

**RECREATIONAL ROCK LOBSTER FISHERIES: AN
EXAMINATION OF THE WELFARE IMPLICATIONS OF THE
MANAGEMENT PROCEDURE OF TAIL FAN CLIPPING**

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Executive Summary

In response to a welfare concern for recreational rock lobsters, expressed by a rock lobster fisher, that tail fan clipping was painful and cruel; a neuroanatomical study and literature review into pain sensation in the rock lobster was carried out.

Histological examination of rock lobster tail fans indicated that nervous tissue is normally present within the central connective tissue section of the central tail fan. The prevalence and size of the nerve bundles was found to decrease towards the distal extremity of the tail fan. No obvious nervous tissue was detectable in the most distal 2-5mm of the tail fan. Nerve bundles were first detectable from approximately 5mm from the distal extremity of the tail fan.

A review of the currently available scientific literature indicates that, in all likelihood, any response to clipping of the tail fan is a reflex escape response to nociceptive stimuli and is not a conscious emotional awareness of pain sensation. In addition, the act of removal of the rock lobster from water is likely to induce physiological stress responses that have the potential to persist for longer periods of time (up to 24 hours) than any escape reflex.

It is likely that the central nervous system of the lobster does not support the complex neuronal networking and specialised regions necessary to allow a conscious, emotional awareness of pain sensation. In addition there is a benefit to the lobster population as a whole derived from marking of recreational catches. Currently, there is insufficient evidence to warrant an abandonment of the marking of recreational rock lobsters by clipping of the central tail fan.

The clipping requirement may be reviewed at a later date should further scientific evidence be presented to indicate an increased probability that any response is a pain response and that the population benefit is less than the cost to the individual.

1 Introduction

The recreational rock lobster fishery is divided into the Northern Zone (NZ) and the Southern Zone (SZ), with fishing allowed between 1 October and 30 April in the SZ and 1 November to 31 May in the NZ. Each zone is managed through arrangements laid down in the appropriate Management Plans and a recent draft assessment report to Environment Australia (Sloan, 2002).

The commercial rock lobster fishery in South Australia in 2001 was valued at \$83 million GVP, with an estimated turnover of \$230 million, representing in the region of 1500 tonnes of catch. By comparison the recreational sector harvested approximately 118 tonnes in 2001. The majority of these rock lobsters were caught in recreational lobster pots. In 2001 pot catches represented 105,620 lobsters. There were 7,682 registered pots as of May 2002; 68% of these registrations were active and 32% not active in fishing with just over 50% of fishing effort in the SZ (Venema et al, 2002).

Recreational fishers are permitted to take lobster during the specified season utilising a number of catching methods, namely diving, hoop nets, drop nets, pots and bait sticks. The current bag limit is set at 4 lobsters per person per day; the boat limit is 8 lobsters per boat per day. In addition a recreational fisher may possess a maximum of 15 lobsters at any time.

All rock lobsters caught by recreational fishers must have the centre tail fan clipped to a recognisable straight line before landing. This allows compliance officers to identify recreational catch and helps prevent the illegal sale of recreational catch, thus attempting to decrease pressure on the rock lobster population to ensure sustainability of the stocks.

PIRSA Fisheries received one letter from a recreational rock lobster fisher indicating that they considered the practice of clipping the tail fan to cause "unnecessary pain and suffering to the lobster". To investigate this claim an anatomical study of the tail fan of the rock lobster was undertaken, and a literature review of published scientific work carried out.

2 Investigation

2.1 *Neuroanatomy of Jasus edwardsii*

The central nervous system of the rock lobster, whilst being developed and specialised for the detection of chemicals and movements, is reasonably simple in overall design and is based on condensations of a number of neurone cell bodies in ganglia. These ganglia lack the complexity of the central nervous system of higher aquatic animals such as the teleost fish. The most cranial portion is the supraoesophageal ganglion, which is connected via paired circumoesophageal connectives and stomatogastric ganglia, to the suboesophageal ganglia. As this suggests the oesophagus passes through the centre of this arrangement. The central nervous system continues caudally from the suboesophageal ganglia as the ventral nerve cord running along the ventral aspect of the tail. The roles of the main ganglia are not fully understood however the suboesophageal ganglia are responsible for the innervation of the mouthparts, whilst abdominal ganglia found along the ventral nerve cord control postural musculature, appendages and intestine. The ventral nerve cord mostly consists of medial and lateral giant axons (motor neurones that drive the rapid tail flip reflex response) and non-giant axons responsible for slower swimming tail flips. No detail on the microanatomy of the tail fan was found, although it is likely that there are mechanoreceptors (sensory structures designed to detect movement or vibration) on the tip of the tail fan.

2.2 *Processing and examination of the tail fan*

To examine the microanatomy of the tail fan, three live rock lobsters of legal size were humanely euthanased by placing in an ice-water slurry at ≤ 0 °C for 30 minutes. The lobsters were then removed from the slurry and the supraoesophageal and suboesophageal ganglia destroyed using a sharp knife. Three animals were used, as this represents the minimum number of animals required to determine normality should one of the specimens be unusual.

The central tail fan was removed at its base and placed in 10% neutral buffered formalin for 24 hours to allow tissue fixation. The tail fan tissues were transferred to the Institute for Medical and Veterinary Science (IMVS), Frome Road, Adelaide for further processing. The tail fans were decalcified in a nitric acid and ethylenediaminetetraacetic acid (EDTA) solution. Three hours was sufficient to decalcify the distal tail fan; a further one hour was required for the proximal tail fan (pers. comm., IMVS)

Following decalcification, the tail fans were embedded in paraffin wax and sectioned at a nominal 5 μ m thickness on a microtome. The tail fan was sectioned into 12 cross sections from proximal to distal ends. Sections were stained with haematoxylin and eosin, trichrome stain and S100 antibody and examined in PIRSA Aquaculture by light microscopy.

2.3 Results of tail fan examination

The use of S100 antibody for tail fan section staining was discontinued, as it was providing no additional information for the study.

The histology sections of the tail fans were comparable between the individual animals giving confidence that the findings were representative of the normal microanatomy of the tail fan of legally sized rock lobsters.

The tail fans consisted of an outer chitinous cuticle, a non-chitinous membranous layer, epithelium, basement membrane and centrally located connective tissues consisting of fibrous tissue, occasional muscle fibres, nerve bundles and haemolymph vessels (figure 1).

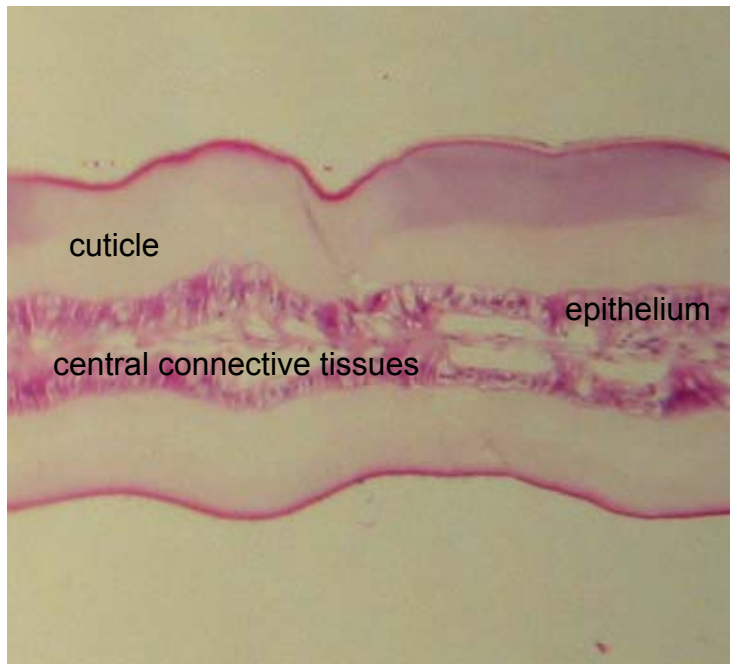


Figure 1. Low power view (x20) of transverse section through lobster tail fan (H&E)

Nervous tissue in the form of nerve bundles (fig. 2) were recognised in the majority of tissue sections, and in all lobsters. The diameter of the nerve bundles was observed to decrease the nearer to the distal tip of the tail fan the section represented.

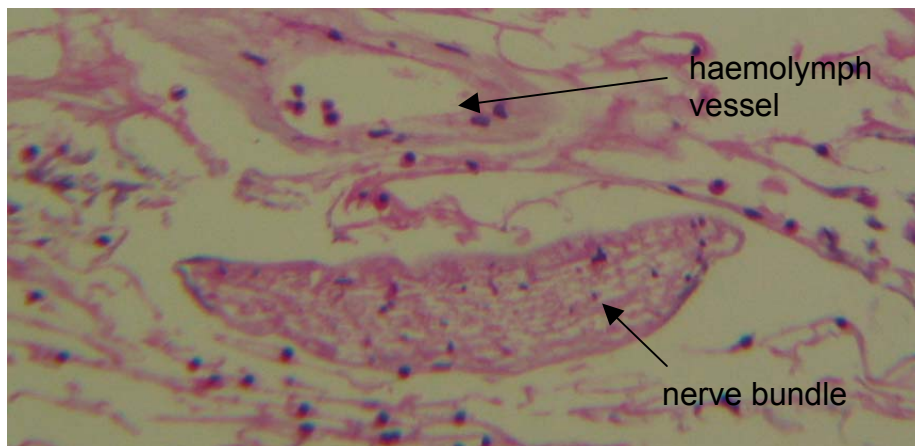


Figure 2. Medium power view (x200) of nerve bundle in middle tail fan (H&E)

Figure 3 illustrates the narrowing in diameter of the nerve bundles in the most distal portions on the tail fan.

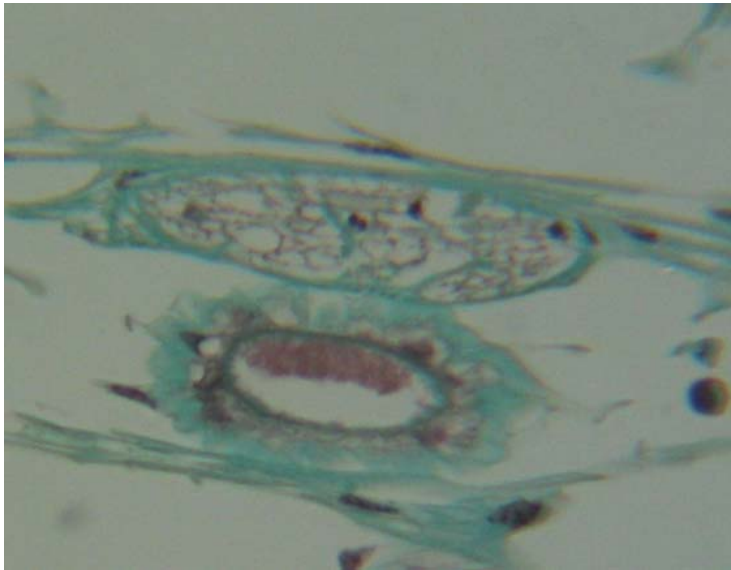


Figure 3. High power view (x400) of distal tail fan showing nerve bundle and haemolymph channel. Note that this view is at twice the magnification of figure 2 and the nerve bundle is therefore less than half the diameter of that in the middle sections of the tail fan. (Trichrome)

In addition the number of structures recognisable as nervous tissue also diminished in number towards the distal extremities of the tail fan. Ultimately no nervous tissue was recognisable in the most distal section of the tail fan (approximately 2mm from distal extremity of tail tip).

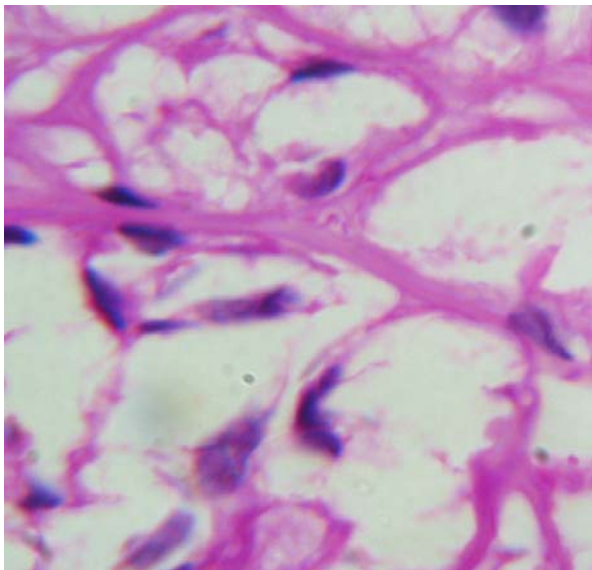


Figure 4. Oil immersion view (x1000) of most distal section of lobster tail fan showing connective tissue and fibrocyte-like cells. This appearance is representative of the whole of the central connective tissue space and no nervous tissue is apparent.(H&E)

The penultimate section (≤ 5 mm from tail fan tip) showed nervous tissue of small diameter and in low numbers.

3 Discussion

3.1 *Tail fan anatomy*

Histological examination of tail fan sections indicated the presence of nervous tissue and haemolymph channels that were continuous to within 2-5mm of the extreme distal tip of the tail fan. Within the final 2-5mm it is sensible to assume that nerve fibres may be present, although at such small diameter that they are not visible under light microscopy. The chitinous nodules on the edges of the tail fan also contain connective tissue and haemolymph channels, although they do not appear to bear any greater innervation than the main part of the tail fan.

3.2 *Nociception and pain sensation*

Accepting that some degree of nervous tissue is present in the tail fan tip, consideration must be given to how any stimulus resulting from sectioning of the nervous tissue is processed in the central nervous system of the lobsters. Central to this consideration is the difference between nociception and pain sensation. Nociception is a physiological event whereby sensory information is passed to the spinal cord, resulting in reflex withdrawal response or is passed on to the brain where it results in autonomic activity. In neither case is there conscious control or awareness of the sensory input. Pain is defined by the International Association for the Study of Pain as an unpleasant sensory or emotional experience associated with actual or potential tissue damage and is characterised by conscious awareness.

An examination of the debate as regards teleost fish is considered essential to illustrate some of the main points that need to be considered. The proponents for and against fish feeling pain are almost equal in numbers. The fundamental difficulty in determining conclusively whether fish do or do not feel pain lies in our inability to know what a fish is experiencing. The question "is animal pain the same as human pain?" has been asked and discussed previously, including during the 1990 conference of ACCART (Australian Council on the Care of Animals in Research and Teaching). It seems likely that the quality of sensation experiences in animals is not the same as in humans, but neither is it necessarily a prerequisite that it be so to be significant. Pain in animals may serve the same physiological function as pain in humans, but it is not necessarily experienced the same and an over-reliance on comparison with human behaviour and physiology is not helpful (Jackson, 2003).

Numerous studies on nociception have been carried out in a number of species, and it is clear that there are well developed sensory systems capable of responding to aversive stimuli throughout the animal kingdom. The examples of learned or adaptive behaviour has been cited as indicative of pain response in animals, however a review of experiments carried out in this field suggest that these adaptive behaviours are most likely to be motor programs designed to respond to sign stimuli with a pre-wired motor sequence. The existence therefore of pre-wired adaptive behavioural units

may well mean that problem solving behaviours may not necessarily indicate awareness. Many of these responses can occur without complex experiences, even in humans. Differences in human and animal experience are likely to relate to differences in the design and complexity of the central nervous systems (Molony, 1992), however a fixation on the prefrontal association cortex as being the only anatomical area of the central nervous system capable of experience or awareness is questionable (Divac, 1990). The presumed mechanised process involved in habituation and learned adaptive responses does not rule out the possible role of consciousness in other behaviours (Griffin, 1981).

Two papers currently frame the two sides of the debate. Rose (2002) presented a detailed scientific review on the subject based on literature review and philosophical argument, in which he argues that the projection onto fish, by humans, of the ability to feel pain is invalid. He argues that this is anthropomorphism and has no place in the debate. Rose relates the function of the central nervous system to its anatomy, and indicates that fish lack the anatomical structures that make conscious appreciation of noxious stimuli likely. The human neocortex, or prefrontal association cortex, is vital in the experience of aversive stimuli (i.e. pain) beyond the simple nociceptive, or reflex, response. This approach supposes that other less complex regions are incapable of allowing consciousness. Rose supports this conclusion stating that it is unlikely that there are alternate, functionally uncommitted systems that could meet the requirements for generation of consciousness, namely an exceptionally highly interconnected network involving cortex, thalamus and nonsensory cortical mass. The responses seen in fish, Rose argues, are effective escape and avoidance responses to noxious stimuli, but without the possibility of higher awareness. He theorises that a response to opiates does not necessarily indicate pain sensation, but can be explained through the action of the opiates at lower nervous levels to reduce nociceptive responsiveness. The emotional responsiveness of humans, Rose states, is highly dependent on such limbic structures as the septal region and the amygdala. Whilst fish have anatomically similar structures, this homology cannot be taken to indicate that emotional response and pain experience is the same in fish and humans, instead the emotional response to noxious stimuli is heavily dependent on the association of the amygdala with the prefrontal cortex, a structure lacking homology in the fish brain. In addition the cingulate gyrus, a structure that has been linked to the emotional aversiveness of pain, has not been identified in fish.

Rose (2002) points out that, regardless of whether the experience of noxious stimuli may be perceived as painful in fish, the receipt of nociceptive stimuli does induce subcortical neuroendocrine and physiological stress responses and that these stress responses can undermine the health and well being of fish.

Very recently a team of scientists in the United Kingdom published the results of their experiments in which they have claimed that fish do in fact feel pain. The release of this information was greeted with widespread media interest and rejuvenated the animal rights debate regarding fishing as a recreational sport. In her paper, Sneddon (2003), reports that they succeeded in identifying nociceptors on the face and head of rainbow trout. Sneddon

injected noxious materials (acetic acid and bee venom) into the lips of rainbow trout to observe the responses, both behavioural and electroneuronal. The results would be judged against certain criteria established prior to the experiment; namely that nociception is a reflex response to noxious stimuli and to suggest pain perception it needed to be shown that any behavioural or physiological responses are not merely reflexive. Ultimately, Sneddon's theory goes, "if a noxious event has sufficient adverse effects on behaviour and physiology in an animal and this experience is painful in humans, then it is likely to be painful in the animal."

Sneddon states that learning experiences (avoidance of electric shock) in fish, and the blocking of this adaptive behaviour by the administration of opiates, indicates that pain perception is likely, however we have already seen that these are not necessarily reliable criteria to use. During the experiments Sneddon was able to demonstrate an increased respiratory rate in the trial fish, but related this to a physiological response and that it was not necessarily an indicator of pain. However she did report a number of anomalous behaviours in the fish. Some fish were noted to rock from side to side, reminiscent of the stereotypical behaviour noted in other animals, taken to be an indicator of poor welfare, and thought to be performed as comfort behaviour (Gonyou, 1994). Rubbing of the injected area against gravel and sides of the tank was also noted and compared to the human act of rubbing a painful area to lessen the painful sensation. A lack of feeding behaviour following the noxious stimuli was compared to a guarding behaviour, the unwillingness of the fish to utilise a painful part of its body.

Unfortunately the paper did not make reference to, or attempt to respond to, the issues raised by Rose in his paper. So whilst the majority of the results presented by Sneddon indicate that reflexive nociception is well developed in the fish, there are some intriguing observations (rocking and lip rubbing) reminiscent of the emotional experience of pain in humans. Whilst the philosophical and neuroanatomical arguments are thoroughly presented by Rose, the abnormal behaviours reported by Sneddon give pause for thought. It is clear the debate is by no means concluded and that further evidence must be gathered to prove one way or the other.

Examining the central nervous system of lobsters in comparison to teleost fish it is obvious that the ganglionic nature of the nervous system renders it even less likely that sufficient complexity of neurone networks could exist that would act as a homologous regions with the neocortex, limbic system, cingulate gyrus and amygdala. If anything it diminishes the possibility of awareness and sensory emotion, however, it cannot be fully ruled out at this stage. The scientific literature is extremely limited in its examination of pain sensation in lobsters. Some brief comments in mainstream publications, such as internet sites, have been attributed to crustacean biologists stating their belief that lobsters can feel pain. However no peer-reviewed papers on the subject have been published by the quoted scientists and therefore it is difficult to assess the evidence for their beliefs.

An examination of terrestrial invertebrate science indicates that most insects have nociceptive capacities; detecting temperature, mechanical and chemical stimuli (Smith, 1991). These responses can be modulated even in insects by

opioids, showing endorphin release may be used to alter physiological or behavioural activities and is not indicative of a capacity for feeling pain (Eisemann, 1984).

Experiments on decorticate mammals have shown complex stereotypical responses to noxious stimuli in the absence of consciousness (Iggo, 1984). It is likely that this is representative of the situation in invertebrates. Pain sensation is a very subjective event and it is difficult to establish clear-cut criteria to measure pain. In mammals pain is often indicated by responses that go on beyond the primary stimulus e.g. decreased use of affected body parts and aggression. Invertebrates, however, show little evidence that responses continue beyond the primary stimulus. Eisemann (1984) states that “no example is known to us of an insect showing protective behavior towards injured parts, such as limping after leg injury or declining to feed...on the contrary, our experience has been that insects will continue with normal activities even after severe injury or removal of body parts.” In addition Eisemann (1984) also relates the functional simplicity of the nervous system with an inability to sense pain, stating that most behaviour patterns are pre-programmed and indicating that a capacity for learning exists even in decapitated insects and isolated ganglia.

The balance of evidence, extrapolated from fish and utilising studies on terrestrial invertebrates, would indicate that responses from injuries to crustaceans are likely to be nociceptive reflex withdrawal or escape responses and that it is unlikely that there is the conscious emotional response to that stimulus that may be considered to be pain.

3.3 *Population considerations*

Tail fan clipping, as already stated, was instituted as a marker of recreationally caught rock lobsters in order to prevent any illegal sale and thus remove any extra pressure on the sustainability of rock lobster stocks that might result from determined capture and sale of lobsters by non-commercially licensed fishers. The use of body marking for population control measures is not restricted to rock lobsters. Cattle and sheep are both subject to compulsory ear tagging (a similar acute, short duration procedure on a body part) and horses are regularly freeze branded. There are good, well established reasons for marking of animals for the overall welfare of the population.

In addition the cutting of the central tail fan tip is only one part of the recreational catching procedure. Lobsters are captured in pots or nets, removed from the water, the tail fan clipped, transported by boat to shore and stored on-shore or killed at that stage. It might be considered unusual to concentrate ones concerns over one aspect of the practice (i.e. tail fan clipping) without considering the overall impact on the individual lobster.

Taylor (1997) details the physiological stress responses that a lobster may undergo following removal from the water and the associated decrease in available oxygen. Oxygen uptake by the lobster is reduced by 50% despite an increase in respiratory rate of 100%. This is due to surface tension of water coating and clumping the gills, combine with oxygen diffusion through this thin water layer at 0.00033% of the rate in air alone. The induced hypoxia means

that the lobster utilises anaerobic metabolic pathways leading to acidotic stress. In addition, without the pH buffering capacity of seawater, no pH plateau is reached in air i.e. the lobster continues to become more acidotic. Should the lobster be placed in a seawater tank it must be adequately cooled to avoid heat stress. The physiological stress responses (heart rate and respiratory rate) remain elevated for up to 24 hours. Electrolyte imbalances correct relatively quickly. It is apparent therefore that the acute nociceptive response, if any, to tail fan clipping is only a small part of the stressful event of capture, storage and preparation for consumption. The whole procedure needs to be viewed from this overall perspective.

4 Recommendations

Given that the body of current scientific evidence suggests that any responses to tail fan clipping are reflexive nociceptive responses, and that the central nervous system of the lobster appears not to support the complex neuronal networking and specialised regions necessary to allow a conscious, emotional awareness of pain sensation; and that there is a benefit to the lobster population as a whole derived from marking of recreational catches there is insufficient evidence currently available to warrant an abandonment of the marking of recreational rock lobsters by clipping of the central tail fan.

Whilst evidently there is a short-term nociceptive cost to the individual, this must be balanced against the overall impact of being caught and the definite benefits for long-term population management.

In order to further explore the debate on nociception in comparison to pain sensation it is evident that further scientific experimentation would be necessary. It is recommended that the practice of tail fan clipping be reviewed at such future time as the body of scientific evidence suggests that pain sensation is more likely than nociception.

Considering the anatomical findings that both haemolymph channels and nerve bundles decrease in both diameter and prevalence towards the distal tip of the tail fan it seems sensible to try and set a maximum depth of cut, for example 5mm, that would result in an obvious mark for compliance purposes but minimise the potential for noxious stimuli. In addition cuts should avoid the chitinous nodules on the side of the tail fan, where possible, to minimise potential for haemorrhage.

A review of the transport and storage conditions for recreationally caught rock lobsters might be considered as a more useful measure to improve the welfare of recreationally caught lobsters.

5 References

- Divac, I.(1990), "The prefrontal cortex: A comparative view". *IBRO News*, **18**:3
- Eisemann, C.H., Jorgensen, W.K., Merritt, D.J., Rice, M.J., Cribb, B.W., Webb, P.D. and Zalucki, M.P. (1984), "Do insects feel pain? A biological view.", *Experientia*, **40**, 164-167

- Gonyou, H.W. (1994), "Why the study of animal behaviour is associated with the animal welfare issue", *Journal of Animal Science*, **72**, 2171-2177
- Griffin, D.R. (1981), "Animal Mind – Human Mind". *Report of the Dahlem Workshop on Animal Mind – Human Mind*
- Iggo, A. (1984), "Pain in animals", *3rd Hume Memorial Lecture*, Universities Federation for Animal Welfare
- Jackson, C. (2003), "Laboratory fish: Impacts of pain and stress on well being.", *Contemporary Topics in Laboratory Animal Science*, **42(3)**, 62-73
- Molony, V. (1992), "Animal pain: models and assessment" in "Animal pain: ethical and scientific perspectives", Australian Council on the Care of Animals in Research and Teaching (ACCART) – proceedings of a conference held at the Barossa Valley, Adelaide, April 1990
- Rose, J.D. (2002), "The Neurobehavioural Nature of Fishes and the Question of Awareness and Pain", *Reviews in Fisheries Science*, **10(1)**: 1-38
- Sloan, S. (2002), "Ecological assessment of the South Australian Rock Lobster (*Jasus edwardsii*) Fishery", *South Australian Fisheries Management Series*
- Smith, J. (1991), "A Question of Pain in Invertebrates.", *ILAR News*, **33(1-2)**, 25-31
- Sneddon, L.U. (2003), "Do fish have nociceptors: Evidence for the evolution of a vertebrate sensory system", *Proceedings of the Royal Society of London Series B*
- Taylor, H.H. (1997), "Physiology and live transport of lobsters: report from a workshop", *Marine and Freshwater Research*, **48**, 817-822
- Venema, S., Boxall, V. and Ward, T.M. (2003), "Survey of recreational rock lobster fishing in South Australia during 2001/02", *Final Report to PIRSA Fisheries Policy Group*.