Fish slaughter practices in Brazilian aquaculture and their consequences for animal welfare

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Abstract

Slaughter is considered an important fish welfare issue. For a slaughter method to be considered humane, effective stunning that lasts until death as well as the reduction of pain and fear throughout all procedures are essential. Our objective was to investigate current techniques for slaughtering fish in Brazil. A digital questionnaire with six multiple-choice and three open questions was distributed to companies registered as fish slaughterhouses and to fish farms in 2019, addressing fish species, quantities processed and slaughter procedures adopted. From 62 facilities in 15 Brazilian states that answered the survey, nine slaughterhouses and 30 fish farms slaughtered fish, totalling 452 tonnes per day. All reported pre-slaughter stunning, and live chilling to be the most commonly cited method (82.0%), followed by electronarcosis (18.0%). Slaughtering techniques included exsanguination (38.5%) and decapitation (2.5%). For the remaining companies, no slaughter method was declared, suggesting death by asphyxiation or by further processing (59.0%). Twenty-nine companies adopted pre-slaughter fasting, lasting from 10 to 48 h. All sites worked with tilapia (100%) and 24 (82.7%) reported that they worked exclusively with this species. Other species reported were: pacu (25.6%), tambacu (17.9%), tambaqui and carp (15.3%), jundiá (12.8%), pintado and pirarucu (7.7%), matrinxã and pangassius (5.1%). Asphyxia and live chilling are not considered humane, as animals remain conscious and, thus, suffer. Results show that most establishments do not perform humane slaughter. This scenario highlights the urgent need for development and enforcement of humane fish slaughter techniques, with routine supervision and normative requirements.

Keywords: *animal welfare, asphyxiation, electronarcosis, live chilling, Nile tilapia, stunning*

Introduction

Studies published by the UN Food and Agriculture Organisation (FAO) in 2018 showed the annual increase in fish consumption to outpace the growth in the consumption of meat from terrestrial animals. In Brazil, the aquaculture sector has grown significantly during the last two decades, reaching approximately 758,000 tonnes in 2019, 4.9% higher than the previous year (PeixeBR 2020). Unfortunately, welfare practices for aquatic animals remain incipient when compared to farmed terrestrial vertebrates. Compared to fish, animals such as pigs, cattle and poultry enjoy more robust, scientifically based recommendations for good practices, evidenced by the existence of protocols for assessing their welfare (Welfare Quality® Assessment Protocols for cattle, poultry and pigs; Blokhuis *et al* 2010) and by recommendations established by the World Organisation for Animal Health (OIE) and the regulations of the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) regarding their humane slaughter.

Scientific research specifically addressing fish welfare has increased exponentially in recent decades, supporting the OIE Aquatic Animal Health Code. This Code, which was first adopted in 2012 and most recently updated in 2013, summarises the recommended fish slaughter methods (OIE 2021). This development has occurred despite several publications still supporting the idea that fish may not be sentient animals (for example, see Browman *et al* 2019). In fact, there is a growing body of evidence supporting the recognition of fish sentience. For example, the ability of fish to feel pain (Sneddon 2003; Braithwaite 2010; Brown 2015), fear (Chandroo *et al* 2004; Agetsuma *et al* 2010), as well as learning, memory, awareness and social skills (Galhardo & Oliveira 2006; Pinto *et al* 2011; Salwiczek *et al* 2012; Bshary *et al* 2014; Hamilton *et al* 2016) have all been studied in detail. Although our knowledge on the specific neural circuitry necessary to understand pain and other emotions in fish is limited, awareness seems present in all vertebrate animals, as a mechanism to allow the organism to

Figure 1

	Questions	Answer possibilities
1	Company information (name, city, contact)	Open answer
2	What is the main activity of the company?	Open answer
3	Which species of fish does the company work with?	Options: Tilapia; Tambaqui: Tambacu; Jundiá; Pacu; Tuna; Carp; Catfish; Pirarucu
4	Are the animals from fishing or farming?	Options: fishing; farming
5	What is the daily processing volume (in tonnes)?	Open answer
6	Which conservation methods are used?	Options: chilled fish (between -0.5 and 2.0ºC); frozen fish; canned fish; drying fish (natural or artificial); salting; smoking; fermentation
7	Animals arrive in company alive or dead?	Options: alive; dead
8	What is the slaughter method? Describe the standard management for slaughter. Important information to consider: 1) Are fish submitted to a fasting period? 2) What equipment is used to manipulate or restrain the animals? 3) Which is the slaughter method adopted? Example: gill cutting.	Open answer
9	There is any stunning procedure performed before slaughtering?	Options: Yes, No
10	If yes, which stunning procedure is performed?	Options: electronarcosis; percussion; spinal cord section; live chilling; other.

Questionnaire applied to participants from Brazilian slaughterhouses and fish meat processing companies during 2019.

rapidly modify behaviour in response to the external environment (Van den Bos 2020). Therefore, despite the need for further research, the knowledge gathered thus far readily justifies the need to develop stunning strategies to avoid severe discomfort during fish slaughter (European Food Safety Authority [EFSA] 2018).

Within the aquaculture production chain, pre-slaughter and slaughter procedures are considered an important fish welfare issue that are in need of attention by the industry. The Normative Instruction No 3, of January 17 from MAPA (2000), describes as humane the slaughter that is performed in the absence of pain and fear, from the reception of animals in slaughterhouse until the conclusion of slaughter procedures, which involve the stunning followed by the bleeding of an unconscious animal, that must remain so until death. However, this norm refers exclusively to the regulation of the slaughter of terrestrial animals. The absence of regulations for humane slaughter of fish seems related to the lack of standardised stunning procedures for these animals whom, for many species, even basic data on slaughter methods cannot be found in the literature. The objective of this work was to study the main stunning and killing methods for farmed fish in Brazilian companies, in order to describe critical welfare points and support improvements.

Materials and methods

Study questionnaire

An initial list of contacts was made covering all companies registered with the Brazilian Federal Inspection Service (SIF/MAPA) as either slaughterhouses or fish meat processors in 2019 (n = 320) and fish producers (n = 324). Representatives from all companies received an invitation by e-mail to participate in the survey, with a summary of the objective and additional relevant information. For those who agreed, an online questionnaire was sent consisting of ten questions regarding the species of fish used, the volume of processing, the fasting practices adopted and the methods used for stunning and killing (Figure 1).

Ethical approval

This survey was approved by the Human Research Ethics Committee (CEP/SD, protocol number 3,986.028) of the Health Sciences Sector of the Federal University of Paraná. Prior to participation, all respondents agreed to the Free and Informed Consent Term, which explained the research objective, the implications and rights of the respondents. Respondents representing processing companies that did not work with live animals were excluded.

Data analysis

Data were grouped by region and fish species for descriptive analyses. Pearson Chi-squared tests were performed to study the independence between stunning and killing procedures adopted in the country.

Results and discussion

Responses were obtained from 62 companies located in 15 Brazilian states. From those, 39 establishments located in eleven states performed fish slaughter and, therefore, met the research profile. Adding the numbers cited by our participants, we estimate a total volume of 452 tonnes of fish was slaughtered daily (114,356 tonnes per year). Nile tilapia (*Oreochromis niloticus*) was the most common species, processed by 100% of participants (n = 39); it was the exclusive species processed in 61.5% (n = 24) of the studied facilities, totalling approximately 357 tonnes of tilapia slaugh-

Figure 2
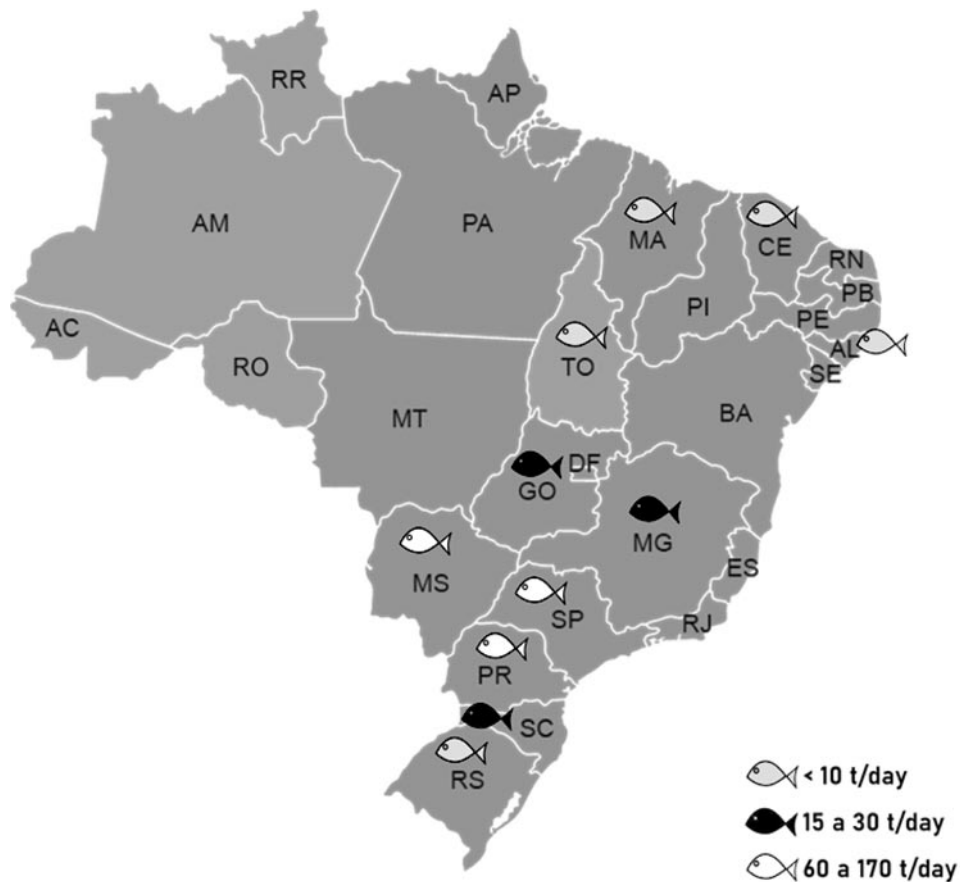
Daily volume of fish slaughtered informed by 39 respondents from different establishments located in eleven states in Brazil, during 2020.

tered daily (90,000 tonnes per year) (Figure 2). This amount represented 20.8% of tilapia production in Brazil in 2019, which was 432,000 tonnes (PeixeBr 2020). Considering that the average slaughter weight of tilapia is 0.8 kg (Kubitza & Kubitza 2000), approximately 540 million individual fish were slaughtered in Brazil in 2019, which gives an indication of just how significant the welfare of tilapia actually is. Respondents also mentioned the processing of pacu (*Piaractus mesopotamicus*) (25.6%), tambacu (hybrid from female tambaqui [*Colossoma macropomum*] and male pacu) (17.9%), tambaqui (15.3%), carp (*Cyprinidae* spp) (15.3%), jundia (*Rhamdia quelen*) (12.8%), pintado (*Pseudoplatystoma corruscans*) (7.6%), pirarucu (*Arapaima gigas*) (7.6%) matrinxã (*Brycon cephalus*) (5.1%) and pangasius (*Pangasius hypophthalmus*) (5.1%). There is, therefore, a great diversity of anatomical and physiological characteristics amongst species, which makes standardisation and adoption of good practice protocols in the aquaculture industry even more challenging, since welfare improvements require species-specific recommendations.

Twenty-nine companies declared the imposition of a pre-slaughter fasting period, varying from 10 to 48 h, with a median of 24 h. Fasting fish before slaughter is common practice in aquaculture. The decrease in gut content promoted by fasting may benefit the fish as it reduces metabolic activity and, consequently, the elimination of ammonia and carbon dioxide in the water during transport (Lines & Spence 2012). However, fish should not be fasted before killing for longer than necessary, eg to clear the gut or to reduce undesirable organoleptic properties (OIE 2021). The duration of food restriction should vary according to each species' specific feeding habits (FSBI 2002; Kim *et al* 2014). According to Lanna *et al* (2004), the average time for gastric emptying in tilapia is dependent upon dietary composition but take up to 13 h. The variation in fasting periods reported in our survey is far in excess of these requirements and would appear unacceptable. Although some period of food deprivation may not have as much impact on fish homeostasis, a consideration of fishes' motivation to eat is essential for their welfare. Considering off-flavour issues, geosmin and 2-methyliso-borneol (MIB) are the chemicals absorbed through the gills, inducing off-flavour in freshwater fish tissues (Howgate 2004; De Souza *et al* 2012; Lindholm-Lehto *et al* 2019). The time necessary for depuration to eliminate it differs depending on fish species, water temperature, level of contamination and fish size, as smaller fish typically have less lipid content (Howgate 2004). An effective depuration

Table 1   Interaction amongst fish stunning and killing methods according to an online survey in Brazil, March to August 2020.

Killing method	Stunning	
	Live chilling	Electronarcosis
Asphyxia	23	0
Decapitation	1	0
Exsanguination	8	7
Total	**32**	**7**

Pearson Chi-Squared test; P = 0.010.

may last for weeks (De Souza *et al* 2012; Lindholm-Lehto *et al* 2019). Schram *et al* (2021) found geosmin was eliminated faster from fed fish due to their higher blood lipid content and gill ventilation rate compared to starved fish. Thus, support for longer fasting periods to reduce off-flavour in tilapia is scarce in the scientific literature. Short-term fasting, of up to 24 h, associated with rapid electronarcosis, can reduce haemostatic alterations and seems to be an option for humane slaughter of tilapia (Costa 2019). The consequences of prolonged fasting can include stress, dorsal fin erosion due to cannibalism and weight loss (Jørgensen *et al* 2002; Davis & Gaylord 2011; Hoseini *et al* 2019). Thus, the reported pre-slaughter fasting periods negatively affect the welfare of fish in a far more complex fashion than merely limiting feed intake and, consequently, seems a major welfare restriction to be mitigated.

Stunning is defined as the process that renders an animal unconscious and insensible without causing avoidable stress and discomfort prior to death for a sufficient period of time to allow killing (Van de Vis *et al* 2014). All respondents reported the use of a stunning technique prior to the killing of fish. The most cited method was live chilling of conscious fish, (n = 32; 82.0%); one respondent used this method in conjunction with spinal cord section (n = 1; 2.5%). However, live chilling should not be considered a humane stunning method, as it exposes the animals to prolonged suffering and pain before death (Lines *et al* 2003; Conte 2004; Barton *et al* 2005; Bagni *et al* 2007; Ellis *et al* 2008; Lines & Spence 2012). Spinal cord section in fish does not provide immediate stunning, but the time required to promote unconsciousness is significantly shorter when compared to live chilling of tilapia (Pedrazzani *et al* 2009). Electronarcosis was reported as being the stunning method of choice for the remaining participants (n = 7; 18.0%), and if performed with appropriate parameters this method may be considered humane due to a complete loss of consciousness by causing disruption to normal brain function for a short period (Van De Vis *et al* 2003). Electronarcosis does not cause an irreversible brain damage and, thus, the immediate bleeding of fish post-stunning is essential to prevent recovery of consciousness (Conte 2004; Hastein *et al* 2005).

The reported stunning and killing methods showed a statistically significant association (Pearson Chi-Squared test; P = 0.010; Table 1). Fifteen facilities (38.5%) reported slaughtering fish by exsanguination through gill cutting, including all of the companies that performed electronarcosis. This technique promotes fish death from anoxia (Van De Vis *et al* 2003). However, more detailed reports are needed, as gill cutting may not be an effective killing method for electrically stunned Nile tilapia (Lambooij *et al* 2008) and Atlantic salmon (*Salmo salar*) (Lambooij *et al* 2010) since individuals may recover consciousness before death.

Verification of loss of consciousness through objective assessment was not reported; however, it is essential to guarantee standards are upheld. The absence of vestibulo-ocular reflex, regular breathing pattern and swimming behaviour immediately after stunning, in combination with technical measurements of the stunning parameters (eg voltage and amperage delivered in the case of electronarcosis) are considered good indicators for fish consciousness assessment (Robb & Kestin 2002; OIE 2021). Finally, the EFSA (2018) recommends a two-step approach for assessing a stunning protocol: (i) establishment of specifications in a laboratory setting to protect fish at slaughter, using EEG measurements; and (ii) evaluation of the subsequent implementation of the results in practice or under similar conditions. Similar methodology is proposed by the European Union Aquaculture Advisory Council, which warns that although it is often not practical to test for unconsciousness on-farm (eg EEG cannot be measured in this setting), it is essential to verify the reliability of stunning parameters in practice, to ensure the fish do not recover consciousness before death (Boyland & Brooke 2017).

From the remaining companies, 23 (59.0%) declared they did not perform other procedures after stunning, suggesting death by asphyxiation and one (2.5%) performed decapitation (Table 1). Neither method promotes instant unconsciousness, causing additional stress and, thus, cannot be considered humane (Hastein *et al* 2005; Branson 2008; Pedrazzani *et al* 2020; OIE 2021).

Animal welfare implications

Welfare research and regulations for fish continue to lag behind those for farmed mammals and birds with, in particular, a paucity of information regarding slaughter practices. The attention to current slaughter methods may contribute to the sense of urgency for the development of alternatives to mitigate this significant fish welfare issue. Our findings may motivate further studies and regulatory actions, by exposing the severity of the welfare challenges in the final life stages of fish used as human food.

Conclusion

Most commercial Brazilian fish processing establishments do not carry out humane slaughter practices. Knowledge about the techniques used and the monitoring of their effectiveness are extremely important for the mitigation of the significant welfare problems faced by fish slaughtered in Brazilian establishments. In addition, more research is

needed regarding the fasting period imposed on fish, especially as the situation in other countries may be similar. Our findings may support future research and development of protocols, as well as improvements in regulations to mitigate fish suffering caused by the current slaughter methods and associated practices.

Declaration of interest

Acknowledgements

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