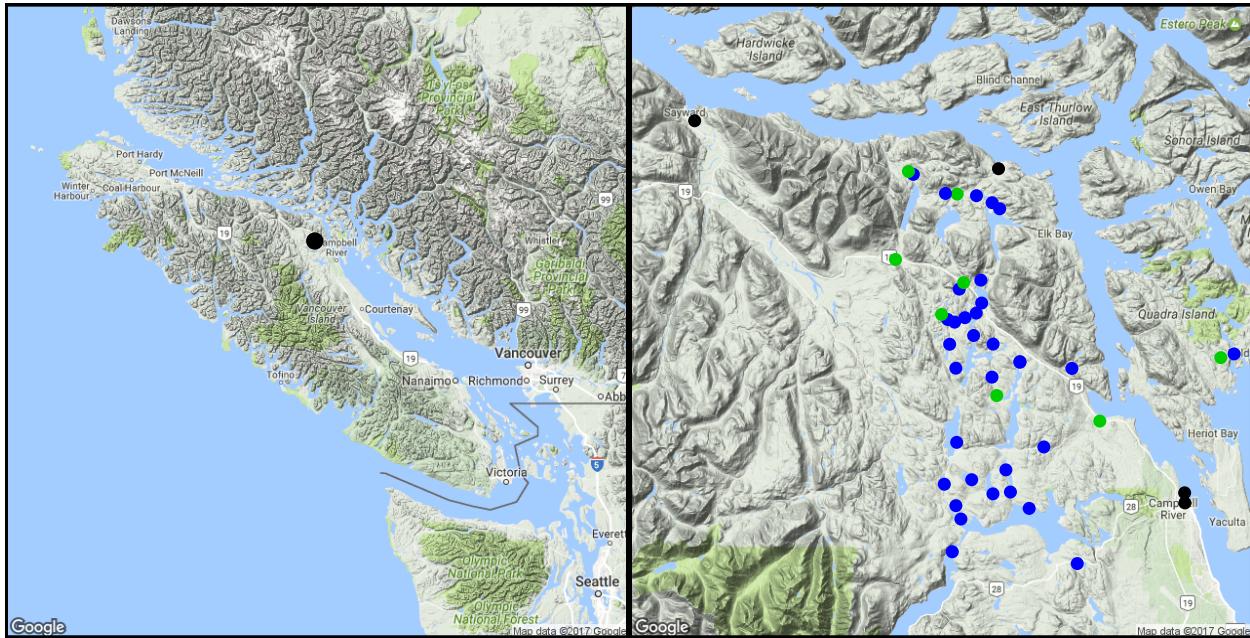


Ecography

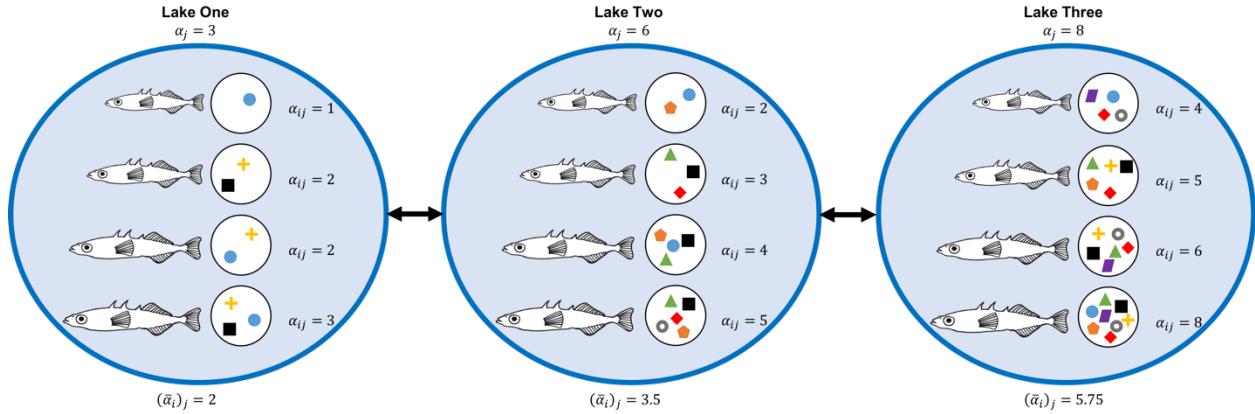
**ECOG-04994**

Bolnick, D. I., Resetarits, E. J., Ballare, K., Stuart, Y. E. and Stutz, W. E. 2020. Host patch traits have scale-dependent effects on diversity in a stickleback parasite metacommunity. – Ecography doi: 10.1111/ecog.04994

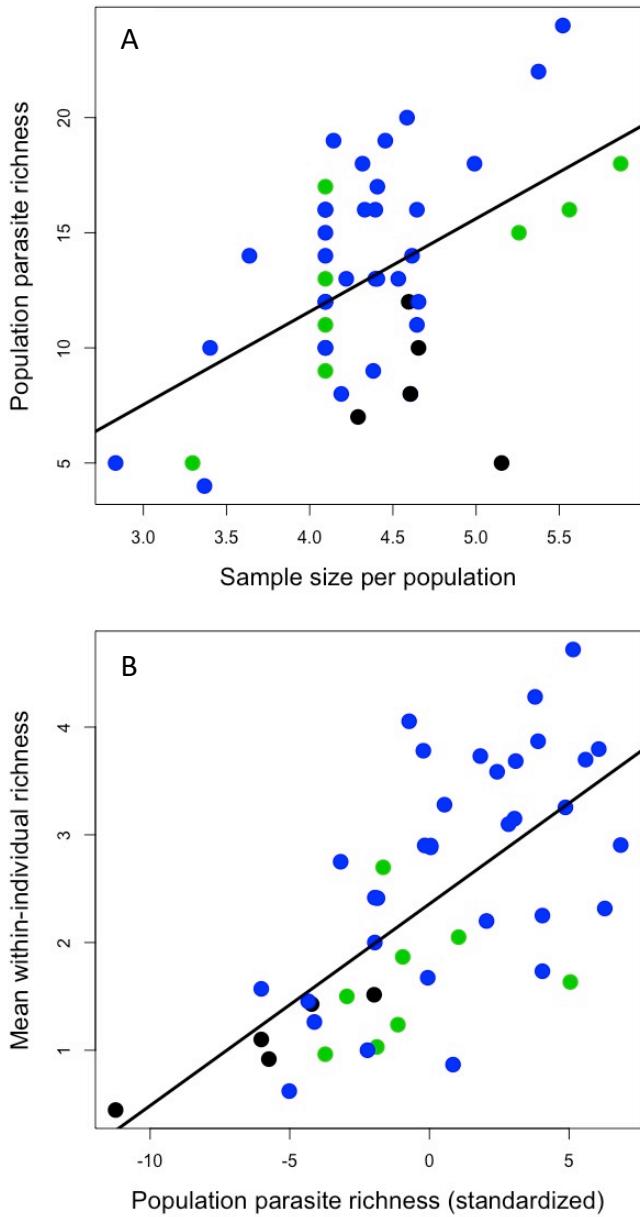
Appendix 1



**Figure A1.** (A) Map of Vancouver Island, British Columbia, with a dark point showing the location of the inset map (B) on which we plot black, green, and blue dots to indicate marine, stream, and lake populations sampled. The 5<sup>th</sup> marine site is farther northwest than shown in (B)



**Figure A2.** Illustration of variation in parasite richness among individual fish and among populations. Each blue circle represents a lake containing phenotypically varying hosts (arranged from small to large). Each host carries parasites (indicated by symbols in small circles). Individuals differ in parasite richness ( $\alpha_{ij}$ ). The populations differ in mean parasite richness  $\overline{\alpha_i}_j$ , the variance in richness among individuals ( $\sigma(\alpha_i)_j$ ), and the total parasite richness per lake ( $\alpha_j$ ).



**Figure A3.** (A) Population-wide parasite richness ( $\alpha_{*j}$ ) increased with the number of sampled fish (shown on a log scale), unlike mean per-fish richness. (B) The two measures of parasite richness, ( $\alpha_{*j}$  and  $\bar{\alpha}_l$ ) are highly correlated. Blue, black, and green points represent lake, marine, and stream sample locations. Here, we use richness standardized by individual host mass.

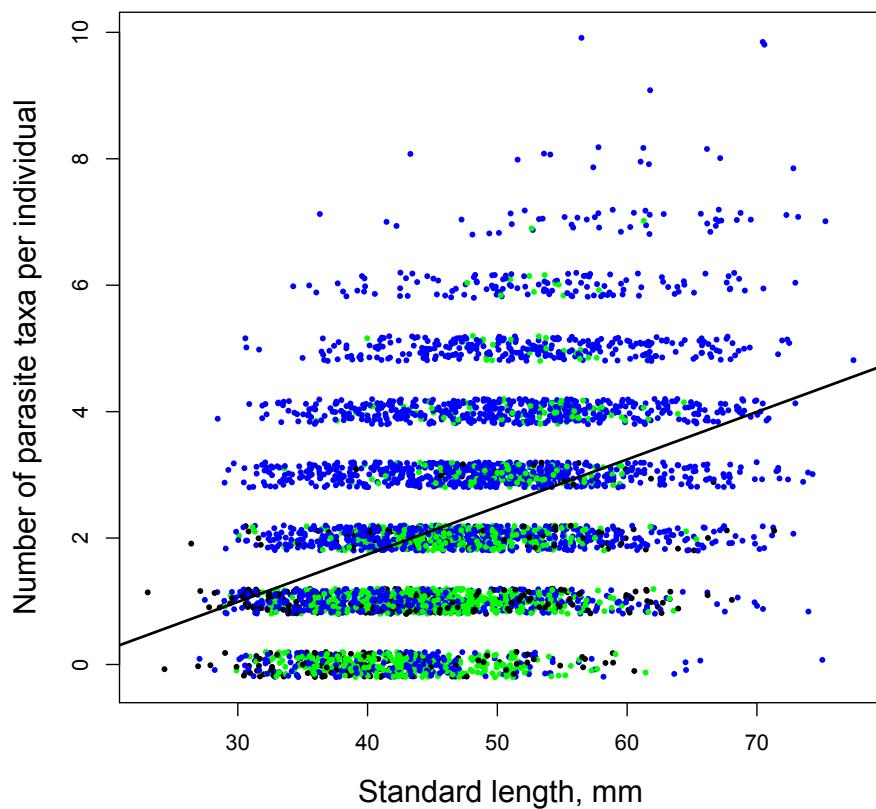
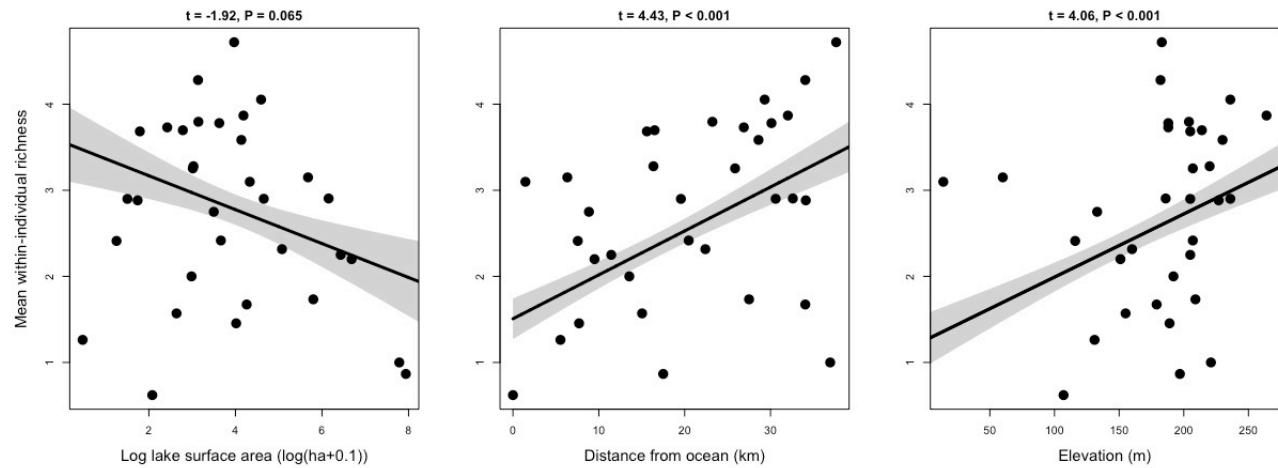
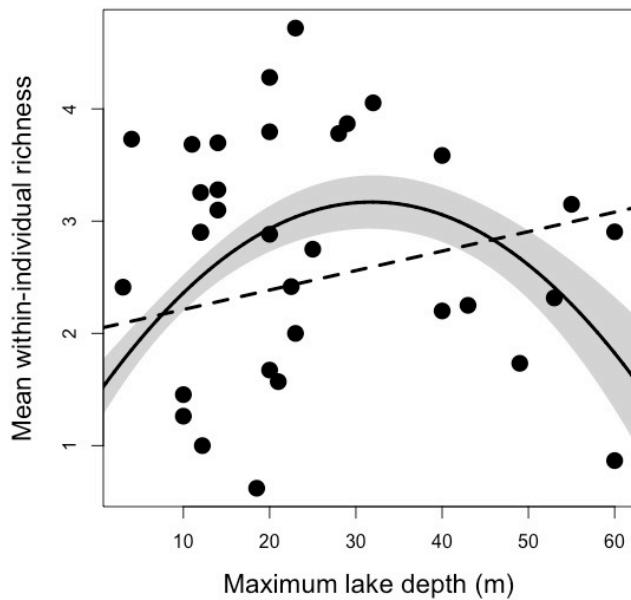
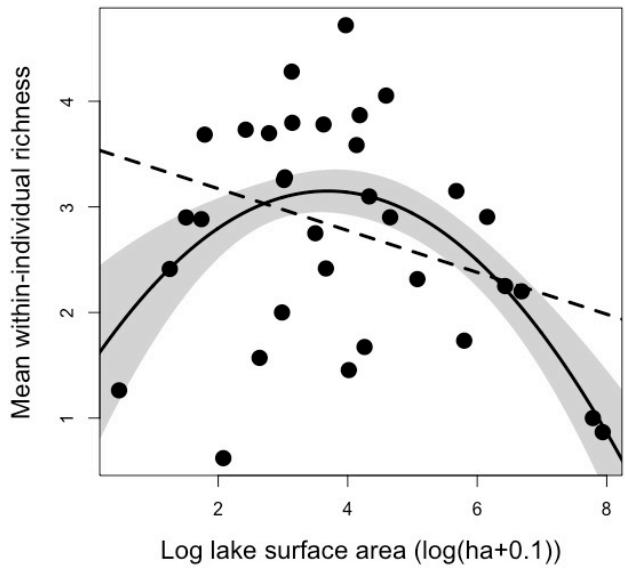


Figure A4. Parasite richness as a function of host length. Points are individual fish. Blue, green, and black dots correspond to lake, stream, and marine fish. Some jitter is added to the y axis to distinguish points.



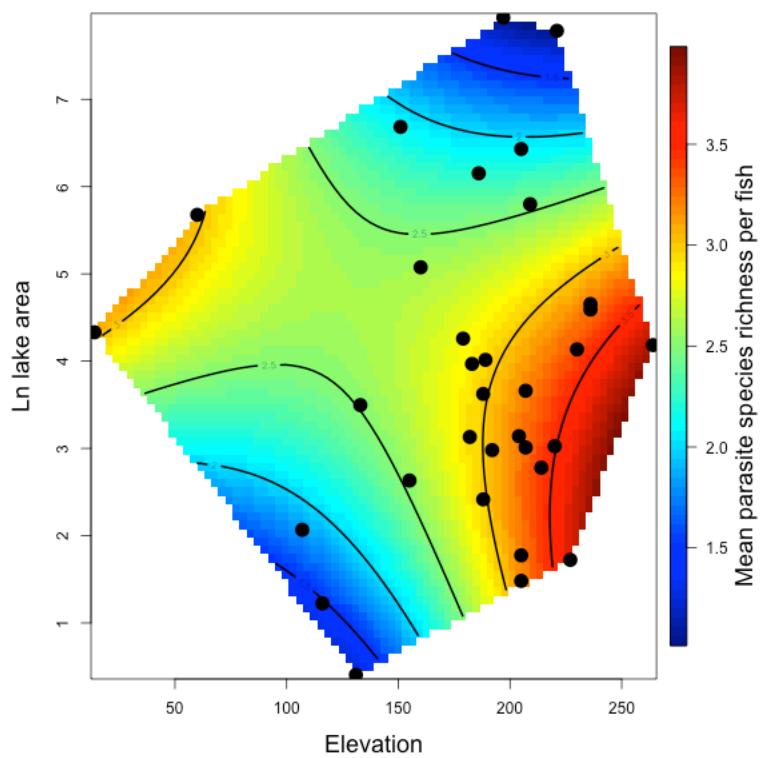
**Figure A5.** Effects of lake characteristics on population mean parasite richness per fish, using only lakes as the level of replication.





**Figure A7.** Quadratic (solid line, with 1 standard error confidence interval

shaded) and linear (dashed line) regression estimates of the effects of log lake area on population mean per-fish parasite richness. The quadratic effect is significant whereas the linear is not (Figure A5), but was only tested after visual inspection of the data, so is a post hoc analysis.



**Figure A8.** An interaction effect between elevation and log lake area on mean per-fish parasite richness: for low elevation lakes (e.g. <150 m), lake area increased parasite richness, whereas for high-elevation lakes the reverse was true. This interaction was identified and statistically tested after visualizing this trend, so is a post hoc analysis.

Site name	Longitude	Latitude	Sample size	Trophic morphol . N	Diet N	ddRAD N	Habitat	Watershed	Mean parasite richness	SD parasite richness
Adam and Eve										
Estuary	-131.9426	50.4012	99	99	0	10	Estuary	Adam River	1.52	0.91
Amor Bridge	-125.6639	50.2543	60	30	23	10	Stream	Amor River	1.63	1.30
Amor Lake	-125.5791	50.1581	60	30	30	10	Lake	Amor River	1.73	1.25
Blackwater Lake	-125.5878	50.1794	82	30	25	16	Lake	Amor River	3.78	1.38
Bob Lake	-125.5281	50.3045	80	61	61	10	Lake	Pye River	1.26	1.09
Boot Lake	-125.5270	50.0467	93	93	0	0	Lake	Campbell River	4.05	1.70
Brewster Lake	-125.5779	50.0924	63	30	28	10	Lake	Campbell River	2.90	1.86
Browns Bay Lake	-125.4159	50.1580	29	0	0	10	Lake	Browns Bay	0.62	0.73
Campbell River										
Marsh	-125.2570	50.0387	105	105	0	0	Estuary	Campbell River	1.43	0.68
Campbell River										
Point	-125.2574	50.0476	173	173	0	0	Estuary	Campbell River	0.45	0.61
Cecil Lake	-125.5440	50.2361	100	100	0	10	Lake	Amor River	1.57	1.08
Cedar Lake	-125.5664	50.2029	98	30	29	10	Lake	Amor River	3.80	1.42
Comida Lake	-125.5283	50.1502	86	86	0	0	Lake	Mohun River	3.70	1.64
Comida Stream	-125.5215	50.1339	192	192	0	0	Stream	Mohun River	2.70	1.40
Cranberry Lake	-125.4553	50.0883	66	66	0	10	Lake	Mohun River	1.45	0.73
Echo Lake	-125.4084	49.9848	68	68	0	10	Lake	Quinsam River	3.28	1.34
Farewell Lake	-125.5905	50.2013	216	216	0	0	Lake	Amor River	3.25	1.64
Farewell Stream	-125.5992	50.2058	260	260	0	0	Stream	Amor River	1.03	1.08
Fry Lake	-125.5720	50.0244	101	101	0	11	Lake	Campbell River	1.67	1.20
Gosling Lake	-125.5023	50.0483	147	146	0	0	Lake	Campbell River	3.59	1.70
Gray Lake	-125.5953	50.0553	75	30	27	9	Lake	Campbell River	4.72	1.35
Higgins Lake	-125.5088	50.0680	81	30	29	10	Lake	Campbell River	2.90	1.27
Lawson Lake	-125.5790	50.0362	82	30	27	10	Lake	Campbell River	4.28	1.85
Little Goose Lake	-125.4890	50.1634	76	31	28	10	Lake	Mohun River	3.68	1.37
Little Mud Lake	-125.5505	50.2069	60	30	29	10	Lake	Amor River	2.90	1.17
Lower Campbell										
Lake	-125.4760	50.0338	30	30	30	10	Lake	Campbell River	0.87	0.86
Lower Stella Lake	-125.5501	50.3107	104	30	30	10	Lake	Pye River	2.75	1.26
McCreight Lake	-125.6390	50.3295	60	30	28	10	Lake	Amor River	3.15	1.27
McCreight Stream	-125.6457	50.3321	60	30	29	10	Stream	Amor River	2.05	1.57

McNair Lake	-125.5744	50.2281	60	30	28	10	Lake	Amor River	2.00	1.01
Merril Lake	-125.5568	50.0593	38	30	28	10	Lake	Campbell River	3.87	1.60
Mohun Creek	-125.3767	50.1113	27	27	21	10	Stream	Mohun River	0.96	0.71
Mohun Lake	-125.4890	50.1640	60	30	28	10	Lake	Mohun River	2.25	1.62
Mud Lake	-125.5541	50.1871	60	30	28	10	Lake	Amor River	2.42	1.14
Muskeg Lake	-125.5808	50.1989	104	30	28	10	Lake	Amor River	3.73	1.10
Ormund Lake	-125.5267	50.1795	60	30	28	10	Lake	Amor River	2.88	1.53
Pye Creek	-125.5772	50.3122	60	29	27	0	Stream	Pye River	1.87	1.40
Pye Outlet	-125.5191	50.3345	73	73	0	10	Estuary	Pye River	0.92	0.60
Roberts Lake	-125.5428	50.2158	250	250	0	0	Lake	Amor River	2.32	1.41
Roberts Stream	-125.5681	50.2339	354	345	0	0	Stream	Amor River	1.24	1.16
Sayward Estuary	-125.9464	50.3769	100	100	0	10	Estuary	Salmon River	1.10	0.85
Snow Lake	-125.5937	50.3127	17	17	3	9	Lake	Pye River	2.41	0.80
Stella Lake	-125.5175	50.2992	60	30	30	11	Lake	Pye River	2.20	1.48
Upper Campbell										
Lake	-125.5841	49.9953	105	30	29	10	Lake	Campbell River	1.00	0.95
Village Bay Lake	-125.1878	50.1708	81	60	59	0	Lake	Village Bay	3.10	1.64
Village Bay Stream	-125.2064	50.1675	60	30	29	0	Stream	Village Bay	1.50	1.08

Table A1. Summary of sampled populations, locations, sample sizes, and mean parasite taxon richness.

NMDS loadings for stickleback diet.

Prey item	NMDS1	NMDS2	NMDS3	NMDS4
Ant	0.002	0.000	0.000	-0.002
Arachnid	0.003	0.003	-0.004	-0.003
Bosmina	0.148	0.017	0.054	0.165
Calanoid	0.072	0.056	-0.036	0.255
Ceratopogonid pupae	0.140	0.129	-0.142	0.851
Ceratopogonid larvae	-0.553	0.587	-0.563	-0.053
Chironomid pupae	-0.029	-0.025	-0.063	-0.133
Chironomid larvae	-0.637	-0.714	-0.118	0.194
Chydorus	0.000	0.038	0.038	-0.052
Clams	-0.014	-0.030	0.012	-0.008
Coleoptera	0.000	0.003	-0.004	-0.004
Collembola	0.005	0.006	0.006	-0.001
Cyclopoid	0.037	-0.016	-0.011	-0.108
Daphnia	-0.041	-0.026	0.046	0.027
Diaphnasoma	0.017	0.016	-0.008	0.007
Diptera pupae	0.028	0.009	0.000	-0.050
Diptera adult	0.005	0.023	-0.012	-0.128
Diptera larvae				
unidentified	0.080	0.027	0.055	-0.099
Empididae larvae	-0.009	-0.011	-0.015	-0.003
Ephemeroptera	-0.072	0.003	0.178	-0.022
Gammarus	-0.464	0.342	0.772	0.153

Harpactacoid	0.088	0.000	-0.052	0.091
Hemiptera	0.002	0.000	0.000	-0.002
Holopedium	0.000	0.001	-0.001	0.000
Hydracarina	0.000	-0.014	-0.011	-0.002
Leptodoridae	0.005	0.001	0.006	-0.005
Mussel	-0.007	-0.005	0.006	-0.001
Odonata	0.002	0.000	0.000	-0.002
Ostracod	-0.029	-0.001	0.006	-0.113
Plecoptera larvae	0.002	-0.001	0.029	-0.055
Plecoptera adult	-0.003	0.001	0.001	-0.001
Polyphemus	0.002	0.000	0.000	-0.003
Snail	0.018	-0.001	-0.005	-0.042
Stickle egg	-0.011	0.041	-0.017	-0.178
Stickle larvae	-0.005	0.005	0.003	-0.010
Tabanidae larvae	0.000	0.001	0.002	0.001
Tanyderidae larvae	-0.001	0.006	-0.007	-0.008
Tipulid pupae	-0.001	-0.004	-0.001	-0.001
Tipulid larvae	0.000	0.007	-0.001	-0.004
Trichoptera pupae	0.002	0.001	0.005	-0.003
Trichoptera larvae	0.003	-0.012	0.048	-0.025
Trichoptera adult	0.002	0.006	-0.008	0.002
Percent variance	7.2	7.1	6.2	5.4

**Table A3. Summary of statistical results from the models listed in Table 1**

M1:  $\text{logit}(\alpha_{ij}) \sim \text{population} (l_j)$

population ( $\lambda_j$ )	
effect	
size	0.731
se	0.08
Z	9.123
P	<0.0001

M2:  $\text{logit}(\alpha_{ij}) \sim \text{population} + \text{sex} + \text{length} + \text{sex} * \text{population}$

	sex	length	population	sex*population
effect				
size	-0.042	0.198	0.403	0.08
se	0.035	0.018		
Z	-1.225	11.015		
P	0.221	<0.0001		

M3:  $\text{logit}(\alpha_{ij}) \sim \text{population} + \text{sex} + \text{length} + \text{sex} * \text{population} + \text{gape width}$

	sex	length	gape width	population	sex*population
effect					
size	-0.06	0.1819	0.2726	0.352	0.1107
se	0.0487	0.0225	0.1443		
Z	-1.224	8.089	1.889		
P	0.2211	<0.0001	0.0589		

M4:  $\text{logit}(\alpha_{ij}) \sim \text{population} + \text{sex} + \text{length} + \text{sex} * \text{population}$

see M2 for summary statistics

M5:  $\text{logit}(\alpha_{ij}) \sim l_j + \text{sex}_j + \text{length} + \text{SNP}_k$

Results not summarized here none of the >39 000 SNPs tested were significant after FDR correction

M6:  $\text{logit}(\alpha_{ij}) \sim \text{population} + \text{sex} + \text{length} + \text{sex} * \text{population}$

see M2 for summary statistics

M7:  $t[\alpha_{ij}] \sim t[\text{length}] + t[\text{NMDS2}]$

	Length dimorphism	Diet NMDS2 dimorphism
effect		
size	0.413	-0.273
se	0.099	0.113
Z	4.139	-2.42
$\bar{\alpha}_{l_j}$	p	0.0004 0.0234

M8:  $\sim \text{habitat}$

	Habitat
SS	24.036
MSq	12.018
F	12.018
p	<0.0001

$\bar{\alpha}_{l_j}$

**Table A3 continued. Summary of statistical results from the models listed in Table 1**

M9: ~ log lake size + ocean distance

	Log lake size	Ocean distance
effect size	-0.182	0.045
se	0.093	0.0154
t	-1.97	2.976
$\bar{\alpha}_l j$	p	0.0579
		0.0057

M10: ~ mean length + mean gape width + mean gill raker number

	mean length	mean gape width	mean gill raker number
effect size	0.0784	6.2	0.261
se	0.0249	2.785	0.137
t	3.152	2.228	1.905
$\bar{\alpha}_l j$	p	0.0038	0.03412
			0.0671

M11: ~ mean NMDS1

	Diet NMDS1
effect size	-1.3007
se	0.7719
t	-1.685
$\bar{\alpha}_l j$	p
	0.107

M12: ~ freq(SNPk) + watershed

$\alpha_l j$	Results not summarized here none of the >39 000 SNPs tested were significant after FDR correction
--------------	---

M13: ~ mean Heterozygosity

	Heterozygosity
effect size	11.66
se	12.6
t	0.925
$\alpha_l j$	p
	0.363

M14: Heterozygosity ~ log lake size + elevation + ocean distance

	Lake size	Elevation	Ocean distance
effect size	0.0028	-0.0002	0.00007
se	0.0012	0.000057	0.00027
t	2.295	-3.723	2.67
$\alpha_l j$	p	0.0297	0.000916
			0.0125

Table A4. Path analysis results for Figure 3. Statistically significant effects are indicated in bold.  
 Lakes (n = 33) represent the level of replication in this analysis.  $r^2$  values for variables are 0.473  
 (parasite richness), 0.686 (benthic diet), 0.306 (standard length), and 0.449 (heterozygosity).

Variable 1	Variable 2	Partial correlation	Std. error	Z	p
<b>Mean heterozygosity</b>	<b>Mean per-fish parasite richness</b>	<b>0.360</b>	<b>0.174</b>	<b>2.07</b>	<b>0.038</b>
<b>Benthic diet</b>	<b>Mean per-fish parasite richness</b>	<b>0.570</b>	<b>0.230</b>	<b>2.48</b>	<b>0.013</b>
Standard length	Mean per-fish parasite richness	0.075	0.159	0.47	0.635
Elevation	Mean per-fish parasite richness	0.245	0.218	1.12	0.261
Log lake surface area	Mean per-fish parasite richness	0.053	0.236	0.225	0.822
Distance from ocean	Mean per-fish parasite richness	0.244	0.219	1.12	0.264
<b>Log lake surface area</b>	<b>Benthic diet</b>	<b>-0.777</b>	<b>0.100</b>	<b>-7.76</b>	<b>&lt;0.001</b>
Standard length	Benthic diet	0.159	0.100	1.16	0.111
<b>Log lake surface area</b>	<b>Standard length</b>	<b>-0.337</b>	<b>0.148</b>	<b>-2.27</b>	<b>0.023</b>
<b>Distance from ocean</b>	<b>Standard length</b>	<b>0.516</b>	<b>0.148</b>	<b>3.48</b>	<b>0.001</b>
<b>Log lake surface area</b>	<b>Mean heterozygosity</b>	<b>0.366</b>	<b>0.133</b>	<b>2.54</b>	<b>0.011</b>
<b>Distance from ocean</b>	<b>Mean heterozygosity</b>	<b>0.553</b>	<b>0.180</b>	<b>3.07</b>	<b>0.002</b>
<b>Elevation</b>	<b>Mean heterozygosity</b>	<b>-0.741</b>	<b>0.177</b>	<b>-4.20</b>	<b>&lt;0.001</b>