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Critical aspects of legislation and their impact on the welfare of water buffaloes during transport

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Abstract Transport is considered a stressful period for livestock that can cause economic and biological losses if inadequate handling procedures exist. Several manuals and guides include recommendations for common domestic species based on scientific evidence. Still, the legislative freedom of each country means that they are not mandatory worldwide, nor do they cover all species, such as the water buffalo (*Bubalus bubalis*). This review aims to analyze the legal strictures currently applicable to the transport of this species. Critical aspects of the legislation that address the pre-transport, transportation, and post-transport stages are discussed, focusing on Asian and Latin American countries and the European Union. Areas of opportunity to improve the norms and laws that impact public policies, civil aspects, and water buffalo welfare in production systems are elucidated.

Keywords: animal welfare, *Bubalus bubalis*, legislation, meat quality, transport, water buffalo

1. Introduction

Worldwide, the handling and agricultural practices involving the water buffalo (*Bubalus bubalis*) have intensified over the past 20 years (Cornish et al 2016) due to the increase in inventories of this species, which now number over 204 million head and have a strategic role in the economy (Borghese et al 2022; Di Stasio and Brugiapaglia 2021). This growth entails social, cultural, and political changes regarding this species (Webster 2001). However, the generation of norms to regulate the welfare of these animals during transport has not evolved at the same pace as this growth (Rojas et al 2005).

Generating norms to ensure compliance, guide inspections, and evaluations, and stipulate sanctions entail adjustments and responsibilities for diverse sectors of society, such as ranchers, shippers, slaughterhouse workers, and processors. This usually involves a complex, prolonged process (Velde et al 2002) that is often delayed or postponed due to vested interests that leave legal voids, which can allow poor practices to persist along the production chain (White 2013; Jacques 2014). Poor handling practices can endanger the physical and mental health of livestock and reduce levels of animal welfare (AW) in general by fostering disease development, high incidences of injuries, fear, anxiety, and chronic or unnecessary stress that can directly affect meat quality and the quality of the death of animals destined for human consumption (Mota-Rojas et al 2005; Mota-Rojas et al 2010a,b; Mota-Rojas et al 2021a,b). Individual countries, of course, are free to legislate following their system of governance and the demands and priorities of industry, consumers, political actors, and intermediaries by generating guidelines and regulatory documents for livestock handling (Rushen and Passillé 2010). The problems just mentioned, coupled with scarce scientific knowledge and a null or deficient regulation of procedures, result in significant biological and economic losses in the raising, transport, and slaughter of water buffaloes (Alarcón-Rojo et al 2021; Guerrero-Legarreta et al 2020; Mota-Rojas et al 2021a; Napolitano et al 2020b; OIE 2021; Schipp and Sheridan 2013).

These circumstances have generated diverse efforts to promote the application of good practices in water buffalo transport by analyzing the economic and biological repercussions of procedures that are not performed adequately. Those works are reference recommendations issued by international organizations like the World Organization for Animal Health (WOAH) and voluntary practices related to AW during the production and transport of livestock. A second important document is the Terrestrial Animal Health Code (TAHC), which is based on scientific findings that promote the maintenance of the good welfare of buffaloes during land and maritime transport (OIE 2021).

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Because these practices are voluntary degrees of application, they depend on various factors. In European countries, for example, where consumers consider AW a factor of great importance, there is a movement toward making compliance with the norms proposed to prevent poor agricultural practices (Lundmark et al 2014, 2018) and rules for the commercialization of products and byproducts obligatory (Maciel 2015). This movement seeks to relate AW to the quality and safety of final food products by recognizing that their physicochemical and microbiological characteristics are affected by handling practices and transport conditions and that this impacts indices of consumer acceptance (Cruz-Monterrosa et al 2020). While this evidences the weight that civil society and consumers can bring to bear, the application of good practices to promote AW is also influenced by industry and its needs. In this regard, countries like Mexico have enacted laws to foment AW to promote good sanitary conditions on farms and ranches to ensure the quality and safety of their products. This legislation includes recommendations for several optional practices whose implementation could allow producers and processors to access better markets (Rojas et al 2005; DOF 2018). Although these policies are not obligatory, producers and processors may begin to apply them due to their commercial and economic interests.

Other means of promoting AW operate in countries where legislative action is lacking since the growth of commerce in products of animal origin has engendered diverse strategies in the private sector regarding AW (Veissier et al 2011; Lundmark et al 2014; Ghezzi 2018). One goal is to negotiate commercial accords to increase profits. Agreements of this kind stipulate specific import/export conditions for consortiums and companies in competitive markets that require their application and proof of compliance with AW protocols (Ghezzi 2018; Romero and Sánchez 2011). Another aim is to ensure that supervision, verification, and compliance assessments are documented in mandatory certifications. Advances are generating significant changes in infrastructure, capacitation, and methodologies, but despite the increase in the commercial importance of water buffaloes and growing insistence on AW, especially in the ante-mortem period of animals destined for slaughter legal voids persist.

Given these circumstances, the objective of this review is to compile, describe, and analyze existing legislation applicable to the transport of water buffaloes by addressing the norms and guidelines adopted in various Latin American countries and other areas of the world to compare and contrast the requirements for the welfare of this species during transport, as well as their application, aims, and impact concerning the critical points of transport that produce the greatest impact on AW.

2. Legislation and the importance of good welfare during the transport of water buffaloes

The WOAH is the international organization responsible for issuing guidelines to promote good AW. Its recommendations reflect the joint efforts of scholars, citizens with policy influence, concerned organisms, and scientific principles whose shared objective is to attend to the ethical responsibility of the five freedoms to foment higher yields and lower economic losses by addressing aspects like environmental conditions, handling, and infrastructure to minimize the risk of trauma, fear, pain, and stress in all livestock species, including in nations where water buffaloes are raised as important productive animals (Napolitano et al 2022).

The CSAT covers supervising the planning, loading, transport, and unloading of livestock and the participation of competent personnel. Specific topics addressed include training handlers, professional competence, optimal trip times, selecting adequate vehicles and maintaining them in optimal conditions for each species, and preparing for emergency conditions that may occur during transport, such as severe injury, illness, animals' inability to move or remain standing, or death. More generally, it recommends measures to minimize the stress that can arise and intensify during transport, prepare for adverse environmental conditions, ensure that the buffaloes have sufficient space in the vehicle, avoid mixing animals from different production units, select compatible groups, and avoid brusque contact and the use of herding tools to move the animals (Figure 1). Finally, the WOAH and CSAT work to promote and improve legislation and government policies related to AW worldwide to reduce animal cruelty and poor welfare by emphasizing the importance of adequate inspections before, during, and after transport and suggesting the application of sanctions for non-compliance. They sustain that improving the laws that govern AW will drive progress and socioeconomic development (Otter et al 2012; Peters et al 2015).

Maintaining the good welfare of livestock destined for human consumption during transport requires adequate nutrition and suitable environments while preventing negative physical impacts and conditions that may later affect their behavior (Mellor 2017). Though these goals are fundamental elements of the ethical and humane treatment of livestock (Deters and Hansen 2020), they are not always achieved during trips because the buffaloes may be exposed to stressors like heat, cold, poor air quality, vibrations, and noise (Omran and Hamdon 2018) that affect not only their health but also increase the risk of injuries, such as skin lacerations and abrasions, among others (Alam et al 2020), of respiratory and digestive pathologies like oxidative or heat stress, or even death (Bertoni et al 2020a; Broom 2019; Deters and Hansen 2020; Nielsen et al 2020).

In addition, these animals may suffer physiological alterations that affect their thermoregulatory mechanisms (since this species has low heat-dissipating capacity) due to such anatomical characteristics as their scarce hair, thicker epidermis than bovine cattle, and black coloration with large amounts of melanin that absorbs heat from the exterior (Barboza 2011; Bertoni et al 2020). Buffaloes have physiological responses –for example, regulating their metabolic rate using energy produced by cell metabolism–

that can eliminate some excess heat by irradiation (Casas-Alvarado et al 2020; Napolitano et al 2020; Mota-Rojas et al 2021b,c,d,e) to regulate their body temperature as long as external conditions are not extreme and physical resources like natural or artificial shade are available, though it is difficult to provide these resources during transport (Bertoni et al 2020b). The impact of the animals' thermal responses can be observed by infrared thermography (Mota-Rojas et al 2021d; Mota-Rojas et al 2022), a useful technique for analyzing and modifying routine practices performed during herding and transport that can produce harmful physiological alterations like heat stress (Figure 2).

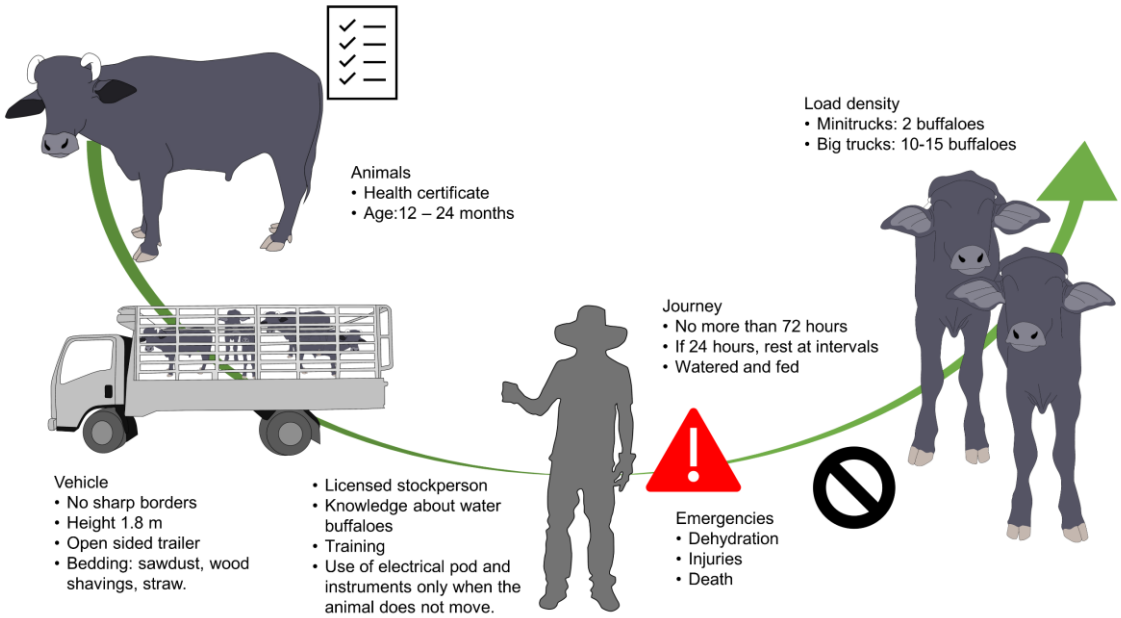

Figure 1 Recommendations for water buffalo transport. The manuals that promote the appropriate handling of water buffalo during transport in some countries include such elements as verifying the health status of the animals before loading and inspecting the physical characteristics of the vehicle. Recommended load densities and trip lengths are also highlighted, as is the importance of stockpeople trained in the proper use of herding instruments. Attending to these aspects will contribute to the welfare of buffaloes during transport and the quality of their meat and byproducts.

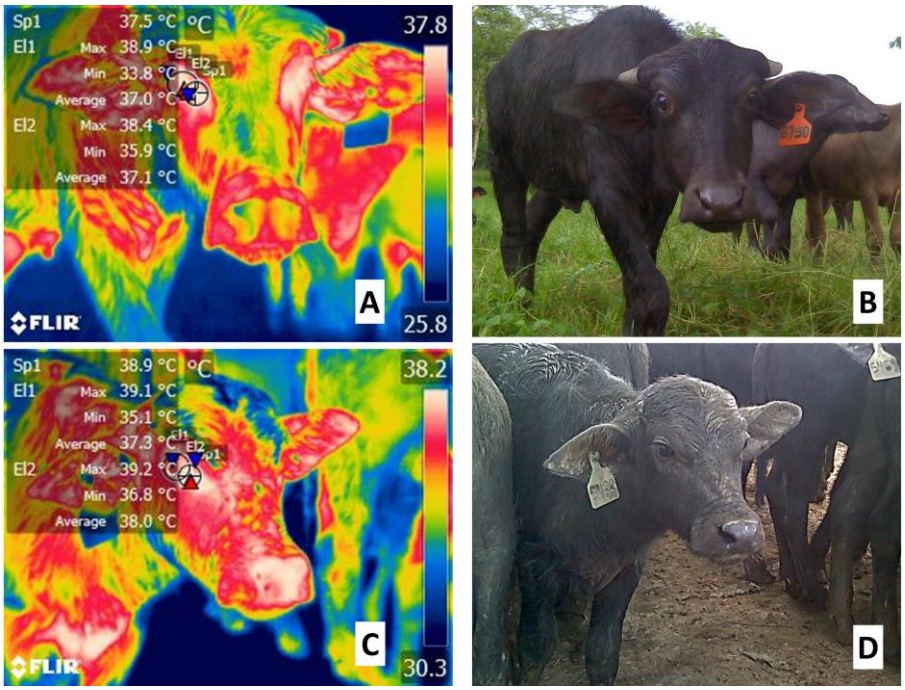

Figure 2 Routine handling of buffalo calves before and after herding and its effect on dermal microcirculation observed by infrared thermography. A, B. Radiometric and digital images of a buffalo in the paddock before transport (corralling). C, D. Radiometric and digital images of a buffalo upon arrival at the holding pen. The average surface temperature of the periocular region (El1) increased by 0.3 °C, while the lacrimal gland (Sp1) and lacrimal caruncle (El2) show average increases of 1.4 °C and 0.8 °C, respectively.

3. Impact of AW on public policies, production, and society

In recent years, AW has established its place in public policy, regulations, and legislative calendars propelled by the specifications imposed by importing countries, private companies, society in general, producers, and processors, all of whom have a shared interest in improving the quality of final products. Practices based on scientific data have been implemented to improve livestock's sanitary and health conditions under the supervision of professionals in various related fields (Jacques 2014; Alonso et al 2020). The growing interest in ensuring the welfare of livestock species has led to the standardization and certification of production units and transport and slaughtering processes (Cockram et al 2020). Internationally, chapter 7.3 of the CSAT contains specifications and requirements for the land transport of animals. It also mentions the capacitation that handlers of each species should receive, adequate methods for moving different animals, the ideal characteristics of trips, vehicles, and containers, and the documentation that must accompany the transported animals (WOAH 2021).

Although we include water buffaloes among the domesticated animals to which that chapter applies, to date, there are no specific, universal guidelines for this species. Despite this, the CSAT has served as the basis for elaborating official documents on the transport of water buffaloes in various countries, including some in Asia that have the largest buffalo populations in the world: 109.8 million in India, 40 million in Pakistan, and 27.3 million in China (Di Stasio and Brugiapaglia 2021). Those countries have passed laws to foster the welfare of water buffaloes, often with a clear religious orientation. In India, for example, a Prevention of Cruelty to Animals Act (#56) was published in 1960. Its goal was to prevent unnecessary pain and stress in animals. It outlines the features of adequate transport and stipulates sanctions for striking, injuring, or inflicting lesions on the in-transport animal, recommends not overloading vehicles and installing physical divisions when necessary as long as they do not cause pain or discomfort (Figure 3). Finally, it names the officials responsible for its application and enforcement (India 1960).

Figure 3 Physical adaptations of vehicles used to transport water buffaloes. A. A truck with the recommended load density reduces the risk of falls and injuries due to the space provided per animal It is equipped with physical divisions to transport animals of different ages, sizes, or origins. B. Vehicles with a roof design provide ventilation but do not open any means of escape.

In 1890, Pakistan ratified a Law for the Prevention of Cruelty to Animals. The original act was modified most recently in 2018 to increase the sanctions and administrative fines applied to those who affect the welfare of livestock, including water buffaloes (PAWS 2018). In 1950, Pakistan enacted a Cattle Slaughter Control act in Karachi, the nation's largest city. That act states that animals must be slaughtered in abattoirs that provide adequate lairage times and effectuate inspections by trained personnel to verify that all animals are in optimal conditions post-transport. Finally, it stipulates monetary sanctions and prison sentences for those who fail to comply (Karachi 1950).

In China, controversy surrounds the long distances that livestock must travel from production units to slaughterhouses and the conditions in which this is carried out. Diverse actors in Chinese society, including the Chinese Normalization Association, the Chinese Association of Veterinary Medicine, and government sectors, are actively working to regulate the practices that impact AW during transport. However, none of the legislative proposals presented to date have been ratified, so there are no specific laws there. In the absence of effective supervision, harmful practices persist (Li et al 2018).

Australia, in contrast, has made supervision mandatory. The water buffalo is classified among the meat and milk protein producer species and is deemed important because of its high efficiency in exploiting forage of medium-to-low quality and the properties of its meat and byproducts. Additionally, buffaloes are valued because they help reduce forest fires due to their natural habitat in swampy areas. In some areas, annual licenses must be obtained to regulate and ensure the correct handling of this species, supported by guidelines published by the federal government that outline the good handling practices for these animals, including during transport (Lemcke 2015a).

The principal water buffalo-producing countries in Latin America are Colombia, Brazil, Argentina, and Venezuela (Patiño 2011; Napolitano et al 2020a; Guerrero-Legarreta et al 2020), followed by Mexico and Chile. While norms for the production and welfare of buffaloes exist, there are marked differences in their respective systems of governance and, hence, divergent levels of concern for AW that open perspectives and areas of opportunity in each. Specific key characteristics of the water buffalo have proven advantageous for production in those nations: the ability to adapt to distinct climatic conditions, the potential for increases in growth and yield rates, potential profitability, contributions to environmental sustainability, and the optimal, attractive nutritional and sensory characteristics of final products (Álvarez-Macías et al 2020; Bertoni et al 2020; Guerrero-Legarreta et al 2020; Joele et al 2017; Mora-Medina et al 2018; Mota-Rojas et al 2020; Sabia et al 2018).

Unfortunately, most of these nations have legal vacuums in their social, commercial, and political policies that impact buffalo production systems. In Venezuela, for example, the only legal referent is the Law for the Protection of Free and Captive Domestic Fauna, which establishes norms for protection, control, and welfare that apply to all animals, including those destined for human consumption. However, that law (in force since 2010) does not specifically mention water buffaloes' transport. It only stipulates that transport conditions must ensure good welfare and prevent, insofar as possible, states of metabolic stress, pain, abuse, and cruelty. Finally, it provides detailed descriptions of acts of cruelty and lists the sanctions that can be imposed when livestock is not handled under optimal conditions (Venezuela 2010).

A detailed reading of this law reveals that it does not mention, or elaborate on, concepts, practices, or methods related to ensuring AW during pre-slaughter transport, nor any projects or proposals for norms, laws, decrees, or regulations that might suggest a tangible interest in effectuating change. This reflects not only voids in political infrastructure, deficient policies, problems in the existing legal framework, and issues of food safety, but also the alimentary, health, and economic crises that the country is experiencing (Page et al 2019; Doocy et al 2019; Pielago 2020). It is clear that passing laws on AW during the transport of water buffaloes is not a priority of the government or most Venezuelans even though it is the second-largest producing country in America (Nava-Trujillo et al 2020).

Colombia presents a contrast, for it has made strides in establishing AW as the means for generating positive actions in agricultural products designed to improve health, food quality, and food safety parameters through regulations, decrees, resolutions, and manuals that optimize the application, vigilance, inspection, and development of measures similar to those supported by the WOAH and FAO. This approach generates production and processing conditions that international markets find attractive due to adopting some of the CSAT's recommendations, recent legislation and guidelines, and international trade agreements. Colombia´s concern for health, food safety, food quality, and ensuring AW during transport has caught the attention of foreign countries and positively impacted society as a whole and, specifically, the companies involved in buffalo production (MADR 2020; OIE 2021).

Brazilian legislation on maintaining AW during the transport of water buffaloes presents a different panorama from that of Colombia. In 1934, the government emitted decree 24.548 that cited the need to organize sanitary conditions to ensure that people would have access to final products that were safe and of good quality. It established measures, such as inspections at key junctures of the production chain, to prevent the spread of disease, and provided guidelines on times and logistics (Matias et al 2019). Diverse political actors, entrepreneurs, and policies recognize Brazil's deficiencies and areas of opportunity. The country's legislature has targeted these through proposals for laws that would ensure adequate environments for maintaining good AW and guidelines that would indirectly impact this domain. The measures proposed are based on scientific findings and international recommendations for each production species. Unfortunately, none of those proposals or measures have been enacted into law due to vested interests and the priorities of the government in power (Henrique et al 2017).

4. Documentation and preparation of animals before transport

The documentation required includes transport permits and certificates of health and vehicular disinfection, among others. The objectives are to prevent the spread of disease and ensure the traceability of the source animals and final products. Several countries, Mexico among them, have cattle identification systems that include the water buffalo. However, the Mexican system has incongruencies because the buffalo is classified as a bovine breed, so it is not differentiated from conventional cattle. This impedes effective traceability though zoosanitary certificates are mandatory for in-country transport. The fact that this species is not identified specifically in existing legislation causes problems during transport (DOF 2018).

Planning is crucial to transporting farm animals and ensuring AW throughout the process. Preparing water buffaloes for transport requires considering numerous factors, such as age, size, and place of origin. Ideally, shippers will move animals with similar characteristics to minimize the potential for injuries (Figure 4) that can impact the meat quality (Guerrero-Legarreta et al 2020). In this regard, it is preferable to transport young animals aged 12-18 months rather than ones aged three years or more (Di Stasio and Brugiapaglia 2021). Following established good practices during loading and unloading (Figure 4a) is also important.

Figure 4 Animal handling during loading. A. Animals on the loading ramp with no apparent separation by size. A young buffalo is being moved with larger ones. This increases the potential for abrasions. B. Loading of buffaloes of similar size and age carried out by trained personnel without physical instruments to avoid injuries on the trip.

On this issue, the guides in some countries –China, for example– recommend transporting and sacrificing animals aged 24 months to obtain adequate yields and meat quality (Li et al 2018). Concerning vehicle design, one study reported that 95.3% of 192 water buffaloes suffered abrasions during transport, as Figure 5 describes in detail based on Alam et al (2010a). It is important to note that water buffaloes may be more susceptible to injury than bovines, possibly due to differences in body structure, a slower pace of walking that often provokes the use of sticks or prods, the style of herding, and flaws in vehicle design that increase friction and impacts (Alam et al 2010a,b).

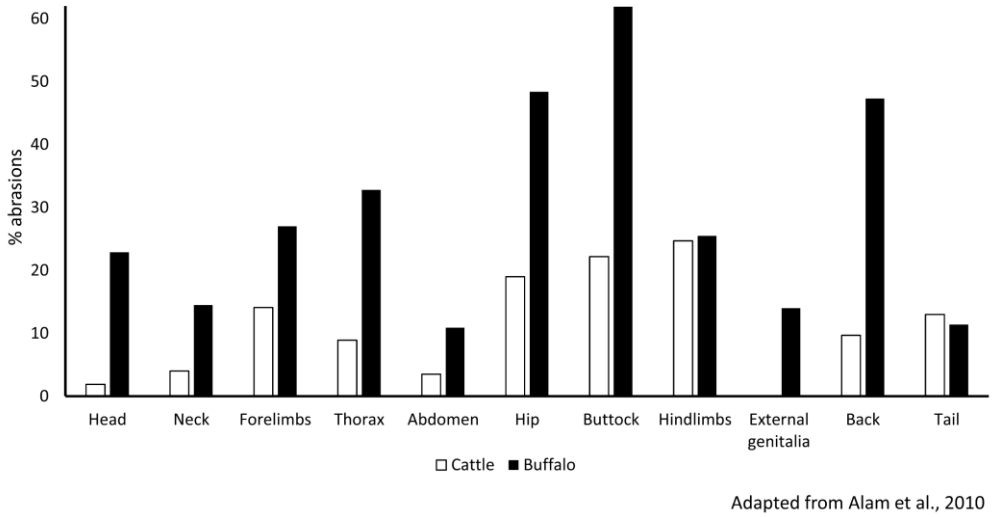

Figure 5 Comparison of abrasions on various body regions of cattle (Hariana, exotic and local to Bangladesh) *vs*. water buffaloes due to transport. Note the greater number of injuries in the buffaloes than cattle on the head (1.9 *vs*. 22.9%), neck (4 *vs*. 14.5%), forelimbs (14.1 *vs*. 27%), thorax (8.9 *vs*. 32.8%), abdomen (3.5 *vs*. 10.9%), hip (19 *vs*. 48.4%), rump (22.2 *vs*. 61.9%), hind limbs (24.7 *vs*. 25.5%) and back (9.7 *vs*. 47.3%).

Legislation in the European Union (EU) stipulates only shippers previously authorized to transport animals can be hired. Shippers must ensure that AW will not be affected by planning for the various phases of trips and considering climatic and road conditions, among other aspects. They must also designate the personnel in charge who, among other responsibilities, must provide the competent authorities with all required information and documentation on the preparations for and the execution and completion of each trip. For especially long trips, they must fill out, sign, and seal planning forms that identify the starting point and destination and include the shipper's declaration and any reports of anomalies found in the animals sampled. Obviously, this cannot occur if the load is not inspected and approved by those authorities (Union 2019).

5. Feeding and lairage periods at the abattoir

Food consumption before and during trips is a matter of debate because of the scarce scientific evidence currently

available on the effects of fasting in water buffaloes. Studies of Hereford and Angus steers show that prolonged fasting (>24h) increases dehydration while fasting for 12-13h produces changes in water consumption (Clariget et al 2021). In other studies, mestizo steers showed the transfer of fatty acids from adipose tissue after 48h of fasting (Herdt 2020; Ortolani et al 2020). These findings suggest that cattle's adequate fasting time should not exceed 12h. Studies of Aberdeen Angus × Nellore bovines indicate that waiting times of 12h in the abattoir allowed the animals to adapt to the new environment, but that after 12h, cortisol tended to increase from 8.7 to 12.5 mcg dL -1 (Moura et al 2021), indicating that fasting and lairage times at the abattoir should not exceed 12h. Handling strategies must take these issues into account.

Legislation like Mexico's official norm, "NOM-051-ZOO-1995, Humane treatment during animal transport, does not stipulate maximum fasting times or optimal lairage periods for cattle, nor does it mention the water buffalo in its specifications. It does, however, state that transport times for bovines should not exceed 18h without rest periods and opportunities to drink water and that longer trips (>24h) must include rest periods at least every 18h and the provision of food, though it fails to recommend the types or amounts of food that should be made available (DOF 1995).

Brazil's laws emphasize preventing disease spread among livestock, including water buffaloes. They establish, for instance, that trip times must not exceed 72 h and that when transport requires more than 24 h, vehicles must make rest stops at specific sites to prevent conditions that may cause sanitary problems. However, those laws do not establish norms for the installations, supervision, and training of handlers, nor do they present guidelines for herding, loading, transport, and unloading practices that could help minimize travel-induced stress (Rojas et al 2005; Henrique et al 2017).

Legislation in Chile mentions that food, water, and rest must be provided in relation to the needs of each species at least every 8 h on trips that exceed 24 h and that this must take place at sites authorized by the Department of Agriculture. When, for whatever reason, rest cannot be provided, the vehicle must be equipped to allow the provision of food and water (Ministerio de Agricultura de Chile 2013).

Similar guidelines are applied in countries like Australia, which specifies that trips should not exceed 30h without unloading the animals and offering them food and water (Lemcke 2017). Other recommendations are that the buffaloes be given long hay instead of pelleted feed in the rest zones to promote ruminal stability and that they are allowed to remain in the zone for at least 12h before renewing the trip (Lemcke 2017).

In the case of the EU, Regulation 1/2005 states that trip duration for cattle should not exceed 8 h and that on longer trips, one hour of rest must be allowed after 14h of travel to provide water and food. After that, the trip can continue for another 14h. When transport ends and the animals have been unloaded, they must be given food and water and allowed to rest for 24h (European Union 2019).

6. Transport

Australia's Department of Primary Industry and Resources stipulates that the trailers used to transport buffaloes must be free of protrusions or sharp structures that could cause injuries (Figure 6). The recommended height of walls is 1.8 m. Ideally, trailers will be of the open-sided type to facilitate loading (Lemcke 2017). Section 14 of the Non-Indigenous Animal Act stipulates that all personnel responsible for handling buffaloes must be licensed (Sheehan 2012).

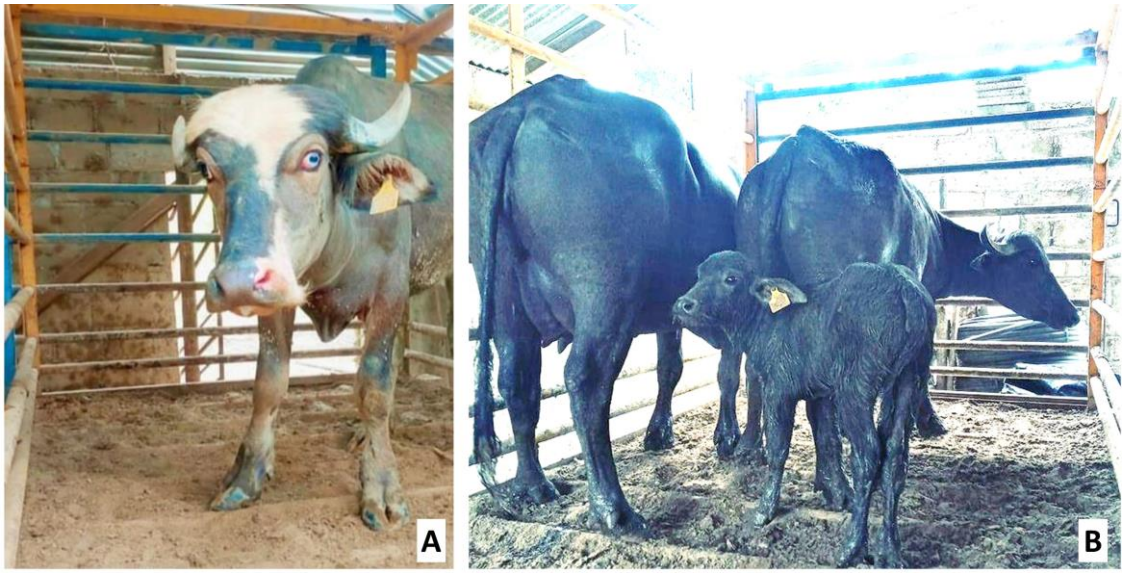

Figure 6 Characteristics that increase or decrease injuries during transport. A. Buffaloes are transported in a tubular structure that allows adequate ventilation with walls free of sharp edges and non-slip flooring to prevent falls and injury. B. Animals of different sizes are about to be transported. This requires physical divisions in the vehicle.

In India, buffalo meat represents 30% of all meat production, making it one of the leading producers countries in the world. The Federation of the Indian Chamber of Commerce and Industry (FICCI) recommends that the vehicles used to transport buffaloes be small trucks with the capacity for two animals or large trailers that can hold 10-15. Data show that 97% of producers in India report that transport is their largest production cost, in part because each animal must have a health certificate issued by a qualified veterinarian that identifies its precedence and quality (Singh et al 2012).

Returning to Latin America, most current regulations fail to distinguish between bovine cattle and water buffaloes. Chapter VII of Colombia's Law 84 (1989) on the protection of animals stipulates principles and procedures for transport designed to prevent cruelty, fatigue, fasting, dehydration, and injuries and to avoid adverse environmental conditions. Decree 1500 (2007) specifies the vehicles and documentation required for each trip. It emphasizes the need for continuous personnel training while underscoring the importance of compliance with these measures because of their impact on food safety. It further states that the vehicles' design must be appropriate for the species transported, has mechanisms of physical division to reduce overcrowding, aggressions, and injuries, and satisfy all published sanitary dispositions (Colombia 2020).

Chile's Law 19162, with regulation 2401, indicates the means of transport that can be used to ship live animals to slaughterhouses and the characteristics they must have, such as divisions when animals of different ages and physical conditions will be loaded. Vehicles must have smooth, perforated walls free of sharp protuberances or be equipped with mechanical ventilators to maintain comfortable temperatures and prevent heat stress. Floors must be made of non-slip materials to prevent injuries and ensure the safety of the animals during loading, transport, and unloading (Figure 4) (Ministerio de Agricultura de Chile 1992). A law passed in 2012 binds shippers to modernize the vehicles used to transport cattle (Strappini 2012), while Decree 30 (2013) prohibits shipping cattle in conditions that cause unnecessary pain or suffering. In Chile, one especially observes strict adherence to the parameters established in the CSAT, including the selection of vehicle characteristics in accordance with the species to be loaded, trip times, and adequate thermoregulation conditions (Ministerio de Agricultura de Chile 2013).

EU Regulation (CE) 1/2005, "Relative to the protection of animals during transport and related operations that modify directives 64/432/CEE and 93/119/CE and Regulation (CE) 1255/97", stipulates the parameters for transport for cattle, sheep, goats, and pigs during long trips. These include roofed vehicles, bedding adequate for each species, the number of animals, trip duration, climatic conditions, and means of ensuring the absorption of urine and feces (European Union 2019). In contrast to other regulations, this one stipulates that the food provided must be sufficient and free of contamination and that the feeding equipment must be designed and installed so that food cannot fall. Moreover, this equipment must be fastened down when the vehicle is in movement. Finally, all food must be stored separately from the animals.

The characteristics of vehicles can also contribute to improving AW about climatic conditions, as demonstrated in a recent study of sheep (Dorper × Mongolia), where a closed truck reduced the incidence of cold stress. That report affirmed that consuming food before transport improved the animals' capacity to resist cold temperatures over short distances (Carnovale et al 2021). Research of this kind suggests that key topics for future studies will be the effects of cold and potential measures to minimize those effects on long trips, especially concerning their impact on the water buffalo.

At the opposite end of the temperature scale, the high temperatures that occur in some months of the year increase animals' susceptibility to heat stress during transport, especially on long trips. This can be aggravated by overcrowding which can trigger anxiety and, on occasions, death (Bhatt et al 2021; Bachelard 2022). Considering this danger, EU Regulation 1/2005 stipulates that vehicles must maintain a temperature between 5 and 30 °C throughout the trajectory with a tolerance of +/-5 °C depending on the exterior temperature (European Union 2019).

7. Load density

Australia's Manual on the River Buffalo, published by the Northern Territory Government (NTG) (Lemcke 2017), and based on the Australian Animal Welfare Standards and Guidelines for the Land Transport of Livestock (Animal Health Australia 2012), states that when the load density of buffaloes is low, the animals must have sufficient space to lie down. The recommendation for long trips is to provide bedding made of sawdust, wood shavings, or straw (Lemcke 2015b). In contrast, if the density is high, the buffaloes will have to remain standing, so it is important to avoid space conditions that would allow them to lie on the floor since they could be trampled by other animals and suffer severe injuries (Lemcke 2017).

Another case of observations on load densities comes from Mexico, where regulations specify the height of the vehicle's roof or tubular structure and the space that should be allowed for each animal. Those parameters, however, fail to differentiate between species with or without horns and make no mention of modifications due to the age or weight of the animals. In addition, they are only applicable to bovines, as the reference utilized by medical officials at zoosanitary inspection and verification points shows (DOF 1995, 2015). Figure 3 presents an example of the load densities stipulated there.

In this regard, Act 56 for the Prevention of Animal Cruelty in India only states that loading densities should not be excessive to ensure that the animals have some degree of comfort and to lessen the risk of injuries that could affect their carcasses when processed. The Act fails, however, to

specify numbers for optimal load densities for buffaloes (India 1960).

8. Capacitation and the human-animal relationship

Studies in Chile have documented that the guillotine doors injure 75.1% of bovines at slaughterhouses due to the inadequate capacitation of handlers. In addition, 49.2% were moved to utilize electric prods (Muñoz et al 2012). This raises concern because the use of such equipment should not exceed 20% (Grandin 2012). Electric prods can cause hematomas during loading and unloading and in the stunning chamber. This is a clear case of poor human-animal interaction (Alam et al 2010a) that occurs in Chile even though current norms stipulate that all handlers involved in transport and slaughtering must demonstrate their competence based on training received on correct handling procedures and AW. Alternatively, these activities must be performed by agricultural professionals or technicians (Ministerio de Agricultura de Chile 1992, 2013).

EU regulation 1/2005, meanwhile, establishes that training is required for all persons involved in handling animals during all stages of transport. Authorized organizations must give the training to teach the personnel to carry out their labors without violent acts or measures that cause fear, physical harm, or suffering (European Union 2019). Article 7.3.8 of the aforementioned CSAT recommends that electric prods be used only on animals that refuse to move when there is sufficient space and adequate conditions for them to do so. It further states that prods must not be applied to the hindquarters of large ruminants, nor to the ears, mouth, eyes, abdomen, or anogenital region. Using authorized instruments (flags, plastic bags, panels, banderillas) should be encouraged only to stimulate the animals to move in the correct direction. This specification is mentioned in current legislation in Mexico that, in addition, indicates the obligation to train all personnel involved in handling livestock and stresses the need to foment the correct utilization of the tools and infrastructure available in loading and reception areas, such as ramps with a maximum slope of 25° (DOF 1995) (Figure 7). These measures, however, are not obligatory there.

Figure 7 Loading and unloading ramps used in Mexico for buffalo transport. A. Trailer and uneven ramp. Though it has slots and an adequate slope, this ramp is not aligned correctly with the trailer, a factor that may cause injuries to the buffaloes' hind limbs. B. Type of trailers used to transport buffaloes in Mexico.

In Colombia, Resolution 253 (2020) preceded the publication of the Manual of Conditions of Animal Welfare. That document mentions that blunt, sharp, or electric instruments should not be used to force livestock if they can cause any type of injury. Instead, it recommends using flags and rattles that promote handling free of stress, pain, fear, and suffering (Colombia 2020).

The capacitation strategies adopted in countries like Australia –available in online courses sponsored by the government– include educating personnel on the differences between buffaloes and conventional cattle. Key differences include the more docile temperament of buffaloes and the fact that they learn more quickly under frequent, careful handling. Scientific findings of this kind emphasize that it is recommendable to move buffaloes calmly without challenging them, though this is often necessary with cattle (*Bos taurus* or *indicus*) (Lemcke 2015a).

9. Procedures for emergency situations

Documents and guidelines elaborated by the government of Australia's Northern Territory (e.g., No. J65, Transportation to the Abattoir, Australia, 2012; Lemcke 2017) recommend that in the event of dehydration, post-transport buffaloes should have their heads sprayed gently with water before unloading and then be moved to a shaded area. There should also be supervision in the lairage pens before slaughter to ensure that the animals do not drink water in excess to prevent premature mortality (Lemcke 2015a).

Colombia's manual on AW also considers that the personnel involved in planning and organizing transport procedures should anticipate and plan for situations of emergency and prepare contingency measures in the event, for example, of natural disasters, circumstances that require providing food and water, or when signs of disease appear (Colombia 2020; Virviescas-Sanabria 2020).

Guidelines in Mexico specify the conditions under which livestock should not be transported to a slaughterhouse. Those conditions include disease, limiting injuries, fatigue, and females close to following, among others. The objective is to avoid transport problems that could put the animals' AW at risk. Legislation in Mexico further stipulates that planning for emergencies should include providing the vehicle with ramps, specific spaces for injured animals, handling animals that die *en route*, and equipment that facilitates efficient unloading. It also stresses the importance of humanely slaughtering animals that have suffered life-threatening injuries (DOF 1995, 2015).

Legislation in Chile specifies the steps to be taken in cases of emergency, emphasizing that the personnel responsible for transport at each cattle production unit must have plans that anticipate emergency situations by identifying the types of possible incidents, the corrective actions to be taken in each case, and the person responsible for ensuring that those actions are taken. It also outlines –in the event that this becomes necessary– a slaughtering method that prevents unnecessary suffering in animals that become ill or are severely injured (e.g., fractures) such that transporting them becomes difficult (Ministerio de Agricultura de Chile 2013).

10. Future perspectives

While the publication of decrees, regulations, laws, norms and other measures have produced positive changes that favor animals, research by NGOs and institutions in the EU and its member states, together with other scientific work, show that much remains to be done to achieve satisfactory protection of livestock, since existing laws, norms, and guidelines are inadequate or their enforcement deficient (Bachelard 2022). In the case of the water buffalo, our review found (i) that this species is rarely identified specifically in the documents discussed, and (ii) where it is included, no specific measures are indicated, despite its productive value and economic importance in numerous regions. These findings highlight the need to include the water buffalo in national norms and regulations to improve the welfare of this species due to its significant physical differences compared to conventional cattle (José-Pérez et al 2022).

Modifications to legislation in the future should stipulate maximum trip times for each species, specify adequate ages for transport, outline strategies for improving inspection procedures, establish vehicle specifications that consider dimensions and physical characteristics, address potential meteorological conditions, and recommend rest periods and the provision of food and water on long trips.

Public and social demands regarding commercializing products of animal origin and practices focused on AW have intensified in recent years; indeed, consumers and industries increasingly see enhancing livestock welfare as a requirement and a non-negotiable issue for acquiring products. An important objective in some geographic areas is to identify opportunities to improve existing legislation following technical and scientific recommendations emitted by international organisms. However, this may upset established distributions of responsibilities and functions. Unfortunately, advances in this direction are not occurring in many of the most important water buffalo-producing and transporting nations. For these two activities, it is essential to promote procedures based on scientific research that establishes optimal conditions for their development and AW as a means, as well, to reduce economic losses worldwide.

The greater availability of information has generated social and political changes such that the scientific community and international organisms have emerged as fundamental entities for modifying laws and guidelines. In addition to providing tools and strategies, they raise awareness that improving AW will generate greater economic profits and significant ethical advances for society as a whole through an emphasis on the traceability of products and improved food safety.

As Broom (2019) argues, traceability is a fundamental aspect of animal transport that must be developed rigorously wherever livestock is raised, including water buffaloes. Traceability is a method for supervising and controlling key elements of livestock production, from the animals' birth to their slaughter, including monitoring the handling procedures applied from the farm to the animals' final destination. It is a procedure that inspects and verifies the health conditions and welfare of the animals transported with strict observance of laws and norms. In Italy, where the production of buffalo milk for elaborating mozzarella cheese is an important industry, a ministerial decree in 2014 made traceability obligatory for all milk production units (Cappelli et al 2021). However, to date, no similar system exists for animals destined for meat.

11. Final considerations

Currently, no global regulations specify standards for the transport of water buffaloes. However, the CSAT, which recognizes the buffalo as a domesticated species, does contain recommendations for preventing or reducing injuries, pain, suffering, and stress during transport. In countries where the populations and production of domesticated water buffaloes grow each year –Pakistan and India, for example– only a few of the points covered in the CSAT are respected; for instance, load densities, rest times, and establishments authorized for sacrifice. China has elaborated legislative proposals related to AW but has not been enacted. Legislation in Australia, meanwhile, is tailored to the specific needs and conditions of different regions. While Australia does not have such large water buffalo populations as India or Pakistan, it has norms and regulations for livestock transport. It stipulates that causing unnecessary injury, pain, or stress are punishable crimes.

In Latin America, Colombia, Chile, and Argentina follow some of the WOAH's recommendations, and Argentina has elaborated an AW manual that covers the production, transport, and sacrifice of water buffaloes. In contrast, Venezuela only pays lip service to the welfare of

buffalo populations, for it has no statutes that refer specifically to the transport of this species. Conditions in Mexico are similar because the water buffalo is not mentioned in legislation to prevent the inadequate handling of livestock. This omission opens legal voids because it is impossible to differentiate each species' products or to effectively supervise the areas of health, production, and commercialization.

Understanding the degrees of application of legislation in the various water buffalo-producing countries demands evaluating regional social and political conditions. All these nations manifest some interest in implementing measures to inspect, supervise, sanction, and certify the practices employed in water buffalo production. Most have developed legislative proposals, decrees, accords, manuals, and norms with recommendations for existing production units. But ratification and enactment processes often take a great deal of time, months or even years.

Fomenting a culture focused on the quality of products for human consumption, voluntary certifications, and the auditing of good agricultural practices in which civil society plays a fundamental role are strategies that can help close existing legal voids related to the water buffalo.

In summary, providing better conditions for domesticated buffalo species during transport requires developing, modifying, and applying laws and regulations based on solid scientific research through the participation of scholars, public organisms, private companies, and the social sector. Achieving these goals requires political changes in each country that, hopefully, will lead to the consolidation of laws for the welfare of the water buffalo.

Conflict of Interest

The authors declare that they have no conflict of interest.

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References

Alam MR, Gregory NG, Jabbar MA, et al (2010a) Skin injuries identified in cattle and water buffaloes at livestock markets in Bangladesh. Vet Rec 167:415-419.

Alam MR, Gregory NG, Uddin MS, et al (2010b) Frequency of nose and tail injuries in cattle and water buffalo at livestock markets in Bangladesh. Anim Welf 19:295-300.

Alam MR, Islam MJ, Amin A, et al (2020) Animal-based welfare assessment of cattle and water buffalo in Bangladeshi slaughterhouses. J Appl Anim Welf Sci 23:219-230.

Alarcón-Rojo A, Mota-Rojas D, García-Galicia I, et al (2021) Dark cutting in large in water buffalo: Effect of management and environmental factors. Agro Product 13:93-98.

Alonso ME, González-Montaña JR, Lomillos JM (2020) Consumers' Concerns and Perceptions of Farm Animal Welfare. Animals 10:385.

Álvarez-Macías A, Mota-Rojas D, Bertoni A, Dávalos-Flores JL (2020) Opciones de desarrollo de los sistemas de producción de búfalos de agua de doble propósito en el trópico húmedo latinoamericano. In: Napolitano F, Mota-Rojas D, Guerrero-Legarreta I, Orihuela A (eds) El búfalo de agua en Latinoamérica, hallazgos recientes., 3ra ed. BM Editores, México, pp 43-74.

Animal Health Australia (2012) Australian Animal Welfare Standards and Guidelines- Land Transport of Livestock. Animal Health Australia (AHA). Canberra, pp 1-115.

Bachelard N (2022) Animal transport as regulated in Europe: a work in progress as viewed by an NGO. Anim Front 12:16-24.

Barboza-Jiménez G (2011) Bondades ecológicas del búfalo de agua: camino hacia la certificación. Tecnol en Marcha 24:82-88.

Bertoni A, Mota- Rojas D, Napolitano F, et al (2020a) Ventanas térmicas en el búfalo de agua: aspectos prácticos para la valoración reproductiva. In: Napolitano F, Mota- Rojas D, Guerrero- Legarreta J, Orihuela A (eds) El búfalo de agua en Latinoamérica, hallazgos recientes, 3ra ed. BM Editores, Mexico City, pp 690-719.

Bertoni A, Mota-Rojas D, Álvarez-Macias A, et al (2020b) Scientific findings related to changes in vascular microcirculation using infrared thermography in the river buffalo. J Anim Behav Biometeorol 8:288-297.

Bertoni A, Napolitano F, Mota-Rojas D, et al (2020c) Similarities and Differences between River Buffaloes and Cattle: Health, Physiological, Behavioral and Productivity Aspects. J Buffalo Sci 9:92-109.

Bhatt N, Singh N, Mishra A, et al (2021) A detailed review of transportation stress in livestock and its mitigation techniques. Int J Livest Res. https://doi.org/10.5455/ijlr.20201109102902

Borghese A, Chiariotti A, Lucia V (2022) Biotechnological applications in buffalo research. Springer Singapore, Singapore.

Broom DM (2019) Welfare of Transported Animals: Welfare Assessment and factors affecting welfare. In: Grandin T (ed) Livestock Handling and Transport, 5 Th. CAB International. Oxfordshire, Oxford, pp 12-29.

Cappelli G, Di Vuolo G, Gerini O, et al (2021) Italian Tracing System for Water Buffalo Milk and Processed Milk Products. Animals 11:1737.

Carnovale F, Xiao J, Shi B, et al (2021) The effects of vehicle type, transport duration and pre-transport feeding on the welfare of sheep transported in low temperatures. Animals 11:1659.

Casas-Alvarado A, Mota-Rojas D, Hernández-Ávalos I, et al (2020) Advances in infrared thermography: Surgical aspects, vascular changes, and pain monitoring in veterinary medicine. J Therm Biol 92:102664.

Clariget J, Banchero G, Luzardo S, et al (2021) Effect of pre-slaughter fasting duration on physiology, carcass and meat quality in beef cattle finished on pastures or feedlot. Res Vet Sci 136:158-165.

Cockram MS, Dulal KJ, Stryhn H, Revie CW (2020) Rearing and handling injuries in broiler chickens and risk factors for wing injuries during loading. Can J Anim Sci 100:402-410.

Council Regulation (EC) No 1/2005 of 22 December 2004 (2019) on the protection of animals during transport and related operations and amending. https://eur-lex.europa.eu/legal-content/en/ALL. Accessed on: July 01, 2022.

Cornish A, Raubenheimer D, McGreevy P (2016) What we know about the public's level of concern for farm animal welfare in food production in developed countries. Animals 6:74.

Cruz-Monterrosa RG, Mota-Rojas D, Ramírez-Bibriesca E, et al (2020a) Scientific findings on the quality of river buffalo meat and prospects for future studies. J Buffalo Sci 9:170-180.

Cruz-Monterrosa RG, Mota-Rojas D, El-aziz AHA, et al (2020b) Calidad de la carne de búfalo de agua: análisis nutricional, sensorial e inocuidad, conservación, empacado y autenticidad. In: Napolitano F, Mota-Rojas D, Guerrero-Legarreta I, Orihuela A (eds) El búfalo de agua en Latinoamérica, hallazgos recientes, 3ra ed. BM Editores, México, pp 1279-1319

Deters EL, Hansen SL (2020) Invited Review: Linking road transportation with oxidative stress in cattle and other species. Appl Anim Sci 36:183-200.

Di Stasio L, Brugiapaglia A (2021) Current knowledge on river buffalo meat: A critical analysis. Animals 11:2111.

DOF (2018) Ley federal de sanidad animal. DOF la Fed 1-55

DOF (1995) NOM-051-ZOO-1995- Trato humanitario en la movilización de animales. http://publico.senasica.gob.mx/?doc=531 Accessed on: July 01, 2022.

DOF (2015) NOM-033-SAG/ZOO-2014 Métodos para dar muerte a animales domésticos y silvestres. https://www.gob.mx/profepa/documentos/norma-

oficial-mexicana-nom-033-sag-zoo-2014-metodos-para-dar-muerte-a-los-animales-domesticos-y-silvestres Accessed on: July 01, 2022.

Doocy S, Ververs M-T, Spiegel P, Beyrer C (2019) The food security and nutrition crisis in Venezuela. Soc Sci Med 226:63-68.

Gallo C (2008) Transporte e bem-estar animal. Ciênc vet tróp 11:11

Gallo CB, Huertas SM (2016) Main animal welfare problems in ruminant livestock during preslaughter operations: a South American view. Animal 10:357-364.

Ghezzi MD (2018) ¿Cómo medimos el bienestar animal? Los porcicultores y su entorno. https://bmeditores.mx/porcicultura/como-medimos-el-bienestar-animal/ Accessed on: July 01, 2022.

González-Lozano M, Mota-Rojas D, Orihuela A, et al (2020) Review: Behavioral, physiological, and reproductive performance of buffalo cows during eutocic and dystocic parturitions. Appl Anim Sci 36:407-422.

Gonzalez-Rivas PA, Chauhan SS, Ha M, et al (2020) Effects of heat stress on animal physiology, metabolism, and meat quality: A review. Meat Sci 162:108025.

Grandin T (2012) Developing measures to audit welfare of cattle and pigs at slaughter. Anim Welf 21:351-356.

Guerrero-Legarreta I, Napolitano F, Cruz-Monterrosa R, et al (2020) River buffalo meat production and quality: sustainability, productivity, nutritional and sensory properties. J Buffalo Sci 9: 159-169.

Henrique A, Regis DP, Cornelli G (2017) Situación jurídica de los animales y propuestas de modificación en el Congreso de la Nación Brasileña. 25:191-198.

Herdt TH (2020) Utilización postabsortiva de los nutrientes. In: Klein BG (ed) Cunningham fisiología veterinaria, 6.ª ed. Elsevier, Barcelona, pp 361-377.

India G of (1960) The prevention of cruelty to animals act 1960. In: Gov Cent Sect 59 1960. https://www.indiacode.nic.in/bitstream/123456789/11237/1/the_prevention_of_cruelty_to_animals_act%2C_1960.pdf Accessed on: July 01, 2022

Jacques S (2014) Science and animal welfare in France and European Union: Rules, constraints, achievements. Meat Sci 98:484-489.

Jeleníková J, Pipek P, Staruch L (2008) The influence of ante-mortem treatment on relationship between pH and tenderness of beef. Meat Sci 80:870-874.

Joele MR, Lourenço LF, Lourenço Júnior JB, et al (2017) Meat quality of buffaloes finished in traditional or silvopastoral system in the Brazilian Eastern Amazon. J Sci Food Agric 97:1740-1745.

José-Pérez N, Mota-Rojas D, Ghezzi M, et al (2022) Effects of transport on water buffaloes (*Bubalus bubalis*): factors associated with the frequency of skin injuries and meat quality. J Anim Behav Biometeorol 10:2216.

Karachi G (1950) Karachi cattle slaughter control Act. http://faolex.fao.org/docs/pdf/pak116012.pdf Accessed on: July 01, 2022.

Lemcke B (2015a) Water buffalo handling: property to abattoir. North Territ Gov 1-4.

Lemcke B (2017) The Australian water buffalo manual. Department of primary industry and resources. Northern Territory Government: 1-147.

Lemcke B (2015b) Water buffalo handling: Property to abattoir, transportation to the abattoir. In: North. Territ. Gov.

Li X, Zito S, Sinclair M, Phillips CJC (2018) Perception of animal welfare issues during Chinese transport and slaughter of livestock by a sample of stakeholders in the industry. PLoS One 13:e0197028.

Lundmark F, Berg C, Röcklinsberg H (2018) Private animal welfare standards—opportunities and risks. Animals 8:4.

Lundmark F, Berg C, Schmid O, et al (2014) Intentions and values in animal welfare legislation and standards. J Agric Environ Ethics 27:991-1017.

Maciel CT (2015) Public morals in private hands? A study into the evolving path of farm animal welfare governance. Dissertation, Wageningen University.

Matheny G, Leahy C (2007) Farm-animal welfare,legislation, and trade. https://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1415&context=lcp Accessed on: July 01, 2022.

Matias BF, Okano W, Pértile SFN, et al (2019) Economic losses due to hematoma in bovine carcasses from the north central mesoregion of Paraná. Acta Vet Bras 13:114-119.

Mellor D (2017) Operational details of the five domains model and its key applications to the assessment and management of animal welfare. Animals 7:60.

Ministerio de Agricultura de Chile (1992) Ley 19162, Sistema obligatorio de clasificación de ganado, tipificación y nomenclatura de sus carnes y regula funcionamiento de mataderos, frigoríficos y establecimientos de la industria de la carne. https://derechoanimal.info/sites/default/files/doc-law/Ley%20de%20la%20carne.pdf Accessed on: July 01, 2022.

Ministerio de Agricultura de Chile (2013) Decreto 30. Reglamento sobre protección del ganado durante el transporte. https://derechoanimal.info/sites/default/files/doc-law/Reglamento%20de%20protecci%2B%EF%BF%BDn%20del%20ganado%20durante%20el%20transporte.pdf Accessed on: July 01, 2022.

Ministerio de agricultura y desarrollo rural (2020) Manual de condiciones de bienestar animal propias de cada una de las especies de producción del sector agropecuario; bovina, bufalina, aves de corral y animales acuáticos. In: Minist Agric y Desarrrollo Rural. Colombia, pp 1-35.

Mora-Medina P, Napolitano F, Mota-Rojas D, et al (2018) Imprinting, sucking and allosucking behaviors in buffalo calves. J Buffalo Sci 7:49-57.

Mota-Rojas D, Becerril-Herrera M, Gay JFR, Lemus FC, Alonso SML, Ramírez NR (2005) Calidad de la carne, salud pública e inocuidad alimentaria. México. Primera edición. Universidad Autónoma Metropolitana Serie Académicos CBS No. 52. México D.F. 353 pp.

Mota-Rojas D. Guerrero Legarreta I, Trujillo O.M.E, (2010a). Bienestar animal y calidad de la carne. Editorial BM Editores. México. p.361.

Mota-Rojas D, Alarcón-Rojo AD, Vázquez GG, Guerrero Legarreta I (2010b). Músculo oscuro firme y seco en bovinos, mecanismos involucrados. En: Bienestar animal y calidad de la carne. Primera edición- BM Editores. México D.F. p. 271-286.

Mota-Rojas D, Broom DM, Orihuela A, et al (2020) Effects of human-animal relationship on animal productivity and welfare. J Anim Behav Biometeorol 8:196-205.

Mota-Rojas D, Ghezzi MD, Napolitano F, et al (2021a) Quality of death in the river buffalo (*Bubalus bubalis*). J Anim Behav Biometeorol 9:1-10.

Mota-Rojas D, Napolitano F, Strappini A, et al (2021b) Pain at the slaughterhouse in ruminants with a focus on the neurobiology of sensitisation. Animals 11:1085.

Mota-Rojas D, Wang D, Titto CG, et al (2021c) Pathophysiology of fever and application of infrared thermography (IRT) in the detection of sick domestic animals: recent advances. Animals 11:2316.

Mota-Rojas D, Pereira AMF.; Wang D, et al (2021d) Clinical applications and factors involved in validating thermal windows used in infrared thermography in cattle and river buffalo to assess health and productivity. Animals, 11, 2247.

Mota-Rojas D, Napolitano F, Braghieri A, et al (2021e) Thermal Biology in River Buffalo in the Humid Tropics: Neurophysiological and Behavioral Responses Assessed by Infrared Thermography. J Anim Behav Biometeorol 2021, 9.

Mota-Rojas D, Wang D, Titto CG, et al (2022) Neonatal infrared thermography images in the hypothermic ruminant model: Anatomical-morphological-physiological aspects and mechanisms for thermoregulation. Front Vet Sci 9:963205.

Moura SV de, Silveira IDB, Ferreira OGL, et al (2021) Lairage periods on temperament score and meat quality of beef cattle. Pesqui Agropecuária Bras 56:1-8. https://doi.org/10.1590/s1678-3921.pab2021.v56.02349.

Muñoz D, Strappini A, Gallo C (2012) Indicadores de bienestar animal para detectar problemas en el cajón de insensibilización de bovinos. Arch Med Vet 44:297-302.

Napolitano F, Bragaglio A, Sabia E, et al (2020a) The human–animal relationship in dairy animals. J Dairy Res 87:47-52.

Napolitano F, Mota-Rojas D, Guerrero-Legarreta I, Orihuela A (2020b) El búfalo de agua en Latinoamérica, hallazgos recientes., 3ra ed. BM Editores,

México. https://www.lifescienceglobal.com/journals/journal-of-buffalo-science/97-abstract/jbs/4550-el-bufalo-de-agua-en-latinoamerica-hallazgos-recientes

Napolitano F., Mota-Rojas D., Guerrero-Legarreta I, Orihuela A, Strappini A, Pereira A, Martínez-Burnes J (2022). El búfalo de agua en las Américas, enfoques prácticos y experimentales. 4th. edición. B.M. Editores, Ciudad de México, 2100 p.

Nava-Trujillo H, Valeris-Chacin R, Quintero-Moreno A, Escalona-Muñoz J (2020) Milk yield at first lactation, parity, and season of calving affect the reproductive performance of water buffalo cows. Anim Prod Sci 60:1073.

Nielsen SS, Alvarez J, Bicout DJ, et al (2020) Welfare of cattle at slaughter. EFSA J 18:e06275.

OIE (2021) Transporte de animales por vía terrestre. Código sanitario para los animales terrestres 1-16.

Omran F, Hamdon H (2018) Transportation, adaptive and productive performance of transported buffalo herd in new environment. J Anim Poult Prod 9:191-196.

Ortolani E, Maruta C, Barrêto Júnior R, et al (2020) Metabolic profile of steers subjected to normal feeding, fasting, and re-feeding conditions. Vet Sci 7:95.

Otter, O'Sullivan, Ross (2012) Laying the foundations for an international animal protection regime. J Anim Ethics 2:53.

Page KR, Doocy S, Reyna Ganteaume F, et al (2019) Venezuela's public health crisis: a regional emergency. Lancet 393:1254-1260.

Patiño EM (2011) Producción y calidad de la leche bubalina. Tecnol en Marcha 24:25-35.

PAWS (2018) The prevention of cruelty to animals. In: Pakistan Anim Welf Soc Pakistan, Govermet.

Pérez-Linares C, Sánchez-López E, Ríos-Rincón FG, et al (2013) Factores de manejo pre y post sacrificio asociados a la presencia de carne DFD en ganado bovino durante la epoca cálida. Rev Mex Ciencias Pecu 4:149-160.

Peters MDP, Silveira IDB, Fischer V (2015) Impact of subclinical and clinical mastitis on sensitivity to pain of dairy cows. Animal 9:2024-2028.

Pielago BS (2020) Uncovering the 5 Major Causes of the Food Crisis in Venezuela. Glocality 3:1-12.

Rojas H, Stuardo L, Benavides D (2005) Políticas y prácticas de bienestar animal en los países de América: estudio preliminar. Rev sci tech Off int Epiz 24:549-565.

Romero M, Sánchez J (2011) Implicaciones de la inclusión del bienestar animal en la legislación sanitaria Colombiana. Rev Colomb Ciencias Pecu 24:83-91.

Rushen J, Passillé AM de (2010) The importance of good stockmanship and its benefits to animals. In: Grandin T (ed) Improving animal welfare: a practical approach. CAB International, Wallingford, UK, pp 50-63.

Sabia E, Napolitano F, Claps S, et al (2018) Environmental impact of dairy buffalo heifers kept on pasture or in confinement. Agric Syst 159:42-49.

Schipp MA, Sheridan AD (2013) Applying the OIE terrestrial animal health code to the welfare of animals exported from Australia. Rev Sci Tech l'OIE 32:669-683.

Sheehan J (2012) Husbandry guidelines for water buffalo. In: West Sydney Inst TAFE.

Singh GS, Kumar AH, Ruchira, et al (2012) The Indian buffalo- meat vale chain. FICCI , New Delhi, pp 1-94.

Strappini A (2012) Problemas y errores comunes encontrados en Chile durante el manejo del Ganado. In: Mota-Rojas D, Huertas S, Guerrero-Legarreta I, Trujillo ME (eds) Bienestar animal: Productividad y calidad de la carne, 2.ª ed. Elsevier, Spain, pp 331-341.

Veissier I, Jensen KK, Botreau R, Sandøe P (2011) Highlighting ethical decisions underlying the scoring of animal welfare in the Welfare Quality® scheme. Anim Welf 20:89-101.

Velde H Te, Aarts N, Woerkum C Van (2002) Dealing with ambivalence: Farmers' and consumers' perceptions of animal welfare in livestock breeding. J ofAgricultural Environ Ethics 15:203-219.

Venezuela G oficial de la RB de (2010) Ley para la protección de la fauna doméstica libre y en cautiverio. In: Gac Of la República Boliv Venez.

Virviescas Sanabria JF (2020) Determinación de los efectos del transporte en las canales procesadas en la planta ecológica de beneficio animal Río Frío SAS. Universidad cooperativa de Colombia facultad de medicina veterinaria y zootecnia.

Webster AJF (2001) Farm animal welfare: the five freedoms and the free market. Vet J 161:229-237.

White S (2013) Into the void: international law and the protection of animal welfare. Glob Policy 4:391-398.