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Review

FARMED FISH WELFARE, WITH INSIGHT INTO THE SITUATION IN SERBIA

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Abstract

Fish are the most commonly cultivated vertebrates in the world. They respond to stress like other vertebrates, and they can feel pain, fear and suffering. These facts are the basis for considering their welfare. The question of formal protection of fish welfare is becoming more relevant with the significant development of aquaculture in the last few decades. However, fish welfare protection is encountering difficulties. Like many terrestrial farm animals, farmed fish are often subjected to poor living conditions and cruelty. Harvesting, transport, and stunning and killing are the most significant welfare issues. This review describes some of the most important procedures that compromise animal welfare during fish farming and the negative effects these procdures have on the fish. It also gives a brief overview of the situation in Serbia in terms of research into fish welfare, public attitudes on this issue, and the state of legislation. Data presented in this paper indicate the need for more effective protection of fish welfare in the legal and executive aspects.

Key Words: aquaculture, fish, regulations, research, stressors, welfare

INTRODUCTION

Fish have been hunted from the earliest prehistory and used in human nutrition as a valuable protein source. The breeding of fish was likely instigated by the increased needs of the growing human population for food of animal origin. Traces of fish husbandry, about 4000 years old, were found in China (Nash, 2010), but there is an

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assumption that cultivation began earlier. Industrial fish farming systems, which are known today, were initiated in the mid-20th century. After the 1990s, global aquaculture production increased remarkably, and it is still a continuously growing segment (FAO, 2020). It is the fastest-growing food sector worldwide, with about a hundred billion fish farmed per year. With more than 350 species cultivated (Segner et al., 2019), fish could be considered the most commonly farmed vertebrates in the world (Ritchie and Roser, 2019; Franks et al., 2021). The number of individual fish killed each year is higher than the number of slaughtered terrestrial farm animals (Mood & Brooke, 2012; FAO, 2020).

Industrial farming in fish, as in terrestrial animals, involves conditions that are not totally in line with the life needs of the animals and their welfare (Relić et al., 2010b). However, the life needs of fish have not often been understood, or they have been neglected. The reasons for that could be human unfamiliarity with the water environment, our inability to commune with aquatic organisms and our means of perceiving fish intelligence (Brown, 2015). The topic of fish welfare is relatively new (Braithwaite & Ebbesson, 2014), since it attracted the special attention of welfare experts and researchers only after the notable changes within the aquaculture industry (Berrill et al., 2012) starting from the last decade of the 20th century.

Studies have indicated that fish possess different types of consciousness (Le Neindre et al., 2017). Their perception and cognitive abilities often match or exceed other vertebrates; they have excellent long-term memories, develop complex societies, show signs of Machiavellian intelligence, cooperate with and recognize one another and are even capable of tool use (Brown, 2015). Fish respond to stress like other vertebrates, and they can feel pain, fear and suffering (Ashley & Sneddon, 2008; Braithwaite & Ebbesson, 2014). Researchers suggested that if an animal can suffer, it should have some form of formal protection (Brown, 2015).

Recommendations on good practice in farmed fish rearing, transport and slaughter procedures were given in a report by the Farm Animal Welfare Council (FAWC, 1996), which covers salmon (*Salmo salar*) and trout (*Oncorhynchus mykiss* and *Salmo trutta*), with brief comments on carp (*Cyprinus carpio*). In 1998, the European Council Directive 98/58/EC laid down minimum standards for the protection of animals bred or kept for farming purposes, including fish. In 2005, the Council of Europe adopted a recommendation on the welfare of farmed fish, and in 2008, the World Organization for Animal Health (OIE) adopted guiding principles for fish welfare. In the same year, the European Food Safety Authority (EFSA) assessed welfare aspects of husbandry systems for the main farmed fish species in the European Union (EU) (Atlantic salmon, trout species, European eel, European sea bass and gilthead sea bream and common carp). Furthermore, EFSA's Panel on Animal Health and Welfare (AHAW) identified potential risks to welfare for each of these species and at all life stages. Many codes of practice have also been adopted by the aquaculture industry, and they include measures that protect fish welfare (Ashley, 2007; EFSA, 2010). In addition to EU regulations, many member states created specific national legislation

for animal welfare, including particular recommendations for fish. In this context, the aquaculture-relevant animal welfare legislation is often not harmonized among European countries (Segner et al., 2019). In many counties in the world, there is no appropriate regulation, and thus, difficulties in protecting the welfare of fish are obvious (Brown, 2015; Masud et al., 2019). According to Segner et al. (2019), the main challenge in developing recommendations and regulations on the welfare of farmed fish is still related to limited scientific knowledge and practical experience, especially if the diversity of cultured species is taken into account. Furthermore, relatively few operational welfare indicators (OWI) for farmed fish have been validated to date.

WELFARE ISSUES FOR FARMED FISH

Animal welfare principles are based on meeting the basic needs of animals and their right to a certain quality of life. Applied to farmed fish, they imply that breeders should provide: 1) adequate nutrition according to the fish species and age, with starvation time before harvesting, transport and slaughter being as short as possible; 2) an appropriate species-specific environment, with optimal values of the water temperature, dissolved oxygen, ammonia, acidity, amount of organic matter, flow rate, light intensity and other parameters; 3) rearing conditions providing minimal possibility of injury, e.g. avoiding rough procedures during capture and handling, and providing disease prevention; 4) rearing conditions in which fish can exhibit normal species-specific behaviour, e.g. providing sufficient space for swimming in all directions and; 5) rearing conditions in which fish are not exposed to fear and chronic stress, e.g. protecting fish from predators, treating fish gently during capture and handling, and using humane methods of slaughter (Relić et al., 2015). Accordingly, potential risks for the welfare of farmed fish are related to environmental conditions, feeding, husbandry practices, disease occurrence and disease control measures (EFSA, 2010). In practice, it is impossible to avoid most procedures that are known to cause a stress response in fish, such as netting, weight measurement and transportation (Pickering, 1993). However, harvesting, transportation and procedures related to stunning and killing present the greatest challenge for fish welfare (Conte, 2004; EFSA, 2009; Relić., 2010; de Castro et al., 2016; Masud et al., 2019).

Rearing environment and related stressors

The rearing environment should be constructed in such a way that it prevents damage to skin and fins and protects fish from predators. The tanks should allow efficient cleaning and disinfection, and easy and effective removal of faeces, avoiding disturbance of the fish as much as possible. Moreover, fish should be protected from disturbance by noise, vibrations and farm visitors. Farms must have plans and appropriate protocols for fish disease prevention and biosecurity. Disease prophylaxis is also required, focusing on the provision of good rearing conditions, including optimal water quality and low levels of stress (Segner et al., 2019).

The negative effects of poor environmental conditions are more severe in fish than in mammals and other terrestrial animals. Water quality parameters should be maintained at the optimal level, without rapid changes, which are especially unfavourable for fish. Excessive feeding, high stocking density and omissions in hygienic procedures can contribute to the deterioration of water quality, which can cause health problems and fish deaths. In aquaculture systems with continuous water inflow and appropriate water treatment equipment, it is possible to provide minimal variations of environmental conditions (Relić et al., 2010b). At a high water flow rate, some aquaculture systems can tolerate much higher stocking density than at a low flow rate. Besides the water quality, stocking density also influences growth, stress level and social interactions, such as aggression, among the fish (Segner et al., 2019).

The basic parameter that enables the life of fish in the water is dissolved oxygen, and the needs for oxygen, *inter alia*, depend on the level of metabolic activity (EFSA, 2008b). Fish measurement and evaluation procedures, if performed with little or no water, can lead to hypoxia and intense stress response (van Raaij et al., 1996). Stress caused by harvesting and transport increases the level of respiration in fish and the consumption of oxygen over time (EFSA, 2008a). Additionally, accumulation of carbon dioxide from respiring fish can lead to displaced available oxygen in the transport container, especially if stocking densities are high (Conte 2004). Deterioration of water quality caused by the accumulation of ammonia (from fish metabolic processes) and fluctuations in dissolved oxygen and pH are consequences of transportation (Masud et al., 2019).

Preparation for transport begins by withholding feed from the fish for about 24 h before harvest and transport so that they do not void faeces and foul the transport water (Conte, 2004). This short-term starvation is stressful but has no detrimental effect on fish health (Waagbø et al., 2017; Sakyi et al., 2020). During the period of starvation, fish are often kept in holding tanks, which allows them to recover from any previous handling. After that, fish are transferred to a tanker using lift nets or pumps, then driven to and off-loaded at the delivery location. Transporting fish by tank truck requires special care to ensure water quality and temperature requirements are met and compensated for when changes occur. Long-distance tankers are insulated and equipped with chillers, carbon dioxide strippers, anti-foam agents, water buffers, circulation pumps and oxygen sources. Short-haul tank trucks are usually equipped with ice, circulation pumps and anti-foam agents (Conte, 2004).

Although contemporary fish transportation has been improved, especially in the characteristics of transport vehicles, fish in transport are exposed to stressors such as capturing, handling, overcrowding, abrupt changes in temperature and physical trauma (Masud et al., 2019). That is why transport acts as a strong and complex stressor that can cause reduced feeding, altered immune response and mortality in fish (Ashley, 2007; de Castro et al., 2016; Masud et al., 2019). Welfare problems can also occur when transporting fish in plastic bags with 25-30% water and 70-75% air or pure oxygen, which is a common method of transporting fingerlings, juveniles and small fish.

The presence of air pockets in polythene bags increases the chances of mechanical stress due to water movement. Stress reactions in fish during transport can lead to immunosuppression and can increase disease susceptibility. Additional problems related to disease occurrence can arise due to the absence of quarantine procedures before and after the transport, routine screening procedures for parasites, or border inspections post-arrival (Masud et al., 2019).

Harvesting, stunning and killing

Fish intended for human consumption experience several very stressful events before they are killed. Increased muscle activity caused by stress affects post-mortem biochemical processes in the fish body, which leads to unwanted changes in the physical parameters and parameters of fish freshness. Besides the ethical reasons, fish should be slaughtered humanely to preserve meat quality and contribute to the safety of fish products (Poli et al., 2005; Relić et al., 2010a).

The process of harvesting farmed fish for slaughter includes crowding inside the rearing system, removal from the rearing unit, and, if the fish are not killed on-site, transport to the abattoir (Segner et al., 2019). The most important hazards for fish welfare in the pre-slaughter phase are related to capturing by the net and rough handling. Netting can cause damage to the fish (e.g. skin injuries and broken fin-rays) as the nets can be abrasive. Severe damage leading to death can occur if a fish is hit with the net frame or stepped on by a worker. If a fish drops from the net or tank, it experiences serious negative consequences, as this causes sudden changes in the gas pressure within the swim bladder and pain. Loading and unloading processes during fish transport can cause temperature shock when the water temperatures of the lairage tank and transport tank are different. If a fish has been fed before transfer into lower temperature water, digestive disorders leading to death can occur as a consequence. During the transfer to another tank, fish are exposed to a sudden light intensity change, which is an additional adverse stressful stimulus. Fish that stay in the lairage tank before slaughter can be exposed to poor water quality if the water exchange is insufficient and metabolic product (such as ammonia) build-up. This can cause gill irritation, increased skin mucus production, or loss. Excessive fish density and increased water temperature, elevated by fish respiration, can lead to oxygen depletion in the water and cause asphyxia. If the tank has abrasive concrete walls, these can cause skin lesions, eye damage and other injuries. In their attempts to escape, jumping fish can hit the cover of the tank and be injured. Lack of a proper cover can allow fish to jump out of the tank, so they fall onto the floor and are exposed to air. Sudden noise from devices or equipment used at the abattoir can seriously disturb fish in the lairage tank. That manifests by signs of fear in fish, such as increased respiration rate. Improper removal of fish from the hand-net (e.g. dropping fish into the container) will lead to broken bones, skin lesions and pain, especially if there is no water in the container. Fish in the lower parts of the container can be subjected to mechanical pressure due to the weight of the fish above (EFSA, 2009).

Before they are killed, fish have to be stunned. Death is induced by various methods that include bleeding, stopping the heart, or preventing access to oxygen. Stunning and killing can occur together but where they are distinct operations, the stun-to-kill time must be minimized to prevent any recovery of consciousness before death occurs (Lines et al., 2003). Common stunning methods for carp are asphyxia followed by percussion and whole-body electrical stunning in water. Regardless of the stunning and killing methods, they are followed by evisceration (EFSA, 2009).

Bleeding without prior stunning typically entails removing fully conscious fish from the water, manually restraining them, inserting a sharp knife under their opercula, and severing all four gill arches on one side of their head. Alternatively, the heart can be pierced, the isthmus cut with a knife, or the blood vessels in the tail severed. If not stunned, fish struggle intensely and can remain conscious for 15 minutes or more from the time when major blood vessels have been cut (to exsanguinate), until they finally loose consciousness. The eel brain can continue to process information up to 30 minutes after being decapitated, and some fish remain conscious for 20–40 minutes after evisceration (Segner et al., 2019).

The practice of exposing fish to air for extended periods while waiting for stunning is another serious welfare hazard. When fish are removed from the water and exposed to air, the gills collapse and the animals have reduced oxygen intake, resulting in anoxia. This practice is extremely aversive to fish, which often show violent escape behaviours accompanied by maximum stress responses (Robb & Kestin, 2002). The time to death depends on the temperature and the relative humidity; if the temperature is low and humidity is high, the delay before death in carp can be many hours (EFSA, 2009). Fish are also asphyxiated by immersing them in a slurry mixture of ice and water or packing them alive in ice flakes. This type of intense, rapid cooling causes muscle paralysis and has been clearly shown to initiate a stress response (Roth et al., 2006).

With percussive stunning, fish are rapidly struck on the head, causing a concussion and cerebral dysfunction. This method renders fish unconscious immediately and irreversibly if sufficient force is applied to the correct part of the head (HSA, 2005).

Electrical stunning is carried out by immersing the whole body of the fish in a water tank and passing an electric current through the water. For electrical stunning methods, the most important hazard is exposure to insufficient current/voltage for a prolonged period, which causes pain, distress, broken bones, muscle bleeding and exhaustion, instead of immediate unconsciousness (EFSA, 2009).

FARMED FISH WELFARE IN SERBIA

In Serbia, aquaculture began to develop in the second half of the 19th century. In the second half of the 20th century, large-scale aquaculture facilities were built for carp farming in Vojvodina and for rainbow trout cultivation in the mountainous areas of Serbia (Marković & Poleksic, 2011; Lujić et al., 2018). In the first two decades of the

21st century, many small, family-owned fishponds were constructed. Today, there are 149 registered fishponds, of which 77 are for carp farming, 68 for trout farming, and 4 for sturgeon farming. In addition to the registered fishponds, dozens of fishponds operate outside legal channels.

Along with the expansion of aquaculture in Serbia, the scientific community made its first contributions on the topic of fish welfare in the form of publications by Filipović et al. (2007), Vučinić and Radisavljević (2009) and Relić et al. (2009; 2010a, b). At the same time, the Center for Fisheries and Applied Hydrobiology of the Faculty of Agriculture (CEFAH) performed experimental research on fish stress response, and assessed the rearing conditions and welfare of common carp (*Cyprinus carpio*), the most economically important fish species in Serbia (Relić et al., 2010b). The research was related to monitoring the growth and mortality of fish, measuring water quality parameters and fish blood parameters (cortisol, glucose, total proteins and immunoglobulins, total cholesterol, triglycerides, inorganic phosphate, aspartate aminotransferase, alanine transaminase and C-reactive protein levels), characterizing body injuries and deformities, and conducting histopathological examination of internal organ tissues. Data were used to determine the effect of common stressors in intensive farming, such as the ammonia level in water (Relić et al., 2010b; 2011; 2012a, c), stocking density (Relić et al., 2012b, c; 2015), handling (Relić et al., 2010b), and the amount and composition of added feed (Ardó et al., 2009; Dulic et al., 2010; Relić et al., 2012b, 2014; Poleksić et al., 2014).

Another complex study was devoted to examining the quality of fish meat concerning the rearing system and nutrition. Fish meat quality is considerably affected in breeding technologies where fish welfare is less taken into account (Relić et al., 2012b; Savić et al. 2012; Relić et al., 2016). Also, the choice of additional feed has a particularly significant impact on the fish meat quality, and above all, fatty acid composition (Živić et al., 2013; Trbović et al., 2013; Trbovic et al., 2018). In addition to the meat quality effects, the influence of particular components in feed on growth was investigated, as was the histology of the liver and intestine (Marković et al., 2012a; Rašković et al. 2013; Poleksić et al. 2014; Rašković et al. 2016a, b).

During 2013, consumer attitudes on the impact of farming conditions and stress on the quality of fish meat were examined (Relić et al., 2013a). Preliminary data on Serbian consumers' knowledge and interest in fish welfare were also collected (Relić et al., 2013b). Almost all respondents knew the quality of fish meat depends on the quality of the water in which the fish lives and the quality of the feed it consumes. However, only a small number of respondents knew stress and the fish slaughter method impact the quality of fish meat. Respondents mostly knew that fish can feel fear and suffering and that these emotions in fish are related to procedures during breeding, transport and slaughter. A significantly higher level of knowledge about the effects of water quality, feed and stress on the fish meat quality was shown by respondents with a higher level of education. In addition, the respondents' knowledge on the effect of feed quality was significantly influenced by their level of income,

while their knowledge on the stress effects was influenced by age. Awareness of the feeling of pain in fish was significantly higher in people with a higher level of income and in smaller households who live in the urban environment. Women believed significantly less than men that fish could feel fear (Relić et al., 2013a). In another study by Relić et al. (2013b), mostly better-educated respondents claimed they know and understand the term "animal welfare" and know that there are regulations in the world on the protection of animal welfare. It is encouraging that, regardless of the level of education and place of residence (large or small cities, rural settlements), most respondents would more often buy fish or fish products produced in conditions where the life needs of fish are maximally respected and their welfare is protected, even if they have to pay more for that. Respondents with a monthly net personal income higher than the national average were better informed about animal welfare.

Serbian regulations regarding the welfare of farmed animals, including fish, were first published in 2009 in the form of the Law on Animal Welfare and the Law on Animal Husbandry (Official Gazette of the RS, No. 41/2009). However, to date, no bylaw has been passed regulating in more detail the conditions for breeding, transport and slaughter of farm-raised fish in Serbia. Therefore, the protection of fish welfare remains to a great extent in the domain of theory and research.

CONCLUSIONS

The welfare of fish, like the welfare of other farm animals, includes ethical, legal, economic, health and other issues. However, effective protection of fish welfare is not easy to achieve. On the one hand, appropriate regulations and an operative mechanism for implementation are needed. On the other hand, there are numerous stressful situations during fish rearing that are almost impossible to avoid. Farmed fish welfare problems arise when environmental and nutritional conditions deviate significantly from natural conditions and are often due to handling during harvesting, transport and slaughter. These events produce suffering, injuries, poor health and production traits, and deaths in farmed fish. The problem of farmed fish welfare in Serbia has been less considered than the welfare of other farm animals. This topic has been covered mainly in basic research, which is insufficient for gaining broader knowledge and making more significant progress in fish welfare protection. Moreover, the problem is exacerbated by the lack of regulations and appropriate enforcement actions. Additional education of aquaculture employees is required.

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Authors' contributions

RR and ZM wrote, drafted and revised the manuscript. Both authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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DOBROBIT FARMSKI GAJENIH RIBA, SA UVIDOM U SITUACIJU U SRBIJI

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Kratak sadržaj

Ribe su najčešće gajeni kičmenjaci na svetu. One reaguju na stres poput ostalih kičmenjaka i mogu da osete bol, strah i patnju. Ove činjenice su osnov za razmatranje njihove dobrobiti. Pitanje formalne zaštite dobrobiti riba postaje značajno sa razvojem akvakulture u poslednjih nekoliko decenija. Međutim, zaštita dobrobiti riba nailazi na poteškoće. Farmski gajene ribe su često izložene lošim životnim uslovima i okrutnosti poput mnogih kopnenih domaćih životinja. Izlov, transport, omamljivanje i ubijanje predstavljaju najvažnija pitanja dobrobiti. U ovom preglednom radu opisani su neki od najvažnijih postupaka koji ugrožavaju dobrobit riba u uzgoju i njihove efekte na organizam ribe. Takođe, dat je kratak pregled situacije u Srbiji u pogledu istraživanja u oblasti dobrobiti riba, stavova javnosti po ovom pitanju i stanja zakonodavstva. Podaci u ovom radu ukazuju na potrebu za efikasnijom zaštitom dobrobiti ribe u zakonskom i izvršnom aspektu.

Ključne reči: akvakultura, ribe, istraživanja, propisi, stresori, dobrobit