonpea. Nair et al. (2017) recorded observed that the activity of cow bug, *L. taurus* started during the vegetative stage of pigeonpea crop and continued up to maturity stage of the pods. These variations in results may be

due to change in location of study, weather parameters and host availability. Adult body color was brown in all three cow bug species, whereas nymphs were in both green and brown forms. In adults, very well developed pronotum has two horns, the pronotum covered the most of head region from top and extended backward.

**Species diversity of ants associated with cow bug and their behaviour:** In pigeonpea ecosystem, all the three species of cow bugs were tended by only one species of ant, *Camponotus compressus* (Fab). there was no species specificity observed for ant attendance. Ant tending behavior is conspicuous and ants were in direct association with the cow bugs by consuming the honeydew directly from the cow bug. Ants were more attracted to cow bugs than any other homopteran pest on pigeonpea, owing to more quantity of honeydew they excrete. Ants were found antennating and guarding the egg batches both in presence and absence of the guarding female cow bug. Ants were also involved in removal of moulted exuviae from the plant twig and consumed the honeydew fell on leaves and stem, thus ensuring hygiene against probable pathogen infection (Plate 4). The honeydew excreted at the site of nymphal aggregation made it difficult for the movement of early instar nymphs by sticking to their legs. But it was absent in the aggregations tended by ants where the nymphs were moving freely. The most important service that ant provided to cow bugs was the protection; whenever the cow bugs were disturbed or attacked, they made vibrational sound, which in turn alerted the ants and an immediate assembling of ants towards the site of disturbance was noticed. Ants' attendance was more abundant in two species of cow bugs, *Otinotus* sp., and *O. apicalis*. This was due to the gregarious feeding habit of these cow bugs which excreted huge quantity of honeydew in a single place, where ants can consume it with less effort of foraging. In contrast, *Leptocentrus* sp. was less associated with ants as it was found as solitary feeder and actively moves from plant to plant more frequently. Ants attendance was more abundant in two species of cow bugs, *Otinotus* sp., and *O. apicalis*. In contrast, *Leptocentrus* sp. was less associated with ants. Ananthasubramanian (1996) also reported that, large black ant, *C. compressus*, found throughout India as a common species that attended on many species of membracids. Misread al (2003) observed that, the nymphs and adults of *O. tarandus* on mulberry plant were attended by a large number of black ants, *Camponotus compressus* Fab., for the honeydew excreted by them.

**Cow bugs and ants association on other host plants:** The different species of cow bugs and associated ants on other host plants recorded during this experiment (Table 1). In brinjal, *Leptocentrus* sp. cow bug attended by the ant, *C.*

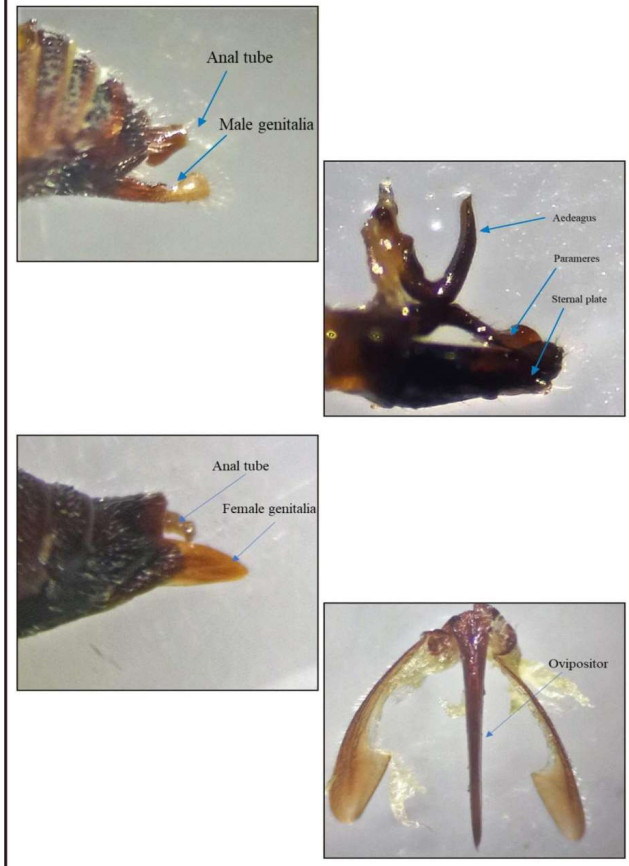
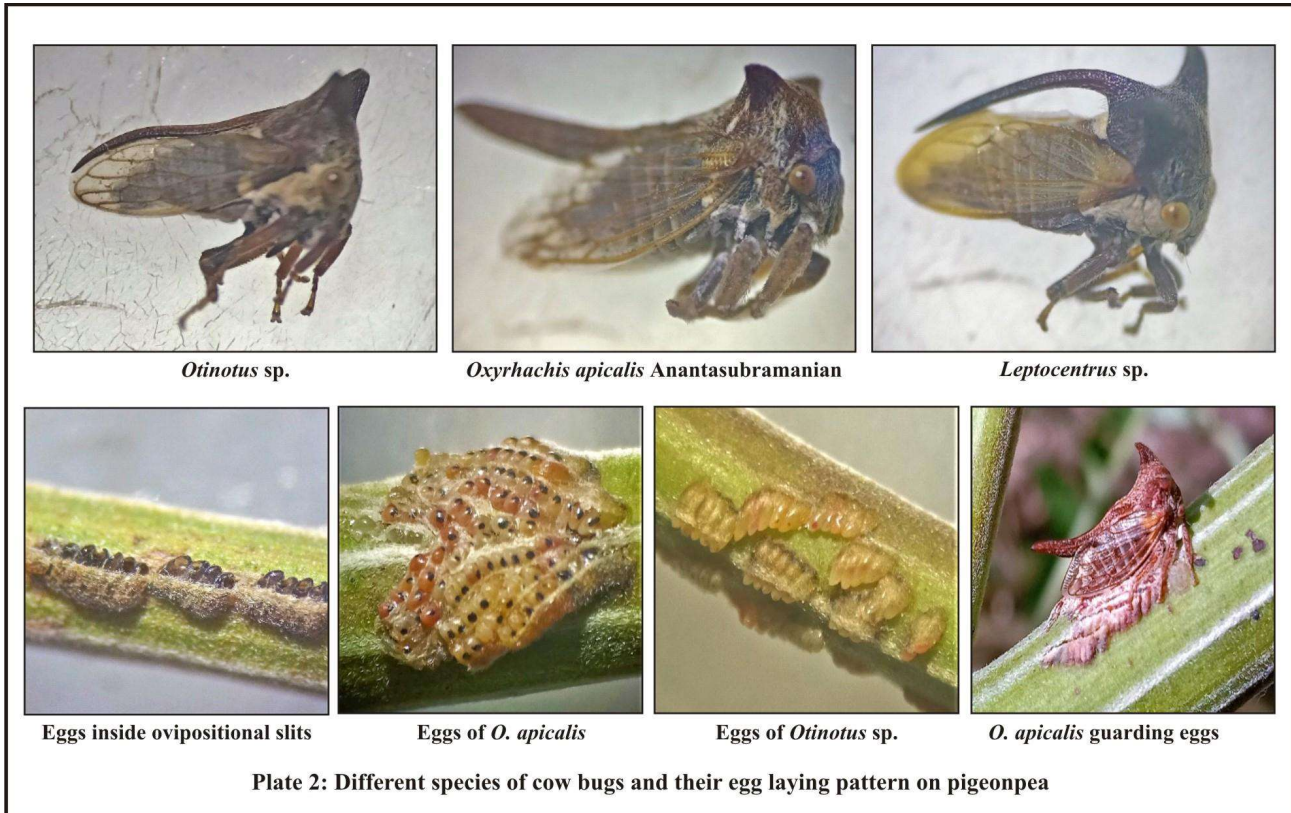


Plate 3: General structure of male and female genitalia in cow bugs

*compressus*. In Acacia (*Prosopis juliflora* Sw.), the cow bug *Oxyrhachis* sp. was found to be tended by *C. compressus*. On parthenium (*Parthenium hysterophorus* L.) the cow bug, *Otinotus* sp. was tended by *C. compressus*. On almond, *Leptocentrus* sp. cow bug was tended by *C. compressus* ant. On black nightshade plant (*Solanum nigrum* L.), the cow bug, *Leptocentrus* sp. was tended by the Hunchbacked ant, *Myrmica riabrunnea* Saunders (Plate 5).

**Species Diversity of Aphids-Ants in Safflower**

**Field observation:** This study recorded two aphid species feeding on safflower viz., *Uroleucon compositae* (Theobald) and *Aphis* sp. (Plate 6). The black aphid, *U. compositae* was the dominant species contributing to more than 90 per cent of aphid population on safflower. Adults of this aphid are black and nymphs are blackish brown in color, with well-developed cornicles on 5<sup>th</sup> abdominal segment. Both adults and nymphs found sucking sap from all parts of plant viz., tender leaves, flower head, whole stem and also found feeding on ventral surface of leaves. Severe infestation of this aphid made the safflower stem appear black. *Aphis* sp. was a pale green colour aphid found both in winged and wingless form, and was mainly feeding on tender leaves. The incidence of this aphid species started during seedling stage of crop and reduced towards flowering and crop maturity. Mallapur et al. (2002) reported many aphid species viz., *Dactynotus carthami* (H.R.L.), *U. compositae*, *Dactynotus orientalis* sp.,

*Dactyonotus jaceae* (Linn.), *Macrosiphum sonchi* (H.R.L.), *Macrosiphum sonchi* (Linn.), *Macrosiphum compositae* (Theobold), *Macrosiphum* spp. (jaceae), *Myzus persicae* (Sulz), *Aphis fabae* (Scop), *Capitophorus eleagni* (Del.Guer), *Aphis gossypi* Glover, *Aphis nerii* Boyer, *Pleotrichophorus glandulosus* Kalt., *Brachycaudus helichrysi* Kalt. were recorded on safflower. These results are in agreement with the present study only with reference to *U. compositae*. The *Aphis* sp. observed in this study was also supported by the report with record of *A. fabae*, *A. gossypi* and *A. nerii* feeding on safflower. Kumar and Chandra (2012) reported the infestation of aphids, *Uroleucon sonchi* (Linn.), *U. compositae*, *Uroleucon carthami* (Linn.) and *Uroleucon gobonis* (Mat.) on the safflower crop right from vegetative to pod stage. Saeidiet al (2015) reported the occurrence of eight species of aphids on safflower viz., *Eucarazzia elegans* Ferrari, *Aphis gossypi* Glover, *Aphis nerii* Boyer., *Brachycaudus helichrysi* Kalt., *Hyadaphis sphondyti* Koch., *Pleotrichophorus grandulosus* Kalt. and *U. compositae*. These reports are in line with the present study with reference to occurrence of *U. compositae* and *Aphis* sp. The black aphid, *U. compositae* was the dominant species contributing to more than 90 per cent of aphids population on safflower. The results pertaining to feeding preference and nature of damage by *U. compositae* aphid was supported by the reports of Nivedita et al (2019) where three aphid species viz., *U. compositae*, *P. glandulosus* and *B. helichrysi* found to feed on whole safflower plant. In present study, *U. compositae* contributed most to the aphid population on safflower with relative abundance 93.98 per cent. population of *Aphis* sp. was very less which represented only 6.01 percent of total aphid population recorded from sample plants throughout the experimental period. Due to high population of *U. compositae*, whole stem of plant appeared black during its high infestation. In contrast, the presence of *Aphis* sp. was noticed only in few spots of field during all weeks of observations. Saeidi and Adam (2011) opined that, the population of the blood aphids (*U. compositae*) was

bigger than that of the green aphids (*P. glandulosus* and *B. helichrysi*) and these two green aphids were mainly seen just as some tiny spots in the fields.

**Relative abundance:** The species, *U. compositae* contributed most to the aphid population on safflower with relative abundance 93.98 per cent and population of *Aphis* sp. was very less which represented only 6.01 percent of total aphid population recorded from sample plants throughout the experimental period.

**Species diversity of ants associated with aphids and their behaviour:** Three species of ant's activity was recorded in safflower ecosystem viz., *C. compressus*, *Tapinom melanocephalum* Fab. and *Polyrhachis* sp. *T. melanocephalum* ants found collecting honeydew even on stem where more *U.compositae* aphids were observed. None of these three ant species were directly attended by antennating its abdomen and collected honeydew from *U. compositae*.. Ants collected honeydew which was on leaf surface and soil. The aphid also feeds on ventral side of leaf, there was much honeydew excreted on to the leaf below and on soil (Plate 7). Despite of their huge population with more honeydew production, the *U. compositae* never attract a greater number of ants unlike other aphid species on different crops, which are tended by ants depending on their density, in turn the honeydew providing capacity. None of the three ant species protect or guard the aphids against attacks, ants were simply engaged in honeydew collection. This might be because of high degree of defensive behavior by aphids (which often found oozing defensive fluid from the cornicles and due to composition of safflower sap which made honeydew less palatable.

The ant species, *T. melacephalum* ant was more abundant in safflower field, followed by *C. compressus* and *Polyrhachis* sp. The relative abundance of *T. melanocephalum* was 46.09 per cent, which made most efficient honeydew sourcing ant species in the experimental site. Relative abundance of *C. compressus* and *Polyrhachis* sp. was 41.74 and 12.17 per cent. *Uroleucon* is large genus

**Table 1.** Species diversity of cow bugs and their associated ants on other host plants

Common name	Host plant	Cow bug species	Tending ant species	Location of collection
Brinjal	<i>Solanum melongena</i> L.	<i>Leptocentrus</i> sp.	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India
Acacia	<i>Prosopis juliflora</i> Sw.	<i>Oxyrachis</i> sp.	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India
Parthenium	<i>Parthenium hysterophorus</i> L.	<i>Otinotus</i> sp.	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India
Black nightshade	<i>Solanum nigrum</i> L.	<i>Leptocentrus</i> sp.	<i>Myrmecaria brunnea</i> Saunders	Tiptur, Tumkur district, Karnataka, India
Almond	<i>Prunus</i> sp.	<i>Leptocentrus</i> sp.	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India

with 226 species distributed worldwide associated almost entirely with the daisy (Asteraceae) and bellflower (Campanulaceae) families. They either feed on one species or on a few related species.. *Uroleucon* are not usually attended by ants (Dransfield and Brightwell 2021). This report is in line with the present study where none of these three ant species were directly (by antennating its abdomen) found collecting honeydew from *U. compositae*. Only indirect honeydew collection by ants was observed *i.e.*, the ants collecting honeydew which was found on leaf surface and soil. These results are deviating with the reports of Tiido (2002) in which, the aphid, *Uroleucon traxaci* (Kaltenbach) on Dandelion plant (*Taraxacum officinale*) unlike other *Uroleucon* spp. was attended by ants. These deviations may be due to change in species and location of study.

Mehrpavar et al (2017) noticed three species of aphids on tansy plant (*Tanacetum vulgare* L.) *viz.*, *Metopeurum fuscoviride* Stroyan, an ant tended species, *Macrosiphoniella tanacetaria* Kalt. and *Uroleucon tanacetii* L. were two untended species which were preyed upon by the ants *Lasius niger* (L.) and *Myrmica rubra* (L). Results of the present study are deviating with this report with reference to fact that *U. Compositae* never attacked by any ant species. Despite of their huge population with more honeydew production, *U. compositae* never attract greater number of ants unlike other aphid species on different crops, which are tended by ants depending on their density, in turn the honeydew providing capacity. This might be because of high degree of defensive behavior by aphids or due to composition of safflower sap which made honeydew less palatable. Ant species, *T. melacephalum* was more abundant in safflower field, followed by *C. Compressus* and

*Polyrhachis* sp. Relative abundance of *T. melanocephalum* was 46.09 per cent, which made them the most efficient honeydew sourcing ant species in the experimental site. Relative abundance of *C. compressus* and *Polyrhachis* sp. were 41.74 per cent and 12.17 per cent. Neves et al (2011) reports most of ant species tending *Uroleucon erigeronense* (Thomas) on shrub, *Baccharis dracunculifolia* (D.C.) belonged to the genus *Camponotus*. Billick et al (2007) found that, aphids, *Pleotrichopho rusutensis* (Pack and Knowlton) and *Uroleucon escalantii* (Knowlton) on *Chrysothamnus viscidiflorus* (Hooker) were occasionally tended by *Formica obscuripes* (Forel) (Hymenoptera: Formicidae) at field sites in central Colorado. In contrary, no ant species from *Formica* genus were recorded in this experiment. This variation in the ant species associated with aphids was due to presence of different species of ants, their differential foraging behavior and resource specificity in different geographical locations.

**Aphids and associated ants on other host plants:** Apart from safflower, different species of aphids and their tending ants on different host plants (Table 2) (Plate 8a and 8b). The aphids, *Pentalonia nigronevosa* Coquerel on banana, *Aphis croccivora* Koch on pigeonpea and *Aphis punicae* Passarini on pomegranate were tended by the ant, *C. compressus*. *Aphis spiraecola* Patch on siam weed and *Hysteroneura setariae* Thomas on deer tongue grass were tended by *Camponotus* sp. On finger millet, *H. setariae* was tended by *T. melanocephalum*. *A. croccivora* on cowpea, *A. spiraecola* on parthenium and *Aphis gossypii* Glover on chilly were tended by *Myrmica riabrunnea* Saunders. Rakhshan and Ahmad (2015) observed 11 species of aphidicolous ants were associated with *A. croccivora* on Fabaceae plants. The association of *C. compressus* and *M. bicolor* was greater on

**Table 2.** Species diversity of aphids and associated ants on other host plants

Host plant	Scientific name	Aphid species	Ant species	Location
Pigeon pea	<i>Cajanus cajana</i> (L.) Millsp.	<i>Aphis croccivora</i> Koch.	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India
Banana	<i>Musa acuminata</i> Colla.	<i>Pentalonia nigronevosa</i> Coquerel	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India
Pomegranate	<i>Punica granatum</i> L.	<i>Aphis punicae</i> Passarini	<i>Camponotus compressus</i> Fab.	College of Agriculture, Vijayapur, Karnataka, India
Parthenium	<i>Parthenium hysterophorus</i> L.	<i>Aphis spiraecola</i> Patch	<i>Myrmecaria brunnea</i> Saunders	Tiptur, Tumkur district, Karnataka, India
Ragi	<i>Eleusine coracana</i> L.	<i>Hysteroneura setariae</i> Thomas	<i>Tapinoma melanocephalum</i> Fab.	Tiptur, Tumkur district, Karnataka, India
Cowpea	<i>Vigna sinensis</i> L.	<i>Aphis croccivora</i> Koch.	<i>Myrmecaria brunnea</i> Saunders	Tiptur, Tumkur district, Karnataka, India
Chilly	<i>Capsicum annum</i> L.	<i>Aphis gossypii</i> Glover	<i>Myrmecaria brunnea</i> Saunders	Tiptur, Tumkur district, Karnataka, India
Siam weed	<i>Chromolaena odorata</i> L.	<i>Aphis spiraecola</i> Patch	<i>Camponotus</i> sp.	Tiptur, Tumkur district, Karnataka, India
Deer tongue grass	<i>Dichanthelium clandestinum</i>	<i>Hysteroneura setariae</i> Thomas	<i>Camponotus</i> sp.	College of Agriculture, Vijayapur, Karnataka, India



Ant removing the exuvium



Honeydew excretion by cow bug nymph



Ant guarding cow bug eggs



Ant tending cow bug nymphs

Plate 4: Different type of interaction between cow bugs and ants



*Camponotus* sp. ant tending *Oxyrhachis* sp.  
on acacia



*Camponotus compressus* tending *Leptocentrus* sp.  
on brinjal



*Camponotus compressus* tending *Otinotus* sp.  
on ber

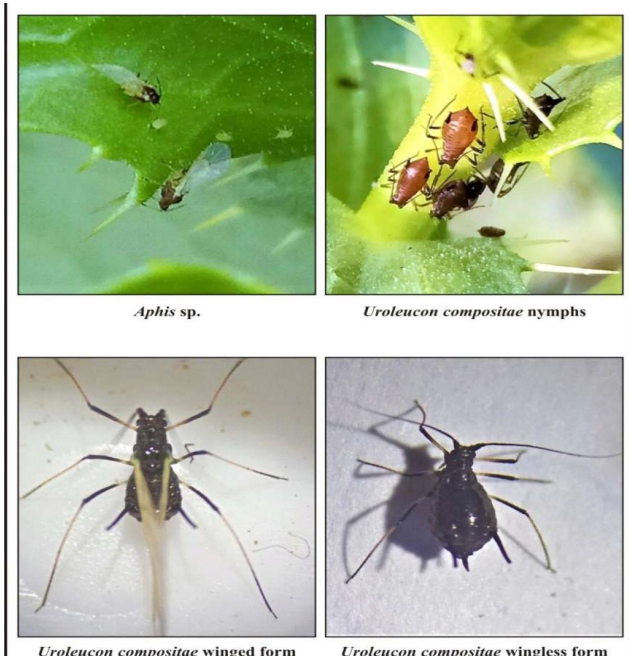


*Myrmecaria brunnea* tending *Leptocentrus* sp.  
on black nightshade plant



*Camponotus compressus* tending *Otinotus* sp.  
on parthenium

Plate 5: Cow bugs and ants association on other host plants



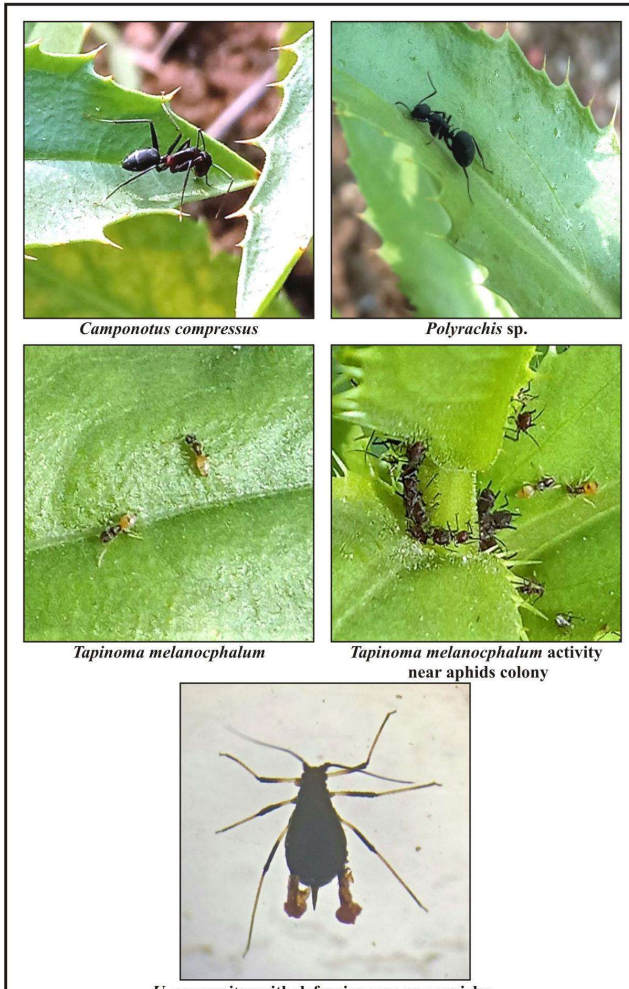
*Aphis* sp.

*Uroleuon compositae* nymphs

*Uroleuon compositae* winged form

*Uroleuon compositae* wingless form

Plate 6: Different species of aphids on safflower



*Camponotus compressus*

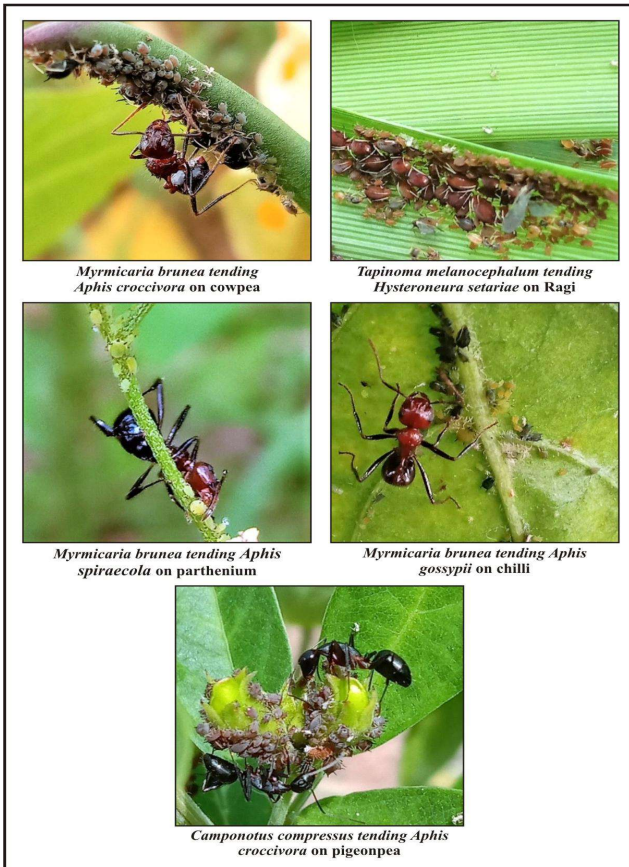
*Polyrachis* sp.

*Tapinoma melanocepalum*

*Tapinoma melanocepalum* activity near aphids colony

*U. compositae* with defensive wax on cornicles

Plate 7: Ants species associated with safflower aphid



*Myrmicaria brunea* tending *Aphis croccivora* on cowpea

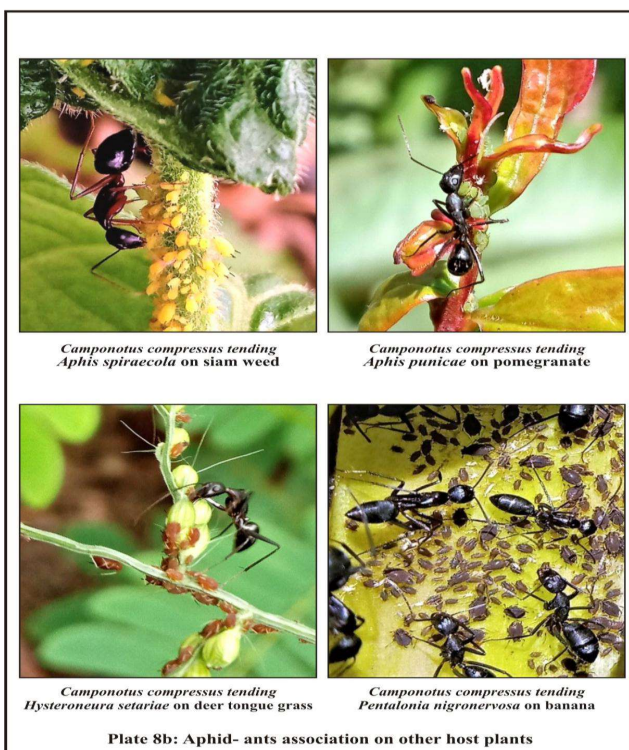
*Tapinoma melanocephalum* tending *Hysteroneura setariae* on Ragi

*Myrmicaria brunea* tending *Aphis spiraeicola* on parthenium

*Myrmicaria brunea* tending *Aphis gossypii* on chilli

*Camponotus compressus* tending *Aphis croccivora* on pigeonpea

Plate 8a: Aphid- ants association on other host plants



*Camponotus compressus* tending *Aphis spiraeicola* on siam weed

*Camponotus compressus* tending *Aphis punicae* on pomegranate

*Camponotus compressus* tending *Hysteroneura setariae* on deer tongue grass

*Camponotus compressus* tending *Pentalonis nigronervosa* on banana

Plate 8b: Aphid- ants association on other host plants



all host plants with *A. craccivora* than other aphids. Hosseini et al (2017) reported that aphid, *A. gossypii* was tended by ant, *T. erraticum*. Idechiil et al (2007) recorded ten ant species viz., *Anoplolepis gracilipes* Smith, *Camponotus reticulatus* Roger, *Cardiocon dylaemeryi* Forel, *Cardiocon dylawroughtonii* Forel, *Paratrechin abourbonica*, *Pheidole* sp., *T. melanocephalum*, *Technomyrmex albipes* Smith, *Technomyrmex* sp. And *Tetramorium bicarinatum* Nylander associated with *Pentalonia nigronervosa* Coquerel on banana (Musaceae), heliconia (Heliconiaceae), and ginger (Zingiberaceae). Three ant species viz., *Camponotus navigator* Wilson, *T. melanocephalum* and *Technomyrmex albipes* were associated with *H. setariae* on several species of grasses. *T. albipes* was observed with *A. gossypii* and a single *Tetraneura* sp. on okra. No ant attendance observed with colonies of *A. craccivora*. This huge difference in aphid-ant association because particular species of ant attending on a particular aphid species in one locality is not very often associated with the same species of aphid in other localities. *A. craccivora* on pigeonpea was attended by *C. compressus* in Vijayapur, while the same species on cowpea was attended by *M. brunnea* in Tumkur.

### CONCLUSION

In pigeonpea, three cow bug species were recorded namely, *Oxyrhachis apicalis*, *Leptocentrus* sp. and *Otinotus* sp. of which, *Otinotus* sp. was dominant species. All cow bugs were actively attended by one species of ant, *Camponotus compressus* Fab. In safflower, two aphid species were recorded viz., *Urolecon compositae* (Theobald) and *Aphis* sp and *U. compositae* was dominant species found feeding on all arial parts of safflower. *Aphis* sp. was found in only tiny patches feeding only on leaves. Three ants species found collecting honeydew from aphids by collecting honeydew fell on plant parts) viz., *C. compressus*, *Tapinoma melanocephalum* Fab. and *Polyrachis* sp.

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