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Guest Editorial

A small fish with a big future: zebrafish in behavioral neuroscience

The zebrafish has been the focus of much attention in developmental biology and genetics for the past three decades. However, more recently numerous studies have appeared that suggest good utility of this species also in behavioral neuroscience. Although these studies are orders of magnitude fewer than those conducted with more traditional laboratory organisms of this field, the increasing number of zebrafish papers is noteworthy. It suggests that the zebrafish could have some advantages over the other laboratory organisms perhaps partly because this species strikes a good balance between system complexity (it is a vertebrate) and practical simplicity (it is easy to breed and keep in large numbers at a low cost). This special issue is not intended to be a comprehensive account of zebrafish behavioral neuroscience research. It is not even a systematically arranged-balanced sampling of this field. This would already be somewhat difficult given the growing number of zebrafish studies. Instead, it is a teaser, a snapshot of interesting topics and recently published results with one main goal in mind: to persuade the reader about the use of this species in behavioral neuroscience. This special issue presents 11 papers discussing behavioral phenomena such as fear, anxiety, stress, learning and memory, social behavior, and sleep. Some of the papers focus on the use of zebrafish to model and study human brain disorders including oculomotor abnormalities, alcoholism, drug abuse, and neuropsychiatric diseases, whereas other papers are technique-oriented and, for example, focus on the modern methods of optogenetics. Furthermore, research with both adult and juvenile or larval zebrafish is represented in the papers of this special issue. Briefly, the special issue presents a variety of approaches already available with zebrafish and forecasts a bright future for behavioral neuroscience research with this novel but powerful laboratory organism.

The zebrafish [*Danio rerio*, first described by Hamilton in 1822; (Weber and De Beaufort, 1916)] is a small (4 cm long) freshwater fish species that inhabits slowly moving streams, lakes, and rice fields of the Indian subcontinent including India, Nepal, Pakistan, and Bangladesh. It has been a popular aquarium fish (better known in the aquarium trade as zebra danio) and it has also been utilized in science for several decades. One of the first scientific studies conducted with zebrafish was aimed at developmental biology analysis (Creaser, 1934), and indeed, zebrafish has become one of the primary model organisms of developmental biology perhaps mainly as a result of the pioneering work conducted by Streisinger et al. (1981). Although most of the research conducted with zebrafish for the past three decades have concerned developmental questions, some studies published already in the 1970s and 1980s showed that zebrafish could also be successfully utilized in behavioral neuroscience (Dill, 1974a,b; McCann and Matthews, 1974; McCann and Carlson, 1982). Currently, an increasing number of behavioral neuroscience laboratories have started employing zebrafish as their main research organism (Sison et al., 2006). There could be several reasons for this. First, during the past few decades numerous genetic methods have been developed for zebrafish and the amount of information on the zebrafish genome, including high resolution genetic markers, has now elevated this species to one of the preferred model organisms of genetics (Patton and Zon, 2001; Chen and Ekker, 2004; Sood et al., 2006). This genetics toolset could be well utilized, along with other methods, for example, pharmacological tools, in the investigation of the mechanisms of the brain and behavior. Second, the zebrafish has proven to possess characteristics that make this species translationally relevant. For example, the nucleotide sequence of its genes is often found to show homology (70% or higher) to that of mammalian (including human) genes (Reimers et al., 2004). It possesses neurotransmitter systems similar to those of mammals (Chatterjee and Gerlai, 2009), and, for example, has neurotransmitter receptors that are sufficiently similar to mammalian receptors to be pharmacologically manipulated using drugs developed for mammals (Blank et al., 2009). Furthermore, although its brain is substantially more primitive than that of mammals, the basic neuroanatomical layout is of a typical vertebrate (Tropepe and Sive, 2003). Finally, it has a sophisticated behavioral repertoire that can allow precise quantification of functional changes in the brain induced by whatever method (e.g., genetic, pharmacological, and environmental manipulations) the experimenter employs (Gerlai, 2010).

These arguments have been made in many of the zebrafish papers published recently all pointing towards a good promise for the utility of zebrafish in behavioral neuroscience. However, it is also noteworthy that zebrafish behavior and brain function still remains relatively uncharacterized (Sison et al., 2006). Some could argue, for example, that the experimental tools developed for the house mouse are more numerous and more sophisticated. Why should anyone prefer zebrafish in experimental brain and behavior research? I hope the following papers will answer this question. Although the reviews presented in this special issue are not systematically organized to cover all areas of zebrafish behavioral neuroscience research, I hope they will provide a sufficiently exciting window to what is possible with this laboratory organism.

The papers of this special issue discuss numerous aspects of behavioral neuroscience research with zebrafish and have been assembled to provide both a unique perspective and some overlap. Some papers, for example, have a methodological focus, and present techniques such as optogenetic methods (Wyart and Del Bene, in press) or a set of behavioral assays (Brennan, in press). Others discuss specific behavioral phenomena including sleep (Zhdanova, in press) or social behavior [shoaling (Miller and Gerlai, in press)]. Yet other papers has a disease focus and discuss the utility of zebrafish in the analysis and modeling of human brain disorders such as stress and anxiety (Levin, in press; Colwill and Creton, in press; Clark et al., in press), alcoholism (Echevarria et al., in press), drug abuse (Stewart et al., in press), and diseases of the visual system (Maurer et al., in press) or the role of early dopaminergic signaling in neuropsychiatric disorders (Souza and Tropepe, in press). These reviews show that analysis of both the adult and the juvenile (or larval) zebrafish can yield important discoveries and could advance our understanding of how the vertebrate brain works and what could be the mechanisms underlying certain human brain disorders.

In summary, it is hoped that this special issue will continue to reinforce what zebrafish researchers already know: zebrafish is a wonderful research tool and its use is rapidly spreading across multiple disciplines of biology.

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