**Appendix A**

Sears, Snyder, and Rohr. 2015. Host life-history and host-parasite syntopy predict behavioral resistance and tolerance to parasites. *Journal of Animal Ecology*

**Appendix A. Supporting Tables A1-A5 and Supporting Figures A1-A6.**

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| **Table A1.** Variables used to assess tadpole pace-of-life rankings and the degree of spatial and temporal overlap (i.e., syntopy) between each tadpole species and the source of cercariae, the snail species *Planorbella trivolvis*. Additionally, size at metamorphosis is also provided. | | | | | | | |
| Species | Rank of syntopy with *P. trivolvis* | Pace-of-life ranking | Minimum duration of larval period | Hydroperiod of natal habitata | Degree of phenological overlap with *P. trivolvis*e | Frequency of breedinge | Size at meta-morphosis (mm) |
| *Scaphiopus holbrookii* | 1 | 7 | 14a | Highly ephemeral | Low | Semi-annually | 8.5-12a |
| *Osteopilus septentrionalis* | 2 | 6 | 19b | Ephemeral to semi-permanent | Medium | Annually | 8-20b |
| *Gastrophryne carolinensis* | 3 | 5 | 20a | Ephemeral to semi-permanent | Medium | Annually | 8-13a |
| *Hyla femoralis* | 4 | 4 | 27c | Semi-permanent to permanent | High | Annually | 11-15a |
| *Pseudacris ocularis* | 5 | 3 | 30d | Semi-permanent to permanent | High | Annually | 7-9a |
| *Hyla gratiosa* | 6 | 2 | 35c | Semi-permanent to permanent | High | Annually | 18-28a |
| *Rana catesbeiana* | 7 | 1 | 180e | Permanent | High | Annually | 25-60f |
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| bRohr, J. R., T. R. Raffel, N. T. Halstead, T. A. McMahon, S. A. Johnson, R. K. Boughton, and L. B. Martin. 2013. Early-life exposure to an herbicide has enduring effects on pathogen-induced mortality. Proceedings of the Royal Society B-Biological Sciences 280:20131502. | | | | | | | |
| cWarner, S. C., J. Travis, and W. A. Dunson. 1993. Effect of pH variation on interspecific competition between 2 species of hylid tadpoles. Ecology 74:183-194. | | | | | | | |
| dWright, A. H., and A. A. Wright. 1949. Tree Frogs: Hylidae. Pp. 217-272. Handbook of Frogs and Toads of the United States and Canada. Cornell University Press, Ithaca, New York. | | | | | | | |
| ePers. obs., B.F. Sears |  |  |  |  |  |  |  |
| fCollins, J. P. 1979. Intrapopulation variation in the body size at metamorphosis and timing of metamorphosis in the bullfrog, *Rana catesbeiana*. 60: 738-749. | | | | | | | |
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| **Table A2.** Five different estimates of host tolerance of cercarial exposure defined as the slope of the relationship between host mass change and cercarial dose. The first estimate of tolerance does not control for actual infections, whereas the second and fourth estimates control for actual infections by excluding animals that were infected and the third and fifth estimates control for actual infections by including the number of metacercarial infections as a covariate. The fourth and fifth estimates of tolerance replace cercarial dose with the number of cercariae that successfully penetrated tadpoles (many cercariae that penetrate are killed by the immune system and thus do not become actual metacercarial infections) when this predictor was available. | | | | | | | | | | | | | | | |
|  |  | Tolerance estimate 1: Cercarial dose as a predictor of mass change | |  | Tolerance estimate 2: Cercarial dose as a predictor of mass change and controlling for number of metacercariae | |  | Tolerance estimate 3: Cercarial dose as a predictor of mass change and excluding any infected animals | |  | Tolerance estimate 4: Cercarial dose or attempted infections as a predictor of mass change and controlling for number of metacercariae | |  | Tolerance estimate 5: Cercarial dose or attempted infections as a predictor of mass change and excluding any infected animals | |
| Species | Syntopy/ POLa rank | Tolerance (ß) | St.Err.ß |  | Tolerance (ß) | St.Err.ß |  | Tolerance (ß) | St.Err.ß |  | Tolerance (ß) | St.Err.ß |  | Tolerance (ß) | St.Err.ß |
| *R. catesbeiana* | 1 | 0.064 | 0.133 |  | 0.064 | 0.133 |  | 0.064 | 0.133 |  | 0.064 | 0.133 |  | 0.064 | 0.133 |
| *H. gratiosa* | 2 | 0.299 | 0.129 |  | 0.344 | 0.207 |  | 0.295 | 0.134 |  | 0.344 | 0.207 |  | 0.295 | 0.134 |
| *P. ocularis* | 3 | 0.171 | 0.220 |  | 0.171 | 0.220 |  | 0.171 | 0.220 |  | 0.171 | 0.220 |  | 0.171 | 0.220 |
| *H. femoralis* | 4 | -0.209 | 0.128 |  | -0.339 | 0.231 |  | -0.267 | 0.163 |  | -0.242 | 0.236 |  | -0.502 | 0.146 |
| *G. carolinensis* | 5 | -0.284 | 0.127 |  | -0.284 | 0.127 |  | -0.284 | 0.127 |  | -0.284 | 0.127 |  | -0.284 | 0.127 |
| *O. septentrionalis* | 6 | -0.270 | 0.127 |  | -0.478 | 0.168 |  | -0.287 | 0.129 |  | -0.478 | 0.168 |  | -0.287 | 0.129 |
| *S. holbrookii* | 7 | -0.044 | 0.250 |  | -0.292 | 0.239 |  | -0.044 | 0.250 |  | -0.292 | 0.239 |  | -0.292 | 0.239 |
| aPace-of-life |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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| **Table A3.** Associated statistics for the relationships between host species syntopy/pace-of-life (POL) ranking and different measures of host tolerance to cercarial exposure (i.e., "Models of tolerance", see Table A2) weighting by the inverse of the variance of the tolerance estimate. Regardless of how tolerance was estimated, the syntopy/POL ranking was a significant positive predictor of tolerance. | | | | | |
| Models of tolerance | Slope (ß) for syntopy/ POL ranking versus tolerance | St.Err.ß | *R*2 | *F*1,5 | *P* |
| Cercarial dose as a predictor of mass change | 0.709 | 0.315 | 0.503 | 5.063 | **0.037** |
|  |  |  |  |  |  |
| Cercarial dose as a predictor of mass change and controlling for number of metacercariae | 0.808 | 0.264 | 0.653 | 9.396 | **0.014** |
|  |  |  |  |  |  |
| Cercarial dose as a predictor of mass change and excluding any infected animals | 0.699 | 0.320 | 0.489 | 4.784 | **0.040** |
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| Cercarial dose or attempted infections as a predictor of mass change and controlling for number of metacercariae | 0.826 | 0.252 | 0.682 | 10.747 | **0.011** |
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| Cercarial dose or attempted infections as a predictor of mass change and excluding any infected animals | 0.713 | 0.314 | 0.508 | 5.159 | **0.036** |

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| **Table A4.** The ten re-orderings of the original pace-of-life ranking and the associated name of each re-ordering. We only considered re-orderings of the original three fastest and three slowest ranked species. | | | | | | | | | | | | | |
|  |  | Ranks shifted only one spot | | | |  | Rankings shifted two spots | | | |  | Last three and first three rankings flip-flopped | |
| Species | Original ranking | One-Shift1 | One-Shift2 | One-Shift3 | One-Shift4 |  | Two-Shifts1 | Two-Shifts2 | Two-Shifts3 | Two-Shifts4 |  | Flipflop1 | Flipflop2 |
| *S. holbrookii* | 7 | 6 | 7 | 7 | 7 |  | 5 | 6 | 7 | 7 |  | 5 | 7 |
| *O. septentrionalis* | 6 | 7 | 5 | 6 | 6 |  | 7 | 5 | 6 | 6 |  | 6 | 6 |
| *G. carolinensis* | 5 | 5 | 6 | 5 | 5 |  | 6 | 7 | 5 | 5 |  | 7 | 5 |
| *H. femoralis* | 4 | 4 | 4 | 4 | 4 |  | 4 | 4 | 4 | 4 |  | 4 | 4 |
| *P. ocularis* | 3 | 3 | 3 | 3 | 2 |  | 3 | 3 | 2 | 1 |  | 3 | 1 |
| *H. gratiosa* | 2 | 2 | 2 | 1 | 3 |  | 2 | 2 | 1 | 3 |  | 2 | 2 |
| *R. catesbeiana* | 1 | 1 | 1 | 2 | 1 |  | 1 | 1 | 3 | 2 |  | 1 | 3 |

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| **Table A5.** Correlation coefficient and probability value for the relationship between pace-of-life ranking and behavioral resistance (slope for relationship between cercarial dose and total time spent swimming and time spent angled swimming) and tolerance when ten re-orderings of the original pace-of-life ranking were considered. See Table A4 for a description of the ten re-orderings. | | | | | | | | |
|  | Total time spent swimming | |  | Time spent angled swimming | |  | Tolerance | |
| Pace-of-life ranking | *R* | *P*a |  | *R* | *P*a |  | *R* | *P*a |
| Original ranking | 0.885 | **0.008** |  | 0.853 | **0.015** |  | -0.826 | **0.022** |
| OneShift1 | 0.910 | **0.004** |  | 0.898 | **0.006** |  | -0.905 | **0.005** |
| OneShift2 | 0.830 | **0.021** |  | 0.725 | **0.065** |  | -0.785 | **0.037** |
| OneShift3 | 0.917 | **0.004** |  | 0.883 | **0.008** |  | -0.868 | **0.011** |
| OneShift4 | 0.804 | **0.029** |  | 0.771 | **0.042** |  | -0.773 | **0.042** |
| TwoShifts1 | 0.884 | **0.008** |  | 0.820 | **0.024** |  | -0.932 | **0.002** |
| TwoShifts2 | 0.819 | **0.024** |  | 0.655 | 0.111 |  | -0.821 | **0.023** |
| TwoShifts3 | 0.896 | **0.006** |  | 0.858 | **0.013** |  | -0.868 | **0.011** |
| TwoShifts4 | 0.766 | **0.045** |  | 0.730 | **0.062** |  | -0.760 | **0.048** |
| Flipflop1 | 0.849 | **0.016** |  | 0.706 | **0.076** |  | -0.890 | **0.007** |
| Flipflop2 | 0.823 | **0.023** |  | 0.786 | **0.036** |  | -0.811 | **0.027** |
| a P-values <0.1 are bolded. | | | | | | | | |

Fig A1.tif

**Figure A1.** Experimental design. Tadpoles were exposed to either a benzocaine or control (artificial spring water; ASW) solution for 10 minutes, then rinsed in ASW and exposed to trematode cercariae for 10 minutes in ASW. Tadpoles were then rinsed again and placed in 1L aquaria for 7 days, then euthanized. For four species (*Scaphiophus holbrookii, Pseudacris ocularis, Hyla femoralis,* and *Hyla gratiosa*), both exposure ASW and rinse water were pooled to obtain any cercariae which had not successfully penetrated the tadpoles’ skin. Cercariae in this water were stained with Lugol’s iodine and counted under a dissecting microscope.



**Fig A2.** Mean back-transformed (± SE) abundance of metacercarial infections in 7 anuran species exposed to trematode cercariae in the presence and absence of the anesthetic benzocaine. Species are arranged by developmental rate, from slow (left) to fast (right).

**Fig A3.** The positive relationship between tolerance estimates based on cercarial dose and attempted infections (controlling for actual infections).



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**A)**

**Fig. A4.** Scatterplots of the relationships between cercarial exposure and proportion of time spent swimming (arcsine square-root transformed) for each tadpole species ordered from slow to fast paced [*Rana catesbeiana* **A)**, *Hyla gratiosa* **B)**, *Pseudacris ocularis* **C)**, *Hyla femoralis* **D)**, *Gastrophryne carolinensis* **E)**, *Osteopilus septentrionalis* **F)**, *Scaphiopus holbrookii* **G)**]. Shown are best fit lines and 95% confidence bands displayed by the visreg package in R statistical software.



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**Fig. A5.** Scatterplots of the relationships between cercarial exposure and proportion of time spent angled swimming (arcsine square-root transformed) for each tadpole species ordered from slow to fast paced [*Rana catesbeiana* **A)**, *Hyla gratiosa* **B)**, *Pseudacris ocularis* **C)**, *Hyla femoralis* **D)**, *Gastrophryne carolinensis* **E)**, *Osteopilus septentrionalis* **F)**, *Scaphiopus holbrookii* **G)**]. Shown are best fit lines and 95% confidence bands displayed by the visreg package in R statistical software.



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**Fig. A6.** Scatterplots of the relationships between cercarial exposure and the number of evasive maneuvers per minute (log + 1 transformed) for each tadpole species ordered from slow to fast paced [*Rana catesbeiana* **A)**, *Hyla gratiosa* **B)**, *Pseudacris ocularis* **C)**, *Hyla femoralis* **D)**, *Gastrophryne carolinensis* **E)**, *Osteopilus septentrionalis* **F)**, *Scaphiopus holbrookii* **G)**]. Shown are best fit lines and 95% confidence bands displayed by the visreg package in R statistical software.



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**A)**

**Fig. A7.** Scatterplots of the relationships between cercarial exposure and mass change per day controlling for number of actual infections for each tadpole species ordered from slow to fast paced [*Rana catesbeiana* **A)**, *Hyla gratiosa* **B)**, *Pseudacris ocularis* **C)**, *Hyla femoralis* **D)**, *Gastrophryne carolinensis* **E)**, *Osteopilus septentrionalis* **F)**, *Scaphiopus holbrookii* **G)**]. The predictor cercarial exposure was the number of cercariae that attempted infection when it was available, otherwise it was cercarial dose. Shown are best fit lines and 95% confidence bands displayed by the visreg package in R statistical software.