RESEARCH PAPER

The geography of snake reproductive mode: a global analysis of the evolution of snake viviparity

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ABSTRACT

Aim Although most reptiles are oviparous, viviparity is a common mode of reproduction in squamates and has evolved multiple times in different lineages. We test two prevailing hypotheses regarding the biogeography of reptile reproductive modes to evaluate the selective forces driving the evolution of viviparity in snakes. The cold climate hypothesis posits that viviparity is selected for in cold climates, whereas the climatic predictability hypothesis predicts that viviparity is advantageous in seasonal climates.

Location Global.

Methods We collated detailed distribution maps and reproductive mode data for 2663 species of the world's terrestrial alethinophidian snakes. We studied the relationship between snake reproductive mode and environmental predictors. We applied both an ecological and an evolutionary approach to study snake reproductive mode by performing the analyses at the assemblage level and species level, respectively. We analysed our data at the global and continental scales to learn whether tendencies to viviparity are similar world-wide.

Results We found strong support for the cold climate hypothesis and the assumption that viviparity is an adaptation to cold environments. There was little support for the climatic predictability hypothesis. Nonetheless, viviparous species are not restricted to cold environments.

Main conclusions We conclude that viviparity is adaptive in cold climates, but not necessarily in unpredictable/seasonal climates. Current distributions may not reflect the climate at the time and place of speciation. We suspect many viviparous snakes inhabiting warm climates are members of lineages that originated in colder regions, and their occurrence in maladaptive environments is a result of phylogenetic conservatism.

Keywords
Cold climate hypothesis, maternal manipulation hypothesis, oviparity, predictability, reproductive mode, seasonality, Serpentes, temperature, viviparity.

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INTRODUCTION

Squamates reproduce either by laying eggs (oviparity) or by giving birth to live young (viviparity). Most squamate species are oviparous (*c.* 80–85%; Sites *et al.*, 2011), and reproductive mode is generally phylogenetically constrained [e.g. all homalopsids are considered to be viviparous (Murphy, 2007) and all anoles are oviparous (Vitt & Caldwell, 2009)]. Nonethe-