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Original Article

Live animal transportation and sustainable supply chain: a systematic literature review

Transporte de cargas vivas e cadeias de suprimentos sustentáveis: uma revisão sistemática da literatura

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ABSTRACT

Purpose – This article aims to map how the literature treats the procedures adopted in transport logistics for live animals.
Design/methodology/approach – To reach our goal, we performed a Systematic Literature Review on live cargo transportation logistics, considering studies published between 2011 and 2021.
Findings – The review indicates that the long distances of the routes and the different modes of transport used had considerable influence on the welfare of the animals. Therefore, there is an international trend to reduce long journeys and to assign more relevant information on the geographical origin of products.
Research limitations/implications – As limitations of this study, the sample analyzed in the Google Scholar database was small. More studies have been expected for the development of analyses and discussions on the current topic.
Practical implications – Efficient and sustainable management can lead to higher financial and non-financial gains for supply chain members and compliance with standards for the appropriate treatment of animals, guaranteeing their well-being and providing superior product quality.
Social implications – Live cargo transportation represents an important activity in several food supply chains, and its management may contribute to supply chain sustainability.
Originality/value – The findings expand the knowledge available on live animals logistics, care regarding the management of each species, difficulties, barriers, and positive aspects of transport. Sustainability is another theme rarely mentioned in the studies analyzed, thus presenting an important area for future studies regarding sustainable management of the supply chain in transporting this type of load.

Keywords: Live animal; International trade; Animal welfare; Sustainability

RESUMO

Objetivo – O objetivo do artigo é mapear como a literatura trata os procedimentos adotados na logística de transporte de animais vivos.
Desenho/metodologia/abordagem – Foi realizada uma Revisão Sistemática da Literatura sobre logística de transporte de carga viva, considerando estudos publicados entre 2011 e 2021.
Achados – Os resultados da Revisão indicam que as longas distâncias das rotas e os diferentes modos de transporte utilizados apresentam uma influência considerável no bem-estar dos animais. Portanto, há uma tendência internacional de redução de viagens longas e de atribuição de informações mais relevantes sobre a origem geográfica dos produtos.
Limitações/implicações da pesquisa – Poucos estudos foram encontrados na base de dados Google Acadêmico. Sugere-se a realização de mais estudos para a ampliação de análises e discussões sobre o tema atual.
Implicações gerenciais – É importante aos gestores que tenham o conhecimento sobre uma gestão eficiente e sustentável e que pode levar a maiores ganhos financeiros e não financeiros para os membros da cadeia de suprimentos. Além de que o cumprimento das normas para o tratamento adequado dos animais, garantindo o seu bem-estar, pode proporcionar produtos de qualidade superior.
Implicações sociais – O transporte de carga viva representa uma atividade importante em diversas cadeias de suprimentos de alimentos e a sua gestão eficiente pode contribuir para a sustentabilidade dessas cadeias.
Originalidade/valor – Os resultados ampliam o conhecimento disponível sobre logística de animais vivos, cuidados com o manejo de cada espécie, dificuldades, barreiras e aspectos positivos do transporte. A sustentabilidade é pouco mencionada nos estudos analisados, apresentando uma área importante para estudos futuros no que diz respeito à gestão sustentável da cadeia de suprimentos no transporte deste tipo de carga.

Palavras-chave: Cargas vivas; Comércio internacional; Bem-estar animal; Sustentabilidade

1 INTRODUCTION

Live animals, including calves, cattle, sheep, pigs, goats, horses, reptiles, birds, fish, crustaceans, and invertebrates, are routinely transported around the world by various modes, such as road, rail, sea, or air (Rahim et al., 2020). "The live animal trading industry is unique because it does not involve manufacturing or other value-adding process but only breeding, rearing process and transportation process from one place to another place domestically or internationally" (Rahim et al., 2020, pp. 450). In addition to the financial impacts on the Supply Chain (SC), live animal transport logistics should offer adequate treatment of animals and ensure product quality (Machado et al., 2016). The logistics process must be concerned with animal welfare throughout the

journey from suppliers to final customers, reducing the mortality rate and increasing the efficiency of operations and the effectiveness of the financial results (Caroprese et al., 2020; Rahim et al., 2020).

Live animals are imported and exported for food production, the pet and aquarium sectors, recreational purposes, and educational, medical, and scientific objectives such as lab investigations, biomedical research, game farms, zoos, bird parks, and breeding (Rahim et al., 2020). Data show that the European Union accounts for more than 75% of world exports of live animals, while Brazil is a pioneer in exporting live cattle. Currently the second-largest exporter globally, it ranks among the leading worldwide exporters of pigs and poultry. In 2019 and 2020, more than 800,000 live oxen were transported by sea for slaughter abroad. In 2019, cattle occupied the 67th position in the rankings of Brazilian exports, corresponding to 0.2% of total exports. The main importing countries were Turkey and Iraq, followed by Lebanon and Egypt. In 2021, around 2.4 million tons of live cattle were exported worldwide, this volume represents approximately 20% of the international trade in cattle, considering the sum of live animals and meat (Governo SP, 2023).

Despite the relevance of the activity and its impact on the sustainability of supply chains, few studies have sought to analyze the transport of live animals (Collins et al., 2020; Rahim et al., 2020), the challenges such activities pose to sustainability (Pohlmann et al., 2020), and how animal welfare impacts sustainability issues (Buller et al., 2018; Keeling et al., 2019; Olmos Antillón et al., 2021).

Olmos Antillón et al. (2021) and Keeling et al. (2019) argue that animal welfare is directly related to sustainability issues, especially those referring to responsible consumption and production. These articles highlight that initial efforts to link animal welfare and sustainability have focused on livestock and food production for human consumption. Buller et al. (2018) also argue that animal welfare is a challenge for food security and environmental conservation. They argue that two challenges, along with other emerging tensions, are changing the positioning of animal welfare

science and policy. The first challenge refers to the growing incorporation of animal welfare into contemporary understandings of sustainability, now formally endorsed in the United Nations Committee on World Food Security Draft Recommendation. The second challenge refers to the growing association of animal and human health, increasingly represented by the 'Welfare' agenda. The term "one welfare", inspired by the concept "one health", emphasizes the links between human welfare and animal welfare, and to acknowledge that both depend on a well-functioning ecological environment (Pinillos, 2016).

According to Olmos Antillón et al. (2021, pp.3), "Agenda 2030 recognizes that the welfare of people depends on the health of the global ecosystem within which we live, and the welfare of all animals is critical if this ecosystem is to be sustainable". Therefore, sustainability is a broad concept that needs to include animal welfare and its relation to responsible consumption.

Thus, in this study, we aim to answer the following research question: What procedures are adopted in the transport (import and export) of live animals to promote animal welfare and sustainability? The study intends to map how the literature treats the procedures adopted in transport logistics for live animals. To answer the research question, we performed a Systematic Literature Review (SLR). The literature review analyzed factors along the SC, including legislation, management, and the major impact (positive and negative) caused by transportation management for this type of cargo, mainly animal health and welfare issues.

The results demonstrate the responsibilities of each supply chain actor in the process of live animal transport and the importance of adequate procedures for live animal transportation logistics. Efficient and sustainable management can lead to higher financial and non-financial gains for supply chain members and compliance with standards for the appropriate treatment of animals, guaranteeing their well-being and providing superior product quality. The findings expand the knowledge available on live animals logistics, care regarding the management of each species, difficulties,

barriers, and positive aspects of transport. Additionally, examples and suggestions for the improvement of live animal logistics have been compiled.

2 SUSTAINABLE SUPPLY CHAIN MANAGEMENT (SSCM)

Research on sustainability in supply chains developed from interactions between environmental and economic issues. Later, the research incorporated corporate social responsibility into the supply chain and, more recently, converged to become the Triple Bottom Line (TBL) approach that represents the economic, environmental, and social dimensions. This approach contributed to the emergence of Sustainable Supply Chain Management (SSCM) as a theoretical model (Carter and Easton, 2011), similar to the pioneering models of Carter and Rogers (2008), Seuring and Müller (2008), and Pagell and Wu (2009).

Carter and Rogers (2008) analyze the relationship between social and environmental practices in the SSC and their effects on organizational performance. However, they do not emphasize how sustainability practices occur along the supply chain. Carter and Rogers (2008) consider SSCM the strategic integration of social, environmental, and economic goals through the systemic coordination of the main intra-organizational business processes. This is done in order to improve the long-term economic performance of the company and its value network.

According to Seuring and Müller (2008), the inclusion of sustainability in the SC is due to pressures and incentives resulting from the actions of different groups outside the chain, on the demand side. There are clients, governments, and stakeholders. It is crucial to emphasize the fact that although the first two groups are also stakeholders of the focal company, customers and governments exert greater influence on the supply chain as pro-sustainability agents. In the third group, other organizations play a relevant role, such as NGOs (non-governmental organizations) focused on social and environmental issues.

Pagell and Wu (2009) analyze what the companies identified as leaders in SSCM do differently from those that stand out in conventional supply chain management.

The authors also examine patterns of action among these benchmark companies to develop a theoretical model. Pagell and Wu (2009) show that sustainable chains are engaged in a series of good management practices.

The models of Seuring and Müller and Pagell and Wu are suitable for analyzing the introduction of socio-environmental practices to the SC by a focal company. Moreover, these models can be considered complementary. Both point out, for example, that SSCM demands that the focal company has fully internalized sustainability in their company culture especially in terms of cultural aspects such as employee-employer relationships and incentives for upholding sustainable practices. These requirements are more explicit in Pagell and Wu's model, in which they are grouped as elements of sustainability integration in the SSCM. In Seuring and Müller's model, there is greater attention paid to external pressures as catalysts for the internalization of aspects related to sustainability. Additionally, both models have an extended view of the chain as an intrinsic characteristic of SSCM – that is, there is a greater concern with the origin of inputs and with the longer-term relationship with their suppliers.

The relationship with suppliers is more explicit in the model of Seuring and Müller, especially in the proposal of Supplier Management strategies for Risks and Performance and Supply Chain Management for Sustainable Products. The authors define SSCM as encompassing "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements" (Seuring and Müller, 2008, pp. 1700).

One of the main challenges for focal companies is to manage sustainability along the whole SC. Organizations have developed different governance mechanisms to extend sustainability to suppliers such as logistics companies (Gimenez and Sierra, 2013). Gimenez and Sierra (2013) examined the governance mechanisms that focal companies can use to improve environmental performance with their suppliers. Two

specific mechanisms were utilized: evaluation of suppliers and collaboration with suppliers. The results suggest that both mechanisms affect environmental performance. In addition to the evaluation facilitating collaborative efforts in and of itself, companies with higher levels of proactivity in their sustainability strategy regarding the SC have higher levels of implementation of both mechanisms and, consequently, better environmental performance.

Pohlmann et al. (2020) present a study in the context of a poultry supply chain in Brazil, discussing the role of the focal company to achieve the Sustainable Development Goals (SDGs) (United Nations adopted the 2030 Agenda for Sustainable Development, which included 17 SDGs and 169 sustainable specific targets, indicators, and metrics). The authors analyze how small and medium-sized food poultry supply chains implement Sustainable Supply Chain Management (SSCM). Food supply chains face challenges of SSCM, such as waste management and environmental issues. The findings of the literature review "indicated the relevance of exploring some approaches to achieving SSCM: corporate social responsibility, green supply chain management, industrial ecology, stakeholder theory, circular economy (reduce, reuse, and recycle with economic prosperity), and sustainability science" (Pohlmann et al. 2020, pp. 1).

The findings of the case study investigated by the authors showed the relevance of addressing legal issues, mainly environmental and sanitary. Specifically, Brazil's environmental legislation needs to be worked on in order to be aligned with the objectives of the SDG. It is indicated that collaboration and engagement are corporate strategies for implementing long-term actions, in order to enable changes in business models, responsibilities to the actors involved in the chain and a sustainable lifestyle. Partnerships between different members of the chain are also highlighted in the study (government, universities, representative institutions and the private sector) playing a strategic role in promoting the SDGs, both in developed and developing countries (Pohlmann et al. 2020).

Transport logistics play a vital role in the SSCM in the context of sustainable supply chains for live animals, especially relating to the proper handling of load,

prioritizing the health and welfare of the animals, and exacting the lowest logistical and environmental cost (Caroprese et al., 2020; Rahim et al., 2020; Fleming et al., 2020).

2.1 Live Animal Transport

Transport Logistics is a branch of logistics that involves the choice of the best modal to transport goods with the minimum cost and the shortest possible time. Live animals are classified as special loads for transport logistics. The storage and transportation of live animals, due to their fragility, are laborious and require different facilities and management practices (Da Silva et al., 2019). The transport of live animals, known as live loads, can be performed by different modalities such as the air, road, rail, and waterways. Each species dictates the appropriate modality for its transportation. Therefore, this varies according to the animal type and characteristics, among other factors such as long or short distance, necessary equipment, and load value (Da Silva et al., 2019).

Air transportation is recommended for small animals such as pets shown at fairs or sporting events and animals used in laboratories because of the transport speed and agility in handling. For wild animals, such as steers, chickens, pigs, animals reared for slaughter or rearing, the most used and recommended modes are road and sea, because freight is more favorable (Da Silva et al., 2019). Another concern regarding shipping live cattle for exportation are the international rules and agreements that must be considered, respecting contractors' obligations and cultural issues that directly influence logistics (Da Silva et al., 2019).

In addition to the aspects related to the method of transport, animal welfare, agility, and costs involved in the process, another important point to be analyzed is the carrier's work. The transport of live loads requires specific skills since many transporters also participate in loading/unloading, selecting the animals to load, and distributing them on the truck according to their weight or commercial category. Night trips, aversive and violent handling (such as shouting and/or the use of electric batons), charging times exceeding two and a half hours, among other stressors, negatively

affect animal performance. Such aspects may be responsible for decreasing meat quality, animal health, and welfare, with potential economic losses (Pulido et al., 2019; Caroprese et al., 2020).

Food loss and waste in Brazil are growing and deserve the attention of researchers (Machado et al., 2016). "In this regard, buyers or focal companies could also consider providing for the rural producer training, including demonstrating how improvements in agricultural and management practices can enhance the farmer's investment capacity" (Martins et al., 2022, pp.15). Studies on the complex food supply system are necessary that take into consideration inventories, production and transport capacities and their interdependencies, as well as the weaknesses of this process (Balster and Friedrich, 2019). In addition to the financial impact, when live cargo in particular is efficiently transported, in addition to ensuring appropriate animal treatment, the quality of the final product improves (Machado et al., 2016). The logistical process of transporting live animals, caring for animals throughout the route from suppliers to final customers, lessens food loss and waste. This process also reduces the mortality rate and increases the efficiency of operations and effectiveness of results (Rahim et al. 2020). Moreover, considering consumer decisions, animal health and welfare conditions are relevant on acceptance and purchase decision-making (Queiroz et al., 2018; Pulido et al., 2019; Caroprese et al., 2020; FAO, 2021).

3 METHODOLOGY

We followed the recommendations of Tranfield et al. (2003), Linnenluecke et al. (2020) and Sauer and Seuring (2023) to perform a Systematic Literature Review (SLR) of studies that analyzed the transport logistics of live animals. Systematic Literature Reviews have become a relevant approach in the field of management to consolidate the extant literature, suggest directions for future studies (Kraus et al., 2020) and stimulate theory development (Koufteros et al., 2018).

The RSL followed the procedures suggested by Sauer and Seuring (2023): (i) definition of the research question - What procedures are adopted in the transport (import and

export) of live animals to promote animal welfare and sustainability?; (ii) determine the required characteristics of primary studies – in the case of research, preference was given to the selection of empirical cases, and inclusion criteria, such as date (from 2011 to 2021) and search within - Title or abstract or keywords; and exclusion, such as: articles under review, conference articles, reports, working papers, dissertations or theses; (iii) retrieve a sample of potentially relevant literature - definition of sources and databases, Google Scholar and Web of Science (WoS), and; definition of search terms and elaboration of a search string: selected keywords, in English: "transport of live animals" (Google Scholar) and "animal welfare"; "live animal"; "transport" (Web of Science); (iv) selection of relevant literature; (v) literature synthesis – extractions and coding – tables; and, (vi) report the results, that is, structure of the article, presentation of the theoretical framework (Appendices A and B, with predetermined categories - Objective, Method, Main results, Conclusions/ contributions and Suggestions for future studies) and discussion of contributions.

We searched in Google Scholar and Web of Science (WoS) databases due to their relevance in academia and because they adopt "free indexing from publications conducted in multilingual online journals" (Mariano and Rocha, 2017, pp. 430; Linnenluecke et al., 2020; Maior et al., 2022).

In the first step of the study, we used the following criteria to query these databases: (i) research with the words "transport of live animals" (Google Scholar); and "animal welfare"; "live animal"; "transport" (Web of Science); (ii) a time parameter between 2011 and 2021; and, finally, (iii) analyze only articles. Using this method, 190 results were found in the Google Scholar database and the search resulted in 170 articles in the Web of Science (WoS). In the second step, we read the abstracts and excluded articles unrelated to live animal transportation logistics and Sustainable Supply Chains. After performing this exclusion, the number of remaining articles was 15 in the Google Scholar and 10 in the WoS.

Then, in the third stage, we read the selected articles and extracted the following information: (i) objective; (ii) research method; (iii) research findings; and (iv) conclusions

and suggestions for future research. We then discarded nine articles in the Google Scholar database, because they are not connected to the objectives of our study, and three in the WoS. They deal with topics such as physiological challenges of reproduction of wild felids (Moreira, 2013) and investigation of synanthropic fauna (Battiston and Trindade, 2017); "Dynamic freight flow modelling for risk evaluation in food supply" (Balster and Friedrich, 2019) and "Comfort and health evaluation of live mutton sheep during the transportation based on wearable multi-sensor system" (Zhang et al., 2020).

Finally, we analyzed six articles found in Google Scholar and seven articles found in the Web of Science database. These articles have been analyzed and four categories emerged: (i) legislation; (ii) management and main impacts related to transportation management; (iii) animal health and welfare; and (iv) relations with the SSCM. In the next section we present the findings, including aspects used in the operations and processes of sustainable supply chain management of live animals, as well as suggestions for future studies.

4 DATA PRESENTATION AND ANALYSIS

Transportation is a time of great stress on an animal's life, as they are exposed to a range of potential stressors such as handling and human contact, loading and storage, different or unfamiliar environments, food and water deprivation, alterations in weather conditions, noise, and environmental pollutants. In addition, they face changes in social structure through separation, mixing, and crowding. Thus, general concerns about the processes along the supply chain and the welfare of these animals has grown (Pulido et al., 2019). Animal health and welfare conditions are relevant to consumer acceptance and decision-making. These aspects should be assessed both geographically and as processes carried out along the supply chain (Queiroz et al., 2018; Pulido et al., 2019; Caroprese et al., 2020; FAO, 2021).

To illustrate how these processes are executed, we present in this subsection data about the legislation on transport, management and its main impacts (positive

and negative), studies on animal health and welfare, and the relationship between animal transport and the SSCM.

4.1 Analysis of the legislation for live animal transport logistics

The first category that emerged from the analysis of the studies deals with the legislation for the transport of live loads. These studies' central focus is on transport standards; transportation modes; vehicle safety standards; conditions of the pre-shipment process; route (time) and discharge and its impacts on welfare, mortality and behavior, and even on animal physiology; as well as the attitudes and training of the people handling and/or transporting animals.

Regarding Brazilian legislation, the norms on the transportation of animals for production, economic interest, sport, leisure, or exhibition are determined by the National Transit Council. In Brazil, the live animal transport vehicle must be constructed or adapted and maintained in such a way as to avoid unnecessary suffering and injury, as well as to minimize the agitation of the animals, to ensure the maintenance of life and animal welfare (Diário Oficial Da União, 2020). Based on the requirements set out in Article 3 of this resolution, the vehicle should: be adapted for the species and category of animals transported, with a height and width allowing the animals to stand during the journey, excepting birds, and an opening of compatible size for loading and unloading; be resistant and compatible with the weight and movement of the transported animals; have means to prevent spillage of waste while driving on public roads; have sides and roof to protect against leakage, falling and exposure of animal body parts outside the vehicle; and in the case of transport of animals in container boxes, the vehicle must have structures to prevent the movement or fall of such boxes, etc. (Diário Oficial Da União, 2020).

Some SLR studies depict how transportation is performed in Brazil and aligns with current legislation. Da Silva et al. (2019) investigated the damage caused in the live animal transport process and explained legislation regarding cattle exportation;

they also showed how these animals are transported and analyzed what risks they suffer, such as injuries and diseases. The main results of the study demonstrated that the long distances, the transport modes and the distribution of loads were important attributes for the animals to have adequate and respectful treatment. Da Silva et al. (2019) believe that the gradual awareness of end consumers increases the qualification process, as it is known that exporters have relevant attributions of responsibility in transportation and with the health, safety and comfort of beef cattle throughout their journey. The findings refer to the proposal of some practices to improve the welfare of cattle exported, among them, the enforcement of laws and supervision and the implementation of environmental awareness programs in an attempt to promote the validation of animal rights and consequently reduce logistical costs.

Lourenço and Van Erven Ludolf (2020) investigated whether live animal exportation methods violate the prohibition of cruelty to animals according to the Federal Legislature of Brazil, in light of parameters that regulate animal welfare and animal rights protection. The authors conducted a literature review in the *Scopus* and *Web of Science* databases, seeking to map the main discussions on the export of live cattle in Brazil and abroad. To explore further, they sent a structured questionnaire to experts in Animal Law. Given the data examined, they found major violations of the Constitution causing physical and psychological suffering to the animals, especially in the areas of pre-shipment, quarantine, and land and maritime transport. The authors therefore proposed that the practice of exporting live cattle be prohibited throughout the nation (Lourenço and Van Erven Ludolf, 2020).

Da Silva et al. (2019) analyzed transportation in live cattle export operations, paying attention to international rules and agreements, issues related to contractors' impositions, and cultural issues that directly influence logistics. The objective of the study was to demonstrate the logistical impacts of road transport of live loads for export in Brazil, including deficiencies and challenges, and calling attention to the care taken during cattle transport, the main buyer countries, and the current situation of

the port of Santos regarding the transportation of this type of load.

To use as scope the transport of live cattle to the port of Santos, Sao Paulo state, it was necessary to identify the main trading partners, which are: Turkey, Egypt, Lebanon, Jordan, and, as of 2019, Kazakhstan, which signed an agreement authorizing Brazil to send live cattle. As demonstrated in the study by Da Silva et al. (2019), some restrictions and standards must be followed, which are imposed in bilateral agreements and global conventions. These restrictions and standards aim to guarantee the quality of bovine animals and that the product will be delivered in perfect conditions for the continuation of the fattening and slaughter process in the destination country, following the traditions of the importer.

Collins et al. (2020) reported the impacts of the air transport on animal welfare in Australia. Little is known about the implications on animal welfare of this transportation method, so the authors conducted a literature review based on an electronic database (*Google Scholar*) to identify journal articles, books, unpublished reports, conference proceedings, and theses. In addition, several publicly available industry-funded research reports that have not been peer-reviewed provided important information about the management and life risks of animals exported in this way.

Collins et al. (2020) noted that Australian standards for cattle exports are mandatory and provide basic animal health and welfare requirements for all Australian animals exported. Considering the international market, the Regulations for Live Animals of the International Air Transport Association stipulate an industry regulatory manual that must be followed by all member airlines. However, the authors also pointed to the lack of direct evidence on the transport of cattle by air, which does not make it clear how different factors influence the behavior, health, and welfare of animals.

These findings refer to reflections on evidence from studies that evaluated mortality, comfort, behavior, and animal physiology for land and sea transport, but not for air. What has been defined is the need to consider the export process in its entirety, from the time of the transport of the animal from the farm to the airport,

finishing at the final destination of the importer. Air transport safety standards forbid livestock from being housed in stalls or decks, similar to maritime transport. The animal needs to be confined in wooden crates, which are loaded in the aircraft hold. Different holds (main and lower) can be used to store the boxes, and these holds may differ in their ventilation characteristics and temperature. The confinement of animals in crates creates challenges for stocking density management, access to animals in case of emergency euthanasia, and ventilation. The crate should be sized according to the internal dimensions of a standard pallet for use in aircraft; the most common sizes are 2.2m x 3.2m and 2.4m x 3.2m (Collins et al., 2020).

Unlike other studies, Pulido et al. (2019) analyzed the transport of sheep in Mexico from the point of view of the transporter. They investigated the knowledge of Mexican transporters concerning transport operations, considering legislation and pre-slaughter logistics. As a complement, they sought to quantify how the distance of the trip affects the occupational risks of transporters and animal welfare. The results helped identify a series of practices that pose risks to health and well-being in sheep transport in Mexico. Many journeys were long (an average of 12 hours), which represents a problem in a country without legal limits on the time of sheep transit. Longer journey times increase the risk of unnecessary suffering for animals and harm transporter health. Although not required by Mexican regulations, most haulers provide feed and water to sheep on arrival at the slaughterhouse or in small collection centers near the slaughterhouse, especially during medium- to long-term transport. The main reason is to compensate for weight loss, even when the animals are slaughtered within 72 hours.

The study by Pulido et al. (2019) highlighted the importance of transporters in the protection of animal welfare throughout the pre-slaughter logistics chain, especially since they can be held legally liable for accidents, among other concerns. It was understood that the attitudes and training of animal handlers and transporters are essential for a successful operation that respects these animals. The results underscored the need to develop new transport regulations and guidelines in Mexico

and Latin America in terms of transport time and conditions. A long-term vision is needed to improve the conditions of thousands of traveling sheep, avoiding suffering and losses to the industry.

4.2 Analysis of live animal handling and its main impacts on transport management

The second category that emerged from the systematic literature review deals with animal handling procedures and their impacts on transportation management. Some studies were identified that addressed this theme, referencing issues such as cost-effective solutions to the producer about the price practiced, routes used and means of transport. In addition, duration (travel time) and the relevance of monitoring the entire process for the final consumer were stressed as important factors. This information can help in the decision-making of customers at the time of purchase or not of the product.

As a way of exemplifying the animal handling procedures, Ribeiro et al. (2018), in a qualitative study, evaluated the alternatives available to decide on the capacity of the slaughter plants (in terms of price), best route (or road), and better means of transport (truck) to propose a method to determine the logistics of selling and transporting livestock heads and to ensure a more profitable solution for the rural producer. The optimal answer was generated via a mathematical model based on the data provided by rural producers of Farm X (Mato Grosso do Sul, Brazil).

As also observed for the authors, the study can advance in several directions, for example in the realization of new computational tests on broader and more complex databases; a study of cattle shipment from multiple origins (i.e., farms) to multiple destinations; introduction of the multiple-journey truck alternative; inclusion of the possibility of multi-period sale (i.e., adding the decision as to when it is most advantageous for the farmer to carry out the sale to the slaughter plants); and introduction of the probability of greater losses to the cargo carried, such as truck

breaks and accidents (Ribeiro et al., 2018).

In another study, Carvalho et al. (2017) analyzed the air transport of live animals in two case studies that ultimately proved successful despite having distinct objectives: the importation of horses for the 2016 Rio Olympics and in the export of Guzerá cattle, a breeding breed that departed for Africa. The process was analyzed from boarding to arrival at the final destination. Both operations involved high costs and short travel time. Airport planning and logistics that focused on maintaining the life and welfare of the animals involved in the process were necessary for each case.

Caroprese et al. (2020) also contributed to the field of transportation management by evaluating the well-being conditions and quality of meat of local and imported lambs, assessing the effects of transport on slaughter for both short-term transport within Italy (farm to slaughter) and long-term (from farms in Romania to slaughter in Italy). They investigated issues of geographical origin, duration of transport time and animal welfare conditions as perceived, expected, and actually accepted by consumers. Transport stress is exacerbated by complex operations that relate to transport itself as well as slaughter and can be measured through behavioral and physiological indicators.

The results showed that neither short- nor long-term transport affected the organoleptic quality of the meat; this result was corroborated by an absence of metabolic and immunological stressors in lambs transported long-term. On the other hand, concerning customer acceptance, positive influence was found to relate to the expectations of information received on geographical origin, transport time, and animal welfare, and such elements were associated with the freshness, taste, quality and safety of lamb meat. Likewise, the sense of confidence that consumers placed in local productive enterprises was increased under these conditions. In addition, as with other animal products, ethical concerns played an important role in guiding consumer purchase decisions, although they were less influential than sensory and safety characteristics (Caroprese et al., 2020).

4.3 Analysis of animal health and welfare during transportation

The third category that emerged from the systematic analysis deals with animal health and welfare. Animal welfare is a matter of high priority. Studies such as Queiroz et al. (2018) and Fleming et al. (2020) reflect this perspective. According to Fleming et al. (2020), considering the Australian community, there is a growing awareness that the change in community values needs to be reflected in management practices. "A live export industry strategy of continued improvement and increased transparency is important to unite, not divide, the various stakeholders involved" in the living animal supply chain (Fleming et al., 2020, p. 16). The results indicated that there is an urgent need for transparent and open management that provides positive animal welfare results and demonstrates values aligned with what is considered good animal care in Australia.

Queiroz et al. (2018) analyzed several aspects related to the perception of Brazilian citizens about animal welfare conditions in three different production chains: poultry, beef, and dairy products. Although a major limitation of the study was the selection of its sample (only members of the academic community), represented by young, educated people with higher salaries, the researchers obtained interesting results. Even for this issue, it was identified that the highest level of education is positively correlated with awareness and concerns about animal welfare issues. Thus, the sample participants had more progressive views. For them, the general conditions of animal welfare in the Brazilian poultry, beef and dairy supply chains were considered very bad, bad, or regular – that is, negative perceptions about animal welfare conditions.

The study by Queiroz et al. (2018) makes a contribution to the subject of animal health and welfare during transportation by analyzing sociodemographic characteristics, awareness about animal welfare, and knowledge about supply chains. In addition, it presented contributions on perceptions regarding agriculture and the quality of life of farm animals. Another point was the perceptions about the use of

animals for human consumption and about transport conditions and slaughter in different supply chains, and whether these factors would impact citizens' perceptions related to general welfare conditions of animals in each of the three surveyed chains.

The study also contributes by showing the respondents' perception on the question of the producers being focused mainly on the economic aspect of agriculture and less on the welfare of an animal, or that animals do not have a good quality of life when housed on farms and the perception that animals are not transported and slaughtered properly. These factors negatively impact perceptions about the general animal welfare conditions in the supply chains of poultry (728 participants), beef (586 participants), and dairy products (300 participants) according to the Brazilian sample (Queiroz et al., 2018). Studies such as this one by Queiroz et al. (2018) add much to the current literature, but remain scarce and require complementary work.

Machado et al. (2016) also discuss the concept of well-being from the farmers' point of view during the production processes in Brazil, relating body weight loss to the dehydration of pigs transported under tropical conditions in different ranges of extra short, medium, and long distances. The main results demonstrated that the ideal distance without weight loss in transported pigs, decreasing the economic impact, is less than 100 km between property and slaughterhouse.

Alves et al. (2016) corroborated this view, pointing to the effect of stress on the quality of animal products such as milk, pig meat, poultry meat, and fish. As main results, the data pointed out that the stress and the effects linked to the rudimentary transport techniques directly affect the quality and the physicochemical characteristics of the animals. Thus, the authors propose that, through changes in the profile of the consumer market, the systems can seek new production management techniques that aim at animal welfare. These changes could help to minimize the effect of stress on the quality of the final product.

Finally, specifically considering the air modality, the findings of the study by Collins et al. (2020) demonstrated that air freight is considerably more expensive than

sea freight per head base, and, even so, there was an increase in the proportion of cattle exported this way in recent years, going from 0.5% in 2016 to 1.0% in 2018. However, when examining animal welfare results, it is important to consider the entire export process. Although there are few studies on this subject, some risks to the welfare of cattle have been identified in the field: ground transport trips, high-density confinement in boxes, long waiting times, long periods with deprivation of water and food, variation in thermal conditions, and potential exposure to harmful gases, all imposed by total travel times. However, the main concerns identified by industry stakeholders were: food and water depot especially when the aircraft is delayed, access to and handling of animals caged in transit, especially in hot and humid climates, and the suitability of ventilation. Another factor that can cause animal discomfort, but not mortality, is motion sickness due to turbulence, which has not been studied at the moment. Therefore, the authors suggest new studies to investigate the behavior and affective state of cattle to ensure the continuous improvement of animal welfare subjected to this mode of transportation (Collins et al., 2020).

4.4 Analysis of Sustainable Supply Chain Management (SSCM) and its relations with Live Animal Transportation

The fourth category emerging from the systematic analysis deals with Sustainable Supply Chain Management (SSCM). Rahim et al. (2020) conducted a qualitative study in three selected companies in the live animal industry in Malaysia. The main motivation of the study was to investigate the challenges in SSCM regarding the trade of these animals. Malaysia is one of the countries that has specified the importance of animal welfare practices in the live animals trade, whether exports or imports. Utilizing SWOT analysis, the results showed, among other weaknesses, the high mortality rate of animals, special requirements, and bureaucracy. Strengths consisted of: a good network of contacts in the chain, several distribution channels, and the experience of work teams. As opportunities, there existed both population and sector growth. Finally,

the findings suggested some threats: the increase of competition, environmental uncertainties, exchange rates, high logistical costs, among others. As the main focus of the study, Rahim et al. (2020) affirmed that SCM is one of the most important parts of the trade of live animals. Thus, efficient management can determine the revenue of members involved in the chain and enable competitive advantage for participating organizations.

Fleming et al. (2020) argue that animal welfare for the export industry of live animals is a very important subject. In Australia, meeting the demands of industry, consumers, and the community, the Sustainable Supply Chain as a whole is a constant worry. There are many challenges in this industry as well. The economic returns need to be in balance with social demands for sustainable and ethical production systems and practices. Thus, constantly evaluation programs of welfare assessment based on indicators aimed at continuous improvements beyond legislative requirements are debated in the country.

According to research data by Fleming et al. (2020), the Australian animal export industry is a major contributor to the country's economy, representing in 2018 and 2019 $1.79 billion AUD (Australian Dollars). In 2018 and 2019, Australia exported by sea and air a total of 2.32 million animals (1.26 million cattle worth $1.64 billion, 0.989 million sheep worth $142 million, and 18,650 goats worth $7.2 million). In addition to the figures, the results point out that there are nearly 10,000 people employed in this industry across Australia, including producers, carriers, and exporters, which benefits communities directly and indirectly. Australian societal perceptions are influenced by several factors, including personal conviction, values, norms, knowledge, and interests. Thus, the study aimed to identify conflict issues of high and low potential about the export industry of live animals, as an important first step to build public confidence in this industry and modify the farming practices that cause concern in the members and the management of the chain (Fleming et al., 2020).

Table 1 summarizes the data analysis of the Systematic Literature Review performed.

Table 1 – Summary of data analysis

Aims	Categories of analysis	Authors
List legislation for live animal transportation	✓ Enforcement of laws and supervision according to each country; ✓ Five Freedoms; ✓ The transport divisions and modes used; ✓ Measures for wooden crates (air transport); ✓ Development of new regulations and guidelines for transport in terms of transport time and transport conditions (longer times/greater distances risk unnecessary suffering to animals and negative effects on transporter health); ✓Attitudes and training of animal handlers and transporters.	Da Silva et al. (2019) Pulido et al. (2019) Collins et al. (2020) Lourenço and Van Erven Ludolf (2020) Van Erven Ludolf and Da Costa (2020)
Verify how the handling is carried out and its main impacts related to the management of transport of live animals	✓ Decide on the logistics of selling and transporting livestock and ensure a more cost-effective solution for the rural producer; ✓ Monitor boarding until arrival at the final destination; ✓ Consumer purchasing decision (ethical concerns); ✓ Sensory and safety characteristics for animals.	Carvalho et al. (2017) Ribeiro et al. (2018) Caroprese et al. (2020)
To analyze aspects of animal health and welfare in the logistics of live animal transport	✓Animal welfare is a matter of high priority; ✓ Values aligned around animal care; ✓ Rudimentary techniques; ✓ Stress and transport-related effects directly affect the quality and physicochemical characteristics of animals; ✓ Focus on the economic aspect of agriculture; ✓ Quality of the final products.	Alves et al. (2016) Machado et al. (2016) Queiroz et al. (2018) Collins et al. (2020) Fleming et al. (2020)
Analyze SSCM and its relationship with live animal transportation	✓ Challenges in the SSCM of live animals (efficient management versus gains of chain members); ✓ Industry that contributes meaningfully to the economies of countries; ✓ Generation of employment (income).	Fleming et al. (2020) Rahim et al. (2020)

Source: Prepared by the authors based on the SLR (2021)

Analyzing the Brazilian context, it is evident for Brazil, because this is an industry that moves millions of dollars and employs a very large amount of people, that constant

controls and laws are needed to have efficient and effective Sustainable Supply Chain Management (SSCM). In the face of world production that faces challenges similar to ours according to the studies presented in the international review, it is imperative to use means that go beyond good practice and well-being, to provide gains (both financial and non-financial) to those involved in the supply chain.

The mapping of the literature about Freight Transport Logistics is not an easy task (mainly due to the lack of empirical studies) and has well-diversified points of view. Previous research recognizes good practices of processes along the supply chain, such as Carvalho et al. (2017). On the other hand, some of them present extreme points, such as Lourenço and Van Erven Ludolf (2020) and Van Erven Ludolf and Da Costa (2020), both of which believe that the practice of exporting live cattle should be prohibited throughout Brazil.

Animal welfare is a common concept considered by farmers during the production stages in Brazil. Animals transported over long distances are exposed to variations in air temperature and humidity, wind, and long deprivation of water and food. Also, when studying the transport processes, the views of the pig farmers are different because the guidelines of developed countries and regions, such as the United States, Canada, and the European Union, are distinct from underdeveloped or developing countries like Brazil.

On the other hand, there is a consensus among the studies that the longer the time and distance between production and final consumption, the greater the risks of animals being injured, resulting in losses, which generates considerable increases to the total cost. Therefore, animal welfare is part of the sustainability of the activity. Thus, the appropriate transport modality varies according to the characteristics of each animal, and so, consequently, each regulatory body will have its rules and legislation to favor adequate logistical planning.

We found that there are few suggestions for future studies in the articles analyzed. We note that more in-depth research is needed for this topic, considering the

different modes of transport, such as air (Collins et al., 2020). This kind of transport has grown in the last few years of pandemic (and it is also already congested), due to crises experienced by international sea transport like delays, blockages due to Covid-19 in several ports and canals such as the Suez Canal, lack of equipment such as containers, the high value of freight, etc. In addition, there is a need for research that continues to address animal welfare aligned with the interests of supply chain participants as a whole, with special attention given to consumers (Fleming et al., 2020), and research that relates to the theme of sustainability in the supply chain (Rahim et al., 2020) for the development of live animal transportation.

Table 2 summarizes the findings.

Table 2 – Summary of findings

Topics of Data Analysis	Findings
The procedures and handling adopted in the logistics of live cargo.	It can promote greater financial and non-financial gains to members involved in the chain and enable competitive advantages for participating organizations if they ensure the appropriate treatment of the animal and guaranteeing its welfare and the quality of the final product.
The legislation of live cargo transportation	Don't have an International convergence of laws. Countries' legislation of live cargo transportation needs to be improved in order to be in line with the objectives of the SDG.
The final consumer	There is the increasing awareness of final consumers. It leads to the process becoming more qualified, generating changes in commercialization habits.
SSCM	To integrate sustainability into the supply chain, it is necessary to reach all levels of the chain, from raw material suppliers and conveyors to the final customer, and relevant stakeholders as public managers, research institutions, and NGOs for the protection of animal rights.

Source: Prepared by the authors (2022-2023)

5 FINAL CONSIDERATIONS

Transporting a live animal is a great responsibility. Concerning the procedures adopted in the logistics of live cargo, the sustainable management of the supply chain is one of the most important parts of the trade-in of these animals. Thus, efficient

management can promote greater financial and non-financial gains to members involved in the chain and enable competitive advantages for participating organizations. In addition, losses (economic impact) can be avoided. Above all, regarding this type of special cargo, it is necessary to carry out the logistic process efficiently, seeking to ensure the appropriate treatment of the animal and guaranteeing its welfare and the quality of the final product.

According to the articles found in the systematic literature review, it can also be inferred that the long distances of the routes and the different modes of transport used had considerable influence on the welfare of the animals. There is therefore an international trend to reduce long journeys and to assign more relevant information on the geographical origin of products, the duration of the transport, and welfare conditions to ensure more perceived, expected, and actual acceptance by consumers. However, the negative effects of the distance from the journey may be aggravated if it occurs in poor conditions (e.g., vehicle or packaging), with inappropriate procedures and handling, in extreme weather, or due to load mismanagement, for instance, the accommodation of animals of different sizes and/or commercial categories in the same compartment, among other reasons.

Another highlight, according to the analysis of data and results, is the gradually increasing awareness of final consumers which in turn crystallizes the demand for improvement of the standards employed. In fact, this awareness leads to the process becoming more qualified, generating changes in commercialization habits. For this reason, organizations must formulate sustainable development projects that contemplate the welfare of animals in the processes of live transport. For these projects to demonstrate efficiency and effectiveness, in other words, to integrate sustainability into the supply chain, it is necessary to reach all levels of the chain, from raw material suppliers and conveyors to the final customer. Other relevant stakeholders to consider include public managers, research institutions, and NGOs for the protection of animal rights; this is because change to an SSCM

is due to pressures and incentives that result from the actions of different groups outside the chain (Seuring and Müller, 2008).

As limitations of this study, the sample analyzed in the *Google Scholar* database was small; more studies have been expected for the development of analyses and discussions on the current legislation, the understanding of care in managing each species, the difficulties and positive aspects of transport, as well as examples and suggestions for improvements in the logistical impact to avoid the suffering and unnecessary mortality of animals when transported across the country (and around the world). As a suggestion for future studies, in addition to those already mentioned in the data analysis, it is proposed to expand the analyzed sample and seek detailed legislation and the correct management for the transport of each type of live cargo as well as different transportation modes.

In turn, we understand that the development of empirical research on the sustainability of the supply chain of this sector can reveal governance practices and mechanisms to be replicated or corrected for good SSCM. This may also expose latent needs for more effective public policies of coordination and control, encouragement of good practices, awareness of those involved, and punishments for offenders.

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Contribution	[Author 1]	[Author 2]	[Author 3]	[Author 4]
1. Definition of research problem	√	√	√	√
2. Development of hypotheses or research questions (empirical studies)	√	√	√	√
3. Development of theoretical propositions (theoretical work)	√	√		√
4. Theoretical foundation / Literature review	√	√	√	√
5. Definition of methodological procedures	√	√		
6. Data collection	√	√		
7. Statistical analysis	√	√	√	√
8. Analysis and interpretation of data	√	√	√	√
9. Critical revision of the manuscript	√	√	√	√
10. Manuscript writing	√	√	√	√

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