FISH PAIN PERCEPTION

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Abstract

The question of whether fish have a capacity to perceive pain and to suffer has recently attracted considerable attention. Despite there being a number of anecdotal observations that fish react to noxious stimuli, it is only recently that neuroanatomical evidence has revealed that teleost fish possess similar pain processing receptors to higher vertebrates. Other approaches have also shown that fish neurophysiology and behaviour are altered in response to noxious stimulation. Here, I will review the recent evidence indicating that fish have a capacity for pain perception and suffering.

Keywords

Fish, pain, welfare, suffering, stress, awareness

Background

Over the last two decades, there has been an increasing interest in the welfare of animals that are farmed for consumption, and recently we have witnessed a growing interest in the welfare requirements of fish. Compared with farmed terrestrial vertebrates, however, we know very little about the welfare requirements of fish (e.g. Dawkins, 1998, Mendl 2001; Sørensen et al. 2001, Braithwaite & Huntingford 2004). Work addressing issues relating to fish welfare are now appearing in a variety of formats; for example, there have been a number of recent scientific papers (Rose 2002; Sneddon et al.2003a; Sneddon et al 2003b, Braithwaite & Huntingford 2004), a document on fish welfare was recently commissioned and published on the Fisheries Society of the British Isles web site (www.le.ac.uk/biology/fsbi/briefing.html). Additionally, the Canadian Council on Animal Care has recently produced a detailed series of Guidelines on: the care and use of fish in research, teaching and testing (Griffin & Gauthier 2003).

The majority of these reviews and studies imply that we should be concerned about the welfare of the fish we interact with. They indicate that fish do not respond well to prolonged periods of stress, and show that stress physiology in fish is apparently directly comparable to those processes occurring in other vertebrates (Wedemeyer et al. 1990; Barton & Iwama 1991; Wendelaar Bonga 1997). Furthermore, as in terrestrial vertebrates, prolonged exposure to aversive conditions produces stress-induced changes in the immune system that makes fish more vulnerable to disease (Pickering & Pottinger 1989). More recently, teleost fish have been found to possess the same types of pain processing fibres as higher vertebrates (Sneddon 2002). Thus, there is growing evidence that fish have sensory systems capable of detecting noxious stimuli, and they generate stress responses in similar ways to other vertebrates. What is less clear is whether fish have an *awareness* of stress and pain; in other words, whether fish have a capacity to experience pain and suffering.

Here, I will present the results of a multidisciplinary research programme which was aimed at determining (i) whether fish possess the necessary neuro-anatomy for pain perception, (ii) if these receptors were present whether they reacted to noxious stimulation, and (iii) whether noxious stimulation generated behavioural responses that were more than simple reflexive reactions to the stimulus.

Are fish capable of perceiving noxious stimuli?

We conducted neuroanatomical and neurophysiological research to ascertain whether teleost fish, such as the trout, possess specialised receptors that exclusively respond to noxious stimuli. These types of specialised receptor are called nociceptors. Earlier work by Wheatear (1971) identified free nerve endings in teleost skin tissue that were considered to be possible candidates for nociceptors, but surprisingly, no further work was done on this until nociceptors were finally identified in the head and snout region of the trout (Sneddon 2002; Sneddon et al. 2003a).

Pain in vertebrates such as birds and mammals is perceived by two classes of nociceptive nerves (i) A-delta fibres which are slow conducting, small, myelinated fibres, and (ii) C fibres which are slower conducting, smaller and unmyelinated. Both of these classes of fibre can be found in the trout trigeminal nerve, this is the main nerve innervating the face and head of vertebrates (Sneddon 2002). In birds and mammals, trigeminal A-delta and C-fibres convey both somatosensory and nociceptive information to the brain. Electrophysiological recordings made from afferent cell bodies in the trigeminal ganglion of trout showed that receptors isolated on the head and face were able to detect noxious stimuli such as, mechanical pressure, temperature and chemical stimuli, thus confirming the presence and activity of nociceptors. Taken together, these results indicate that fish possess the necessary neuroanatomy and neurophysiology to perceive and process information about stimuli that would be regarded as painful by humans.

Related to these studies, a number of behavioural experiments were also used to investigate changes in behaviour as a consequence of noxious stimulation (Sneddon et al. 2003a). Trout treated with noxious chemical stimuli (acetic acid or bee venom) showed a prolonged decreased motivation to feed and a dramatically increased opercula beat rate in comparison to identically handled saline treated control fish. Fish that were recovering from noxious stimulation also exhibited anomalous behaviours such as rocking whilst the fish rested on the substrate. Similarly, some fish were also observed rubbing their snouts, the site where the noxious stimulus was administered, on the walls and substrate of the tank.

Further behaviour-based work investigated how attention was affected by noxious stimulus. Here, fear responses were investigated in fish administered with weak acetic acid, an irritant. Trout generally show considerable fear of novel objects; fear was therefore quantified by the amount of time a fish spent avoiding a novel object temporarily placed into its tank. Sneddon, Braithwaite and Gentle (2003b) observed that the fear response was reduced in fish that were administered with the acetic acid but this reduction in fear was reversed with the application of an analgesic (morphine). These results suggest that the attention of a fish currently responding to nociceptive stimulation is preoccupied and, consequently, its ability to generate a normal fear response is decreased. This hypothesis is supported by the fact that the application of a pain relieving analgesic largely restores the fear response (Sneddon et al. 2003b). These results support the earlier observations of Ehrensing, Michell and Kastin(1982) who found that intracranial application of morphine in goldfish decreased their response to electric shock. Subsequent application of opiate antagonists reversed this effect. Although compelling, the approach by Ehrensing and his colleagues (1982) was criticised because the application of morphine might be expected to reduce reactions to a stimulus regardless of whether it was associated with pain or not. Sneddon, Braithwaite and Gentle's approach tackles this criticism because here the effect of the morphine is to revive the novel object avoidance behaviour in the fish.

By determining that fish have the same types of nociceptors as other vertebrates (A-delta and C fibres), that these respond to noxious stimulation, and that the motivation and general behaviour of fish are adversely affected by such stimulation would appear to provide compelling evidence that fish can perceive and react to noxious stimuli. Whether this is evidence that fish have the capacity to experience pain and suffering is a harder question to resolve because to determine this it is necessary to understand the cognitive capacities of fish. Work is now being directed at this, and the results to date suggest that some species of fish are capable of quite complex cognitive processing. However, it is important to appreciate that the simpler brain structure and the lack of a neocortex indicates that the form pain perception and suffering experienced by fish will be very different to that perceived by humans.

Conclusions

The increasing rate at which humans now interact and manage different types of fish populations indicates that an interest in fish welfare is both timely and necessary. In particular, the increasing reliance that humans are placing on farmed fish for is raising our demands on the aquaculture industry. To meet these demands this industry needs to expand and fish farmers will be required to intensify fish production. Welfare in fish is a novel concept. Recent suggestions that fish cannot experience pain or suffering do not appear to be supported by the current research. The evidence I have presented suggests that fish do have the capacity to experience pain and fear, and therefore we need to consider how to minimise their potential suffering. There would appear to be an urgent need for the development of appropriate fish welfare guidelines.

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