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Challenges and potentialities of the integrated production regime implementation in the Brazilian marine shrimp farming: a systematic review

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Abstract

Integrated production (IP) is a relatively new production regime that supports environmental, labor, and management issues through the production process. As the marine shrimp farming in Brazil has been recently impacted by environmental and sanitary issues, IP principles could provide tools to improve the productivity in a systemic method. Our goal was to compare a hypothetical IP shrimp farm with the conventional cultivated marine shrimp production (CP) and identify possible challenges that IP would face if adopted as an alternative production regime for the Brazilian shrimp farming scenario. IP and CP data were obtained through application of PRISMA (preferred reporting items for systematic reviews and meta-analyses) methodology and the comparison was conducted through a strength, weakness, opportunity, and threat (SWOT) analysis and based on concepts derived from the Delphi methodology. The results indicate that the major challenges for IP in Brazil are as follows: (i) the absence of specific technical standards (STS) for the certification of shrimp farms, (ii) the possibility of increasing investment costs for implementation and operation of certified farms, and (iii) non-differentiation in the internal market of certified and non-certified products. Conversely, IP introduces significantly superior forces than CP. The most important of these forces are (i) the adoption of a systemic view of the productive chain, (ii) the traceability of products and processes, (iii) the reduction of barriers to environmental licensing of aquaculture farms, (iv) the reduction of risks and damages caused by diseases, and (v) the optimization in the use of natural resources, inputs, and energy.

Keywords Aquaculture · Certification · Delphi methodology · Production regime · Shrimp farming · SWOT

This paper has not been submitted elsewhere in identical or similar form, nor will it be during the first three months after its submission to the Publisher

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Introduction

Marine shrimp farming is one of the fastest-growing animal production sectors worldwide (Kumar et al. 2016; Kumaran et al. 2017). Currently, approximately 50% of shrimps consumed in the world (approximately 4,000,000 mt/y) are derived from aquaculture (FAO 2016).

In Brazil, shrimp farming is characterized as one of the main production activities of the national aquaculture, and the country is the second largest producer of cultivated shrimp in the Americas (Rocha 2015b; FAO 2016). Brazil has approximately 2500 farms dedicated to the cultivation of shrimp. Of these farms, 74% are classified as small (up to 10 ha), 23% as average (greater than 10 ha and less than 50 ha), and 3% are considered large (greater than 50 ha) (Araújo 2015; Rocha 2015a). Most of these farms adopt intensive and semi-intensive production regimes, which explains the high average productivity (3500 kg/ha) of the enterprises installed in the country (Rocha 2015b; Nascimento Vicente et al. 2017).

Brazilian shrimp farming fosters a complex production, processing, and distribution chain, involving companies, producers of post-larvae, inputs, equipment, processing, technical consulting, logistics, and marketing, which confers a notable socio-economic role on the national production scenario (Rocha 2015a, b). Therefore, in addition to direct financial benefits, shrimp production can help to promote social inclusion and development in rural areas, as well as being a source of jobs (direct and indirect) and products of high added value (Natori et al. 2011; Ribeiro et al. 2014; Rocha 2015a).

Nevertheless, Brazilian shrimp farmers still face a series of problems that hamper the regularization of these ventures, deterring new investors, and limiting the development of the activity, such as (i) slow and extensive bureaucracy related to the environmental licensing process (ABCC 2013); (ii) conflicts with other users of coastal areas, such as raftmen, shellfish extractors, and artisanal fishers (Pinto et al. 2015), as well as other extractors (Dias et al. 2012); and (iii) problems related to the polluting potential of this shrimp farming, mainly due to the effluents from the cultivation systems (Ribeiro et al. 2014; Cardoso-Mohedano et al. 2016). In recent years, Brazilian producers have also faced serious outbreaks of diseases affecting cultivated shrimps, such as the White Spot Syndrome (WSSV). WSSV impacted the shrimp production scenario of several countries, resulting in large financial losses (de Negreiros and Santos 2015; Thitamadee et al. 2016).

In view of this scenario, which generally is repeated throughout all the shrimp-producing regions in Brazil, it is crucial to seek new alternatives for the operation and management of shrimp farms. The integrated production (IP) regime would represent an additional option to address some of these bottlenecks that threaten the existence of currently installed enterprises and limit the expansion of shrimp farming in Brazil.

According to Titi et al. (1995) and Andrigueto et al. (2003), IP is a regime aimed at producing food and other high-quality products with the main goals of (i) minimizing all types of losses and wastes generated in both the pre- and post-production phases; (ii) reducing the use of energy and products (e.g., fertilizers, pesticides, antibiotics, fuels, or any other inputs) through intelligent management of natural, human, and financial resources; iii) maximizing the environmental, social, and economic benefits related to the production system; and iv) providing consumers with tracked and certified final product.

This regime has been successfully employed in different areas of Brazilian and global agricultural production, as in the fruit growing (Fachinello et al. 2003; Pereira et al. 2010; Braga Sobrinho 2014; de Souza et al. 2014; Junior et al. 2017; de Mendonça et al. 2017), cattle breeding (Andrigueto and Kososki 2005), aviculture (Lima 2017), and horse breeding sectors

(Medeiros et al. 2005), among others. There is, however, no shrimp farm certified by the IP regime in Brazil.

IP is a voluntary and free-adherence production process. However, to obtain the certification of its ownership or its productive process, the producer must follow a rigorous set of specific technical standards (STS) and must have their property periodically audited (MAPA 2017). In Brazil, certification of conformity is carried out by companies previously accredited by the National Institute of Metrology, Quality, and Technology (Inmetro). The management and promotion of IP-Brazil are conducted by the Ministry of Agriculture, Livestock and Food Supply (MAPA), which also coordinates the partnerships necessary for administrative, financial, operational feasibility, and execution of conformity assessment. However, in the case of shrimp farming, there are no STS established for certification.

The objective of the present work was to comparatively and conceptually analyze IP and conventional production (CP), evaluating the challenges and potential involved in the use of IP as a tool for sectoral development of shrimp farming in Brazil under social, economic, environmental, and management considerations.

Materials and methods

The comparison between IP and CP of shrimps was conducted by a SWOT analysis (initials of Strengths, Weaknesses, Opportunities, and Threats) based on the methodology proposed by Weihrich (1982) and Silva Filho (2015).

In order to compose the SWOT matrix, a broad systematic literature review and application of the PRISMA methodology (Moher et al. 2009) were used. The literature review was carried at scientific databases (Web of Knowledge, Wiley Online Library, Web of Science, Science Direct, Springer, Portal of Newspapers CAPES, Scopus, Google search engine, and Google Scholar) using the internet protocol number of the Federal University of Paraná. Search was performed in English and Portuguese, with the terms presented in Table 1, and included books, scientific articles, technical articles, case studies, theses, and dissertations published until August of 2017. At the end of the search phase, 3,030,000 documents were obtained. After systematic selection, 30 technical and scientific articles met the established prerequisite: to present concepts, fundamentals, and/or results that allowed the identification and evaluation of the current challenges and potentialities of CP or IP of cultivated shrimps.

The main themes (here defined as "Components") discussed in each document, found during systematic review, were later grouped into the following "thematic areas": (1) technical,

Table 1 Search terms used for research on topics related to integrated and conventional shrimp production

Integrated production	Conventional production
"Shrimp" and "Integrated production"	"Shrimp aquaculture"
"Integrated production" and "aquaculture"	"Shrimp farming"
"Shrimp farming" and "Integrated production"	"Shrimp farm"
"Integrated production" and "forces"	"Shrimp farming" and "forces"
"Integrated production" and "weaknesses"	"Shrimp farming" and "weaknesses"
"Integrated production" and "opportunities"	"Shrimp farming" and "opportunities"
"Integrated production" and "threats"	"Shrimp farming" and "threats"
"Integrated production" and "challenges"	"Shrimp farming" and "challenges"
"Integrated production" and "potentialities"	"Shrimp farming" and "potentialities"

(2) organizational, (3) economic, (4) market, (5) social, (6) environmental, (7) sanitary, and 8) institutional. These "thematic areas," in turn, were organized according to the "categories" used in a SWOT matrix.

As there are no IP-certified shrimp farms, information related to forces, opportunities, weaknesses, and threats were listed based on different areas of Brazilian and world agricultural production, which have already been successful with the implementation of this production regime such as fruit production (Fachinello et al. 2003, Braga Sobrinho 2014; Andrigueto and Kososki 2005), poultry farming (Lima 2017), and cattle ranching (Medeiros et al. 2005), among others. The components were organized according to SWOT categories (Strengths, Weaknesses, Opportunities, and Threats) and transformed into quantitative indexes called in the present work of "final score." The "final score" of each "component" was calculated by Eq. 1:

$$\mathrm{P} = \mathrm{I} \times \mathrm{D} \tag{1}$$

where:

P Final score calculated for each CP and IP component;
I Relevance degree of each component;
D Performance index of each component.

The "relevance degree" was defined on the basis of concepts and techniques derived from Delphi methodology (Linstone and Turoff 1975), which is widely used to seek consensus regarding the risks of a project (Pareja 2002). In the present case, the degree of relevance was associated with the total number of citations on the "Google" and "Google Scholar" search platforms for terms representative of each component of the SWOT matrix. For example, if the component to be surveyed was related to the productivity of shrimp farms, the terms used were "productivity" and "shrimp farming." If the component was related to the susceptibility of cultured shrimp to disease, the terms used included "susceptibility," "diseases," and "shrimp farming." After tabulation of the number of citations obtained for each component, i.e., for each strength, weakness, opportunity, and threat. Then, Eq. 2 was used to calculate the "relevance degree."

$$\mathrm{I} = \mathrm{Z}\left[(\log \mathrm{G} + \log \mathrm{GA}) \div 2\right] \tag{2}$$

where:

I Relevance degree;
Z Set of integers;
G Number of citations obtained for each component searched on Google;
GA Number of citations obtained for each component searched on Google Scholar.

The "performance index," adapted from Nogueira (2010), considered the current and future scenarios related to each production regime (CP and IP) and the degree of sensitivity of these regimes to each of the analyzed components. The integer values attributed to each component ranged from 1 to 3. Strengths and opportunities were represented with a positive sign, and weaknesses and threats were represented with a negative sign.

The final score obtained for the set of components of each category was analyzed using the Shapiro-Wilk normality test, Levine's variance test, and the Brown and Forsythe's homoscedasticity test. After confirming that the data were normally distributed ($p > 0.05$), comparisons between the categories of the SWOT matrix related to CP and IP were made using the

Student's t test ($p < 0.05$). All analyses were conducted using Statistica® 10.0 software (StatSoft, USA).

Results

The main intrinsic (strengths, weaknesses) and extrinsic (opportunities and threats) characteristics associated with the productive chain of shrimp farming in Brazil, and the respective estimated quantitative parameters, are presented in Table 2.

It was observed that the largest differences in terms of final score in favor of IP were registered in relation to (1) the potential reduction of the losses caused by diseases, (2) a more systemic view on the management of the productive chain, and (3) the most efficient use of energy in its different forms. Adoption of this production regime and the associated management practices could also involve lower risks of introduction and dissemination of pathogens and occurrence of environmental impacts, as well as the possibility of reducing social conflicts that currently undermine Brazilian farmers. In contrast, CP has in its favor the fact that there is a large number of shrimp farms already operating in this production regime in the country, especially family-scale ventures. It is also important that the methods and techniques routinely used in conventional farms are relatively well dominated by agents providing technical assistance and rural extension to producers, which will not occur (at least in the first instance) with producers who seek to produce under IP standards.

When the final scores are grouped according to the respective thematic areas and represented in the form of radar-type graphs, the largest differences between both regimes relate precisely to their strengths. Regarding the set of weaknesses, opportunities, and threats, there is no such clear differentiation between CP and IP (Fig. 1).

This trend is confirmed when analyzing the sum of the final score achieved by the set of components of the two production regimes studied. In this case, there was no significant difference in relation to the final score attributed to the weaknesses, opportunities, and threats of both regimes, but the PI presented a higher sum of strengths ($p < 0.05$) than CP (Table 3).

Discussion

Similarities between IP and CP

When analyzing the common negative points between CP and IP, several problems and risks are particularly notable. For example, animal health problems represent a real and widespread weakness in Brazilian shrimp farming, which has been affected by disease outbreaks (de Schryver et al. 2014; Lafferty et al. 2015). Disease outbreaks not only harm the installed enterprises but also compromise the viability of the activity itself (Rocha 2015b). One of the ways to prevent these problems from occurring is through a national system for monitoring and controlling diseases of aquaculture animals (Figueiredo 2008). In this way, there will be an increase in the competitiveness of Brazilian products in the foreign market, which is becoming more rigorous in this regard. According to Bagumire et al. (2009), an effective health monitoring and control system would be an important tool to ensure the quality and health of shrimp animals and products. In the absence of this system, CP and IP will also be affected.

Table 2 Qualitative and quantitative parameters derived from the SWOT analysis. Degree of relevance (I), performance index (D), and final score (P) attributed to the different components of conventional (CP) and integrated (IP) production regimes of the Brazilian shrimp farming

Category	Thematic area	Component	I	$D_{(CP)}$	$D_{(IP)}$	$P_{(CP)}$	$P_{(IP)}$	$P_{(IP)} - P_{(CP)}$
Strengths	Sanitary	Reduction of damage caused by diseases	10	1	3	10	30	20
Strengths	Economic	Energy usage	9	1	3	9	27	18
Strengths	Technical	Systemic vision in production chain management	9	1	3	9	27	18
Threats	Social	Conflict with other users	8	− 3	− 1	− 24	− 8	16
Threats	Institutional	Deficiency of the public rural extension and technical assistance system	8	− 3	− 1	− 24	− 8	16
Weaknesses	Environmental	Potential to cause environmental impacts	8	− 3	− 1	− 24	− 8	16
Weaknesses	Sanitary	Risks of introducing and disseminating pathogens from the management practices adopted	8	− 3	− 1	− 24	− 8	16
Strengths	Marketing	Certification of shrimp farming products	8	1	3	8	24	16
Strengths	Economic	Optimization of resources and inputs and maximization of benefits	8	1	3	8	24	16
Opportunities	Marketing	Potential for marketing exploration to conquer new markets	8	1	3	8	24	16
Strengths	Environmental	Potential to reduce the environmental impacts associated with the activity	8	1	3	8	24	16
Opportunities	Marketing	Reduction of international trade restrictions	8	1	3	8	24	16
Threats	Sanitary	Susceptibility to diseases	7	− 3	− 1	− 21	− 7	14
Strengths	Organizational	Control and standardization of data, productive, administrative and management processes	7	1	3	7	21	14
Strengths	Economic	Economic efficiency of currently used systems	7	1	3	7	21	14
Strengths	Marketing	Process and product traceability	7	1	3	7	21	14
Strengths	Environmental	Facilitation of the environmental licensing process	6	1	3	6	18	12
Strengths	Technical	Productivity of installed enterprises	9	2	3	18	27	9
Strengths	Marketing	Quality of cultured shrimp	9	2	3	18	27	9
Threats	Environmental	Classification of activity as highly polluting by environmental agencies	8	− 3	− 2	− 24	− 16	8
Strengths	Marketing	Increased competitiveness and efficiency of the shrimp production chain	8	2	3	16	24	8
Strengths	Social	Development of the surrounding communities through the generation of direct and indirect jobs	8	2	3	16	24	8
Threats	Institutional	Bureaucracy related to environmental licensing	6	− 3	− 2	− 18	− 12	6
Opportunities	Organizational	Possibility of group (associations and cooperatives) certification	3	1	3	3	9	6
Opportunities	Economic		6	2	3	12	18	6

Table 2 (continued)

Category	Thematic area	Component	I	$D_{(CP)}$	$D_{(IP)}$	$P_{(CP)}$	$P_{(IP)}$	$P_{(IP)} - P_{(CP)}$
		Geographical position in relation to potential importing countries (US and EU)						
Threats	Sanitary	Absence of a national system for monitoring and control of shrimp health and biosafety	7	−3	−3	−21	−21	0
Weaknesses	Organizational	Difficulty in mobilizing and organizing small producers	8	−2	−2	−16	−16	0
Threats	Economic	High tax burden	5	−3	−3	−15	−15	0
Threats	Institutional	Ambiguous legislation and institutional uncertainty regarding its application	7	−2	−2	−14	−14	0
Threats	Economic	Anti-dumping processes	6	−2	−2	−12	−12	0
Threats	Economic	Persistent economic crisis through which the country passes	6	−2	−2	−12	−12	0
Threats	Economic	Difficulty accessing official credit lines	6	−2	−2	−12	−12	0
Weaknesses	Institutional	Risk of reduction of genetic vigor due to the prohibition of imports of breeding animals	6	−2	−2	−12	−12	0
Threats	Economic	High costs of banking financing	5	−2	−2	−10	−10	0
Weaknesses	Institutional	Political-institutional fragility of the sector	5	−2	−2	−10	−10	0
Threats	Economic	Poor infrastructure and logistics	5	−2	−2	−10	−10	0
Threats	Environmental	Legal restrictions related to the use of permanent preservation areas	5	−2	−2	−10	−10	0
Threats	Environmental	Legal restrictions related to the use of exotic species	3	−2	−2	−6	−6	0
Threats	Institutional	Repeal of the prohibition of imports of live or processed crustaceans	6	−1	−1	−6	−6	0
Threats	Economic	Exchange valuation/devaluation	2	−2	−2	−4	−4	0
Opportunities	Environmental	N/I	0	0	0	0	0	0
Strengths	Institutional	N/I	0	0	0	0	0	0
Weaknesses	Marketing	N/I	0	0	0	0	0	0
Threats	Organizational	N/I	0	0	0	0	0	0
Opportunities	Sanitary	N/I	0	0	0	0	0	0
Opportunities	Social	N/I	0	0	0	0	0	0
Weaknesses	Social	N/I	0	0	0	0	0	0
Opportunities	Technical	Development of new cultivation systems	3	3	3	9	9	0
Strengths	Organizational	Survey and dissemination of sectoral data and information	9	1	1	9	9	0
Opportunities	Economic	Entry of multinational companies producing inputs and equipment	6	2	2	12	12	0
Opportunities	Institutional	Creation of new universities and research institutions	8	2	2	16	16	0
Strengths	Social	Respect for employees' rights and working conditions	8	2	2	16	16	0
Opportunities	Economic	Expressive grain production	7	3	3	21	21	0
Opportunities	Marketing	Potential domestic market of more than 200 million consumers	7	3	3	21	21	0
Opportunities	Economic	Possibility of interiorization of shrimp farming	7	3	3	21	21	0
Opportunities	Marketing	Increased demand for shrimp in the international market	8	3	3	24	24	0
Strengths	Economic	Structured and demand-driven supply chain	8	3	3	24	24	0

Table 2 (continued)

Category	Thematic area	Component	I	$D_{(CP)}$	$D_{(IP)}$	$P_{(CP)}$	$P_{(IP)}$	$P_{(IP)} - P_{(CP)}$
Opportunities	Marketing	Decreased supply of products through extraction fishing	8	3	3	24	24	0
Strengths	Technical	Domains of production techniques and systems	9	3	3	27	27	0
Opportunities	Economic	Natural potential for shrimp farming	9	3	3	27	27	0
Strengths	Organizational	Organized aquaculture sector (large and medium-sized producers)	9	3	3	27	27	0
Weaknesses	Economic	Low capitalization level of producers	5	− 2	− 3	− 10	− 15	− 5
Threats	Technical	Low schooling and qualification level of workers	6	− 2	− 3	− 12	− 18	− 6
Weaknesses	Technical	Difficulty in hiring skilled labor	7	− 1	− 2	− 7	− 14	− 7
Weaknesses	Institutional	Lack of information and specific technical standards on PI	5	− 1	− 3	− 5	− 15	− 10
Threats	Economic	Increased installation and operating costs	5	− 1	− 3	− 5	− 15	− 10
Threats	Economic	Non-differentiation by the domestic market of certified products	8	− 1	− 3	− 8	− 24	− 16
Strengths	Organizational	Existence of enterprises in operation	8	3	1	24	8	− 16
Strengths	Social	Social importance of shrimp farming on a family scale	8	3	1	24	8	− 16

N/I, not identified

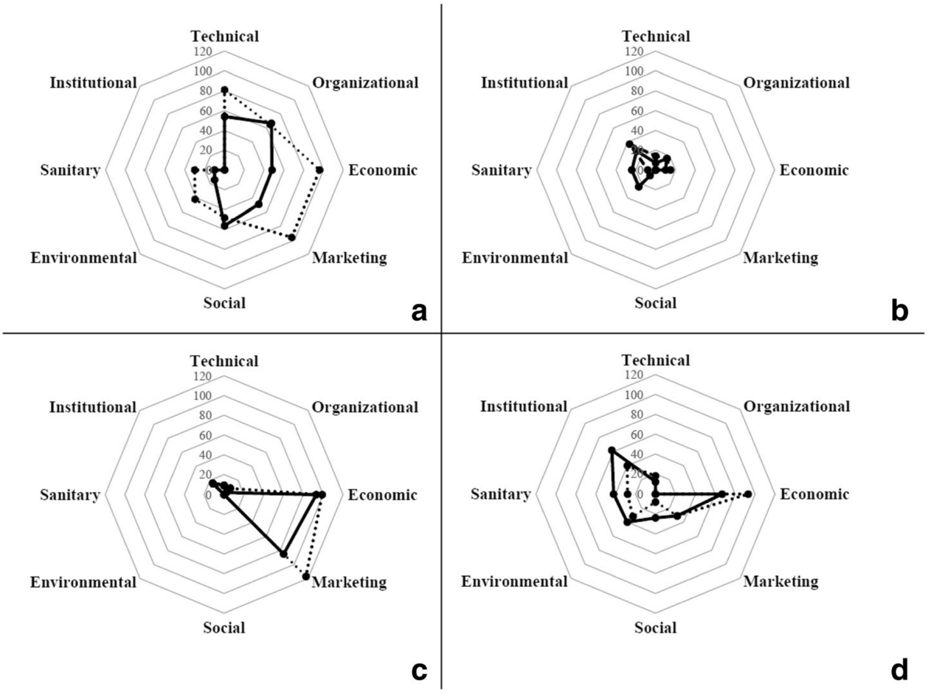

Fig. 1 Final score calculated for the conventional (—) and integrated (·····) production in the different thematic areas analyzed. (A) Strengths, (B) weaknesses, (C) opportunities, (D) threats

Table 3 Sum of the final score (P) calculated for the conventional production (CP) and integrated production (IP) in Brazilian shrimp farming

Category	$P_{(CP)}$	$P_{(IP)}$
Strengths	298^{A}	458^{B}
Weaknesses	108	98
Opportunities	206	250
Threats	278	250

Uppercase letters indicate significant differences (Student's *t* test—$p < 0.05$) between CP and IP. When significant differences were not detected ($p > 0.05$), letters were omitted

Nevertheless, there is no national system for monitoring and control of aquacultured animal disease (Figueiredo 2008), limiting the competitiveness of Brazilian products on the external market, which is increasingly strict in relation to this subject. According to Bagumire et al. (2009), an effective health monitoring and control system would be an important tool to ensure the quality and health of animals and products from shrimp farming. In the absence of this system, both CP and IP will also be affected.

Paradoxically, another threat that has relation to the production regime to be adopted is associated with a prohibition of imports of any species of crustacean, whether marine or freshwater, at any stage of its life cycle, whole or in pieces, even in the form of fresh, frozen, or processed products, of any origin (Brasil 1999). The ordinance that determined this prohibition was adopted with the aim of preventing the entry of viral pathogens into the country and protecting national shrimp farming. However, the impossibility of obtaining genetic material to renew the breeding stocks used in the country can affect the genetic variability of shrimp cultivated in Brazil (Thitamadee et al. 2016), possibly worsening the problem and affecting the activity as a whole, independent of the chosen production regime.

Another aspect in which regimes operate closely resembles the excessive bureaucracy related to environmental licensing, which causes many producers (especially the small ones) to choose between the obligation to quit or work informally. However, those who choose to work without the legalization of their farms do not have the possibility to access bank credits as formal regularization is a mandatory requirement to obtain such a benefit. As a result of this scenario, currently in Brazil, only 7% of shrimp farmers have access to official credit lines (ABCC 2013).

As a positive point, it is noted that shrimp farming is one of the most organized sectors of national aquaculture (Rocha 2015b). One of the biggest groups responsible for this organization is the Brazilian Association of Shrimp Farmers (ABCC), which has a vast history of struggles and achievements in favor of domestic producers (Schwab et al. 2002). The direct action of the ABCC with producers is also responsible for two important strengths of the national shrimp farming industry: the mastery of techniques and production systems, and the high productivity level achieved by the farms operating in the country (Nascimento Vicente et al. 2017). As the adhesion to IP does not imply the development of new techniques or production technologies, this new production regime can take advantage of this strength already present by the Brazilian CP.

Another positive similarity between IP and CP is associated with Brazil's natural potential for shrimp farming (Natori et al. 2011). The country has 7367 km of coastline with excellent climate, soil, and water conditions. In most of these areas, traditional agriculture is not viable and shrimp farming emerges as an economic and social alternative to modify regional economic and social stagnation (Pereira and Rocha, 2015). Even so, Brazilian entrepreneurs often face obstacles (mostly of the political, institutional, or legal order) that marginalize the activity, and in many cases hinder or retard sector development (Nascimento Vicente et al. 2017). This is true of problems such as the political-institutional fragility of the shrimp farming sector, the existence of ambiguous legislation and institutional uncertainties regarding its application, difficulty accessing official credit lines, and regional deficiencies in infrastructure and logistics.

Disadvantages of IP over CP

Among the main obstacles related to the adoption of IP is that this is an unprecedented way of producing shrimps. Therefore, the first challenge will be to define STS that are suitable for the certification of Brazilian enterprises. This is because excessively rigid standards can make certification a failure, because of the lack of adherence and high costs for entrepreneurs. Alternatively, standards that are too loose can counteract the potential benefits that certification has to offer to Brazilian's farming.

A threat associated with the IP regime that presented a high negative score is the possible difficulties for the differentiation of the CP and IP products by the market and consumers (da Silva et al. 2011). This is due to the fact that the argument that this regime values the health of the producers and consumers and that it contributes to the protection of the environment is undoubtedly valid, but perhaps insufficient to make the consumer agree to pay more for a certified product. For this, integrated shrimp farmers should seek to balance between the increase in production costs associated with certification and the reduction of costs associated with process optimization and resource savings.

Advantages of IP over CP

According to Shrestha et al. (2004), the category of strengths is the most influential in decision-making compared to the other three categories of SWOT analysis, and it was precisely in relation to their potential strengths that IP stands out in relation to CP.

Among the forces that make IP a possible alternative for the development of Brazilian shrimp farming is the possibility of reducing damage caused by diseases outbreaks and of the risks of introduction and dissemination of pathogens. The adoption of good management practices, biosafety, and animal welfare are basic and compulsory principles to be respected in the IP and are considered indispensable operational tools to avoid the proliferation and the spread of diseases (Castilho-Westphal and García-Madrigal 2017). The adoption of good management practices and biosafety at shrimp farming in the states of Rio Grande do Norte and Ceará, Northeast of Brazil, resulted in a reduction of damages caused by viral diseases (Silveira 2017). Thus, it is clear that the inclusion of associated compulsory principles of IP could improve production at the current Brazilian shrimp farming scenario.

Another fairly positive aspect related to IP is that it should induce shrimp farmers to a systemic view of both their own enterprise and the production chain, including the identification of problems and the technological demands that this production regime imposes (Coelho et al. 2016; Tahim and Junior 2014; Broman et al. 2017). For example, such a business perspective enables a better understanding of how the various components of the system interact and determine the final results obtained. In the adoption of the systemic vision throughout the productive process allowed the identification and correction of inadequacies in an integrated culture of marine shrimps located in Mazatlan, Mexico (Fierro-Sañudo et al. 2015) Therefore, it is evident that the adoption of the implementation of the systemic vision of the productive process, one of the principles of IP, provides verification and correction of inadequacies of the operated systems, the diagnosis and prioritization of the vulnerabilities of the enterprise, and could bring more resilience to marine shrimp farms in Brazil.

This perspective also draws attention to the focus of IP on reducing energy usage and optimizing the use of resources and inputs (Titi et al. 1995; EMBRAPA 2001; IOBC 2004). However, for this approach to be employed, the STS for certification of enterprises under the aegis of IP usually require the entrepreneurs to implement a plan for energy rationalization in their enterprises (WWF 2011). In the present case, the steps to ensure efficiency in terms of energy use, waste minimization, planning of installations and works, use of fuel and machinery, work practices, and a schedule of maintenance and revision of equipment and facilities suitable to the farm routine should be detailed, and goals to be achieved should be specified (GLOBALG.A.P. 2010). According to Fonseca et al. (2017), the adoption of the integration system in a 42.4 ha marine shrimp farm in the state of Santa Catarina in Brazil allowed for an increase in the technical and economic viability of the property. With the adoption of IP, it is expected to achieve optimization of the use of resources and inputs and a consequent increase in the returns that can be obtained through the cultivation of marine shrimps.

The natural consequence of the optimization process in resource utilization is the reduction of impacts and waste (Stevanato 2017). Many of the principles supporting IP are intrinsically related to environmental quality, ensuring the stability of the environment through the least possible disturbance of ecosystems (EMBRAPA 2001). Another principle adopted in IP is the use of integrated management, which considers that the use of such treatments as fertilizers, pesticides, and antibiotics is a last resort to be used only if the losses are economically unacceptable and cannot be prevented by natural regulators mechanisms (de Souza et al. 2014).

An additional advantage of IP is related to the greater control and standardization of data, production, administrative, and management processes along the productive chain (Jappur et al. 2010). Such procedures facilitate the identification of problems, the correction of misused techniques, the prevention of risks, and the reduction of losses and waste disposal which usually occur throughout a crop (Silva 2013). Furthermore, these procedures serve as a basis for the fulfillment of another certification standard generally required: the traceability of products and processes. Brazilian shrimp farmers who systematically record and use the data generated in previous cycles of production to improve their productive and managerial process are rare. To work under the IP regime, this reality will have to change. Lamartine Jr. (2006) evaluated a marine shrimp culture in the state of Santa Catarina in Brazil, before and after the implementation of an Integrated Management System (GIS) model, and concluded that the implementation of the GIS, which included traceability, enabled the identification and mapping of production process and also employee training, resulting in a significant improvement in the operational performance of the farm. Exactly, what is expected to be achieved with the adoption of IP.

Conversely, cultivated shrimp have conquered a larger slice of the market due to such factors as the high competitiveness in relation to shrimp from fisheries, quality of the product marketed, and regularity of supply (Natori et al. 2011). Waste reduction, balanced use of resources, care with environmental issues, traceability, and the associated social aspects are all elements that can be exploited as new marketing alternatives by certified enterprises (IOBC 2004). In this way, it is possible that IP-certified products will be able to gain access to new market niches and conquer space in markets already accessed by farmed shrimp. Tran et al. (2013) studied the return of certification for shrimp farming along the coast of Vietnam and noted that certified companies had greater access to more profitable markets. With the adoption of IP, it is expected to achieve greater control and standardization of production processes and, thus, to ensure compliance with the norms imposed by the importing markets and, consequently, to facilitate access to those markets that are currently closed to the market shrimp from Brazil.

Conclusions

It is not expected that a voluntary membership certification (as it is and how it should be with IP) will (at least in the short term) revolutionize a sector as diverse in systems and technologies of production and as full of challenges as the Brazilian shrimp farming industry. This shortcoming is predicted because IP involves a different and holistic way of facing both the enterprise and the productive process, which requires a higher level of qualification of all actors involved in the production chain. Even so, IP possesses potentially higher strengths than CP, and in the medium and long term, it is almost certain that many of its concepts will be irreversibly incorporated into the routine of shrimp farms in Brazil, even in non-certified farms. However, improving the quality of products and in the production processes always tends to involve increased costs. It is expected that part or even all of this cost could be offset by losses reduction, increased efficiency, and productivity gains. Nevertheless, in a current scenario, where price is important for consumers, perhaps the greatest challenge for IP will be to seek and overcome a consumer market that is more demanding and willing to pay more for a quality product that is produced in a socially fair and environmentally responsible way.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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