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REVIEW

Major Sustainable Development Goals applied to Aquaculture

Lissandra Souto Cavalli[1], Andréa Ferretto da Rocha[1], Benito Guimarães de Brito[1], Kelly Cristina Tagliari de Brito[1], Marco Aurélio Rotta[1]

Abstract - Aquaculture based on environmentally friendly practices is the best alternative for building a better world when it comes to the production of food of animal origin. The 17 Sustainable Development Goals (SDG) of the United Nations (UN) reinforce and direct this new form of farming. Scientists and farmers are concerned with maintaining stocks and sources of natural resources for the next generations, as well as for the maintenance of life on earth. In this perspective, this work brings together the 17 SDG around aquaculture. It briefly presents how we can apply them to make aquaculture better, more sustainable and productive.

Keywords: 17 SDG. UN. Eco-friendly. Food security. Decent work.

Principais Objetivos de Desenvolvimento Sustentáveis aplicados à Aquicultura

Resumo - A aquicultura baseada em práticas ecologicamente corretas é a melhor alternativa para a construção de um mundo melhor no que se refere à produção de alimentos de origem animal. Os 17 Objetivos de Desenvolvimento Sustentável (ODS) da ONU reforçam e direcionam essa nova forma de agricultura. Cientistas e agricultores estão preocupados em manter estoques e fontes de recursos naturais para as próximas gerações, bem como com a manutenção da vida na Terra. Nessa perspectiva, este trabalho reúne os 17 principais ODS em torno da Aquicultura e apresenta de forma resumida como podemos aplicá-los para tornar a aquicultura melhor, mais sustentável e produtiva.

Palavras-chave: 17 ODS. ONU. Eco-amigável. Alimentação segura. Trabalho decente.

[1] Departamento de Diagnóstico e Pesquisa Agropecuária, Secretaria de Agricultura, Pecuária e Desenvolvimento Rural do Rio Grande do Sul, Brazil. *Correspondent author: liscavalli@gmail.com

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Introduction

The development of aquaculture as a subsistence activity presents itself as a relevant alternative to extractive fishing, from the perspective of threatening wild fish stocks. The 17 goals and 169 targets that make up the United Nation (UN) Sustainable Development Goals (SDG) have been in force in Brazil since 2015. These goals and targets involve diverse themes such as poverty eradication, health, education, water and sanitation, energy, food security and agriculture, sustainable patterns of consumption and production, protection and sustainable use of oceans and terrestrial ecosystems, among others. In this sense, aquaculture activity can permeate several of these objectives collaborating with sustainable development, particularly with goal 14.7, which states that "by 2030 it is necessary to increase the economic benefits for small island developing states and countries of lower relative development from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

According to the Food and Agriculture Organization (FAO) report (FAO, 2014), increased aquaculture activity is key to meeting the demand for food associated with global population growth, and more and more people depend on aquaculture activity for food and income. The report also reports that about 17 percent of the world's protein consumption (up to 70 percent in some coastal and island countries) comes from fish, making it a food security item.

The increase in aquaculture activity has contributed in recent years to the feeding and supply of quality protein to many people, especially in poor rural areas, where food often lacks essential nutrients. Aquaculture is considered the fastest growing food production sector in the world (TACON, 2020). However, FAO (2014) warns that to continue to develop sustainably, the aquaculture sector must increase efforts to become less dependent on wild fish for feed and implement greater diversity of species and practices in aquaculture.

According to FAO (2017, 2017b), implementing sustainable aquaculture is therefore central to achieving many of the SDGs. This will directly affect the success of SDG 1 (end poverty); SDG 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture); SDG 3 (health); SDG 6 (water); SDG 13 (climate action); SDG 14 (marine ecosystems), SDG 15 (terrestrial ecosystems, forests and land). As well as will significantly influence the outcome of several other goals and targets related to economic growth and employment (SDG 8), gender equality and empowerment of women (SDG5), access to resources, responsible consumption and production (SDG12); and the achievement of SDG 16 on peace and inclusive societies, and SDG 17 on means of implementation and partnering for sustainable development. Although the 17 SDGs are completely interconnected, we will try to show a perspective in which aquaculture fits into each of the SDGs with the greatest adherence to aquaculture (FAO, 2017).

Review Methodology was performed searching by keywords on 17 SDG applied aquaculture data using the Google Scholar and Web of Science databases, through a wide range of related keywords. The surveys were conducted in English and Portuguese. At the end of the searches in each database, indexed original articles related with one of the SDG addressed in this manuscript were included, regardless of the date of

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publication. FAO and International Labour Organization (ILO) databases were also used.

Aquaculture and economic and social inequality (SDG 1 and SDG 2)

SDG 1 (end poverty in all forms everywhere) is particularly important in low-middle income countries. This is because, according to the UN, 10% of the world population live in extreme poverty, and the poverty rate in rural areas is three times higher than urban areas. Poverty alleviation is linked to zero hunger - SDG 2 (Zero hunger). Increasing aquaculture productivity and sustainable food production are crucial to help alleviate the dangers of hunger (UN, 2021).

Aquaculture can influence poverty alleviation in two main ways: by increasing income for family farmers and by generating jobs, specifically for very low income or poor people, by larger scale producers. In this way, aquaculture offers an effective mechanism to lift out of poverty for those able to enter the sector (STEVENSON; XAVIER, 2009). So, aquaculture can contribute to the alleviation of poverty and hunger through the entry of the poorest population in the sector, employment of poor people in aquaculture farms, as well as in other sectors of the supply chain, poor farmers integrating aquaculture on small farms and the supply of fish for consumption by the poor population. However, some authors emphasize that the literature still questions whether and how aquaculture has a satisfactory effect on poverty alleviation (STEVENSON; XAVIER, 2009; BÉNÉ *et al*., 2016). On the other hand, a study from Tanzania showed that the increase in fish production with government incentives, provided more opportunities for people to be employed and earn money, as well as greater availability of animal protein (MOSCHA, 2020). In low-income populations or low-middle income countries, this can be a real opportunity to reduce hunger and poverty, as long as there are incentives on the part of governments.

Aquaculture and human rights impacts (SDG 5 and 8): Gender equity and Decent work

SDG 5 refers to achieving gender equality and empowering women and girls. Women are victims of discrimination, much more than men, and often report finding barriers, prejudice, sexism, and harassment in the aquaculture labor market (ROSALEM; NAGATA, 2018). Aquaculture is gendered as most farm production is undertaken by men. Women's participation varies according to the type and scale of aquaculture (BRUGERE; WILLIAMS, 2017). However, the empowerment of women and the promotion of gender equality in all social and economic activities are guarantees for the effective strengthening of economies, business dynamism, improved quality of life for women, men and children, and sustainable development (UN WOMEN, 2013). Promoting greater participation of women in aquaculture, with equal wages and opportunities in the sector, means valuing aquaculture, providing dignity and decent work for working women. From this gender perspective, it is essential to initiate a process of women's empowerment, through studies, actions and strategies that seek equality and women's participation in aquaculture (MARQUES *et al*., 2018). Women's participation in world aquaculture is mainly based on feeding, harvest and fish and shellfish processing. In LAC, women participate mainly in small scale or family productions. They can act as managers or owners of small domestic companies, ie fish ponds to increase the income and family nutrition (CAVALLI; MARQUES; WATTERSON, 2020). Women in fishing communities also lack access to credit or to co-financing systems for running their activities. Access to credit to invest in aquaculture provides possibilities for production improvements and risk control measures, such as PPE investment.

The low participation of women in worker organizations in aquaculture is a limitation to be considered. Fishermen's organizations, for example, were traditionally formed by men and access for women has been slow. This is due not only to the organizations themselves where power and internal dynamics are all too often the territory of men, but also because women do not recognize they are as capable as men and may not be motivated to join these organizations (FAO, 2016b; CAVALLI; MARQUES; WATTERSON, 2020).

According to Bosma *et al*. (2019), many countries have developed Gender Action Plans (GAPs) that support equal access for both sexes to education, employment and finance. Gender action plans in the aquaculture value chain are needed to tackle persistent gender biases, especially in countries with strong patriarchy (BOSMA *et al*., 2019). Strengthen gender equity in aquaculture to undergo a structural change in society, in which women have the same rights as men, in salary or in the conditions to be chosen in a job vacancy, for any activity in the sector. But mainly, in decision-making positions.

Another relevant aspect is the eradication of child labor in all social areas, including aquaculture. Child labor is closely linked to situations of extreme poverty. In this sense, ILO Conventions 138 and 182 are relevant to controlling child labour (ILO, 2018). The eradication of child labour is closely related to decent work (SDG 8), poverty eradication (SDG 1), the reduction of inequalities (SDG 10) and the inclusion of children in school environments (SDG 4).

FAO and ILO (2013) published a Guide to combat child labor in the fisheries and aquaculture sector, highlighting decent work and eradication of child labor. The objective was to guide governments, development partners, fisher's organizations, fishers, workers and employers in the fisheries and aquaculture sector on child work. The document points out important considerations and measures to effectively address child labor. It includes an overview of current international legal and regulatory frameworks; requirements for better information and how to obtain data; practical measures against child labor, based on the strategies defined by the ILO (prevention, removal, orientation and rehabilitation and protection) (CAVALLI; MARQUES; WATTERSON, 2020).

In Latin America, 48% of the 12 million working children are engaged in agricultural activities. Child labor is a response to poverty, the lack of opportunities for the whole family and the need to generate income for household subsistence. Adding to these problems is the belief by many parents that child labor is a positive thing (ILO, 2016). This is a major concern and efforts must be combined to ensure the eradication of child labor. At the Third World Conference on Child Labor, Latin American and Caribbean countries committed themselves to accelerating the reduction of child labor in the region (CAVALLI; MARQUES;

WATTERSON, 2020).

Child labor is prohibited in ILO Conventions 138 and 182 as well as in the UN Universal Declaration of the Rights of the Child. Both conventions were ratified by most Latin American countries. All nations, researchers and employers must be aligned with these treaties to eradicate all forms of exploitation and child labor all around the world (CAVALLI; MARQUES; WATTERSON, 2020).

Decent work (SDG 8) is work adequately remunerated, performed in conditions of freedom, equity and security, capable of guaranteeing a decent life (ILO, 2006). FAO has a decent work program that covers improvements in working conditions for aquaculture (WATTERSON *et al*., 2019). ILO programs applied to aquaculture include the International Program on the Elimination of Child Labor and Forced Labor, Occupational Safety and Health - Global Action for Prevention and the Better Work program, which has a 'decent work' approach linked to worker empowerment, should be applied to aquaculture (WATTERSON *et al*., 2019). Decent work is among the 17 UN Sustainable Development Goals (SDG). SDG 8 aims to promote inclusive and sustainable economic growth, full and productive employment, and decent work for all.

Aquaculture plays an important role in social development. Besides the direct generation of food and income, there is the generation of jobs, directly or indirectly. Therefore, decent work and decent pay contribute to improving the quality of life and reducing poverty. When the worker has a decent wage, this guarantees dignity, freedom and better conditions for survival and family support (CAVALLI; MARQUES; WATTERSON, 2019). Decent work means a decent life with the guarantees of a safe workplace. Ensuring decent work means providing "a fair income, place of work and social protection for families; better prospects for personal and social development; freedom for people to express their concerns and to participate in decisions that affect their lives; equal opportunities and treatment for all women and men". Decent work is a universal goal, based on fundamental guarantees, which should be aligned with activities in aquaculture as well (FAO, 2016c), addressed by Goal 8 (Decent work and economic growth) from United Nations. Decent work also impacts on forms of discrimination against minorities and the use of child labor, both of which are related to the dignity and freedom of individuals. In this way, promoting a safe working environment is to ensure the establishment of decent work for aquaculture workers as well (CAVALLI; MARQUES; WATTERSON, 2020).

Aquaculture and environmentally friendly production (SDG 6 and SDG 12)

Aquaculture under a sustainable and environmentally friendly perspective is approached by SDG 6 (Ensure availability and sustainable management of water and sanitation for all) and SDG 12 (Ensure sustainable consumption and production patterns). Production technologies in integrated and multitrophic systems have been improved in order to develop economically, environmentally and socially sustainable production systems. These technologies include the RAS recirculation system, bioflocs system and aquaponic.

RAS (Recirculation Aquaculture System) is based on a system with low or no water renewal, used only

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to replace losses by evaporation (FERRI; ROCHA; BRAZ FILHO, 2018). In this system, the water of the culture tanks passes through a biological filter for the action of nitrifying bacteria responsible for the conversion of ammonia to nitrite and, later, to nitrate, a compound less toxic to animals (FERRI; ROCHA; BRAZ FILHO, 2018).

The bioflocs system is based on the conversion of nitrogen compounds present in the water, especially the ammonia excreted by the animals, into bacterial biomass, called bioflocs, by the heterotrophic bacteria of the environment, functioning as a biofilter (AVNIMELECH, 2007). This occurs in the aquatic environment due to the maintenance of a high C:N ratio (between 15:1 and 20:1) in the water through the addition of feed and an additional source of organic carbon, such as molasses and wheat bran (AVNIMELECH, 1999). This system has been researched and developed worldwide, both for fish and shrimp, and even for both together in a multitrophic system, with countless environmental and economic advantages, although it depends on significant knowledge about the system's functioning and intense management. The bioflocs system has been researched to be used as a multitrophic system, where different species are raised together, optimizing the system resources, and good results have already been demonstrated in the maintenance of shrimp, which is the target species, together with mullets, secondary species (HOLANDA *et al*., 2020; BORGES *et al*., 2020).

Aquaponic is the interaction between hydroponics and aquaculture (Fig. 1), where one culture benefits from the byproduct of another, causing the respective ecological gaps of both systems to be converted into strengths, considerably reducing the need for nutrient inputs and effluent production, as opposed to when the same systems are executed individually (RAKOCY *et al*., 2006). Thus, aquaponic promotes the production of plants in a recirculation system integrated to the production of fish or other aquatic animals, being the plant culture nourished by the aquaculture effluent and can be produced in an organic way.

The production process of vegetables in an aquaponic system allows two products to be produced together, and in an environmentally friendly way. This process can be a facilitator of both environmental licensing and the implementation of the fish farming project, also meeting an increasing demand for healthy and organic products (ROCHA *et al*., 2017).

Investment in sustainable production systems for aquaculture is an alternative that should be encouraged to ensure environmental protection that is also economically viable and socially just. The native fish species are in the ranking of the most produced fish in Brazil (SAINT-PAUL, 2017). However, tilapia is the leading fish-farmed species in Brazil representing 57 percent of the total national farming (PEIXEBR, 2020; MARQUES *et al*. 2020). Boosting the production of native species in the country, Brazilian research institutes have focused on improving technologies that enable greater production of native fish, such as matrinxã (GOMES *et al*., 2020), surubim and its hybrids (FANTINI *et al*., 2020), silver catfish (BALDISSEROTTO; RADÜNZ-NETO, 2004; MARTINELLI *et al*, 2013; POLI; SCHVEITZER; NUNER, 2015; ROCHA *et al*., 2017, tambacu (REIS NETO *et al*., 2020; CARDOSO *et al*., 2020), pacu (REIS NETO *et al*., 2020), curimatã (ALMEIDA *et al*., 2015), mullet (BORGES *et al*., 2020; HOLANDA *et al*., 2020;

ROCHA *et al*., 2012), pink shrimp (WASIELESKY Jr. *et al*., 2018), among others. The development of technologies for the creation of native species is a path that may be more appropriate to local ecosystems, as well as with the objective of serving local markets (SAINT-PAUL, 2017).

Fig. 1. Image of an experimental aquaponic system at the DDPA/SEAPDR North Coast Research Center in Maquiné, RS, Brazil. Photo: Courtesy of AFR.

Regarding sustainable consumption in aquaculture, many aspects must be taken into account, such as the species produced, the production systems, applied technology, purpose, aquafeeds, inputs, etc. The increase in aquaculture yield, as well as intensive systems, has reached a peak in demand for essential ingredients used in aquafeeds, especially fish meal and fish oil (SHEPHERD; JACKSON, 2013). However, many efforts have been made in an attempt to replace fish meal and fish oil from fish caught in aquafeeds.

Studies have already shown, for example, that it is possible to reduce the catch of wild fish by up to 30% by replacing it with marine microalgae products (BEAL *et al*., 2018). An example of replacing fish meal and fish oil is the use of the microalgae Spirulina and linseed oil, up to 50%, in mullet *(Mugil liza*) juveniles diet (ROSAS *et al*., 2019).

Soybean products, like bioprocessed soybean meal (VOORHEES *et al*., 2019) and fermented soybean meal (CHOI *et al*., 2020), can replace at least 80% and 40% of the fish meal in rainbow trout (*Oncorhynchus mykiss*) diets, respectively. It was also verified the possibility of replacing fish meal with fermented soybean meal up to 40% for Japanese sea bass (*Lateolabrax japonicus*) (RAHIMNEJAD *et al*., 2019) and up to 20% for juvenile white shrimp (*Litopenaeus vannamei*) (SHAO *et al*., 2019). In addition to soybean flour, other sources of fish meal replacement have been tested, such as mealworm (IDO *et al*., 2019) and fly larvae meal

(LI *et al*., 2020), which can replace 100% of fishmeal in diet for red seabream (*Pargus major*) and for Atlantic salmon (*Salmo salar*), respectively.

As explained, many other sources of protein and oil are being researched for aquafeeds production, expending efforts in the search for alternative ingredients to fish by-products, in an attempt to reduce the fishing pressure and promote more sustainable aquaculture.

Aquaculture and Ocean protection and climate change (SDG 13 and SDG 14)

Enhanced sustainable production (ESP) in aquaculture resources is a goal that is included in several international agreements, for example Rome Declaration of the Second International Conference on Nutrition (ICN2), the United Nations Framework Convention on Climate Change (COP21) and in the 2030 Agenda for Sustainable Development (FAO, 2016). The COP21 emphasizes the importance of oceans and aquatic ecosystems for the regulation of temperature and carbon sequestration, and highlights the need to combat pollution, overexploitation and restore productivity and ecosystem services (FAO, 2017b). This is particularly important from the perspective of SDG 13: (Take urgent action to combat climate change and its impacts) and SDG 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development).

Duarte *et al*. (2017) present the important role of seaweed farms, such as potential CO2 mitigation. Seaweed aquaculture contributes to climate change adaptation by damping wave energy and protecting shorelines, and by elevating pH and supplying oxygen to the waters, thereby locally reducing the effects of ocean acidification and de-oxygenation.

Stentiford *et al*. (2020) report some success metrics for aquaculture ESP, regarding the environment, through the One Health perspective, including optimal water usage and quality, protected biodiversity and natural capital, low-energy production and a low spatial footprint. Therefore, to achieve these goals it will be necessary to use water resources efficiently, avoiding the factors that may adversely impact the environment, minimizing negative impact of aquaculture on natural biodiversity and designing aquaculture systems to be energy efficient.

Depending on how it is structured, aquaculture can be beneficial for biological and ocean conservation. The concept of conservation aquaculture (CA) supports this understanding. In this way, it highlights the ways in which aquaculture has historically, and is currently being integrated into conservation (for example, restoration of oyster bed habitats) and areas that could be improved for the protection of critical species and habitats, for example, trade in coral reefs in aquariums (FROEHLICH; GENTRY; HALPERN, 2017). According to these authors, conservation aquaculture is not a hypothetical idea. Almost all possible ways of aquaculture can be used to improve the status and condition of species and ecosystems are already in place somewhere on the planet, usually at the local level, but occasionally on larger scales. Calling attention to such approaches helps to highlight the potential of aquaculture to assist conservation, guide how to scale practices appropriately and, finally, offer conservationists a new tool. Evidently, sustainable and eco-friendly aquaculture has become one of the most promising ways to increase the production of marine fish in the future, as the capture of wild fish expands the limits of renewable production (NAYLOR; BURKE, 2005).

Aquaculture and life on land (SDG 15)

It is consensus that all decisions related to any phase or link in the aquaculture chain will have more or less impact on the environment, and the choice of farmed species must take into account that their production must cause minimal impact on the farm as well as the environment. This runs through the diet, production system, health and environmental issues, among others.

This is related with target 15.8: by 2020 introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems, and control or eradicate the priority species. Currently, about 10% of fish biomass caught from wild-capture fisheries is used to feed high value, and often carnivorous, species (FAO, 2018). Aquafeeds are still dependent on fish meal and fish oil from forage fish caught in the wild, what is already becoming unsustainable. In this way, the aquaculture industry needs to develop programs for plant-based diets or from other sources of protein, ensuring genetic gain and productivity (HUA *et al*., 2019).

Additionally, there is a need for an increase in research aimed at developing technological packages for the production of native fish. However, this is a concern of the main aquaculture research institutions in Brazil, which have already been developing studies with native species, as previously described.

Aquaculture under One Health perspective

The One Health approach has been recognized as an important element of disease control and prevention strategies by agencies including the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (OIE) and the World Health Organization (WHO) (RABINOWITZ *et al*., 2013; CAVALLI; BRITO; BRITO, 2015). It is a practical and innovative approach to global health challenges that recognizes the interconnections between humans, animals and their shared environment also with the economic, cultural and physical factors that influence health (CONRAD; MEEK; DUMIT, 2013).

The concept of One Health applied to aquaculture includes many aspects involving animal, human and environmental health, politics, economics and social developments. This approach seeks to ensure a healthy system of aquaculture in which production includes environmentally friendly practices, good farming practices, and human and food health and safety (CAVALLI; BRITO; BRITO, 2015). Healthy animal production systems converge with efforts to reduce the risk of disease outbreaks through the implementation of agricultural and development policies that improve food security (LUBROTH, 2013) as well as human health. As Stentiford *et al*. (2020), we underscore the importance of increasing aquaculture production through the One Health perspective, which will define a set of successful metrics - underpinned by evidence, policy and legislation - that must be incorporated into aquaculture sustainability.

Actions and challenges for aquaculture development

Investment and development actions are needed to support aquaculture, especially in developing countries. From family farmers to large-scale aquaculture they need structuring and incentives to strengthen and organize the production chain. Support for sustainable aquaculture should be prioritized, with generation and implementation of environmentally friendly production units. Investment in sustainable production systems for aquaculture is an alternative that should be encouraged to ensure environmental protection that is also economically viable and socially just (MARQUES *et al*., 2020).

Research then plays a key role in generating knowledge applied to aquaculture. Support for aquaculture research should be among the public policies for the sector. Research support is based on specific calls for proposals for aquaculture, opening of undergraduate and graduate programs for training of qualified human resources and intellectual capital focused on the production chain and generation of products, processes and services, as well as innovations and application of knowledge and new technologies directed to this field.

The strengthening of the supply chain also involves the organization of associations, unions, integrative networks for technology transfer and discussion, reference units for training and transfer of production technologies. The qualification of fish farmers and workers is an important step in the modernization and training of the aquaculture chain. These qualifications should include sustainable management and production techniques as well as animal health and occupational health. Regarding animal health, it is necessary to ensure health protection and diagnostic methods with trained and qualified personnel in aquatic animal health production (OLIVEIRA *et al*., 2015).

The challenges regarding aquaculture range from demands related to sustainability, licensing requirements for production, aquatic animal health, occupational health and safety, economic challenges related to increased investment and the application and effectiveness of certification schemes. Certifications are expensive and time consuming, requiring a high financial investment from the producer (MARQUES *et al*., 2020). However, incentives should be proposed in this regard, including public policies created specifically for the sector to promote differentiated aquaculture. Regarding fish production, possible solutions to reduce potential environmental conflicts include the use of native or sterile species; monitoring of rearing and adoption of measures to control and prevent fish escape (ZANIBONI-FILHO; PEDRON; RIBOLLI, 2018; MARQUES *et al*., 2020).

A better world requires better practices for aquaculture, taking into consideration so many issues involved, such as environmental, health and labor issues, in order to ensure that the activity is economically viable but guaranteeing the preservation of the environment as well as the health of all.

Conflict of interests

The authors declare that the research was conducted in the absence of any potential conflicts of interest.

Ethical statements

The authors confirm that the ethical guidelines adopted by the journal were followed by this work, and all authors agree with the submission, content and transfer of the publication rights of the article to the journal. They also declare that the work has not been previously published nor is it being considered for publication in another journal.

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ORCID

Lissandra Souto Cavalli https://orcid.org/0000-0001-8531-7362
Andréa Ferretto da Rocha https://orcid.org/0000-0002-0445-1277
Benito Guimarães de Brito https://orcid.org/0000-0001-7815-5166
Kelly Cristina Tagliari de Brito https://orcid.org/0000-0002-0429-8276
Marco Aurélio Rotta https://orcid.org/0000-0002-5026-3306

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