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**Supplementary Material**

**Super-predation and intraguild interactions in a multi-predator-one-prey system alter the abundance and behaviour of green peach aphid (Hemiptera: Aphididae)**

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**Table S1. Aphid abundance, summary of regression models.** This table provides the full model results including the insignificant levels, all extracted from the model summery. The displayed results are related to the first regression model (natural-enemy combination [NE] effect), the second regression model (natural-enemy numbers [pressure]), and the third regression model (natural-enemy identity, with and without interaction with other members of the natural-enemy combination). The models are testing aphid abundance (described in the main text); see also (Fig. 2) in the main text and Supplementary Tables S3–S2. L = *Chrysoperla carnea*, LB = *Adalia bipunctata*, W = *Aphidius colemani*, S = *Parasteatoda tepidariorum*.

**Aphid abundance analysis**, model 1: effect of natural enemy combination

Model: quasipoisson, response: aphid abundance

Model 1 summary

Deviance Residuals:

Min 1Q Median 3Q Max

-19.979 -6.851 -1.972 4.956 26.387

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| --- |
| Coefficients: |
| Estimate Std. Error t value Pr(>|t|) |
| (Intercept) 6.70270 0.15616 42.922  **< 2e-16** |
| **Nat.Enemy.ComboL -0.64873 0.26653 -2.434 0.017735** |
| **Nat.Enemy.ComboLB -1.21459 0.32640 -3.721 0.000420** |
| **Nat.Enemy.ComboLBxL -1.24482 0.33024 -3.769 0.000359** |
| **Nat.Enemy.ComboLBxLxS -1.75963 0.40752 -4.318 5.59e-05** |
| **Nat.Enemy.ComboLBxLxSxW -1.03766 0.30531 -3.399 0.001170** |
| **Nat.Enemy.ComboLBxLxW -2.34343 0.52764 -4.441 3.62e-05** |
| **Nat.Enemy.ComboLBxS -0.93563 0.29418 -3.180 0.002267** |
| **Nat.Enemy.ComboLBxSxW -1.55288 0.37364 -4.156 9.80e-05** |
| **Nat.Enemy.ComboLBxW -1.10132 0.31263 -3.523 0.000794** |
| Nat.Enemy.ComboLxS -0.06885 0.22474 -0.306 0.760324 |
| Nat.Enemy.ComboLxSxW -0.36516 0.24397 -1.497 0.139365 |
| **Nat.Enemy.ComboLxW -2.24603 0.50481 -4.449 3.51e-05** |
| **Nat.Enemy.ComboS -0.60283 0.26257 -2.296 0.024971** |
| Nat.Enemy.ComboSxW -0.17182 0.23096 -0.744 0.459637 |
| **Nat.Enemy.ComboW -1.78418 0.41182 -4.332 5.31e-05** |
| --- |

Null deviance: 17966 on 79 degrees of freedom

Residual deviance: 6162.5 on 75 degrees of freedom

**Aphid abundance analysis**, model 2: effect of natural enemy pressure (enemy numbers)

Model: quasipoisson, response: aphid abundance

Model 2 summary

Deviance Residuals:

Min 1Q Median 3Q Max

-26.600 -13.397 -2.296 6.554 30.986

|  |
| --- |
| Coefficients: |
| Estimate Std. Error t value Pr(>|t|) |
| (Intercept) 6.7027 0.2217 30.228 **<0.0001** |
| **1 Natural Enemy -0.9579 0.2850 -3.362 0.001222** |
| **2 Natural Enemies -0.7291 0.2572 -2.834 0.005895** |
| **3 Natural Enemies -1.2260 0.3018 -4.063 0.000118** |
| **4 Natural Enemies -1.0377 0.4335 -2.393 0.019192** |
| --- |

Null deviance: 17966 on 79 degrees of freedom

Residual deviance: 14650 on 75 degrees of freedom

**Aphid abundance analysis**, model 3: effect of the natural enemy ID, with and without

interaction with other members of the natural-enemy combination

Model: quasipoisson, response: aphid abundance

Model 3 summary

Deviance Residuals:

Min 1Q Median 3Q Max

-20.433 -8.160 -1.282 3.184 34.834

|  |
| --- |
| Coefficients: (4 not defined because of singularities) |
| Estimate Std. Error t value Pr(>|t|) |
| (Intercept) 6.7027 0.1851 36.219 **<0.0001** |
| **Nat.Enemy\_Presence\_yes -2.7679 1.3531 -2.046 0.0446** |
| ParasitoidismNAN NA NA NA NA |
| **Parasitoidism\_no 1.2900 0.5949 2.169 0.0335** |
| Parasitoidism\_Yes 0.9788 0.5391 1.815 0.0737 |
| SpiderNAN NA NA NA NA |
| Spider\_no 0.1087 0.4610 0.236 0.8143 |
| **Spider\_yes 0.7147 0.3517 2.032 0.0460** |
| LacewingNAN NA NA NA NA |
| Lacewing\_no 0.1546 0.4642 0.333 0.7401 |
| Lacewing\_Yes -0.1511 0.3900 -0.388 0.6996 |
| LadybirdNAN NA NA NA NA |
| Ladybird\_no 0.7205 0.5151 1.399 0.1663 |
| Ladybird\_Yes -0.1900 0.4638 -0.410 0.6833 |
| --- |

Null deviance: 17966.3 on 79 degrees of freedom

Residual deviance: 8591.5 on 70 degrees of freedom

**Table S2. Supportive multiple post-hoc comparisons.** Following the first regression (model 1) testing aphid abundance (described in the main text), we used the package “lsmeans” (Lenth, 2016); and the results were verified using the R package “multcomp” (Hothorn *et al.* 2008), in R environment (R Development Core Team, 2016; RStudio Team, 2017) to further examine the multiple pairwise comparisons via a Tukey‘s honestly significant difference. Only significant and marginally significant results are shown. A = aphid (*Myzus persicae*) alone, L = *Chrysoperla carnea*, LB = *Adalia bipunctata*, W = *Aphidius colemani*, S = *Parasteatoda tepidariorum*.

|  |
| --- |
| **contrast estimate SE df z.ratio p.value** |
| **A - LB 1.21458626 0.3264016 NA 3.721 0.0183** |
| **A - LBxL 1.24481526 0.3302386 NA 3.769 0.0154** |
| **A - LBxLxS 1.75962722 0.4075186 NA 4.318 0.0017** |
| **A - LBxLxSxW 1.03765555 0.3053128 NA 3.399 0.0545** |
| **A - LBxLxW 2.34342755 0.5276428 NA 4.441 0.0010** |
| **A - LBxSxW 1.55287984 0.3736425 NA 4.156 0.0034** |
| **A - LBxW 1.10131665 0.3126345 NA 3.523 0.0365** |
| **A - LxW 2.24602702 0.5048087 NA 4.449 0.0009** |
| **A - W 1.78417719 0.4118175 NA 4.332 0.0016** |
| **LB - LxS -1.14573367 0.3290535 NA -3.482 0.0418** |
| **LBxL - LxS -1.17596267 0.3328599 NA -3.533 0.0353** |
| **LBxLxS - LxS -1.69077464 0.4096457 NA -4.127 0.0038** |
| LBxLxS - LxSxW -1.39446347 0.4204989 NA -3.316 0.0703 |
| **LBxLxS - SxW -1.58780765 0.4130894 NA -3.844 0.0117** |
| **LBxLxW - LxS -2.27457496 0.5292873 NA -4.297 0.0019** |
| **LBxLxW - LxSxW -1.97826380 0.5377312 NA -3.679 0.0213** |
| **LBxLxW - SxW -2.17160798 0.5319570 NA -4.082 0.0046** |
| **LBxSxW - LxS -1.48402725 0.3759612 NA -3.947 0.0078** |
| **LBxSxW - SxW -1.38106027 0.3797105 NA -3.637 0.0247** |
| LBxW - LxS -1.03246407 0.3154021 NA -3.273 0.0799 |
| **LxS - LxW 2.17717443 0.5065274 NA 4.298 0.0018** |
| **LxS - W 1.71532461 0.4139225 NA 4.144 0.0035** |
| **LxSxW - LxW 1.88086327 0.5153443 NA 3.650 0.0236** |
| LxSxW - W 1.41901344 0.4246664 NA 3.341 0.0651 |
| **LxW - SxW -2.07420745 0.5093164 NA -4.073 0.0048** |
| **SxW - W 1.61235762 0.4173309 NA 3.863 0.0108** |

P value adjustment: Tukey method for comparing a family of 16 estimates, Confidence level used: 0.95, pairwise contrasts

**Table S3. Data exploration and descriptive statistics of aphid abundance data.** In line with the information depicted in Figure 2, exploratory data analysis was done here to further communicate the data. This table provides an extra assimilation of the aphid performance ranks and the differential suppressive impact of the natural-enemy (NE) combination. We used the packages “Hmisc” (Alzola and Harrell 2006), “Lattice” (Sarkar 2008), ‘corrplot’ (Wei and Simko 2017), and “Pastecs” (Grosjean *et al.* 2015) in R environment (R Development Core Team, 2016; RStudio Team, 2017). A = aphid (*Myzus persicae*) alone, L = *Chrysoperla carnea*, LB = *Adalia bipunctata*, W = *Aphidius colemani*, S = *Parasteatoda tepidariorum*.

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| **16 natural- enemy combinations** | **A** | **LB** | **L** | **W** | **S** | **LBxL** | **LBxW** | **LBxS** | **LxW** | **LxS** | **SxW** | **LBxLxW** | **LBxSxW** | **LBxLxS** | **LxSxW** | **LBxLxSxW** |
| **nbr.val** | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Min** | 697 | 98 | 151 | 93 | 257 | 8 | 119 | 183 | 32 | 468 | 492 | 28 | 45 | 16 | 271 | 42 |
| **Max** | 894 | 394 | 906 | 216 | 530 | 743 | 454 | 510 | 207 | 1097 | 979 | 140 | 258 | 351 | 860 | 682 |
| **Range** | 197 | 296 | 755 | 123 | 273 | 735 | 335 | 327 | 175 | 629 | 487 | 112 | 213 | 335 | 589 | 640 |
| **Sum** | 4073 | 1209 | 2129 | 684 | 2229 | 1173 | 1354 | 1598 | 431 | 3802 | 3430 | 391 | 862 | 701 | 2827 | 1443 |
| **Median** | 839 | 212 | 360 | 125 | 485 | 137 | 255 | 273 | 65 | 817 | 666 | 50 | 200 | 93 | 496 | 205 |
| **Mean** | 814.6 | 241.8 | 425.8 | 136.8 | 445.8 | 234.6 | 270.8 | 319.6 | 86.2 | 760.4 | 686 | 78.2 | 172.4 | 140.2 | 565.4 | 288.6 |
| **SE.mean** | 33.87 | 62.86 | 128.91 | 21.36 | 48.49 | 129.74 | 66.23 | 60.4 | 30.84 | 109.75 | 91.39 | 25.28 | 36.42 | 64.14 | 106.08 | 118.82 |
| **CI.mean.0.95** | 94.03 | 174.52 | 357.91 | 59.29 | 134.63 | 360.23 | 183.88 | 167.68 | 85.63 | 304.7 | 253.74 | 70.2 | 101.13 | 178.07 | 294.53 | 329.9 |
| **Var** | 5734.3 | 19755.2 | 83087.2 | 2280.2 | 11755.7 | 84168.3 | 21932.2 | 18237.8 | 4755.7 | 60220.3 | 41762.5 | 3196.2 | 6633.3 | 20567.7 | 56268.3 | 70590.3 |
| **std.dev** | 75.73 | 140.55 | 288.25 | 47.75 | 108.42 | 290.12 | 148.1 | 135.05 | 68.96 | 245.4 | 204.36 | 56.53 | 81.45 | 143.41 | 237.21 | 265.69 |
| **coef.var** | 0.09 | 0.58 | 0.68 | 0.35 | 0.24 | 1.24 | 0.55 | 0.42 | 0.8 | 0.32 | 0.3 | 0.72 | 0.47 | 1.02 | 0.42 | 0.92 |
| **Skewness** | -0.49 | 0.12 | 0.72 | 0.72 | -0.93 | 0.96 | 0.12 | 0.33 | 0.96 | 0.11 | 0.3 | 0.25 | -0.51 | 0.42 | 0.07 | 0.42 |
| **skew.2SE** | -0.27 | 0.06 | 0.4 | 0.39 | -0.51 | 0.53 | 0.06 | 0.18 | 0.52 | 0.06 | 0.17 | 0.14 | -0.28 | 0.23 | 0.04 | 0.23 |
| **Kurtosis** | -1.58 | -2.2 | -1.28 | -1.32 | -1.08 | -1.03 | -2.11 | -1.92 | -1.03 | -1.83 | -1.86 | -2.24 | -1.54 | -1.84 | -1.97 | -1.81 |
| **kurt.2SE** | -0.39 | -0.55 | -0.32 | -0.33 | -0.27 | -0.26 | -0.53 | -0.48 | -0.26 | -0.46 | -0.46 | -0.56 | -0.39 | -0.46 | -0.49 | -0.45 |
| **normtest.W** | 0.94 | 0.85 | 0.88 | 0.88 | 0.77 | 0.73 | 0.91 | 0.93 | 0.73 | 0.96 | 0.92 | 0.78 | 0.93 | 0.89 | 0.95 | 0.91 |
| **normtest.p** | 0.65 | 0.21 | 0.29 | 0.3 | 0.04 | 0.02 | 0.47 | 0.59 | 0.02 | 0.81 | 0.53 | 0.05 | 0.61 | 0.34 | 0.77 | 0.48 |
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|  | **A** | **LB** | | **L** | | **W** | | **S** | | **LBxL** | **LBxW** | **LBxS** | **LxW** | **LxS** | **SxW** | **LBxLxW** | **LBxSxW** | **LBxLxS** | **LxSxW** | **LBxLxSxW** |
| **Pop. Mean** | 354.20 Population mean (grand mean) | | | | | | | | |  |  |  |  |  |  |  |  |  |  |  |
| **Pop.std.dev** | 239.26 Population std.dev | | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |
| **Z-Score\*** | 1.92 | | -0.47 | | 0.30 | | -0.91 | | 0.38 | -0.50 | -0.35 | -0.14 | -1.12 | 1.70 | 1.39 | -1.15 | -0.76 | -0.89 | 0.88 | -0.27 |
| **Percentile\*** | 97.28 | | 31.93 | | 61.76 | | 18.18 | | 64.91 | 30.86 | 36.37 | 44.25 | 13.13 | 95.52 | 91.72 | 12.43 | 22.37 | 18.55 | 81.13 | 39.20 |
|  | | | | | | | | | | | | | | | | | | | | |

\*The Z-scores and percentile ranks were derived from the table above via the following formulae:

Z-Score= X - Population mean (grand mean)/Population std.dev

Pi=NORMSDIST(Z-score)\*100

**Table S4. Aphid polyphenism, summaries of regression models.** This table provides details extracted from the model summery with respect to model 1 and model 2 testing aphid polyphenism (alata production). The displayed results are related to the first regression model (natural-enemy combination effect); the second one (natural-enemy numbers [pressure]).

**Aphid polyphenism analysis**, model 1: effect of natural enemy combination

Model: quasipoisson, response: polyphenism

Model 1 summary

Deviance residuals:

Min 1Q Median 3Q Max

-1.61572 -0.56775 -0.02378 0.12982 2.50130

Null deviance: 74.673 on 79 degrees of freedom

Residual deviance: 45.501 on 64 degrees of freedom

**Aphid polyphenism analysis**, model 2: effect of natural enemy numbers (pressure)

Model: quasipoisson, response: polyphenism

Model 2 summary

Deviance residuals:

Min 1Q Median 3Q Max

-1.6157 -0.7660 -0.1921 0.1830 3.0141

Null deviance: 74.673 on 79 degrees of freedom

Residual deviance: 50.937 on 75 degrees of freedom

**Fig. S1. Aphid abundance and polyphenism in details.** This illustration provides both holistic and individual views of aphid performance (abundance and phenotypic plasticity) subject to different scenarios of natural enemy combinations. Aphid abundance measured, as average total raw numbers, is presented as enriched and detailed box-plots with presentation of medians (M), means (± SEM), quantiles (0.75, 0.90), and annotated statistical significance values extracted from model 1 and model 2 of the main text (testing aphid abundance). The box-plots are also supported with circled numbers, indicating ranks ®, which comparatively show the differential suppressive magnitude of the effect of the natural-enemy combinations. The *P*-values shown on top of the box-plots were extracted from the summary of model 1 (see the methods for model specifications) and they show the significance of each level of the natural-enemy combination where the level “Aphid alone” is the baseline of the model. Note that the *P*-values annotated at the bottom of the illustration are extracted from the summary of model 2 (see the methods for model specifications) and they show the effects of the level comprising the natural-enemy pressure on aphid population where the absence of aphids was the baseline of the model. The percentages in the rectangle below the x-axis refer to the respective proportions of winged morphs (alates) signifying polyphenism. Wherever, applicable for the corresponding natural-enemy combinations, the virulence of the parasitoid wasp (parasitoidisation rate) is shown as a percentage (% Vir). A =Aphid (*Myzus persicae*) alone, L = *Chrysoperla carnea*, LB = *Adalia bipunctata*, W = *Aphidius colemani*, S = *Parasteatoda tepidariorum*.

Fig. S1 (1)

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