Digest: The Guppy Project: predicting evolution in the wild

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Footnote: This article corresponds to Kemp, D. J., F.-K. Batistic, and D. N. Reznick. 2018. Predictable adaptive trajectories of sexual coloration in the wild: Evidence from replicate experimental guppy populations. Evolution https://doi.org/10.1111/evo.13564. https://onlinelibrary.wiley.com/doi/abs/10.1111/evo.13564

ABSTRACT

Is the evolution of sexual traits predictable in the wild? Using replicate experimental guppy populations, Kemp et al. (2018) addressed this question and found that males evolved more elaborate ornamentation in response to a manipulation that increased the influence of sexual selection. Moreover, the study reveals that evolutionary trajectories of male ornamentation are causally affected by female preference and the environmental conditions under which sexual coloration is displayed and perceived.

MAIN TEXT

In the last decade, a growing number of studies have sought to predict evolutionary trajectories of populations. Studies using Trinidadian guppies have played an important role by performing experiments in nature and providing empirical support for theoretical evolutionary models, especially those predicting the evolution of life histories under high predation pressure. In a recent study, Kemp and colleagues used these poeciliid fish to explore whether the evolution of sexual ornamentation follows predictable trajectories in the wild (Kemp et al. 2018).

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Trinidadian mountain streams represent natural replicates of local adaptation in guppies. In larger streams such as the Guanapo River, guppies typically co-occur with a suite of predators and exhibit a "fast" life history, meaning that they mature at an early age, reproduce frequently, and produce many offspring per brood. Populations that colonize upstream headwaters or small tributary streams are released from this high predation pressure and evolve a slower pace of life, with delayed maturity and the production of larger offspring. Laboratory studies have confirmed that these differences have a genetic basis, and small-scale translocation experiments revealed that life histories (Reznick et al. 1990) and many other traits (Ender 1980) can evolve rapidly in these novel environments.

In early 2008, David Reznick and colleagues, encouraged by the success of early translocation experiments, set out to conduct what is likely the largest ongoing study of experimental evolution in the wild: The Guppy Project (www.theguppyproject.weebly.com). The research team simulated replicated natural invasions by introducing guppies from a single high-predation locality into four predator-free streams above barrier waterfalls. These experimental populations have been intensely monitored ever since using a mark–release–recapture approach. Each month, nearly all guppies in the streams are caught, marked or identified, photographed, and weighed. Scales are collected from each individual in order to extract DNA and reconstruct pedigrees. Two of the four sites are subject to canopy thinning, allowing the researchers to explore the role that relative light intensity may play in shaping the evolution of guppy phenotypes (Figure 1; Travis et al. 2014).

Beyond differences in life history strategies, high-predation and low-predation guppies also differ in male sexual coloration. Visually-conspicuous males are preferred by females but also suffer higher predation risk, leading to combined and conflicting influences of natural and sexual selection in high-predation environments. This interaction between natural and sexual selection is manipulated in The Guppy Project. Males with more elaborate ornamentation are predicted to evolve in the focal streams because selection due to female mating preferences is expected to be stronger under relaxed predation. Kemp, Batistic, and Reznick use the empirical power of the replicated experimental populations from The Guppy Project to test this prediction (Kemp et al. 2018).

In this study, the authors collected males from the ancestral population in the Guanapo River and the four experimental streams. Photographs were used to partition the coloration patterns of these males into three main features: i) black spots, ii) orange spots, and iii) iridescent blue and green (i.e. structural colors). As predicted, male ornamentation was more elaborate in the experimentally-evolved fish. Interestingly, most populations tended to have a greater coverage of structural colors, in some cases at the expense of black and orange. This is in stark contrast to the results from early translocation experiments at other sites (e.g. Endler 1980), but consistent with those conducted in the Guanapo drainage (Kemp et al. 2009). Moreover, the authors describe a strong effect of the environment under which male coloration is displayed and perceived (i.e. sensory environment). Populations exhibiting a greater coverage of reflective markings (i.e. iridescent blue and green) evolved in streams with thinned canopies, which had greater ambient light intensities and slightly different spectral characteristics (Endler 1993). This implies that these environmental parameters play an important role in the evolution of visual signals in this species.

Taken together, these results highlight how a detailed understanding of the study system, such as knowledge about biased preferences in the ancestral population and the role of (often confounding) environmental factors in the wild, is crucial for predicting the evolutionary trajectories of adapting populations.

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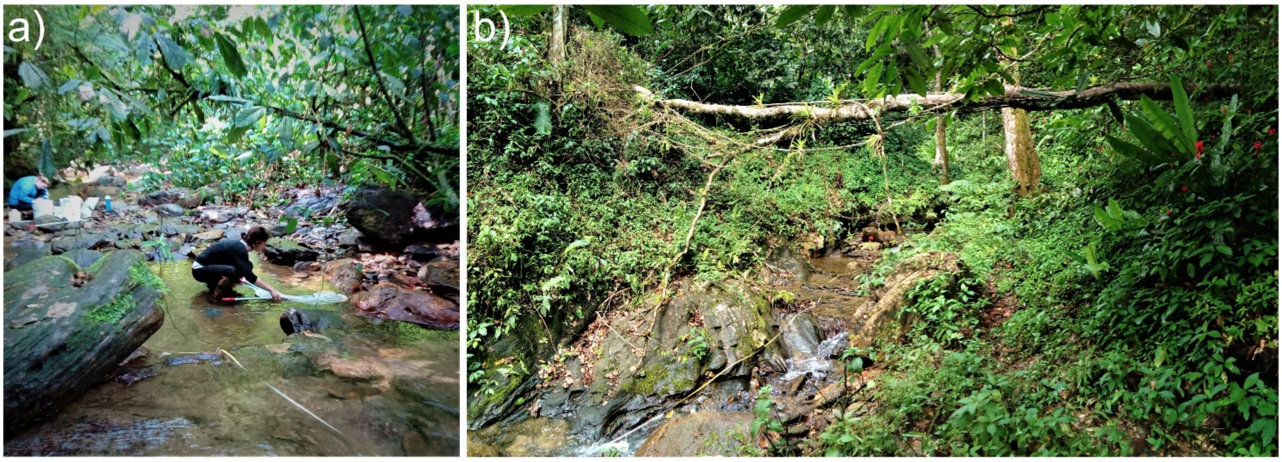

Figure legend

Figure 1. The introduced populations of The Guppy Project have been monitored monthly since 2008. a) Research interns aim to collect all the guppies from the Caigual – a stream with intact canopy cover – in early 2018. b) In streams with thinned canopies, such as the Taylor stream depicted here, males experience more intense sexual selection and evolve more rapidly. Photographs by Erik van Bergen.

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