Quantifying personality in Mongolian salmonid populations in order to predict population persistence in a rapidly changing river system

Introduction: Behavior is one major way organisms respond to novel conditions in human-altered habitats. An animal's behavior is often moderated by its personality, also known as behavioral type, which is consistency in behavioral response across contexts. Not only does behavioral type influence individual fitness, but its variation within a natural population affects population stability (Sih et al. 2012, Wolf & Weissing 2012). That is, personality variation can influence demographic outcomes via differences in survival and reproductive success between behavioral types, which in turn affect population growth rates (Wolf & Weissing 2012).

Naturally occurring personality variation can also help buffer populations against environmental change, as individuals might respond differently to selection pressures brought on by anthropogenic disturbances (Smith & Blumstein 2013). Common personality traits associated with an individual's ability to cope with human-altered habitats are their level of "boldness," which is their willingness to approach a novel object, and "exploratory" behavior, often defined by their movement an in open field (Dall & Griffith 2014). For example, experimental fishing of rainbow trout shows that bolder, faster-growing fish are caught more often than slow-moving individuals (Biro & Post 2008). In fact, boldness and high reactivity (i.e., how actively an individual copes with a stressful event) are often associated with high physical activity and high metabolic rate in a correlated trait cluster known as the "pace of life" syndrome (Réale et al. 2010). These trait clusters might be connected to other behavioral strategies, such as diet or mating, which could explain personality differences between closely related species, in addition to within-species variation. The correlation between personality and physiological traits might affect how successfully individuals or populations respond to environmental heterogeneity, and their potential for adaptive flexibility in responses to rapid change.

One major and rapid anthropogenic disturbance for river ecosystems is the introduction of dams for hydroelectric power, which can be especially damaging to fish populations. For example, although fish passage devices on dams are intended to improve fish mobility, evidence suggests that dams remain a barrier to fish movement (Brown et al. 2013). Potential hypotheses for underused passage devices have focused on physiological impediments, like swimming ability or navigational capacity (Goodwin et al. 2014, Volpato et al. 2009). However, the relative boldness of individuals and populations might also influence the use of fish passage devices (Hirsch et al. 2016). In fact, relative physical swimming ability and personality might be correlated in these populations. Furthermore, behavioral type could affect how fish respond to other changes in the local habitat brought on by dam construction. For example, differences in foraging and movement behavior might influence response to changes in flow regime and diet flexibility could affect the ability to cope with changing food availability. Thus, in order to predict how species will fare after the introduction of a dam, it is essential to measure personality variation within wild populations with regards to ecologically relevant behaviors.

Questions: How bold are individuals in the population toward novel structures? Is this indicative of population foraging strategies? Are boldness levels associated with a fish's physical ability to navigate changes in flow or utilize fish passage devices? How might this connect to other ecologically important personality traits that influence behavioral responses to environmental change, like exploration or reactivity?

Objective: I propose to quantify the personality composition of two different species of salmonids on the Eg River in northern Mongolia using pseudo-natural assay conditions. I propose to measure behavioral type variation in populations of lenok (*Brachymystax lenok*) and Baikal grayling (*Thymallus arcticus baicalensis*), top predators in this system, whose population dynamics have important repercussions for lower trophic levels. Due to the relatively undisturbed environment and low fishing pressure compared to most other rivers in the world, fish populations in the Selenge River Watershed in northern Mongolia are an excellent system to measure baseline individual behavioral type variation in a wild population before anthropogenic change. In particular, I plan to measure individual differences in behavioral responses to novel man-made objects, including a within-tank barrier, as a proxy for rapid human development. Due to the proposed hydroelectric dam project on the Eg River, parameterizing personality is important for making predictions about population use of fish passage devices, their responses to potential food availability changes, and their behavioral flexibility toward environmental change in general. Furthermore, this study will set a reference for future studies investigating changes in fish behavior during and after dam construction. Lastly, although there has been a call for more personality studies of wild populations (Adriaenssens & Johnsson 2011, Brown et al. 2005, Dall & Griffith 2014), few studies have attempted to measure fish personality directly in the field (but see Brown et al. 2005, Byrnes et al. 2016). By measuring personality in semi-natural outdoor mesocosm arenas, this study will provide a rare insight into behavioral variation outside a classic lab setting and add to a growing understanding of how laboratory conditions interpret the behavior of wild populations.

I hypothesize that both lenok and grayling populations will demonstrate personality differences (i.e., individuals will show inter-trial repeatable differences in behavioral responses across different contexts). I predict that individual levels in activity and reactivity will be positively correlated with boldness, as predicted by the pace-of-life syndrome framework (Réale et al. 2010). *I hypothesize that there will be significant differences in the relative boldness response to novel objects between the two species of salmonids because of the differences in foraging strategies between the two populations.* I predict that grayling, which have a more generalized surface-oriented diet, will be bolder due to higher general sampling effort required for their foraging niche, compared to lenok, which forage primarily on the benthos (Olson et al. 2015). *Lastly, I hypothesize that the bolder grayling population will have on average a higher swimming velocity, since I expect bolder fish to have higher metabolic and activity rates.*

Methods: I will collect 12 individuals of both lenok and grayling (6-8 inch in length) from two different sites (n = 24 individuals per species) along the Eg River from July-August 2018. Each individual will be housed in tanks for 5 days post collection to acclimate to captive conditions. During this period fish will be fed pellets twice a day *ad libitum* in order to reduce the influence of hunger on behavior. On days 6-8, individuals will go through a series of behavioral assays before either a swimming velocity test or a release event on day 9.

Aim 1: *Quantify personality composition of both populations.*

Prior to testing, individuals will be placed in 63 x 63 x 11.8 inch collapsible pools lined with local sediment and vegetation. Following one hour of acclimation, fish will undergo a series of assays, which will be repeated in the same order every day for three consecutive days and video recorded for posterior analysis. Trials will consist of three assays in the following order:

Open field test. In order to measure general activity and exploratory behavior, fish will be recorded for 10 minutes during undisturbed swimming. Exploratory behavior will be measured

as the time spent in the middle of the arena versus the time spent along the wall. General activity will be measured as total time spent swimming and average swimming velocity (cm/s).
Novel object test. Following the open field test, a novel object will be dropped into the middle of the tank. Each individual will interact with three different novel objects. The bottom of the test arena will be divided into two distinct zones: 5 cm radius around the novel object (the novel object zone) and the remaining area. Boldness will be measured as the latency to enter the novel object zone, the amount of time the fish spent in the novel object zone, and the number of times the fish enters the novel object zone (Larsen et al. 2015). Depending on feasibility, one novel object test will include inserting a barrier that would split the tank in half, with a small passage in the middle (i.e., to mimic a within-stream barrier scenario). In this test, boldness would be measured as the time to approach and cross through the passage, and the number of times the barrier is crossed.
Restraining test. After the novel object test, a fish will be held in an emerged net for 3 minutes. The restraining test is a commonly used personality assay used as a proxy for reactivity (Larsen et al. 2015, Sneddon et al. 2003). Reactivity will be measured as the latency to attempt to escape the net (struggle), number of escape attempts, and total time spent struggling against the net.

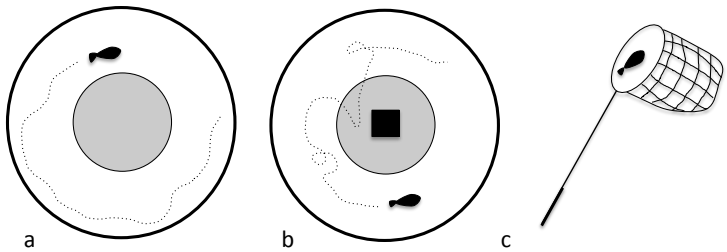

Fig 1. *Schematic representation of the experimental set-up.* Circles represent the boundary of the arenas. Shaded areas represent the 5 cm-radius novel object zone. Each behavioral trial will consist of the (a) open field, (b) novel object, and (c) net restraining test.

Aim 2: *Correlate boldness to swimming performance.* If swimming velocity is being measured by another concurrent project, these measurements can be directly correlated with personality attributes within individuals. If not, I will use past data sets of swimming velocity from tunnel respirometer assays with the same populations from previous years to make connections between general boldness and swimming performance ability between the two populations.

Conclusion: Understanding behavioral type variation in wild populations facing novel selection pressures, like the building of a dam, is crucial for predicting how populations will respond to rapid environmental change. For example, dams can act as selective filters for certain features of the population, including personality. That is, by acting as a filter for specific behavioral types, in-stream barriers could remove bold-active phenotypes from a downstream population (Hale et al., 2016). Furthermore, if other traits are also associated within bold-active individuals, like exploratory tendency or post stress reactivity, the personality variation in future generations could be limited in other traits beyond the ones actively under selection. Thus, not only can personality mediate a population's response to dam construction, but dam construction can also influence a population's personality make-up, influencing its potential ability to respond to other anthropogenic stressors. This project will be an important first step in assessing how fish personality, and our understanding of it, affects outcomes of dam construction and other anthropogenic environmental change.

Supplies Needed:

- 6 collapsible pools (63 x 63 x 11.8 inch)
- 3 cameras (potentially able to borrow from Sih lab)
- 3 tripods to suspend cameras above pools
- duct tape to secure cameras
- SD cards and portable hard drive for videos (able to bring)
- salmonid feed
- 6 bubblers for collapsible pools
- novel object supplies (likely able to borrow from Sih lab)
- 3 nets for restraining assay (likely able to borrow from Sih lab)

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