

## Article

# Promoting beneficial arthropods in urban agroecosystems: focus on flowers, Maybe not native plants

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## Supplementary Material

**Table S1.** List of ground-foraging spider, ladybeetle, bee and ant species encountered, abundance across all sites and years, and native status.

Species	No. indiv.	Native Status	Source
<b>ARANAE - SPIDERS</b>			
<i>Amaurobiidae</i> sp. 1	2	Likely Native	[66]
<i>Amaurobiidae</i> sp. 2	1	Likely Native	[66]
<i>Anyphaenidae</i> sp. 1	1	Unknown	[66]
<i>Araneidae</i> sp. 1	2	Unknown	[66]
<i>Araneidae</i> sp. 2	3	Unknown	[66]
<i>Caponiidae</i> sp. 1	7	Native	[66]
<i>Clubionidae</i> sp. 1	2	Unknown	[66]
<i>Clubionidae</i> sp. 2	1	Unknown	[66]
<i>Corinnidae</i> sp. 1	3	Unknown	[66]
<i>Corinnidae</i> sp. 2	1	Unknown	[66]
<i>Corinnidae</i> sp. 3	6	Unknown	[66]
<i>Corinnidae</i> sp. 4	1	Unknown	[66]
<i>Corinnidae</i> sp. 5	21	Unknown	[66]
<i>Cybaeidae</i> sp. 1	4	Likely Native	[66]
<i>Dictynidae</i> sp. 1	2	Likely Native	[66]
<i>Drassyllus</i> saphes	66	Native	[67]
<i>Dysdera</i> crocata	66	Not-Native	[66, 67]
<i>Hahnidae</i> sp. 1	2	Likely Native	[66]
<i>Linyphiidae</i> sp. 1	18	Likely Native	[66]
<i>Linyphiidae</i> sp. 2	3	Likely Native	[66]
<i>Linyphiidae</i> sp. 3	4	Likely Native	[66]
<i>Micaria</i> utahna	35	Native	[67]
<i>Miturgidae</i> sp. 1	3	Not-Native	[66]
<i>Miturgidae</i> sp. 2	1	Not-Native	[66]

<i>Nesticidae sp. 1</i>	41	Likely Native	[66]
<i>Nesticidae sp. 2</i>	60	Likely Native	[66]
<i>Nesticidae sp. 3</i>	1	Likely Native	[66]
<i>Oecobiidae sp. 1</i>	11	Unknown	[66]
<i>Oecobiidae sp. 2</i>	7	Unknown	[66]
<i>Oonopidae sp. 1</i>	1	Unknown	[66]
<i>Oxyopidae sp. 1</i>	1	Native	[66]
<i>Pardosa sierra</i>	976	Native	[67, 68]
<i>Pholcidae sp. 1</i>	2	Unknown	[66]
<i>Pholcidae sp. 2</i>	2	Unknown	[66]
<i>Pimoidae sp. 1</i>	2	Likely Native	[66]
<i>Pimoidae sp. 2</i>	1	Likely Native	[66]
<i>Salticidae sp. 1</i>	1	Unknown	[66]
<i>Salticidae sp. 2</i>	5	Unknown	[66]
<i>Salticidae sp. 3</i>	2	Unknown	[66]
<i>Schizocosa mccoocki</i>	8	Native	[67, 68]
<i>Theridiidae sp. 1</i>	5	Unknown	[66]
<i>Theridiidae sp. 2</i>	1	Unknown	[66]
<i>Thomisidae sp. 1</i>	1	Likely Native	[66]
<i>Thomisidae sp. 2</i>	1	Likely Native	[66]
<i>Trachyzelotes barbatus</i>	81	Not-Native	[67, 68]
<i>Urozelotes rusticus</i>	67	Not-Native	[66, 67]
<b>COLEOPTERA: COCCINELLIDAE - LADYBEETLES</b>			
<i>Adalia bipunctata</i>	1	Native	[64]
<i>Coccinella californica</i>	26	Native	[64]
<i>Coccinella septempunctata</i>	17	Not-Native	[64]
<i>Cycloneda munda</i>	14	Native	[52]
<i>Cycloneda polita</i>	9	Native	[64]
<i>Cycloneda sanguinea</i>	35	Native	[64]
<i>Harmonia axyridis</i>	91	Not-Native	[64]
<i>Hippodamia convergens</i>	91	Native	[64]
<i>Hyperaspis quadrioculata</i>	12	Native	[64]
<i>Hyperaspis sp. A</i>	2	Native	[65]
<i>Nephus binaevatus</i>	12	Not-Native	[64]
<i>Olla v-nigrum</i>	1	Native	[64]
<i>Psyllobora vigintimaculata</i>	1109	Native	[64]
<i>Scymnus cervicalis</i>	1	Native	[64]
<i>Scymnus coniferarum</i>	2	Native	[64]
<i>Scymnus marginicollis</i>	22	Native	[64]
<i>Scymnus nebulosus</i>	1	Native	[64]
<i>Scymnus sp. 1</i>	3	Native	[65]
<i>Scymnus sp. A</i>	5	Native	[65]

<i>Stethorus punctum</i>	112	Native	[64]
<b>HYMENOPTERA - BEES</b>			
<i>Agapostemon sp. A</i>	3	Likely Native	[61, 62]
<i>Agapostemon texanus</i>	150	Native	[61]
<i>Andrena sp. 1</i>	1	Likely Native	[62]
<i>Andrena sp. 2</i>	3	Likely Native	[62]
<i>Andrena sp. A</i>	1	Likely Native	[62]
<i>Anthidium manicatum</i>	2	Native	[62]
<i>Anthophora urbana</i>	7	Native	[62]
<i>Anthophora sp. 1</i>	2	Likely Native	[62]
<i>Anthophora sp. 2</i>	1	Likely Native	[62]
<i>Anthophora sp. A</i>	1	Likely Native	[62]
<i>Apis mellifera</i>	2544	Not-Native	[62]
<i>Ashmeadiella buconis</i>	6	Native	[61]
<i>Ashmeadiella sp. 1</i>	1	Native	[61]
<i>Bombus californicus</i>	1	Native	[62]
<i>Bombus caliginosus</i>	153	Native	[62]
<i>Bombus vosnesenskii</i>	224	Native	[62]
<i>Ceratina acantha</i>	70	Native	[61]
<i>Ceratina nanula</i>	27	Native	[62]
<i>Ceratina sequoiae</i>	1	Native	[62]
<i>Ceratina sp. 1</i>	21	Likely Native	[61, 62]
<i>Ceratina sp. 2</i>	10	Likely Native	[61, 62]
<i>Coelioxys rufitarsis</i>	2	Native	[62]
<i>Coelioxys sp. 1</i>	1	Likely Native	[62]
<i>Colletes sp. A</i>	7	Likely Native	[62]
<i>Diadasia sp. 1</i>	3	Native	[61]
<i>Dufourea sp. A</i>	1	Likely Native	[61]
<i>Eucera actiosa</i>	4	Native	[62]
<i>Eucera sp. A</i>	1	Likely Native	[62]
<i>Halictus confusus</i>	3	Native	[61]
<i>Halictus farinosus</i>	11	Native	[62]
<i>Halictus ligatus</i>	79	Native	[61]
<i>Halictus rubicundus</i>	4	Native	[62]
<i>Halictus tripartitus</i>	1328	Native	[61]
<i>Halictus sp. 1</i>	1	Native	[61]
<i>Halictus sp. 2</i>	4	Native	[61]
<i>Halictus sp. A</i>	4	Native	[61]
<i>Holcopasites sp. A</i>	1	Native	[62]
<i>Hylaeus leptcephalus</i>	21	Not-Native	[62]
<i>Hylaeus mesillae</i>	106	Native	[62]
<i>Hylaeus panamensis</i>	13	Native	[62]

<i>Hylaeus polifolii</i>	7	Native	[63]
<i>Hylaeus punctatus</i>	58	Not-Native	[63]
<i>Hylaeus rudbeckiae</i>	98	Native	[62]
<i>Hylaeus</i> sp. 1	34	Unknown	NA
<i>Hylaeus</i> sp. 2	3	Unknown	NA
<i>Hylaeus</i> sp. 3	2	Unknown	NA
<i>Hylaeus</i> sp. A	6	Unknown	NA
<i>Hylaeus</i> sp. B	1	Unknown	NA
<i>Hylaeus</i> sp. C	12	Unknown	NA
<i>Lasioglossum (Dialictus) incompletum</i>	1	Likely Native	[63]
<i>Lasioglossum (Dialictus) sp. A</i>	139	Likely Native	[62]
<i>Lasioglossum (Evylaeus) sp. A</i>	7	Likely Native	[62]
<i>Lasioglossum (Lasioglossum) sp. A</i>	39	Likely Native	[62]
<i>Lasioglossum</i> sp. 1	4	Likely Native	[62]
<i>Lasioglossum</i> sp. 2	3	Likely Native	[62]
<i>Lasioglossum</i> sp. 3	13	Likely Native	[62]
<i>Lasioglossum</i> sp. 4	1	Likely Native	[62]
<i>Lasioglossum</i> sp. 5	10	Likely Native	[62]
<i>Lasioglossum</i> sp. 6	7	Likely Native	[62]
<i>Lasioglossum</i> sp. 7	2	Likely Native	[62]
<i>Lasioglossum</i> sp. 8	2	Likely Native	[62]
<i>Lasioglossum</i> sp. 9	2	Likely Native	[62]
<i>Lasioglossum</i> sp. 10	1	Likely Native	[62]
<i>Lasioglossum</i> sp. 11	1	Likely Native	[62]
<i>Lasioglossum</i> sp. 12	4	Likely Native	[62]
<i>Lasioglossum</i> sp. 13	5	Likely Native	[62]
<i>Lasioglossum</i> sp. 14	111	Likely Native	[62]
<i>Lasioglossum</i> sp. 15	4	Likely Native	[62]
<i>Lasioglossum</i> sp. A	43	Likely Native	[62]
<i>Martinapis</i> sp. 1	1	Likely Native	[62]
<i>Megachile apicalis</i>	1	Not-Native	[63]
<i>Megachile brevis</i>	4	Native	[62]
<i>Megachile latimanus</i>	1	Native	[62]
<i>Megachile mendica</i>	1	Native	[62]
<i>Megachile perihirta</i>	30	Native	[61]
<i>Megachile relativa</i>	1	Native	[62]
<i>Megachile rotundata</i>	7	Not-Native	[61]
<i>Megachile</i> sp. 1	1	Unknown	NA
<i>Megachile</i> sp. 2	3	Unknown	NA
<i>Megachile</i> sp. 3	7	Unknown	NA
<i>Megachile</i> sp. 4	1	Unknown	NA
<i>Megachile</i> sp. 5	1	Unknown	NA

<i>Megachile sp. A</i>	1	Unknown	NA
<i>Megachile sp. B</i>	2	Unknown	NA
<i>Melissodes robustior</i>	100	Native	[61]
<i>Melissodes sp. 1</i>	27	Native	[61]
<i>Melissodes sp. 2</i>	2	Native	[61]
<i>Melissodes sp. A</i>	1	Native	[61]
<i>Melissodes sp. B</i>	8	Native	[61]
<i>Nomada edwardsii</i>	2	Native	[61]
<i>Nomada sp. A</i>	4	Likely Native	[62]
<i>Osmia sp. 1</i>	1	Likely Native	[62]
<i>Peponapis pruinosa</i>	7	Native	[61]
<i>Peponapis sp. A</i>	1	Native	[61, 62]
<i>Sphecodes sp. 1</i>	3	Unknown	NA
<i>Sphecodes sp. A</i>	3	Unknown	NA
<i>Svastra aegis</i>	2	Native	[61]
<i>Xylocopa tabaniformis</i>	36	Native	[61]
<i>Xylocopa varipuncta</i>	47	Native	[62]
Unknown Unknown	4	Unknown	NA
<b>HYMENOPTERA: FORMICIDAE - ANTS</b>			
<i>Cardiocondyla mauritanica</i>	123	Not-Native	[69]
<i>Formica moki</i>	1	Native	[69]
<i>Hypoponera opacior</i>	106	Native	[69]
<i>Linepithema humile</i>	369	Not-Native	[59]
<i>Nylanderia vividula</i>	36	Not-Native	[59]
<i>Prenolepis imparis</i>	5	Native	[69]
<i>Tapinoma sessile</i>	11	Native	[69]
<i>Tetramorium caespitum</i>	75	Not-Native	[59]

14

15

16

**Table S2.** List of all native plant species encountered in urban community gardens in the California central coast, and their relative abundance as a fraction of total and native plant species cover.

Family	Genus	Species	Species or morphospecies or common name	% of total native cover	% of all plant cover
Amaranthaceae	<i>Amaranthus</i>	<i>palmeri</i>	Pigweed	3.57	0.09
Apocynaceae	<i>Asclepias</i>	<i>fascicularis</i>	Milkweed	0.22	0.01
Asteraceae	<i>Achillea</i>	<i>millefolium</i>	Yarrow	5.58	0.14
Asteraceae	<i>Cirsium</i>	<i>douglasii</i>	Thistle	1.34	0.03
Asteraceae	<i>Erigeron</i>	<i>canadensis</i>	Horseweed	1.23	0.03
Asteraceae	<i>Helianthus</i>	<i>annuus</i>	Sunflower	39.04	0.99
Asteraceae	<i>Matricaria</i>	<i>discoidea</i>	Pineapple weed	0.17	0.00
Boraginaceae	<i>Phacelia</i>	<i>sp.</i>	Scorpionweed	1.67	0.04
Boraginaceae	<i>Plagiobothrys</i>	<i>sp.</i>	Popcorn flower	2.51	0.06
Brassicaceae	<i>Cardamine</i>	<i>oligosperma</i>	Popweed	0.17	0.00
Brassicaceae	<i>Nasturtium</i>	<i>officinale</i>	Watercress	1.51	0.04
Equisetaceae	<i>Equisetum</i>	<i>sp.</i>	Horsetail	0.84	0.02
Lamiaceae	<i>Salvia</i>	<i>mellifera</i>	Black sage	1.56	0.04
Montiaceae	<i>Claytonia</i>	<i>sp.</i>	Miner's lettuce	0.11	0.00
Onagraceae	<i>Clarkia</i>	<i>sp.</i>	Clarkia	0.73	0.02
Onagraceae	<i>Epilobium</i>	<i>sp.</i>	Fireweed	3.90	0.10
Orobanchaceae	<i>Castilleja</i>	<i>exserta</i>	Owl's clover	0.06	0.00
Papaveraceae	<i>Eschscholzia</i>	<i>californica</i>	California poppy	28.56	0.72
Pteriadaceae	<i>Adiantum</i>	<i>sp.</i>	Maiden-hair fern	0.11	0.00
Ranunculaceae	<i>Delphinium</i>	<i>sp.</i>	Larkspur	7.14	0.18

**Table S3.** Model output from GLMM (bees and ladybeetles) and GLM (spiders and ants) models testing relationships between arthropod and native arthropod abundance and richness and local and landscape features of urban agroecosystems.

Dependent variable	Model reported	Predictor Variables in Model	No. of models	Estimate	z or t score*	p-value
LNBeIndiv	best	(Intercept)	1	4.956	14.728	<0.001
		LNGardenSize	1	0.297	3.719	<0.001
LNNumNativeLikelyNativeBeeIndiv	average	(Intercept)	4	4.301	11.937	<0.001
		LNGardenSize	2	0.303	2.349	0.019
		LNNumNativePlantSpp	2	-0.392	1.601	0.1094
LNNumNativeBeeIndiv	best	(Intercept)	4	4.154	9.023	<0.001
		LNGardenSize	2	0.333	2.351	0.018
		LNNumNativePlantSpp	2	-0.475	1.777	0.076
NumNonNativeBeeIndiv	average	(Intercept)	2	3.737	7.421	<0.001
		Natural2km	2	0.016	4.176	<0.001
		LNGardenSize	1	0.203	2.235	0.0254
NumBeeSpp	average	(Intercept)	3	15.21	6.296	<0.001
		LNGardenSize	3	2.056	2.987	0.003
		LNNumNativePlantSpp	1	-0.81	0.627	0.53
		LNNumTreesShrubs	1	0.074	0.122	0.903
NumNativeLikelyNativeBeeSpp	average	(Intercept)	2	12.008	6.05	<0.001
		LNGardenSize	2	1.806	3.338	<0.001
		LNNumNativePlantSpp	1	-0.554	0.542	0.587
NumNativeBeeSpp	average	(Intercept)	2	8.135	3.946	<0.001
		LNGardenSize	2	1.525	3.007	0.003
		LNNumNativePlantSpp	1	-0.009	0.01	0.992
NumNonNativeBeeSpp	best	(Intercept)	1	0.461	2.236	0.175
LNNumLBIndiv	average	(Intercept)	2	3.566	13.268	<0.001
		Natural2km	1	-0.018	3.124	0.002
LNNumNativeLBIndiv	best	(Intercept)	1	3.3695	17.15	<0.001
LNNonNativeLBIndiv	best	(Intercept)	1	1.132	8.333	0.013
NumLBSpp	average	(Intercept)	3	4.614	4.28	<0.001
		LNNumTreesShrubs	3	1.038	3.393	<0.001
		Natural2km	3	-0.061	3.987	<0.001
		LNNumNativePlantSpp	1	-0.482	0.787	0.431
		LNNumFlowers	1	-0.391	1.195	0.231
NumNativeLBSpp	average	(Intercept)	3	3.963	5.736	<0.001
		LNNumTreesShrubs	2	0.558	1.885	0.059
		Natural2km	1	-0.042	3.28	0.001
		LNNumNativePlantSpp	1	-0.041	0.074	0.941
NonNativeLBSpp	best	(Intercept)	1	1.0811	8.271	0.032

26  
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28

LNNumSpiders	average	(Intercept)	6	3.655	4.816	<0.001
		LNGardenSize	2	0.477	1.684	0.092
		LNNumFlowers	2	0.216	1.244	0.214
		Mulch1m	1	-0.018	1.263	0.207
		Natural2km	1	0.011	0.917	0.359
LNNumNativeLikelyNativeSpiders	average	(Intercept)	5	3.529	6.063	<0.001
		Mulch1m	2	-0.029	1.529	0.126
		LNGardenSize	1	0.446	1.195	0.232
		Natural2km	1	0.015	1.017	0.309
LNNumNativeSpiders	average	(Intercept)	3	2.961	5.06	<0.001
		Natural2km	1	0.021	1.195	0.232
		Mulch1m	1	-0.02	0.869	0.385
NonNativeSpiderIndiv	best	(Intercept)	1	-6.057	-0.795	0.438
		LnNumFlowers	1	3.488	2.395	0.028
NumSpiderSpp	average	(Intercept)	2	1.739	6.135	<0.001
		LNNumFlowers	2	0.123	2.344	0.019
		LNGardenSize	1	0.127	1.299	0.194
NumNativeLikelyNativeSpiderSpp	average	(Intercept)	2	1.473	3.933	<0.001
		LNNumFlowers	1	0.099	1.434	0.151
NumNativeSpiderSpp	average	(Intercept)	5	1.804	2.068	0.039
		Natural2km	2	0.022	1.531	0.126
		LNNativePlantSpp	2	-1.459	2.036	0.042
		LNNumFlowers	2	0.474	1.988	0.047
		LNNumTreesShrubs	1	0.405	1.407	0.159
NonNativeSpiderSpp	average	(Intercept)	2	0.321	0.429	0.66
		LNGardenSize	2	0.903	4.1	<0.001
		LNNumTreesShrubs	1	0.3	2.038	0.041
		Mulch1m	2	0.023	2.053	0.04
		LNNumFlowers	2	0.279	2.403	0.016
NumAntOccur	average	(Intercept)	3	3.562	44.037	<0.001
		Mulch1m	1	0.004	1.888	0.059
		LNNumTreesShrubs	1	0.054	1.484	0.138
NumNativeAntOccur	best	(Intercept)	1	1.477	7.341	<0.001
		Natural2km	1	0.017	2.478	0.024
LNNumNonNativeAntOccur	average	(Intercept)	5	3.509	14.488	<0.001
		LNNumFlowers	2	-0.071	1.419	0.156
		Mulch1m	2	0.005	1.296	0.195
		Natural2km	1	-0.003	0.922	0.356
NumAntSpp	best	(Intercept)	1	3.579	12.82	<0.001
NumNativeAntSpp	best	(Intercept)	1	1.421	8.945	<0.001

NumNonNativeAntSpp	average	(Intercept)	3	2.401	4.234	<0.001
		LNNumFlowers	1	-0.16	1.067	0.286
		Natural2km	1	-0.009	0.847	0.397
NumLinepithema.humile	average	(Intercept)	3	17.507	3.773	<0.001
		LNNumTreesShrubs	1	3.074	1.408	0.159
		LNGardenSize	1	-2.503	0.897	0.370
NumHarmonia.axyridis	average	(Intercept)	2	1.247	5.922	<0.001
		Natural2km	2	-0.015	2.507	0.012
		Mulch1m	1	-0.007	1.014	0.310

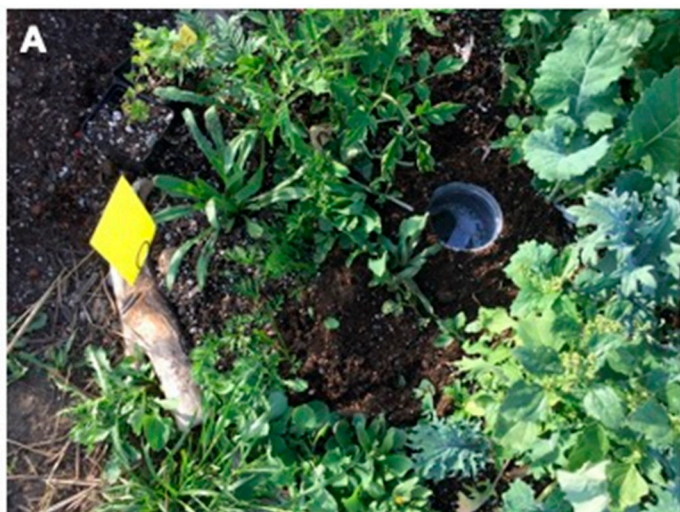
\* z-score for averaged models, t-score for best models

29

30

31

**Figure S1.** Photo of a sticky trap and a pitfall trap before placing the cover (A) and a pitfall trap with the green plastic plate cover (B) in urban garden study sites.



34

35

36

**Figure S2.** Significant relationships between abundance of the non-native ladybug species *Harmonia axyridis* and one landscape factor (natural habitat cover within 2 km) in urban gardens in the California Central Coast. The relationship is significant at  $P=0.012$ .

