Encephalization and mating system in fishes

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1 The Social Brain Hypothesis

Also known as the Machiavellian Intelligence Hypothesis, The Social Brain Hypothesis (SBH) was originally proposed to account for the evolution of unusual large brains for body size in primates, especially in humans, compared to all other species.

According to the SBH, the main driving force for the evolutionary increase in brain size relative to body size in primates was the complexity of their social systems, and not the ecological demands they faced. Thus, “primates need large brains because they live in unusually complex societies that involve many interdependent relationships that change dynamically through time.” (Dunbar, 2014, p. 109).

2 Social complexity: group size vs pair bonding?

Several studies have tried to extended the SBH to nonprimate taxa, such as ungulates, carnivores, bats, and birds, with mixed results (e.g., Beauchamp & Fernández-Juricic, 2004; Pérez-Barbería et al., 2007; Périck et al., 2006).

An index of social complexity that has commonly been used to test the SBH in various higher-vertebrates is social group size, since it is expected that a higher number of relationships would increase the information-processing demands (Dunbar, 1996). This index is easy to quantify and widely available. However, a robust cost-benefit relationship between social group size and some measure of brain size has only be found in anthropoid primates (Dunbar & Shultz, 2007).

Dunbar and Shultz (2007) have shown that for bats, artiodactyls, ungulates, carnivores, and 135 species of birds “the relationship between brain size and sociality is qualitative and not quantitative. In each case, large relative brain size is associated explicitly with pairbonded (i.e., social) monogamy” (pp. 1345-1346).

Pair bonding is taken here as “a lasting (sometimes, but not always, lifelong) relationship between a male and a female, normally for reproductive purposes” (Dunbar, 2009, p. 164). The duration of this relationship is important, since many species live alone in separate territories and only form temporary pairs for mating.

3 The Social Brain Hypothesis in fishes

Several examples can be found in the fish literature that shows that fishes are capable of complex social behaviors, such as living in individualized groups, social learning and tradition, cheating, punishment, and co-operative hunting (Bshary et al., 2002).

Bhary and colleagues (2014) have pointed to various important similarities in brain structures involved in social cognition between fishes and other vertebrates, suggesting that “fishes are suitable to test general hypotheses about vertebrate social cognition and its evolution” (p. 1). Accordingly, there is some evidence that suggests that the SBH could also be applied to the evolution of brain size in fishes (e.g., González-Voyer et al., 2009; Pollen et al., 2007; Shumway, 2010).

In several Ectodinii cichlids species, a significant correlation was found between mating system (monogamy vs. polygamy) and telencephalic size (Pollen et al., 2007; Shumway, 2010).

We propose a methodology based on (variants of) the regression model. As the core of these models, we will regress the encephalization quotient (EQ) on a set of variables that represent species-dependent characteristics. In this way, besides having a very large and diverse sample of species, we will integrate multiple social, ecological, and life history variables, such as mating system, parental care, frequency of spawning, mode of reproduction, habitat, migratory and feeding habits, and other special abilities.

Given that the available species are organized in genera, families, orders, and classes, where species belonging to the same group are more homogeneous, hierarchical (or multilevel) extensions of the regression model will be required. Furthermore, due to the rather large number of missing values, we plan to analyze the data within Rubin’s framework for missing data based on multiple imputation. This avoids the loss of information as well as possible incorrect inferences that go with traditional ways of dealing with missing data such as case deletion of single imputation. We also propose to analyze the data in a Bayesian framework, which both leads to easier-to-interpret inferences and handles in a more elegant way hierarchical models and small number of observations at some levels of the hierarchy.

There are several examples of fishes in which pair bonding appears to be unrelated to reproductive behavior or parental care. In addition, many species with a monogamous mating system form transient breeding pairs, but remain solitary throughout their lives (Brandt & Bellwood, 2014). Therefore, we will review the literature for evidence of pair bonding in a subset of data.

References