Supplementary material

Top-down and bottom-up regulation of codling moth populations in cider apple orchards

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Appendix A. Study area

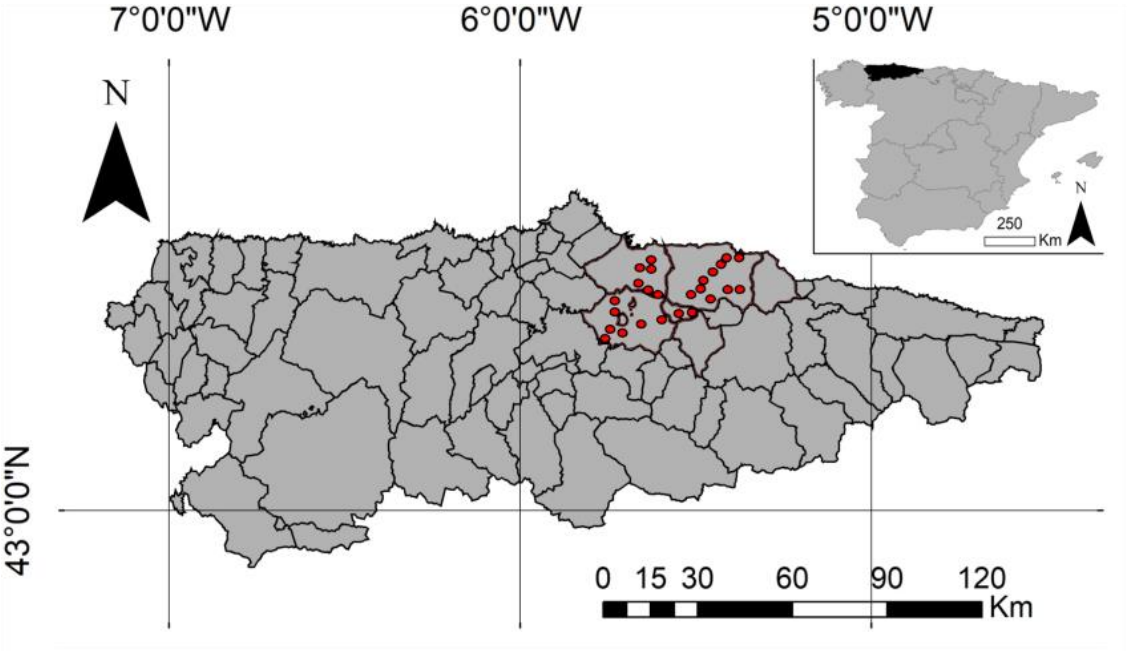

Figure A1. Study area. Inset shows location within Spain of Asturias region. Larger image shows Asturias, with the cider-apple orchards selected for this study depicted as red spots.

Appendix B. Details of cardboard trap experiment

Figure B1. Cardboard trap positioned below the first branch and 40 cm above the ground. Image by Daniel García.

Appendix C. Codling moth abundance, crop damage and parasitism rate between years

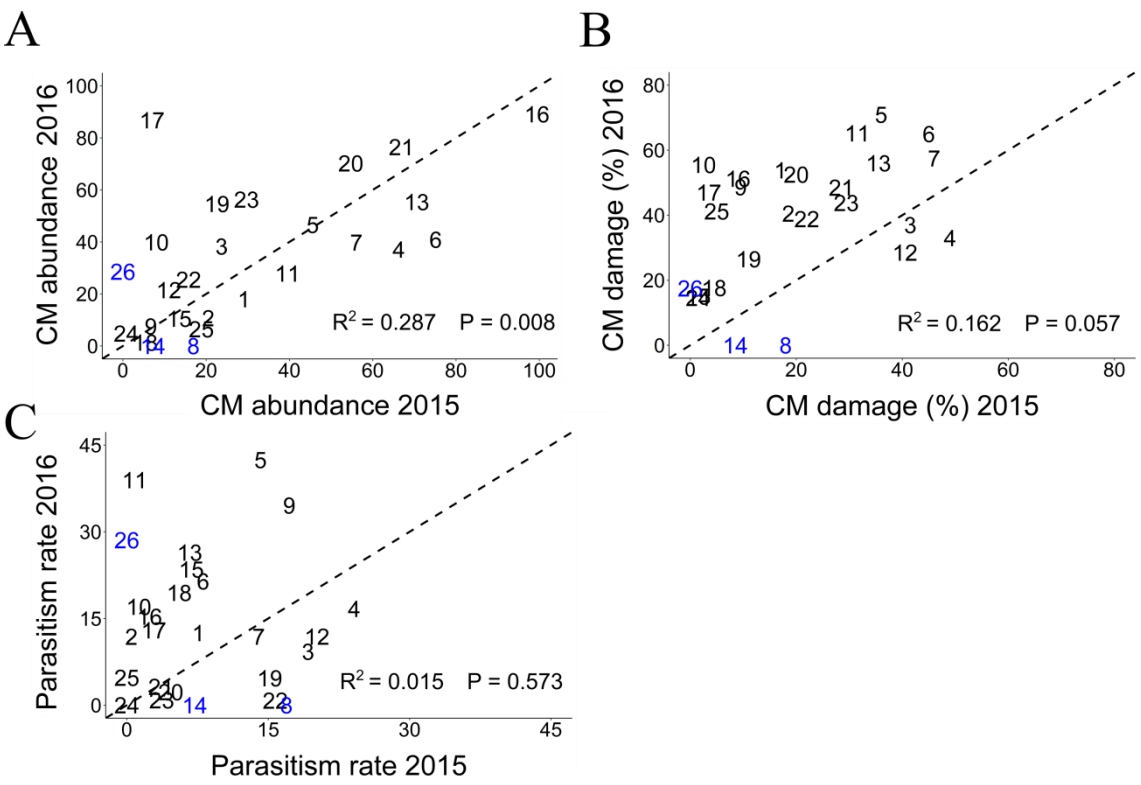

Figure C1. Relationship between the average of codling moth abundance per cardboard trap (A), codling moth damage (B) and parasitism rate (C) in the 26 cider apple orchards studied in 2015 and 2016 (black numbers: cider apple orchards sampled in both years; blue numbers: cider apple orchards sampled in only one year). Coefficient of determination and significance level from correlation tests between years are also shown. The dashed lines represent bisectors.

Appendix D. CM abundance, CM damage and number of parasitized larvae across years and orchards

Table D1. Differences in CM abundance, CM damage, number of parasitized larvae and parasitoid richness across years and orchards. T-tests were performed on CM abundance, CM damage and number of parasitized larvae to compare between years. Kruskal-Wallis tests were performed on CM abundance and CM damage among orchards. A Wilcoxon test was performed on parasitoid richness between years.

	Variable	Df	Statistical test value	p-value
CM abundance	Year	22	t = -0.791	0.437
	Orchard (2015)	24	χ^2 = 166.600	<0.001
	Orchard (2016)	22	χ^2 = 159.230	<0.001
CM damage	Year	22	t = -5.955	<0.001
	Orchard (2015)	24	χ^2 = 178.230	<0.001
	Orchard (2016)	22	χ^2 = 119.520	<0.001
Number of parasitized larvae	Year	22	t = -1.523	0.142
Parasitism rate	Year	22	z = -6.026	<0.001
Parasitoid richness	Year	22	z = -1.625	0.104

Appendix E. Model selection process following a step-wise procedure

Table E1. Models that were included in the procedure for the backward step-wise deletion of non-significant ($p>0.05$) fixed factors from full local-scale models, for response variables of CM abundance, CM damage and number of parasitized larvae. Values of Akaike Information Criterion (AIC) for the various full- and nested models, and the results of likelihood ratio tests comparing nested models to their corresponding full model are shown. Non-significant predictors that were detected and removed in the step-wise process are shown in bold.

CM abundance(local-scale model)	**df**	**AIC**	**BIC**	**logLik**	**L.Ratio**	**p-value**
Apple production + hedgerow R125 + apple plantation R125 + Orchard size + **Apple canopy cover** + Diameter + Year	10	210.372	229.084	-95.185		
Apple production + **hedgerow R125** + apple plantation R125 + Orchard size + Diameter + Year	9	208.375	225.215	-95.187	0.003	0.957
Apple production + apple plantation R125 + Orchard size + **Diameter** + Year	8	206.390	221.360	-95.195	0.019	0.991
Apple production + apple plantation R125 + **Orchard size** + Year	7	205.057	218.155	-95.528	0.685	0.877
Apple production + apple plantation R125 + Year	6	203.617	214.845	-95.809	1.246	0.871
CM damage (local-scale model)	**df**	**AIC**	**BIC**	**logLik**	**L.Ratio**	**p-value**
Apple production + **hedgerow R125** + apple plantation R125 + Orchard size + Apple canopy cover + Diameter + Year	10	-40.251	-21.539	30.125		
Apple production + apple plantation R125 + **Orchard size** + Apple canopy cover + Diameter + Year	9	-42.155	-25.314	30.077	0.096	0.756
Apple production + apple plantation R125 + **Apple canopy cover** + Diameter + Year	8	-43.663	-28.693	29.831	0.588	0.745
Apple production + apple plantation R125 + **Diameter** + Year	7	-44.592	-31.494	29.296	1.658	0.646
Apple production + **apple plantation R125** + Year	6	-43.425	-32.198	27.713	4.826	0.306

Apple production + Year	5	-42.466	-33.110	26.233	7.785	0.169
Number of parasitized larvae (local-scale model)	**df**	**AIC**	**BIC**	**logLik**	**L.Ratio**	**p-value**
Parasitoid richness + CM abundance + hedgerow R125 + apple plantation R125 + Orchard size + **Apple canopy cover** + Diameter + Year	11	129.202	149.785	-53.601		
Parasitoid richness + CM abundance + hedgerow R125 + apple plantation R125 + **Orchard size** + Diameter + Year	10	127.325	146.037	-53.663	0.123	0.725
Parasitoid richness + CM abundance + **hedgerow R125**+ apple plantation R125 + Diameter + Year	9	126.172	143.013	-54.086	0.971	0.616
Parasitoid richness + CM abundance + apple plantation R125 + Diameter + **Year**	8	124.877	139.846	-54.438	1.675	0.643
Parasitoid richness + CM abundance + **apple plantation R125** + Diameter	7	123.662	136.760	-54.831	2.460	0.652
Parasitoid richness + CM abundance + **Diameter**	6	124.097	135.324	-56.048	4.895	0.429
Parasitoid richness + CM abundance	5	125.105	134.461	-57.552	7.903	0.245

Table E2. Models that were included in the procedure for the backward step-wise deletion of non-significant ($p>0.05$) fixed factors from full landscape models, for response variables of CM abundance, CM damage and number of parasitized larvae. Values of Akaike Information Criterion

(AIC) for the different full- and nested models, and the results of likelihood ratio tests comparing nested models to their corresponding full model are shown. Non-significant predictors that were detected and removed in the step-wise process are shown in bold.

CM abundance (landscape model)	df	AIC	BIC	logLik	L.Ratio	p-value
Apple production + **apple plantation1000** + snwh1000 + pasture1000 + exotic1000 + Year	9	210.761	227.602	-96.380		
Apple production + **snwh1000** + pasture1000 + exotic1000 + Year	8	208.851	223.821	-96.425	0.090	0.764
Apple production + pasture1000 + **exotic1000** + Year	7	207.050	220.149	-96.525	0.289	0.865
Apple production + **pastures1000**+ Year	6	207.435	218.662	-97.718	2.674	0.445
Apple production + Year	5	206.311	215.667	-98.156	3.551	0.470
CM damage (landscape model)	df	AIC	BIC	logLik	L.Ratio	p-value
Apple production + apple plantation1000 + **snwh1000** + pasture1000 + exotic1000 + Year	9	-37.836	-20.995	27.918		
Apple production + **apple plantation1000** + pasture1000 + exotic1000 + Year	8	-39.002	-24.033	27.501	0.835	0.361
Apple production + **pasture1000** + exotic1000 + Year	7	-40.064	-26.966	27.032	1.772	0.412
Apple production + **exotic1000** + Year	6	-41.107	-29.880	26.553	2.729	0.435
Apple production + Year	5	-42.466	-33.110	26.233	3.370	0.498
Number of parasitized larvae (landscape model)	df	AIC	BIC	logLik	L.Ratio	p-value
CM abundance + parasitoid richness + apple plantation1000 + snwh1000 + **pasture1000** + exotic1000 + Year	10	131.112	149.824	-55.556		
CM abundance + parasitoid richness + apple plantation1000 + **snwh1000**+ exotic1000 + Year	9	129.126	145.967	-55.563	0.0142	0.905
CM abundance + parasitoid richness + apple plantation1000 + exotic1000 + **Year**	8	127.643	142.613	-55.822	0.531	0.767
CM abundance + parasitoid richness + **apple plantation1000** + exotic1000	7	126.411	139.510	-56.206	1.299	0.729

CM abundance + parasitoid richness + **exotic1000**	6	125.268	136.495	-56.634	2.156	0.707
CM abundance + parasitoid richness	5	125.105	134.461	-57.552	3.993	0.551

Appendix F. Codling moth parasitoids and parasitism rate among orchards and years

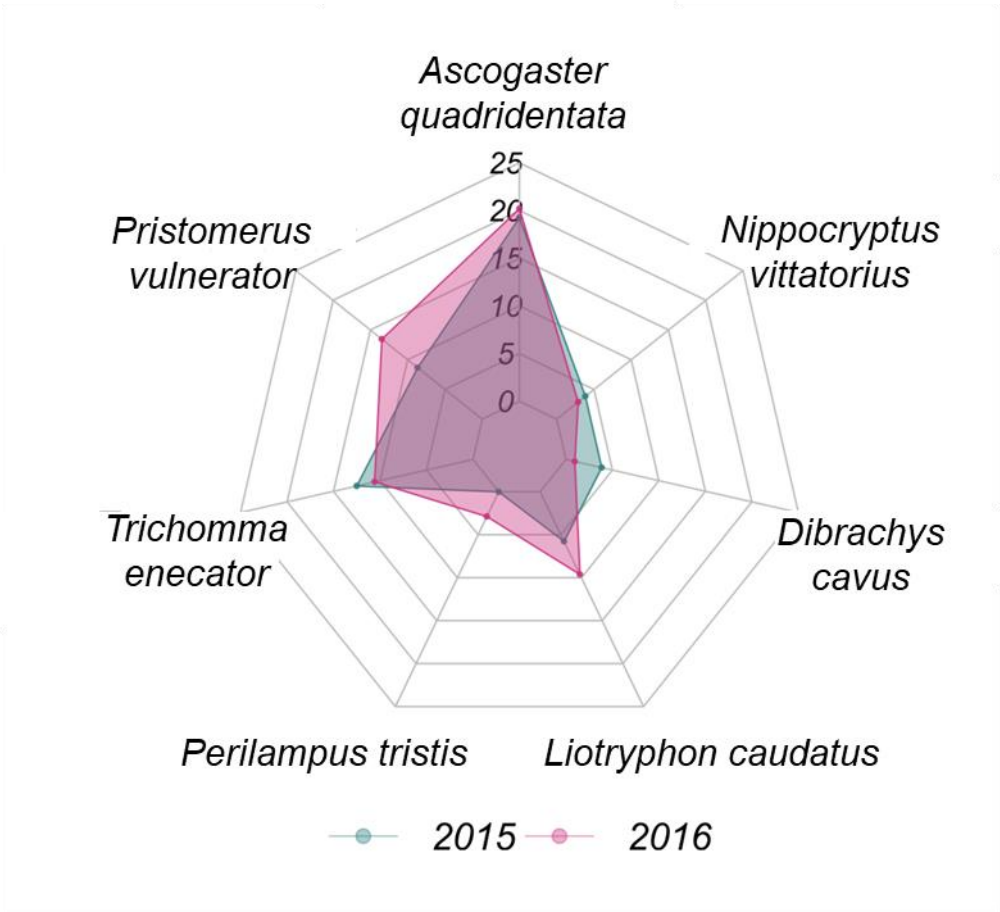

Figure F1. Number of orchards in which each parasitoid occurred.

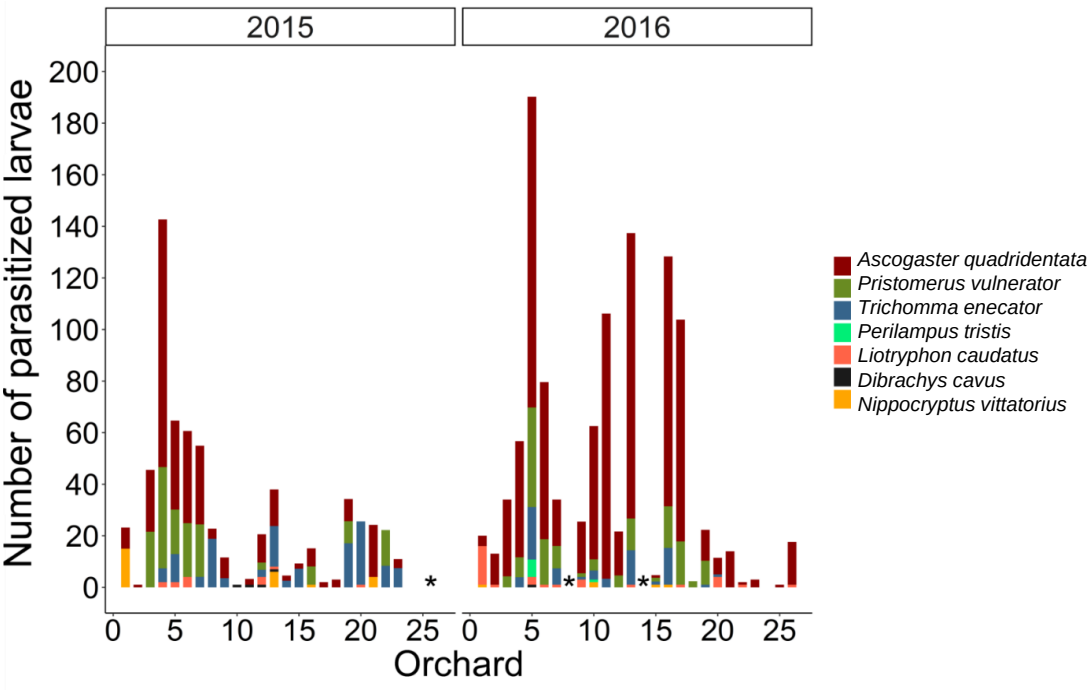

Figure F2. Number of parasitized larvae per year (2015, 2016) by species of parasitoid in the twenty-six cider apple orchards studied.

* indicates orchards not sampled that year.