Internship for a master's student

Title

Exploring the visual characteristics of aquatic habitats and how they relate to sexual signal design in *Etheostoma*, a genus of freshwater fishes that occupy those habitats

Keywords

Processing bias; sensory drive; natural statistics; aquatic habitats; secondary sexual signal design; computer vision; video database

Location

Centre for Functional and Evolutionary Ecology (CEFE, UMR5175), Montpellier, France

Supervisors

Yseult HEJJA-BRICHARD (Post-Doc, UMBC/CNRS)
Julien RENOULT (CR CNRS) & Tamra MENDELSON (Professor, UMBC)

Context and general objectives

Natural scenes contain regularities or spatial statistics that our visual system exploits to reduce the metabolic cost of visual processing. Studies from experimental aesthetics and psychology have demonstrated that humans tend to prefer images that reproduce those natural statistics as they may be 'easier on the eye'. The processing bias theory (Renoult and Mendelson, 2019) suggests that this fluency effect, which results in a preference for natural statistics, should be found in other species. Those preferences could then have implications for the design of visual signals. As such, the processing bias complements the sensory drive model that posits that the environment influences the evolution of signal design (Endler and Basolo 1998).
Our lab specialises in the study of *Etheostoma*, a genus that comprises over 200 freshwater fish species characterised by a rich diversity of secondary sexual signals.
We have gathered a database of several dozens of hours of videos of aquatic environments in which species of *Etheostoma* are found.

The objectives of the internship are two-fold:

- Quantify the spatial statistics of aquatic environments and determine how categories of aquatic environments/habitat types differ from each other
- Identify species of *Etheostoma* that commonly inhabit each of those aquatic environments and test for correlations between patterns of the fish and those of their habitat

A previous study (Hulse et al., 2020) found a correlation between the statistics of body patterns and a species habitat for males only. However, they limited their analysis to the main body of the fish (excluding the highly decorated fins) and used only one measure of

natural statistics. Here we propose to extend this study to include more species and a greater variety of aquatic habitats to determine whether this correlation holds when including more species and across measures of statistical similarities (for different measures of image statistics for aquatic habitats, see e.g. Cai et al., 2023).

Moreover, a recent study conducted in the lab (Moodie et al, in prep) suggested that patterns of the decorated dorsal fins have the strongest correlation with habitat characteristics. We will therefore add analyses of the dorsal fins to this study. In addition, habitat characteristics were quantified in that study using verbal descriptions. For this project, we will use video images of the habitats, which will allow for a more objective and detailed analysis of habitat patterns.

What the student will learn

During the internship, the student will learn how to use deep learning algorithms, learning first-hand how tools based on artificial intelligence can be used to inform biological questions.
The student will also learn how to perform phylogenetic comparative analyses to interpret patterns across species.

Organisation of the internship

During the internship, the student is expected to

- Help to clean the video database (a parallel project using the same database will be conducted by the postdoc supervising this internship)
- Identify ways of categorising habitats based on their ecological features and/or their visual characteristics
- Pair fish species to a category of habitat using two guides of reference for freshwater fishes and species from the *Etheostoma* genus specifically
- Model the statistical relationship between different body patterns and the habitat characteristics using the most relevant image similarity measures
- Write a master's thesis that links the results to the sensory drive and processing bias frameworks

The student will receive monetary compensation for the time of the internship.

References

Cai LT, Krishna VS, Hladnik TC, Guilbeault NC, Vijayakumar C, Arunachalam M, Juntti SA, Arrenberg AB, Thiele TR, Cooper EA (2023). Spatiotemporal visual statistics of aquatic environments in the natural habitats of zebrafish. Scientific Report. doi: 10.1038/s41598-023-36099-z.

Endler JA & Basolo AL (1998). Sensory ecology, receiver biases and sexual selection. Trends in ecology & evolution, 13(10), 415-420.

Hulse SV, Renoult JP & Mendelson TC (2020). Sexual signaling pattern correlates with habitat pattern in visually ornamented fishes. Nature communications, 11(1), 1-8

Renoult JP & Mendelson TC (2019). Processing bias: extending sensory drive to include efficacy and efficiency in information processing. Proceedings of the Royal Society B: Biological Sciences 286, 20190165.