The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK

Animal Welfare 2012, 21(S2): 3-8
doi: 10.7120/096272812X13353700593248
ISSN 0962-7286

A review of the humaneness of puntilla as a slaughter method

G Limon*, J Guitian and NG Gregory

Royal Veterinary College, Hawkshead Lane, Hatfield AL9 7TA, UK
* Contact for correspondence and requests for reprints: glimon@rvc.ac.uk

Abstract

*Puntilla is a traditional slaughter method in which a knife is plunged into the back of the neck to sever the spinal cord. The aim is to produce immediate collapse of the animal. Puntilla is not condoned as a stunning method by the World Animal Health Organisation (OIE) because there is concern that the animal could be conscious during and after the neck stab. Nonetheless, it is still used in some developing countries. The effectiveness and humaneness of puntilla followed by neck sticking was examined at two slaughterhouses in Bolivia. Twenty llamas (*Lama glama*) and 309 cattle were observed during routine puntilla without stunning. The number of neck stabs was recorded, and then brain and spinal functions (rhythmic breathing, palpebral reflex and eyeball rotation) were assessed. In addition, the presence of specific cognitive responses (such as responses to a threat stimulus and noise, as well as to flavours and odours), were also assessed in cattle. Breed, sex, live weight, body condition score and the slaughterman's experience were recorded. Repeat stabbing was needed to penetrate the foramen ovale in 45% of the llamas and two of them attempted to stand following collapse after the initial stab. All llamas showed rhythmic breathing movements at the flank following puntilla and before sticking, and 95% had a positive palpebral reflex at the same time. Twenty-four percent of the cattle needed repeat stabbing. Repeat stabbing was significantly less frequent with experienced slaughtermen, and more frequent in heavyweight animals (> 380 kg). Brain and spinal responses were present in 91% of the cattle following the stabs. When cattle attempted to stand after a neck stab they were more likely to have rhythmic breathing, positive palpebral response and responsiveness to threat, noise and brief air stimulus applied to the face. These findings indicate that it is difficult in practice to penetrate the spinal cord with a single puntilla stab. Some nerve pathways are often functional after the neck stab and therefore it is highly likely that the animals remain conscious in at least some modalities for the next part of the slaughter procedure. The challenge in developing countries, however, is to find a strategy that encourages use of a method which limits suffering whilst being accessible for routine slaughter practice.*

Keywords: *animal welfare, Bolivia, cattle and llamas, degree of awareness, puntilla, slaughter*

Introduction

Puntilla (also known as neck stabbing and *evernazione*) is a traditional slaughter method in which a knife is plunged into the back of the neck of the animal to sever the spinal cord (Dembo 1894). The animal immediately collapses, and can then be stuck and processed in the normal way. In the past this method has been advocated by animal protection groups as a humane alternative to contemporary methods (Gregory 1989), but now it is not condoned as a stunning method by the World Organisation for Animal Health (OIE) (World Organisation for Animal Health 2006), and is forbidden in European Union slaughterhouses because it is considered inhumane. The method is, however, still used in many developing countries (Cartes-Sanchez 2000; Pham Hong Nhat 2006; Osborne 2009) where no alternative methods are available other than sticking the animal without stunning.

In the human, 4 out of 17 patients with transcranial stab wounds that involved either the midbrain or brainstem survived the insult even though there was persistent hemiplegia in each of the four subjects (Nathoo *et al* 2000). This study showed that incomplete transection of the lower brain does not invariably induce irreversible unconsciousness.

It has also been shown in mice (*Mus musculus*) that sensory responses are dependent on the severity of the lesion in the spinal cord. In addition, pain from stimuli, which is not normally painful (ie allodynic behaviour), can be induced when some ascending fibres are left intact (Hoschouer *et al* 2010).

Puntilla is different from pithing. For example, in fish, pithing is a common procedure in some parts of the world and usually involves maceration of the lower brain without direct transection of the spinal cord. It is not clear whether pithing is a humane procedure but it is recognised that it requires skill on the part of the operator (Noga 2000).

It has been recognised by the Food and Agriculture Organisation of the United Nations (FAO) that animal welfare is highly relevant to success in international development. Within a range of topics that need to be addressed, slaughter and pre-slaughter are some of the areas that require assessment, capacity building and creation of incentives. Much of the research on these topics has been done in economically developed countries, and there is now a need to develop expertise in animal welfare science in developing countries (Food and Agriculture Organisation 2008).

Bolivia is one of the poorest countries in Latin America having the third lowest Human Development Index in the region (Klugman 2010). As in most developing countries, livestock have many roles in Bolivia's rural areas. Llamas (*Lama glama*) are mainly used for fibre production and in some parts they are still used as pack animals, but recently, they have been promoted as a local source of meat (United Nations 2008). Investment in llama abattoirs in South America began during the 1970s and recently local government programmes have promoted the reintroduction of llamas in the high plateau communities.

The work presented in this paper is based on two previous published studies (Limon *et al* 2009, 2010). The aim of the studies was to assess the humaneness of puntilla method in llamas and cattle. The specific objectives were to develop a better understanding of the degree of awareness and consciousness in animals following the neck stab. This paper also discusses the implications in applying the conclusions of the research in developing countries.

Materials and methods

Data collection

Two studies were conducted during routine slaughter, in the Department of Tarija, southern Bolivia; one at a small llama slaughterhouse between August and September 2008 and the second at a cattle slaughterhouse between the 16th and 27th of March 2009. In both slaughterhouses the following parameters were measured after puntilla (in the case of cattle after the animal was ejected from the slaughter pen): whether or not the animal showed brain and spinal function following the neck stab, number of stabs before the animal collapsed, sex, and live weight. In addition, the following parameters were recorded in llamas: age, refusal to move and vocalisation when led to slaughter pen; in cattle: whether or not selected cognitive responses were present after the neck stab, breed, body condition score and level of experience of the slaughterman carrying out the puntilla. Body condition score was subjectively assessed by observation, based on a scale 1 to 5 (1 very poor condition and 5 obese). The level of experience of each slaughterman was obtained by asking them the number of years they had been performing puntilla.

Brain and spinal function following the neck stab

In order to evaluate brain and spinal function the following parameters were recorded immediately after puntilla in both species: presence of rhythmic breathing, palpebral reflex and eyeball rotation. Nystagmus and pupillary reflex were also recorded in cattle. Eyeball rotation was present when the sclera was obvious in the exposed eye. Rhythmic breathing excluded spasmodic gasping and gagging. Pupillary reflex was assessed by pupil closure in response to a torch allowing 5 s for the response to occur. Nystagmus was recognised as involuntary rapid eyeball flicker. When eyeball rotation was present, neither nystagmus, nor the pupillary reflex were tested. When nystagmus was present the pupillary reflex was not tested.

Brain and spinal function was said to be present if one or more of the above criteria were present immediately after the puntilla stab. In addition, it was present in those animals that attempted to stand after the stab.

In order to evaluate if there was a cranial-spinal response, cardiac acceleration was assessed using a Littmann stethoscope at approximately 30 s after the animals had been ejected from the pen, in response to introducing up to 5 ml cold water into an ear. Acceleration was recognised if the heart rate increased to a level that exceeded 120 bpm.

Cognitive responses after the neck stab

In order to evaluate whether cranial nerve responses were still patent, and which parts of the spinal cord were still intact, the following responses were evaluated immediately after the animals were ejected from the pen:

- Response to threat stimulus. This was done by rushing the hand towards the eyes and observing if the animal reacted by closing its eyes. Some of them also moved the head backwards.
- Response to sudden noise stimulus was done by clapping the hands up to 5 cm from the animal's ear and observing an ear movement and alerting response.
- Response when blowing air on the nose was positive when there was a backward movement of the head. Responses to short (less than 1 s) and long draughts (3 s) were examined in each animal.
- Response when introducing a stick into the nostril.
- Response to different odours and flavours, including molasses, lime juice, vinegar and salt, applied separately. For response to odours, a stick impregnated with each odour was presented within 5 cm of the front of the nose, and for the response to a flavour a stick impregnated with the test substance was introduced into the mouth. A positive reaction to the odour was said to occur when the animal's nostrils flared; a response to flavour or the presence of the stick occurred when there was tongue movement.
- Response to a single needle stimulus in the skin over the frontal bone using a 10 cm 19 G needle and observing for a localised skin response.

All variables were recorded as binary: whether the animal responded or not.

All observations were made by one of the authors. The observer offered no advice or instructions on how the animals should be slaughtered. For safety reasons, cattle presenting violent head and/or limb movements were not included in the study.

https://doi.org/10.7120/096272812X13353700593248 Published online by Cambridge University Press

Statistical analysis

In the case of the cattle, slaughterhouse numerical variables representing number of stabs before the animal collapsed and weight were re-categorised into binary variables, this was done by using the mean or the median as a cut-off, depending on which was considered more appropriate after examining the histograms. After re-categorisation, these variables became as follow: 'Number of stabs before the animal collapsed': animals that received one stab and animals that received more than one stab; 'weight': animals weighing up to 380 kg and animals heavier than 380 kg. Breed was also re-categorised as mixed breeds versus Zebu. Slaughterman experience was grouped as beginners (for those who had been carrying out the puntilla method for less than 5 years) and experienced (for those with more than 5 years experience). This cut-off was carried out based on the criteria given by slaughtermen themselves.

Number of stabs before the animal collapsed, slaughtermen experience, weight, breed, sex and physical condition score were considered predictor variables; brain and spinal function, cognitive responses were the outcome variables.

As a first step in the analysis collinearity between predictor variables was explored. This was done by two-tailed Fisher exact test or Chi-squared test. When collinearity was present ($P < 0.05$) just one of the two related independent variables was kept for further analysis. Then, we determined extent to which predictor variables were associated with each of the individual outcomes using Chi-squared test (or Fisher exact when necessary). For each of those associations that were significant in the bivariate analysis ($P < 0.05$), a logistic model was built to assess the relationship between the individual predictor variable and the outcome, accounting for the potential confounding and interaction effect of other variables. A step-wise selection procedure was used where only variables significant at $P < 0.05$ were retained in the model.

Odds ratios were obtained as a measure of strength of the association between independent and outcome variables.

The analyses were carried out using the statistical packages Stata, version 7.0 (Stata Corporation, College Station, TX, USA).

Results

Llamas

During the puntilla procedure, a single edge knife was inserted into the foramen ovale at the atlanto-occipital axis. The most common sequence of events at the abattoir was as follows: the procedure was carried out in couched (sternal recumbency with front and hind limbs flexed) unrestrained animals. The slaughterman's left hand held the animal's ears forcing the nose downwards and his right hand made the stab in the upper neck. The stabbed animal was then shackled by one hind leg and hoisted onto a bleeding rail where it was stuck by inserting a knife to cut both carotid arteries. The time between puntilla and sticking was between 30 and 180 s (median 60 s, average 70 s [± 38]).

Twenty llamas were observed. All the llamas were between two and five year-old males, weighing between 56 and 92 kg (median 74 kg). None of them were aggressive during handling, but 11 (55%) refused to move at some stage during transfer to the slaughter area and 4 (20%) vocalised. Between one and three attempts were made at penetrating the foramen ovale with the puntilla knife by one slaughterman (mean 1.3 [± 0.72]), and between one and eleven attempts were made by the less experienced slaughterman (mean 5 [± 3.8], $P = 0.005$). Two of the animals (10%) attempted to stand after the initial stab with the knife and all llamas presented rhythmic breathing (Table 1).

Table 1 Prevalence of brain and spinal responses in cattle and llamas subjected to puntilla.

Brain and spinal function parameters	Prevalence (%)	
	Cattle (n = 309)	Llamas (n = 20)
Attempt to stand	22	10
Rhythmic breathing	81.6	100
Palpebral reflex	72.8	95
Eye rotation	23.6	0
Nystagmus[†]	23.7	–
Pupillary reflex[‡]	12.4	–
Cardiac acceleration after water in ear	11.7	–

[†] Nystagmus was not tested when eye rotation was present.
[‡] Pupillary reflex was not tested when eyeball rotation or nystagmus were present.

Cattle

The most common sequence of events at the abattoir was as follows: the stunning pen was loaded with either one or two animals. Once the animal(s) were in a suitable position, a single edge knife was inserted into the dorsal aspect of the neck above the foramen ovale at the atlanto-occipital axis. When two animals were in the box at the same time the knife was inserted in the second animal immediately after the first. The stabbed animal(s) were then ejected from the side of the pen; a second slaughterman shackled one hind leg and hoisted the animal onto a bleeding rail where it was stuck by inserting a knife into the neck to cut both carotid arteries. The time between being ejected from the pen and being hoisted onto the bleeding rail was not systematically recorded for all animals but it was observed that in some cases it could have been up to 15 min.

Observations were made on 309 cattle, of which 35% were females (mean weight 344.3 [± 67.7]) kg and 65% were males (predominantly steers; mean weight 408 [± 90.4]). Body condition score was 4 for 46.6% of the animals and 3 for 42%. All animals were stabbed in the neck as described above, 214 (69.26%) by an experienced slaughterman and the rest by four different beginner slaughtermen. The number of stabs at the first attempt ranged between one and eight tries; the prevalence of repeat stabbing was 24%,

Table 2 Prevalence of cognitive and cranial-spinal responses in cattle.

Parameters indicating cognitive responses	Prevalence (%)
Vocalisation	4.5
Response to threat stimulus	61.2
Response to noise stimulus	21.4
Response to short air stimulus	13.6
Response to long air stimulus	17.8
Response to stick in nostril	20.1
Response to needle skin stimulus	11.7
Response to molasses odour	39.2
Response to lime odour	19.1
Response to vinegar odour	36.6
Response to salt odour	22
Response to molasses flavour	13.9
Response to lime flavour	4.2
Response to vinegar flavour	7.4
Response to salt flavour	9.1

which was significantly associated with slaughterman experience ($P = 0.004$) and weight of the animal ($P = 0.028$). The experienced slaughterman gave just one stab in 75% of the animals in order to produce collapse, while only 27% of the animals stabbed by beginner slaughtermen collapsed after the first stab. Nearly 63% of the heavier animals (> 380 kg) received more than one stab.

Two hundred and eighty-four (92%) of the 309 animals presented one or more of the parameters which indicated a brain and spinal function (presence of rhythmic breathing, positive palpebral reflex, eyeball rotation, nystagmus and pupillary reflex).

The prevalence of each of the parameters recorded to evaluate brain and spinal function, as well as cognitive responses after the neck stab are presented in Tables 1 and 2, respectively.

Over 70% of the animals presented a palpebral reflex, which was present in 78% of the animals weighing 380 kg or less, and 67% of the heavier animals (> 380 kg) ($P = 0.021$). Palpebral reflex was present in one out of every four Zebu animals, whereas just less than 10% of the mixed breeds had a positive reflex ($P = 0.020$). More than 80% of the animals had rhythmic breathing after being stabbed, with more than 90% of the Zebu cattle showing this behaviour compared with 79% in the mixed breed cattle ($P = 0.020$). Almost 40% responded to molasses odour, and this response was present in 35% of the animals stabbed by the experienced slaughtermen and nearly half of the cattle stabbed by beginners ($P = 0.026$).

Animals attempting to stand were 4.5 times more likely to have rhythmic breathing ($P = 0.002$), 4.1 times more likely to have a positive palpebral reflex ($P = 0.0004$), two times more likely to respond to a threat stimulus ($P = 0.02$), 2.3 times more likely to respond to the noise stimulus ($P = 0.004$) and 2.5 times more likely to respond to a short air stimulus ($P = 0.007$).

The odds ratios (OR) resulting from the logistic regression analysis are given in Table 3. Only the models that were significant are presented. In general, the Zebu cattle were heavier and were 3.34 times more likely to be breathing and 2.73 times more likely to have pupillary reflex after being stabbed. Animals weighing > 380 kg were half as likely to have a positive palpebral reflex. Cattle stabbed by beginner slaughtermen were 1.75 times more likely to respond to the molasses odour.

Discussion

These findings showed that in practice puntilla is difficult to perform proficiently, it is difficult to penetrate the atlanto-occipital space and there is the risk of failing to completely sever the spinal cord with a single stab and inflicting pain when repeating the procedure. In these studies the prevalence of repeat stabbing was 45% in llamas and 23.3% in cattle, this difference could be linked to slaughterman experience and size of the foramen ovale. Nevertheless, the prevalence of brain and spinal function in cattle (91.1%) was considerably higher than the 8.7% prevalence reported for cattle receiving a captive bolt (Gregory *et al* 2007).

Two llamas showed righting behaviour of the neck following puntilla, indicating that the medial (and lateral) pathways of the spinal cord were still intact including the vestibulospinal tract, which is involved in reflex control of balance and posture (Ghez 1991). All llamas and 80% cattle showed rhythmic breathing movements in the flank region after puntilla, indicating that the corticospinal, ventral and lateral columns of the spinal cord were not completely severed (Mitchell & Berger 1975). A palpebral reflex was present in 95% llamas after puntilla, and 70% cattle, indicating that the Vth and VIIth cranial nerve pathways to and from the brain stem were still patent (Scagliotti 1991; May & Porter 1998).

In addition, results for the cattle slaughterhouse showed that nearly 40% of the animals had a positive response to at least one odour, which means that the Ist cranial nerve pathway was still patent (de Lahunta & Glass 2009). Nearly one-third of the animals observed responded to at least one flavour, presenting tongue movements when an impregnated stick was put in their mouth, which demonstrates that the hypoglossal neurons from the XIIth nerve pathway were patent as well as the IXth and Xth nerve pathways (de Lahunta & Glass 2009). Although there were differences in response to different flavours, it is possible that some of the responses were due to physical stimulation rather than flavour. In that case, the cranial nerve involved would have been the Vth. Molasses was the odour and flavour which more animals reacted to, which could be because it is a familiar odour and a smell related to a taste cattle tend to like. Finally, 21% of the animals responded to a noise stimulus indicating that the cochlear nucleus in the medulla (VIIIth nerve pathway) was still functional (Shore 2005).

Animals that attempted to stand were more likely to have rhythmic breathing, a positive palpebral response, respon-

https://doi.org/10.7120/096272812X13353700593248 Published online by Cambridge University Press

Table 3 Final logistic regression models for variables that were significant in the Chi-squared test.

First models			**Second models**		
*Independent variable: Breathing after stabbed**			*Adjusted by weight*		
	OR (95% CI)	***P*-value**		**OR (95% CI)**	***P*-value**
Mixed breed	1	–	Mixed breed	1	–
Zebu	3.27 (1.13–9.4)	0.028	Zebu	3.34 (1.15–9.71)	0.026
Independent variable: Pupillary reflex†*			*Adjusted by weight*		
Mixed breed	1	–	Mixed breed	1	–
Zebu	3.04 (1.15–8)	0.024	Zebu	2.73 (1.02–7.34)	0.034
*Independent variable: Palpebral reflex**					
Weight < 380 kg	1	–			
Weight > 380 kg	0.55 (0.33–0.91)	0.021			
*Independant variable: Respond to molasses odour**					
Experience slaughterman	1	–			
Beginner slaughterman	1.74 (1.06–2.84)	0.27			

* All independent variables were coded as 0 negative response; 1 positive response.
† Animals that could not be tested for pupillary reflex were not considered in the model.

siveness to a threat stimulus, responsiveness to a noise stimulus and responsiveness to a short air stimulus, which indicates that in those animals that attempted to stand cranial nerve pathways were often functional and it is highly likely that they were still conscious.

It is important to note that the cranial nerve pathways examined in the cattle study spanned the length of the brainstem. This leaves little opportunity for subdivisions of the brain stem being viable in cases where all responses were negative.

The fact that Zebu were more likely than crossbred cattle to present rhythmic breathing can be explained by the anatomy of the Zebu's neck, which makes the puntilla method even more difficult to perform proficiently.

Even though the puntilla method is not condoned by international organisations such as OIE (World Organisation for Animal Health 2006), there is evidence that it is still used in small- and medium-sized slaughterhouses in some developing countries such as Viet Nam (Nhat 2006), México (Osborne 2009), Chile (Cartes-Sanchez 2000) and Peru (Artigas, personal communication 2010). In Bolivia, puntilla is an everyday practice in some parts of the country. It is not the official method recommended by the national legislation but it is not disallowed (SENASAG 2005). Unofficial use such as this makes it difficult to appreciate the extent to which the method is actually used.

Animal welfare implications

From a welfare point of view, the purpose of stunning is to render the animal insensible (Gregory 1998). A previous study plus practical experience has shown that puntilla can cause immediate collapse in cattle when the spinal cord is severed (Dembo 1894). However, as shown in the studies presented here, it is difficult to perform proficiently, which means it cannot be assumed that it is always a painless way of immobilising cattle and llamas. Furthermore, an experimental study in sheep showed that the pre-puntilla electroencephalogram (EEG) can be similar to that up to 130 s after incomplete severance of the spinal cord, suggesting that puntilla can have limited immediate effect on brain function during this time-period (Tidswell *et al* 1986).

FAO has recognised the need to develop expertise in animal welfare science in developing countries (Food and Agriculture Organisation 2008). However, animal welfare issues in developing countries should be addressed while taking into account their limited resources and the cost of upgrading to alternative methods. Whilst enforcing new methods in slaughterhouses which wish to access international markets might be relatively straightforward, introducing more expensive methods in small- to medium-size abattoirs could represent an increase in slaughterhouse fees, which might lead people to stop taking their cattle to an abattoir and instead slaughter them at home. Thus, the challenge in developing countries is to find a strategy that encourages use of a method which compromises animal welfare as little as possible and at the same time is accessible for everyone.

These findings emphasise the need to stun cattle and llamas before slaughter. Previously, captive-bolt guns have had only limited success in Bolivia. This is because it has been difficult to get import permission, and when guns have been introduced they have fallen from use because of poor maintenance. Presently, cattle in some parts of Bolivia are stunned with a long-handled mallet before sticking. In the short term, this method should be extended to all cattle. In the absence of captive-bolt guns, it is unclear what the best method for stunning llamas would be in countries such as Bolivia. With any change, it is essential that there is training and demonstration programmes.

Acknowledgements

This work was funded by Human Slaughter Association. We wish to thank the slaughterhouses' staff for their assistance in this work.

References

Cartes-Sanchez MM 2000 *Evaluacion De La Eficiencia En El Uso De La Pistola De Proyectil Retenido Para La Insensibilizar Ganado Bovino En Tres Plantas Faeneadoras De Carne De La Decima Region.* Facultad de Ciencias Veterinarias Instituto de Ciencias y Tecnologia de Carnes: Universidad Austral de Chile. [Title translation: An evaluation of the efficiency of pneumatic captive bolt to desensitise cattle in three slaughterhouses of the tenth region]

de Lahunta A and Glass E 2009 *Veterinary Neuroanatomy and Clinical Neurology*. Saunders Elsevier: China

Dembo JA 1894 *In the Jewish Method of Slaughter Compared with Other Methods from the Humanitarian, Hygienic and Economic Point of View*. Kergan, Paul, Trench, Trubner & Co Ltd: London, UK

Food and Agriculture Organization 2008 Capacity Building to Implement Good Animal Welfare Practices. *FAO Expert Meeting*. 10 September-3 October 2008, Rome, Italy

Ghez C 1991 The control of movement. In: Kandel ER, Schwartz JH and Jessell TM (eds) *Principals of Neural Science* pp 531-547. Elsevier: New York, USA

Gregory N 1998 *Animal Welfare and Meat Science*. CABI Publishing: UK

Gregory N 1989 Slaughtering methods and equipment. *Veterinary History 6*: 73-84

Gregory N, Lee C and Widdicombe J 2007 Depth of concussion in cattle shot by penetrating captive bolt. *Meat Science 77*: 499-503. http://dx.doi.org/10.1016/j.meatsci.2007.04.026

Hoschouer EL, Basso DM and Jakeman LB 2010 Aberrant sensory responses are dependent on lesion severity after spinal cord contusion injury in mice. *Pain 148*: 328-342. http://dx.doi.org/10.1016/j.pain.2009.11.023

Klugman J 2010 *Human Development Report 2010, 20th Anniversary Edition*. Published for United Nations Development Programme. http://hdr.undp.org/en/media/HDR_2010_EN_Complete_reprint.pdf. (Accessed October 2011)

Limon G, Guitian J and Gregory N 2009 A note on the slaughter of llamas in Bolivia by the puntilla method. *Meat Science 82*: 405-506. http://dx.doi.org/10.1016/j.meatsci.2009.01.022

Limon G, Guitian J and Gregory N 2010 An evaluation of humaneness of puntilla in cattle. *Meat Science 84*: 352-355. http://dx.doi.org/10.1016/j.meatsci.2009.09.001

May VC and Porter JD 1998 The distribution of primary afferent terminals from the eyelids of macaque monkeys. *Experimental Brain Research 123*: 368-381. http://dx.doi.org/10.1007/s002210050582

Mitchell RA and Berger AJ 1975 Neuronal regulation of respiration. *American Review of Respiratory Disease 111*: 206-224

Nathoo N, Boodhoo H, Nadvi SS, Naidoo S and Gouws E 2000 Transcranial brainstem stab injuries: a retrospective analysis of 17 patients. *Neurosurgery 47(5)*: 1117-1123. http://dx.doi.org/10.1097/00006123-200011000-00018

Nhat PH 2006 Environmental performance improvement for small and medium-sized slaughterhouses in Vietnam. *Environment, Development and Sustainability 8*: 251-269. http://dx.doi.org/10.1007/s10668-005-9017-0

Noga EJ 2000 *Fish Diagnosis and Treatment*. Blackwell Publications: UK

Osborne M 2009 Horse slaughter conditions in Mexico explored by Aaep group. *Journal of American Veterinary Medical Association 1(234)*: 584-585

SENASAG 2005 *Manual De Metodos De Sacrificio Y Destruccion De Animales, Productos, Subproductos E Insumos De Uso Veterinario.* Trinidad Beni: Bolivia. [Title translation: Manual of methods of slaughter and destruction of animals, products and by-products of veterinary use]

Shore SE 2005 Multisensory integration in the dorsal cochlear nucleus: unit responses to acoustic and trigeminal ganglion simulation. *The European Journal of Neuroscience 21(12)*: 3334-3348. http://dx.doi.org/10.1111/j.1460-9568.2005.04142.x

Tidswell SJ, Blackmore DK and Newhook JC 1986 Slaughter methods: electroencephalographic (EEG) studies on spinal cord section, decapitation and gross trauma of the brain in lambs. *New Zealand. Veterinary Journal 35*: 46-49. http://dx.doi.org/10.1080/00480169.1987.35377

United Nations 2008 UNECE Standard on Llama/Alpaca Meat Carcases and Cuts. *United Nations Publications* pp 38. Sales number E.07.II.E.3. UN: New York and Genova

World Organization for Animal Health 2006 Terrestrial Animal Code: Guidelines for the Slaughter of Animals. Appendix 3.7.5. *Meeting of the OIE Terrestrial Animal Health Standards Commission*. 2-13 October 2006, Paris, France