Transgenerational Developmental and Behavioral Plasticity of Threespine Stickleback *Gasterosteus aculeatus* of Lake Myvatn, Iceland

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Introduction

Much research has been conducted exploring phenotypic plasticity, the ability for an organism to alter its phenotype in response to its environment within its lifetime (Denver and Middlemis-Maher, 2010; Kishida et al., 2010; Klemetsen, 2010). However, there is increasing interest in so-called transgenerational plasticity (TGP), wherin plastic responses to environmental conditions are passed down to offspring (Hellmann et al., 2020; Richter-Boix et al., 2014; Bell and Hellmann, 2019; Shama et al., 2014). This concept holds particular importance in the face of rapid environmental change, because it allows organisms to evolve without relying on actual genetic changes. One of the most well-known model systems for studying plasticity is *Gasterosteus aculeatus*, commonly named the threespine stickleback. Stickleback populations often form species pairs, with two or more morphs coexisting in a single body of water via niche partioning. In lake Myvatn, two morphs exist, the "mud" and "lava" morphs, defined mainly by habitat type, as well as morphology and behavior (Kristjánsson et al., 2002; Millet et al., 2013). Different sections of lake Myvatn act as distinct habitats (referred to as the North, South, and (sometimes) East basins), and so the sticklebacks can also be distinguished by habitat of origin (Millet et al., 2013; Einarsson et al., 2004). Millet et al. (2013) in particular found that there was a large difference in size between sticklebacks from different habitats, with those of the

North basin being larger ($\geq$ 55mm) and of different age classes than those of the South. They posit that these differencee could be due to differences in life history strategies between the populations, or plasticity in response to resources. Interestingly, they also note that North basin stickleback have larger spines than those of the South basin, possibly owing to differences in abundance of gape-limited predators, which occur at rates of up ten times higher in the North basin than the south (Millet et al., 2013). While we know that plasticity in traits does occur in lake Myvatn stickleback, there is little data on whether this plasticity is transgenerational. Indeed, much of the research on TGP in stickleback has been performed on oceanic populations, and thus TGP in freshwater stickleback represents a current gap in our knowledge of the ecology and evolution of these organisms (Shama et al., 2014). Evidence from marine stickleback suggests that TGP does occur, although it varies between populations (Shama et al., 2014; Heckwolf et al., 2018; Kozak and Boughman, 2012). Research by Kozak and Boughman (2012) found that TGP led to increased shoaling behavior in response to predators by limnetic morphs of stickleback in British Columbia, while Benthic morphs did not show evidence of TGP. This is particularly interesting the the context of lake Mývatn, because as noted above, different subpopulations of stickleback occur in regions with different predator abundances. Particularly in the North basin, where predator abundance is much greater than the South, we could expect to see TGP acting to alter antipredator behavior. Other research has implications for responses to climate change. Heckwolf et al. (2018) investigated adaptive and nonadaptive TGP in marine stickleback in response to changes in salinty. They found that directional selection of nonadaptive TGP accelarated the evolutionary response in offspring, but that it was dependent on life stange and the particular environmental factor they are exposed to. In the context of lake Mývatn, the different basins apply different environmental factors to the sticklebacks living in them (in terms of different temperatures, prey and predator abundances, and seasonal dynamics) and thus the evolutionary selection on TGP might be altered.

Major questions I want to address:

- Do lake Mývatn stickleback experience morphological/behavioral TGP in response to food and predator presence, temperature, and salinty? Are maternal or paternal effects stronger?

- How does TGP impact eco-evolutionary dynamics within lake Mývatn? Specifically, does TGP contribute to sympatric speciation of morphs?

1 Methods

I will use a half-sibiling common garden expiriment to assess TGP in Mývatn stickleback.

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