

Appendix 1

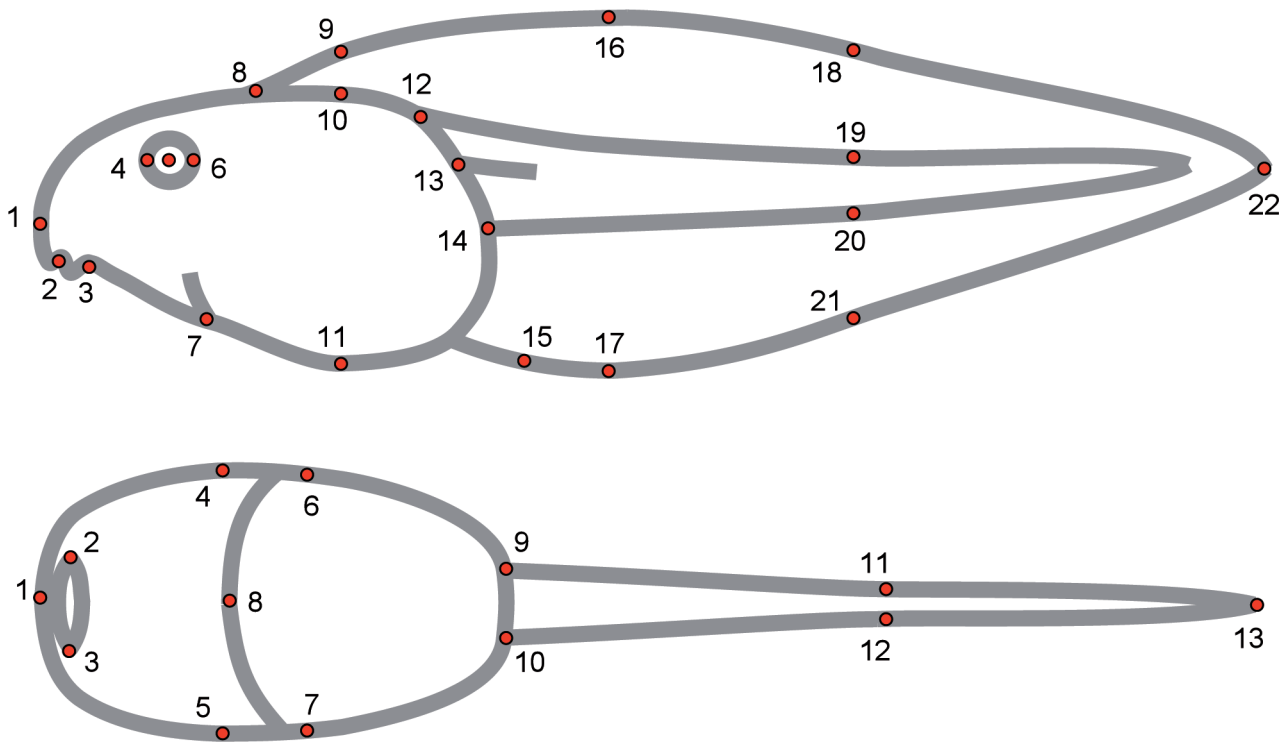
Ponds included in this study

List of ponds included in the field survey (A) and source ponds for amphibians used in the experiment (B). Area and depth were estimated at maximum water level; proportion canopy cover was measured in mid May after leafout.

	Pond	Lat./Lon.	Area (m ²)	Max. depth (cm)	Canopy cover
(A) Survey ponds					
	Adlikon	47°58'2"N, 8°69'9"E	2500	120	0.13
	Allmendteich South	47°48'1"N, 8°54'5"E	2500	100	0.14
	Airport West Marsh	47°46'7"N, 8°53'9"E	850	65	0.02
	Airport Woodland Pond	47°46'2"N, 8°54'0"E	850	90	0.58
	Kiesgrube Ebnet	47°54'2"N, 8°78'1"E	360	85	0.00
	Räubrichseen West	47°61'3"N, 8°67'7"E	1500	140	0.59
	Richetsriet	47°57'2"N, 8°73'9"E	80	35	0.67
	Schlosswinkel East	47°46'5"N, 8°53'6"E	250	80	0.59
	Schlosswinkel West	47°46'5"N, 8°53'5"E	1000	95	0.32
	Schoorenriet	47°58'8"N, 8°86'1"E	15000	100	0.58
	Weierhof	47°62'5"N, 8°68'6"E	4000	90	0.01
(B) Source ponds for the experiment					
<i>Rana temporaria</i>					
	Unterholz	47°39'7"N, 8°56'7"E	5	25	0.72
	Weierhof	47°62'5"N, 8°68'6"E	4000	90	0.01
<i>Hyla arborea</i>					
	Jonas Pond	47°49'5"N, 8°52'5"E	225	40	0.00
<i>Triturus alpestris</i>					
	Strickhof	47°39'5"N, 8°54'9"E	60	40	0.20

Appendix 2

Landmarks for anurans



Side-view landmarks

- 1 Most anterior point on the nose
- 2 Center of the partially-opened mouth when viewed from the side
- 3 Junction of the posterior edge of the lower labium and the body wall
- 4 Anterior edge of the iris on a horizontal line extending through the center of the eye
- 5 Center of the pupil
- 6 Posterior edge of the iris
- 7 Lower edge of the head/body at the anterior gut margin
- 8 Point at which the edge of the dorsal tail fin attaches to the top of the head/body
- 9 Highest point of the head/body or tail fin at 2/3rds of the distance between no. 1 and no. 14
- 10 Dorsal edge of the head/body at 2/3rds the distance between no. 1 and no. 14
- 11 Ventral edge of the body at 2/3rds the distance between no. 1 and no. 14
- 12 Point where upper edge of the tail muscle meets head/body
- 13 Point where the notochord (identified from the pattern of myotomes) meets the head/body
- 14 Bottom edge of tail muscle meets head/body
- 15 Point where the center of the anus meets the lower edge of the tail fin
- 16 Dorsal edge of the tail fin at the deepest point
- 17 Ventral edge of tail fin directly below no. 16
- 18 Upper edge of the tail fin halfway between no. 14 and no. 22
- 19 Top of tail muscle at halfway point
- 20 Bottom of tail muscle at halfway point
- 21 Ventral edge of the tail fin at halfway point
- 22 Tip of tail fin

Bottom-view landmarks

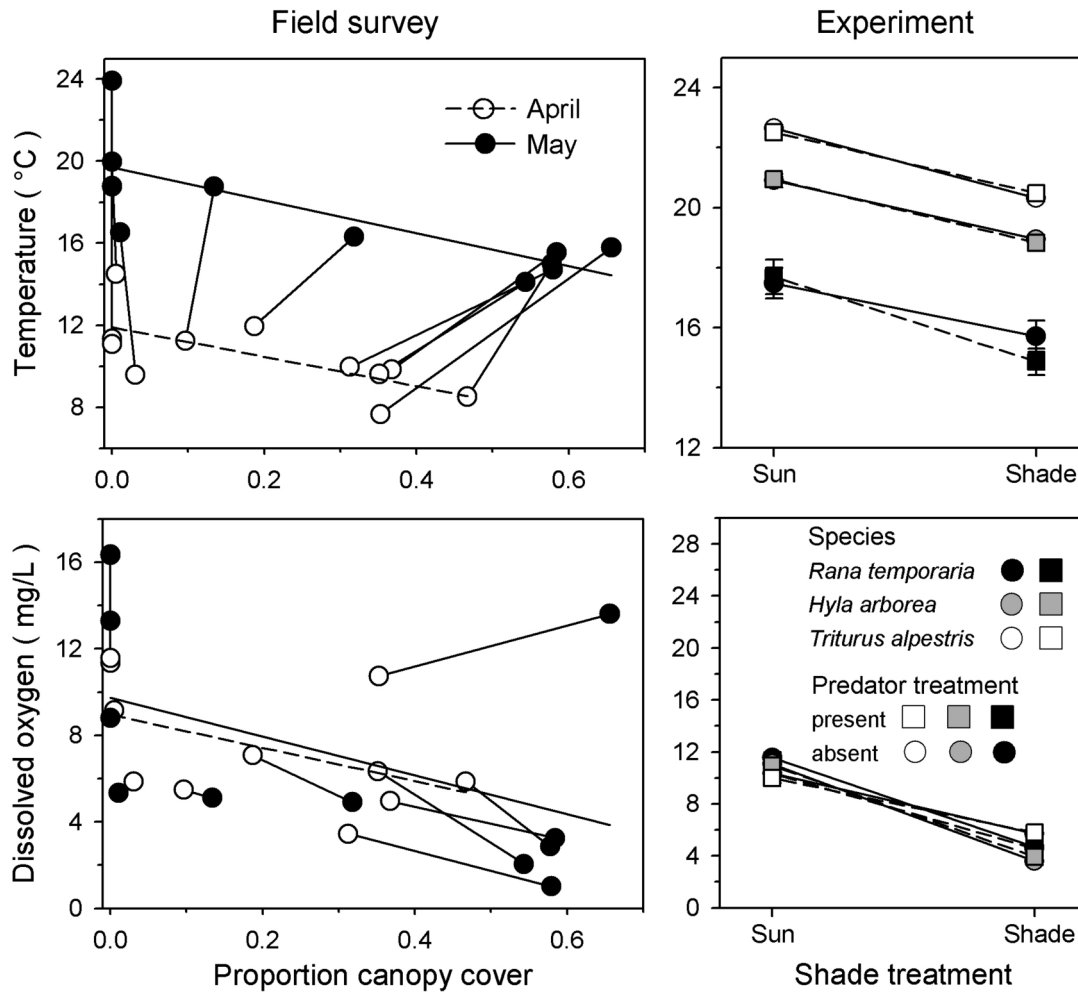
- 1 Most anterior point on the nose
- 2 Left edge of mouth, where the anterior and posterior labial tooth rows converge
- 3 Right edge of mouth
- 4 Left edge of body at widest point anterior to spiracle
- 5 Right edge of body at widest point anterior to spiracle
- 6 Left edge of body where intestinal mass is widest

- 7 Right edge of body at widest part of gut mass
- 8 Separation of the head and gut at the midline
- 9 Point where the left edge of tail muscle intersects the body
- 10 Point where the right edge of tail muscle intersects the body
- 11 Left tail muscle edge at half the distance between no. 9/10 and no. 13
- 12 Right tail muscle edge at halfway
- 13 Tip of tail fin

Appendix 3

Comparison between mesocosms and natural ponds

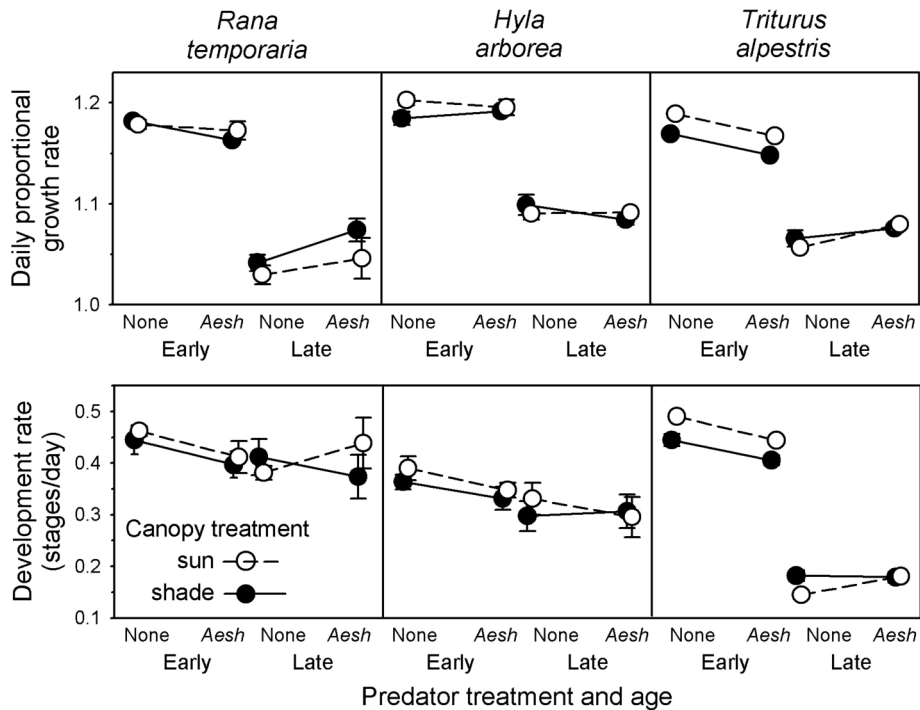
Temperature and dissolved oxygen in ponds surveyed in the field (left) and in the experimental mesocosms (right). April and May field samples from the same pond are connected by a line; the May sample occurred after the deciduous canopy had leafed out. Experimental results (mean \pm SE) are averaged across all sample dates. For temperature and DO, the difference between sunny and shaded mesocosms roughly paralleled that between open- and closed-canopy ponds in nature



Appendix 4

Results and statistical analysis of growth and development

Means \pm 1 SE of larval growth rate (proportion per day) and development rate (stages per day) of three amphibian species measured over two time intervals. The table depicts the F-ratio (p-value) for each effect from repeated measures ANOVA. Block was not significant. Abbreviations for the error terms are B = Block, A = Age, S = Species, C = Canopy and P = Predator.

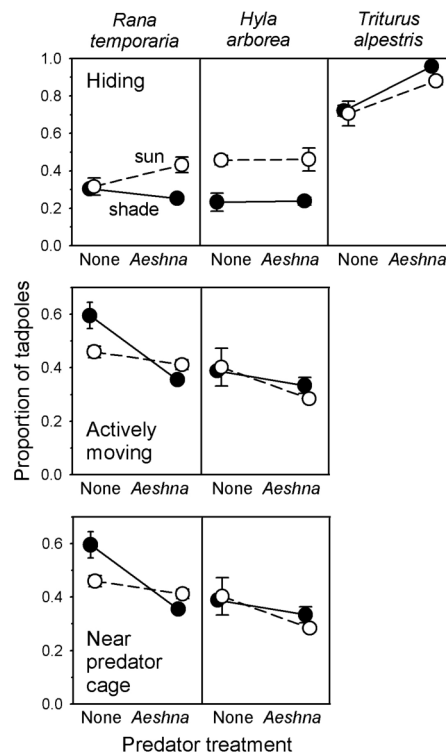


	DF	Error term	Type of response	
			Growth rate	Development rate
Between-subjects effects				
Species	2,9	B(S)	123.74 (0.0000)	198.89 (0.0000)
Canopy	1,9	C×B(S)	1.64 (0.2323)	5.65 (0.0414)
Predator	1,9	P×B(S)	0.00 (0.9846)	10.78 (0.0095)
Species × Canopy	2,9	C×B(S)	15.00 (0.0014)	0.05 (0.9522)
Species × Predator	2,9	P×B(S)	2.21 (0.1660)	0.34 (0.7194)
Canopy × Predator	1,9	C×P×B(S)	0.53 (0.4839)	2.67 (0.1364)
Species × Canopy × Pred	2,9	C×P×B(S)	1.01 (0.4024)	9.18 (0.0067)
Within-subjects effects				
Age	1,9	A×P×C×B(S)	1354.94 (0.0000)	169.63 (0.0000)
Age × Species	2,9	A×B(S)	3.13 (0.0927)	39.35 (0.0000)
Age × Canopy	1,9	A×C×B(S)	4.74 (0.0574)	0.52 (0.4887)
Age × Predator	1,9	A×P×B(S)	9.21 (0.0141)	2.76 (0.1309)
Age × Canopy × Predator	2,9	A×P×C×B(S)	0.18 (0.6846)	1.05 (0.3322)

Appendix 5

Results and analysis of behavior

Behavioral (mean \pm 1 SE) of three amphibian species reared under experimental manipulation of shade and predation risk. Hiding is the proportion of individuals hiding in the substrate; active is the proportion swimming or feeding of those visible; near cage is the proportion within 15 cm of the floating cage. The table depicts the F-ratio (p-value) from separate analyses of variance for each response, which were arcsin-sqrt transformed. Block was never significant. Abbreviations for the error terms are B = Block, S = Species, C = Canopy, and P = Predator.

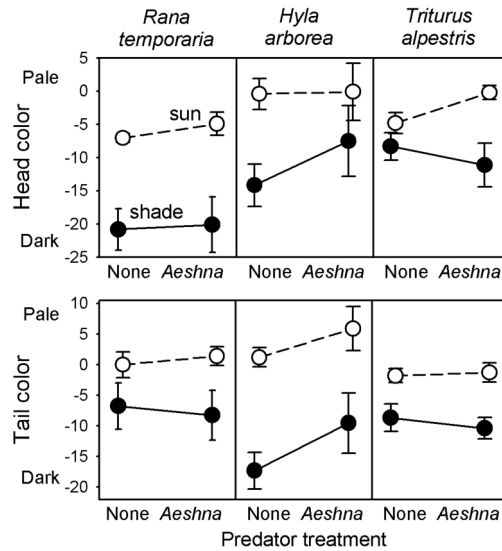


	Error term	Response variable		
		Hiding	Active	Near cage
Species	B(S)	151.72 (0.0000)	13.23 (0.0109)	5.34 (0.0602)
Canopy	C×B(S)	10.99 (0.0090)	1.83 (0.2249)	0.53 (0.4935)
Predator	P×B(S)	19.82 (0.0016)	46.15 (0.0005)	131.07 (0.0000)
Species × Canopy	C×B(S)	11.83 (0.0030)	0.25 (0.6325)	2.34 (0.1770)
Species × Predator	P×B(S)	13.23 (0.0021)	2.82 (0.1441)	87.99 (0.0000)
Canopy × Predator	C×P×B(S)	0.14 (0.7147)	1.25 (0.3068)	1.56 (0.2583)
Species × Canopy × Predator	C×P×B(S)	5.83 (0.0238)	4.93 (0.0681)	0.04 (0.8397)

Appendix 6

Results and analysis of color

Head and tail color (means \pm 1 SE) of three larval amphibian species (above) and multivariate analysis of variance (MANOVA) on head and tail color scores (below) under experimental manipulation of shading and predation risk in mesocosms. The response is a gray-scale measurement corrected for the overall brightness of the image. In the MANOVA, treatments involving shade and predation were tested over their interaction with block.



Source	DF	Wilks' F	p-value
Block(Species)	18,16	6.67	0.0002
Species	4,16	4.17	0.0168
Canopy	2,8	43.44	0.0000
Predation	2,8	1.10	0.3785
Species \times Canopy	4,16	6.36	0.0029
Species \times Predator	4,16	1.86	0.1666
Canopy \times Predator	2,8	0.10	0.9053
Species \times Canopy \times Predator	4,16	3.22	0.0405

Appendix 7

Statistical analysis of relative warps in anuran larvae

Analyses of variance on relative warps describing morphological shape in anuran larvae. The data for *Hyla arborea* were averaged across two sample dates. The table depicts the F-ratio (p-value) for each effect. Block effects, not reported here, were significant only for one bottom-view relative warp. Abbreviations for the error terms are B = Block, S = Species, C = Canopy, and P = Preda-

Response variable	% morph. variation	Source of variation							
		Species	Canopy	Predator	Canopy × Predator	Species × Canopy	Species × Predator	Species × Can × Pred	
Error term		B(Sp)	C×B(Sp)	P×B(Sp)	E	C×B(Sp)	P×B(Sp)	E	
DF		1,6	1,6	1,6	1,6	1,6	1,6	1,6	
Side morphology									
RW1	76.8	363.70 (0.0000)	0.53 (0.4923)	11.48 (0.0147)	0.02 (0.8904)	0.03 (0.8642)	1.45 (0.2744)	1.50 (0.2663)	
RW2	9.0	3.32 (0.1183)	1.35 (0.2896)	8.81 (0.0250)	0.26 (0.6311)	0.93 (0.3714)	0.00 (0.9753)	0.34 (0.5802)	
RW3	4.1	0.38 (0.5587)	21.40 (0.0036)	1.46 (0.2728)	0.00 (0.9968)	2.71 (0.1511)	0.24 (0.6425)	0.36 (0.5681)	
RW4	2.8	0.01 (0.9340)	7.27 (0.0357)	0.93 (0.3715)	0.72 (0.4293)	2.52 (0.1632)	5.69 (0.0544)	0.01 (0.9369)	
RW5	1.7	5.31 (0.0607)	37.58 (0.0009)	197.61 (0.0000)	0.34 (0.5816)	14.28 (0.0092)	30.99 (0.0014)	0.23 (0.6491)	
Bottom morphology									
RW1	50.4	3.02 (0.1332)	0.84 (0.3940)	10.14 (0.0190)	0.43 (0.5369)	0.60 (0.4665)	3.06 (0.1309)	3.02 (0.1329)	
RW2	17.1	32.59 (0.0013)	52.07 (0.0004)	12.93 (0.0114)	1.00 (0.3557)	8.65 (0.0269)	0.01 (0.9228)	0.13 (0.7325)	
RW3	13.5	13.43 (0.0105)	26.93 (0.0020)	1.50 (0.2672)	0.69 (0.4389)	4.37 (0.0814)	4.09 (0.0895)	5.68 (0.0546)	

Appendix 8

Statistical analysis of relative warps in *Triturus* larvae

Analysis of variance on relative warps describing morphological shape of *Triturus alpestris*, averaged over two sample dates (age 22 and 38 days). The table depicts the F-ratio (p-value) for each effect. The block effect was never significant. Abbreviations for the error terms are B = Block, S = Species, C = Canopy, and P = Predator.

Response variable	% shape variation	Source of variation		
		Canopy	Predator	Canopy × Predator
Error term		C×B	P×B	P×C×B
DF		1,3	1,3	1,3
Side morphology				
RW1	39.7	43.23 (0.0072)	0.14 (0.7336)	0.01 (0.9196)
RW2	20.6	195.36 (0.0008)	79.73 (0.0030)	21.29 (0.0192)
RW3	12.6	13.32 (0.0355)	1.40 (0.3214)	1.36 (0.3283)
RW4	6.4	5.10 (0.1091)	47.18 (0.0063)	0.69 (0.4669)
Bottom morphology				
RW1	48.6	20.28 (0.0204)	0.11 (0.7591)	0.54 (0.5156)
RW2	16.1	12.17 (0.0398)	16.49 (0.0269)	3.98 (0.1399)
RW3	9.8	9.11 (0.0568)	3.16 (0.1734)	0.98 (0.3962)

Appendix 9

Conventional morphometric results and statistical analysis

Effects of shading and caged predators on size-corrected measures of the shape of amphibian larvae. Part (1) presents results for *Rana temporaria* and *Hyla arborea*; part (2) presents results for *Triturus alpestris*. Traits are residuals after regression against body size (centroid size). Statistical tests are ANOVAs; entries in the tables are F-ratio (p-value). Symbols depict means \pm 1 SE.

(1) **Anuran larvae.** Head length is the distance between landmarks 1 and 14 in the side view; head depth is between 10 and 11 in side view; head width is between 4 and 5 in side view; tail length is between 14 and 22 in side view; tail depth is between 16 and 17 in side view; and tail muscle width is between 9 and 10 in the bottom view. See Appendix 2 for landmark definitions.

Source	Error term	DF	Head length	Head depth	Response variable			
					Head width	Tail length	Tail depth	Muscle width
B(S)	C×P×B(S)	6,6	8.70 (0.0093)	2.07 (0.1989)	6.56 (0.0188)	0.74 (0.6397)	0.34 (0.8944)	1.17 (0.4261)
Species	B(S)	1,6	0.30 (0.6062)	113.46 (0.0000)	3.36 (0.1164)	33.64 (0.0012)	1276.54 (0.0000)	49.58 (0.0004)
Canopy	C×B(S)	1,6	61.32 (0.0002)	4.31 (0.0833)	46.38 (0.0005)	32.39 (0.0013)	8.61 (0.0262)	1.20 (0.3154)
Predator	P×B(S)	1,6	1.71 (0.2387)	7.41 (0.0346)	26.25 (0.0022)	18.47 (0.0051)	61.33 (0.0002)	1.50 (0.2662)
S × C	C×B(S)	1,6	39.68 (0.0007)	8.31 (0.0279)	6.86 (0.0396)	3.23 (0.1226)	2.60 (0.1580)	9.73 (0.0206)
S × P	P×B(S)	1,6	0.78 (0.4102)	7.56 (0.0333)	26.41 (0.0021)	0.02 (0.8909)	4.93 (0.0681)	17.35 (0.0059)
C × P	C×P×B(S)	1,6	0.12 (0.7443)	0.39 (0.5530)	0.60 (0.4682)	0.45 (0.5266)	1.52 (0.2632)	3.49 (0.1111)
S × C × P	C×P×B(S)	1,6	0.15 (0.7152)	0.59 (0.4708)	1.09 (0.3375)	0.43 (0.5356)	0.04 (0.8523)	3.64 (0.1049)

values are F-ratios and p-values calculated from type III SS

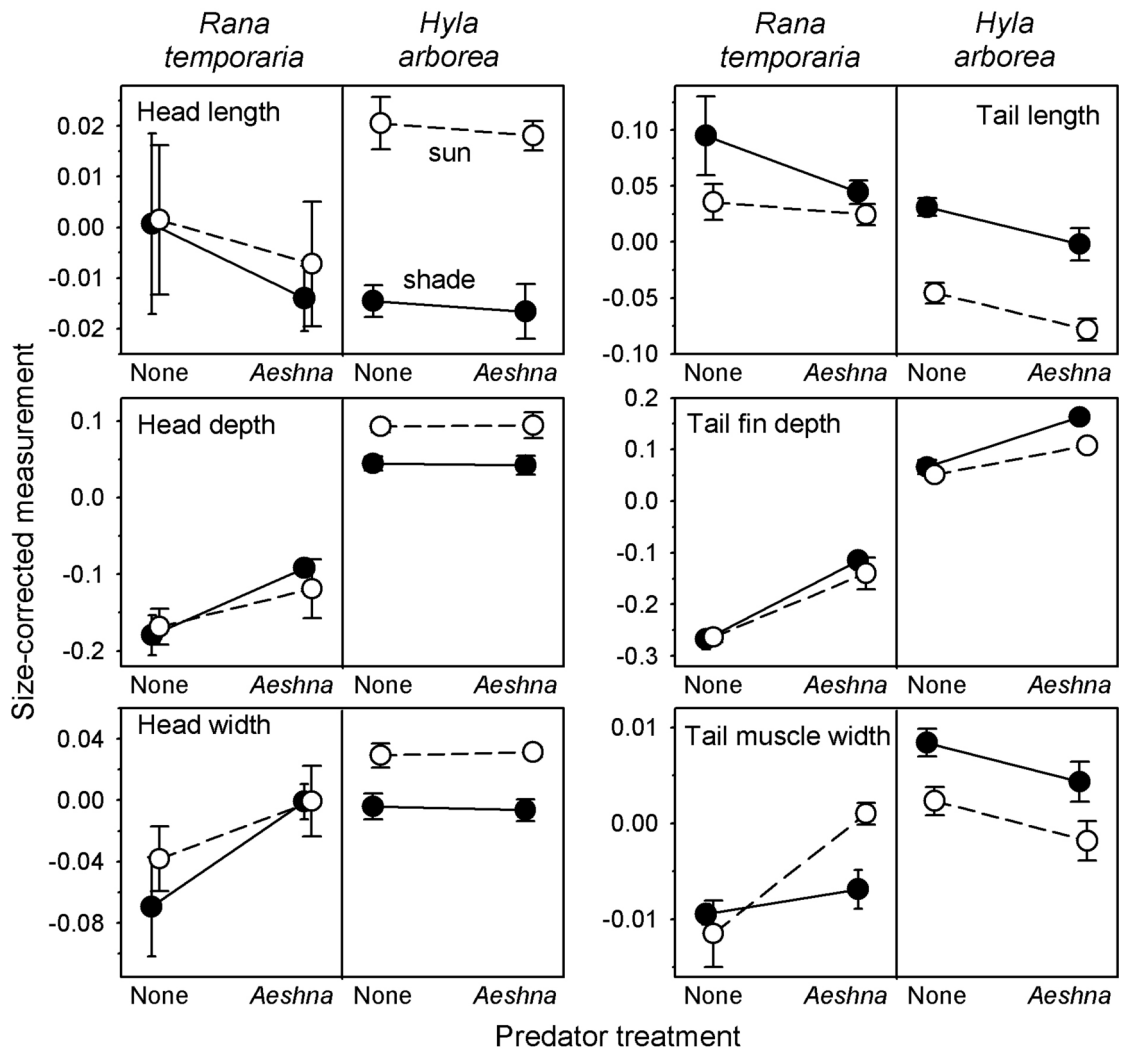
abbreviations are:

B(S) = Block(Species)

S = Species

C = Canopy

P = Predator



(2) *Triturus alpestris* larvae. Head width and depth were measured at the anterior edge of the gills. Torso measurements were halfway between the forelegs and hind legs. Tail depth and muscle measurements were made at 1/3rd the length of the tail. All measures came from two dates (at age 22 and 38.5 days).

Response variable	Source of variation			
	Block	Canopy	Predator	Canopy × Predator
Error term	P×C×B	C×B	P×B	P×C×B
DF	3,3	1,3	1,3	1,3
Head length	6.22 (0.0837)	3.82 (0.1456)	0.98 (0.3947)	3.84 (0.1450)
Head depth	3.30 (0.1764)	31.09 (0.0114)	41.57 (0.0076)	1.57 (0.2987)
Head width	1.26 (0.4279)	4.05 (0.1378)	1.80 (0.2726)	0.53 (0.5190)
Torso depth	0.36 (0.7857)	0.45 (0.5514)	0.02 (0.9069)	0.20 (0.6879)
Torso width	1.55 (0.3633)	1.69 (0.2849)	2.23 (0.2325)	0.62 (0.4888)
Tail length	0.52 (0.6999)	93.97 (0.0023)	1.06 (0.3785)	0.38 (0.5818)
Tail depth	2.98 (0.1971)	69.58 (0.0036)	110.54 (0.0018)	14.79 (0.0310)
Muscle depth	12.28 (0.0343)	0.25 (0.6525)	13.02 (0.0365)	0.77 (0.4440)
Muscle width	0.89 (0.5357)	57.33 (0.0048)	9.83 (0.0518)	0.10 (0.7729)

values are F-ratios and p-values based on type III SS.

abbreviations are:

- B = Block
- S = Species
- C = Canopy
- P = Predator

