

Oikos

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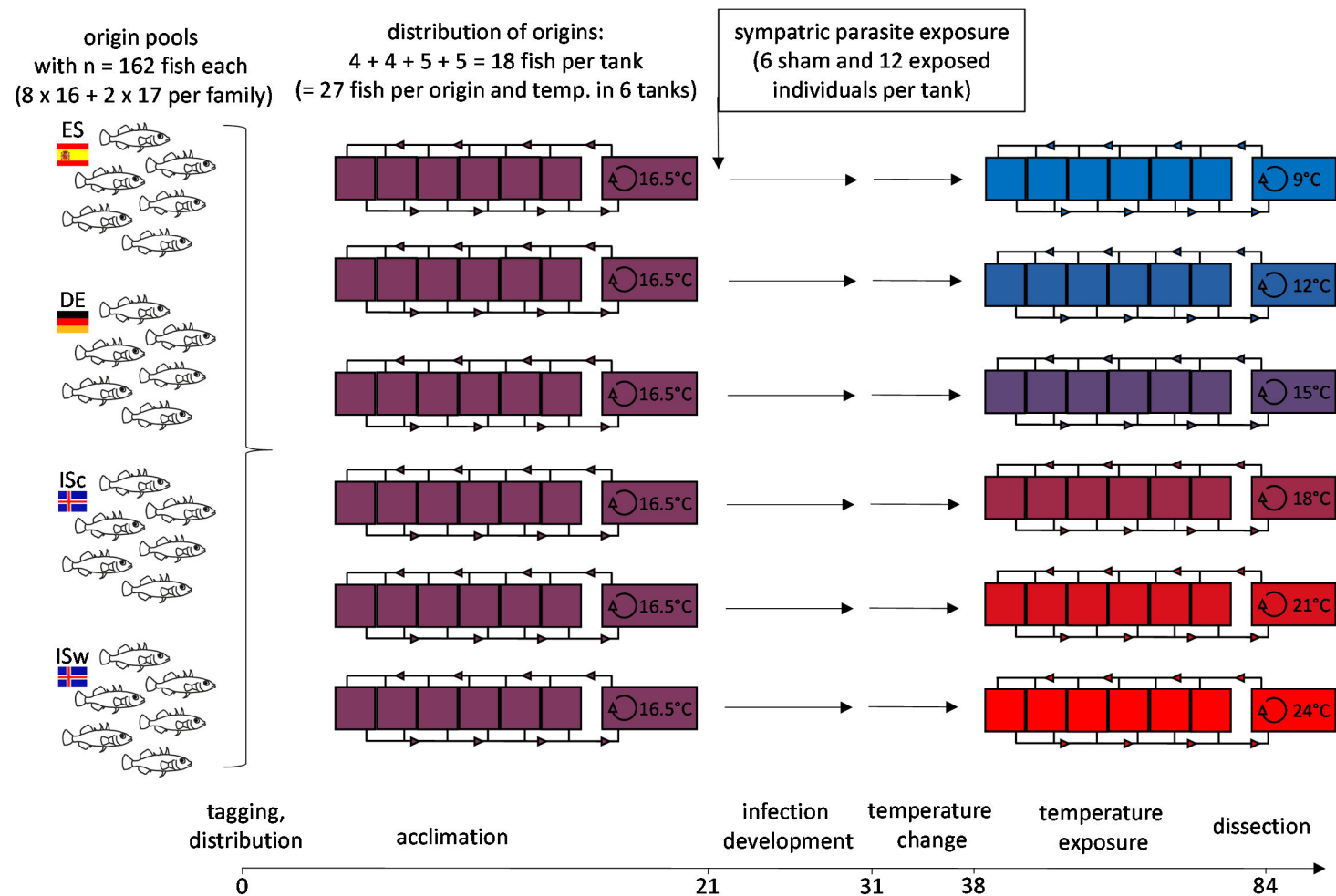
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optima in a host–parasite system. – Oikos doi:

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Appendix 1





**Figure A2.** Experimental setup. Six sets of each six 16 L tanks with recirculated, temperature-controlled water supply were used. After acclimation sticklebacks were exposed to copepods infected or not infected (sham) with *S. solidus*. Each tank was stocked with 18 sticklebacks in a way that each origin and each infection treatment (sham/exposed) was present in each tank. Temperature exposure was assigned randomly to each set of tanks and temperatures were changed steadily at a maximum rate of 1 °C per 24 h.

**Table A1.** Linear mixed models (LMMs) on parasite and host response variables. Simple comparisons for significant effects with categorical predictor variables (E1-E14) can be found in Table A2. Symboling: ‘-’ = not included into the model, bold letters = significant ( $p \leq 0.050$ )

	parasite index	relative egg count	egg size	relative coracidia count	relative HKL count	lymphocyte proliferation	monocyte proliferation	respiratory burst activity	relative weight increase
temperature	$F_{1,124} = 59.55, P < 0.001$	$F_{1,124} = 5.42, P = 0.022$	$F_{1,64} = 8.59, P = 0.005$	$F_{1,124} = 0.36, P = 0.551$	$F_{1,571} = 1.11, P = 0.292$	$F_{1,560} = 8.14, P = 0.005$	$F_{1,560} = 0.87, P = 0.351$	$F_{1,571} = 18.15, P < 0.001$	$F_{1,571} = 11.69, P < 0.001$
origin	<b>E1: <math>F_{3,124} = 4.88, P = 0.003</math></b>	<b>E2: <math>F_{3,124} = 4.25, P = 0.007</math></b>	$F_{3,64} = 0.70, P = 0.554$	<b>E4: <math>F_{3,124} = 4.17, P = 0.008</math></b>	<b>E5: <math>F_{3,571} = 5.12, P = 0.002</math></b>	<b>E7: <math>F_{3,560} = 5.18, P = 0.002</math></b>	$F_{3,560} = 2.32, P = 0.074$	<b>E11: <math>F_{3,571} = 3.63, P = 0.013</math></b>	<b>E13: <math>F_{3,571} = 12.24, P &lt; 0.001</math></b>
host sex	$F_{1,124} = 0.70, P = 0.403$	$F_{1,124} = 1.62, P = 0.206$	$F_{1,64} = 1.79, P = 0.186$	$F_{1,124} = 0.33, P = 0.566$	$F_{1,571} = 0.29, P = 0.593$	$F_{1,560} = 1.53, P = 0.217$	<b>E9: <math>F_{1,560} = 7.63, P = 0.006</math></b>	$F_{1,571} = 0.73, P = 0.394$	<b>E14: <math>F_{1,571} = 5.71, P = 0.017</math></b>
infection group	-	-	-	-	<b>E6: <math>F_{2,571} = 9.16, P &lt; 0.001</math></b>	<b>E8: <math>F_{2,560} = 3.28, P = 0.041</math></b>	$F_{2,560} = 1.67, P = 0.189$	<b>E12: <math>F_{2,571} = 3.64, P = 0.027</math></b>	$F_{2,571} = 2.02, P = 0.133$
temperature × temperature	<b><math>F_{1,124} = 28.36, P &lt; 0.001</math></b>	$F_{1,124} = 0.39, P = 0.532$	<b><math>F_{1,64} = 6.73, P = 0.012</math></b>	$F_{1,124} = 2.78, P = 0.098$	$F_{1,571} = 0.37, P = 0.542$	<b><math>F_{1,560} = 5.16, P = 0.023</math></b>	$F_{1,560} = 0.33, P = 0.564$	<b><math>F_{1,571} = 13.15, P &lt; 0.001</math></b>	<b><math>F_{1,571} = 25.46, P &lt; 0.001</math></b>
temperature × origin	<b><math>F_{3,124} = 6.30, P &lt; 0.001</math></b>	<b><math>F_{3,124} = 9.77, P &lt; 0.001</math></b>	$F_{3,64} = 0.36, P = 0.785$	<b><math>F_{3,124} = 8.40, P &lt; 0.001</math></b>	<b><math>F_{3,571} = 7.20, P &lt; 0.001</math></b>	<b><math>F_{3,560} = 3.77, P = 0.011</math></b>	$F_{3,560} = 1.80, P = 0.146$	<b><math>F_{3,571} = 2.85, P = 0.037</math></b>	$F_{3,571} = 1.22, P = 0.303$
temperature × host sex	$F_{1,124} = 0.15, P = 0.697$	<b><math>F_{1,124} = 5.13, P = 0.025</math></b>	$F_{1,64} = 0.66, P = 0.419$	$F_{1,124} = 0.72, P = 0.398$	$F_{1,571} = 0.29, P = 0.589$	$F_{1,560} = 2.92, P = 0.088$	<b><math>F_{1,560} = 10.37, P &lt; 0.001</math></b>	$F_{1,571} = 0.40, P = 0.530$	$F_{1,571} = 1.28, P = 0.259$
temperature × infection group	-	-	-	-	$F_{2,571} = 2.61, P = 0.075$	$F_{2,560} = 1.55, P = 0.213$	$F_{2,560} = 1.54, P = 0.216$	$F_{2,571} = 1.65, P = 0.192$	<b><math>F_{2,571} = 5.23, P = 0.006</math></b>
origin × host sex	$F_{3,124} = 1.14, P = 0.335$	$F_{3,124} = 0.69, P = 0.562$	<b>E3: <math>F_{3,64} = 3.68, P = 0.016</math></b>	$F_{3,124} = 1.39, P = 0.250$	$F_{3,571} = 0.79, P = 0.502$	$F_{3,560} = 1.17, P = 0.323$	$F_{3,560} = 1.06, P = 0.364$	$F_{3,571} = 2.47, P = 0.061$	$F_{3,571} = 1.73, P = 0.159$
origin × infection group	-	-	-	-	$F_{6,571} = 1.42, P = 0.204$	$F_{6,560} = 1.91, P = 0.077$	$F_{6,560} = 2.06, P = 0.056$	$F_{6,571} = 1.98, P = 0.066$	$F_{6,571} = 0.76, P = 0.601$
host sex × infection group	-	-	-	-	$F_{2,571} = 1.24, P = 0.290$	$F_{2,560} = 0.17, P = 0.840$	<b>E10: <math>F_{2,560} = 4.91, P = 0.008</math></b>	$F_{2,571} = 0.80, P = 0.450$	$F_{2,571} = 1.98, P = 0.139$

**Table A2.** Post-hoc comparisons for significant effects with categorical predictor variables (see Table A1 for an overview of all significant effects).  
 Symbolloging: ES = Spain, DE = Germany, ISc Iceland cold, ISw = Iceland warm, bold letters = significant ( $p \leq 0.050$ )

main effect (see table S11)	1 <sup>st</sup> (interaction) effect	2 <sup>nd</sup> interaction effect	P-value
<b>E1</b> model on parasite index origin $F_{3,124} = 4.88, P = 0.003$	<b>origin</b>		
	ES vs. DE		0.187
	ES vs. ISc		0.434
	ES vs. ISw		0.107
	DE vs. ISc		0.786
	DE vs. ISw		0.765
	ISc vs. ISw		0.765
<b>E2</b> model on relative egg count origin $F_{3,124} = 4.25, P = 0.007$	<b>origin</b>		<b>&lt; 0.001</b>
	ES vs. DE		
	ES vs. ISc		0.163
	ES vs. ISw		0.221
	DE vs. ISc		<b>0.010</b>
	DE vs. ISw		0.078
	ISc vs. ISw		0.931
<b>E3</b> model on egg size origin x host sex $F_{3,64} = 3.68, P = 0.016$	<b>origin</b>	<b>host gender</b>	<b>0.001</b>
	ES	male vs. female	
	DE	male vs. female	0.865
	ISc	male vs. female	0.977
	ISw	male vs. female	0.051
	<b>host gender</b>	<b>origin</b>	
	male	ES vs. DE	0.188
	male	ES vs. ISc	0.295
	male	ES vs. ISw	0.163
	male	DE vs. ISc	1.000
	male	DE vs. ISw	1.000
	male	ISc vs. ISw	1.000
	female	ES vs. DE	<b>&lt; 0.001</b>
	female	ES vs. ISc	<b>&lt; 0.001</b>
	female	ES vs. ISw	0.397
	female	DE vs. ISc	0.858
female	DE vs. ISw	0.340	
female	ISc vs. ISw	0.397	
<b>E4</b> model on relative coracidia count origin $F_{3,124} = 4.17, P = 0.008$	<b>origin</b>		<b>0.001</b>
	ES vs. DE		
	ES vs. ISc		<b>&lt; 0.001</b>
	ES vs. ISw		0.408
	DE vs. ISc		0.408
	DE vs. ISw		0.408
	ISc vs. ISw		0.226
<b>E5</b> model on relative HKL count origin $F_{3,571} = 5.12, P = 0.002$	<b>origin</b>		<b>0.010</b>
	ES vs. DE		
	ES vs. ISc		<b>&lt; 0.001</b>
	ES vs. ISw		<b>&lt; 0.001</b>
	DE vs. ISc		0.109
	DE vs. ISw		0.355
	ISc vs. ISw		0.602
<b>E6</b> model on relative HKL count infection group $F_{2,571} = 9.16, P < 0.001$	<b>infection group</b>		
	sham vs. exposed		0.615
	sham vs. infected		<b>&lt; 0.001</b>
	exposed vs. infected		<b>&lt; 0.001</b>

mail effect (see table S11)	1 <sup>st</sup> (interaction) effect	2 <sup>nd</sup> interaction effect	P-value
<b>E7</b> model on lymphocyte proliferation origin $F_{3,560} = 5.18, P = 0.002$	<b>origin</b>		
	ES vs. DE		0.834
	ES vs. ISc		0.844
	ES vs. ISw		0.834
	DE vs. ISc		0.453
	DE vs. ISw		0.122
	ISc vs. ISw		0.844
<b>E8</b> model on lymphocyte proliferation infection group $F_{2,560} = 3.28, P = 0.041$	<b>infection group</b>		
	sham vs. exposed		0.318
	sham vs. infected		0.774
	exposed vs. infected		0.329
<b>E9</b> model on monocyte proliferation host sex $F_{1,571} = 7.63, P = 0.006$	<b>host gender</b>		
	male vs. female		0.230
<b>E10</b> model on monocyte proliferation host sex x infection group $F_{2,560} = 4.91, P = 0.008$	<b>host gender</b>	<b>infection group</b>	
	male	sham vs. exposed	0.252
	male	sham vs. infected	0.253
	male	exposed vs. infected	1.000
	female	sham vs. exposed	0.065
	female	sham vs. infected	0.088
	female	exposed vs. infected	0.769
	<b>infection group</b>	<b>host gender</b>	
	sham	male vs. female	0.068
	exposed	male vs. female	<b>0.026</b>
	infected	male vs. female	0.070
<b>E11</b> model on respiratory burst activity origin $F_{3,571} = 3.63, P = 0.013$	<b>origin</b>		
	ES vs. DE		<b>&lt; 0.001</b>
	ES vs. ISc		1.000
	ES vs. ISw		1.000
	DE vs. ISc		<b>&lt; 0.001</b>
	DE vs. ISw		<b>&lt; 0.001</b>
	ISc vs. ISw		1.000
<b>E12</b> model on respiratory burst activity infection group $F_{2,571} = 3.64, P = 0.027$	<b>infection group</b>		
	sham vs. exposed		0.206
	sham vs. infected		<b>0.014</b>
	exposed vs. infected		0.105
<b>E13</b> model on relative weight increase origin $F_{3,571} = 12.24, P < 0.001$	<b>origin</b>		
	ES vs. DE		<b>&lt; 0.001</b>
	ES vs. ISc		<b>&lt; 0.001</b>
	ES vs. ISw		<b>&lt; 0.001</b>
	DE vs. ISc		<b>&lt; 0.001</b>
	DE vs. ISw		<b>&lt; 0.001</b>
	ISc vs. ISw		0.191
<b>E14</b> model on relative weight increase host sex $F_{1,571} = 5.71, P = 0.017$	<b>host gender</b>		
	male vs. female		<b>&lt; 0.001</b>

**Table A3.** Calculated temperature optima (vertexes of the quadratic regression curves) of individual groups. Symboling: 'min'/'max' = vertex is a local minimum/maximum, '(...)' = regression model not significant ( $p > 0.050$ ), '-' = value not available (quadratic regressions were only calculated in case of a significant effect of temperature  $\times$  temperature).

infection group	origin	parasite index	relative egg count	egg size ( $\sigma^2$ / $\sigma$ host)	relative coracidia count	relative HKL count	lymphocyte proliferation	monocyte proliferation	respiratory burst activity	relative weight increase ( $\sigma^2$ / $\sigma$ )
sham	ES	-	-	-	-	-	min 18.9	-	(max 15.4)	max 14.7 / max < 9.0
sham	DE	-	-	-	-	-	(min > 24.0)	-	(min 10.7)	max 9.9 / (max 12.2)
sham	Isc	-	-	-	-	-	min 20.0	-	(min > 24.0)	max < 9.0 / max < 9.0
sham	ISw	-	-	-	-	-	(min 14.9)	-	(min 21.3)	max 12.7 / max 14.5
exposed	ES	-	-	-	-	-	min > 24.0	-	(min 17.9)	max 13.3 / max 14.5
exposed	DE	-	-	-	-	-	min > 24.0	-	(min 19.7)	max < 9.0 / max < 9.0
exposed	Isc	-	-	-	-	-	(min 16.0)	-	min 18.7	max 12.1 / max 10.9
exposed	ISw	-	-	-	-	-	min 16.6	-	min 17.5	max 12.1 / max 13.0
infected	ES	max 22.1	linear regression	min 19.8 / (min > 24.0)	-	-	min 22.4	-	(min 16.9)	(max 11.9) / (max 13.2)
infected	DE	max 23.7	linear regression	min 23.4 / (min 20.7)	-	-	min > 24.0	-	(min > 24.0)	max < 9.0 / (min > 24.0)
infected	Isc	max > 24.0	linear regression	(min 20.9) / (min > 24.0)	-	-	min > 24.0	-	(min 18.1)	max 10.6 / (min > 24.0)
infected	ISw	max > 24.0	linear regression	(min 20.4) / -	-	-	min 18.8	-	min 18.6	max 14.6 / (max < 9.0)