




# AI methods to study sexual selection

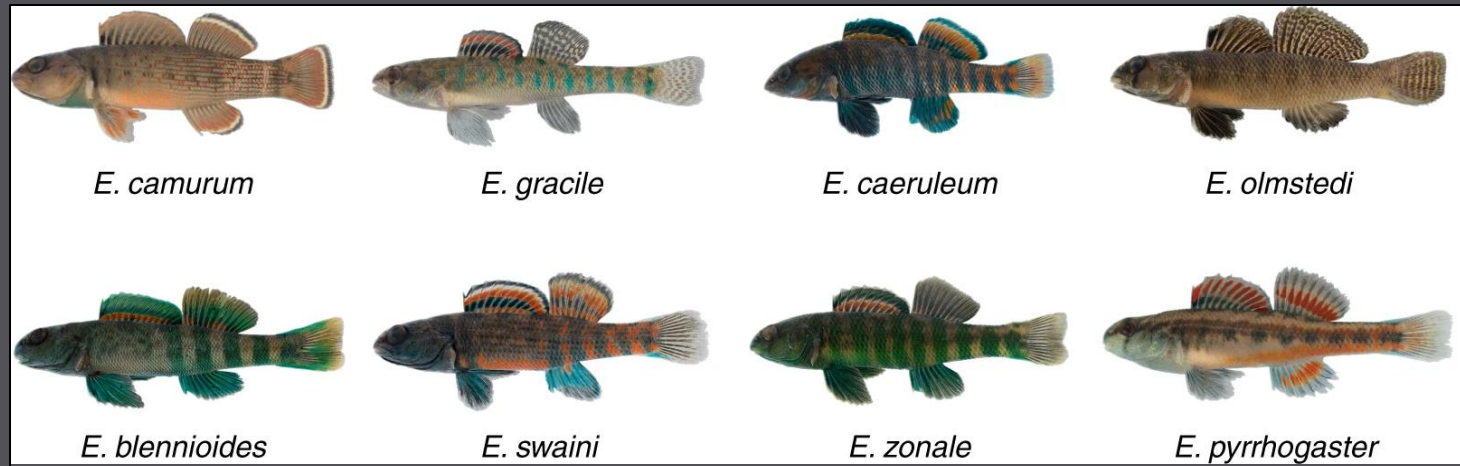
Yseult Hégja-Brichard

University of Maryland, Baltimore County

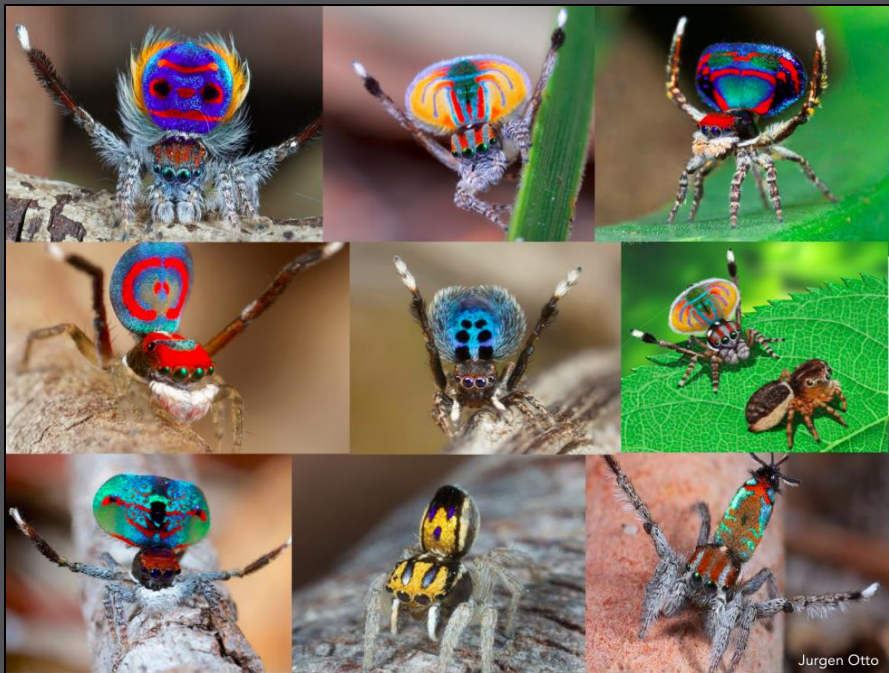
imaginecology2, 29-30 Sept., Villeurbanne

Tamra Mendelson & Julien Renoult 

# Evolution of sexual signals

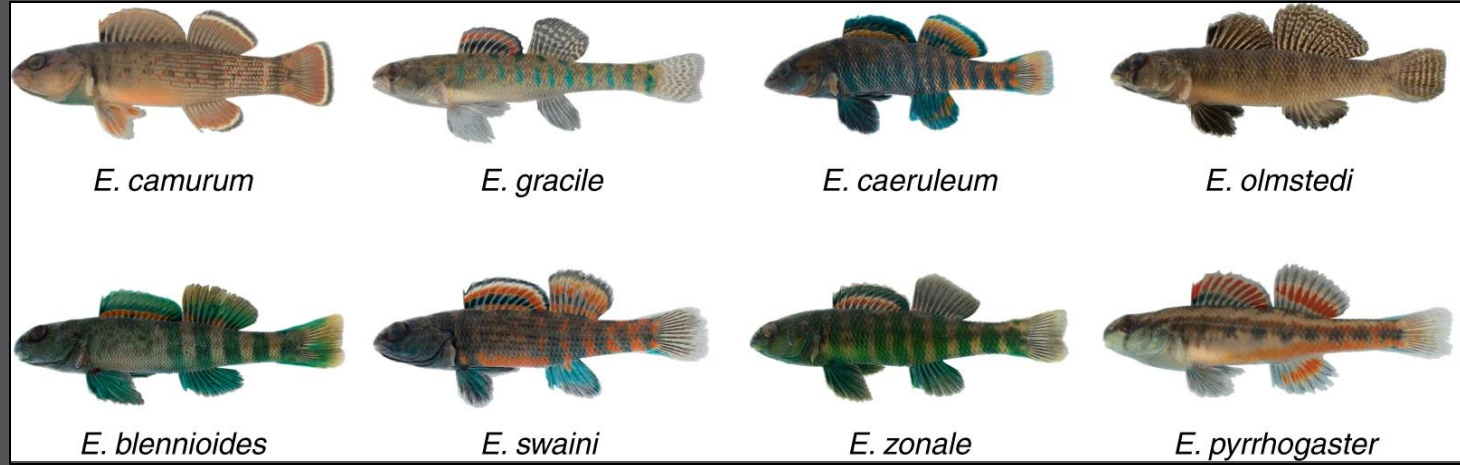


Sam Hulse



timlaman.com

# Evolution of sexual signals



Sam Hulse

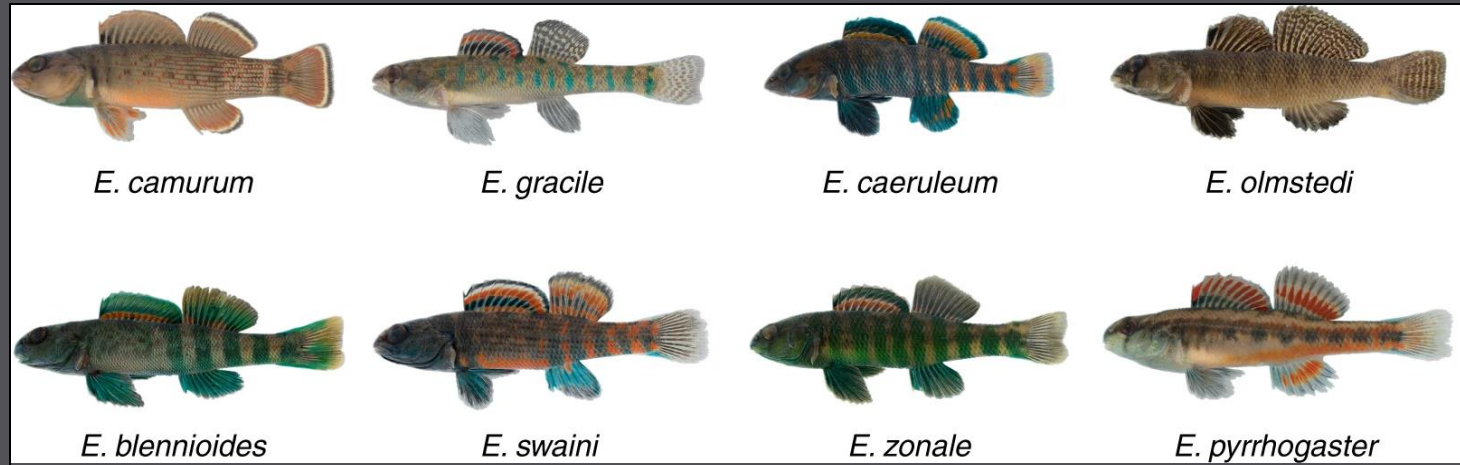
Environmental characteristics

Signal detection theory  
Sensory drive and signal efficacy

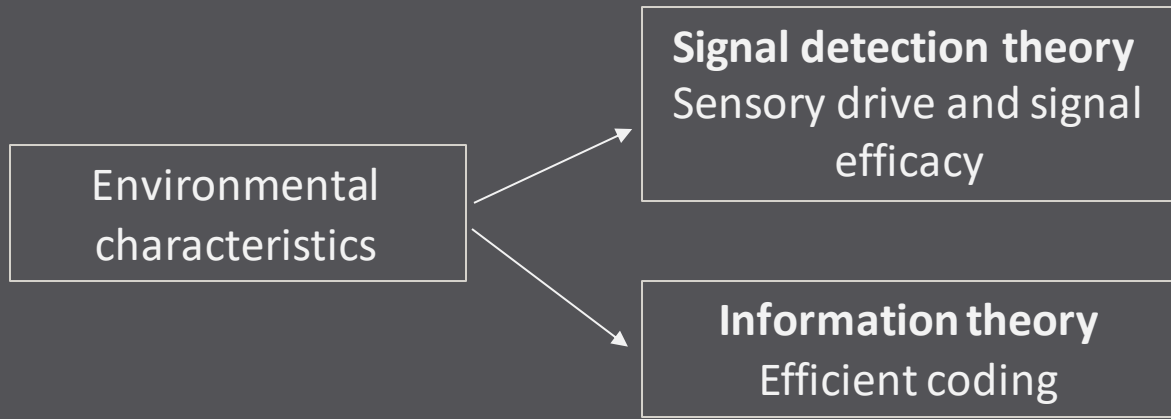


Fleishman et al, 2022

# Evolution of sexual signals

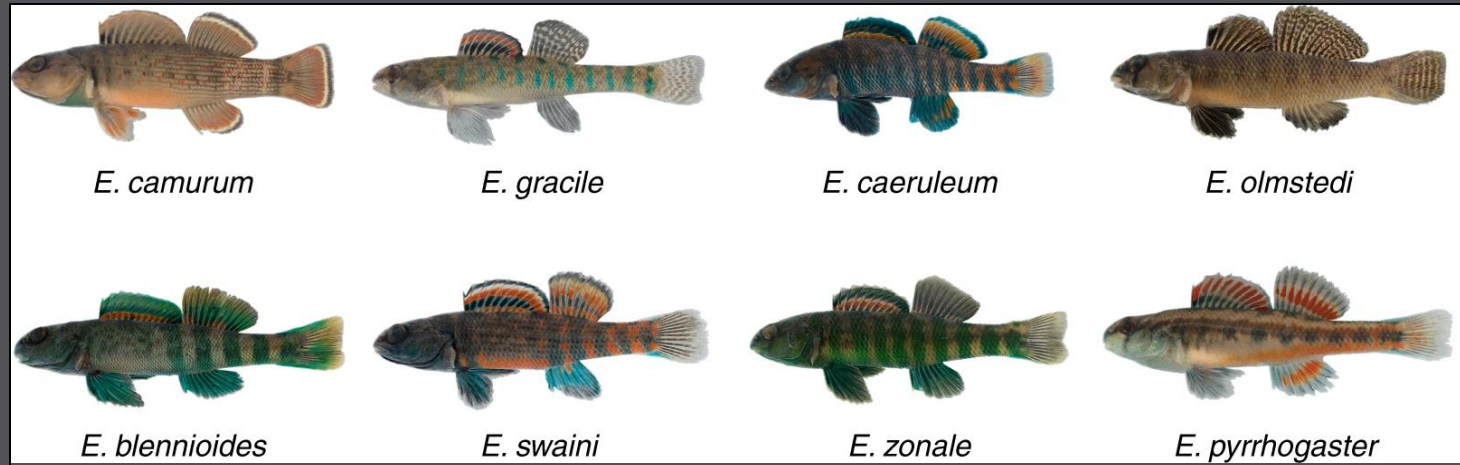


Sam Hulse

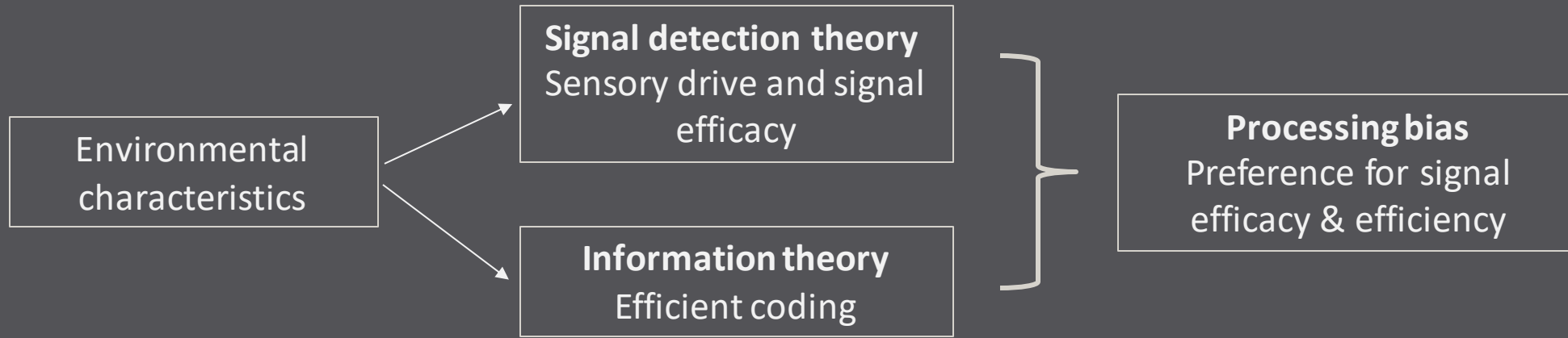


T. Moran, 1907

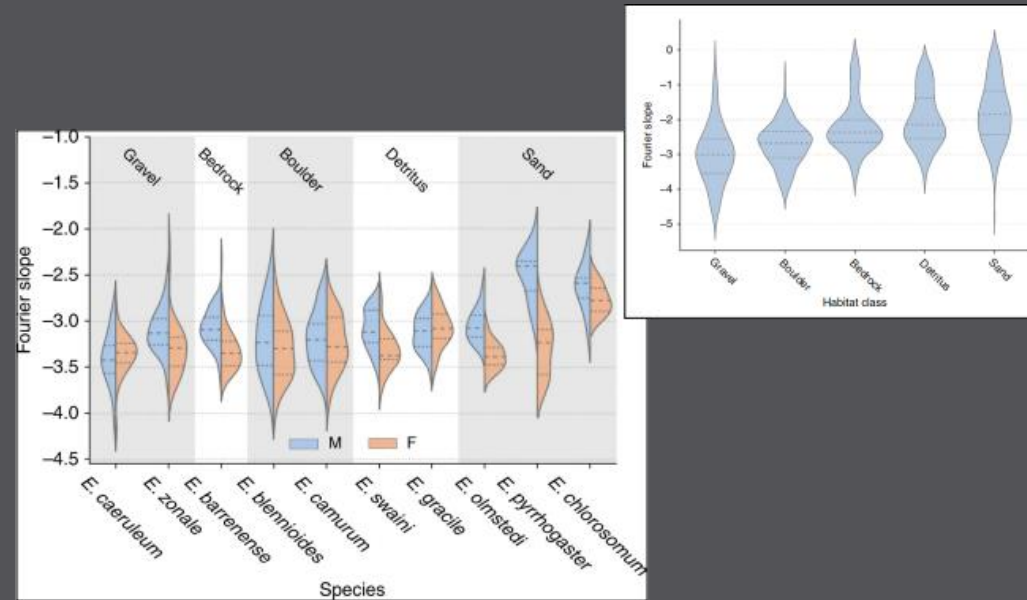
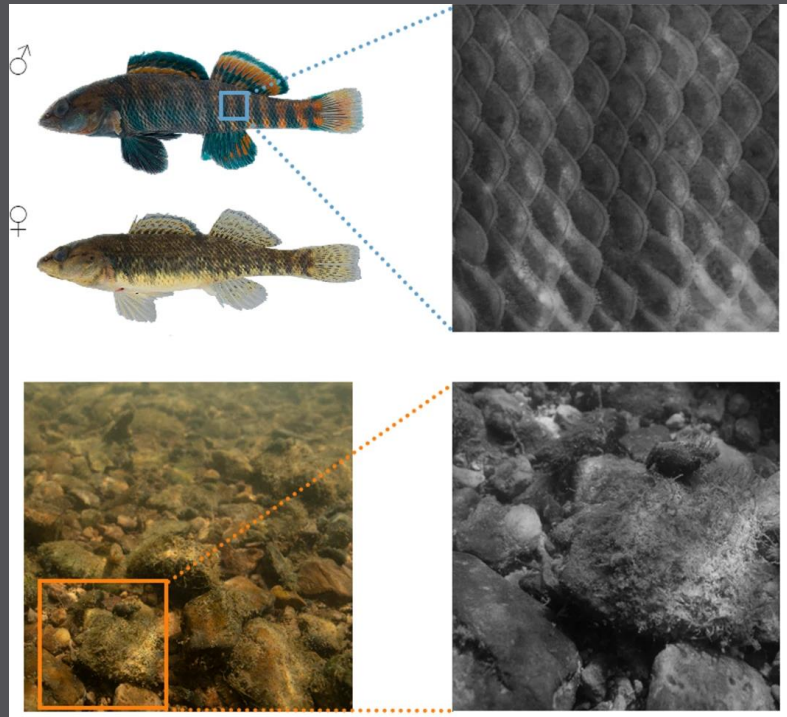
# Evolution of sexual signals



Sam Hulse

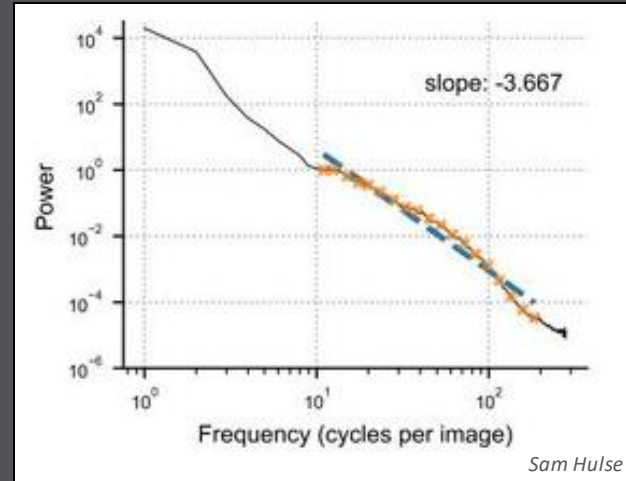
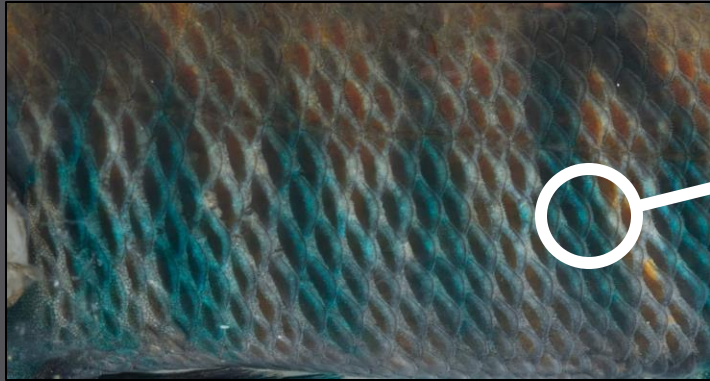


# Link between body pattern and habitat statistics



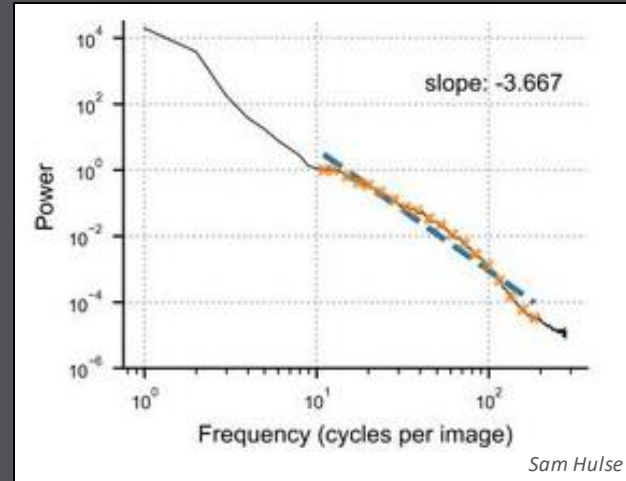
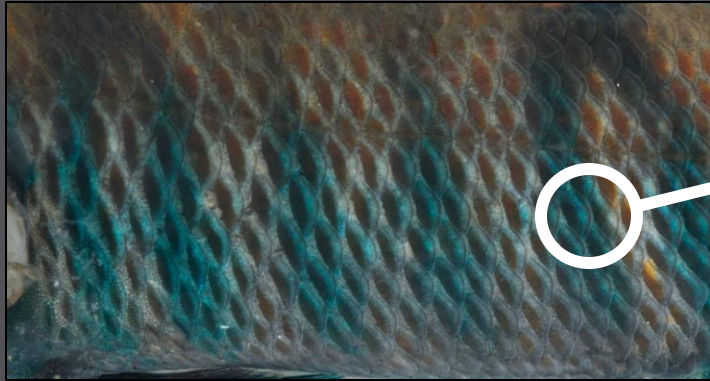
Correlation between the slope of body patterns and the slope of habitats in males only

# Going beyond the one feature analysis



Classical approach: arbitrary selection of one trait and correlation with one/several variables (e.g., reproductive success)

# Going beyond the one feature analysis



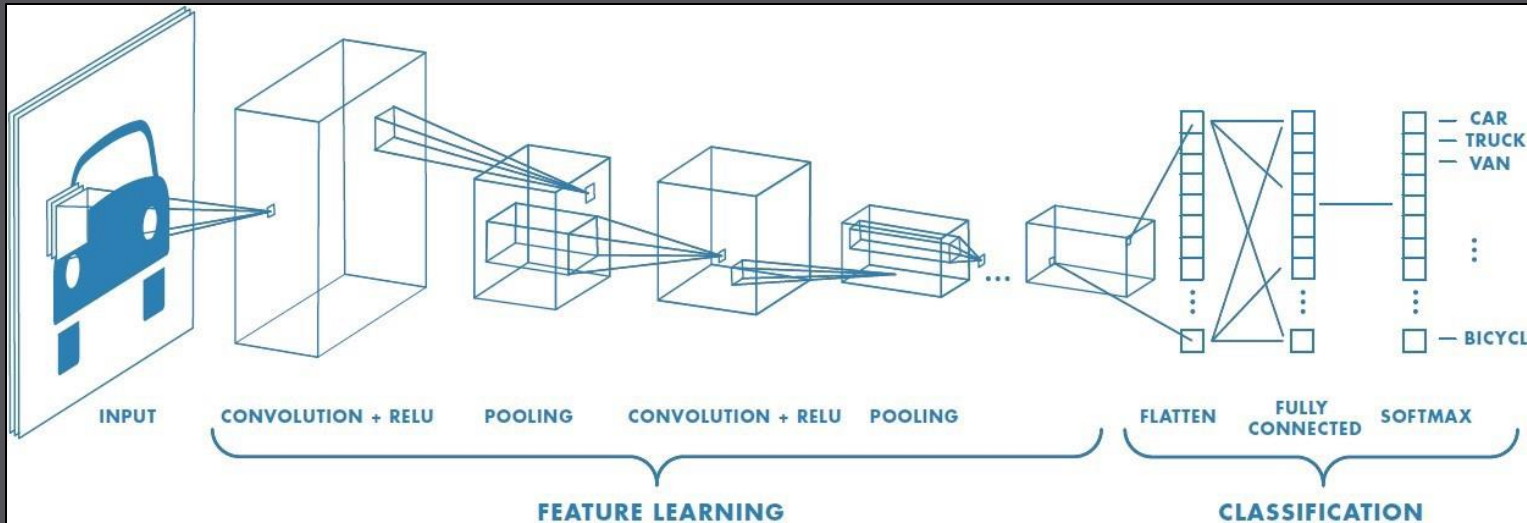
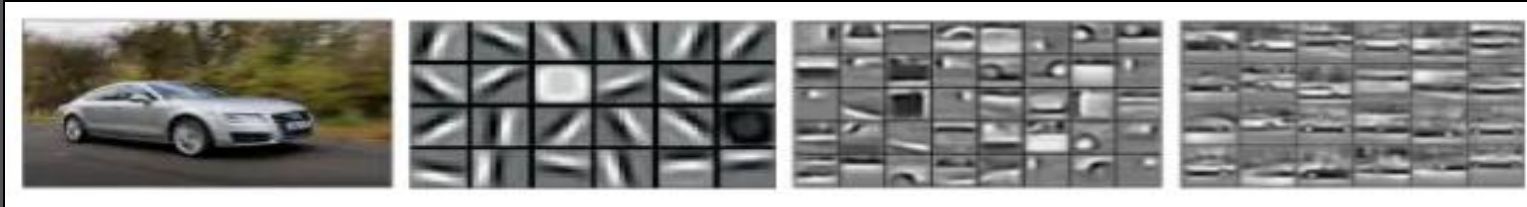
Classical approach: arbitrary selection of one trait and correlation with one/several variables (e.g., reproductive success)

CNN-based approach: automatic selection of traits/features  
> more complex patterns

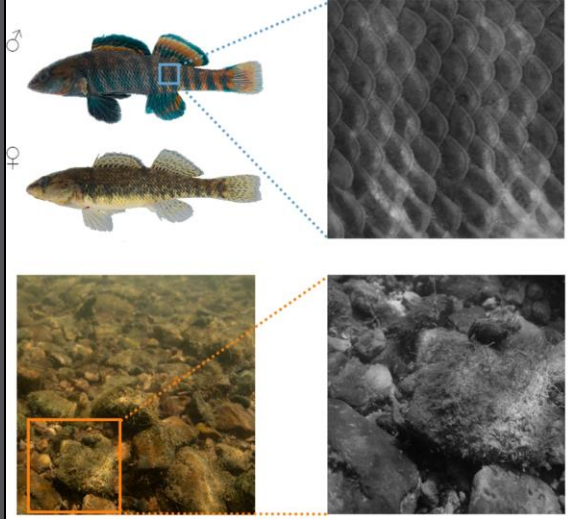
Complementary!



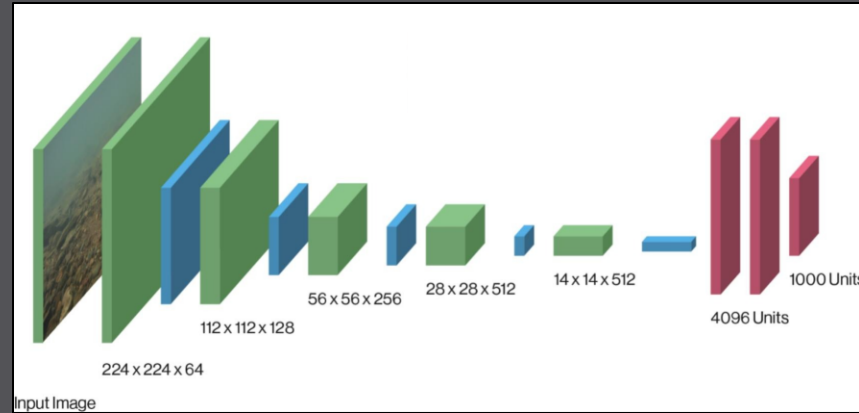
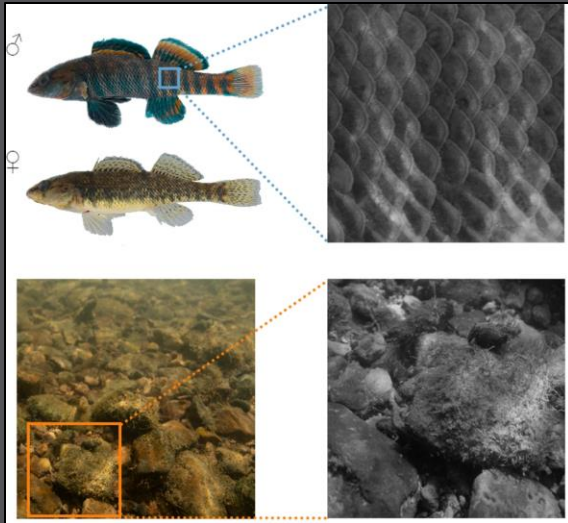
# CNN and feature extraction



# Link between body pattern and habitat statistics

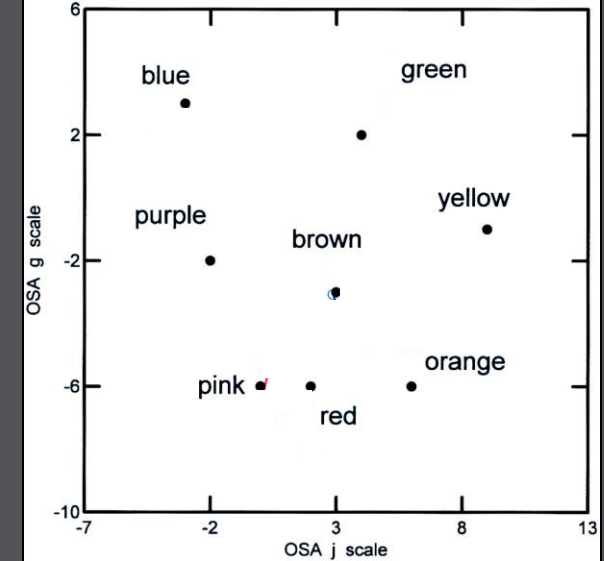
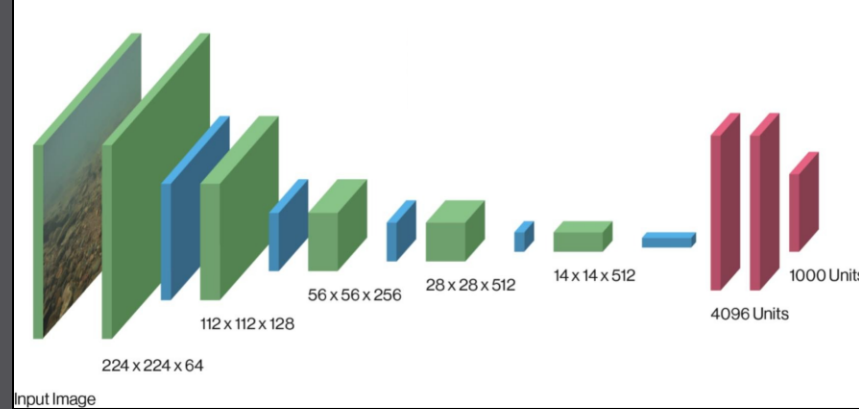
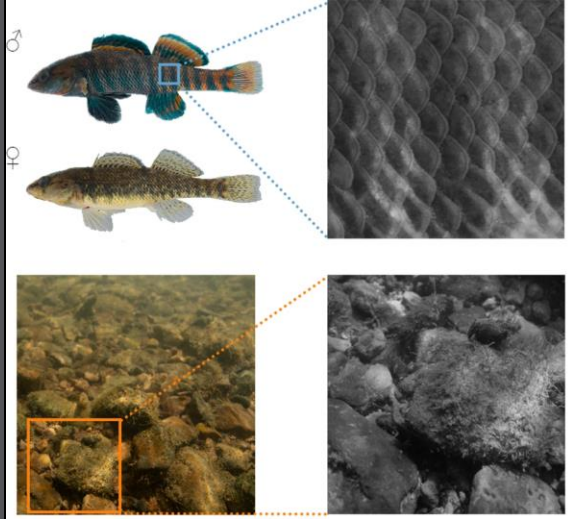


# Link between body pattern and habitat statistics



550 darter images (288 male and 262 female)  
597 habitat images (5 types)  
Training set: half of the images of each category

# Link between body pattern and habitat statistics



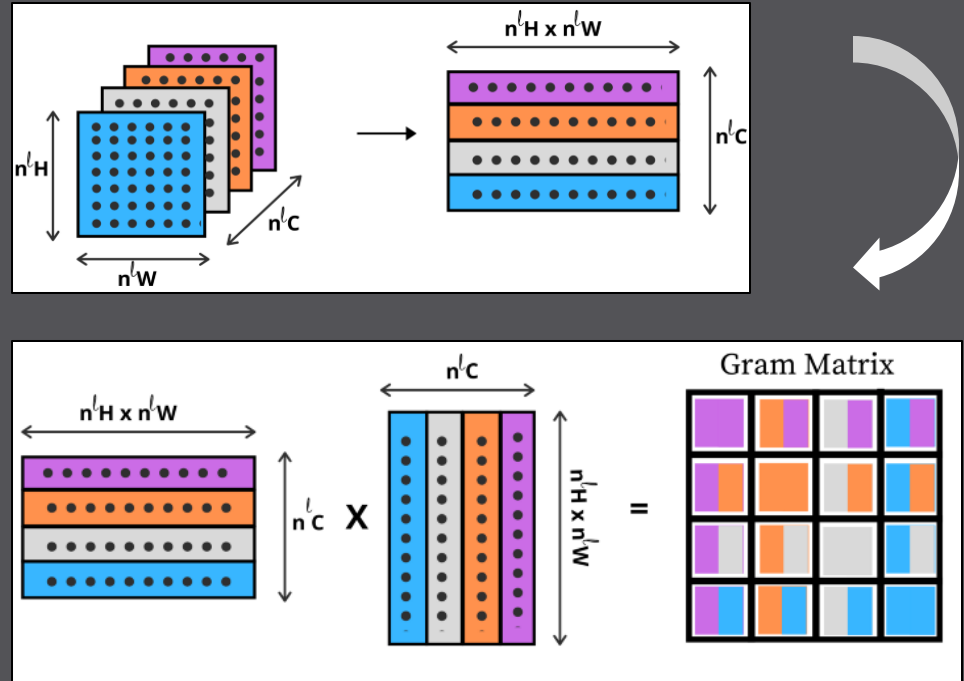
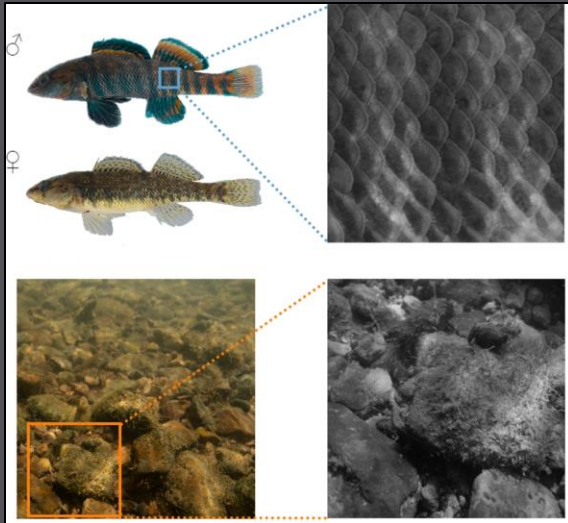
550 darter images (288 male and 262 female)

597 habitat images (5 types)

Training set: half of the images of each category

For every layer: vector of mean activations + Gram matrix used  
as the species centroid > species prototype

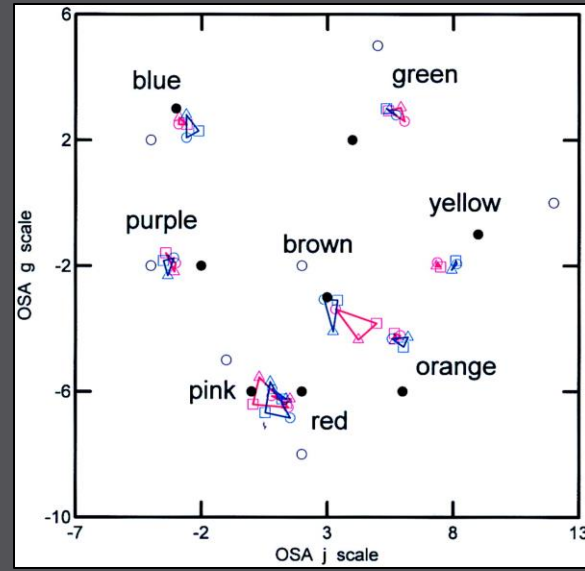
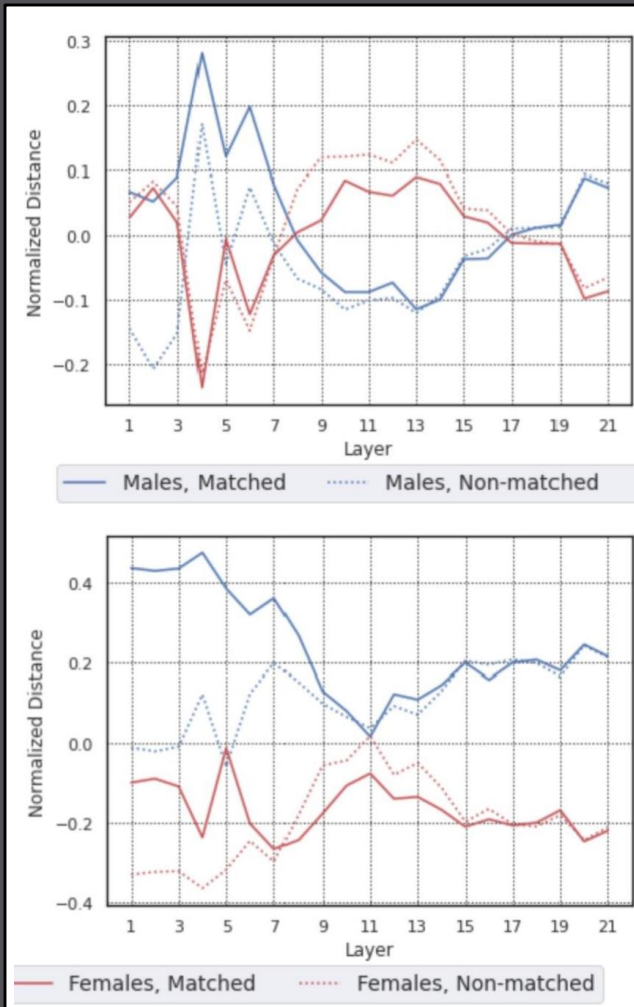
# Link between body pattern and habitat statistics



Aman Kumar Mallik

> how often image features cooccur

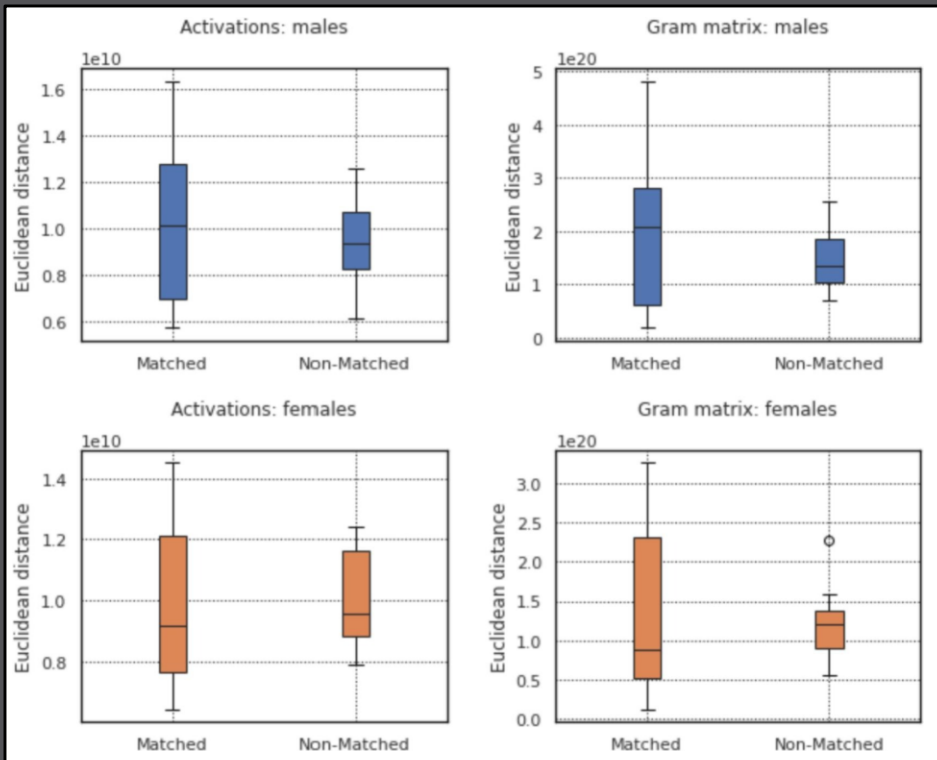
# Link between body pattern and habitat statistics



Classification metric:

$$|\text{centroid}_{sp\_a} - \text{test images}_{sp\_a}| < |\text{centroid}_{sp\_!a} - \text{test images}_{sp\_a}|$$

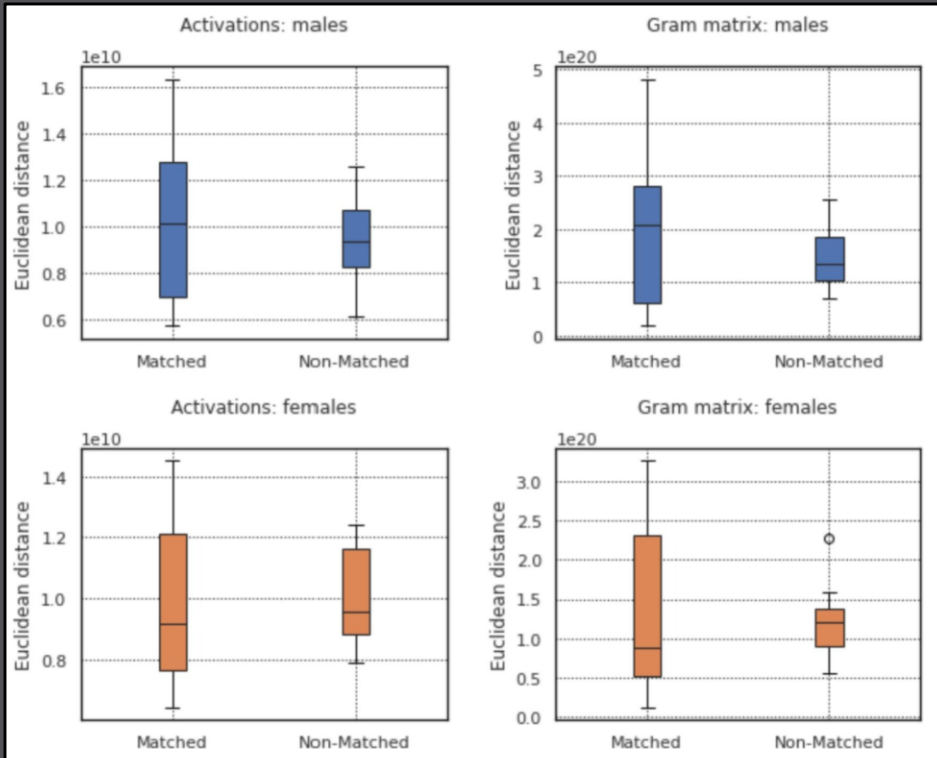
# Link between body pattern and habitat statistics



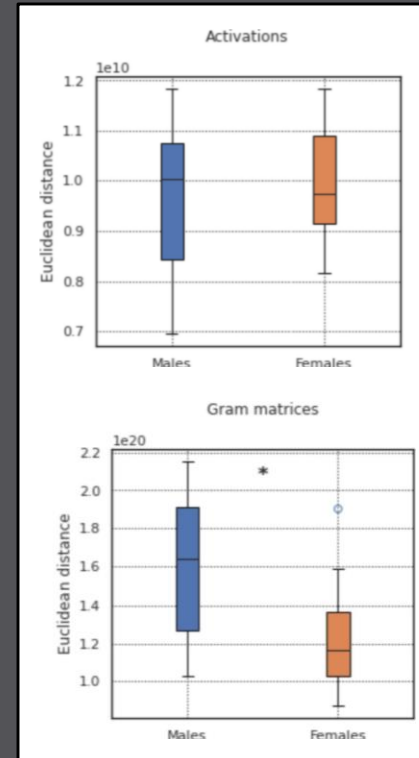
Layer 3

No significant difference in distances between darters and matched habitats versus non-matched habitats

# Link between body pattern and habitat statistics



Layer 3



Sex differences

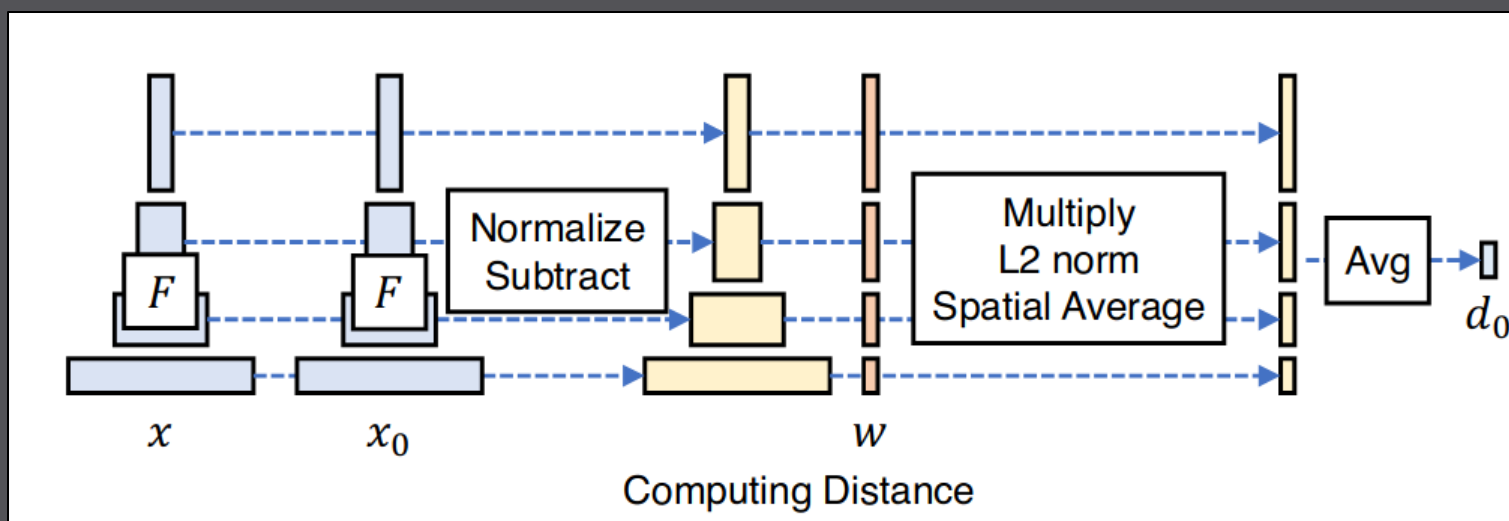
At shallow layers: female darters significantly more similar to darter habitats than males for Gram matrices only

No significant difference in distances between darters and matched habitats versus non-matched habitats



# Deep Features as a Perceptual Metric

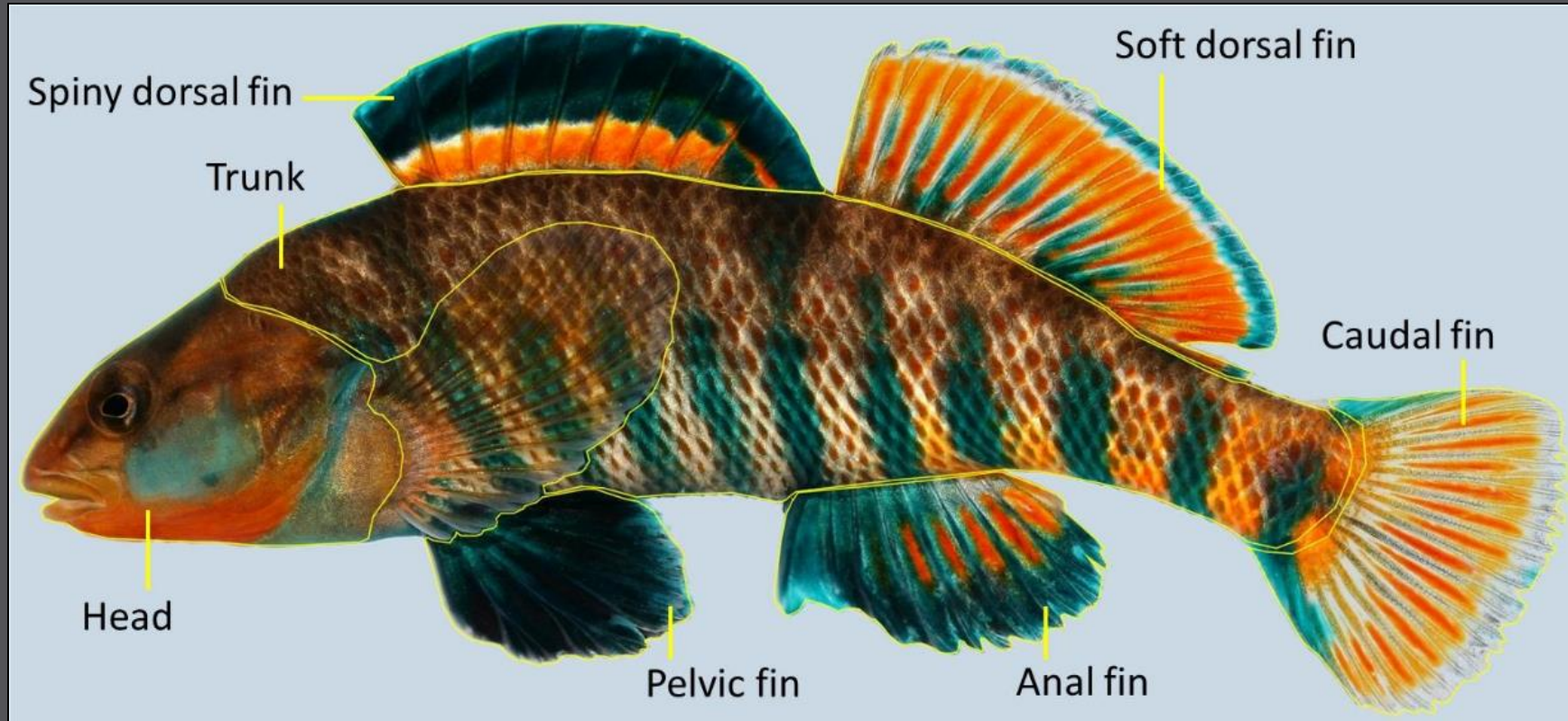
"Perceptual distance", a measure of how similar are two images in a way that coincides with human judgment



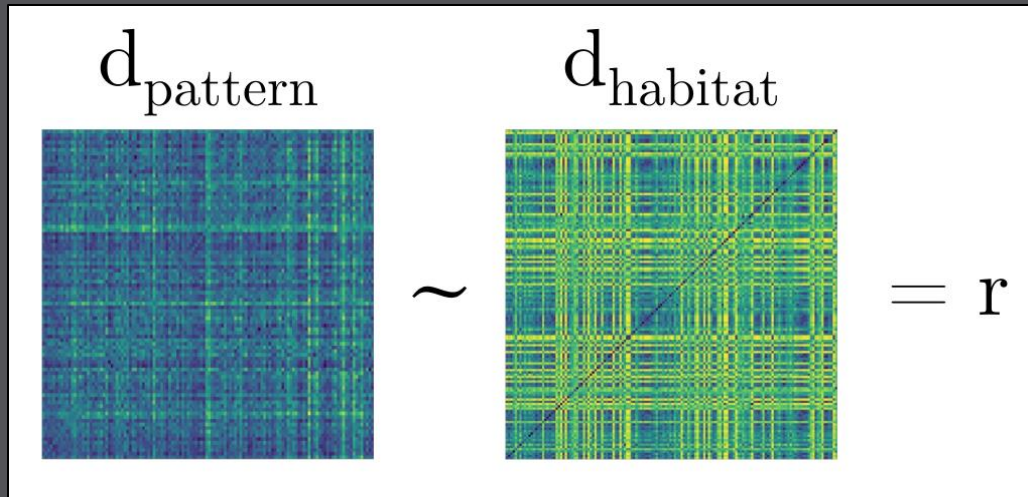
$$d(x, x_0) = \sum_l \frac{1}{H_l W_l} \sum_{h,w} \|w_l \odot (\hat{y}_{hw}^l - \hat{y}_{0hw}^l)\|_2^2$$



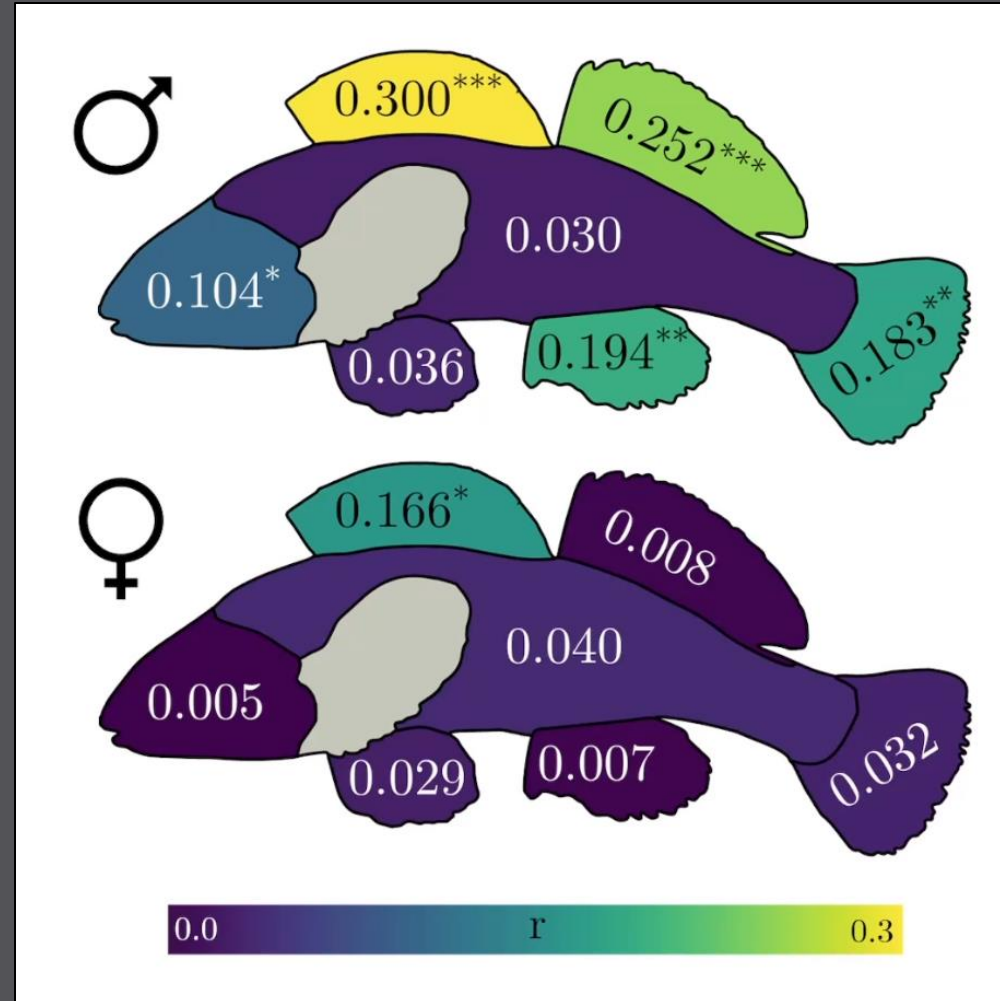
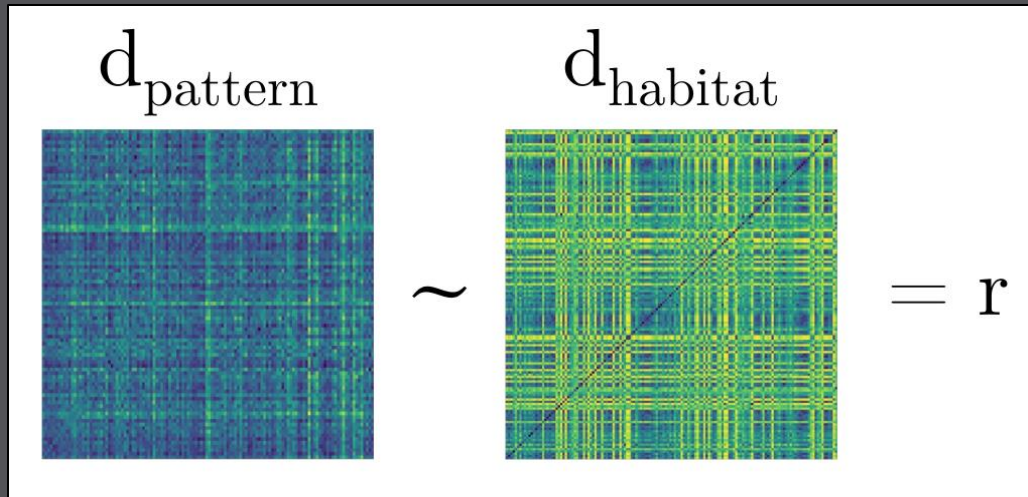
# Deep Features as a Perceptual Metric



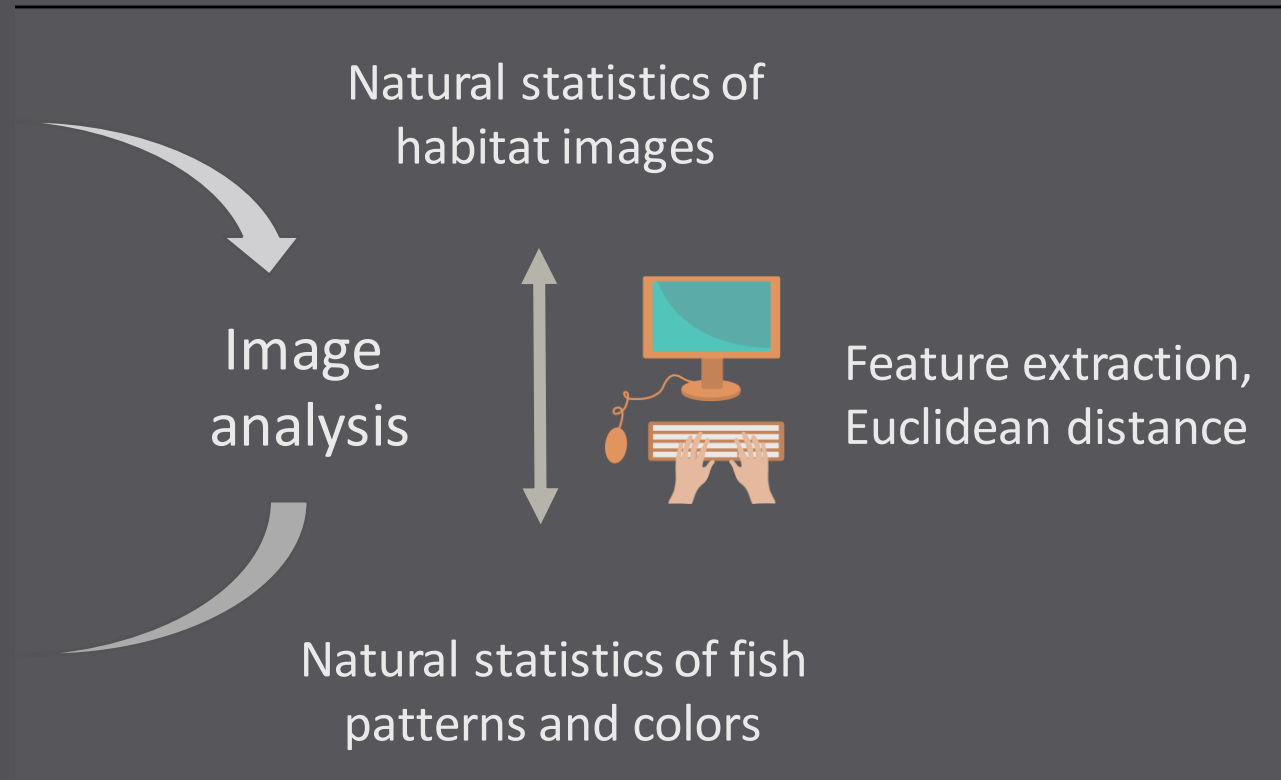
# Deep Features as a Perceptual Metric



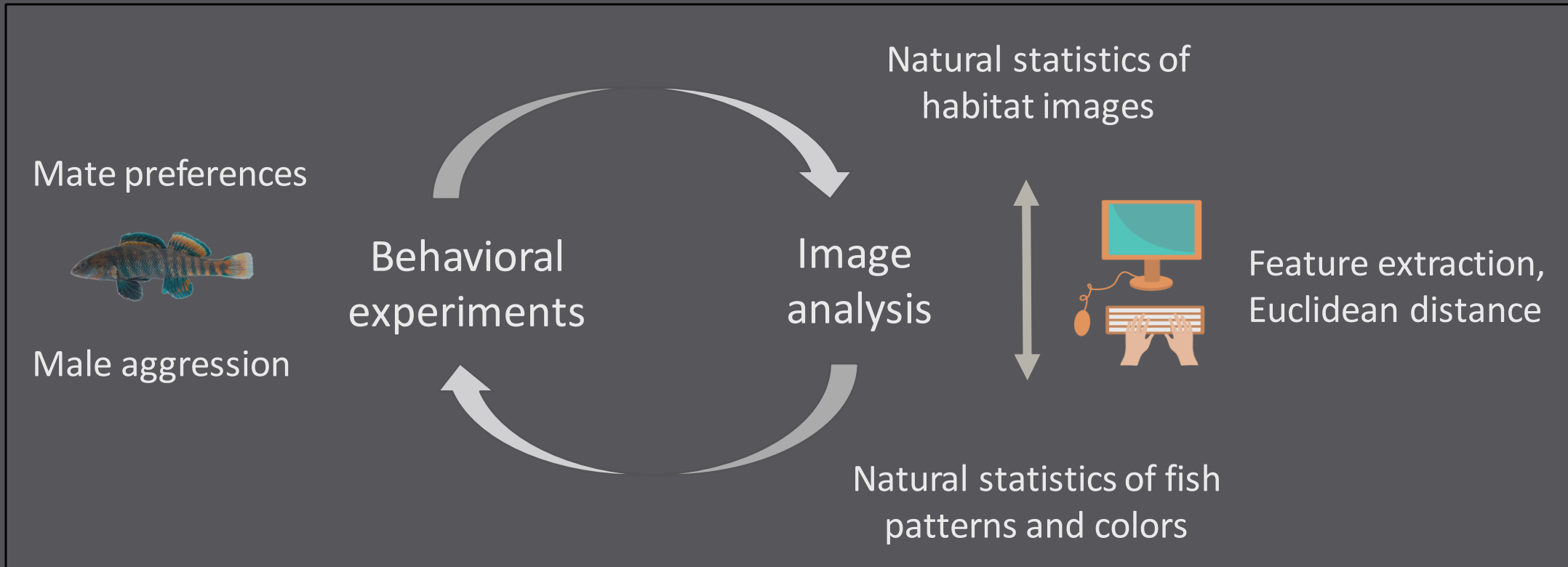
# Deep Features as a Perceptual Metric



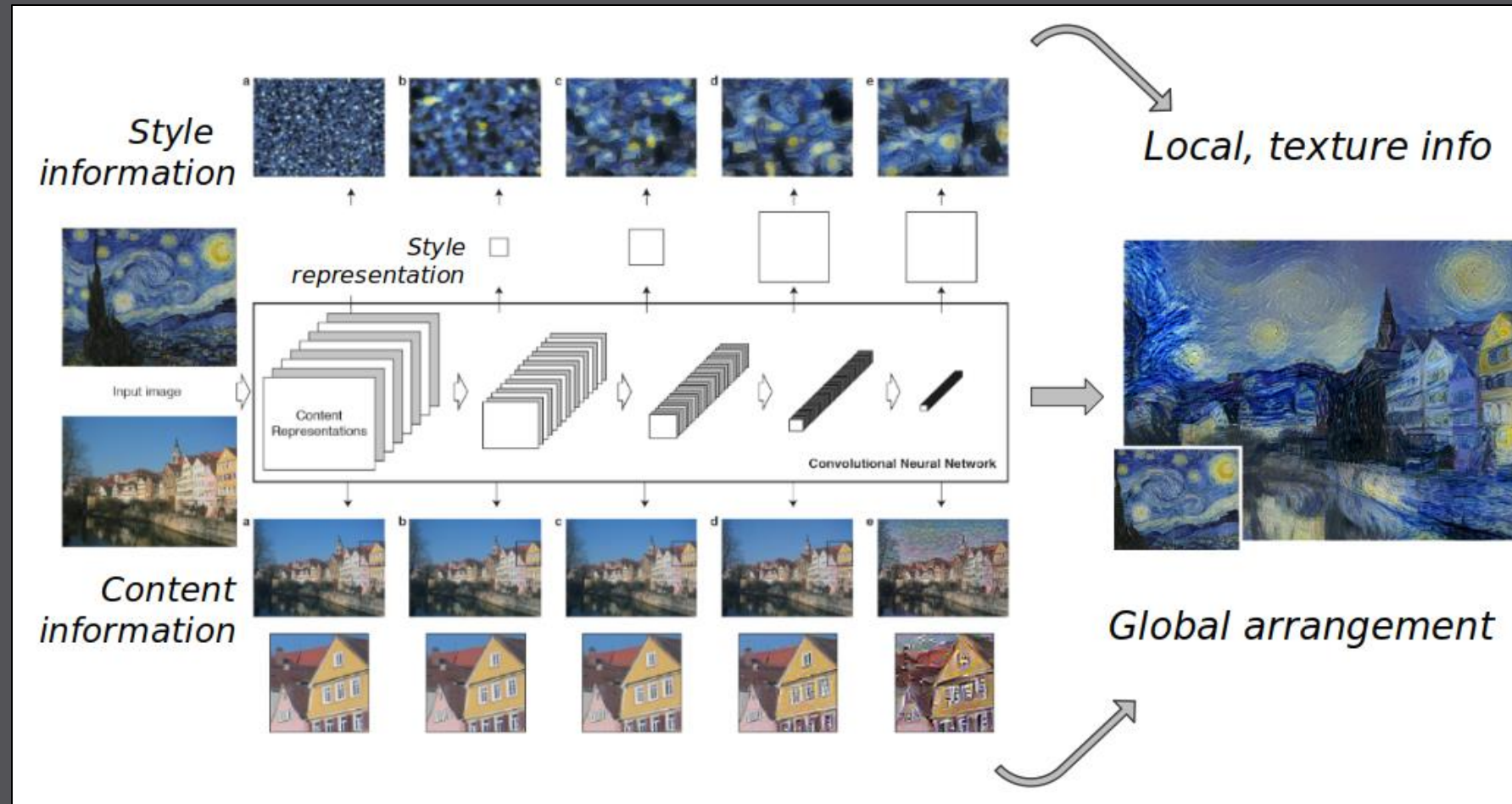
# Link between body pattern and habitat statistics



# Link between body pattern and habitat statistics



# Neural Style Transfer

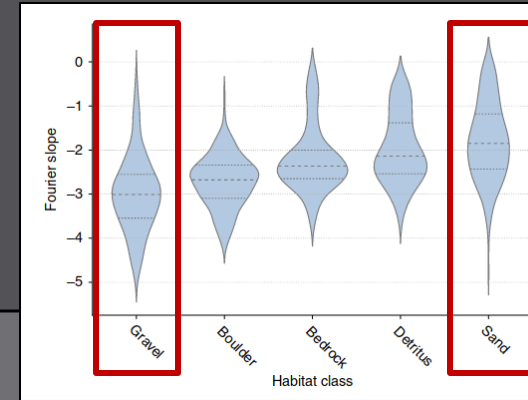




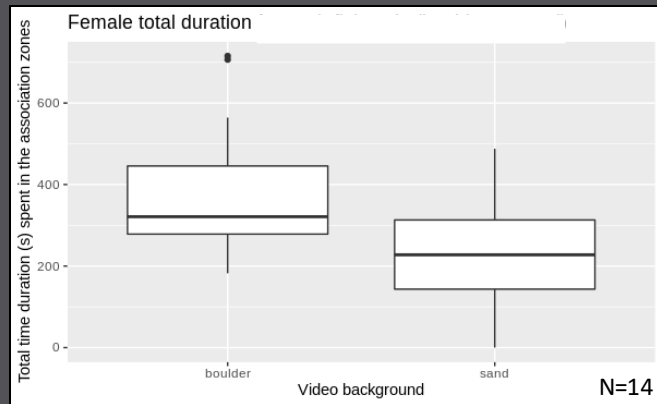
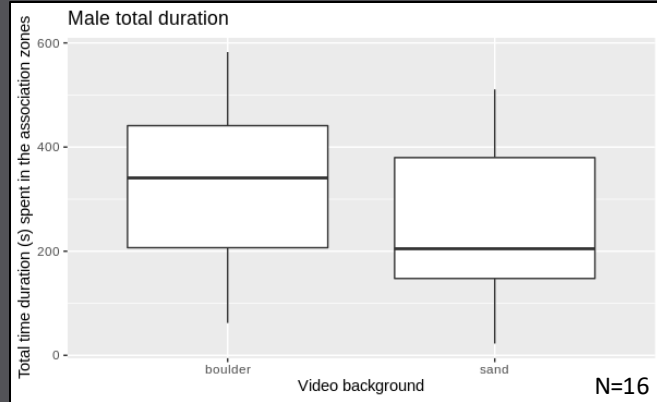
# Neural Style Transfer



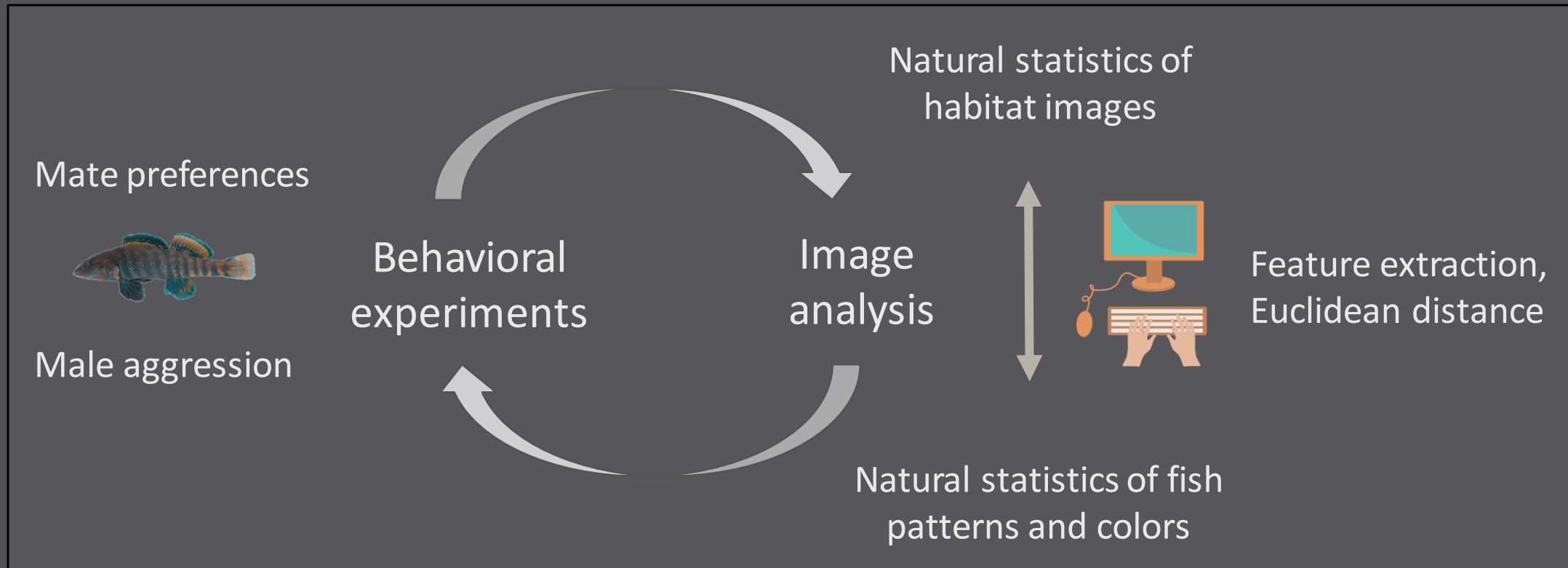
# Neural Style Transfer



# NST: Preliminary results



# DL is an interesting tool for visual ecology



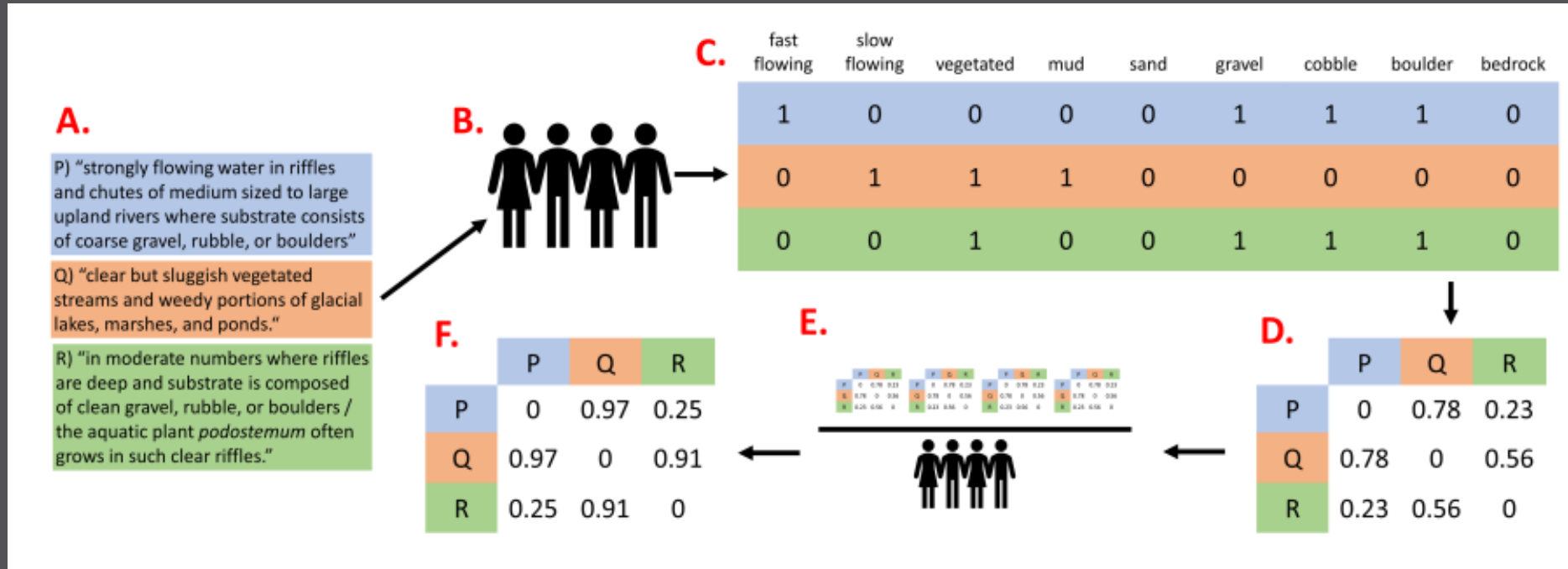
ETHEOSTOMA  
CAERULEUM



# Thank you!

- Renoult, J. P., & Mendelson, T. C. (2019). Processing bias: Extending sensory drive to include efficacy and efficiency in information processing. *Proceedings of the Royal Society B: Biological Sciences*
- Hulse, S. V., Renoult, J. P., & Mendelson, T. C. (2020). Sexual signaling pattern correlates with habitat pattern in visually ornamented fishes. *Nature Communications*
- Hulse, S. V., Renoult, J. P., & Mendelson, T. C. (2022). Using deep neural networks to model similarity between visual patterns: Application to fish sexual signals. *Ecological Informatics*

# Method to convert written descriptions to habitat dissimilarity matrices



# Going further: Autoencoders

