## **1** Supplementary Material

2 Table S1. Theoretical predictions for offspring sex ratios under different types of dispersal 3 and scales of competition, and mean observed (± standard error) offspring sex ratios in the different selection regimes. Here we present predictions for offspring sex-ratios (measured as the 4 proportion of sons) for haplodiploid organisms obtained using several models of sex allocation. 5 Taylor and Bulmer (1980) derive a result for individual dispersal in populations where females 6 7 mate before dispersal, dispersal is complete, and there is no population regulation prior to dispersal (Taylor & Bulmer, 1980). Note, this model (Taylor & Bulmer, 1980) advances on Hamilton's 8 original model (Hamilton, 1967) providing explicit predictions for haplodiploid species. Thus, it 9 10 is analogous to the 'Global Random' selection regime (GR, with two foundresses, n=2). Here (1985) derived a similar model, with the exception of having population regulation before 11 dispersal, which is analogous to the 'Local Random' selection regime (LR, with n=2) (Herre, 12 13 1985). Gardner et al. (2009) derived a model of budding dispersal with no population regulation which we use to approach the 'Global Budding' selection regime (GB, with two foundresses, n=2; 14 complete budding dispersal dB=1; no migration between patches after budding, m=0) (Gardner et 15 al., 2009). Gardner et al (2009) can also be used to approach the other two regimes. Indeed, full 16 17 budding dispersal and migration (dB=1, m=1) recovers the result from Taylor and Bulmer (1980), while no budding dispersal but full migration recovers the result from Herre (1985) (thus 18 19 analogous to the GR and LR selection regimes, respectively). Note that the Gardner et al. (2009) model is expected to break down when considering local competition and no budding dispersal 20 (dispersal dB  $\rightarrow$  0, migration m $\rightarrow$  0, equivalent to the 'Local Budding' selection regime, LB). 21 22 Under these conditions there is no genetic mixing between lines for selection to act. Observed 23 offspring sex ratios were defined as the mean offspring sex-ratio of females from the different

## 24 selection regimes, after 33 generations of selection and two generations in a common environment,

25 in the 'Sex allocation in response to patch fecundity' assay.

	Budding dispersal		Random dispersal		
	Predicted Observed		Predicted	Observed	
Local competition	na	na	0.42	$0.241 \pm 0.022$	
Global competition	$\rightarrow 0$	$0.296\pm0.031$	0.21	$0.192 \pm 0.020$	

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28	Table S2. Results of experiment measuring the effect of X-ray irradiation on <i>T. urticae</i>
29	survival, fecundity and egg viability. Groups of thirty T. urticae adult females were placed on a
30	bean leaf fragment (16 $\text{cm}^2$ ) on moistened cotton wool in a plastic Petri dish (9 $\text{cm}$ diameter). Each
31	group was then irradiated at 0 (control), 10, 25, 50 or 100 Gy, with a dose rate of 2,7 Gy/min using
32	a Xstrahl® XenX pre-clinical irradiator at the Institute of Cancer Research, Montpellier (IRCM).
33	Petri dishes were checked daily for female survival, fecundity (number of eggs laid) and
34	hatchability over the following 6 days. Note that due to logistical constraints, the results in Table
35	S2 correspond to a single replicate (i.e. a single Petri dish containing 30 adult females) per
36	irradiation dose. Results shown refer to measures taken 6 days after irradiation.



X-ray dose (Gy)	Mortality (%)	Number of eggs produced	Proportion of eggs hatching
0	0	457	19.5
10	0	490	7.5
25	0	567	2.3
50	26.7	394	2
100	3.3	427	0

41	Table S3. Description of the statistical models used for data analysis in each experiment.
42	Sample size corresponds to the total number of individual replicates (i.e., number of patches from
43	which measurements were taken) included in each analysis. "Maximal model" gives the complete
44	set of explanatory variables (and their interactions) included in the model (note: "*" represents
45	both the interaction between two explanatory variables and their individual effects). "Minimal
46	model" gives the model containing only the variables and the interactions that were statistically
47	significant. Round brackets indicate that the variable was included as a random factor. Square
48	brackets indicate the error structure used ("bb": beta-binomial, "bbI": binomial, accounting for
49	zero inflation; "qp": quasi-poisson, "qpI": quasi-poisson, accounting for zero inflation; "nb":
50	negative binomial). " $\mathcal{J}$ ": number of sons; " $\mathcal{Q}$ ": number of daughters; Generation, "gen": the
51	generations at which the variable of interest was measured across selection regimes during
52	experimental evolution (generations 12, 17, 20 and 31), (note that Generation was analysed as a
53	covariate and was log transformed to improve the fit of the model). Selection Regime, "SelReg":
54	'Global Budding' (GB), 'Global Random' (GR) and 'Local Random' (LR) (note that in models
55	no. 5 and 6, "SelReg" refers to 'Global Random' (GR) and 'Local Random' (LR) only); Replicate,
56	"rep": experimental replicate; "day": the day when different replicates of the experiment were
57	tested; Number of females, "no. females": the number of females present in a patch (1 or 2) where
58	measurements were taken; Total Patch fecundity, "TPF": the total number of eggs laid by one
59	fertile focal and one sterilised female together on a patch; Relative Patch Fecundity, "RPF": the
60	total number of offspring produced by the focal fertile female divided by the total number of eggs
61	laid by the two females (focal and sterile) present on the same patch; Number of mates, "no.
62	mates": the number of times a female was exposed to a male for 5 hours (single mate or double
63	mates); "box": the container in which several individual replicates were maintained. Model no: 1

64	= offspring sex ratio during experimental evolution, 2 = offspring sex ratio in a common
65	environment, 3 = offspring sex ratio of the focal female in response to total patch fecundity, 4 =
66	offspring sex ratio of the focal female in response to relative patch fecundity, $5 = offspring sex$
67	ratio in the "Sexual conflict" experiment, 6 = total fecundity in the "Sexual conflict" experiment,
68	7 = total number of adult offspring produced by the focal female in the "Sex allocation in response"
69	to patch fecundity" experiment, $8 =$ total number of sons produced by the focal female in the "Sex
70	allocation in response to patch fecundity" experiment , $9 = \text{total number of daughters produced by}$
71	the focal female in the "Sex allocation in response to patch fecundity" experiment. <sup>a</sup> includes all
72	individual replicates measured each generation (generations 12, 17, 20, 31); <sup>b</sup> includes all
73	individual replicates measured after one generation in a common environment (generation $31 + 1$ ),
74	in patches with one or two females and excludes experimental replicate LR-1 due to a lack of
75	individual replicates; <sup>c</sup> includes females that were alive on day 4 and produced offspring and
76	excludes experimental replicates GR-1 and LR-1 due to a lack of individual replicates; $^{\rm d}$ only
77	includes individual replicates in which fecundity was higher than zero; <sup>e</sup> only includes individual
78	replicates in which females were alive on day six; $^{\rm f}$ includes females that were alive on day 4 and
79	excludes experimental replicates GR-1 and LR-1 due to a lack of individual replicates.

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Model no.	Var. of interest	Response variable	Sample size	Maximal model Minimal model		K subroutine [err struct.]
1	sev-ratio	$chind(3^\circ)$	432 to	log(gen)*SelReg	SelReg	glmmTMB
1	SCA-Taulo	$\operatorname{cond}(\cup, +)$	384/Gen <sup>a</sup>	+(rep)+(day)	+(rep)+(day)	[bb]
2	sev ratio	$chind(\mathcal{A} \cap)$	504b	no. females*SelReg	SelReg	glmmTMB
2	Sex-latio	$cond(0, \pm)$	504	+(rep)	+(rep)	[bbI]
3	sev ratio	$chind(\mathcal{A} \cap)$	1600	TPF*SelReg	Eggs+SelReg	glmmTMB
5	Sex-latio	$cond(0, \pm)$	109	+(rep)	+(rep)	[bb]
4	cov rotio	abind (1 0)	1600	RPF*SelReg	RF+SelReg	glmmTMB
4 sex-1	sex-ratio	cbind(⊖,∓)	109	+(rep)	+(rep)	[bb]
5	sex-ratio	$chind(\mathcal{A} \cap)$	133d	no. mates*SelReg	(rep)+(hox)	glmmTMB
		cond(0,+)	155	+(rep)+(box)	(rep) (box)	[bb]
6	total patch	total number of	1730	no. mates*SelReg	SelReg	glmmTMB
0	fecundity	eggs	125	+(rep)+(box)	(rep)+(box)	[qp]
7	number of	total number of	176f	SelReg	SelReg	glmmTMB
/	offspring	adult offspring	170	+(rep)	+(rep)	[qpI]
0	number of	total number of	1600	SelReg	SelReg	glmmTMB
0	sons	sons	109	+(rep)	+(rep)	[nb]
	number of	total number of	1.600	SelReg	SelReg	glmmTMB
9	daughters	daughters	169°	+(rep)	+(rep)	[qpI]

Table S4. Results obtained from each statistical analysis. "Df" indicates the degrees of 85 freedom: " $\chi^2$ " provides the Chi-square value obtained in each analysis: "Selection regime": 86 'Global Budding' (GB), 'Global Random' (GR) and 'Local Random' (LR) (note that in models 87 88 no. 5 and 6, "SelReg" refers to 'Global Random' (GR) and 'Local Random' (LR) only); "Generation": the generations at which the variable of interest was measured across selection 89 90 regimes during experimental evolution (12, 17, 20 and 31); "Number of females": the number of females present in a patch (1 or 2) where measurements were taken; "Total Patch fecundity": the 91 92 total number of eggs laid by the focal and sterilised females together on a patch; "Relative Patch Fecundity": the number of offspring produced by the focal female divided by the total number of 93 94 eggs laid by the two females (focal and sterile) present on the patch; "Number of mates": the number of males a female was exposed to for 5 hours (one or two mates). Model no: 1 = offspring 95 sex ratio during experimental evolution, 2 = offspring sex ratio in a common environment, 3 = 96 97 offspring sex ratio of the focal female in response to total patch fecundity, 4 =offspring sex ratio of the focal female in response to relative patch fecundity, 5 = offspring sex ratio in the "Sexual98 conflict" experiment, 6 = total fecundity in the "Sexual conflict" experiment, , 7 = total number of 99 100 adult offspring produced by the focal female in the "Sex allocation in response to patch fecundity" experiment, 8 = total number of sons produced by the focal female in the "Sex allocation in 101 response to patch fecundity" experiment ,  $9 = \text{total number of daughters produced by the focal$ 102 female in the "Sex allocation in response to patch fecundity" experiment. Statistically significant 103 terms in models are represented in bold. 104

Model	Var. of	Explanatory var.	Df	γ2	P value	Figure
no.	interest			x		
		Selection Regime x Generation	2	4.351	0.114	
1	sex-ratio	Selection Regime	2	14.046	<0.001	2a
		Generation	1	2.229	0.135	
		Selection Regime x Number of females	2	4.114	0.128	
2	sex-ratio	Selection Regime	2	11.845	0.003	2b
		Number of females	1	0.9449	0.331	
		Selection Regime x Total Patch Fecundity	2	0.555	0.757	
3	sex-ratio	Selection Regime	2	9.015	0.011	S2
		Total Patch Fecundity	1	5.366	0.021	
	sex-ratio	Selection Regime x Relative Patch Fecundity	2	2.548	0.28	
4		Selection Regime	2	10.9	0.004	3
		<b>Relative Patch Fecundity</b>	1	6.87	0.009	
	sex-ratio	Number of mates x Selection Regime	1	0.073	0.788	
5		Number of mates	1	0.024	0.876	S3
		Selection Regime	1	0.028	0.867	
	4-4-1	Number of mates x Selection Regime	1	0.408	0.523	
6	fecundity	Number of mates	1	1.62	0.203	4
		Selection Regime	1	4.336	0.036	
7	number of	Solastian Pagima	2	18.06	<0.001	\$4
/	offspring	Selection Regime	2	10.00	<0.001	34
8	number of	Selection Regime	2	8 365	0.015	\$5
0	sons	Seccusi regime	-	0.000	0.010	55
9	number of	Selection Regime	2	10.196	0.006	85
У	daughters	Second regime	-	10.170	5.000	55

107	Table S5. A posteriori contrasts of significant explanatory variables. A posteriori contrasts
108	with Bonferroni corrections were done to interpret the significant effect of selection regime. "Z"
109	= z-scores; "Selection regime": Global Budding (GB), Global Random (GR) or Local Random
110	(LR). Model no: 1 = offspring sex ratio during experimental evolution, 2 = offspring sex ratio in a
111	common environment, $3 = offspring sex ratio of the focal (fertile) female in response to total patch$
112	fecundity, 4 = offspring sex ratio of the focal (fertile) female in response to relative patch fecundity,
113	7 = total number of adult offspring produced by the focal female in the "Sex allocation in response"
114	to patch fecundity" experiment, $8 = $ total number of sons produced by the focal female in the "Sex
115	allocation in response to patch fecundity" experiment , $9 = \text{total number of daughters produced by}$
116	the focal female in the "Sex allocation in response to patch fecundity" experiment. Statistically
117	significant contrasts are represented in bold (* marginally significant).

Model no.	Var. of interest	Comparison	Z	P value	Figure
		GB vs GR	-3.741	<0.001	
1	sex-ratio	GR vs LR	1.554	0.361	2a
		GB vs LR	-2.289	0.066	
		GB vs GR	-3.384	0.002	
2	sex-ratio	GR vs LR	-1.597	0.3776	2b
		GB vs LR	1.53	0.331	
		GB vs GR	-2.963	0.009	
3	sex-ratio	GR vs LR	1.774	0.228	S2
		GB vs LR	-1.366	0.516	
4		GB vs GR	-3.298	0.003	
	sex-ratio	GR vs LR	1.814	0.209	3
		GB vs LR	-1.685	0.276	
		GB vs GR	3.523	0.001	
7	number of offspring	GR vs LR	0.513	1.000	S4
		GB vs LR	4.051	< 0.001	
		GB vs GR	-2.634	0.025	
8	number of sons	GR vs LR	2.371	0.053*	S5
		GB vs LR	-0.437	1	
		GB vs GR	2.182	0.015	
9	number of daughters	GR vs LR	0.213	1.000	S5
		GB vs LR	2.975	0.009	

122	Figure S1. Schematic representation of the protocol for exposure to a common environment
123	prior to trait measurements in all selection regimes. Sex allocation in a common environment:
124	At generation 31, ninety-six mated daughters were haphazardly chosen from the 48 patches within
125	each selection regime and placed on a large leaf patch (rectangles) where they laid eggs together.
126	Fourteen days later the offspring on these patches emerged as adults and mated amongst
127	themselves (Generation 31 + 1). After mating, these females were placed on individual leaf patches
128	(squares) where sex allocation measurements were done (see detailed protocol in the main text).
129	Sex allocation in response to patch fecundity: At generation 33, ninety-six mated daughters were
130	haphazardly chosen from the 48 patches within each selection regime and placed on a large leaf
131	patch where they laid eggs together, developed until adulthood and mated. This process was
132	repeated for a second generation (96 mated female offspring from the first generation were placed
133	together on a large leaf patch to lay eggs and offspring to emerge, develop and mate). At the same
134	time, 3 replicate groups of 96 adult mated females from the ancestral population were placed
135	together on a large bean leaf patch to generate sterile females, also over 2 generations (see details
136	in the main text and Table S2). After these two generations in a common environment (Generation
137	33 + 2), their offspring were used to seed the experiment: single females were placed on leaf
138	patches with a sterile (irradiated) female from the ancestral population (see detailed protocol in the
139	main text). Note that for the 'Sexual Conflict' assay juvenile females were taken from the same
140	mating pools as the mated females used to measure patch fecundity, (not shown in the schematic).
141	("G": generation)



Figure S2. Offspring sex ratio as a function of total patch fecundity in the 'Global Budding' (black), 'Global Random' (dark grey) and 'Local Random' (light grey) selection regimes.
Females from the different selection regimes were placed on individual patches with a female from the ancestral population that was previously sterilised. On each patch, the total number of eggs laid by both females (total patch fecundity), and the offspring sex-ratio of the focal female (i.e., female from the selection regime) was measured. Each dot represents an individual replicate (the patch from which measurements were taken).



Figure S3. Mean offspring sex-ratio (± standard error) of females from the ancestral population placed with either one or two mates from the 'Global Budding' (GB, black) or 'Global Random' (GR, grey) selection regimes. Means are shown for each experimental replicate (different symbols) in each selection regime.



Figure S4. Total number of adult offspring produced (± standard error) by focal females from the 'Global Budding' (GB, black), 'Global Random' (GR, dark grey) and 'Local Random' (LR, light grey) selection regimes, when sharing a patch with sterilised females from the ancestral population. Means are shown for each experimental replicate (different symbols) in each selection regime.



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Figure S5. Total number of adult a) sons and b) daughters (± standard errors) produced by focal females from the 'Global Budding' (GB, black), 'Global Random' (GR, dark grey) and 'Local Random' (LR, light grey) selection regimes, when sharing a patch with sterilised females from the ancestral population. Means are shown for each experimental replicate (different symbols) in each selection regime.





## 181 References

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