AIR BUBBLES FOR DISCOMFORT IN FISH

Peters-RC* 2019

SDT Reference Series International 1, 76-83

Carp spitting air after a video of Dr. R.J.A. Buwalda shown by Dr. F.J. Verheijen at the Combined Ichthyology - Herpetology Meeting of the Amer. Zool. Soc. 1988, Ann Arbor MI, USA. Title of presentation: Verheijen-FJ & Buwalda-RJA 1988. Angling practice and feelings in some cyprinid fishes (pictures courtesy of F.J. Verheijen).

In 1988 a brochure (NL) was issued on Pain, Fear, and Suffering in fishes by Dr. R.J.A. Buwalda and Prof. Dr. F.J. Verheijen. The study was performed at the former Laboratory of Comparative Physiology of Utrecht University, and supported by the Animal Protection Foundation "Stichting Bouwstenen", the Netherlands Ministry of Agriculture and Fisheries, the Netherlands Angling Societies NWS and CNHV, and the Organization for Improvement of Inland Fisheries OVB. The authors gave permission to cite parts of this publication, provided reference to the source were given. Here we explain the incubation process of this study, and present its summary in English (source: ISBN 90-9002167-1).

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Dijkgraaf's involvement (1943-1974)

It is not easy to understand why academics study feelings like pain and fear of fish, when governments are bombing cities, and destroy lives of civilians. Nevertheless, interest in the feelings of animals, not being humans, has a relatively long academic history. In this paper we shall skip Aristotle's *Historia Animalium* and begin more recently with a letter[1] of Sven Dijkgraaf, lecturer at Groningen University, to the *Nederlandsche Vereeniging tot Bescherming van Dieren* (Netherlands Animal Protection Organization) on October the 17th, 1943. He writes that the Organization illustrates a story about bats with the picture of an owl. He also points to other inconsistencies in the paper, and suggests a more intensive cooperation between the animal protection people and biologists. A next letter, on animal welfare, is dated 02 February 1950, and is sent this time ***by*** an animal protection organization, the *Bond voor Daadwerkelijke Dierenbescherming te Amsterdam* (Alliance for Actual Animal Protection at Amsterdam). In the mean time, Sven Dijkgraaf has been nominated professor and head of the Laboratory of Comparative Physiology at Utrecht (NL). As a former disciple and distant relative of the ethologist Karl von Frisch, his expertise is focused on animal behavior and sensory perception. As such he is considered a specialist. The letter brings the following points to his attention:

1) There are no regulations in the Netherlands regarding animal welfare, whereas for instance in England a law has been introduced on this topic (the sender refers to *the Lancet* of 06 August 1949).

2) If possible animals should be anesthetized before an experiment by an appropriate expert; at least a veterinary specialist should be present.

3) Central breeding is needed: populations will be more uniform and healthier. Moreover they adapt quicker to captivity. If not bred for trading, a spacey and enriched environment should be provided.

4) After an experiment animals should be killed, instead of dwell indoor.

1 Today, the letters of Sven Dijkgraaf belong to the collection of the Utrecht University Museum.

From a following letter of this organization dated 16 March 1950, we learn that animals are rats, rabbits, guinea pigs, dogs, cats, and monkeys. To a biologist such an enumeration is difficult to understand, since the total number of animal species exceeds the millions, where each species has a specific genome, and a specific neural and behavioral adaptation to the environment. What precisely do these animal protection people want from a comparative physiologist?

The next letter Sven Dijkgraaf received on animal welfare is dated 18 March 1953. This letter is a cry for help from the *Ministerie van Sociale Zaken en Volksgezondheid* (Ministry of Social Affairs and Public Health) by the chairperson of the *Interdepartementaal Overleg Inzake Dierenbescherming* (Interdepartmental Consultation on Animal Protection[2]), the IOID-group. Apparently animal protection lobbyists have asked the government to formulate more precise regulations regarding the interaction between human beings and animals. The IOID-group wonders if the present legislation is adequate; is upgrading necessary? Mistreatment, *i.e.* causing pain without reasonable aim, and causing pain more than considered acceptable to reach a goal, is already punishable. However, unknown is whether "*lower*" animals can feel pain. This holds apparently in particular for fish. The Ministry of Fisheries has therefore asked input from the *Rijksinstituut voor Visserijonderzoek* (National institute of Fisheries Research), the RIVO, the director of which consulted colleagues, and suggested also to consult Sven Dijkgraaf as well as a human psychologist. In the mean time the IOID-group had already formulated preliminary regulations intended to reduce discomfort, regarding 1) transport of live fish with objects between gills or jaws, 2) piercing body parts with a weight hook, and 3) cutting the spinal cord and descaling of live fish. The correspondence further discusses the de-sliming of eel, the cooking of lobsters, the way consciousness is lost, immediately or slowly, the advantages and disadvantages of electrocution, "pain" caused by angling, hooking, submersion in boiling water or saturated salt solutions, live skinning, and discomfort of baitfish, and being kept in a keep net. The RIVO does not have the expertise to answer all these questions properly, but gives as a general opinion that the more unlike human beings animals are, the more difficult it is to define similarities. The RIVO advises extreme caution in accepting a point of view without scientific basis.

Dijkgraaf writes on 21 March 1953 that he recognizes, and is familiar with, the problems mentioned by the Ministries and the Animal Protection people and the RIVO. According to his experience fish suffer most by skin damage. He also has found that strangely enough the head of fish continues to live for more than 15 to 20 minutes after decapitation. For lower animals as few directives as possible should be formulated. The treatment of lobsters he finds particularly difficult. He condemns the tearing apart of frogs and considers it worse than hooking. He also states that natural events are more cruel than is generally realized. In 1966 he received an announcement of a symposium on acceptability of animal experiments (11 November 1966, Leiden University), and in 1968 he received again a letter from the *Nederlandse Vereniging tot Bescherming van Dieren* about the punishability of bleaching, skinning, and killing of eel (06 November 1968). His response letter of 06 November 1968 explains that not enough knowledge is available to answer these questions. Dijkgraaf's legacy – up till his retirement in 1974 - does not contain further correspondence on animal welfare.

His experiences with animal welfare can be summarized as follows: he has published on the gas-spitting reflex of fish (Dijkgraaf 1950) and supervised a PhD-study on this topic (Qutob 1960, 1962), is surprised that fish eat immediately after physical damage, knows that a fish head remains alive up to 15 or 20 minutes after decapitation, suspects definitely an equivalent of pain sensation in the brain after skin damage, and explains that he does not know how to assess accurately pain in 'lower' animals. Finally he proposes to instruct the RIVO and National Institutes of Applied Sciences to investigate the problematic issues mentioned above more in depth.

2 This letter also contains earlier correspondence and communications between other ministries on animal welfare (justice, internal affairs, agriculture fisheries food, education-arts-sciences, social affairs, public health).

Verheijen takes over (1975-1985)

Dr. F.J. Verheijen succeeded Sven Dijkgraaf from 1975 till 1985 as professor of Comparative Physiology. Unlike Dijkgraaf, however, Verheijen left the University no correspondence or other documentation about research or discomfort in fish; only his publications on this topic, most of which are in Dutch, remain. Even the video of a carp spitting air bubbles has disappeared. The only known remnant of this video consists of 4 photographs of a bubbling carp, which the author of this paper received from Verheijen for an advertising leaflet of a physiology topic. In retrospect we cannot pinpoint an exact moment for the beginning of Verheijen's involvement in pain and fear in fish. Moreover, the publications during his professorship deal with other objects, like orientation and the visual system (see reference list deTraditie.nl), However, a few years before his retirement we can detect a switch of research focus towards pain in fish. The reasons for this switch might reflect a coincidence of several factors. In the first place Verheijen's research group was faced with severe redundancies. At the same time a longer existing wish to study animal welfare materialized in national and international invitations to write project proposals. The threat of displacement of his lab to the new campus outside the city was also imminent. At the time, he told me about his private contact with a Mr. A. Void[3], who was active in the animal protection world, and who could provide limited funds for research on fish welfare. He further might have seen possibilities to use the psychophysical and electrophysiological expertises of Dr. R.J.A. Buwalda and other resident researchers in a new research line on animal welfare. The renewal of the aquariums of the lab might also have been of help. On the other hand, his interest in fish might be traced to his youth. Living at the rim of the city of Utrecht near polders, ditches and a fortress moat, he must have been familiar with the world of fishermen. His work at the University of Utrecht began with joining Dijkgraaf's research on hearing in fish in 1950, and not much later with his own study about the alarm substance in fish. We then see a PhD intermezzo about the trapping effect in light fields, but refocus on the gas bladder in 1962 when Dr. Ziad Qutob receives his doctorate on the function of the gas bladder in hydrostatic equilibrium. It is then that Verheijen (1962) publishes an alternative, original, view on the function of the gas bladder: ***Besides maintaining hydrostatic equilibrium, the physostomatous gas bladder of fish has the broader function of adapting the density of the fish to momentary needs.*** In other words: physostomous fish sink to the bottom by spitting gas, if threatened. In 1983, two years before Verheijen's retirement, Buwalda receives an assistantship paid by the animal protection people through Mr A. Void, while Verheijen supports Buwalda's work by writing papers in Netherlands angling periodicals (see reference list deTraditie.nl). In 1988, three years after Verheijen's retirement the results of Buwalda's work are published as a brochure on pain and fear in carp (Verheijen & Buwalda 1988). In the same year Verheijen presents these results at the Combined Ichthyology - Herpetology Meeting of the American Zoological Society 1988, Ann Arbor MI, USA. I attended this session where also the gas spitting video was showed. I was shocked by the reaction of a fellow-biologist who shouted: "*Are you telling me that I cannot throw a fish in formalin because of a few bubbles?*" One year later, in 1989, Buwalda leaves the lab; animal welfare research is taken over by other research groups than Comparative Physiology. A last publicity twitch on welfare of fish was presented on behalf of Verheijen & Flight by the author of this paper at *Fishes and their environment*, a conference of the European Society of Ichtyology at Oviedo (Spain) in 1994.

Author's view (1963-2006)

Although I got my first paid assistantship at Comparative Physiology in 1963, I was too much preoccupied with teaching and electroreception research to pay much attention to Verheijen's animal welfare interest. On the other hand my personal urge to avoid mistreatment of animals was tickled already during my regular 3rd year practical of Comparative Physiology, when frogs were decerebrated for teaching muscle physiology; fast but definitely not stimulating. It took me many years to

3 Mr. A . Void (pseudonym) was an entrepreneur, associated with animal welfare organizations

change this particular program item into a practical more fitting fundamental neurophysiology wihtout damaging the animals. My paper of 1988 describes eventually how to record action potentials non-invasively from a single sensory nerve fiber in an intact vertebrate (Peters *et al.* 1988). Since then I performed my teaching with much more satisfaction. As a consequence, I know Verheijen's and Buwalda's research of fish only superficially, although Verheijen stimulated me to write and participate a number of project proposals on fish welfare together with other groups. However, none of them were successful.

On the other hand, I do remember several animal-welfare-related moments. Most instructive perhaps was that hooked carps swam apparently 'happily' around in their tanks, while a hook through the lip was attached to a floating cork. In this way electrical stimulation of the mouth parts as well as mechanical traction was possible in an otherwise 'normally' swimming carp. Also my senior colleague Dr. J.F.W. Nuboer had a beautiful green tank designed of about 50 x 50 x 50 cm wherein nicely distributed goldfish swam as eye catcher for a demonstration project. Unfortunately all the fish dropped to the bottom after displacement, decently supporting Verheijen's view! I should not forget Dr. R. Bootsma, the fish specialist of the Veterinary Faculty, leaving the University before animal research grants became fashionable, and before the law on animal experiments from 12 January 1977 (revisions 1998, 2014, 2018) came into effect.

But what to think of human piercings, herons swallowing fish *in toto* into gastric acid, goldfish surviving hypoxia by producing alcohol, or people feeding cats with one-day chicks. What to think of all those overfed dogs at home, and other animals in captivity for which no license is needed. What struck me most was that even for viewing guppies in a tank a license was needed, and that killing animals caused less discomfort for the animals than recovery from anesthesia (according to the instruction list provided by the university).

Conclusion

I see Buwalda's and Verheijen's work as a very elegant scientific approach of the description of discomfort in fish, which might help human beings to improve their interaction with animals. To be able to discriminate between pain and fear in an animal so unlike man, is a top accomplishment. At the same time it becomes clear that in spite of the taking effect of legal regulations, there is a lot of work to do regarding the experience of welfare of the millions of other animal species. I hope that the legally introduced guide lines do not prevent the study of animals not commercially interesting. One should realize that the study of other species than man, helps to describe the potential and limitations of the human species. The website of the Nobel committee summarizes how, for instance, frogs helped to recognize the function of neurotransmitters, squid was essential for understanding the nervous conduction, and the horse shoe crab showed the mechanisms of contrast enhancement. Just to name a few.

I hope that the following summary of the work of Buwalda and Verheijen stimulates future investigators to further unravel the mysteries of the animal world.

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Acknowledgements

The comments of Dr. Franklin Bretschneider, Rob van Weerden, and the board members of *Stichting De Traditie* are gratefully acknowledged.

Appendix Verheijen & Buwalda: Original Summary in English

The following summary was scanned, and afterwards optically recognized, from the original booklet: Verheijen-FJ & Buwalda-RJA 1988. Doen pijn en angst een gehaakte en gedrilde karper lijden? Vakgroep Vergelijkende Fysiologie, Rijksuniversiteit Utrecht. ISBN 90-9002167-1.

Verheijen-FJ & Buwalda-RJA 1988:

SUMMARY: Do pain and fear make a hooked carp in play suffer?

It is common angling practice to return cyprinids and other coarse fish alive to the water after capture. Being captured is presumably an experience that fish find unpleasant, for when such animals are returned to the water they show decreased vulnerability to angling owing to their hook or bait avoidance. Although pain caused by injury is often considered to be the major cause of the unpleasant experience (see Medway, 1980), the brief restriction of freedom and the concomitant fear may also contribute. The experiments described in this report were designed to find responses indicative of pain and fear, to differentiate responses indicative of pain from responses indicative of fear, and to investigate whether fish find pain or fear the more unpleasant experience. Finally we tried to estimate whether or not pain and/or fear make the fish suffer according to recent definitions of suffering (in mammals) where suffering is attributed exclusively to the high(est) levels of "stress", i.e. *distress* as defined by Ewbank (1985). Most experiments were carried out with the common carp (*Cyprinus carpio*), but some involved other cyprinids, viz. the bleak (*Alburnus alburnus*), the roach (*Rutilus rutilus*), the rudd (*Scardinius erythrophthalmus*), and the grass carp (*Ctenopharyngodon idella*).

The carp were taken by hook and line in aquaria (Laboratory of Comparative Physiology, University of Utrecht) in which they had been living for some time, and also in ponds (Organization for Improvement of Inland Fisheries OVB). Physically noxious ("pain") stimuli were administered separately by a) hooking the fish, immediately followed by relaxation of line tension, and, in other experiments, by b) electrical stimulations via an electrode implanted in the roof of the mouth of the free-swimming fish. Fear stimuli were given by c) keeping a hooked fish in action by altering the tension of the line, which is normal practice in angling. In other experiments fear was provoked by d) the introduction of the alarm

substance (a pheromone released from damaged skin), and e) confinement to a small jar.

Upon being hooked the fish make some *rapid darts* (1), and subsequently, while swimming freely on the slackened line, show *spit* (2) and *shake head* (3). Some carp resumed feeding only a few minutes later while swimming around on the slackened line. Reactions similar to responses (2) and (3) are also shown by a non-hooked fish when it gets unwanted material in its mouth while ventilating or taking food. The fish in play show behaviour designed as *flee* (4), *spitgas* (5), *sink* (6) and *lie* (7). Response (5), prolonged spitting of gas from the swimbladder, disturbs the hydrostatic equilibrium (see also Verheijen, 1962), resulting in (6). Response (7) can be maintained for a long period (some hours). Responses 1-7 were also elicited successively by electrical stimulations with stepwise increasing intensity and duration. Responses 1, 4, 5, 6 and 7 were also observed in carp after the alarm substance had been introduced, or after the fish had been confined to a small jar or otherwise restrained.

We assume that the behavioural sequence shown by a hooked carp in play corresponds to the natural alarm reaction in response to, for instance, the alarm substance (see Bolles, 1970). Both behavioural sequences seem to parallel the behaviours that characterize the perceptual-defensive-recuperative model of pain and fear proposed for mammals by Bolles and Fanselow (1980). We suggest that response 1 (*rapid dart*), which was shown by the fish in all our experiments, is the Mauthner "fast escape" reflex (see also Verheijen, 1986). The natural alarm reaction to the alarm substance also starts with a Mauthner reflex (Pfeiffer et al., 1986). The Mauthner reflex can be triggered by any sudden strong stimulus; the occurrence of response 1 therefore does not necessarily indicate pain or fear. Reactions 2 (*spit*) and 3 (*shake head*) on the other hand were performed only in conditions where possibly noxious, i.e. "painful" stimuli, occurred either in isolation or together with fear-provoking stimuli. We conclude, that *spit* and *shake head* do indicate low-level pain unless, of course, these responses are also reflexes.

Reactions 4-7 are shown not only in the various fear-provoking situations indicated above, but also, in a quantitatively and qualitatively virtually similar way, during and after repeated strong electrical shocks. In the latter case these reactions might be either a response to intense pain or, alternatively, a result of fear associated with, for instance, the expected continuation of the strong stimulation. The behaviour of the hooked fish in play could also conceivably be attributed to (a combination of) pain and fear. However, since in the model of Bolles and Fanselow (1980) fear inhibits pain in the defensive phase (i.e. the fish struggling) of the behavioural sequence, we assume that reactions 4-7 of the hooked fish in play are indicative of fear, and not of pain. The perceptual-defensive-recuperative model is not really a suitable model with which to study the rather unnatural situation of strong electrical stimulation, and therefore cannot be used to rule out the possibility that pain is the major determinant of behaviour in the shocked fish. However, even if conceived of as highly effective pure pain stimuli, electrical shocks appear to be no more disturbing than fear stimuli alone. Obviously, fear is a most potent motivation.

That the perceptions evoked in fish by local electrical stimulation do parallel to some degree the similarly produced sensations of pain in man is indicated by the results of other experiments. We have found, for instance, that conspicuous transitions in fish behaviour on the one hand, and in sensations of human subjects on the other hand, tend to occur at comparable levels of electrical stimulation in either species. Moreover, both in man and in fish the dynamic range of effective stimuli appears to be particularly small: The difference between a just noticeable stimulus (producing a "tingling sensation" in man, and a temporary slight slowing of heart and ventilation rate, a slight erection of some fins etc., in fish) and a highly effective shock (producing "very strong pain" in man, and wild erratic darting, bumping into the wall, occasionally "freezing", in fish) is no more than a factor 3, as opposed to a factor million or more for e.g. auditory or visual stimuli.

The similarity between quantitative aspects of electrical stimulus detection in man and fish is significant. Even more interesting is our finding that the perception of, and reactions to, electrical stimuli by fish (the heart

rhythm being used as an indicator) can be manipulated in accordance with the Signal Detection Theory (SDT). SDT, originating from experimental psychology, explains human perceptual performance in terms of decision processes localized in higher if not conscious levels of the brain. That the fish's performance in discriminating between electrical stimuli fits SDT is strong evidence for the non-reflex character of "pain perception" in fish.

However real the sensation of pain may be for fish, we conclude that the pain (if any) produced by impalement by the hook contributes less to the unpleasantness of the catching procedure than fear. On the basis of the scoring system proposed by Morton and Griffiths (1985) for assessing levels 0 -1 -2 -3 of pain and distress in mammals (see, however, Sanford et al., 1986) we conclude that the pain involved corresponds to the (lowest) level 0; this is the level which, according to Morton and Griffiths, characterizes the effects (in mammals) of many veterinary manipulations or minor surgical procedures such as injections. The combined effects of pain and fear together bring the level to 1 -2. This means that, in stress terminology, the hooked carp in play is subjected to overstress (Ewbank, 1985). On the basis of the relation between stress condition and suffering suggested by Ewbank (1985), Sanford et al. (1986) and others for certain species of mammals, the carp cannot be considered to be suffering, in the sense of being in distress (Ewbank, 1985). The experiments with the other species of cyprinids mentioned above lead us to a similar conclusion. This should, of course not be taken to indicate that the combination of pain and fear involved is insignificant. After all, level 1-2 in the classification of Morton and Griffiths does stand for mild to moderate discomfort.

Moreover, we emphasize that the above conclusions are valid only for fish of the cyprinid family that are caught by skilled anglers avoiding unduly prolonged playing. The practice of hooking, playing, and immediately returning the fish alive to the water seems to parallel the natural sequence of alarm responses so that the animal is able to terminate the behavioural sequence with the consummatory response *lie*, and calm down "on schedule". However, less skillful handling or ignorance may result in distress, and consequently in suffering. For instance, in the case of a live fish used as bait the response *flee* is artificially prolonged. The bait fish may eventually succumb to stress or injury, if it is not taken alive by a predatory fish. This (ill-)treatment of the fish shows some of the characteristics of biomedical experiments in Category E (for instance "inescapably severe stress or terminal stress") which "are considered to be highly questionable or unacceptable irrespective of the significance of anticipated results" (Orlans, 1986). The practice of holding fish captive in keepnets for several hours and not releasing them until fishing has ended is open to criticism for similar reasons. Again, the behavioural response *flee* is prolonged, and if performed as *bunt-out* (Pitcher, 1979), it may result in injury and the release of the alarm substance, particularly under crowding conditions. Respiratory problems occur fairly frequently. Obviously the custom of holding fish in keepnets has some of the characteristics of Category D biomedical experiments (for instance "induction of an anatomical or physiological deficit that will result in pain or distress; prolonged periods, up to several hours or more, of physical restraint") which places "an explicit responsibility on the investigator to explore alternative designs to ensure that animal distress is minimized or eliminated" (Orlans, 1986). If the fish succumbs, the treatment should be rated equivalent to biomedical experiments in Category E: highly questionable or unacceptable.

This project was supported by the Animal Protection Foundation "Stichting Bouwstenen", the Dutch Ministry of Agriculture and Fisheries, the Dutch Angling Societies NVV and CNHV, and the Organization for Improvement of Inland Fisheries OVB.

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