Recommendations for
Good Husbandry and the Painless Killing of Farmed Fish

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Introduction

Fish is gaining increasing importance at present, not only because it is a high-quality foodstuff, but also because it is a firm component of the menu of health-conscious people, thanks to its low fat and cholesterol levels.
Due to the limits of natural resources, the proportion of fish production on fish farms is increasing, and at the same time the husbandry problems which are relevant to animal welfare are also increasing. Questions being asked are about stress and the sensitivity to pain, husbandry systems, types of transport and, as in fisheries, above all about slaughter.
The Association Fair-Fish has taken on the task to study in depth the available scientific research on these questions and link these results with our own knowledge. The aim of the following recommendations is to achieve improvements for farmed fish. However, many questions remain open and require scientific examination.

1. Sensitivity to Pain

According to the latest literature, there is no longer a question about whether fish experience pain. On the basis of available knowledge it must be accepted as a principle that fish are capable of experiencing pain.

Criteria for the Ability of Animals to Experience Pain:
The Committee on Pain and Distress in Laboratory Animals has named the following criteria for the determination of the experience of pain in animals (1991):

1a Anatomical and physiological similarities to humans,
1b Avoidance of impulses which are unpleasant for the animal,
1c Examination of the effect of pain-reducing substances.

In the following it will be discussed whether these criteria are met for fish.

1.a Anatomical Structures for the Experience of Pain

In mammals the free nerve endings, which register in the brain all the pain impulses from the periphery and the inner organs, joints etc., are the peripheral part of the experience of pain. Free nerve endings have been found in numerous species of fish (roach, rainbow trout, eels, whitefish, carp and gras carp) (Blüm 1988; Ollenschläger and Reichenbach-Klinke, 1978; Schulz, 1978; Schulz, 1992). There is however only a small number of them in fish (Kämpfe, 1993).
The transmission of the impulses from the free nerve endings to the central nervous system takes place in fish along slow C-cells as well as along fast A-cells (Schulz, 1978).
The anatomical requirements for conscious pain experience in humans are the neocortex and the limbic system (Schaible and Schmidt, 1996) These are not developed in fish. There are however more and more points which suggest that fish have similar structures to animals and humans. Neurones have been found in the front part of the brain in fish which are homologous with neurones in the neocortex in mammals (Echteler and Saidel, 1981; Reiner and Northcutt, 1992; Wicht and Northcutt, 1992). Therefore Verheijen and Flight (1997) speak about an «emotional brain» in fish.

1.b Behaviour

After the effect of acute pain has been absorbed, the human behaves with the intention of removing danger or protecting from it (Zimmermann, 1984). This type of behaviour is also observed in fish after pain has been registered.
For example, it has been shown that with trout, once they had been caught on a line and returned to the water, only 10% of the fish rose to the bait a second time and only 1% a third time (Shetter and Allosin, 1955). Similar results were found with carp. Even a year later it was harder to catch these fish than ones which had never been caught before (Verheijen and Buwalda, 1988). These experiments demonstrate the existence of avoidance behaviour and memory performance in fish. The complicated behavioural patterns and psychological achievements in fish suggest that the brain of fish – notwithstanding a comparatively simple structure – has a high capability (Klausewitz, 1989).

1.c Biochemical and Neuropharmacological Data

Asparate and glutamate, which are responsible for the transmission of pain signals in humans, can also be found in fish (Heath, 1995). Further classical neurotransmitters, such as azetylcholin, adrenaline and dopamine, are also present in fish (Heath, 1995; Mazeaud and Mazeaud, 1981; Rowing and Sutters, 1980). In addition, certain neuropeptides, which play a part in humans in the pain/impulse experience, are present in fish (Kestin, 1993; Holmgren, 1982).

Conclusion:
According to current scientific knowledge, it is necessary to assume that fish experience pain. This is supported in particular by the neuropharmacological and biochemical facts. On the basis of the definition of pain in animals it must be accepted, leaving aside all still open questions about the emotional digestion, that fish experience pain (Oidtmann and Hoffmann, 2000).

2. Stress

A stress reaction may be the result of a number of effects, as for example a restriction of the freedom of movement (e.g. being held in a net or bucket, catching a fish on a line), social stress (fight for position in a group) or the handling of the fish (Albrecht, 1977; Oidtmann and Hoffmann, 2000).
Reichenbach-Klinke (1987) names a series of outer signs that the fish are harmed by stress effects. Klinger (1988) points out that the reaction to stress is slower and more tentative in fish than in mammals, which makes an evaluation of the results of stress more difficult.
There is no doubt that there are stress reactions in fish. Therefore the question about the ability to suffer in the sense of the German Animal Protection Law (Version of May 25, 1998) must be answered clearly with “yes” (Oidtmann and Hoffmann, 2000).

Conclusion:
The research results of the various authors show that stress reactions in fish can be proven beyond any doubt.

3. Stocking Density and Husbandry System

It is not possible to give a general indication for the appropriate density of fish in a pond. It depends on the one hand on the age and the stage of development, and on the other hand on the water quality. Regarding the social requirements, it should be noted that not only a too high stock level can lead to problems, but also, for example with adult salmon types (Salmonides), eels and catfish, a too low stock level can provoke increased aggressiveness, territorial fighting and cannibalism (Hoffmann and Oidtmann, 1997).
It is sometimes hard to objectify a negative influence from husbandry and environmental conditions on the well-being of the fish. Damages may, but do not necessarily reveal themselves as substance defects. However, the appearance of non-contagious, chronic illnesses can be analysed as a sign of harm due to poor husbandry (Peters, 1990). Morphologically recognisable changes such as shortened fins or even their absence, skin lesions and gill changes should be included in this category. Clearly dependent on the form of husbandry are the usually reversible fin defects, which can be found in particular when salmonides are kept intensively (Oidtmann, 1994).
The trend towards decreasing stock levels – also in intensive farms – and a replacement of quantity with quality has begun and will continue (Bernoth, E.-M. 1991). A few years ago the Norwegians began to produce salmon intensively in net cages. After a boom of successes at the beginning they began to have bad experiences, which culminated in the “salmon crisis” in 1987. Too high stocking levels were recognised as one of the main reasons for the crisis. (Pohlhausen, 1988).

Conclusion:
The stocking level must enable the fish to behave normally according to their species, with a minimum of pain and stress. Based on the available literature, the stocking level should not be above 15 kg/m^3 for salmon and 30–40 kg/m^3 for trout; higher levels could be permitted in individual cases for short time periods (FAWC, 1996). There is however a lack of research on the optimum stocking levels for the normal behaviour of the fish. There is also a lack of research on how the premises should be designed and structured, so that the fish can behave in accordance with their species - in particular as regards their natural social behaviour, taking into account the current, light and other fish as well as feeding.

4. The Keeping of Different Species

Peters (1982), Klinger (1983) and Mann (1983) report on experiments with trout and eels, in which two fish of each type of a very different size were kept together in an aquarium with no possibility of hiding. Within a very short time, the larger fish dominated the whole space and tried to bite the smaller fish and push it into a corner. Histological changes developed in the stomach and intestinal tract of the smaller fish, which one could consider, in a manner of speaking, as an inflammation of the stomach lining. In addition, it would be easier for pathogens to enter the body through the stomach. According to Klinger, the fish which is attacked in this way is almost always so badly harmed that it dies within two weeks.

Conclusion:
Fish of different types or sizes should only be held in the same part of a farm, if aggression can be safely ruled out.

5. Live Transportation, Handling

Transportation should be understood as every movement of fish from one body of water into another. Not included is movement within an enclosed fish farm (Reichenbach-Klinke, 1980a)
The transportation of live fish may be necessary for a variety of reasons, for example for stocking measures in lakes or streams, for the live sale of fish for food or for the purchase of aquarium fish. The usual transport vehicles for larger numbers of fish are specially equipped lorries, which have a transport capacity for up to 10'000 kg of live fish (Schultz, 1974). Railway transporting is now no longer usual (Nilz, 1992).
Any transportation is a heavy strain for the fish, because they have to cope with stress factors such as loading and unloading, high stocking levels and varying water quality. Avoidance or reduction of this stress is called for from the point of view of animal welfare (Schmid, 1978).

In the available literature there are various measures to reduce stress:

- **Clean Water:** Before being transported for longer distances the fish should be kept in clear, oxygen-rich water, so that they can clean their gills and recover from the stress of being caught (Haider, 1986).
- **Fasting:** As a basic principle it is recommended (e.g. Hoyer, 1975; Berka, 1986; Baur and Rapp, 1988), to transport fish after food has been withheld from them, because then their use of oxygen is lower.
- **Narcotic drugs:** These are sometimes added to the water during transport, because stress conditions and oxygen shortages during the transport of live fish can lead to transport damages and even to cases of death, which can be drastically reduced through the appropriate use of sedatives (Bonath, 1977 and 1982). However, a transport practice which makes the use of sedatives necessary should be seriously questioned.
- **Sorting:** Before transport the fish should be sorted according to size, because mixed transporting is particulary difficult for the smaller fish. They are squeezed by the older fish or beaten by their tails (Vollmann- Schippner, 1975).
- **Season and time of day:** It is best to transport fish during the cold part of the year. Longer journeys should at least be made only during the night or in the early morning (Proske, 1974).
- **Measurements:** The containers should have a height of at least 1 metre and be closed with a non-transparent lid, so that the fish are not unnecessarily disturbed by the penetration of light (Vollmann-Schippner, 1978).
- **pH values:** The water used for transport should have a pH value between 6 and 8, because these values can be regarded as giving no cause for concern for all types of fish (Reichenbach-Klinke 1980a; Berka 1986).
- **Water temperature:** According to Igler (1990), water with a temperature of more than 15 °C should be regarded as unsuitable, at least for the transport of trout. According to research by Lachner (1973), the transportation of carp at 20°C instead of 15°C causes twice as much stress for the fish.
- **Temperature difference:** A direct transfer of the fish is only permitted if the temperature difference is less than 3°C. In other cases where the difference is higher, a gradual process is required; for example, for more then 10 °C a time span of more than 15 minutes is necessary (Vollmann-Schippner, 1975). If this is not assured, then irreversible damages and even death are possible, days or even weeks after transport (Sauer, 1997).
  According to Untergasser (1989), the acclimatisation of the fish to new temperatures should be very much slower; it should not be more than about 1°C per hour.
- **Stocking level:** This is also a critical factor for a transport in accordance with animal welfare. As a guideline. the literature gives a maximum of 1.4:1 (1400 kg fish per cubic metre of water) for carp on short journeys, and for long journeys a proportion of a maximum

1,25:1 is required. For the transport of trout, a ratio of 0,33:1 is the highest acceptable level, and for long journeys a ratio of maximum 0,22:1 is required (Vollmann-Schippner, 1975; Reichenbach-Klinke 1980a).
However, in practice slightly lower stocking levels are considered ideal: for carp 1:1 kg per litre, for trout 0.2:1.

- **Length of transport:** During longer transportation the water must be changed on time, because the metabolic products of the fish lead to increasing strain and unnecessarily increase the transportation stress (Vollmann-Schnipper, 1978). Therefore the water should be changed at least after 20 hours, and for species particularly sensitive to transportation such as trout at least after 12 hours, whereby the quality requirement for transportation water must also be met by the water which is added (Reichenbach-Klinke, 1980a; Igler 1990).
  The longest possible transportation times may be still lower. According to Jens (1973) and TVT (1993/94), the fish should not be transported for more than 12 hours and according to the Naturland Directive (1999) not more than even 10 hours.
- **Recovery:** After transportation the fish require a recovery period of at least three days, before they can be exposed to further stress (Carmichael, 1984b).

Conclusion:
A fish farm should organise itself in such a way that it can avoid dependence on the transportation of live fish, in order to avoid stress and damage. Where transportation is absolutely necessary, all measures should be taken to keep the stress for the fish as low as possible, with above all: short journeys, a correct choice of stocking level and pH value and enough time to get accustomed to different water temperatures.

6. Storage/Showing of Live Fish

Storage facilities and aquaria must – as also the breeding and fattening facilities – pay attention to the needs of the fish. Of particular importance here is the choice of location. On the one hand, a supply of adequate artificial or natural light must be assured, while on the other the container must not be in direct sunlight or too bright and constant artificial light. Containers for observation must always be in the shade. In addition, the shyness of many fish must be taken into account and irritation due to noise or fast movements should be avoided. (Nowak, 1989).
Very important is the avoidance of the combination of types of fish which are aggressive towards each other, such as a common storage of predator fish such as pike with peaceful fish such as carp or tench (Nowak, 1989).
At least as important is the observation of a reasonable stocking level. According to TVT, the maximum stocking level for trout under optimum conditions is 80 kg/m^3, for carp and eels 200 kg/m^3, for sheatfish and pike 100 kg/m^3.
It is apparent that these values are considerably higher than those recommended for breeding and fattening facilities. This points to the need for further research. There is also a need for research on the species-appropriate form and structure of the storage facilities, not least as regards retreat options; there is as yet no literature on this.

Conclusion:
The breeding of fish should be organised in such a way, that it can manage without the storage of fish, in order to avoid stress and damages. Where storage is unavoidable, all appropriate measures should be met to keep the level of stress low for the fish, above all:

choice of a calm, shady location, the keeping of a responsible stocking level and the creation of retreat options.

7. Stripping

The advantage of the artificial extraction of reproductive products as opposed to natural reproduction is very much higher fertility rates, which can reach 100 percent (Leitritz, 1980). The disadvantage of artificial reproduction is the stress for the fish connected to it, which many parent fish have to suffer even several times per spawning period, until the individual ripe stage is reached. There is however a lack of research to clarify this question.
Artificial reproduction through stripping is most important for rainbow trout, as it is practically the only form of reproduction today. In contrast, traditional reproduction in the spawning pond is still most common for carp (Sauer, 1997).

A modern stripping centre should be organised in such a way that the fish need not be carried or transported in, but can be pushed into the stripping room pool from outside without being taken out of the water (Leitritz, 1980). Only a few fish should be taken out of the water at a time for sorting and stripping, after which they should be returned to the pond as gently as possible. A pleasant inside temperature of the stripping room of around 20°C makes the work much easier, because with cold hands one has much less feeling for the strength of the pressure used on the fish.
For male fish, the sperm is sometimes extracted from the stomach cavity through suction rather than stripping, which avoids contamination with urine and thus improves the fertility results. However, the technical application of this process is difficult (Hofer, 1971).
Various authors recommend the stripping of fish under narcosis, because an anaesthetised fish does not fight against the process (Hattop, 1960; Hofer, 1971; Stein, 1978; Leitritz,1980; Steffens, 1981). Other authors recommend an electrical contact anaesthetisation, which is suggested to have very good regulation options (Agethen, 1982 and Wendler, 1983).

Conclusion:
A fish farm should organise its reproduction in such a way, that the stress for the parent fish can be reduced to the lowest possible minimum.

8. Stunning, Killing, Slaughter

Often used or described methods of stunning and/or killing are:
8.1 a blow on the head
8.2 electrical
8.3 chemical
8.4 with $C0_2$
8.5 through bleeding
8.6 through lack of water
8.7 with salt or ammonia

These methods will be examined regarding animal welfare in the following.

8.1 A blow on the head with a hard object

This method is to be recommended from an animal welfare point of view for the killing of individual fish, whether for food or other reasons (Bernoth and Wormuth, 1990; Schulz, 1984). After a correctly performed blow, unconsciousness takes place immediately (Kestin,

1992; Schulz, 1984). A blow is however not a completely safe method of killing. In some cases fish may survive, e.g. if the blow was weak or not accurate (Kestin, 1992). Therefore fish must be gutted and in some way bled (cut in the heart or neck) or decapitated, so that death is caused by a quickly developing anoxia in the brain. It must be ensured that the fish are really dead (Neukirch, 1994).
This process is not appropriate for the stunning and killing of larger quantities of fish for practical reasons (time required, too long lying of the fish etc.). This is also confirmed by a survey among veterinary officers and biologists who belong to the «Fachgruppe Fische und Fischkrankheiten» of the Deutschen Veterinär-Medizinischen Gesellschaft (DVG) and the German Section of the European Association of Fish Pathologists (EAPF) (Bernoth and Wormuth, 1990).

8.2 Stunning or killing using electricity

Instruments on the market either function without water („Dry Killing Instruments“) or direct the electricity through a pool containing water (Bernoth and Wormuth, 1990; Drawer, 1990; Schulz, 1984). Both types of instrument can be attached to the normal electricity net or to a portable generator. According to the literature, it seems that an instrument using direct current is better than one using alternating current, both from an animal welfare and a food technological point of view (Neukirch, 1994).
This method is suitable for stunning or killing larger quantities of fish. But here as well it must also be ensured that the fish are really dead, if they are not immediately bled and gutted.

8.3 Sedating or killing with chemical substances

Effective narcotics are available for the sedating – and as an overdose for killing – of fish (Ames, 1986; Bonath, 1977; Perry, 1990). From the point of view of animal welfare this method is very suitable for the killing of large quantities of fish (Ames et al., 1986; Zwart, 1989), because the effect, depending on the concentration of the substance used, takes place quickly and painlessly (Ames et al, 1986; Kestin et al, 1991). **However**, **fish stunned or killed with chemical substances may not be marketed** (EC Directive 91/C314/10).

8.4 Stunning in water saturated with CO_2

According to the EC Directive 91/C314/10 cited above, the use of CO_2 for the stunning or killing of animals for reasons of slaughter is only suitable for pigs. However, CO_2 is regarded as the best method for the slaughter of fish in Scandinavia and the USA (Bernoth and Wormuth, 1990), because the CO_2 which is added to the water leaves no trace in the fish and the body quality is not damaged at slaughter (Azam, 1989). Because CO_2 dissolves in water about 20 times easier than oxygen (Widderich, 1990), the process is easy. The narcotic effect is based on a hypoxia in the brain as a result of too much CO_2. It is also possible to introduce CO_2 to a container which already contains fish, although this delays the moment of stunning. According to Azam (1989), the stunning (visible by the fish floating belly upwards in the water) took place after 2-5 minutes for salmonides – research by Kestin (1992) gave much more detailed results for salmonides. After being placed in CO_2–saturated water the fish first show significantly increased activity, connected with increased swimming movements and frequent attempts to escape. The author comes to the conclusion that the use of CO_2 for fish may lead to a period of suffering. Sedgewick (1986; after Widderich, 1990) comes to the same conclusion. It must be mentioned here that the research was done above all on salmonides and that there are no concrete results for less sensitive types of fish. The suggestion that stunning takes place later with some cyprinides because of their lower O_2–requirement does seem possible (Neukirch, 1994).
Stunning or killing with CO_2, whether it is in gas form, saturated or over-saturated water solution, should be rejected from the point of view of animal welfare because of the

length of time until stunning takes place, during which there is serious excitement, and because the stunning and killing effect is insufficient.

8. 5 Killing through bleeding

In the discussion on the effect of bleeding it must be clearly distinguished between two cases:
a) Bleeding after previous stunning (blow to the head, electrical current) ensures that the fish has been killed. This measure is absolutely acceptable from the point of view of animal welfare.
b) **Bleeding without previous stunning is however not recommended from the point of view of animal welfare.** Schulz (1984) examined decapitation (in flatfish) and the cutting open of the visceral cavity or a cut as far as the vertebrae behind the head, with an immediate removal of the innards including the heart (in eels and flatfish). There were large difficulties in practice, in terms of animal welfare, with all of these methods.

8.6 Removal of water (dry transport over long distances)

Leaving or storing fish in air without the addition of ice as well as storage on ice **should be rejected for reasons of animal welfare** (Neukirch, 1994). This practice corresponds to suffocation.

8.7 „Running to death" in salt or killing using ammonia (for eels)

Schulz (1984) clearly rejects a NH_3 bath treatment for stunning/killing/removing slime for animal welfare and food hygiene reasons and instead recommends stunning with electricity. Own research on the use of NH_3 does not appear to be the base for this judgement. There is no data to support this opinion. Deufel (1994) considers the use of NH_3 to be the method of choice under present conditions.
Saurer (1993), however, considers the traditional stunning/killing methods such as the NH_3 bath or running to death on salt to be unacceptable from an animal welfare and food hygiene point of view. **These killing methods must be clearly rejected for reasons of animal welfare**.
Rapp (1995 a,b) considers, on the basis of own experiments, that the use of electrical stunning with rectified alternating current is suitable for eels in practice. Prerequisite is a water conductivity of at least 550µS (microsiemens). He sees the combination of electrical stunning/killing with a NH_3 treatment as useful, because this increases the killing effect and simultaneously also achieves the necessary removal of slime.

Conclusion:
Individual fish should be stunned quickly and in accordance with animal welfare by accurate, heavy blows to the head and should be slaughtered immediately afterwards or be bled and gutted.
If a lot of fish are to be killed at the same time, there is only one alternative if the fish are to be used for human consumption: electrical stunning followed immediately by slaughter. This process should also be used if larger quantities of fish are to be processed into animal feed.

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