Causes of embryonic mortality in the Emerald Glass Frog *Espadarana prosoplepon* (Anura: Centrolenidae)

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Introduction

In frogs, many species exhibit parental care, which broadly defined, is any behavior that increases offspring survival. In the family of the Glass Frogs (Centrolenidae), egg attendance occurs in ~20% species, and in recent years, several studies determining whether parental care exists have been undertaken (Delia et al. 2017). However, within the family, species that lack this 'interesting' behavior have been largely neglected despite the fact that several aspects of their reproductive biology remain unknown. One example of this is the Emerald Glass Frog *Espadarana prosoblepon*.

In this species, females lay eggs and neither of the parents stays tending the clutch (Jacobson 1985). **Most details of the natural history of *E. prosoblepon* are unknown, including aspects of their embryonic development.**

Question

What are the sources of embryonic mortality in *Espadarana prosoblepon*, a Glass Frog without parental care?

Study System

Espadarana prosoblepon occurs from eastern Honduras to northern Colombia and Western Ecuador. In Costa Rica it is found along the Atlantic and Pacific slopes (except in the Pacific Northwest; Fig 1). Amplecting pairs deposit their eggs on the upper surface of leaves, moss-covered rocks and tree trunks, and branches. Their breeding peak season occurs from May to November.

Males and females of *E. prosoblepon* had an average snout-vent length of 23.7 mm (±1 .4 SD; range 20.7–27.2) and 25.7 mm (±1 .4 SD; range 22.8–28.9) respectively (Fig 2).

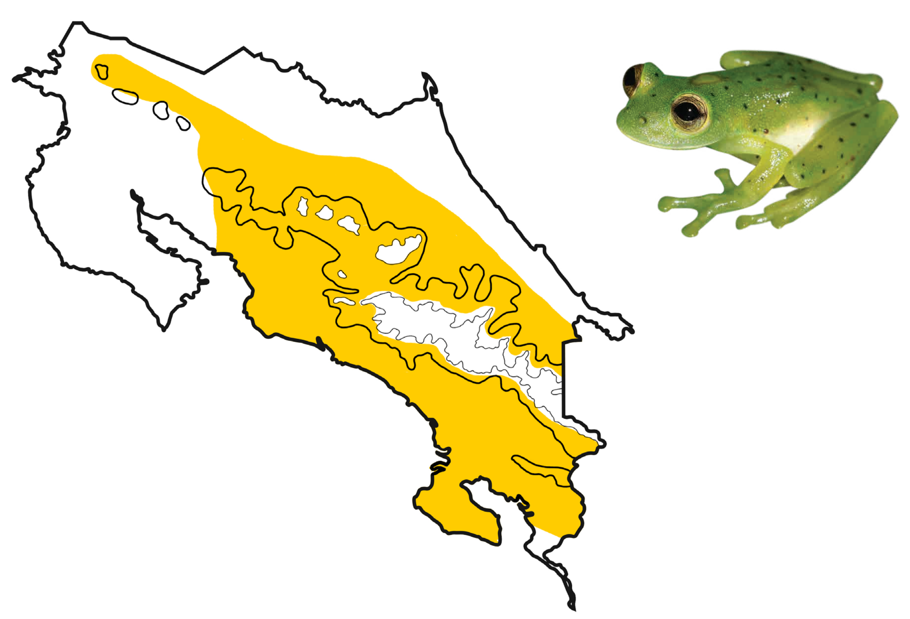

Fig. 1. Geographic distribution of *Espadarana prosoblepon* in Costa Rica. Map courtesy of Twan Leenders. Photo by Johana Goyes Vallejos.

Study Site

This study took place at Las Cruces Biological Station, San Vito de Coto Brus, Punta Arenas Province, Costa Rica.

Fig. 2. A. Males of *Espadarana prosoblepon* have humeral hooks on their forearms used in territorial combats (white arrow). **B**. Females of *E. prosoblepon* can be distinguished for the lack the humeral hooks. in Costa Rica. Photos by Johana Goyes Vallejos.

Results

We monitored a total of 19 clutches from June 9 to July 12, 2018. The average clutch size was 25 eggs (± 6 SD; range 15–41). Embryonic hatching success was on average 14.5% (± 26.3 SD).

We identified five causes of embryo mortality in *E. prosoblepon* clutches: dessication (n = 1), failure to develop or failure to fertilize the eggs (n = 14), fungal infection (n = 2), predation (n = 9), and loss of egg clutches due to heavy rain (rain stripped; n = 10).

The mean percentage of clutch mortality attributed to the different mortality causes is shown in Fig 3.

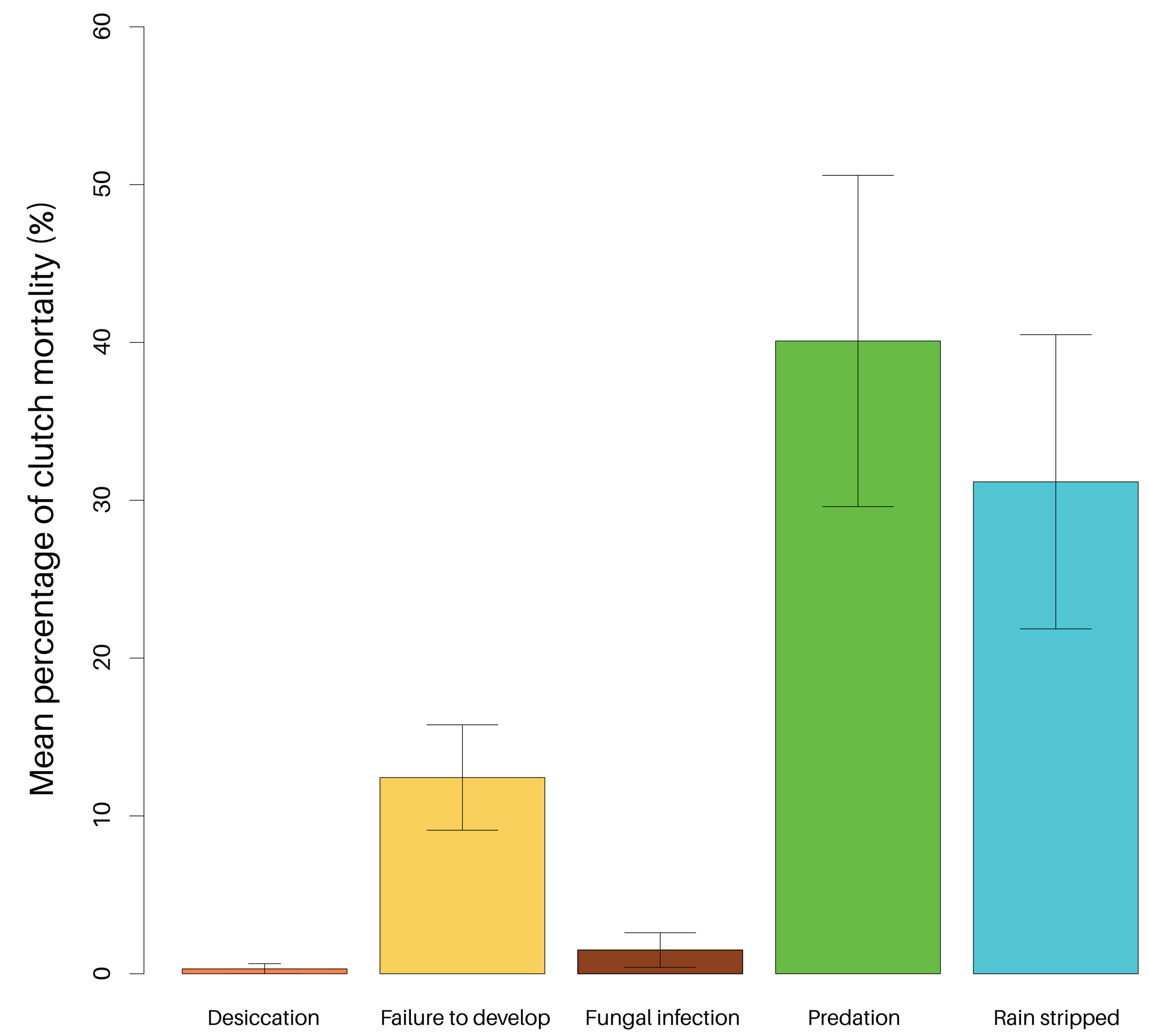

Fig. 3. Mean percentage (±SE) of egg/embryo mortality in clutches of *Espadarana prosoblepon* due to desication, failure to develop/unfertilized, fungal infection, predation, and rain stripped.

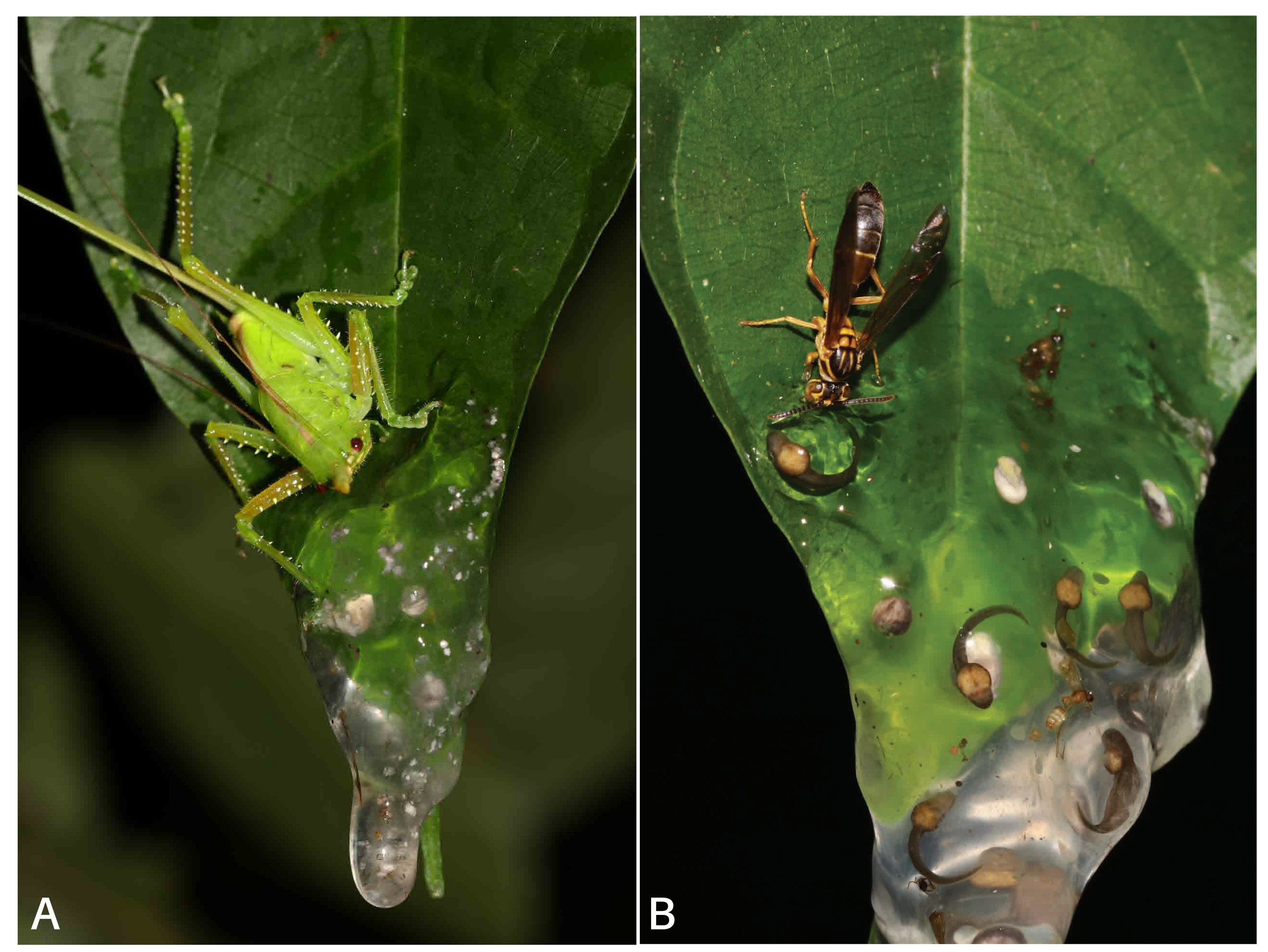

Fig. 4. A. Orthopteran and **B.** hymenopteran predators consuming Espadarana prosoblepon eggs at night. Photos by Johana Goyes Vallejos.

Takeaway

Arthropod predation was the primary source of egg/embryo mortality in *E. prosoblepon* (Fig 4), followed by 'clutch drowning' due to heavy rainfall. This is opposite to what has been found in other Centrolenids were desiccation is the second most important source of mortality (Hawley 2006; Lehtinen et al. 2014).

Our study contributes with valuable information for future studies in this species, and also for comparative research within the family Centrolenidae to elucidate the factors driving the evolution of parental care in glass frogs.

Methods

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Literature Cited: Delia, J., L. B. Valencia, and K. M. Warkentin. 2017. Patterns of parental care in Neotropical glassfrogs: fieldwork alters hypotheses of sex-role evolution. Journal of Evolutionary Biology. Hawley, T. J. 2006. Embryonic development and mortality in *Hyalinobatrachium pulveratum* (Anura: Centrolenidae) of South-Western Costa Rica. Journal of Tropical Ecology 22:731–734. Jacobson, S. K. 1985. Reproductive behavior and male mating success in two species of glass frogs (Centrolenidae). Herpetologica 41:396–404. Lehtinen, R. M., S. E. Green, and J. L. Pringle. 2014. Impacts of paternal care and seasonal change on offspring survival: A Multiseason experimental study of a caribbean frog. Ethology 120:400–409.