Population responses of wood frog (*Rana sylvatica*) tadpoles to over-wintered bullfrog (*R. catesbeiana*) tadpoles

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Abstract

In temperate latitudes, the larval stage of bullfrogs typically lasts two years prior to metamorphosis. As such, ephemeral ponds are not suitable breeding sites for bullfrogs. Other amphibian species having shorter larval periods might breed successfully in both permanent and ephemeral ponds. Larvae in ephemeral ponds, therefore, experience a different community structure than those larvae of the same species in permanent ponds where bullfrogs are also present. We examined the population responses of sympatric wood frog tadpoles to native over-wintered bullfrog tadpoles. The presence of an over-wintered bullfrog tadpole had a negative effect on the growth of wood frog tadpoles allotopic (naïve) to bullfrogs, whereas the presence of bullfrogs had no effect on growth of syntopic (experienced) wood frog tadpoles. There were also differential behavioral responses of the wood frog populations to over-wintered bullfrog tadpole visual and chemical cues. Only allotopic wood frog tadpoles decreased activity levels and increased use of refugia in the presence of over-wintered bullfrog tadpoles. These observations indicate that over-wintered bullfrog tadpoles might exert a selective pressure on other sympatric amphibians, and that bullfrog establishment within its native range might have negative consequences on larval dynamics of other amphibian species.

Introduction

- Bullfrogs (Fig. 1) can regulate amphibian community structure (2) and often out-compete syntopic amphibian species (7).
- Bullfrog larvae development takes 2 years at temperate latitude, such that larvae are present in early Spring when other amphibian larvae are developing.
- Over-wintered bullfrog larvae negatively effect growth and survival of other larvae (1) through altering patterns of refuge use and foraging (3).
- Wood frogs (Fig. 2) alter their activity in response to predators (5), a behavioral shift that might vary with experience (3).

Purpose

To elucidate the mechanisms underlying the effects of bullfrog establishment within its native range, we examined the responses of wood frog larvae from populations that are either syntopic or allotopic to bullfrogs.

Hypotheses

Null #1 : Behavior, growth, and survival of wood frog larvae are not affected by over-wintered bullfrog larvae.
Null #2 : Responses to bullfrog larvae do not differ between allotopic and syntopic wood frog populations.

Fig. 1. Ranidae: *Rana catesbeiana*

VS.

Fig 2. Ranidae: *Rana sylvatica*

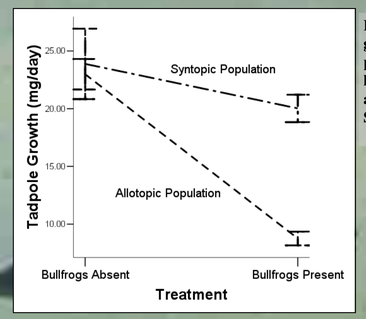

Fig 3. Wood frog larval growth in response to presence of a bullfrog larva. Response values are shown as means ± 1 SE in all figures.

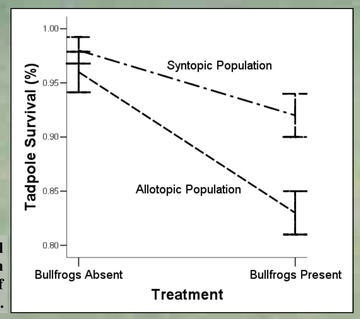

Fig 4. Wood frog larval survivorship in response to presence of a bullfrog larva.

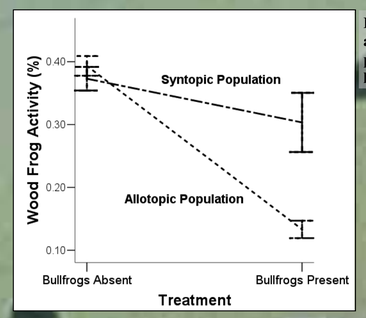

Fig 5. Wood frog larval activity in response to presence of a bullfrog larva.

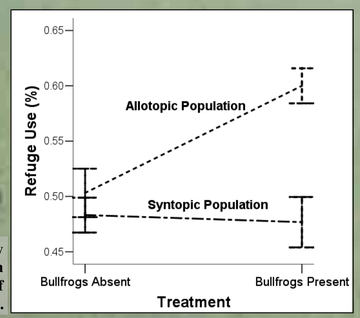

Fig 6. Refuge use by wood frog larvae in response to presence of a bullfrog larva.

Methods

- 8 wood frog egg masses collected in Coles Co., Illinois, in early March 2005 – 4 from ponds lacking bullfrogs (allotopic/'naïve') and 4 from ponds with established bullfrogs (syntopic/'experienced').
- Egg masses incubated in aquaria at 20 °C and 12:12 h L:D photoperiod. Larvae transferred to cohort-specific aquaria containing native water.
- Bullfrog larvae seined from syntopic ponds – Gosner stages 30-35, mass = 7.32 ± 1.84 g (mean ± 1 SE).
- Independent variables were population (experienced vs. naïve) and bullfrog larvae (1 present vs. absent/'control'). Each treatment had 5 replicates; MANOVA analyses with Tukey-Kramer *post hoc* tests.

Growth/Survivorship (randomized block design)

- Test aquaria contained 25 L water, 2 g leaf litter, 1 g of powered rodent chow, and 20 wood frog larvae (Gosner stages 26-30).
- Dependent variables were growth (change in mass, ± 0.01 g) and survivorship over two weeks.

Activity/Refuge Use (2x2 factorial design)

- Test aquaria contained 20 L water, 20 wood frog tadpoles, a 12-cm deep 'bullfrog enclosure' (restricted physical presence, Fig. 7), and a 1-cm deep layer of leaf litter in one half of aquaria.
- Dependent variables were activity (larvae moving, *sensu* 5) and refuge use (larvae occupying leaf litter layer), both sampled 3 times within each replicate.

Results

Wood frog larvae – especially those from allotopic/naïve populations – exhibited changes in the measured variables when a bullfrog larva was present (*p ≤ 0.05; **p ≤ 0.001).

Variable	Population	% change from control
Growth	naïve	– 61.9**
(Fig. 3)	experienced	– 13.2
Survivorship	naïve	– 11.7*
(Fig. 4)	experienced	– 8.7*
Activity	naïve	– 57.5**
(Fig. 5)	experienced	– 18.8
Refuge use	naïve	43.1*
(Fig. 6)	experienced	– 5.4

Fig 7. Enclosure for bullfrog larva in aquarium with wood frog larvae.

Conclusions

- Bullfrog larvae had negative effects on fitness traits of wood frog larvae; significant population-by-bullfrog interactions indicate that these effects were greater for naïve wood frogs.
- Reduction in larval growth rate is likely linked to reduced activity (5) and increased use of refugia (4).
- Because size at metamorphosis confers greater adult fitness (6), the presence of over-wintered bullfrog larvae influences wood frogs beyond the interval of interaction.
- Just as wood frog larvae can respond to other predators (4,5), those in syntopic populations appear to have adapted to the presence of over-wintered bullfrog larvae.
- Management of pond hydroperiod can limit the impacts of bullfrog dispersal, both within its native range and elsewhere.

References

1. Boone *et al*., 2004, Copeia 2004:683-690.
2. Hecnar & M'Closkey, 1997, Amer. Midl. Nat. 137:145-150.
3. Kiesecker & Blaustein, 1997, Ecology 78:1752-1760.
4. Petranka & Hayes, 1998, Behav. Ecol. Sociobiol. 42:263-271.
5. Relyea, 2002, Ecol. Monogr. 72:523-540.
6. Werner, 1986, Amer. Nat. 128:319-341.
7. Werner & Anholt, 1996, Ecology 77:157-169.

A paper based on this presentation is forth-coming in J. Herpetol.

Ranid larva

Acknowledgments

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