Notice of the Final Oral Examination
for the Degree of Master of Science
of
NICHOLAS PLANIDIN
BSc (University of Victoria, 2018)

“Asymmetry in the lateral line of threespine stickleback, Gasterosteus aculeatus: ecology, evolution and behaviour.”

Department of Biology

Thursday, May 6, 2021
9:00 A.M.
Conducted Virtually

Supervisory Committee:
Dr. Thomas Reimchen, Department of Biology, University of Victoria (Supervisor)
Dr. Francis Juanes, Department of Biology, UVic (Member)
Dr. Roswitha Marx, Department of Biology, UVic (Member)
Dr. John Taylor, Department of Biology, UVic (Member)

External Examiner:
Prof. Dr. Catherine Peichel, Institute of Ecology and Evolution, University of Bern

Chair of Oral Examination:
Dr. Brian Thom, Department of Anthropology, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

Behavioural asymmetry (laterality) is widespread among bilaterally symmetrical organisms, playing a part in many aspects of life history from reproduction to feeding. Laterality is typically thought to occur due to morphological asymmetry within the brain, in which one hemisphere becomes specialized for a given task. However, the influence of sensory receptor asymmetry on the development of lateralized behaviour has undergone little investigation. The role of inconspicuous receptor asymmetry in behavioural laterality is particularly important, given the ubiquity of small deviations from symmetry.

Here I have investigated morphological asymmetry in the lateral line, a series of mechanoreceptors that comprise one of the major sensory modalities of fishes. I examined a subset of the lateral line of 3,987 threespine stickleback from 64 populations from coastal British Columbia, characterizing mechanoreceptor (neuromast) count and asymmetry among habitats. Furthermore, I scored four experimental transplant populations of stickleback relocated from stained lakes to unstained ponds to assess the rate at which neuromast count and asymmetry change in a novel habitat. I found that neuromast count did not differ between oceanic and freshwater stickleback, or between sympatric lake-stream pairs but did differ among clarity regimes, ranging from a complete lack of neuromasts to a doubling of neuromasts compared to oceanic stickleback. Loss of neuromasts was associated with reduced light transmission, lower pH and a lack of piscivorous fishes. Stickleback with more lateral plates developed more neuromasts and males bore more neuromasts than females. One transplant pond underwent a 70% increase in neuromast count within just a couple of generations, whereas the other three transplant populations underwent more incremental change, suggesting both phenotypically plastic and genetic mechanisms underlying difference in neuromast counts among populations.

Asymmetry was widespread in the neuromast counts, differing by up to seven neuromasts between the two sides on a single bony plate. However, no populations exhibited a strong directional bias. The degree of absolute asymmetry differed among clarity regimes, with stickleback in stained habitats having less asymmetry in their neuromasts counts, but asymmetry did not differ between oceanic and freshwater populations or sympatric lake-stream pairs. Males exhibited greater asymmetry than females, particularly in large-bodied
populations. As with neuromast count, neuromast asymmetry quickly changed in some transplant populations and more gradually in others, increasing by up to 14% in just a couple of generations.

To assess the functional consequences of my geographic survey, I experimentally tested 40 stickleback for their response to a simulated predator, localization of vibrations in the dark and rheotaxis. I compared behaviour and laterality to neuromast count and asymmetry measured by fluorescent microscopy. Stickleback with fewer neuromasts were more likely to respond to simulated predator strikes, but other non-lateralized behaviours were independent of neuromast count. The strongest laterality I observed was the ‘hugging’ of the arena wall with the right side 57% of the time, with laterality being present in other behaviours, albeit weakly. While some behaviours correlated with lateral line asymmetry, there was no consistent association between lateralized behaviour and asymmetry in the lateral line.

I found that ecological factors such as predation landscape and photo-regime shape both mechanoreceptor count and asymmetry in the lateral line, with potential phenotypic plasticity in both traits. The lateral line’s role in response to a model predator and lateralized behavior supports the influence of mechanosensory asymmetry in eco-evolutionary dynamics.