

Ant–Aphid Relations in Costa Rica, Central America (Hymenoptera: Formicidae; Hemiptera: Aphididae)

by

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ABSTRACT

We present the first catalogue of ant-aphid associations (Hymenoptera: Formicidae / Hemiptera: Aphididae) of Costa Rica. 29 species of ants and 18 species of aphids establish 48 relationships. Those interactions seem not to be rare in Costa Rica.

Key words: Formicidae. ants, Aphididae. aphids, Costa Rica, Central America

RESUMEN

Se establece el primer catálogo homiga-pulgón (Hymenoptera: Formicidae / Hemiptera: Aphididae) de Costa Rica, que consta de 29 especies de hormigas y 18 de áfidos que establecen 48 relaciones. Se ofrecen datos sobre las especies citadas y se comenta la composición faunística.

PALABRAS CLAVE: Formicidae. Hormigas. Aphididae. Áfidos. Costa Rica. Centroamérica.

INTRODUCTION

The relationships of ants with Hemiptera in general, and with aphids in particular, have been treated in several aspects in many works since the 1950s (Way 1963; Hölldobler & Wilson 1990; Stadler & Dixon 2008). In the context of the study of the aphid fauna of Costa Rica, sixty-four aphid species (Hemiptera, Sternorrhyncha: Aphididae) were caught during 2008. The aphid catalogue consists now of 89 species (Villalobos *et al.* 2010; Pérez Hidalgo *et al.* 2012) and the list of “host plant species – aphid species”

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relationships was compiled by Voegtlin *et al.* (2003) and complemented by Villalobos *et al.* (2010), Sánchez-Monge *et al.* (2010) and Pérez Hidalgo *et al.* (2012). The aphid parasitoid fauna of Costa Rica has been recently reviewed by Zamora Mejías *et al.* (2010, 2011). Nevertheless, the association with others Arthropods, including ants, has not been suitably studied in Costa Rica. Here we attempt to provoke further field research by noting the scarcity of published accounts of aphid-ant associations in the Neotropics. As this short –but focused– field sampling study shows, aphid-ant associations are indeed frequent and deserve enhanced attention.

METHODS

We carried out two intensive aphid collection campaigns in February and December 2008, covering almost the entire territory, as well as other sporadic expeditions that year and in 2009. The aphids were mainly collected by prospecting the plants and they were studied in alcohol or in microscopic slides. They are now in the University of Leon Zoological Collection and in the University of Costa Rica (Centro de Biología Celular y Molecular) collection. The list of aphid species and plants is published in Villalobos *et al.* (2010).

The ants were identified using the excellent available keys, images and information at <http://academic.evergreen.edu/projects/ants/> and the recent revision of *Linepithema* by Wild (2007). Vouchers are in the Museum of Zoology of Barcelona and the personal collection of X.E.

We did an extensive search at FORMIS (2011) using as keywords: Colombia, Costa Rica, Guatemala, Honduras, Nicaragua, Panamá, or Venezuela AND aphids, áfidos, hemiptera, coccidae, mealybugs, pulgones, whiteflies, or leaf-, plant-, or tree-hoppers. In addition, general textbooks (Beattie 1985; Bristow 1991; Dixon 1998; Hölldobler & Wilson 1990; Rico-Gray & Oliveira 2007; Stadler & Dixon 2008 and reviews by Way (1963), Buckley (1987a, b), and Delabie (2001) were also specifically searched for Neotropical cases of aphid-ant interactions.

RESULTS

A total of 597 samples of aphids with colonies were studied, and only in 48 of them there were relations with ants (see Appendix).

Neotropical aphid-ant literature reports seem to be very scarce

Homoptera-ant relationships are highly diverse in the Neotropics but they concern mainly Auchenorrhyncha (treehoppers, mealybugs) and non-Aphididae Sternorrhyncha (scales). Aphid-ant relationships reports seem to be exceedingly scarce in Costa Rica and, by extension, in Central America. Kleinfeldt (1978) noted *Crematogaster longispina* tending unidentified homoptera on *Pentaclethra macroloba* (Willd.) Ktze. (Leguminosae) and on pejibaye (*Bactris utilis* Benth. and Hook; Palmae) and *Ectatomma ruidum* tending unidentified aphids on *Codonanthe crassifolia* (Focke) Morton (Gesneriaceae) in Costa Rica. Vergara *et al.* (2007) mention *Solenopsis geminata* and *Paratrechina* sp. tending unidentified Aphididae at the Arboretum of Medellín University (Colombia). Ramírez *et al.* (2001) in an extensive survey of deciduous forest fragments in Colombia, mention a single association, that of *Cerataphis* sp. with *Dolichoderus bispinosus*.

Delabie (2001) and Delabie & Fernández (2003), in a couple of very useful reviews of the biological intricacies of ant-Homoptera relationships, note the commonness of ant-attendance in temperate regions of the Northern hemisphere albeit fail to mention but a case of tropical (Asian) aphid-ant relationship, that of *Pseudoregma sundanica* (van der Goot, 1917) with several ant species (Schütze & Maschwitz 1991).

Here we have detected 48 aphid-ant associations involving 19 aphid species and 29 ant species. Therefore, the image we obtained seems to be in contrast with what is currently known.

On the specialist *vs.* generalist aphid-ant interactions

As a mere exploration of the interactions, the numbers of partners in each group (ants, aphids) was analyzed. The frequency distribution of cases in which the number of partners is 1, 2, etc. is marginally significant (Table 1; collapsing columns 4-9, Chi square = 7.4; 3 d.f.; $P = 0.0598$) between both insect groups. There is a highly biased general distribution towards one-to-one or few interactions. Thus, we detected 20 ant species interacting with a single aphid species, and 6 aphid species attended only by one ant species. Some species, though, are able to interact with many partners (8 or 9). Thus, *Solenopsis geminata* (black form) was detected attending eight aphid species and the polyphagous, world-wide distributed aphids *Aphis gossypii* and *Aphis*

Table 1. Frequency distribution of the number of aphid or ant species with different partners in Costa Rica (*Greenidea* not included).

Number of partners	1	2	3	4	5	6	7	8	9
Aphid species with number of partners	6	3	4	2	1	-	-	1	1
Ant species with number of partners	20	5	1	2	1	-	-	1	-

spiraecola were attended by nine and eight ant species respectively. We refrained from performing any nestedness analysis because of the small data base.

DISCUSSION

Scarcity of aphid-ant literature reports

Ants are ubiquitous everywhere in the Neotropics (Wilson 1990). Thus, the scarcity of aphid-ant interactions in this region is not for shortage of ants. Instead, this is attributable to the aphid component, either directly by the low number of aphids in the tropics or indirectly by the low density of their plant hosts (Bristow 1991; Dixon *et al.* 1987). Notwithstanding, as this note shows, there may be geographical areas in which aphid-ant relationships are not rare, thus calling for regular, and more focused, field surveys of ant-aphid interactions in the Neotropical region. A useful example to start from would be the revision of aphid-plant associations in Peru by Delfino (2005), where he notes 66 aphid species and 238 plant species. Nine of those aphid species were found in our survey as well. Peronti & Sousa-Silva (2002) listed 25 aphid species –mostly exotics– from 49 ornamental plant species in São Carlos, Brazil. The cosmopolite, polyphagous *Aphis gossypii* and *A. spiraecola* were the most abundant in their list.

In our aphid study the predominant aphid species (those most frequently captured) were *A. gossypii* and *A. spiraecola*, which likely have a stable extensive presence on a considerable number of plants all over the country. The nearctic species, *Aphis coreopsidis*, always on *Bidens pilosa*, present a strong relation with ants and *Aphis craccivora*, *Hysteroneura setariae*, *Myzus persicae* and *Toxoptera aurantii*, were also frequently captured, and, like the previously mentioned species, are alochthonous in Central America and distributed worldwide, feeding on a large range of plant species (Blackman & Eastop 2006). Most of the remaining aphid species were captured only once or very rarely. Nev-

ertheless, species that do not establish relations with ants, as *Myzus ornatus*, *Brachycaudus helichrysi*, *Neomyzus circumflexus* and *Aulacorthum solani* have been captured often in our study, which confirms the scanty relation that aphids, as a group, establish with the ants in this territory.

Specialist vs. generalist aphid-ant interactions

The results reported here contrast with the general non-specificity of aphid-ant interactions that is theoretically expected (Law & Koptur 1986), and usually accepted (Bristow 1991; Stadler & Dixon 2008). The current concept of ant-homoptera interactions is one of facultative mutualism (Letourneau & Choe 1987; Delabie & Fernández 2003) depending on scale of analysis, viz. at the level of individual trees (Gove & Rico-Gray 2006) or in the context of the presence/absence of extrafloral nectaries (Oliveira & Freitas 2004).

Of course, the most parsimonious hypothesis to explain the high abundance here detected of one-to-one species aphid-ant association, and vice versa, is one of defective sampling: our sample might be too small to show the expected trend towards a lack of specificity of the ant-aphid interactions. An alternative explanation would be that the pattern is genuine in Costa Rica but has been unattested for several reasons (scarcity of focused visits, or poor attention of aphid taxonomists visiting the Neotropics, or lack of expectancy to find those associations). The test of both hypotheses is straightforward: more aphid-ant determined field sampling, looking specifically for aphid-ant relations. Time will tell.

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REFERENCES

- Beattie, A.J. 1985. The evolutionary ecology of ant-plant mutualisms. Cambridge University Press, New York.
- Blackman, R.L.; V.F. Eastop 2006. Aphids on the World's Herbaceous Plants and Shrubs. John Wiley & Sons; London.

- Bristow, C.M. 1991. Why are so few aphids ant-tended? *In*: Ant-plant Interactions, C. R. Huxley and D. F. Cutler (eds.). Oxford University Press, Oxford: 104-119.
- Buckley, R.C. 1987a. Interactions involving plants, Homoptera, and ants. *Annual Review of Ecology and Systematics* 18: 111-135.
- Buckley, R.C. 1987b. Ant-plant-homopteran interactions. *Advances in Ecological Research* 16: 53-85.
- Delabie, J. & F. Fernández 2003. Capítulo 11. Relaciones entre hormigas y “Homópteros” (Hemiptera: Sternorrhyncha, Auchenorrhyncha). *En*: Fernández, F. (ed.). *Introducción a las hormigas de la región Neotropical*. IIRB Alexander von Humboldt, Bogotá, Colombia: 181-197.
- Delabie, J. H.C. 2001. Trophobiosis between Formicidae and Hemiptera (Sternorrhyncha and Auchenorrhyncha): an overview. *Neotropical Entomology* 30: 501- 516.
- Delfino, M.A. 2005. Inventario de las asociaciones áfido-planta en el Perú. Checklist of aphid-plant associations in Peru. *Ecología Aplicada* 4(1,2): 143-158.
- Dixon, A. F. G., P. Kindlmann, J. Leps, & J. Holman 1987. Why there are so few species of aphids, especially in the tropics? *American Naturalist* 129: 580–592.
- Dixon, A.F.G. 1998. *Aphid ecology*, 2nd. Edition. Chapman & Hall.
- FORMIS 2011. FORMIS: A Master Bibliography of Ant Literature. (at <http://www.ars.usda.gov/saa/cmave/ifahi/formis>; last accessed 3 February 2012).
- Gove, A.D. & V. Rico-Gray 2006. What determines conditionality in ant – Hemiptera interactions? Hemiptera habitat preference and the role of local ant activity. *Ecological entomology* 31: 568-574.
- Hölldobler, B. & E.O. Wilson 1990. *The ants*. Belknap Press; Harvard University Press.
- Kleinfeldt, S.E. 1978. Ant-gardens: the interaction of *Codonanthe crassifolia* (Gesneriaceae) and *Crematogaster longispina* (Formicidae). *Ecology* 59: 449-456.
- Law, R. & S. Koptur 1986. On the evolution of non-specific mutualisms. *Biological Journal of the Linnean Society* 27: 251-267.
- Letourneau, D.K. & J.C. Choe 1987. Homopteran attendance by wasps and ants: the stochastic nature of interactions. *Psyche* 94: 81-91.
- Oliveira, P.S. & A.V.L. Freitas 2004. Ant–plant–herbivore interactions in the neotropical cerrado savanna. *Naturwissenschaften* 91: 557-570.
- Pérez Hidalgo, N., D. Martínez-Torres, J.M. Collantes-Alegre, W. Villalobos Muller & J.M. Nieto Nafria 2012. A new species of *Rhopalosiphum* (Hemiptera: Aphididae) on *Chusquea tomentosa* (Poaceae: Bambusoideae) from Costa Rica. *Zookeys*, 166: 59-73. doi: 10.3897/zookeys.166.2387.
- Peronti, A.L.B. & C.R. Sousa-Silva 2002. Aphids (Hemiptera: Aphidoidea) of ornamental plants from São Carlos, São Paulo state, Brazil. *Revista de Biologia Tropical* 50(1): 137-144.
- Ramírez, M., P. Chacón de Ulloa, I. Armbrrecht & Z. Calle 2001. Contribución al conocimiento de las interacciones entre plantas, hormigas y homopteros en bosques secos de Colombia. *Caldasia* 23(2): 523-536.

- Rico-Gray, V. & P.S. Oliveira 2007. The ecology and evolution of ant-plant mutualisms. The University of Chicago Press.
- Schütze, M. & U. Maschwitz 1991. Enemy recognition and defense within trophobiotic associations with ants by the soldier caste of *Pseudoregma sundanica* (Homoptera: Aphidoidea). *Entomologia Generalis* 16: 1-12.
- Stadler, B. & A.F.G. Dixon 2008. Mutualism. Ants and their insect partners. Cambridge University Press, Cambridge.
- Vergara, E.V., H. Echavarría & F.J. Serna 2007. Hormigas (Hymenoptera Formicidae) asociadas al Arboretum de la Universidad Nacional de Colombia, sede Medellín. *Boletín Sociedad Entomológica Aragonesa* 40: 497–505.
- Sánchez-Monge, A., A. Retana-Salazar, S. Brenes & R. Agüero 2010. New records of aphid-plant associations (Hemiptera: Aphididae) from Eastern Costa Rica. *Florida Entomologist* 93(3): 489-492.
- Villalobos Muller W, N. Pérez Hidalgo, M.P. Mier Durante, & J.M. Nieto Nafría 2010. Aphididae (Hemiptera: Sternorrhyncha) from Costa Rica, with new records for Central America. *Boletín de la Asociación Española de Entomología* 34 (1-2): 145–182.
- Voegtlin, D., W. Villalobos, M.V. Sánchez, G. Saborío & C. Rivera 2003. Guía de los áfidos alados de Costa Rica / A guide to the winged aphids of Costa Rica. *Revista de Biología Tropical*, 51, suplemento 2, 1–214.
- Way, M.J. 1963. Mutualism between ants and honeydew-producing Homoptera. *Annual Review of Entomology* 8: 307-344.
- Wild, A.L. 2007. Taxonomic revision of the ant genus *Linepithema* (Hymenoptera: Formicidae). University of California Publications in Entomology 126: 1-159.
- Wilson, E.O. 1990. Success and dominance in ecosystems: the case of the social insects. *Excellence in ecology*, 2. Ecology Institute. Oldendorf/Luhe.
- Zamora Mejías, D., P.E. Hanson, & P. Starý 2010. Survey of the aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of Costa Rica, with information on their aphid (Hemiptera: Aphidoidea)-plant associations. *Psyche* 2010: Article ID 278643, 7 pp.
- Zamora Mejías, D., P.E. Hanson, P. Starý, & E. Rakhshani 2011. Parasitoid (Hym., Braconidae, Aphidiinae) complex of the black citrus aphid, *Toxoptera citricidus* (Kirkaldy) (Hem., Aphididae) in Costa Rica and its relationships to nearby areas. *Journal of the Entomological Research Society* 13(3): 107-115.

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APPENDIX

Ant-aphid-host plant catalogue

***Brachymyrmex santschii* Menozzi, 1927**

Myzocallis pepperi on *Quercus sapotifolia*, Frailes, 27-12-2008.

***Camponotus atriceps* (F. Smith, 1858)**

Cerataphis brasiliensis on *Chamaedorea costaricana*, San Pedro Montes de Oca, 27-12-2008.

***Camponotus novogranadensis* Mayr, 1870**

Aphis coreopsidis on *Bidens pilosa*, Cervantes, 5-12-2008.

Greenidea psidii on *Psidium* sp., San Pedro Montes de Oca, 21-12-2008.

This relation must be considered to be doubtful because in all the samples of this species recorded by us in Costa Rica (Pérez Hidalgo *et al.* 2009) we have never observed relations with ants. Probably the ants were attending to Coccidae who were present also in the same host plant.

***Camponotus planatus* Roger, 1863**

Aphis gossypii on *Thunbergia grandiflora*, San Pedro Montes de Oca, 7-12-2008.

***Camponotus rectangularis* Emery 1890**

Aphis craccivora on *Phaseolus vulgaris*, Filadelfia, 23-2-2008.

Myzocallis discolor (Monell, 1879) on *Quercus oleoides*, Liberia, 24-12-2008.

***Camponotus striatus* (F. Smith, 1862)**

Sitobion avenae on *Penisetum purpureum*, Nuevo Arenal, 24-12-2008.

***Camponotus textor* Forel, 1899**

Toxoptera aurantii on unidentifiable plant, Upala, 21-2-2008.

***Crematogaster carinata* Mayr, 1862**

Aphis gossypii on unidentifiable plant, La Fortuna, 21-2-2008.

Aphis spiraecola on *Senecio* sp., La Fortuna, 20-2-2008.

Toxoptera aurantii on unidentifiable plant, Sarapiquí, 25-12-2008.

***Crematogaster limata* F. Smith, 1858**

Aphis spiraecola on unidentifiable plant, Agua Buena, Cotobrus, 17-12-2008.

***Ectatomma ruidum* (Roger, 1861)**

Aphis gossypii on unidentifiable plant, Tronadora, 24-12-2008.

Hysteroneura setariae on unidentifiable Gramineae, Liberia, 22-12-2008. *Myzocallis discolor* on *Quercus oleoides*, Liberia, 22-12-2008. *Myzus persicae*, without data of host-plant, locality and date. *Rhopalosiphum maidis* on *Panicum* sp., Liberia, 24-12-2008.

***Ectatomma tuberculatum* (Olivier, 1792)**

Aphis spiraecola on unidentifiable plant, Monterrey, 21-2-2008; on *Iresine diffusa*, La Fortuna, 24-12-2008. *Pseudoregma panicola* on *Panicum* sp., La Fortuna, 24-12-2008.

***Linepithema angulatum* (Emery, 1849)**

Sarucallis kahawaluokalani on *Lagerstroemia indica*, San Francisco de Dos Rios, 27-12-2008.

***Linepithema iniquum* (Mayr, 1870)**

Aphis spiraecola on *Conyza canadensis*, Braulio Carrillo, 22-12-2008; on *Phenax rugosus*, San Pedro Montes de Oca, 5-12-2008.

***Linepithema neotropicum* Wild, 2007**

Aphis gossypii on *Commelina* sp., San Pedro Montes de Oca, 5-12-2008.

***Monomorium floricola* (Jerdon, 1851)**

Aphis craccivora on *Desmodium* sp., Platanera, 25-12-2008. *Myzocallis discolor* on *Quercus oleoides*, Liberia, 25-12-2008.

***Myrmelachista zeledoni* Emery, 1896**

Aphis spiraecola on *Phenax rugosus*, San Pedro Montes de Oca, 5-12-2008.

***Nylanderia steinbeili* (Forel, 1893)**

Toxoptera citricidus on *Crescentia cujete*, Sarapiquí, 25-12-2008.

***Paratrechina longicornis* (Latreille, 1802)**

Myzuspersicae on *Catharanthus roseus*, San Francisco de Dos Rios, 27-12-2008. *Sarucallis kahawaluokalani* on *Lagerstroemia indica*, San Francisco de Dos Rios, 27-12-2008.

***Pheidole bilimecki* Mayr, 1870**

Aphis coreopsidis on *Bidens pilosa*, San Pedro Montes de Oca, 7-12-2008. *Aphis gossypii* on *Thunbergiagrandiflora*, San Pedro Montes de Oca, 7-12-2008. *Aphis spiraecola* on *Bidens pilosa*, Agua Buena, Cotobrus, 18-12-2008. *Hysteroneura setariae* (Thomas, 1878) on *Eleusine indica*, San Pedro Montes de Oca, 24-2-2008 and 7-12-2008.

***Pheidole fallax* Mayr, 1870**

Aphis gossypii on unidentifiable plant, Santo Domingo de Heredia, 14-12-2008.

***Pheidole flavens* Roger, 1863**

Aphis gossypii on *Blechnum pyramidatum*, La Fortuna, 20-2-2008.

***Pheidole megacephala* (Fabricius, 1793)**

Cerataphis brasiliensis on *Chrysalidocarpus lutescens*, Alajuela, 6-12-2008.

***Pheidole pugnax* Dalla Torre, 1892**

Hysteroneura setariae on *Oplismenus burmannia*, Parque Nacional Santa Rosa, 23-12-2008.

***Pheidole punctatissima* Mayr, 1870**

Toxoptera aurantii on *Citrus* sp., Coronado, 28-12-2008.

***Pheidole variegata* Emery, 1896**

Aphis coreopsidis on *Bidens pilosa*, Frailes, 27-12-2008.

***Solenopsis geminata* Fabricius 1804 (black form)**

Aphis gossypii on unidentifiable plant, Tronadora, 24-12-2008. *Aphis spiraecola* on *Ixora* sp., Aguas Zarcas, San Carlos, 25-12-2008; on *Priva lappulacea*, Cahuita, 25-12-2008. *Hysteroneura setariae* on *Axonopus* sp., Estación Experimental 28 Millas, 26-12-2008. *Pentalonia nigronervosa* on *Musa* sp., Cahuita, 25-12-2008. *Rhopalosiphum maidis* on unidentifiable Gramineae, Upala, 21-2-2008; on *Penisetum purpureum*, Cahuita, 25-12-2008. *Schizaphis rotundiventris* *Cyperus* sp., Upala, 21-2-2008. *Tetraneura fusiformis* on *Eleusine indica*, La Fortuna, 21-2-2008. *Toxoptera citricidus* on *Citrus limetoides*, Sarapiquí, 25-12-2008.

***Solenopsis geminata* (yellow form)**

Aphis coreopsidis on *Bidens pilosa*, Cervantes, 5-12-2008.

Aphis craccivora Koch, 1854 on *Phaseolus vulgaris*, Filadelfia, 23-2-2008.

***Tetramorium bicarinatum* (Nylander, 1846)**

Rhopalosiphum maidis on *Penisetum purpureum*, Cahuita, 25-12-2008.

***Wasmannia auropunctata* (Roger, 1863)**

Aphis gossypii on *Commelina* sp., Sarapiquí, 25-12-2008. *Aphis spiraecola* on *Priva lappulacea*, Cahuita, 25-12-2008. *Cerataphis brasiliensis* on *Alpinia purpurata*, San José, 24-2-2008. *Hysteroneura setariae* on *Eleusine indica*, Sarapiquí, 25-12-2008.

***Wasmannia sigmoidea* (Mayr, 1884)**

Toxoptera aurantii, without data of host-plant, locality and date.

Aphid-ant catalogue***Aphis coreopsidis* (Thomas, 1878)**

Camponotus novogranadensis, *Pheidole bilimecki*, *Pheidole variegata*, *Solenopsis geminata* (yellow form)

***Aphis craccivora* Koch, 1854**

Camponotus rectangularis, *Monomorium floricola*, *Solenopsis geminata* (yellow form)

***Aphis gossypii* Glover, 1877**

Camponotus planatus, *Crematogaster carinata*, *Ectatomma ruidum*, *Linepithema neotropicum*, *Pheidole bilimecki*, *Pheidole fallax*, *Pheidole flavens*, *Solenopsis geminata* (black form), *Wasmannia auropunctata*

***Aphis spiraecola* Patch, 1914**

Crematogaster carinata, *Crematogaster limata*, *Ectatomma tuberculatum*, *Linepithema iniquum*, *Myrmelachista zeledoni*, *Pheidole bilimecki*, *Solenopsis geminata* (black form), *Wasmannia auropunctata*

***Cerataphis brasiliensis* (Hempel, 1901)**

Camponotus atriceps, *Pheidole megacephala*, *Wasmannia auropunctata*

***Greenidea psidii* van der Goot, 1916**

Camponotus novogranadensis (See comment on this ant species).

***Hysteroneura setariae* (Thomas, 1878)**

Ectatomma ruidum, *Pheidole bilimecki*, *Pheidole pugnax*, *Solenopsis geminata* (black form), *Wasmannia auropunctata*

***Myzocallis discolor* (Monell, 1879)**

Camponotus rectangularis, *Ectatomma ruidum*, *Monomorium floricola*

***Myzocallis pepperi* Boudreaux & Tissot, 1962**

Brachymyrmex santschii

***Myzus persicae* (Sulzer, 1776)**

Ectatomma ruidum, *Paratrechina longicornis*

***Pentalonia nigronervosa* Coquerel, 1859**

Solenopsis geminata (black form)

***Pseudoregma panicola* (Takahashi, 1921)**

Ectatomma tuberculatum

***Rhopalosiphum maidis* (Fitch, 1856)**

Ectatomma ruidum, *Solenopsis geminata* (black form), *Tetramorium bicarinatum*

***Sarucallis kahawaluokalani* (Kirkaldy, 1907)**

Linepithema angulatum, *Paratrechina longicornis*

***Schizaphis rotundiventris* (Signoret, 1860)**

Solenopsis geminata (black form)

***Sitobion avenae* (Fabricius, 1775)**

Camponotus striatus

***Tetraneura fusiformis* Matsumura, 1917**

Solenopsis geminata (black form)

***Toxoptera aurantii* (Boyer de Fonscolombe, 1841)**

Camponotus textor, *Crematogaster carinata*, *Pheidole punctatissima*,
Wasmannia sigmoidea

***Toxoptera citricidus* (Kirkaldy, 1907)**

Nylanderia steinheili, *Solenopsis geminata* (black form)