

# Dynamic color change

## Functions and mechanisms of dynamic color change in anurans



### Introduction

Body coloration can serve as visual signal that animals use as part of their multimodal communication systems. A number of anuran species (frogs and toads) are able to change body coloration rapidly and reversibly. The dorsal body usually changes from a cryptic brown to bright and conspicuous colorations, specifically during the mating season (Bell et al. 2017). Until today we know little about its behavioral functions, or the physiological mechanisms that support its production and integration into a reproductive and most likely sexual selected display.

The PhD project will investigate the functions and mechanisms of dynamic color change in monsoon breeding anurans. Males of the Common Indian Toad (*Duttaphrynus melanostictus*) and the Indian Bullfrog (*Hoplobatrachus tigerinus*) are able to rapidly change their body coloration from a cryptic brown to bright yellow. We propose that dynamic dichromatism has evolved as a sexual signal to communicate male fitness during a time when many males are competing for a limited number of females, and/or to promote instantaneous mate recognition and avoid mismatching. We further propose that dynamic color change is hormonally regulated by sex steroids or stress hormones, which modulate tissues regulating rapid color change.

### Questions

- What are the behavioral functions of dynamic color change?
- What are the physiological mechanisms of dynamic color change?

### Material & Methods

With a manifold approach, we will combine behavioral and hormonal experiments (*in-situ* and *ex-situ*) within the field site in Karnataka in India and the Vienna Zoo to draw conclusions on function and mechanism of multimodal communication in monsoon breeding frogs.

#### Behavioral experiments

Male coloration as quality signal? We will record advertisement calls, measure body coloration and perform morphometric measurements before, during and after the appearance of males at dense breeding aggregations (*in-situ*). Color parameters will be compared with advertisement calls and morphometric measurements.

Male coloration to avoid mismatching or female choice? We will present different experimental models (brown, yellow, yellow with pulsating vocal sacs or yellow with static vocal sacs) to males and females during breeding aggregations and videotape the behavioral response (attack – avoid – mating attempt).

#### Physiological experiments

Quantification of baseline hormone levels: We will measure and compare hormones (non-invasive water-borne hormone sampling) before, during and after mating in both species to determine hormone actions and their influence on skin pigmentation.

Which hormones mediate color change? To test which hormones modulate dynamic color change, males will receive sex steroids (testosterone and estradiol) and stress hormones (catecholamines and corticosterone) via subcutaneous injection and color changes will be compared to a control (saline) group.

### References

- Bell, R. C., & Zamudio, K. R. (2012). Sexual dichromatism in frogs: natural selection, sexual selection and unexpected diversity. *Proceedings of the Royal Society B: Biological Sciences*, 279, 1–7. doi:10.1098/rspb.2012.1609
- Stückler, S., Fuxjäger, M., Hödl, W., and Preininger, D. (in prep.) Stress hormones trigger dynamic color change in male Asian common toads.

### Preliminary results

Which hormones mediate color change? Stress hormones (epinephrine and norepinephrine) induced significant color changes around the injection site in male Asian common toads, *D. melanostictus* (Fig. 1). Epinephrine (EP) increased brightness and yellow chroma for up to three hours, whereas norepinephrine (NE) decreased hue, increased brightness and yellow chroma only for up to 30 min (Fig. 2).



Figure 1 Male *D. melanostictus* displaying dynamic yellow color change, 30 minutes after epinephrine treatment.

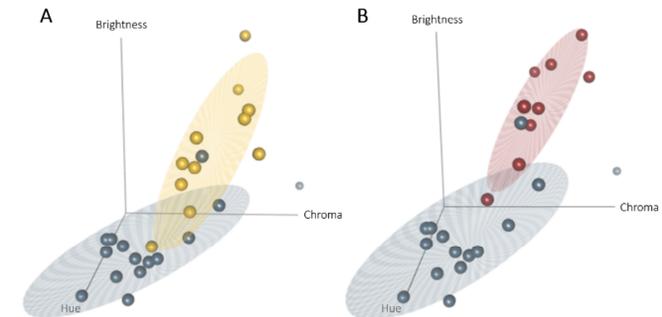


Figure 2 Color space graphs of back coloration 30 min after hormone (epinephrine (yellow), or norepinephrine (red)) or control treatment (grey).

### Outlook

In June 2022 and 2023, behavioral and hormonal experiments (*in-situ*) with both study species will take place in Karnataka, India. Comparative studies with the Moor frog, *Rana arvalis* will take place in Styria (Austria) in March 2022 and 2023.

The results will help us to further deepen and extend our understanding of functions mechanisms of color signals in the communication of explosive breeding anurans with dynamic dichromatism.

