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Ethics and welfare: Pain perception in fish

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Abstract

Fish welfare is currently a controversial subject with many scientific studies now demonstrating the possibility for fish to experience negative events such as pain, fear and stress. This has important implications in the treatment of fish during commercial and experimental procedures in terms of ethics and welfare. In this review, the evidence for pain perception in fish is considered and the repercussions for the use of fish as a research model as well as in aquaculture and large-scale fisheries. These issues are discussed briefly from a welfare and ethical perspective.

What is pain?

As humans, it is likely that we have experienced pain in some form whether it has been a sensory or physical experience whereby we have sustained tissue damage (cut or burn) or an emotional trauma such as the loss of a loved one yet we have no physical injury. This makes pain a complicated concept comprising of both sensory and emotional components and can be thought of as a motivational state that drives us to protect ourselves, avoid damaging stimuli or situations and guard damaged areas against further pain in order to promote healing. Humans can communicate pain to each other but detecting and assessing pain in animals is particularly problematic. Pain is a very specific experience and we behave very differently with each type of pain we endure. For example, a limp may indicate a sprained ankle or some other ambulatory pain, with abdominal pain an individual may lie down but with a headache one might take painkillers and carry on with daily life and it is not apparent that the individual is experiencing pain. Similarly, in animals there is no universal behavioural indicator to suggest an animal is in pain. To detect and assess pain in animals, scientists make indirect measurements in behaviour and physiology in response to a potentially painful event and if there are adverse effects and this experience is painful to humans then it is likely to be painful to the animal.

Zimmerman (1986) proposed a definition of animal pain that can be used as a set of guidelines to determine whether an animal is capable of pain perception. Animal pain is defined as an adverse sensory experience caused by noxious or potentially tissue damaging stimuli such as extremes of temperature, high mechanical pressure and damaging chemicals. When injury is caused by these noxious stimuli the animal should move away from the stimulus in a protective motor response but vegetative responses should also be elicited such as changes in the cardiovascular system and inflammation at the site of damage. This would be relevant to the sensory experience of pain where the

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sensation is detected and the animal responds at a physiological and behavioural level. To examine the psychological or emotional component, Zimmerman (1986) states that there must be complex behavioural changes that are indicative of suffering. The animal should learn to avoid a noxious stimulus and its behaviour should be adversely affected such that normal behaviour should be suspended. These behavioural changes should not be simple reflexes such that a prolonged response suggests higher brain processing is occurring.

Do fish fulfil the criteria for pain perception?

In order to detect noxious events, an animal must possess the neural apparatus to sense, process and respond to potentially painful stimuli. Recent studies have shown that rainbow trout possess similar nerve fibres to those that detect pain in humans (Sneddon, 2002). These nerve fibres are called nociceptors and are preferentially activated by noxious stimuli. The trout nerves were remarkably similar to those in mammals with identical physiological properties (Sneddon 2003a) and were found distributed over the face of the fish (Figure 1).

Central nervous system processing of pain in mammals involves specific areas of the brain; the pons, medulla, reticular formation, locus coeruleus, periaqueductal grey, the thalamus and cortex. Fish do possess all of these areas, however, one area of debate is the size of the cortex since this is thought to be crucial to pain processing in humans (Sneddon, 2004). The

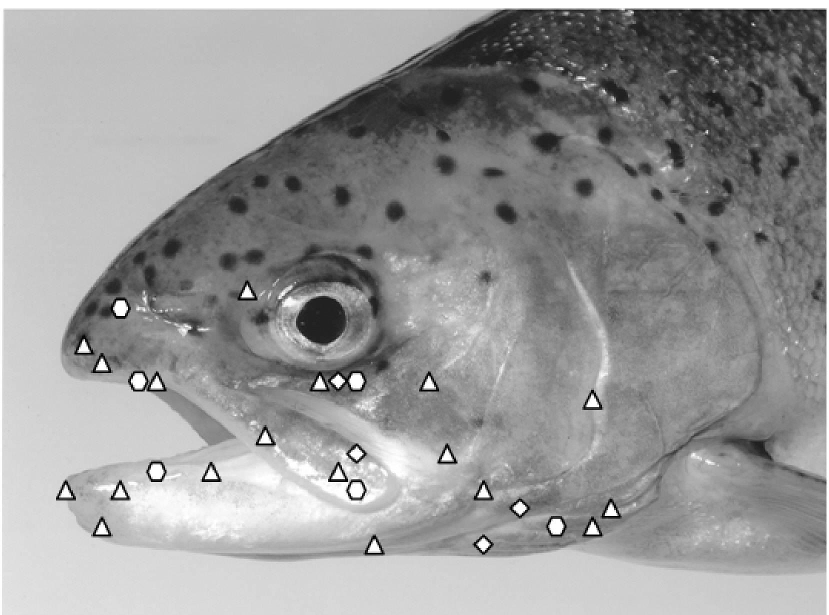

Figure 1. Position on polymodal nociceptors, mechanothermal nociceptors and mechanochemical receptors on the head and face of the rainbow trout, *Oncoryhnchus mykiss* △ = polymodal nociceptor; ◇ = mechanothermal nociceptor; ⬡ = mechanochemical receptor; Sneddon et al., 2003a).

fish cortex is relatively much smaller and less differentiated that the human cortex although this is true of all animal brains. Therefore, in some opinions fish are unable to experience pain as they have a smaller cortex. Studies are now addressing this criticism directly. Dunlop and Laming (2005) have measured physiological responses in the brain during noxious stimulation in goldfish and rainbow trout. This study has shown that potentially painful information from the flank is conveyed to the forebrain of fish and thus the brain is active. In the Sneddon laboratory, we have shown that the brain is active at the molecular level by assessing gene expression in different areas. The majority of gene expression changes occur in the forebrain where the cortex is situated (Reilly & Sneddon, MS submitted). Using functional magnetic resonance imaging (fMRI), we have also demonstrated that the forebrain and midbrain of common carp are activated by noxious stimulation (Sneddon, Verhoye & Van der Linden, unpub. data). If the response to potentially painful stimuli in fish were a simple reflex then there would be no brain activity yet this research has conclusively proven that the brain is active and specifically the cortical areas.

To investigate the psychological aspects of possible pain perception in fish, *in vivo* experiments were conducted whereby fish were given a subcutaneous injection of acute acting noxious chemicals. Compared to control groups, these noxiously stimulated rainbow trout and zebrafish showed a dramatic rise in respiration rate that was similar to rates shown by fish swimming at their maximum speed (Sneddon et al., 2003a; Reilly & Sneddon, unpub. data). An increase in respiration is also seen in mammals enduring a painful event. Noxiously stimulated trout, carp and zebrafish also displayed abnormal behaviours over a prolonged period of time (3-6 hours) and normal feeding behaviour was suspended during this time until all behavioural and physiological effects subsided. Administration of morphine, a painkiller, ameliorated these adverse behavioural and physiological responses demonstrating that these were pain related responses (Sneddon, 2003b). Psychological approaches also revealed that trout subject to noxious stimulation failed to show an appropriate fear response to fear causing stimuli (Sneddon et al., 2003b). These results suggest that the pain they experienced dominated their attention and thus they failed to respond normally to the competing fear stimulus revealing that pain took precedence and was more important in these tests. Other studies have shown that fish are capable of avoidance learning and that this is abolished when morphine is administered (e.g. Ehrensing et al., 1982).

Research into the question of pain perception in fish has yielded robust evidence that there is the real potential for pain. Fish have a similar sensory system; show adverse behavioural and physiological responses and normal behaviour is suspended during a potentially painful event. Therefore, sensory pain is more than likely to occur and there does seem to be evidence of psychological suffering since these behavioural responses are prolonged and are not simple reflexes. The debate then becomes more philosophical and the question is not that they can sense and react to painful events but do the fish actually know they are in pain and do they suffer? It is virtually impossible to get inside the animal mind and know what they experience or how they are feeling, therefore, I believe we should give fish the benefit of the doubt and treat them as if they are capable of pain perception.

Consequences of pain in fish

If we accept that fish are capable of pain perception, then we must accept that their welfare is significantly affected by invasive practices that cause tissue damage. As experimental models, fish are subject to many injurious procedures such as tagging, injections, surgery etc but we obtain a wealth of important biological information that may be beneficial in understanding how we can improve environmental conditions for fish and manage them more effectively. Therefore, we subject our experimental approaches to a cost-benefit analysis whereby we weigh up the costs to the fish in terms of severity of the procedure and number of fish used against the benefits of the research outcome. For example, when deliberately causing pain to fish in order to study it, low sample sizes are a necessity but the information obtained may improve the treatment of fish and will provide a basis upon which welfare decisions can be made by the public, industry and government. To study parasites or disease, fish are intentionally infected but the information obtained might help to prevent, treat, cure or eradicate such infections and ultimately benefit fish welfare.

Fish are an important foodstuff for our growing global populations and fish are harvested in large-scale fisheries and intensively farmed to meet growing demands. Animal welfare ethos states that we have the right to use animals but we must do this humanely. Many procedures in aquaculture and fisheries are invasive and are likely to be painful but many of these practices are necessary e.g. vaccination to prevent disease, size grading to reduce aggression, slaughter. It is of course in the interests of industry to maintain good welfare since animals in "optimum" condition grow better and give a better economic return. Studies addressing these welfare concerns are being conducted with the aim of providing a better understanding of the impact of these procedures and ultimately improving our techniques and equipment to make the experience less invasive for the fish (e.g. anaesthesia and vaccination, Sørum & Damsgård, 2004; stress in aquaculture procedures, Conte, 2004; hooking, Cooke et al., 2003).

Therefore, ethical questions about our use of fish must be carefully considered in light of recent research into the capacity of fish to experience not only pain but fear, stress and suffering. In research, scientists already consider the costs of their research against the benefits of the information and are encouraged to adopt the 3Rs namely replacement, reduction and refinement. Replacement encourages the use of cell culture and alternatives instead of live animals where possible. Reduction promotes a decrease in the number of animals used to provide significant experimental results. Finally, refinement of procedures requires the fine-tuning of techniques to reduce the negative impacts on the animal. These ideas are somewhat applicable to industry in that refinement might lead to less invasive practices and improved techniques that allow a more humane and welfare considered approach to the treatment of fish.

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