ASSESSMENT OF ELECTRICAL AND MECHANICAL STUNNING OF FARMED EEL (*Anguilla anguilla*, L.)

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Background

In slaughter animals (including fish) the welfare ante mortem and the quality of the meat or flesh post mortem are easily adversely affected by farming conditions and harvest conditions. Farming conditions comprise amongst others water quality and stocking density. Harvest consists of crowding and catching, sorting, transport, lairage and slaughter. It is known that harvest is one of the most intense stressors in fish farming (Thomas et al., 1999). Harvest is the process in aquaculture whereby a living animal is converted into an edible product. It is the key time when both product quality and welfare can be affected. Fish welfare is a relative new concept. However, in case of mammals the concept of animal welfare has gained acceptance. On basis of similarities in basic structure of neurones and neuronal biochemistry to that of mammals and similarities in stress responses to higher vertebrates it is likely that welfare of fish can be affected, especially at harvest (Kestin et al., 1991, 1995; Kestin, 1994; Verheijen and Flight, 1997; Clarke and Squire, 1998; Spruijt, 1999).

The stress response in teleost fish (e.g. farmed eel) shows many similarities to that of terrestrial vertebrates. This concerns the principal messengers of the brain-sympathetic-chromaffin cell axis (equivalent to the brain-sympathetic-adrenal medulla axis) and the brain-pituitary-interrenal axis (equivalent of the brain-pituitary-adrenal axis), as well as their functions, involving stimulation of oxygen uptake and transfer, mobilisation of energy substrates, reallocations of energy away from growth and reproduction, and mainly suppressive effects on immune functions (Wendelaar Bonga, 1997).

Stunning of animals is in the first place applied to induce a state of unconsciousness and insensitivity of sufficient duration to ensure that the animal does not recover before death intervenes via exsanguination. Secondly, stunning should produce sufficient immobility to facilitate the initiation of exsanguination. It is generally stated that unconsciousness and insensitivity should be induced as soon as possible without a detrimental effect on the welfare of the animal and the meat quality of the carcass (Blackmore & Delany, 1988). For the application of stunning methods it is necessary to confine or restrain the animal and to line up before the stunning itself. Mechanical methods, electricity and gas mixtures are used to stun slaughter animals.

In various EU countries government and consumer organisations are increasingly demanding correct restraining and stunning methods for the farmed fishes. The current pre-slaughter process, used in the Netherlands, may not render the eels unconscious and insensitive prior to killing (Verheijen and Flight, 1997;Van de Vis et al., 2000). The pre-slaughter process consists of placing live eels in a so-called salt bath for desliming. In the next steps the eels are washed with tap water and gutted (i.e. the viscera are removed). Subsequently, the eels are processed. A few electro-physiological and behavioural studies have been performed to determine the onset of unconsciousness and insensitivity at harvest (Kestin, et al, 1991; Van de Vis et al., 2000). Effects of pre-slaughter handling of fish on *post mortem* biochemical changes and product quality have scarcely been studied. There is some evidence that stress at harvest can affect these aspects (Templeton, 1996; Thomas et al., 1999).

Objective

Methods to indicate sensitivity / awareness of fish are available for evaluation of restraining and stunning methods to be applied under practical conditions. These methods have been used for fish in only a few cases (Kestin et al, 1991; Van de Vis et al, 2000). There are, however, insufficient data to set up good scientific criteria for identification and evaluation of sensitivity / awareness of fish during restraining and stunning. The objective of the proposed study is assessment of pre-slaughter electrical and mechanical stunning methods for farmed eel *(Anguilla anguilla, L.)*.

Methods

A number of heads of eels were obtained and anatomically dissected to determine the position of the electrodes for measurement of the EEG and position for mechanical stunning with the captive needle pistol.

Forty-nine eels with a live weight of 700 to 800 g were used. Seven days before the experiment the required number of eels were fasted and delivered at the institute. At the laboratory the eels were placed in a tank with fresh water of 13° C. The experiment was performed with approximately 15 animals per day. In each case two stunning experiments were performed.

On the day of the experiment the eels were placed one by one in a special developed restrainer. This restrainer consists of two halves of a tube of 10 cm, which were fixed together by elastic robes. The lower jaw of the eel was fixed by a hook and the tail was placed in a wide plexiglass tube. Prior to stunning the eel was equipped with EEG and ECG electrodes. The 10 mm long silver spiked EEG electrodes were positioned in the head using a modified air-tacker: one electrode 1 mm to the right and one electrode to the left of the sagittal suture and 6 mm caudal the line extending between the caudal eye-lines. The steel ECG electrodes were placed subcutaneously caudal the implantation of the pectoral fins. The earth electrode for both the EEG and ECG was the hook placed in the lower jaw. The EEG and ECG were recorded during 1 minute before and during 2 minutes immediately after stunning and during 30 s after 5 and 10 minutes after stunning using an Elema Schönander (Sweden) recorder. The traces were analysed after the experiment. Pain stimuli (reaction in behaviour and on the EEG to needle scratches in the skin of the tail) were checked. The behaviour of the animals was recorded on video and analysed afterwards. During stunning the EEG and ECG recordings were blocked and the current strength (voltage and amperage) and time (seconds) were recorded.

In the first stunning method the current was delivered via scissor-model stunning tongs with spiked electrodes during approximately 1 s. The electrodes were placed on the head between the eye and opposite opening of the gill. A stunning apparatus that set a constant voltage of 150, 200 and 250 V (50 Hz) was used. In the second stunning method the animals were stunned either with an electric current of 250 V during approximately 3 s which was followed by a 50 V during 5 minutes with spiked electrodes on the head and tail, or mechanically by captive needle pistol using a shooting pressure of 8 bar and an air injection of 3 bar during 1.5 s, according to the method described by Lambooij et al., (1999).

Preliminary results and discussion

Aquaculture is growing in importance throughout the European Community. At present, most research has been directed at increasing production, with little emphasis on welfare. However, as the industry matures, so the quality, including welfare, becomes increasingly important. In addition, concern for animal welfare is increasing, especially at harvest. Furthermore, in bird and mammal slaughter industries it has been found that in many cases improvements in animal welfare can lead to improvements in meat quality. There are preliminary indications that this may also apply to fish. It is therefore timely that the improved methods for assessment of slaughter methods become available and that research on the development of restraining methods is carried out to reduce stress in fish under pre-slaughter conditions.

Electrical stunning. The first stunning method was started with a head only current application of 150 V in 6 eels. The characteristics of a general epileptiform insult were observed in 4 out of the 6 eels. The next 3 eels were stunned with 200 V, where 1 eel showed the characteristics of a general epileptiform insult and 2 eels did not. The general epileptiform insult on the EEG was characterised by a tonic / clonic phase and an exhaustion phase. The behaviour showed tonic alternated by clonic phases. Such an insult was characterised in sheep in the following ways: the relatively small waves (initial phase) grew irregularly (tonic phase), with an irregular increase in amplitude and decrease in frequency (clonic phase) followed by a phase of strong depression of electrical activity (exhaustion phase). In addition, extension of the flexors and tonic spasms into clonic spasms eventually followed by exhaustion were observed (Lambooij, 1981). During these phases an animal is considered to be unconscious and insensitive, however, the behaviour of such an insult can be different in species (Lambooij, 1981). The successive eels in the first stunning procedure were stunned with 250 V. In total 40 eels were stunned with this voltage, however, in 9 animals the electrodes were disconnected with the consequence that the EEG could not be recorded. The voltage, amperage and duration were on average 255 ± 4 V, 545 ± 32 mA and 1.2 ± 0.2 s (n=31), respectively. The tonic / clonic phase and exhaustion phase were 11 ± 9 and 105 ± 20 s (n=28) on the EEG, respectively and the tonic / clonic phase in behaviour was 38 ± 25 s (n=30), where a distinct exhaustion and recovery phase was not clear. The rate of the heartbeat was 22 ± 8 (n=31) prior to stunning. After stunning the ECG revealed fibrillation. The rates of the heart beat were 2, 5, and 10 minutes after stunning 28 ± 9, 24 ± 9 and 24 ± 8 (n=23, 29 and 27), respectively. The appearance of the general epileptiform insult on the EEG and in behaviour may be affected by the heart fibrillation as described for slaughter pigs (Lambooij et al, 1997). One eel reacted in behaviour and on the EEG to needle scratches at 0.5 minute, 3 eels at 1 minute and 10 at 2 minutes after stunning. The other animals reacted at 5 minutes, however 1 animal did not react at al.

A second head – tail stunning for 1 s using a voltage and amperage of on average 253 ± 3 V and 128 ± 32 mA followed by 5 minutes 53 ± 5 V performed in 16 animals. After stunning an iso-electric line and no reaction on needle scratches were observed after stunning. However, the animals may be considered unconscious and insensitive after stunning, the initial voltage may be too low to induce immediate unconsciousness as described for the first stunning method.

Mechanical stunning. A last group of 15 eels was stunned by captive needle pistol using air pressure. The EEG of the animals showed immediately after stunning theta and delta waves tending to an iso-electric line. Captive needle stunning using air pressure has been applied in broilers and ostriches (Hillebrand et al, 1996; Lambooij et al, 1999). The authors concluded that the possibility of perception of pain can be excluded since theta and delta waves (4 – 8 Hz and < 4 Hz, respectively) occurred on the EEG. Occurrence of delta and theta waves supports the assumption that the animals were unconscious as gauged by analogy with similar EEG changes described in man (Lopes da Silva, 1983). The induction of unconsciousness is induced by laceration, crushing and / or shock waves (Hillebrand et al., 1996).

Conclusions

It may be concluded from our results that eels are effectively stunned with an average current of 545 mA (approximately 255 V). Since eels are not debleeded during slaughter an effective procedure for electrical killing should be developed. It is easy to stun eels with a captive needle pistol. However, more research is needed for the development of a suitable restraining device.

References

Blackmore, D.K. and Delany, M.W., 1988. Slaughter of stock. Publ. No. 118. Vet. Con. Ed. Massey University. Palmerston North, New Zealand.
Clark, R.E. and Squire, L.R. 1998. Science, 280, 77-81.
Flight, W.F.G., 1993. Utrecht Biophysics Institute, Division of Comparative, Physiology, Utrecht University, pp 1-13.
Hillebrand, S.J.W., Lambooy, E. and Veerkamp, C.H., 1996. Poultry Sci. 75, 664-671.
Kestin, S.C., 1994. Pain and stress in fish. Royal Society for the Prevention of Cruelty to Animals
Kestin, S.C., Wotton, S.B. and Gregory, N.G., 1991. Vet. Rec. 128, 443-446.
Kestin, S.C., Wotton, S.B. and Adams, S., 1995. In: Quality in aquaculture (K. Scheire, L. Apselagh and H. Jonkeere, eds.) Int. C. Aquacult. Eur. '95, Trondheim, Norway, pp 380-381.
Lambooy, E.,1981. Some neural and physiological aspects of electrical and mechanical stunning in ruminants. Thesis, State University of Utrecht.
Lambooij, B., Merkus, G.S.M., Voorst, N. van und Pieterse, C., 1997. Fleischwirtsch Int. 2,13-14.
Lambooij, E., Pieterse, C., Potgieter, C.M., Snyman, J.D. & Nortjé, G.L., 1999. Meat Sci. 52, 339-345.
Lopes da Silva, H.F., 1983. In: Stunning of animals for slaughter (G. Eikelenboom ed.) pp 3-12, The Hague: Martinus Nijhoff.
Thomas, P.M., Pankhurst, N.W. and Bremner, H.A., 1999. J. Fish Biol., 54, 1177-1196.
Templeton, J., 1996. Seafood research. A New Zealand perspective. At "Making the most of the catch" Seafood Symp. Brisbane.
Van de Vis, J. W., Oehlenschläger, J., Kuhlmann, H., Münkner, W., Robb, D.F.H. Schelvis-Smit, A.A.M., 2000. In the Proceedings of the International Conference of Farmed Fish, Bristol, UK, April 1999, in press.
Verheijen, F.J. and Flight, W.F.G., 1997. Aquaculture Research, 28, 361-366.
Wendelaar Bonga, S., 1997. Physiological reviews 77(3), 592-625