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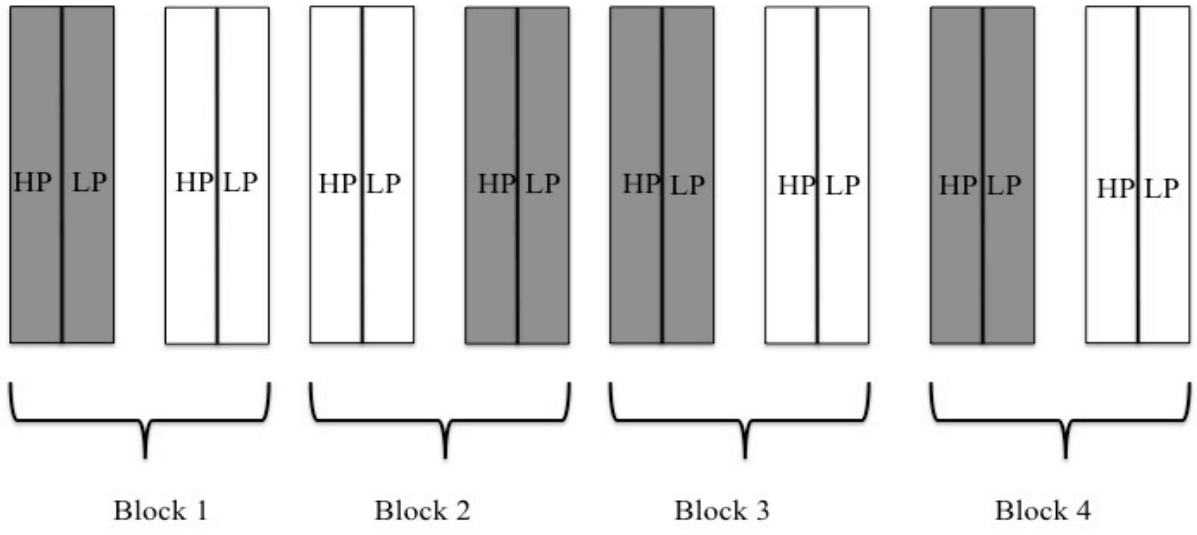
Appendix 1

Experimental and statistical design



The above figure illustrates the experimental design of the light x phenotype factorial experiment. The design was a complete random block design with all light x phenotype treatments represented in each of four blocks. Each rectangle is a flow-through channel divided laterally to create two mesocosms. HP is high predation guppy treatment, and LP is low predation guppy treatment. White structures are high light treatments (created with 20% agricultural shade cloth), and shaded structures are the low light treatments covered with 80% shade cloth. Water was diverted to the mesocosms from a nearby fishless spring via a settling tank, and then delivered to each mesocosm

using garden hoses (100 ft long, 3/4 inches wide). An equal mixture of sand and gravel was evenly spread to a depth of 5 cm at the bottom of each mesocosm. Mesocosms were then conditioned in running water for ~7 days to allow for the build up of biofilm and benthic organic matter. Invertebrates and benthic organic matter were collected using kick nets from the slow-running portions of a nearby tributary of the Arima River. The collection area was equivalent to total mesocosm area. Large larvae of predaceous insects (such as odonates) were removed by hand, and the remaining material was homogenized then distributed equally between all mesocosms. Insects were allowed one week to colonize the mesocosms before the experiment began.

Algal accrual rates

Spatial block, day of the experiment, light treatment (high light or low light), phenotype and interaction between day, light and phenotype were entered as fixed effects. We added a repeated effect with the mesocosm number as the subject to obtain the proper between-subject (mesocosm) and within-subject (mesocosm × day) error terms and degrees of freedom for all tests. An autoregressive repeated covariance structure was used to account for the non-independence of data-points within mesocosms and error terms grouped by light treatment because it provided a better fit to the data as judged by a likelihood ratio test ($\chi^2 = 6.74$, $p = 0.034$). This analysis is similar to repeated measures ANOVA but is more powerful because models the error associated with different treatments more accurately than ANOVA. Unbiased estimates of effects and errors was obtained using restricted maximum likelihood (REML).

Leaf litter decomposition

Leaf litter decomposition rates (K) are analyzed using a non-linear model. Leaf litter decay rates are an exponential function of time, which takes the form:

Percent initial dry mass litter day t = intercept x $\exp(-K \times t)$

K is the rate of decay and the intercept is the dry mass of the leaves at time t = 0. We modeled K as linear function of our treatments:

K = LPLL + LPHL + HPLL + HPHL

Where the values on the right side are marginal means for each of the treatment (example, LPLL=Low predation, Low light) We tested the effects of our factorial design by constructing contrast matrices that yielded main effects of phenotype and density as also the interaction between phenotype and light. Spatial block effects were also initially included in the model, but were subsequently removed because they were non-significant.

Guppy-mediated nutrient recycling rates (i.e. excretion rates)

For females, body size and its interactions between each fixed categorical effect were initially entered as fixed covariates. Since excretion rate should be an allometric function of body size, the dependent variable and the body size covariate were natural log transformed prior to analysis to obtain linear relationships. Interactions between the covariate and the categorical fixed effects were removed, one at a time if they were not significant. When interactions between size and fixed categorical effects were significant, the covariates were centered at three points (mean – 1 SD, mean, mean + 1 SD) and tested the treatment effects at each of these sizes. Body size was not entered as a covariate in the analysis for males because males cease to grow after maturity and LP males are generally larger than HP males. Hence, including size as a covariate would reduce our ability to separate the independent effects of size and phenotype on male excretion rates.

Appendix 2

Supplementary figures and tables

Table A1. Model selection for guppy somatic growth. B is block, S is body size, L is light and P is guppy phenotype.

Fixed effects	AICc	Δ AICc	Relative likelihood	AICc weight	Cum. AICc weight	AICc weight for averaging
B+ S+ P + L + P × L + S × P	292.99	0	1	0.26	0.26	0.26
B+ S+ P + L + P × L	293.01	0.02	0.99	0.25	0.51	0.25
B+ S+ P + L + P × L + S × L + S × P	293.06	0.07	0.97	0.25	0.76	0.25
B+ S+ P + L + P × L + S × L	293.79	0.8	0.67	0.17	0.93	0.17
B+ S+ P + L + P × L + S × L + S × P + S × P × L	295.64	2.65	0.27	0.07	1	0.07
S+ P + L + P × L + S × L + S × P	316.07	23.08	0	0	1	
S+ P + L + P × L	316.35	23.36	0	0	1	
S+ P + L + P × L + S × P	316.44	23.45	0	0	1	
S+ P + L + P × L + S × L	316.77	23.78	0	0	1	
S+ P + L + P × L + S × L + S × P + S × P × L	318.49	25.5	0	0	1	

Table A2. Model selection for guppy fecundity. B is block, S is body size, L is light and P is guppy phenotype.

Fixed effects	QAICc	ΔQAICc	Relative likelihood	QAICc weight	Cum. QAICc weight	QAICc weight for averaging
S+ P + L + P × L	278.28	0	1	0.89	0.89	0.94
S+ P + L + P × L + S × L	283.84	5.56	0.06	0.06	0.94	0.06
S+ P + L + P × L + S × P	284.19	5.91	0.05	0.05	0.99	
B+ S+ P + L + P × L	288.19	9.91	0.01	0.01	1	
S+ P + L + P × L + S × L + S × P	290.22	11.94	0	0	1	
B+ S+ P + L + P × L + S × P	294.42	16.14	0	0	1	
B+ S+ P + L + P × L + S × L	294.77	16.49	0	0	1	
B+ S+ P + L + P × L + S × L + S × P	301.51	23.23	0	0	1	
S+ P + L + P × L + S × L + S × P + S × P × L	302.34	24.06	0	0	1	
B+ S+ P + L + P × L + S × L + S × P + S × P × L	316.5	38.22	0	0	1	

Table A3. Model selection for guppy probability of reproduction. B is block, S is body size, L is light and P is guppy phenotype.

Fixed effects	QAICc	ΔQAICc	Relative likelihood	QAICc weight	Cum. QAICc weight	QAICc weight for averaging
S+ P + L + P × L	161.48	0	1	0.69	0.69	0.73
S+ P + L + P × L + S × L	163.97	2.5	0.29	0.2	0.89	0.21
S+ P + L + P × L + S × P	166.33	4.85	0.09	0.06	0.95	0.06
B+ S+ P + L + P × L	168	6.52	0.04	0.03	0.97	
S+ P + L + P × L + S × L + S × P	168.82	7.34	0.03	0.02	0.99	
B+ S+ P + L + P × L + S × L	170.6	9.12	0.01	0.01	1	
B+ S+ P + L + P × L + S × P	173.16	11.68	0	0	1	
B+ S+ P + L + P × L + S × L + S × P	175.68	14.2	0	0	1	
S+ P + L + P × L + S × L + S × P + S × P × L	179.52	18.04	0	0	1	
B+ S+ P + L + P × L + S × L + S × P + S × P × L	187.42	25.95	0	0	1	

Table A4. Model selection for guppy size at birth. B is block, SD is stage of development, L is light and P is guppy phenotype.

Fixed effects	AICc	Δ AICc	Relative likelihood	AICc weight	Cum. AICc weight	AICc weight for averaging
SD+ P + L + P × L	70.49	0	1	0.9	0.9	0.9
B+ SD+ P + L + P × L	74.85	4.36	0.11	0.1	1	0.1

Table A5. IPM model averaged parameter estimates and standard errors. LP is low predation, HP is high predation, LL is low light, and HL is high light. NA means that residual variances were not computed or not used in the IPM.

Effect	Level	Somatic growth	No. of offspring	Prob. reproduction	Offspring length
Intercept		4.762 (0.2373)	1.284 (0.1521)	7.768 (2.3107)	7.133 (0.1665)
Stage of Development		-	-	-	-0.005 (0.0059)
Block	1	-1.103 (0.2499)	-	-	-0.207 (0.13)
Block	2	0.556 (0.2586)	-	-	-0.121 (0.1214)
Block	3	-0.128 (0.2594)	-	-	-0.123 (0.12)
Block	4	0	-	-	0
Body size		-0.42 (0.0486)	2.49 (0.2372)	1.163 (0.3681)	-
Phenotype	LP	0.419 (0.2538)	-0.364 (0.1143)	-0.051 (1.5059)	0.678 (0.1213)
Phenotype	HP	0	0	0	0
Light	LL	-1.708 (0.252)	-0.502 (0.1397)	-0.445 (1.9856)	0.134 (0.1293)
Light	HL	0	0	0	0
Phenotype × Light	LPLL	-0.507 (0.3625)	-0.302 (0.2047)	-2.535 (1.5976)	0.116 (0.1909)
Phenotype × Light	LPHL	0	0	0	0
Phenotype × Light	HPLL	0	0	0	0
Phenotype × Light	HPHL	0	0	0	0
Body size × Light	LL	0.046 (0.0498)	0.012 (0.1212)	0.134 (0.3117)	-
Body size × Light	HL	0	0	0	-
Body size × Phenotype	LL	-0.061 (0.0538)	0 (0)	-0.007 (0.1734)	-
Body size × Phenotype	HL	0	0	0	-
Body size × Phenotype × Light	LPLL	-0.001 (0.0353)	-	-	-
Body size × Phenotype × Light	LPHL	0	-	-	-
Body size × Phenotype × Light	HPLL	0	-	-	-
Body size × Phenotype × Light	HPHL	0	-	-	-
Residual variance		0.657 (0.1059)	NA	NA	0.146 (0.0261)

Table A6. (A) The effects of experimental treatments on reproductive allotment in female guppies, and 8B) The marginal means of the treatment effects on reproductive allotment. These were not used in the IPM but are typically reported in guppy life history studies. HP is high predation phenotype, and LP is the low predation phenotype. HL is the high light treatment, and LL is the low light treatment. Panel A reports the results of a GLM model. Panel B reports the parameter estimates from the models.

(A)

Effect	Num DF	Den DF	F-value	Pr > F
Block	3	9	1.06	0.4131
stage of development	1	51	3.78	0.0574
Phenotype	1	9	2.2	0.1719
Light	1	9	0.05	0.8227
Phenotype × Light	1	9	2.73	0.1328

(B)

Treatment	Estimate	Standard error	DF	t-value	Pr > |t|
HP-HL	0.1363	0.01298	9	10.5	<.0001
HP-LL	0.1585	0.009958	9	15.92	<.0001
LP-HL	0.174	0.01114	9	15.63	<.0001
HPL-LL	0.1563	0.01006	9	15.54	<.0001

Table A7. The effect of experimental treatments on guppy-mediated nutrient recycling.

(A) Effects on N excretion on medium (18 mm) female guppies

Effect	NumDF	DenDF	F	P
Final body size	1	11	58.2303	<0.001
Phenotype	1	12	6.3829	0.0266
Light	1	12	11.2951	0.0057
Phenotype × Light	1	12	0.1571	0.6988
Size × Phenotype	1	11	4.5378	0.0566

(B) Effects on small (< 12 mm) female guppies

Effect	NumDF	DenDF	F	P
Final body size	1	11	58.2303	<0.001
Phenotype	1	12	0.0344	0.8560
Light	1	12	11.2951	0.0057
Phenotype × Light	1	12	0.1571	0.6988
Size × Phenotype	1	11	4.5378	0.0566

(C) Effects on large (> 24 mm) female guppies

Effect	NumDF	DenDF	F	P
Final body size	1	11	58.2303	<0.001
Phenotype	1	12	11.0811	0.0060
Light	1	12	11.2951	0.0057
Phenotype × Light	1	12	0.1571	0.6988
Size × Phenotype	1	11	4.5378	0.0566

(D) Effect on P excretion in females

Effect	NumDF	DenDF	F	P
Block	3	9	3.0136	0.0869
Final body size	1	12	16.4496	0.0016
Phenotype	1	9	0.1368	0.7200
Light	1	9	0.9009	0.3673
Phenotype × Light	1	9	0.4955	0.4993
Size × Phenotype	1	12	2.4608	0.1427
Size × Light	1	12	1.5337	0.2392

(E) Effect on N excretion in male guppies

Effect	NumDF	DenDF	F	P

Phenotype	3	9	3.0136	0.0869
Light	1	11	4.3867	0.0602
Phenotype × Light	1	11	0.3292	0.5777

(F) Effects on P excretion in male guppies

Effect	NumDF	DenDF	F	P
Block	3	7	2.6367	0.1313
Phenotype	1	7	1.1153	0.3260
Light	1	7	1.7042	0.2330
Phenotype × Light	1	7	0.7447	0.4167

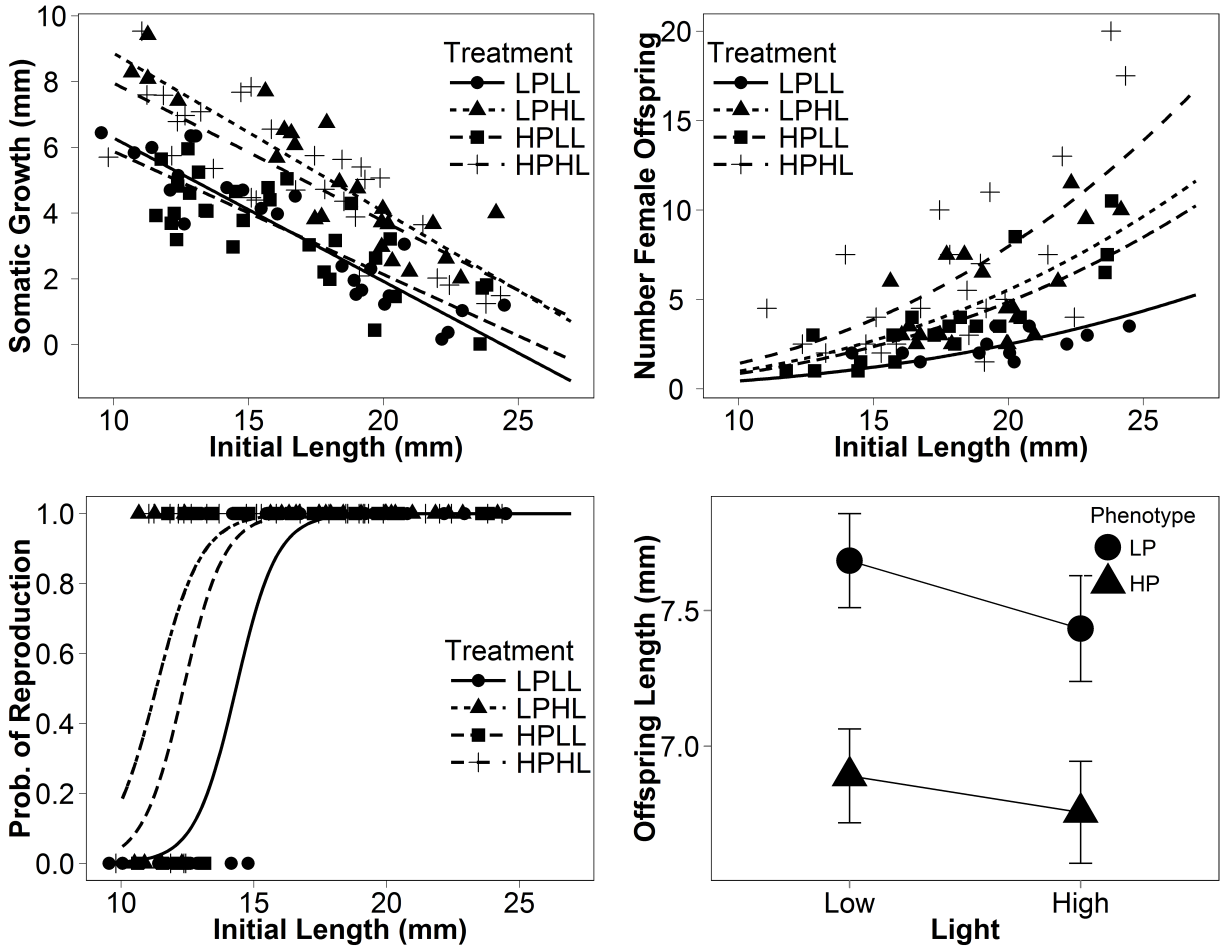


Figure A1. Estimates of demographic guppy traits for each of the light and phenotype treatments using the model selection process described in Table A1 and A2. LP is low predation, HP is high predation, LL is low light, and HL is high light.

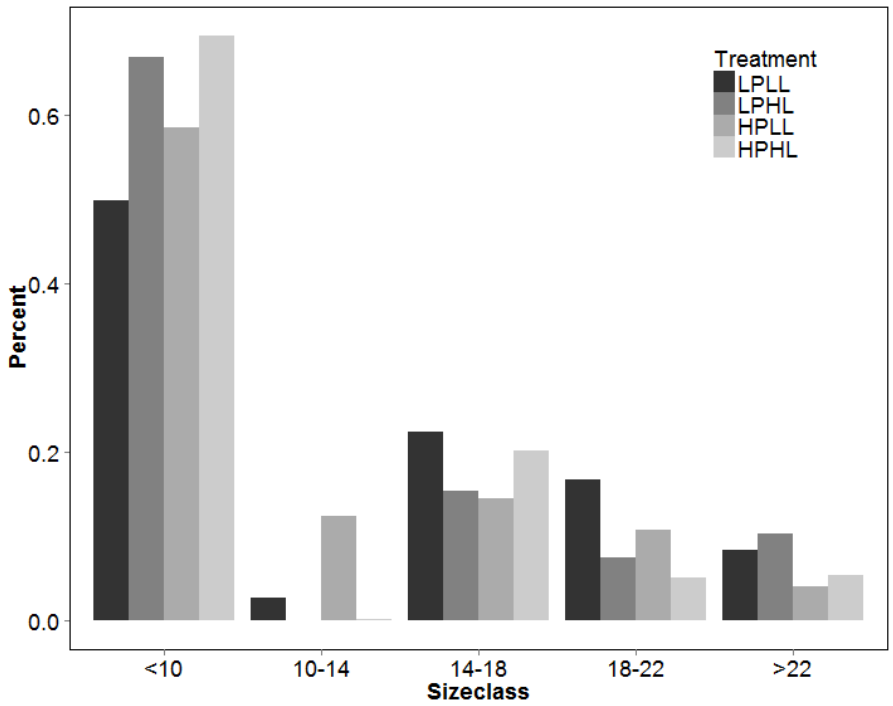


Figure A2. Stable size distributions of each of the light and phenotype treatments as a function of size. LP is low predation, HP is high predation, LL is low light, and HL is high light.

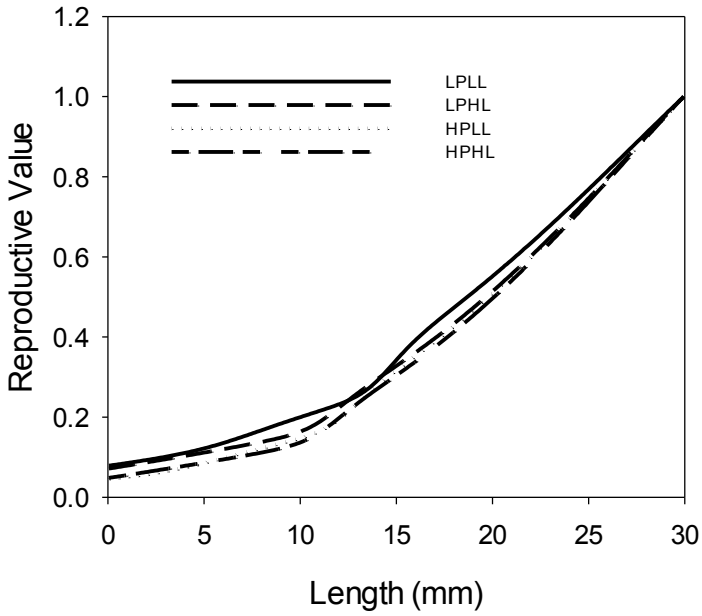


Figure A3. Reproductive value as a function of size generated for each of the experimental treatments. LP is low predation, HP is high predation, LL is low light, and HL is high light.

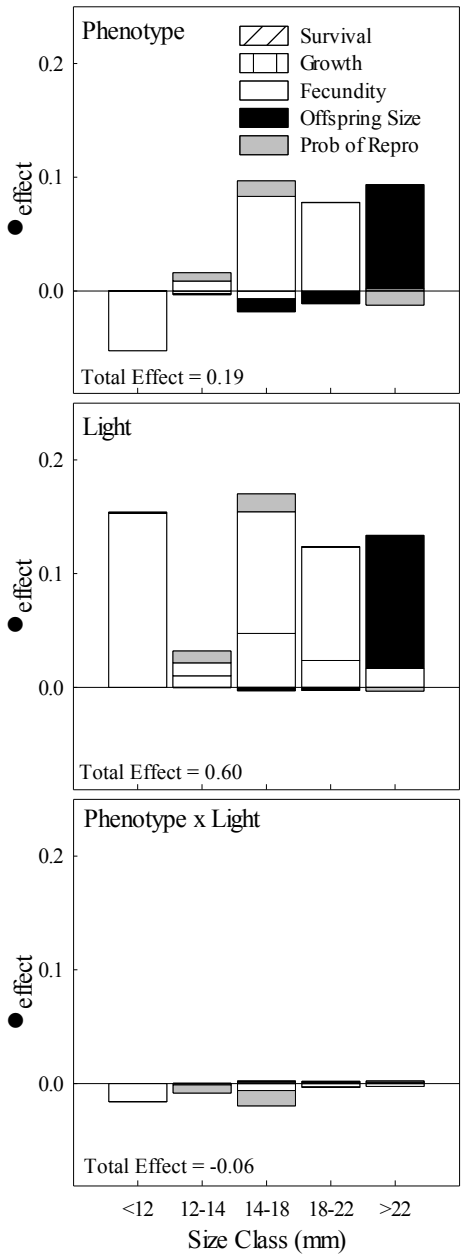


Figure A4. Effect of treatments on population growth rates (λ) divided into several size classes. Effects of size classes are the total effect of all individuals within that size class. Classes were chosen to represent approximate developmental stages of guppies. Individuals less than 12 mm are generally less than one month old and immature, individuals 12–14 mm are older immature fish, fish that are 14–18 mm are reproducing for the first time, 18–22 mm are mature fish and those greater than 22 mm have reproduced several times.

Appendix 3

Details of the invertebrate community found in the experimental channels. Density is in mg dry mass per m^2, averaged across all experimental channels. St. Dev is standard deviation. The small fraction (invertebrates < 1mm) and the large fraction (invertebrates > 1 mm) were split by passing the invertebrate samples through a 1 mm steel mesh.

Fraction	Order	Family	Genus/Tribe/Subfamily	Average density	St. Dev
Small	Oligochaeta	Other	Other oligochaete	0.58	0.53
	Unsegmented Worms	Other	Other oligochaete	0.07	0.16
	Ephemeroptera	Baetidae	Cloeodes	0.08	0.28
	Ephemeroptera	Caenidae	Caenis	7.76	11.37
	Ephemeroptera	Leptohyphidae	Tricorythodes	0.79	1.11
	Ephemeroptera	Baetidae	Unknown	0.08	0.25
	Ephemeroptera	Euthyplociidae	Euthyplocia	0.04	0.16
	Odonata	Libellulidae	Libellula	0.03	0.11
	Odonata	Libellulidae	Unknown	0.15	0.27
	Zygoptera	Unknown	Unknown	0.01	0.05
	Zygoptera	Coenagrionidae	Unknown	0.01	0.03
	Hemiptera	Veliidae	Microvelia	0.03	0.07
	Trichoptera	Polycentropodidae	Cernotina	0.77	0.88
	Trichoptera	Calamoceratidae	Phylloicus	0.18	0.43
	Trichoptera	Hydropsychidae	Unknown	0.03	0.12
	Trichoptera	Hydroptilidae	Unknown	0.18	0.34
	Trichoptera	Hydroptilidae	Neotrichia	0.01	0.03
	Coleoptera	Elmidae	Neoelmis	0.28	0.58
	Coleoptera	Scirtidae	Unknown	0.10	0.19
	Coleoptera	Psephenidae	Psephenus	0.00	0.01
	Diptera	Ceratopogonidae	Bezzia/Palpomyia complex	0.53	0.58
	Diptera	Ceratopogonidae	Atrichopogon	0.03	0.05
	Diptera	Chironomidae	Non-tanypodinae	120.63	100.57
	Diptera	Chironomidae	Pupae	1.22	0.83

	Diptera	Chironomidae	Tanypodinae	7.83	4.94
Large	Ephemeroptera	Baetidae	Cloeodes	0.74	1.41
	Ephemeroptera	Leptohyphidae	Tricorythodes	4.17	6.66
	Ephemeroptera	Leptophlebiidae	Thraulodes	0.06	0.22
	Ephemeroptera	Euthyplocidae	Euthyplocia	0.15	0.61
	Ephemeroptera	Caenidae	Caenis	1.71	4.62
	Odonata	Libellulidae	Libellula	33.96	40.48
	Odonata	Coenagrionidae	Argia	1.89	6.24
	Trichoptera	Polycentropodidae	Cernotina	4.36	10.44
	Trichoptera	Hydropsychidae	Smicridea	0.23	0.92
	Trichoptera	Hydroptilidae	Hydroptila	0.43	1.48
	Trichoptera	Calamoceratidae	Phylloicus	1.20	4.65
	Coleoptera	Elmidae	Heterelmis	0.46	1.47
	Coleoptera	Elmidae	Phanocerus	1.41	3.44
	Coleoptera	Elmidae	adults	0.06	0.25
	Diptera	Ceratopogonidae	Bezzia/Palpomyia complex	5.48	7.16
	Diptera	Ceratopogonidae	Atrichopogon	0.01	0.02
	Diptera	Chironomidae	Tanypodinae	27.47	20.47
	Diptera	Chironomidae	Non-tanypodinae	104.25	76.44
	Diptera	Stratiomyiidae	Maruina	0.03	0.12
	Diptera	pupae	Unknown	2.68	1.77

Appendix 4

Least square means and standard errors of ecosystem variables

(A) Least square means for high predation (HP) guppies at low light (LL) and high light (HL)

Variable	Units	Transformation	HP-HL	St. Error	HP-LL	St. Error
Algal standing stock Day 7	mg chl per m^2	none	18.8	5.62	7.3	2.82
Algal standing stock 14	mg chl per m^2	none	64.8	5.62	23.6	2.82
Algal standing stock 21	mg chl per m^2	none	51.0	5.62	38.8	3.33
Algal standing stock 28	mg chl per m^2	none	56.5	5.62	26.8	2.82
Leaf decay rate	% loss per day	none	0.09	0.01	0.09	0.01
Areal GPP	mg O_2 per m^2 per day	natural log	5.6	0.08	5.3	0.08
Biomass GPP	mg O_2 per mg chl per day	natural log	1.5	0.24	2.4	0.24
CR24	mg O_2 per m^2 per day	none	-22.1	1.30	-17.7	1.30
NDM	mg O_2 per m^2 per day	natural log	5.7	0.08	5.4	0.08
N flux	µg N per m^2 per hour	none	35.0	108.00	-113.7	108.00
N excretion of small guppies	µg N per fish per hour	natural log	-0.8	0.10	0.1	0.10
N excretion of medium guppies	µg N per fish per hour	natural log	-0.5	0.10	0.1	0.10
N excretion of large guppies	µg N per fish per hour	natural log	-0.3	0.10	0.1	0.10
Small invertebrate standing stocks	mg DM per m^2	natural log	5.2	0.21	3.9	0.21
Large invertebrate standing stocks	mg DM per m^2	natural log	5.7	0.18	4.9	0.18
Small chironomid standing stocks	mg DM per m^2	natural log	5.1	0.22	3.8	0.22
Big chironomid standing stocks	mg DM per m^2	natural log	5.4	0.25	4.6	0.25
Total invertebrate standing stocks	mg DM per m^2	natural log	6.2	0.18	5.2	0.18
Total chironomid standing stocks	µg P per m^2 per hour	natural log	6.0	0.19	5.0	0.19
Total population excretion N	µg N per hour	none	463.0	40.00	249.1	40.00
Total population excretion P	µg N per hour	none	47.6	1.20	38.8	1.20

(B) Least square means for low predation (LP) guppies at low light (LL) and high light (HL)

Variable	Units	Transformation	LP-HL	St. Error	LP-LL	St. Error
Algal standing stock Day 7	mg chl per m^2	none	19.1	5.62	10.8	2.82

Algal standing stock 14	mg chl per m^2	none	54.7	5.62	19.4	2.82
Algal standing stock 21	mg chl per m^2	none	44.3	5.62	15.0	3.33
Algal standing stock 28	mg chl per m^2	none	59.6	5.62	21.7	2.82
Leaf decay rate	% loss per day	none	0.08	0.01	0.08	0.01
Areal GPP	mg O_2 per m^2 per day	natural log	5.3	0.08	5.2	0.08
Biomass GPP	mg O_2 per mg chl per day	natural log	1.3	0.24	2.6	0.24
CR24	mg O_2 per m^2 per day	none	-16.5	1.30	-16.1	1.30
NDM	mg O_2 per m^2 per day	natural log	5.5	0.08	5.3	0.08
N flux	µg N per m^2 per hour	none	-182.9	108.00	-418.0	108.00
N excretion of small guppies	µg N per fish per hour	natural log	-0.8	0.10	-0.4	0.10
N excretion of medium guppies	µg N per fish per hour	natural log	-0.3	0.10	0.0	0.10
N excretion of large guppies	µg N per fish per hour	natural log	0.1	0.10	0.4	0.10
Small invertebrate standing stocks	mg DM per m^2	natural log	5.6	0.21	3.7	0.21
Large invertebrate standing stocks	mg DM per m^2	natural log	5.3	0.18	4.4	0.18
Small chironomid standing stocks	mg DM per m^2	natural log	5.5	0.22	3.5	0.22
Big chironomid standing stocks	mg DM per m^2	natural log	4.7	0.25	4.0	0.25
Total invertebrate standing stocks	mg DM per m^2	natural log	6.2	0.18	4.8	0.18
Total chironomid standing stocks	µg P per m^2 per hour	natural log	5.9	0.19	4.5	0.19
Total population excretion N	µg N per hour	none	284.7	40.00	210.9	40.00
Total population excretion P	µg N per hour	none	47.2	1.20	40.2	1.20