Pain and Distress in Fish: A Review of the Evidence

Lysa Pam Posner

Les poissons, les poissons, how I love les poissons.
– *Les Poissons*, The Little Mermaid
(Disney Productions, 1989)

As evidenced in Paleolithic cave paintings of fish dating from 17,000 years ago, human-fish interactions have existed for thousands of years (Valladas et al. 2001). The earliest interactions likely involved fish as food and were necessarily tied to geographic access (i.e., island or coastal locations). Over time, the establishment of farm fishing and the emergence of modern capture and transportation methods for wild-caught fish have encouraged more widespread consumption of fish, as have the health benefits of fish as a dietary component (Calder and Yaqoob 2009). According to the WorldFish Center, worldwide per capita fish consumption doubled in the past half-century, from about 8 kilograms in the early 1950s to about 15.8 kg in 1999 (Ahmed 2009).

As societies moved beyond survival needs, human-fish interactions developed beyond those of fish as food. Angling and sport fishing have become common practices in which not all fish caught are used for food. But there is controversy in both the scientific literature and the general press about whether catch and release methods are distressful for fish or inhumane.

The Chinese developed another nonfood use for fish: reports from the Sung dynasty, dating back to 960 AD, indicate that keeping ornamental fish in ponds was a hobby for the privileged. Today in China and other countries, the confinement of ornamental and tropical fish both publicly (in aquaria) and privately (in ponds and tanks) is still quite popular. As with the arguments against sport fishing, however, there is controversy about the appropriateness of keeping fish simply for human pleasure.

More recently, the use of fish as research animals has increased significantly. Although fish were the subject of scholarly articles from the 1860s (Ransom 1867), the accounts were primarily descriptive of fish anatomy and physiology. In the early 1950s, the research focus shifted with the hypothesis of fish as a model of human tumor formation (Takahashi 1950). The widespread use of molecular biological techniques in the 1980s launched the use of fish as models for many gene and receptor studies. Thanks to quick gestation, relatively smaller space requirements, and less restrictive legislation, fish are now one of the most common research animals. The scientific community therefore has a responsibility to acknowledge and address fish pain and distress.

The articles in this issue of the *ILAR Journal* consider both the philosophical and scientific aspects of fish pain and distress as well as the use of fish as models for research on human diseases. The issue's topic is important both because of the number of species involved (some 30,000) and because controversy persists about whether fish experience pain and/or distress.

The first three articles explore questions of fish welfare and pain perception. In Challenges in Assessing Fish Welfare, Gilson Volpato provides historical context and describes the evolution of opinion on animal welfare. He acknowledges that it is not possible to know what fish "want" and discusses the limitations of being able to "prove" that an animal is in pain. Cautioning against anthropomorphism, he suggests the use of preference tests to determine how to keep an animal "in a good state." He observes that there is mounting evidence that fish have the neuroanatomy, neuropharmacology, and behavioral responses to indicate that they can feel pain and suffer—and little evidence that they cannot—and thus wonders whether, if fish are indeed sentient beings that can suffer, it is acceptable to use them for human pleasure activities such as recreational fishing and aquarism. Volpato argues that humans must assume that fish can feel pain and treat them accordingly.

In Pain Perception in Fish: Indicators and Endpoints, Lynne Sneddon reviews the criteria for nociception and pain in fish and logically builds the case that teleost fish have the neuroanatomy—nociceptors and ascending neurologic tracts (spinothalamic and trigeminal)—to experience pain. She supports this argument with various study findings, including a report that functional magnetic resonance imaging (fMRI) recorded activity in the forebrain of teleost fish during noxious stimulation, and that prolonged activation of nociceptors resulted in altered gene expression in the forebrain (as is also true in mammals). Furthermore, Sneddon notes the presence of an opioid pathway (receptors and endogenous ligands) in fish and points out that, evolutionarily, it does not make sense to develop a pain-modulating pathway if an animal does not

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perceive pain and need to modulate it. She also addresses the importance of identifying pain and determining humane endpoints. Much more research is needed to determine how to both assess fish pain and effectively alleviate it.

Claudia Harper and Jeffrey Wolf, in their article on the Morphologic Effects of the Stress Response in Fish, provide a progressive look at alternative methods of stress evaluation in fish. They begin with the frustration in the inconsistent use of the word "stress" and with the challenges of evaluation itself. They review stressors common to the animal world (e.g., lack of refuge, inadequate food, predation) as well as those particular to fish (e.g., oxygen supply, pH, salinity). Many indirect methods are commonly used to assess fish welfare, including changes in body weight, biochemical assays, immune function, and gene expression. As an alternative to these indirect assessments the authors propose histopathologic evaluation of morphologic changes. They review organs that have been shown to indicate stress (e.g., morphologic gill changes in Crucian carp in response to hypoxia) and suggest that other organs (the liver, integument, genitourinary tract, nervous system, cardiovascular system) can also be useful for identifying stress in fish.

Donald Neiffer and Andrew Stamper provide a robust overview of drug use in fish in their article on Fish Sedation, Analgesia, Anesthesia, and Euthanasia: Considerations, Methods, and Types of Drugs. They review the indications for such drugs as well as the drugs themselves. They also address concerns associated with drug administration, in terms of both anatomy (e.g., opercular flow vs. ram ventilators) and husbandry (e.g., water quality, stocking density). Most importantly, the authors remind readers of the overwhelming number of fish species and repeatedly point out that different species respond differently. It may seem intuitive not to extrapolate elasmobranch research to bony fish; it is less evident that although goldfish may respond successfully to anesthesia with MS-222, Gulf of Mexico sturgeon are rather resistant to even very high doses of MS-222.

In Effects of Restraint and Immobilization on Electrosensory Behaviors of Weakly Electric Fish, Éva Hitschfeld, Sarah Stamper, Katrin Vonderschen, Eric Fortune, and Maurice Chacron provide some insight to experiences that cause distress in fish. Weakly electric fish possess a specialized organ that produces an electric field that the fish use behaviorally. Because the fish maintain their electrosensory behaviors even when immobilized, these species can be used to study stress induced by confinement or immobilization. As Volpato cautioned, humans may not know what is stressful for fish. Mammals and humans generally show a strong stress response to restraint and immobilization, but the weakly electric fish showed minimal changes in electrosensory behavior, indicating that restraint and immobilization were not painful or distressful to them. However, the same fish showed marked changes in their electrosensory behavior in response to hypoxemia and handling, indicating significant pain or distress.

Veronica Gonzalez-Nunez and Raquel Rodríguez describe The Zebrafish: A Model to Study the Endogenous Mechanisms of Pain and illustrate why fish and in particular zebrafish have become so popular as a research animal. The authors discuss the advantages of fish models in terms of generation times, space requirements, and anatomy (e.g., extrauterine development facilitates observation). They observe that in molecular, pharmacological, and biochemical terms zebrafish do not differ fundamentally from their mammalian counterparts. This homology should enable both easier study of the opioid system and in vivo testing of novel opioid receptor drugs, and thus advance understanding of the mechanisms of pain.

Although there is great interest in zebrafish as a model to elucidate human opioid pathways, the fact that the fish possess such a pathway is a strong indicator that they feel pain that itself should be alleviated. Future research should therefore aim to advance analgesic applications not only for higher vertebrates but also for fish.

The fact that the *ILAR Journal* has chosen to dedicate an entire issue to Pain and Distress in Fish suggests growing acceptance in the scientific community that fish neuroanatomy and behavioral responses reveal that these animals feel pain. It would then be logical to conclude that an animal that can feel pain can also experience distress. It is likely that humans will never fully know the extent to which fish feel pain, but acknowledging that they do raises the likelihood that fish will receive the humane treatment increasingly provided to higher vertebrates.

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