Oikos

OIK-00434

Erwin, A. C., Geber, M. A. and Agrawal, A. A. 2013. Specific impacts of two root herbivores and soil nutrients on plant performance and insect–insect interactions. – Oikos 000: 000–000.

Appendix A1

Table A1. Values (cm) substituted for mean main root damage when no main root was recovered. N refers to nutrient level.

	Insect treatment			
	Tetraopes only		*Tetraopes* + Wireworms	
Insect density	Low N	High N	Low N	High N
4	8.7	5.1	5.74	6.32
5	6	6	n/a	n/a
6	6.75	9.4	14.73	13.23

Table A2**.** Least squares means ± standard errors of *Asclepias syriaca* main root (MR) and fine root (FR) damage (cm), and shoot (SH), MR and FR biomass (mg) as predicted by insect identity, soil nutrient level, and their interaction. The Identity term indicates which insect was present.

	Plant damage		Plant biomass		
Factor	MR	FR	SH	MR	FR
Identity					
Wireworms	3.96 ± 0.60	3.75 ± 0.43	5.02 ± 0.08	4.99 ± 0.14	4.08 ± 0.09
T. tetraophthalmus	6.31 ± 0.63	0.49 ± 0.44	4.38 ± 0.08	1.78 ± 0.14	3.01 ± 0.09
Nutrients					
Low	4.55 ± 0.62	1.67 ± 0.44	4.08 ± 0.08	3.14 ± 0.14	3.29 ± 0.09
High	5.72 ± 0.62	2.57 ± 0.43	5.31 ± 0.08	3.63 ± 0.14	3.80 ± 0.09
Identity × Nutrients					
Wireworms × Low	3.92 ± 0.86	2.98 ± 0.61	4.32 ± 0.11	4.55 ± 0.19	3.65 ± 0.12
Wireworms × High	4.01 ± 0.85	4.52 ± 0.60	5.71 ± 0.11	5.43 ± 0.19	4.52 ± 0.12
T. tetraophthalmus × Low	5.17 ± 0.89	0.35 ± 0.62	3.84 ± 0.11	1.73 ± 0.19	2.93 ± 0.13
T. tetraophthalmus × High	7.44 ± 0.91	0.62 ± 0.62	4.91 ± 0.11	1.83 ± 0.19	3.08 ± 0.13

Table A3. Least squares means ± standard errors of the mass of individual wireworms and *Tetraopes tetraophthalmus* larvae (mg) as predicted by insect identity, soil nutrient level, and their interaction. The Identity term refers to whether heterospecific insects were present.

	Insect mass	
Factor	Wireworms	*T. tetraophthalmus*
Identity		
With conspecifics only	20.40 ± 0.94	19.69 ± 2.20
With con- and heterospecifics	19.41 ± 1.59	23.67 ± 3.96
Nutrients		
Low	21.95 ± 1.24	13.81 ± 3.35
High	17.86 ± 1.36	29.55 ± 3.06
Identity × Nutrients		
With conspecifics only × Low	21.50 ± 1.35	17.92 ± 3.23
With conspecifics only × High	19.31 ± 1.31	21.47 ± 2.99
With con- and heterospecifics × Low	22.41 ± 2.09	9.71 ± 5.86
With con- and heterospecifics × High	16.41 ± 2.39	37.63 ± 5.33

Table A4. Analysis of covariance (ANCOVA) of wireworm density, soil nutrient level, and their interaction as predictors of *Asclepias syriaca* shoot (SH), main root (MR), and fine root (FR) biomass (mg). By excluding *Tetraopes tetraophthalmus* data, this analysis tests whether the significant effects of density, identity-by-density, and identity-by-nutrients in the whole model (Table 1) were driven by *T. tetraophthalmus* alone. Numbers in parentheses after column headers refer to DF. Numbers in table are F-values with asterisks indicating significant differences (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

Factor	SH $_{(1,77)}$	MR $_{(1,77)}$	FR $_{(1,77)}$
Density	0.01	0.30	0.14
Nutrients	**86.2076*** **	**23.0697*** **	**27.5047*** **
Density × Nutrients	0.48	0.19	0.00

Table A5. Model selection statistics to estimate survival of wireworms and *Tetraopes tetraophthalmus* larvae. Dens, insect density; Hetero, presence of heterospecifics; Nutr, soil nutrient level; *k*, number of parameters in a model; ΔAICc, difference between an alternative model and the best model; w_i, weight, indicating relative likelihood of model *i*; LL, log likelihood value.

Parameters	Model ID	*k*	AICc	ΔAICc	w_i	LL
(a) *H. abbreviatus*						
Dens, Hetero	3	3	**289.15**	0.00	0.51	-141.47
Dens, Hetero, Nutr	9	4	291.09	1.94	0.20	-141.37
Dens, Hetero, Dens × Hetero	6	4	291.26	2.10	0.18	-141.46
Hetero	2	2	293.16	4.01	0.07	-144.53
Hetero, Nutr	5	3	295.05	5.90	0.03	-144.42
Hetero, Nutr, Hetero × Nutr	8	4	296.60	7.45	0.01	-144.13
Dens	1	2	300.90	11.75	0.00	-148.40
Dens, Nutr	4	3	302.80	13.65	0.00	-148.30
Dens, Nutr, Dens × Nutr	7	4	304.85	15.70	0.00	-148.26
(b) *T. tetraophthalmus*						
Dens	1	2	**172.98**	0.00	0.28	-84.45
Dens, Hetero	3	3	173.72	0.74	0.19	-83.77
Dens, Nutr	4	3	173.72	0.74	0.19	-83.77
Dens, Hetero, Nutr	9	4	174.49	1.51	0.13	-83.09
Dens, Hetero, Dens × Hetero	6	4	174.75	1.77	0.11	-83.22
Dens, Nutr, Dens × Nutr	7	4	175.01	2.03	0.10	-83.35
Hetero	2	2	190.56	17.58	0.00	-93.23
Hetero, Nutr	5	3	191.19	18.21	0.00	-92.51
Hetero, Nutr, Hetero × Nutr	8	4	193.18	20.20	0.00	-92.44

Table A6. Model-averaged coefficients and associated statistics for parameters predicting the survival of wireworms and *Tetraopes tetraophthalmus* larvae. Dens, insect density; Hetero, presence of heterospecifics; Nutr, soil nutrient level. Confidence intervals that exclude zero indicate that that parameter is a key predictor of survival. Relative importance values provide a relative metric of statistical support for the impact of each parameter.

Parameter	Coefficient	SE	Lower CI	Upper CI	Relative importance
Wireworm survival					
Intercept	–0.87	0.50	–1.85	0.11	.
Dens	–0.18	0.09	**–0.35**	**–0.01**	0.89
Hetero	0.86	0.39	**0.09**	**1.62**	1.00
Nutr	–0.08	0.24	–0.56	0.39	0.24
Dens × Hetero	0.03	0.16	–0.28	0.34	0.18
Dens × Nutr	–0.04	0.14	–0.32	0.23	0.00
Hetero × Nutr	–0.37	0.49	–1.33	0.59	0.01
T. tetraophthalmus survival					
Intercept	–0.53	0.64	–1.80	0.73	.
Dens	–0.45	0.14	**–0.73**	**–0.17**	1.00
Hetero	0.67	0.73	–0.77	2.12	0.43
Nutr	–0.22	0.6	–1.41	0.96	0.42
Dens × Hetero	–0.25	0.24	–0.73	0.22	0.11
Dens × Nutr	–0.21	0.23	–0.65	0.24	0.10
Hetero × Nutr	0.27	0.76	–1.22	1.77	0.00

Table A7. Composition of the solution – made of Jack's Professional LX All Purpose Water Soluble Fertilizer (J. R. Peters, Inc. Allentown, PA, USA) plus EPSO Top® Epsom salt (K+S KALI GmbH, Kassel, Germany) – used to create the 'high' and 'low' soil fertility treatments. Elements are derived from ammonium nitrate, potassium phosphate, potassium nitrate, magnesium sulfate, boric acid, iron EDTA, manganese EDTA, zinc EDTA, copper EDTA and ammonium molybdate.

Element	Percentage
Fertilizer	
Total nitrogen (N)	21.00
ammoniacal	7.92
nitrate	13.08
Available phosphate (P_2O_5)	5.00
soluble potash (K_2O)	20.00
magnesium (Mg), water soluble	0.15
zinc (Zn), chelated	0.0525
manganese (Mn), chelated	0.0525
Boron (B)	0.0210
copper (Cu), chelated	0.0105
iron (Fe), chelated	0.0105
molybdenum (Mo)	0.0105
Epsom salts	
$MgSO_4$, water soluble	0.0400

Figure A1. Biomass of plant shoots (A), main roots (B), and fine roots (C) growing in low (white bars) and high (grey bars) nutrient soil when no insects were present (control) or when either wireworms or *Tetraopes tetraophthalmus* larvae were present. Shoot biomass C: $F_{1,180} = 36.38$; H: $F_{1,180} = 78.88$; T: $F_{1,180} = 30.21$. Main root biomass C: $F_{1,181} = 1.24$; H: $F_{1,181} = 8.90$; T: $F_{1,181} = 0.12$. Fine root biomass C: $F_{1,181} = 2.16$; H: $F_{1,181} = 23.09$; T: $F_{1,181} = 0.42$. Asterisks indicate significant differences at $p \leq 0.05$ (*), $p \leq 0.01$ (**) and $p \leq 0.001$ (***).