Supplementary Material

Host availability, repulsive companion planting, and predation interact and shape how a parthenogenetic aphid population responds to a stratified ecological challenge

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Running title: Multiple bio-stressors alter aphid fitness

Table S1. Experimental design. The first column details the seven levels of experimental environment in the absence/presence of predator. The environmental context in *Experiment I* is defined as the different numbers of shallots (signifying a variable shallot perturbation effect) to the available savoy cabbage host numbers per microcosm, with and without predation. The context in *Experiment II* is defined as the different numbers of available savoy cabbage hosts per microcosm, with and without predation. There were always four plants in the microcosm. In total, we applied 7 different environments, with and without predator presence, resulting in 14 treatments and 87 microcosms.

Environment	**No. of replicates**	**Predator** (Lacewing absence [aphids alone] = 0, Lacewing present = 1)
Experiment I (Shallot perturbation, -/+ predator)		
0% Shallot (0 Shallot: 4 Cabbage hosts)	6	0
	6	1
25% Shallot (1 Shallots : 3 Cabbage hosts)	6	0
	6	1
50% Shallot (2 Shallots : 2 Cabbage hosts)	6	0
	6	1
75% Shallot (3 Shallots : 1 Cabbage host)	6	0
	6	1
Experiment II (Host gradient, -/+ predator)		
4-Cabbage (4 Cabbage hosts)	6	0
	6	1
3-Cabbage (3 Cabbage hosts)	5	0
	4	1
2-Cabbage (2 Cabbage hosts)	4	0
	5	1
1-Cabbage (1 Cabbage host)	4	0
	5	1

Note 1. Extra information and further contrasts on aphid aggregative abundance and dispersion, Experiment I: Effects escalated shallot perturbation, predator presence, and PDB

On the one hand, *in predator absence*, aphids were least abundant (103 ±28.84 SEM) in the 75% Shallot context, while they were most abundant (215.33 ±52.87 SEM) in the 25% Shallot context (1 Shallot : 3 Cabbage). Overall, ranking of aphid abundance relative to Shallot perturbation, minus predator, revealed that the abundance (103± 11.77 SEM) under the highest perturbation (75% Shallot context) was ~38% smaller than the abundance in the context 50% Shallot (with 11% smaller PDB); ~52% smaller than the abundance in the context 25% Shallot (with 30% smaller PDB); whereas, the abundance in the context 50% Shallot was ~23% smaller than in the context 25% Shallot (with 22% smaller PDB). This suggests an increasing negative impact, via escalating shallot perturbation and decreasing availability of cabbage-host biomass, on aphid population when the predator was absent, Supplementary Material (Table S2). The rates of decrease in aphid abundance were the most pronounced in the contrast (75% Shallot *versus* 25% Shallot), followed by (75% Shallot *versus* 50% Shallot). However, the rates of PDB decrease were the highest in the contrast (75% Shallot *versus* 25% Shallot), followed by (50% Shallot *versus* 25% Shallot). Interestingly, the decrease rates are on par for PDB and aphid abundance when the context 50% Shallot is compared with the context 25% Shallot; see Supplementary Material (Table S2) for further contrasts including comparisons with the optimal predator-free context 0% Shallot (0 Shallot : 4 Cabbage).

On the other hand, *in predator presence*, aphids were least abundant (75.33 ±21.02 SEM) in the 75% Shallot context, while they were most abundant (184.67± 72.58 SEM) in the 25% Shallot context. Overall, ranking aphid abundance relative to shallot perturbation, plus predator, reveals that the abundance under the highest perturbation (75% shallot context) was ~32% smaller than the abundance of the context 50% shallot (with 13% larger PDB); ~59% smaller than the abundance of the context 25% shallot (with 25% larger PDB); whereas, the abundance of the context 50% Shallot was ~40% smaller than that of the context 25% Shallot (with 10% larger PDB). As such, a similar trend to the observations in the above-mentioned predator-free cases can be seen but, however, the negative impact on aphid abundance was more pronounced in the contexts 75% Shallot and 50% Shallot when respectively compared to the 25% Shallot context, main text (Fig. 1) and Supplementary Material (Table S2). PDB = cabbage host plant dry biomass.

Table S2. Contextual comparisons in *Experiment I*. The first column details within-context and between-contexts contrasts. The second column displays aphid abundance change per centum (larger or smaller in the focal context relative to the compared one). The third column shows host-plant dry biomass (PDB) change per centum (larger or smaller in the focal context relative to the compared one). Experiment I is an investigation of aphid abundance as function of the effects of PDB and predator presence under escalated shallot perturbation from 0% Shallot (optimal) to 75% Shallot (most hostile) in the microcosm, Pred-free = predator absent from the microcosm, +Pred = predator present in the microcosm.

Context Comparison	Abundance change%	PDB change%
+Pred compared to Pred-Free, context 0% Shallot Optimal (4 Cabbage)	73% Smaller	**2% Larger**
+Pred compared to Pred-Free, context 25% Shallot (1 Shallot : 3 Cabbage)	14% Smaller	26% Smaller
+Pred compared to Pred-Free, context 50% Shallot (2 Shallot : 2 Cabbage)	33% Smaller	**5% Larger**
+Pred compared to Pred-Free, context 75% Shallot (3 Shallot : 1 Cabbage)	27% Smaller	**33% Larger**
Pred-Free [(25% Shallot) compared to (0% Shallot Optimal)**]**	42% Smaller	2% Smaller
+Pred [(25% Shallot) compared to (0% Shallot Optimal)**]**	**84% Larger**	29% Smaller
+Pred (25% Shallot) compared to **Pred-Free** (0% Shallot Optimal)	~50% Smaller	27% Smaller
Pred-Free (25% Shallot) compared to **+Pred** (0% Shallot Optimal)	**115% Larger**	5% Smaller
Pred-Free [(50% Shallot) compared to (0% Shallot Optimal)**]**	55% Smaller	24% Smaller
+Pred [(50% Shallot) compared to (0% Shallot Optimal)**]**	**11% Larger**	22% Smaller
+Pred (50% Shallot) compared to **Pred-Free** (0% Shallot Optimal)	70% Smaller	20% Smaller
Pred-Free (50% Shallot) compared to **+Pred** (0% Shallot Optimal)	**65% Larger**	26% Smaller
Pred-Free [(75% Shallot) compared to (0% Shallot Optimal)**]**	72% Smaller	32% Smaller
+Pred [(75% Shallot) compared to (0% Shallot Optimal)**]**	25% Smaller	12% Smaller
+Pred (75% Shallot) compared with **Pred-Free** (0% Shallot Optimal)	80% Smaller	10% Smaller
Pred-Free (75% Shallot) compared to **+Pred** (0% Shallot Optimal)	**3% Larger**	34% Smaller
Pred-Free [(50% Shallot) compared to (25% Shallot)**]**	23% Smaller	22% Smaller
+Pred [(50% Shallot) compared to (25% Shallot)**]**	40% Smaller	**10% Larger**
+Pred (50% Shallot) compared to **Pred-Free** (25% Shallot)	48% Smaller	18% Smaller
Pred-Free (50% Shallot) compared with **+Pred** (25% Shallot)	10% Smaller	**5% Larger**
Pred-Free [(75% Shallot) compared to (50% Shallot)**]**	38% Smaller	11% Smaller
+Pred [(75% Shallot) compared to (50% Shallot)**]**	32% Smaller	**13% Larger**
+Pred (75% Shallot) compared to **Pred-Free** (50% Shallot)	55% Smaller	**19% Larger**
Pred-Free (75% Shallot) compared to **+Pred** (50% Shallot)	7% Smaller	15% Smaller
Pred-Free [(75% Shallot) compared to (25% Shallot)**]**	52% Smaller	30% Smaller
+Pred [(75% Shallot) compared to (25% Shallot)**]**	59% Smaller	**25% Larger**
+Pred (75% Shallot) compared to **Pred-Free** (25% Shallot)	65% Smaller	7% Smaller
Pred-Free (75% Shallot) compared to **+Pred** (25% Shallot)	44% Smaller	6+% Smaller

Table S3. Test of cabbage dry biomass in *Experiment I*. The main effects, via analysis of deviance table (Type II tests), are shown regarding the generalised linear model, with Gaussian family, to test cabbage dry biomass in the microcosm as explained by shallot density (0% Shallot [0 Shallot : 4 Cabbage], 25% Shallot [1 Shallot : 3 Cabbage], 50% Shallot [2 Shallot : 2 Cabbage], 75% Shallot [3 Shallot : 1 Cabbage]), and predator presence (0 or 1), and the interaction between shallot density and predator presence. There were always four plants in the microcosm.

Variable	Cabbage dry biomass
Predator presence	$F_{(1,40)}$=0.01; P=0.927
Shallot density	$F_{(3,40)}$=2.54; P=0.07
Predator presence x Shallot density	$F_{(3,40)}$=2.03; P=0.124

Table S4. Test of aphid polyphenism in *Experiment I*. The main effects, via analysis of deviance table (Type II tests), are shown regarding the generalised linear model, with quasiPoisson family, applied to test percentage of alata production (indicating polyphenism) in the microcosm as explained by shallot perturbation (0% Shallot [0 Shallot : 4 Cabbage], 25% Shallot [1 Shallot : 3 Cabbage], 50% Shallot [2 Shallot : 2 Cabbage], 75% Shallot [3 Shallot : 1 Cabbage]), predator presence (0 or 1), and cabbage host-plant dry biomass (PDB), and all possible interactions between the said explanatory variables. There were always four plants in the microcosm. Significant results are shown in bold.

Variable	Aphid dispersion
Host-plant dry biomass (PDB)	$F_{(1,32)}$=1.17; P=0.287
Shallot perturbation	$F_{(3,32)}$=6.42; **P=0.002**
Predator presence	$F_{(1,32)}$=0.34; P=0.564
PDB x Shallot perturbation	$F_{(3,32)}$=1.83; P=0.161
PDB x Predator presence	$F_{(1,32)}$=0.49; P=0.49
Shallot perturbation x Predator presence	$F_{(3,32)}$=1.58; P=0.213
PDB x Shallot perturbation x Predator presence	$F_{(3,32)}$=1.02; P=0.397

Note 2. Extra information and further contrasts on aphid aggregative abundance and dispersion, Experiment II: Effects of decreasing host plant availability, predator presence, and PDB

On the one hand, *in predator absence*, the least aphid abundance (81.25 ±23.61 SEM) was observed in the 1-Cabbage context, while the most aphid abundance (798.2 ±77.73 SEM) was observed in the 3-Cabbage context. Overall, comparing aphid abundance in the least hospitable and nourishing 1-Cabbage context to variable host plant availabilities, minus predator, revealed that the 1-Cabbage context had 78% smaller abundance (with 2% larger PDB) than in the optimal 4-Cabbage context, 90% smaller abundance (with 6% smaller PDB) than in the 3-Cabbage context; 78% smaller abundance (with 17% smaller PDB) than in the 2-Cabbage context. Whereas the abundance in the 2-Cabbage context was 53% smaller (with 14% larger PDB) than in the 3-Cabbage context; and 1+% larger in abundance (with 23% larger PDB) than in the optimal 4-Cabbage context. Note that the abundance in the 3-Cabbage context was 116% larger (with7% larger PDB) than in the optimal 4-Cabbage context. Comparatively, the PDB values of all contexts, except the optimal 4-Cabbage, were larger than the PDB of the 1-Cabbage context, and aphids were more abundant in all contexts when there were more than 1 cabbage in the microcosm, (Fig. 2) and Supplementary Material (Table S5). To our surprise, in the 3-Cabbage context, without predator, the PDB value (5^{th} rank) was high notwithstanding the sharp increase in aphid abundance in this context, (Fig. 2) and Supplementary Material (Table S5) for further contrasts when the predator was absent. In the absence of predator, there was a notable margin of PDB difference when the contextual contrast (1-Cabbage *versus* 3-Cabbage) is compared with (2-Cabbage *versus* 3-Cabbage).

On the other hand, *in predator presence*, the least aphid abundance (59.25 ±27.27 SEM) was observed in the 3-Cabbage context, while the most aphid abundance (241 ± 96.95 SEM) was observed in the 1-Cabbage context. Overall, comparing aphid abundance in the least hospitable and nourishing 1-Cabbage context with other host availabilities, plus predator, shows that the abundance in the said context was ~140% larger (with ~80% larger PDB) than in the optimal 4-Cabbage context, ~307% larger (with 65% smaller PDB) in the 3-Cabbage context; ~3% larger (with ~17% smaller PDB) than in the 2-Cabbage context. Whereas the abundance in the 2-Cabbage context was ~294% larger (with ~37% larger PDB) than in the 3-Cabbage context; the abundance in the 2-Cabbage context was ~133% larger (with ~50% larger PDB) than in the optimal 4-Cabbage context; and the abundance in the 3-Cabbage context was ~41% smaller (with ~9% larger PDB) than in the optimal 4-Cabbage context. The increases in abundance were smaller in the contextual contrast (1-Cabbage *versus* 2-Cabbage) than what was observed for the contrasts (1-Cabbage *versus* 3-Cabbage) and (2-Cabbage *versus* 3-Cabbage). Further, compared to the 3-Cabbage and 4-Cabbage contexts, clearly there was more PDB (provision for aphid), accompanied by larger aphid abundances, in the microcosms of the 1-Cabbage and 2-Cabbage contexts despite having fewer hosts (smaller host densities). In the predator-free microcosm, the production of alates peaked in the 3-Cabbage context which had the highest aphid abundance and relatively good cabbage biomass of the 5^{th} rank. This was followed by the 2-Cabbage context (more than two times smaller abundance and ~1.14 times the PDB of the value recorded in the 3-Cabbage context), then the optimal 4-Cabbage context (more than two times smaller abundance and ~0.93 times the PDB of the value in the 3-Cabbage context); whereas alates were lacking in the 1-Cabbage context (9.85 times smaller abundance and ~0.94 times the PDB compared to the 3-Cabbage context). By contrast, when the predator was available, the largest alata proportions were observed in the 1-Cabbage context followed by the 3-Cabbage context, as there were proportionally more alata production relative to population size in these contexts. Apparently, predator presence induced less alates (in the 2-Cabbage context) or no alates at all (in the 4-Cabbge context) compared to the 1-Cabbage and the 3-Cabbage contexts, as offspring conditioning into winged morphs varied by context contingent on predation, and the interaction of predation effect with cabbage density or biomass, (Fig. 2). Moreover, when comparing the optimal

4-Cabbage with the other contexts, the biggest difference is seen in contrast with the 3-Cabbage context (when the predator was absent) and with the 1-Cabbage context (when the predator was present); PDB = cabbage host-plant dry biomass.

Table S5. Contextual comparisons in *Experiment II*. The first column details within-context and between-contexts contrasts. The second column displays aphid abundance change per centum (larger or

smaller of the focal context relative to the compared one). The third column shows host-plant dry biomass (PDB) change per centum (larger or smaller of the focal context relative to the compared one). Experiment II is an investigation of aphid abundance as function of the effects of PDB and predator presence under decreasing cabbage host availability (HPA) in the microcosm (4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, 1 Cabbage host [least hospitable]), Pred-free = predator absent from the microcosm, +Pred = predator present in the microcosm.

Context Comparison	Abundance change%	PDB Change%
+Pred compared to Pred-Free, context Optimal (4 Cabbage)	73% Smaller	**2% Larger**
+Pred compared to Pred-Free, context (3 Cabbage)	93%% Smaller	**4% Larger**
+Pred compared to Pred-Free, context (2 Cabbage)	37% % Smaller	**25% Larger**
+Pred compared to Pred-Free, context (1 Cabbage)	**197% Larger**	**82% Larger**
Pred-Free [(3 Cabbage) compared to (Optimal)**]**	**116% Larger**	**7% Larger**
+Pred [(3 Cabbage) compared to (Optimal)**]**	41% Smaller	**9% Larger**
+Pred (3 Cabbage) compared to **Pred-Free** (Optimal)	84% Smaller	**12% Larger**
Pred-Free (3 Cabbage) compared to **+Pred** (Optimal)	**695% Larger**	**5% Larger**
Pre-Free [(2 Cabbage) compared to (Optimal)**]**	**1+% Larger**	**23% Larger**
+Pred [(2 Cabbage) compared to (Optimal)**]**	**133% Larger**	**50% Larger**
+Pred (2 Cabbage) compared to **Pred-Free** (Optimal)	37% Smaller	**54% Larger**
Pred-Free (2 Cabbage) compared to **+Pred** (Optimal)	**270% Larger**	**20% Larger**
Pre-Free [(1 Cabbage) compared to (Optimal)**]**	78% Smaller	**2% Larger**
+Pred [(1 Cabbage) compared to (Optimal)**]**	**140% Larger**	**80% Larger**
+Pred (1 Cabbage) compared to **Pred-Free** (Optimal)	35% Smaller	**85% Larger**
Pred-Free (1 Cabbage) compared to **+Pred** (Optimal)	19% Smaller	1+% Smaller
Pred-Free [(2 Cabbage) compared to (3 Cabbage)**]**	53% Smaller	**14% Larger**
+Pred [(2 Cabbage) compared to (3 Cabbage)**]**	**294% Larger**	**37% Larger**
+Pred (2 Cabbage) compared to **Pred-Free** (3 Cabbage)	71% Smaller	**43% Larger**
Pred-Free (2 Cabbage) compared to **+Pred** (3 Cabbage)	**527% Larger**	**10% Larger**
Pre-Free [(1 Cabbage) compared to (2 Cabbage)**]**	78% Smaller	17% Smaller
+Pred [(1 Cabbage) compared to (2 Cabbage)**]**	**3% Larger**	**20% Larger**
+Pred (1 Cabbage) compared to **Pred-Free** (2 Cabbage)	35% Smaller	**50% Larger**
Pred-Free (1 Cabbage) compared to **+Pred** (2 Cabbage)	65% Smaller	34% Smaller
Pre-Free [(1 Cabbage) compared to (3 Cabbage)**]**	90% Smaller	6% Smaller
+Pred [(1 Cabbage) compared to (3 Cabbage)**]**	**307% Larger**	**65% Larger**
+Pred (1 Cabbage) compared to **Pred-Free** (3 Cabbage)	70% Smaller	**72% Larger**
Pred-Free (1 Cabbage) compared to **+Pred** (3 Cabbage)	**37% Larger**	10% Smaller

Table S6. Test of cabbage dry biomass in *Experiment II*. The main effects, analysis of deviance table (Type II tests), are shown regarding the generalised linear model run to test cabbage dry biomass as explained by host plant availability (HPA) in the microcosm (4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, 1 Cabbage host [least hospitable]), predator presence (0 or 1), and the interaction between host availability and predator presence. There were always four plants in the microcosm. Significant results are shown in bold.

Variable	Cabbage dry biomass
Predator presence	$F_{(1,31)}$=4.2; **P=0.049**
HPA	$F_{(3,31)}$=2.58; P=0.071
Predator presence x HPA	$F_{(3,31)}$=1.87; P=0.155

Table S7. Test of aphid polyphenism in *Experiment II*. The main effects, via analysis of deviance table (Type II tests), are shown regarding the generalised linear model applied to test percentage of alata production (indicating polyphenism) in the microcosm as explained by host plant availability (HPA) (4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, 1 Cabbage host [least hospitable]), predator presence (0 or 1), Cabbage host-plant dry biomass (PDB), and all possible interactions between the said explanatory variables. There were always four plants in the microcosm. Significant results are shown in bold.

Variable	Aphid dispersion
Host-plant dry biomass (PDB)	$F_{(1,23)}$=10.87; **P=0.003**
Host plant availability (HPA)	$F_{(3,23)}$=2.95; *P=0.054*
Predator presence	$F_{(1,23)}$=0.51; P=0.482
PDB x HPA	$F_{(3,23)}$=1.41; P=0.265
PDB x Predator presence	$F_{(1,23)}$=9.12; **P=0.006**
HPA x Predator presence	$F_{(3,23)}$=9.52; **P=0.0003**
PDB x HPA x Predator presence	$F_{(3,23)}$=2.36; P=0.098

Note 3: All-inclusive approach of analysing organism traits under combined stress

In the main text, we split the concept and the analysis of the investigation into two routes, here we alternatively apply an all-inclusive approach that test aphid traits (aggregative abundance and polyphenism, respectively) within different contextual scenarios of combined biological stress where the reference frame (baseline) is the optimal context of four cabbage hosts in predator absence. The first stressor is decreasing host plant availability (HPA) spanning 4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, and 1 Cabbage host [least hospitable]). The second stressor is increasing perturbation by shallots ranging from 0% Shallot [0 Shallot : 4 Cabbage, optimal], 25% Shallot [1 Shallot : 3 Cabbage], 50% Shallot [2 Shallot : 2 Cabbage], to 75% Shallot [3 Shallot : 1 Cabbage], most perturbing). There were always universally, four plants in the microcosm. The third stressor is predator by lacewing; the pressure on aphid population increases when the predator is present in each of said contexts. This means that the aphid population resides within the sharpest hostility in the context 75% Shallot with predator. Cabbage host plant dry biomass (PDB), indicating food availability for the pest, was used as a covariate to add precision of the analysis of aphid traits under escalated compounded stress.

We tested aggregative aphid abundance (a quaternary variable: aphid counts on both sides of the leaf and on stem and off plant) as function of the mentioned predictors and all their possible interactions by applying a vectorised generalised linear model (vglm)with multinomial family, R package VGAM (Yee 2015, Yee 2017) and the main effects are shown in an analysis of deviance table using a command of ANOVA (Type II) irrespective of the order of the predictors in the model.

Aphid polyphenism (proportions of produced alates [dispersive morphs denoting polyphenism] was also tested by applying a generalised linear model with a quasiPoisson family quasi-Poisson family (due to over-dispersion and non-normal data distribution), R package multcomp (Hothorn *et al.* 2008) and the main effects are shown using in an analysis of deviance table using an ANOVA (Type II), as explained above. Additionally, cabbage dry biomass, signifying cabbage well bring in the microcosm, was examined as function of shallot density, cabbage host availability and predator effect (absence/presence) and the interactions (cabbage host availability x predator effect, and shallot density x predator effect), using a generalised linear model with Gaussian family; see Supplementary Material (Table 9) and (Fig. S2); PDB = cabbage host-plant dry biomass.

Table S8. Test of aphid abundance under combined stress. The main effects, via analysis of deviance table (Type II tests), are shown regarding a vectorised generalised linear model (vglm) with a multinomial family, R package VGAM, applied to test aphid abundance in the microcosm as explained by: cabbage host

plant dry biomass (PDB), host plant availability (HPA) (4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, 1 Cabbage host [least hospitable]), shallot perturbation (0% Shallot [0 Shallot : 4 Cabbage], 25% Shallot [1 Shallot : 3 Cabbage], 50% Shallot [2 Shallot : 2 Cabbage], 75% Shallot [3 Shallot : 1 Cabbage]), predator presence (0 or 1), and the interactions (PDB x Shallot perturbation, PDB x HPA, PDB x Predator presence, Shallot perturbation x Predator presence, HPA x Predator presence, PDB x Shallot perturbation x Predator presence, PDB x HPA x Predator presence). There were always four plants in the microcosm. Significant results are shown in bold.

Variable	Aphid abundance
Host-plant dry biomass (PDB)	$F_{(18,141)}$=3.78; **P<0.0001**
Host plant availability (HPA)	$F_{(21,141)}$=5.26; **P<0.0001**
Shallot perturbation	$F_{(11,141)}$=10.98; **P<0.0001**
Predator presence	$F_{(17,141)}$=8.76; **P<0.0001**
PDB x Shallot perturbation	$F_{(9,141)}$=5.53; **P<0.0001**
PDB x HPA	$F_{(10,141)}$=5.22; **P<0.0001**
PDB x Predator presence	$F_{(6,141)}$=4.03; **P=0.0009**
HPA x Predator presence	$F_{(10,141)}$=2.79; **P=0.004**
Shallot perturbation x Predator presence	$F_{(9,141)}$=4.4; **P<0.0001**
PDB x Shallot perturbation x Predator presence	$F_{(9,141)}$=1.73; P=0.087
PDB x HPA x Predator presence	$F_{(9,141)}$=4.34; **P<0.0001**

Table S9. Test of aphid polyphenism under combined stress. The main effects, via analysis of deviance table (Type II tests), are shown regarding a generalised linear model (glm) with a quasi-Poisson family (due to over-dispersion and non-normal data distribution), R package multcomp, applied to test aphid alata proportions (indicating polyphenism) in the microcosm as explained by: cabbage host plant dry biomass (PDB), host plant availability (HPA) (4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, 1 Cabbage host [least hospitable]), shallot perturbation (0% Shallot [0 Shallot : 4 Cabbage], 25% Shallot [1 Shallot : 3 Cabbage], 50% Shallot [2 Shallot : 2 Cabbage], 75% Shallot [3 Shallot : 1 Cabbage]), predator presence (0 or 1), and the interactions (PDB x Shallot perturbation, PDB x HPA, PDB x Predator presence, Shallot perturbation x Predator presence, HPA x Predator presence, PDB x Shallot perturbation x Predator presence, PDB x HPA x Predator presence). There were always four plants in the microcosm. Significant results are shown in bold.

Variable	Aphid polyphenism
Host-plant dry biomass (PDB)	$F_{(1,47)}$=41.38; **P<0.0001**
Host plant availability (HPA)	$F_{(3,47)}$=0.91; P=0.442
Shallot perturbation	$F_{(3,47)}$=150.67; **P<0.0001**
Predator presence	$F_{(1,47)}$=560.16; **P<0.0001**
PDB x Shallot perturbation	$F_{(3,47)}$=2.37; P=0.082
PDB x HPA	$F_{(10,47)}$=0.44; P=0.727
PDB x Predator presence	$F_{(1,47)}$=0.12; P=0.735
HPA x Predator presence	$F_{(3,47)}$=2.95; **P=0.042**
Shallot perturbation x Predator presence	$F_{(3,47)}$=12.91; **P<0.0001**
PDB x Shallot perturbation x Predator presence	$F_{(3,47)}$=1.32; P=0.279
PDB x HPA x Predator presence	$F_{(3,47)}$=0.73; P=0.539

Table S10. Test of cabbage

dry biomass under combined stress of aphids. The main effects, analysis of deviance table (Type II tests), are shown regarding the generalised linear model run to test cabbage dry biomass as explained by shallot perturbation effect (0% Shallot [0 Shallot : 4 Cabbage], 25% Shallot [1 Shallot : 3 Cabbage], 50% Shallot [2 Shallot : 2 Cabbage], 75% Shallot [3 Shallot : 1 Cabbage]), host plant availability (HPA) in the microcosm (4 Cabbage hosts [optimal], 3 Cabbage hosts, 2 Cabbage hosts, 1 Cabbage host [least hospitable]), predator presence (0 or 1), and the interactions (Shallot effect x predator presence, HPA x predator presence). There were always four plants in the microcosm. Significant results are shown in bold.

Variable	Cabbage dry biomass
Shallot effect	$F_{(3,61)}$=12.9; **P<0.0001**
Predator presence	$F_{(1,61)}$=3.41; P=0.07
HPA	$F_{(3,61)}$=3.98; **P=0.012**
Shallot effect x Predator presence	$F_{(3,61)}$=1.95; P=0.13
HPA x Predator presence	$F_{(3,61)}$=2.89; **P=0.043**

Fig. S1. Assimilation of the effects of the complex stress environmental from an aphid's perspective. The infographic provides comparative comparisons and relative understanding of the applied complex environmental challenge when the embedding context included 1, 2 or 3 cabbage hosts, represented respectively in each triangle part of the big triangle. From an aphid's standpoint the challenge was either an added single stressor (shallot or predator) or combined stressors (shallot and predator) to the cabbage embedding context. The effects on the aphid population size (abundance) were additive or non-additive in a context-dependent fashion. As such, the focus here on 6 different scenarios of stress and resulting in 63 microcosms. The the stress is stratified in each context as follows: predation only, shallot perturbation (with variable density corresponding to the context), or predation with shallot perturbation In the respective contexts, the links between the stressors signal the contrasts: shallot effect *versus* predator effect, combined stress [shallot + predator] *versus* shallot effect, combined stress [shallot + predator] *versus* predator effect. When an effect is larger than another in said contrasts the part of the link emerging from the larger effect is thickened. The shallot effect link is purple, the predator link is orange, while the combined stress effect is a mix between the purple and the orange. PDB = cabbage host-plant dry biomass; predator = lacewing. This figure is available in the Figshare data repository [https://figshare.com/s/68f9c1b3f62ac5baf0ae].

Fig. S2. All-inclusive illustration of aphid aggregative abundance, polyphenism, and cabbage host-plant dry biomass subject to stratified combined stress from an aphid's position. From an aphid's perspective, the infographic provides comparative comparisons of the applied complex environmental challenge when the embedding context included the following sets of stressors: 0% Shallot and 100% Cabbage (shallot-free, *4 cabbage hosts* [6 replicates with predator, 6 replicates without predator], 0% Shallot and 75% Cabbage (shallot-free, 3 *cabbage hosts* [5 replicates with predator, 4 replicates without predator], 25% Shallot and 75% Cabbage (*1 shallot : 3 cabbage hosts* [6 replicates with predator, 6 replicates without predator], 0% Shallot and 50% Cabbage (shallot-free, 2 *cabbage hosts* [4 replicates with predator, 5 replicates without predator], 50% Shallot and 75% Cabbage (2 *shallots : 2 cabbage hosts* [6 replicates with predator, 6 replicates without predator], 0% Shallot and 25% Cabbage (shallot-free, 1 *cabbage host* [4 replicates with predator, 5 replicates without predator], 75% Shallot and 25% Cabbage (3 *shallots : 1 cabbage host* [6 replicates with predator, 6 replicates without predator]. At the bottom of the chart, the context 0% Shallot and 100% Cabbage (minus predator) was the most hospitable, nourishing and stress-free scenario; whereas, the context 5% Shallot and 25% Cabbage at the top of the chart was the most hostile, least nourishing, and stress-laden scenario. The bars represent aphid numerical success as aggregative abundance (mean of total numbers in the microcosm per treatment at the end of the experiment ± SE); the overall average plant dry biomass (PDB±SE) per treatment is shown next the bars in rectangles. In total, we applied 14 different stress scenarios (single stressors [predator or shallot perturbation]or combined stressors [predator (lacewing) and shallot perturbation]) with variable perturbation levels, host availabilities and dry biomass in the microcosm. This made the environmental challenge of aphid reproductive and phenotypic plasticities stratified and elevated by design. The different proportions of aphid aggregation/spatial distribution on- and off-plant are presented in grades of grey and all bar stacks are proportional. Each embedding cabbage context (of 1, 2, 3, or 4 host plants) are aggrouped into with (+) predator and without (-) predator. The respective encircled percentages at the end of the bars refer to the average proportions of winged aphids (dispersive morphs). This figure is available in the Figshare data repository [https://figshare.com/s/b83f8b101c972e6d7ea6].

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