Complex Habitats Boost Predator Co-Occurrence, Enhancing Pest Control in Sweet Pepper Greenhouses

Habitat-level environmental complexity increases co-occurrences between natural and introduced predators in sweet peppers under protected environments with a positive effect on pest regulation

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Study system

Annual community's habitat comprised *Tuberarietea guttatae* Br.-Bl. 1952 em. Rivas-Martínez 1978, *Trachynietalia distachyae* Rivas-Martínez 1978, *Trachynion distachyae* (calciphile), *Sedo-Ctenopsion* (gypsophile), and *Omphalodion commutatae* (dolomitic and silico-basiphile), with species in these alliances including *Dactylis hispanica*, *Asphodelus ramosus*, *Anthyllis vulneraria*, *Carlina corymbosa*, *Sedum sediforme*, *Reichardia picroides*, *Phlomis lychnitis*, and *Venula bromoides*.

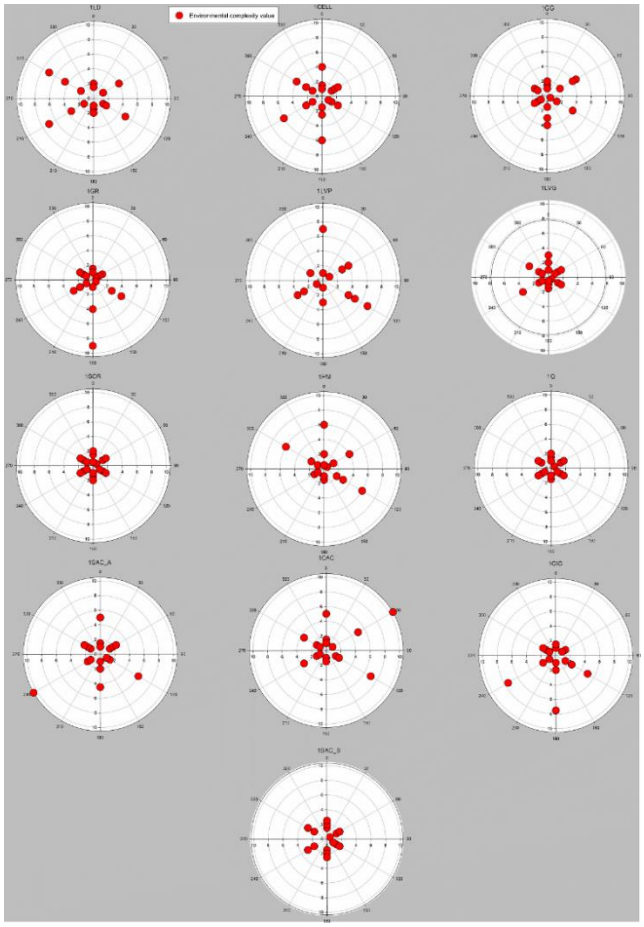

Figure S1. Example for 2020 to calculate the environmental complexity values (ECVs) in the various coordinates analyzed for each site. The ECV values ranged from a minimum of 0.5 to a maximum of 10.5.

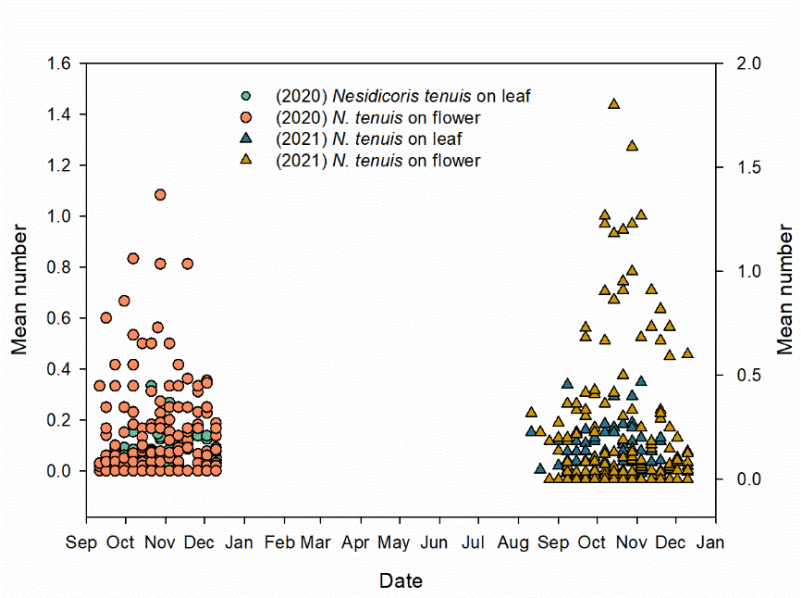

Figure S2. Weekly mean of *Nesidiocoris tenuis* on leaf and flower (2020 left, 2021 right). The figures represent juveniles and adults in leaf or flower.

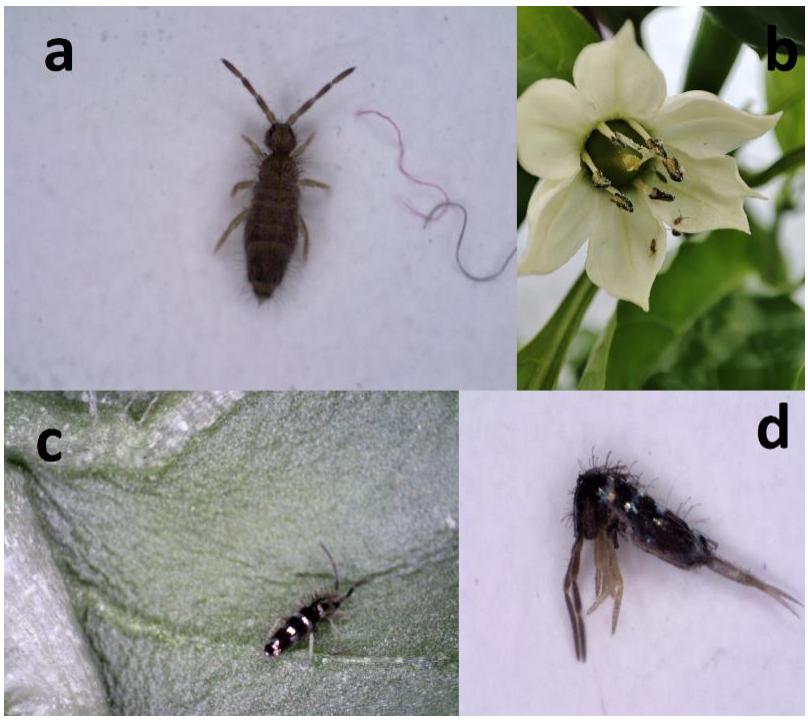

Figure S3. a) Entomobrya sp (Fam. Entomobryidae: Entomobryinae); b) Springtails *Entomobrya* sp. on pepper flower; c) *Seira* sp. (Fam. Entomobryidae: Seirinae); d) Lateral view of *Seira* sp.

Table S1. Means, standard deviation at different sites. *Orius laevigatus*, *Nesidiocoris tenuis*, *Amblyseius swirskii* and WFT at different sites are the total of juveniles and adults for each flower

		2020			2021		
Site	Species	Mean (2020)	Std. Error	N	Mean (2021)	Std. Error	N
1CAC	*Amblyseius swirskii*	0.45	0.071	576	0,08	0.023	672
	WFT	0.70	0.29	576	0.39	0.036	672
	Orius laevigatus	0.29	0.024	576	0.55	0.029	670
	Nesidiocoris tenuis	0.38	0.030	576	0.09,	0.013	672
1CEL	*Amblyseius swirskii*	0.30	0.067	429			
	WFT	0.55	0.071	429			
	Orius laevigatus	0.61	0.038	428			
	Nesidiocoris tenuis	0.06	0.013	429			
1GG	*Amblyseius swirskii*	0.58	0.11	263	0.30	0.07	330
	WFT	0.95	0.082	264	1.03	0.086	330
	Orius laevigatus	0.40	0.038	264	0.30	0.027	329
	Nesidiocoris tenuis	0.07	0.017	263	0.61	0.051	329
1GIG	*Amblyseius swirskii*	0.53	0.123	195	1.64	0.279	135
	WFT	0.25	0.052	195	0.25	0.056	135
	Orius laevigatus	0.98	0.073	195	0.42	0.056	135
	Nesidiocoris tenuis	0.21	0.044	195	0.0	0.0	135
1GR	*Amblyseius swirskii*	0.79	0.171	169			
	WFT	0.72	0.092	169			

	Orius laevigatus	0.47	0.052	169			
	Nesidiocoris tenuis	0.10	0.025	169			
1LD	*Amblyseius swirskii*	2.96	0.20	754			
	WFT	0.87	0.054	754			
	Orius laevigatus	0.19	0.017	754			
	Nesidiocoris tenuis	0.14	0.015	754			
1LVG	*Amblyseius swirskii*	0.30	0.054	462	0.12	0.06	297
	WFT	1.83	0.104	462	1.46	0.101	297
	Orius laevigatus	0.25	0.028	462	0.21	0.027	297
	Nesidiocoris tenuis	0.08	0.015	462	0.09	0.019	297
1LVP	*Amblyseius swirskii*	0.16	0.053	168	0.09	0.031	180
	WFT	1.99	0.198	168	1.38	0.133	180
	Orius laevigatus	0.22	0.035	168	0.37	0.045	180
	Nesidiocoris tenuis	0.38	0.047	168	0.28	0.041	180
1PM	*Amblyseius swirskii*	1.35	0.106	650	0.29	0.052	700
	WFT	1.53	0.071	650	0.54	0.0425	700
	Orius laevigatus	0.11	0.012	650	0.29	0.052	700
	Nesidiocoris tenuis	0.02	0.028	650	0.54	0.0425	700
1Q	*Amblyseius swirskii*	0.61	0.096	364	0.57	0.094	392
	WFT	2.72	0.158	364	1.60	0.111	392
	Orius laevigatus	0.20	0.029	364	0.32	0.027	392

	Nesidiocoris tenuis	0.01	0.05	364	0.01	0.0044	392
1SAC_A	*Amblyseius swirskii*	0.07	0.046	156	0.12	0.054	156
	WFT	0.38	0.065	156	1.12	0.121	156
	Orius laevigatus	0.67	0.070	156	0.30	0.045	156
	Nesidiocoris tenuis	0.25	0.048	156	0.01	0.090	156
1SAC_S	*Amblyseius swirskii*	0.31	0.071	260	0.11	0.044	180
	WFT	1.36	0.118	260	1.64	0.134	180
	Orius laevigatus	0.37	0.036	260	0.12	0.025	180
	Nesidiocoris tenuis	0.02	0.009	260	0.00	0.00	180
1SOR	*Amblyseius swirskii*	,18	0.052	336	0.27	0.71	392
	WFT	2.12	0.156	336	0.06	0.060	392
	Orius laevigatus	0.13	0.020	335	0.26	0.026	392
	Nesidiocoris tenuis	0.02	0.009	336	0.04	0.010	392
1 COST	*Amblyseius swirskii*				0.32	0.074	322
	WFT				0.96	0.084	322
	Orius laevigatus				0.32	0.032	319
	Nesidiocoris tenuis				0.12	0.02	319
1MANB	*Amblyseius swirskii*				0.83	0.132	240
	WFT				0.31	0.046	240
	Orius laevigatus				0.07	0.022	240
	Nesidiocoris tenuis				0.70	0.064	240

1MANP	*Amblyseius swirskii*				0.34	0.077	352
	WFT				0.74	0.065	352
	Orius laevigatus				0.24	0.025	351
	Nesidiocoris tenuis				0.44	0.041	351
TOTAL	*Amblyseius swirskii*	0.93	0.041	4782	0.33	0.021	4348
	WFT	1.25	,0.028	4782	0.856	0.022	4348
	Orius laevigatus	0.31	0.009	4782	0.338	0.088	4348
	Nesidiocoris tenuis	0.12	0.006	4782	0.17	0.079	4348

Table S2. Pearson correlation matrix for monitored sites. WFT (western fly thrips), *Orius laevigatus*, *Amblyseius swirskii* and *Nesidiocoris tenuis* at different sites are the total of juveniles and adults for each flower.

2020	**WFT**	***A. swirskii***	***O. laevigatus***	***N. tenuis***	**2021**	**WFT**	***A. swirskii***	***O. laevigatus***	***N. tenuis***
All sites					**All sites**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.074**	**1**			*A. swirskii*	-0.039*	**1**		
O. laevigatus	-0.185**	-0.086**	**1**		*O. laevigatus*	-0.251**	-0.091**	**1**	
N. tenuis	-0.107**	-0.013	-0.027	**1**	*N. tenuis*	-0.087**	-0.008	-0.036*	**1**
1CAC					**1CAC**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.042	**1**			*A. swirskii*	-0.03	**1**		
O. laevigatus	-0.111**	-0.054	**1**		*O. laevigatus*	-0.23**	-0.08*	**1**	
N. tenuis	-0.123**	0.010	-0.084*	**1**	*N. tenuis*	-0.048	-0.03	0.062	**1**
1CELL					**1COST**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.011	**1**			*A. swirskii*	-0.071	**1**		
O. laevigatus	-0.184**	-0.034	**1**		*O. laevigatus*	-0.25**	0.015	**1**	
N. tenuis	-0.103*	0.039	-0.02	**1**	*N. tenuis*	-0.101	0.038	0.006	**1**
1GG					**1GG**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.026	**1**			*A. swirskii*	-0.049	**1**		
O. laevigatus	-0.153*	-0.088	**1**		*O. laevigatus*	-0.306**	-0.093	**1**	
N. tenuis	-0.097	-0.147*	-0.050	**1**	*N. tenuis*	-0.201**	0.015	-0.024	**1**
1GIG					**1GIG**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.040	**1**			*A. swirskii*	-0.09	**1**		
O. laevigatus	-0.201**	-0.117	**1**		*O. laevigatus*	-0.162	-0.235**	**1**	
N. tenuis	0.048	-0.056	-0.159*	**1**	*N. tenuis*				**1**
1GR					**1MANB**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.226**	**1**			*A. swirskii*	-0.169**	**1**		
O. laevigatus	-0.265**	-0.067	**1**		*O. laevigatus*	-0.074	-0.13	**1**	
N. tenuis	-0.096	-0.12	-0.11	**1**	*N. tenuis*	-0.177**	-0.149**	-0.06	**1**
1LD					**1MANP**				

WFT	**1**				WFT	**1**			
A. swirskii	-0.126**	**1**			*A. swirskii*	-0.07	**1**		
O. laevigatus	-0.117**	-0.139**	**1**		*O. laevigatus*	-0.218**	0.095	**1**	
N. tenuis	-0.101**	-0.026	0.031	**1**	*N. tenuis*	-0.043	-0.017	-0.017	**1**
1LVG					**1LVG**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.057	**1**			*A. swirskii*	-0.083	**1**		
O. laevigatus	-0.147**	-0.051	**1**		*O. laevigatus*	-0.234**	-0.045	**1**	
N.tenuis	-0.13**	0.037	0.027	**1**	*N. tenuis*	-0.135*	-0.33	0.118*	**1**
1LVP					**1LVP**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.091	**1**			*A. swirskii*	0.092	**1**		
O. laevigatus	-0.192*	0.077	**1**		*O. laevigatus*	-0.329**	-0.133	**1**	
N. tenuis	-0.197*	-0.117	-0.257**	**1**	*N. tenuis*	-0.152*	0.036	0.055	**1**
1PM					**1PM**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.048	**1**			*A. swirskii*	0.17**	**1**		
O. laevigatus	-0.058	0.05	**1**		*O. laevigatus*	-0.289**	-0.144**	**1**	
N. tenuis	0.018	-0.036	-0.04	**1**	*N. tenuis*	-0.053	-0.003	0.053	**1**
1Q					**1Q**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.116*	**1**			*A. swirskii*	-0.108**	**1**		
O. laevigatus	-0.159*	0.026	**1**		*O. laevigatus*	-0.32**	-0.09	**1**	
N. tenuis	-0.052	-0.030	-0.033	**1**	*N. tenuis*	-0.024	-0.027	-0.042	**1**
1SAC_A					**1SAC_A**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.059	**1**			*A. swirskii*	-0.089	**1**		
O. laevigatus	-0.191*	-0.111	**1**		*O. laevigatus*	-0.269**	-0.093	**1**	
N. tenuis	0.0	-0.052	-0.014	**1**	*N. tenuis*	-0.009	-0.02	-0.061	**1**
1SAC_S					**1SAC_S**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.082	**1**			*A. swirskii*	**0.038**	**1**		
O. laevigatus	-0.214**	0.057	**1**		*O. laevigatus*	-0.169**	0.018	**1**	
N. tenuis	-0.056	0.229**	-0.052	**1**	*N. tenuis*				**1**
1SOR					**1SOR**				
WFT	**1**				WFT	**1**			
A. swirskii	-0.086	**1**			*A. swirskii*	-0.063	**1**		
O. laevigatus	-0.171**	0.060	**1**		*O. laevigatus*	-0.197**	-0.077	**1**	
N. tenuis	-0.051	0.034	0.006	**1**	*N. tenuis*	-0.45	0.041	-0.013	**1**

*P<0.05 - **P<0.01