Long-term behavioural repeatability in wild Eurasian perch (*Perca fluviatilis*) in a natural lake: a high-resolution biotelemetry study

S. Nakayama[1,2,3], K. Laskowski[1], P. Doering-Arjes[2], T. Klefoth[1] and R. Arlinghaus[1,2]

[1]Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater and Inland Fisheries, Berlin, Germany.

[2]Faculty of Life Sciences, Humboldt-Universität zu Berlin, Berlin, Germany.

[3]shinn407@gmail.com

Abstract

Consistent behavioural differences among individuals over time, also known as 'personality', have been discovered in many animals in a wide realm of behaviours [1]. To identify whether individual animals exhibit consistent individual differences in behaviour, repeated measures of the same behaviour are needed. Most personality studies achieve this through repeatedly measuring behaviour in standardized laboratory conditions over fairly short time intervals (one to a few days). However, these measures should be interpreted with caution if repeatability fluctuates over time, or varies with the number of observations. Moreover, behaviour can be especially sensitive to the external environment and the field is still lacking high-resolution repeated measurements of individual behaviour in natural settings. In our study, we used a unique long-term data set on fish behaviour in the field to investigate (1) whether behavioural repeatability is stable over time, (2) whether repeatability changes with temporal intervals at which the behaviour was measured, and (3) whether repeatability changes with the number of observations.

To accomplish these objectives, we tracked wild Eurasian perch (*Perca fluviatilis*) in a natural lake over 12 months using a high-resolution 3D acoustic telemetry system. The Kleiner Döllnsee (~25 ha) is a dimictic, shallow (mean depth 4 m, maximum depth 8 m), and slightly eutrophic lake, located 80 km northeast of Berlin, Germany. We installed 20 acoustic hydrophones in the lake, and recorded the positions of 16 adult female perch at high rates (up to 9-s intervals) for one year (from September 2009 to September 2010). The experiments were approved through an animal care permit (23-2347-15-2010) granted by the Ministry of Environment, Health and Consumer Protection Brandenburg, according to the German Animal Protection Act.

For each individual, we calculated daily mean values of swimming speed (m/s), turning rate (radian/s), and depth of fish (m). For each behavioural variable, we estimated repeatability as $r = s_A^2/(s^2 + s_A^2)$, where s_A^2 is the variance among individuals and s^2 is the variance within individuals, using a linear mixed model with individual as a random effect (MCMC method). We found that repeatability for a whole study period was comparable to previously published data [1] (swimming speed 0.176, turning speed 0.474, depth 0.160). However, behavioural repeatability differed between seasons, with higher repeatability found in winter compared to summer. To further investigate the temporal change of repeatability, we estimated repeatability every six consecutive days over a year, sliding by one day. Repeatability fluctuated markedly during the study period (for example, 0.262-0.822 for swimming speed). We then performed a linear model (with an autocorrelation term) on the repeatability to see whether abiotic environmental variables explain the temporal trend in repeatability. The model parameters were averaged over the models that constituted up to 95% model probability, and the significance of parameters were estimated using hierarchical partitioning. As a result, the fluctuation of repeatability was well explained by a number of environmental factors. For example, fish showed higher repeatability in swimming speed when water temperature was lower and light intensity was higher, but the repeatability was not explained by temperature fluctuation, air pressure, or precipitation. Secondly, to investigate the effect of temporal intervals on repeatability,

the repeatability was calculated between randomly sampled two days. Repeatability declined with the interval between days, but the effect was very small. Finally, to investigate the effect of the number of observations on repeatability, we resampled the data and recalculated repeatability with different numbers of observations. We found that repeatability was underestimated when the observation number was small, but stabilized with increasing observations.

Our study is unique in offering an extremely high-resolution measurement of individual behaviour in the wild providing detailed insight into the temporal patterns and the influence of sampling on behaviour. These results demonstrate that personality of animals is expressed in nature and is rather stable over time, but that the description of this behavioural variation can be influenced by the time interval between and number of observations.

Reference

1. Bell, A.M., Hankison, S.J., Laskowski, K.L. (2009) The repeatability of behaviour: a meta-analysis. *Animal Behaviour* 771-783.