

Main animal welfare problems in ruminant livestock during preslaughter operations: a South American view

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Animals destined for meat production are usually exposed to many stressful conditions during production and particularly during preslaughter operations. Handling animals on farm, loading into and unloading from vehicles, transportation, passing through livestock markets, fasting, lairage and stunning can all affect their welfare. How badly welfare can be affected will depend on both the intrinsic factors of the specific type of animal involved and the extrinsic factors of the environment where those animals live or are being handled, including the animal handlers. In South America (SA), it has been part of a strategy for improving animal welfare (AW) to address not only ethical aspects, but to emphasize the close relationship existing between handling ruminants preslaughter and the quantity and quality of the meat they produce. This has resulted not only in improvements in AW, but has also brought economic rewards to producers which in turn can lead to higher incomes for them and hence better human welfare. For producers with a high number of animals, considering AW during production and preslaughter operations can determine the possibility of exporting and/or getting better prices for their products. At smallfarmer level, particularly in some less developed countries, where human welfare is impaired, using this strategy together with education has also been relevant. It is important that education and training in AW are done not only considering global knowledge, but also including specific geographical and climatic characteristics of each country and the cultural, religious and socio-economical characteristics of its people; therefore, research within the context of each country or region becomes relevant. The aim of this review was to show the results of research dealing with AW of ruminant livestock in Chile and some other SA countries. Some of the main problems encountered are related to lack of proper infrastructure to handle animals; long distance transport with high stocking densities in the larger countries; long fasting times due to animals passing through livestock markets and dealers; bad handling of animals by untrained personnel in these and other premises; and finally the lack of knowledge and skills by operators in charge of stunning procedures. Interventions at these stages have considered training animal handlers and transporters by showing them the consequences of bad handling with audiovisual material prepared on site. Research results have helped to improve AW and support the development of new legislation or to make changes in the existent legislation related to AW.

Keywords: livestock, welfare, handling, South America

Implications

In South America the interest in animal welfare when it comes to production animals is based more on economic reasons, related to the loss of quality and quantity of the meat due to mistreatment or loss of access to higher priced markets, rather than just on ethical reasons. Therefore, the strategy used by researchers has been to produce scientific evidence that emphasizes critical points for AW during

preslaughter operations that also affect meat quality. Evidence obtained under the conditions of each country has helped in improving animal welfare and meat quality, supporting new legislation and training animal handlers and transporters along the meat chain.

General introduction

Ruminant production in South America (SA) is characterized mainly by grazing, usually in extensive systems, which are perceived by consumers generally as allowing better welfare conditions for animals than intensive systems; however, in many cases seasons are extreme (either very dry or very wet)

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with low forage production, and consequently drastic reductions on the body condition scores of the animals can be seen during these periods (Gallo and Tadich, 2008). Owing to the socioeconomic and cultural situation in many SA countries the human population is more concerned about food safety and a fair price for the meat than about maintaining animal welfare (AW) standards. Ruminants are in a high proportion in hands of smallholders; the range of people involved, in terms of age, sociocultural, educational and cultural backgrounds, is so wide that different educational strategies on how to improve AW must be adopted (Gallo *et al.*, 2010).

In SA there are some of the world's most important beef production and exportation countries (Brazil, Argentina); there are also some countries where, even with a small cattle population, meat exports are an important part of their economy (Uruguay) or have access to high meat price markets because of good animal health conditions (Chile). Hence, meat exportation has provided a good opportunity to make improvements in quality assurance schemes and good livestock practices that consider AW as a component in the production chain on farm, during transport and at slaughter (Gallo and Tadich, 2008; Del Campo *et al.*, 2014). Demands established directly from the importing countries regarding AW have been crucial for fast improvement. However, the OIE is encouraging its member countries to put into practice the AW standards (Organización Mundial de Sanidad Animal (OIE), 2013), which has led to new regulations on AW in several SA countries that apply for domestic markets as well as for exports (e.g. Chile, 2013a, 2013b and 2013c).

Preslaughter handling of ruminants and meat quality

Considering the above mentioned background, in SA the interest in AW when it comes to production animals has been based more on economic reasons (the loss of quality and quantity of the meat due to mistreatment or loss of access to higher priced markets) rather than just on ethical reasons. Poor AW due structural deficiencies and to bad handling of meat producing animals leads to economical losses by increasing animal deaths, carcass weight losses, trimmings due to injections and bruising, and by negatively affecting meat quality.

Bruises and dark cutting are some of the main problems encountered. A bruise is defined as a tissue injury with rupture of the vascular supply and accumulation of blood and serum (Hoffman *et al.*, 1998). The presence of bruises on ruminant carcasses directly affects meat quality because bruised tissues need to be trimmed off; it is also used as an indicator of poor welfare during preslaughter operations, because it shows that animals have been hit or handled in an inappropriate way, resulting not only in animal fear but also pain (Strappini *et al.*, 2009, 2012 and 2013; Romero *et al.*, 2013). When meat quality alterations are present *postmortem* it implies that AW was impaired (Gregory, 1998). Meat colour and pH alterations are a reflection of stressful conditions due to inadequate handling of animals during preslaughter operations and long deprivation of

food and water (Gallo, 2009; Romero *et al.*, 2013). Stressful conditions during preslaughter handling reduce muscle glycogen content which at the moment of slaughtering results in low production of lactic acid; therefore, meat has a high pH (>5.8), high water holding capacity and an unattractive dark colour; this condition is known as DFD (dark, firm and dry) meat (McVeigh and Tarrant, 1982). The effects of chronic stress on muscle glycogen depletion and the consequent dark cutting condition have been well reviewed (Ferguson and Warner, 2008). As colour and pH alterations affect consumer acceptability and shelf life of meat it has economical implications. Therefore, the measurement of muscle pH at 24 h after slaughter is a criterion routinely used at slaughterhouses to determine meat quality and take further processing decisions.

By improving productivity and product quality in livestock production through better AW, the provision of appropriate amounts of good quality food for human consumption can be assured and the welfare of people can be also improved. Therefore, the strategy for most of the research in AW of meat producing livestock in SA has dealt with relating AW to product quality (Gallo, 2012; Paranhos Da Costa *et al.*, 2012; Huertas *et al.*, 2014). Complementarily, the dissemination of information about AW topics and relevant research in the subject has been important in order to socialize AW global knowledge and understand practical applications. Since 2004 numerous national and international meetings dealing with AW have been organized in countries such as Argentina, Brazil, Chile, Colombia and Uruguay (Gallo *et al.*, 2010). During 2009 the Animal Welfare Programmes of the Universidad Austral de Chile and the Universidad de la República del Uruguay were officially recognized by the OIE as a Collaborating Centre for Animal Welfare Chile-Uruguay. In 2013 the OIE Collaborating Centre for AW and livestock production systems has also incorporated the Animal Welfare Programme of the Faculty of Veterinary Sciences at Universidad Nacional Autónoma de México. Its mission is to promote AW with particular emphasis in production and working animals under SA production systems.

The aim of this review is to show the results of research dealing with AW of ruminant livestock for meat production in Chile, although results could be made extensive to many other countries in SA according to earlier published information on the region (Grandin and Gallo, 2007; Gallo, 2008; Gallo and Tadich, 2008).

General characteristics of the handling of ruminant livestock in SA

It is common in SA countries that animals undergo many different handling situations during production, transport, commercialization and particularly during preslaughter operations.

Stakeholders

According to Gallo and Tadich (2008) the main stakeholders of the meat chain are producers, livestock markets, livestock

dealers, livestock transporters, slaughterhouses, supermarkets and butchers. Moreover, cattle producers can be divided in those who breed and fatten beef (complete cycle), those who only produce weaned calves, and those who buy calves and other cattle for fattening and selling. Cattle producers in most SA countries, frequently sell their stock through cattle dealers instead of selling directly to slaughterhouses. Small ruminants like lambs, goats and camelids can go directly to slaughterhouses, to livestock markets and to intermediate dealers; however, the market for goats and camelids is small and scarcely developed, meaning that there is a considerable amount of animals that are slaughtered for home consumption and do not pass through slaughterhouses; moreover, this meat is rarely found for sale in butcher shops or supermarkets.

Handling of animals pre-transport

Animals that are bred extensively usually have few contact with people and are difficult to handle. There are also some structural deficiencies at farm and slaughterhouse level, mainly due to inadequate design and poor maintenance of handling structures (pens, corrals, races, crates, loading ramps and others). In the case of sheep, it is common that the flock, including ewes and lambs, is rounded up and driven for several kilometres to the farm corrals, then the lambs are weaned and immediately afterwards loaded into the transport vehicles. These commercial procedures in lambs destined for slaughter, particularly when transported for 48 h as it is the case of the Chilean Patagonia, are stressful and exhaust body reserves (Tadich *et al.*, 2009). In the case of goats and camelids, there is very little information regarding preslaughter operations in SA; a recent study in llamas (Mamani-Linares and Gallo, 2014) concluded that preslaughter handling of llamas under commercial conditions produces physiological changes similar to those in other species, which fall within acceptable limits for their welfare; however, stress could be reduced and adverse effects like bruises could be minimized by designing proper facilities and following OIE recommendations.

Training of animal handlers

In general, a lack of formal training of animal handlers has been evidenced (Cáraves *et al.*, 2006 and 2007; Strappini *et al.*, 2007), which constitutes a primary problem that affects AW in SA countries. Most of the stockpersons (65%) observed by De Vries (2011) at Chilean livestock markets had a negative human–animal relationship. Moreover, it has been well established that cattle going through markets have more bruises than cattle going directly from farm to slaughterhouse (Strappini *et al.*, 2009, 2010, 2012 and 2013).

Bad practices used to get the animals to move, especially when loading and unloading, are observed to be commonplace (Gallo and Tadich, 2008); there is a tendency to use aggressive strategies to drive animals and inappropriate aids (sticks, goads, shouting and sometimes even unsuitable handling practices that are described by the OIE, 2013), such

as pulling sheep from the fleece or twisting of tails. Training abattoir personnel has been used in intervention studies and its effectiveness has been assessed after the training, using animal behaviour and meat quality measures in slaughterplants (Gallo *et al.*, 2003a and 2003c). In 2013 new regulations have been passed in Chile, making it mandatory that there should be at least one trained person in charge of handling animals in each of the premises involved: farms, livestock markets, slaughterhouses, transporters (Chile, 2013a, 2013b and 2013c), getting in line with OIE standards.

Characteristics of the transport of ruminant livestock in SA

The situation of the transportation of farm animals in countries of SA has been described in detail by Gallo and Tadich (2008) and Gallo (2008). Due to the different country sizes, climatic, geographic and sociocultural conditions, there are vast differences in livestock transport durations and conditions between countries (Gallo, 2007; Gallo and Tadich, 2008).

Vehicles and roads

The great majority of the animals destined for slaughter are transported by road, in trucks; there are only a few circumstances where a small proportion of animals also have to travel by ferry (Chile) or on boats (some journeys in Amazonian countries). In most SA countries there are paved carriageways in good condition leading to the main cities, but there are also many unpaved or stone roads, often in bad conditions; this is specially the case of side roads serving the farms (Gallo and Tadich, 2008). Consequently, travelling is slow because of the geography (including mountainous and winding roads) and the nature of the roads, and there is no close relationship between distance travelled and journey duration (Strappini *et al.*, 2007; Tarumán, 2013).

It is common in Chile and other countries to use trucks with a coupled trailer, making the job of drivers more difficult and adding further risks to livestock transportation. Trucks have no roof and additionally, the use of internal separations in the loading compartment for cattle transport is unfrequent, usually transporting them in big groups (18 to 22 heads/compartment, Gallo *et al.*, 2005) instead of smaller groups as recommended (Grandin and Gallo, 2007). Vehicles used for the transport of sheep are generally metallic, with two or three floors, also without roof; these have internal separations for transporting the sheep in small groups (Gallo, 2009).

Transport duration and conditions for ruminants during the journey

Bad practices during loading, transport and unloading of cattle are common, as well as overstocking the trucks (Gallo *et al.*, 2005). There is no indication that space allowance in longer journeys is higher than in shorter journeys (Aguayo and Gallo, 2005 and 2006). In fact 34.4% of the 413 loads surveyed by Gallo *et al.* (2005) arrived at the slaughterhouses at estimated stocking densities higher than

permitted by the current legislation (500 kg/m²). High stocking densities are commonly observed in SA countries and overloading trucks when transporting cattle has been observed to be a problem in the region, but no precise figures on actual stocking densities used are available, except for the case of Chile (455 kg/m² by Gallo *et al.*, 2005; Strappini *et al.*, 2007) and Uruguay (450 kg/m² by Huertas *et al.*, 2003; Bianchi and Garibotto, 2004). The effect of stocking densities of 400 v. 500 kg/m² during transportation on the concentration of blood variables indicators of stress was studied in steers transported for 3 and 16 h (Tadich *et al.*, 2003a); a stocking density of 500 kg/m² produced higher cortisol ($P = 0.0021$), glucose ($P = 0.039$) and CK ($P = 0.024$) at arrival at the slaughterhouse.

With the exception of some countries (Paraguay, Brazil, Uruguay, Argentina), it is not a common practice to separate cattle in smaller groups within the truck (Gallo and Tadich, 2008) and there is no provision of water/feed for animals in the vehicle, also it is uncommon that they are unloaded at resting posts (Grandin and Gallo, 2007; Gallo, 2008). One of the longest journeys would be the one affecting cattle and sheep produced in the Chilean Patagonia Region of Aysén; these animals are frequently transported without water and food, by road and ferry, for distances up to 1700 km and durations up to 72 h (Aguayo and Gallo, 2005; Werner *et al.*, 2013). Transport durations of 24 and 36 h have been observed to negatively affect cattle welfare, when measured through blood indicators of stress and animal behaviour (Tadich *et al.*, 2000).

Very little information on small ruminant transport in SA is available. In Chile most common distances travelled by over 80% of the sheep are short (up to 400 km, Tarumán and Gallo, 2008). Total transport time for lambs in Chile fluctuates between 0.75 and 75 h (around 5% of the sheep are subjected to the latter which includes maritime ferry crossing) and distances between 5 and 1356 km (Carter and Gallo, 2008; Gallo, 2009). Owing to the particular characteristics of the roads in the Patagonia (stone roads, very winding and with high slopes), where most Chilean lambs are produced, journeys usually take much longer than expected for the distances travelled (Strappini *et al.*, 2007; Tarumán, 2013). The space availability found by Tarumán and Gallo (2008) for lambs was 0.16 to 0.22 m²/lamb (4.55 to 6.14 lambs/m²).

From a welfare point of view as well as from a meat quantity/quality point of view an aspect to be improved is the provision of water and food when transport is prolonged over 24 h. For the case of the ferry crossing in Chile Navarro *et al.* (2007), showed that during the sea crossing and when trucks had stopped, lambs did consume water when available.

Transport of ruminant livestock and meat quality

In relation to the effects of transport duration on bruising, most studies have registered bruises on the carcasses of cattle (Strappini *et al.*, 2009, 2010 and 2012; Huertas *et al.*, 2010; Romero *et al.*, 2013), sheep (Carter and Gallo, 2008; Tarumán and Gallo, 2008; Tarumán, 2013) or llamas

(Mamani-Linares and Gallo, 2014) at the end of the process (at slaughter), therefore it was not possible to distinguish if bruises had occurred on farm, during transport or at the slaughterhouse. In order to try to distinguish exactly where bruises originate we followed the whole process of loading, transport, unloading, lairage and stunning of culled dairy cows using direct continuous observation and videos (Strappini *et al.*, 2013). It was possible to register when and where the potential bruising events occurred. It was remarkable to find out that after a mean of 3 h transport and 19 h lairage, a total of 1792 events occurred; 91% of these were observed during lairage, 5.4% in the stunning box, 2.5% at loading, 0.4% during transport and 0.5% at unloading (Strappini *et al.*, 2013). Hence, many events happened very close to slaughter time, whereas few traumatic events happened during short transport. When using the video analysis, it was possible to detect the moment, stage of infliction and the type of event that caused the lesion for 52 bruises (66.7%) out of the total of 78 bruises observed; 38.5% of the bruises occurred within 1 h before slaughter, in the stunning box and were due to impact with a blunt object, this was the case of the sliding doors at the stunning box. Pricking with sticks was commonly observed, usually during loading of the cattle on the farm. All bruises observed by Strappini *et al.* (2013) were sampled for macro/microscopic and histochemical analyses and a sample of 16 bruises with known origin (and hence known age between <1 and 23 h) was used to find out whether it would be possible to use these techniques for determining age of the lesions. Through macroscopic (colour, diameter, depth, shape and anatomical location) and microscopic (presence of erythrocytes, hemosiderin, inflammatory infiltrate, fibrin, necrosis and fibrosis) characteristics of the bruises it was possible to determine at which stage during preslaughter handling they had been originated; however, within the age range of the bruises studied (up to 23 h) it was not possible to determine actual age by colour nor by immunohistochemical markers (fibronectin, collagen III and IL8) (Vargas, 2014).

In sheep 7.5% bruised carcasses were found; bruises were mainly small in extension and affected only subcutaneous tissue (Tarumán and Gallo, 2008). In Chilean studies (Carter and Gallo, 2008; Tarumán and Gallo, 2008; Tarumán, 2013) a directly proportional relationship between the incidence of bruises and transport duration (up to 48 h) has been observed; however, in none of the studies a separation was made between transport itself and the handling during loading and unloading of the lambs. In the case of llamas, methods of loading and unloading, as well as the lack of loading ramps on farms and llama slaughterhouses have been observed to increase animal–handler interactions, which could lead to bruising (Mamani-Linares and Gallo, 2014).

Training of transporters

It is crucial that drivers transporting livestock are trained. OIE standards (OIE, 2013) recommend compulsory formal training, evidenced through a certificate given by an institution recognized by the competent authority of each country.

Livestock transport drivers as well as animal handlers who help in the process of loading and unloading the animals in general lack training (Cáraves *et al.*, 2006 and 2007; Strappini *et al.*, 2007; De Vries, 2011). Efforts are being made in many SA countries to fulfil AW recommendations provided by the OIE (2013) through the development of national legislation. In Chile, the new regulations approved in 2013 (Chile, 2013a, 2013b and 2013c) state that animal handlers during transport need to be trained and accredited through a formal certificate given by institutions approved by the Agriculture and Livestock Service of the Ministry of Agriculture.

Handling of ruminant livestock at slaughterhouses

There have been improvements regarding structure and training of personnel in most export slaughterhouses in SA, but there is still much improvement to be done in public (municipal) and small village slaughterhouses. In general, there is lack of organization and planning between farmers, transporters and slaughterhouses, in order to reduce to a minimum the transport and waiting times spent by the animals.

Lairage

A common problem mentioned in several SA countries is the long waiting time before the animals are unloaded in the stockyards, as well as long lairage times once at the slaughterhouse. In most SA countries there is by law a minimum lairage time between 6 and 24 h (Gallo and Tadich, 2008). In Chile there is no minimum lairage time for ruminants (Chile, 2009). Frequently lairage times are extended much longer than the minimum because of operational reasons and/or inadequate planning.

The time animals spend without food and water is important from a welfare point of view, as they suffer from thirst and hunger, as well as from a meat quantity (carcass weight loss) and quality (high pH meat) point of view (Gallo and Gatica, 1995; Gallo *et al.*, 2003b). The effect of food deprivation in cattle on blood variable indicators of stress differs according to duration (hours) and whether it occurs together with transport or not. Results of the effects of fasting for 3 and for 16 h, in both cases with and without transport, show that fasting with transport has an additional effect compared with deprivation of food in pens, which reflects more stress (Tadich *et al.*, 2003b). Steers with 24 h of fasting at the slaughterhouse showed 9.4 times a higher probability of having a muscle pH >5.8 in their carcasses than those with 3 h fasting, independently of the previous transport time (Amtmann *et al.*, 2006). During lairage an increase in live and carcass weight can be observed in steers that were previously transported for over 12 h, but not in those with short transport (<6 h) (Gallo *et al.*, 2000 and 2003b). This can be attributed to water intake, as it has been also found that steers with over 24 h transport drink water in the lairage pen as soon as they arrive, whereas steers with <6 h transport do not drink (Estrada *et al.*, 2009).

Lairage times have been in general reduced in Chilean slaughterhouses in the last few years, and also regulations

do not state a minimum duration for ruminant lairage. However, still the most common situation is that cattle and sheep arrive the night before slaughter, reaching 12 h lairage as a mean (Herrera and Gallo, 2009); it is not mandatory for ruminants to receive feed during this time, only if they stay over 24 h.

If feed deprivation due to transport is added to fasting during lairage, it is not uncommon that cattle and sheep proceeding from the Patagonia (over 1000 km transport) reach up to 60 ± 19 h fasting due to transport plus lairage (Aguayo and Gallo, 2005; Carter and Gallo, 2008). Considering this fasting duration, Gallo and Gatica (1995) found a significant decrease in carcass and liver weight. Carcass muscular pH has also been shown to be higher as lairage time increases, being more evident if previous transport has also been prolonged (Gallo *et al.*, 2003b). The effects of lairage duration need to be studied in each country according to their own production and transport conditions, as well as type of cattle. In Colombia, it has been observed that cattle remain in lairage for up to 5 days in some cases, with water but no food available (Ramírez and Gallo, 2012).

Experiments observing the behaviour of steers (Estrada *et al.*, 2009) and cows (Opitz *et al.*, 2012) during lairage show that during this period many animal–animal interactions occur, that can produce bruises and also use glycogen reserves favouring high pH presentation in the carcasses. Estrada *et al.* (2009) found that during lairage steers that underwent a long previous transport journey (>24 h) lie down sooner and more and drank water immediately after arrival, whereas those with short transport journeys (up to 3 h) remained standing and did not drink. On the other hand agonistic behaviours were more frequent in the steers with short transport journeys.

In Chile a direct relationship between cattle transport duration and lairage duration has been established with high pH. After a transport of 16 h, carcass weight of steers of the same origin and similar live weights have been observed to be lower than after a transport of 3 h (Gallo *et al.*, 2003b); steers transported for 16 or 24 h present 3.6 and 5.4 times a higher probability of having carcasses with pH >5.8, respectively, compared with those transported for 3 h, independently of the lairage time (Amtmann *et al.*, 2006). In general from an AW point of view, prolonging lairage duration from 3 to 24 h in order to recover basal blood indicators from transport stress, does not help much in cattle because basal levels are not recovered before 24 h and negative effects on meat quality such as dark cutting do not justify it, particularly if animals are not fed (Tadich *et al.*, 2005).

In sheep, feed deprivation times due to transport and lairage are also prolonged in Chile. The mean lairage time for sheep has been found to be 15 h, fluctuating between 5 and 26 h (Gallo, 2009). It needs to be considered that in lambs slaughter age is proportionately shorter than in cattle and in most cases lambs are also weaned immediately before loading and transporting them for slaughter, with a consequently additional stress. The concentration of

β -hydroxybutyrate, an indicator of prolonged feed deprivation, increases significantly in lambs with 68 h fasting; this time includes collection from the paddocks, a 48 h transportation time and lairage afterwards, indicating that body reserves are being used for maintenance (Tadich *et al.*, 2009). In fact it coincides with the BW losses and almost no reserves of glycogen found in the carcasses of the same animals (Carter and Gallo, 2008).

In lamb carcasses, muscle pH is not measured routinely at slaughterhouses in SA because conservation technologies such as vacuum packaging are less developed than for beef. Tarumán (2013) found 51% of lamb carcasses with pH $>5.8 <6.3$, and only a 0.1% of carcasses with pH >6.3 . In the same study a positive association was also found between the presence of bruises and high pH.

More research within and between countries in SA is necessary to improve AW during lairage, as situations may vary largely due to type of animals, climate, farming, transport and slaughterhouse facilities and handling (Del Campo *et al.*, 2010).

Stunning

The purpose of stunning animals before slaughter is to avoid unnecessary suffering and pain when they are slaughtered through bleeding and it is mandatory according to OIE (2013) AW standards and also Chilean regulations (Chile, 2013a). Out of all preslaughter handling operations, stunning is an overlooked aspect in many SA countries; there has been little awareness to avoid animal suffering during this stage, probably by assuming that the animal will die anyway within a short time (Gallo, 2009). A survey in 2006 (Gallo, 2007) showed that the whole process of stunning is not well understood among slaughterhouse operators and even professionals in many SA countries. Most countries have regulations covering this stage, however, it is still possible to find small and municipal slaughterhouses where the Spanish knife or just bleeding is performed, demonstrating that there is not much enforcement of the regulations. The evaluation of the actual efficiency (efficacy) of the process, meaning if methods are accomplished accordingly to OIE recommendations (OIE, 2013) or national regulations for each species, if they are applied correctly and if actual checking of unconsciousness is assured, has started only recently (Gallo *et al.*, 2003a and 2003c; Romero *et al.*, 2012).

Stunning is usually performed according to OIE recommendations in all export and bigger slaughterhouses. A low efficacy of the stunning process, as well as the use of unacceptable methods is still a common situation in some SA countries (Gallo, 2007). A study performed in a sample of Chilean slaughterhouses in 2000 (Gallo and Cartes, 2000), showed that only a mean of $<85\%$ of cattle slaughtered fell with the first shot when using captive bolt stunning; moreover, there was a high percentage of cattle showing signs of recovery after stunning. These results would be considered unacceptable according to Grandin (1998). The same study showed that the time between stunning and bleeding was longer than a minute. A study performed

after these findings (Gallo *et al.*, 2003c) showed that improvements could be made through implementing a headholder in the stunning box, using a new penetrating captive bolt pneumatic stunner and through the training of personnel. A frequent problem observed in sheep stunning is the placing of electronarcosis electrodes in the wrong anatomical sites (for instance neck); the problem is due to lack of training (Cáraves *et al.*, 2007). More recent intervention studies in 14 of the largest cattle and sheep slaughterplants in Chile, showed that the efficacy of stunning was being further improved (Cáraves *et al.*, 2006 and 2007). Devices for the restriction of body movement are required by law in Chile since 2009 (Chile, 2009a and 2013a); these devices need to be carefully designed and animals have to be immobilized for as short time as possible, otherwise they can end up being more stressful for the animals rather than an advantage (Muñoz *et al.*, 2012).

At present training of people handling animals at the slaughterhouses and particularly during stunning has been given a main focus; most SA countries that export meat evaluate the process periodically and train their personnel in order to reach acceptable standards of AW during slaughter (Gallo *et al.*, 2010).

Conclusions

In SA the strategy for improving AW during preslaughter operations in ruminants has been based mainly on emphasizing the close relationship between animal handling and the quantity and quality of the meat they produce.

Improvements in AW have been faster in SA meat exporting countries due to the requirements imposed by some of the importing countries

Education and training in AW in SA has been done not only considering global knowledge but also including research results that consider specific environmental, ethnic and animal characteristics of each country (region).

Regional scientific evidence regarding AW as published in international journals is still scarce, however has been increasing rapidly in the last 5 years.

Although new legislation regarding AW has been implemented in several SA countries, it needs to be more effectively enforced.

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