

Speaker Abstracts

**Humane Slaughter Association Centenary International Symposium:
Recent Advances in the Welfare of Livestock at Slaughter**
30th June & 1st July, Portsmouth Historic Dockyard, Portsmouth, UK



FUTURE CHALLENGES OF THE NEW EUROPEAN REGULATION ON THE PROTECTION OF ANIMALS AT THE TIME OF KILLING AND ITS RELEVANCE TO INTERNATIONAL TRADE

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On 1st January 2013, a new European regulation on the protection of animals at the time of killing - Regulation (EC) No 1099/2009¹ - will apply within the European Union. It will replace a directive adopted 20 years ago. The contexts for trade in meat in the European Union and internationally has changed with the increased interest by the public in the ways animals are treated. Science and technology on stunning and handling animals has evolved too. The meat industry has become highly industrialised. The EU legislation on food safety assumes that business operators are responsible. The Regulation of 2009 will affect both slaughterhouse operators and competent authorities. The first one will have to fully integrate animal welfare in their process and ensure its implementation. Studies have shown that some operators in the EU have already moved this way due to pressure in particular from the retailing system. One important challenge will be to educate workers to understand animal welfare in slaughterhouses because of the innovative aspects of the issue and the need to convince them of the cost/benefits derived from the proper handling of the animals. A further challenge for slaughterhouse operators will be to ensure the monitoring of the "level" of animal welfare on the basis of systematic procedures.

To deal successfully with all those challenges the close collaboration between authorities and operators will be essential. This is why the new regulation requires Member States, for the first time in the area of animal welfare, to set up a "scientific support" which will provide technical and scientific assistance to inspectors and stakeholders. Facilitating access to technical information is a key element for improving the enforcement of welfare standards. A system of certification of competence should provide to operators and competent authorities a new tool to further compete on "quality" and animal welfare ensuring transparency and reassuring the consumers. This will be even more relevant in relation to imported products. The new regulation maintains the same requirement of the Directive of 1993 requiring that imported meat from third countries to be accompanied with a certificate that guarantees equivalent welfare standards to EU ones. Based on the international standards² the EU reaffirmed in this way its commitment to improve the welfare of animals at international level. The proper enforcement of these requirements has been developed together with the partnership agreements with third countries in animal welfare and offering training and capacity building opportunities in order to promote mutual understanding on the issue.

¹Official Journal of the European Union L 303, 18.11.2009, p.1.

²Adopted by the World Organisation for Animal Health (OIE) in 2005

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METHODS FOR WHOLE HOUSE GASSING OF POULTRY

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Whole house gassing of poultry using liquid carbon dioxide (CO₂) is one method of culling that can be implemented in the case of a disease outbreak. Although birds find CO₂ aversive, the method is relatively quick and reduces human exposure to zoonotic disease. However, it is important that lethal gas levels are achieved quickly and uniformly, to prevent protracted suffering of the birds being culled. In this study, various methods of gas injection were tested for evenness of CO₂ distribution. They were (Figure): a) a single lance injecting into one end of the shed; b) two lances injecting into each end of the shed; c) upstands placed down the middle of the shed; and d) twin lances injecting into the side of the shed (see Figure). For all methods except method (b), a single tanker of liquid carbon dioxide could be used, but with method (b) two tankers were required. Gas concentration of oxygen and CO₂ were measured using Combi Check analysers (PBI Dansensor, Denmark). All methods were effective in filling poultry houses with lethal concentrations of gas (i.e. 45% in ~8 min) apart from upstands which took >14 min to reach 45%. Method b) is required to fill larger poultry houses. Method a) was used to cull a flock of ~12,000 5-week old pullets suffering from Marek's in a shed 30 x 12 m. Carbon dioxide levels reached 45% at the rear of the building in 5'20", at which point gas ingress was stopped. Carbon dioxide at bird level was 50% (max) and 46% at the end of a 1 h soak period. On inspection, all birds were dead and there was no evidence of smothering or panic judging by position and distribution of carcasses. Post mortem examination of 20 birds found no evidence of fatal hypothermia, a concern when injecting liquid CO₂. Liquid CO₂ can be used to cull poultry quickly and relatively humanely.

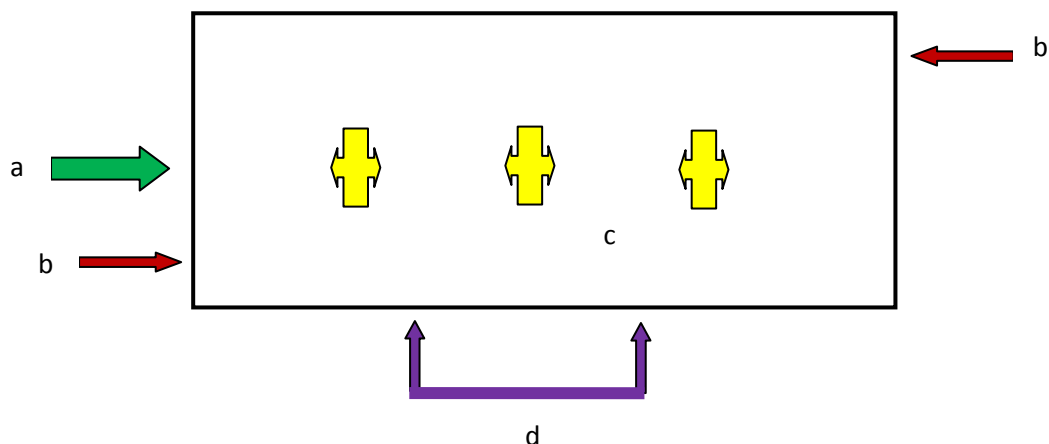


Figure. Overhead view of a poultry shed, showing gas entry points: a) single lance; b) two lances; c) upstands; d) twin lances

ELECTRICAL STUNNING OF FARMED FISH

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Quality-oriented food animal production has become more important during the last few years. All animals, including fish, should be protected from anthropogenic excitement, pain or suffering during transport, lairaging, restraint, stunning, slaughter or killing.

An applied method of electro-anaesthesia is widely used for the stunning of slaughter animals based on the induction of a general epileptiform insult ('grand mal' or seizure-like state). Provided that sufficient electrical current is passed through the head a general epileptiform insult, which is indicative for unconsciousness, will occur. Ineffective stunning can be very painful and paralysis may occur. Therefore, the use of EEG recordings and responses to stimuli are recommended. The so-called eye roll appeared insufficient to assess loss of consciousness.

Fish can be rendered unconscious in water by applying a voltage across two plate electrodes for 1 s. When the voltage is applied top-to-bottom, perpendicular or head to tail, the minimum current density depends on the orientation of fish relative to the electric field. The minimum current needed for an immediate stun depends on the fish species, conductivity of the water and, waveform of the current. A combination of electrical stunning for 5-20 s followed by chilling in ice water resulted in death of the stunned fishes. Analysis of the flesh quality showed product quality is comparable to that obtained by for instance live chilling. Using chilling as killing method for electrically stunned fish is a recommended method for application in a commercial setting.

An alternative for stunning in water is dry electro-stunning head to body. For this approach a stunner that consists of rows of steel flaps with a conveyor belt as positive and negative electrodes respectively, is used. The conveyor belt transports the fish during exposure to electricity through the stunner. The waveform of the current consists of an ac (100 Hz sinusoidal) and dc component. For head to body stunning of Atlantic salmon a minimum current of 0.67 A_{rms} (≈107 V_{rms}) is needed. Methods to prolong the unconscious conditions until death ensues should be sought. Dry electro-stunning followed by decapitation is a useful method for the slaughter of African catfish and hybrids. The method is easy for industrial fish processors to apply if their current procedure includes decapitation and evisceration. When using a minimum current of 0.57 A head to body for an individual catfish for 5 s, decapitation should be applied within 60 s post stun to prevent recovery.

ADVANCES IN THE ELECTRICAL STUNNING AND BLEEDING OF OSTRICHES

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Stunning of ostriches has traditionally been with hand-held tongs as birds are held in the restraining area by pressure normally applied by gently pushing from behind on the tail feathers. The area is often a V-shaped structure, high enough that the stunning operator is not kicked. After (and sometimes during) stunning, the birds are rocked backwards and a rubberised leg clamp placed over the legs at the tarso-metatarsal bone, thereby immobilising them, and allowing the birds to be ring/chain shackled via the big toes. Birds are hoisted onto a 3.4 m overhead rail and manually conveyed to another area for exsanguination. This conventional stunning procedure has been replaced in many abattoirs with a new restraining and stunning mechanism that completely encompasses the ostrich in a padded clamp holder. Double padded sides restrain the bird's upper thighs and a rubberized foot clamp holds the feet so that there is no physical damage to the bird. As the bird is electrically stunned (110 V, 50 Hz, 0.9 A, 30 s) with the head placed inside an electrical stunning box that contains two electrodes that are automatically extended to touch both sides of the head, the entire stunning box rotates 180° so that toe clamps can be applied without any danger to the stunning operators. The restraint is opened after stunning and the bird is hoisted and conveyed for exsanguination.

Within 20 seconds of stunning, the birds should be bled by means of a complete ventral cut to the neck and/or by thoracic sticking. The head is normally held between two horizontal metal bars to minimise blood spillage on the feathers and skin. After stunning ostriches are bled by means of a complete ventral cut to the neck and/or by thoracic sticking (TS). Although no research has been reported on the effectiveness of these two methods, personal observation seems to indicate that better and faster bleed-out is obtained when both the neck cut and thoracic stick is performed. In a pilot investigation where the two bleeding methods were applied, ten ostriches subjected to ventral throat cut alone had an average (\pm s.d.) bleed-out percentage (defined as weight of blood expressed as a percentage of live weight) of $2.8 \pm 1.03\%$. When the ventral cut was combined with thoracic sticking, the bleed-out was $3.3 \pm 0.34\%$. The means could not be proven to differ significantly ($P=0.16$), but the magnitude and direction of the absolute difference seem to warrant further investigation.

Personal observation also indicated that the TS ensured that all birds remained insensible to pain until death. The whole stunning procedure also gives an impression of a more humane and socially acceptable stunning procedure, whether it is more humane is still to be determined using scientifically accepted methods.

CURRENT SLAUGHTER METHODS IN BOLIVIA: REALITY AND CHALLENGES

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Puntilla followed by neck sticking was examined at two slaughterhouses in Bolivia in terms of the effectiveness and humaneness of this slaughter method.

Puntilla is a traditional slaughter method where 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 Animal Health Organization (OIE) because there is concern that the animal could be conscious after the neck stab. Nonetheless, it is still used in some developing countries.

Twenty llamas and 309 cattle were observed during routine puntilla without stunning. The number of neck stabs was recorded, and then brain and spinal function (rhythmic breathing, palpebral reflex and eye ball rotation) were assessed. In addition, in cattle, the presence of specific cognitive responses (such as response to threat stimulus and noise, as well as different flavours and odours) was also assessed. Breed, sex, live weight, body condition score and slaughterman experience were recorded.

Repeat stabbing was needed to penetrate the foramen ovale in 45% of the llamas and two of them attempted to stand 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; it was significantly less frequent in experienced slaughtermen, and more frequent in heavy weight 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.

These findings indicate that it is difficult in practice to penetrate the spinal cord with a single puntilla stab. Nerve pathways are often functional after the neck stab and therefore it is highly likely that the animals remain conscious for the next part of the 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.

THE ATTITUDES AND BEHAVIOUR OF STOCKPEOPLE AT AUSTRALIAN SHEEP AND CATTLE ABATTOIRS

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There are accumulating international data in a number of livestock industries that show that a negative attitude by stockpeople towards interacting with pigs, dairy cows and poultry, is correlated with increased levels of fear and stress in farm animals and, in turn, reduced animal productivity. While most of this research has been on-farm, one study has shown similar attitude-behaviour correlations in a pig abattoir. The major aim of this study was to examine the attitude-behaviour relationships of stockpeople handling sheep and cattle prior to slaughter at abattoirs. Twenty two abattoirs participated in the study; 59% were registered as export abattoirs, and 41% were domestic works. The locations of the abattoirs varied, with six plants in both Victoria and New South Wales, three plants in each of Western Australia, South Australia and Queensland, and one plant in Tasmania. Eighty-one stockpeople (35 cattle stockpeople and 46 sheep stockpeople) at these 22 cattle and sheep abattoirs (6 abattoirs slaughtering cattle, and 6 slaughtering sheep and 10 slaughtering both cattle and sheep) handling 3,309 cattle and 11,578 sheep were studied. Stockpeople were observed handling their stock prior to slaughter and were subsequently asked to complete an attitude questionnaire. Several significant correlations between stockperson attitudes and behaviour were detected. In particular, the pressures imposed by perceived lack of control over their actions, perceived time constraints, perceived effect of poor facilities and inappropriate beliefs about arousing livestock were all associated with frequent use of forceful handling behaviours by the stockperson. These results were similar to observations in pig abattoirs that have been reported previously. These attitude-behaviour relationships at cattle and sheep abattoirs indicate that there is an opportunity to improve stockperson behaviour at Australian abattoirs by targeting attitudes (and behaviour) for improvement with appropriate educational and training material, in a way that is similar to the uses of such training with other livestock species. A multimedia program has been developed but has yet to be evaluated in the field.

SLAUGHTER OF ATLANTIC SALMON (*SALMO SALAR*, L) IN THE PRESENCE OF CARBON MONOXIDE (CO) AND THE IMPORTANCE OF NEUROGLOBIN (NGB)

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Stunning methods for Atlantic salmon vary considerably and are at present not satisfactory with regard to welfare. The ban on CO₂ as stunning agent in Norway has recently been postponed due to lack of knowledge, as well as lack of appropriate alternative methods. Carbon monoxide (CO) is a colorless, odorless, tasteless and non-irritant gas. At exposure to exogenous CO the main toxic effect is its combination with hemoglobin, preventing carriage of oxygen by the red blood cells. CO has been used in animal euthanasia. When the technique is performed correctly, it does not induce noticeable fear in the animals before they become unconsciousness. Neuroglobin (Ngb) is an ancient member of the heme containing globins. It is expressed in the brain and neural tissues of vertebrates. Current hypotheses on Ngb function include oxygen storage, radical scavenger, or cell redox state surveillance and signalling. *Saccus vasculosus* is a richly vascularised sac in fish brain. One hypothesis is that *Saccus vasculosus* has developed in order to help fish in depth adaptation and function as a blood depot providing the brain with oxygen during oxygen deprivation and hypoxia. Salmon exposed to carbon monoxide expressed no aversive reactions towards CO, but convulsions occurred after 15-20 minutes of exposure. The fish were easily stunned by percussion after 20 minutes of exposure. CO exposed fish showed an earlier onset of rigor mortis, and a faster decrease in muscle pH, but no significant difference in drip loss was found compared to control. Also, higher levels of plasma lactate and potassium were found, as well as redder gills and fillets. Exposure to CO did not increase the levels of cortisol, sodium, hematocrit or glucose. In order to study the involvement of Ngb in CO related processes we have purified Ngb from salmon brain tissue as well as characterized the genomic structure and expression of the Ngb. We believe that use of CO could improve quality and welfare of fish when slaughtered, compared to current methodology.

DO CRUSTACEANS EXPERIENCE PAIN?

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I consider evidence that crustaceans might experience pain in ways that are analogous to those of vertebrates. I distinguish between nociception and pain and then review various criteria that should be fulfilled to indicate a pain experience: 1) a suitable central nervous system and receptors, 2) avoidance learning, 3) protective motor reactions that might include reduced use of the affected area, limping, rubbing, holding or autotomy, 4) physiological changes, 5) opioid receptors and evidence of reduced pain experience if treated with local anaesthetics or analgesics, 6) high cognitive ability and sentience and, 7) trade-offs between stimulus avoidance and other motivational requirements.

As a key test, hermit crabs were given small electric shocks within their shells. Only crabs given shocks evacuated the shells indicating the aversive nature of the stimulus but fewer crabs evacuated from a preferred species of shell indicating a motivational trade-off. Most crabs, however, did not evacuate at the stimulus level we used, but when these were subsequently offered a new shell, shocked crabs were more likely to approach and enter the new shell. Furthermore, they approached that shell more quickly, investigated it for a shorter time and used fewer cheliped probes within the aperture prior to moving in. Thus the experience of the shock altered future behaviour in a manner consistent with a marked shift in motivation, which lasted 24 hours, to get a new shell to replace the one occupied. These data, and those from other experiments, are consistent with the idea of pain in these animals. Thus I conclude that either they experience pain or the criteria are incorrect. Whilst it is not possible to be unequivocal about the nature of pain in crustaceans the way that they are used in the food chain should be reviewed with a principle of erring on the side of caution.

AUDITING ANIMAL WELFARE AND PRACTICAL IMPROVEMENTS IN BEEF, PORK, AND SHEEP SLAUGHTER PLANTS

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A welfare audit that utilizes numerically scored animal based outcome measures have been successfully used by McDonald's and other restaurant companies for over 10 years. In 2010, audit data from two restaurant companies indicated that all 30 North American plants rendered 95% or more of the cattle insensible with a single shot from a captive bolt gun. Eight pork plants that used electrical stunning placed the tongs correctly on 99% or more of the pigs. All animals were insensible prior to hoisting. In 32 beef plants, the percentage of cattle vocalizing in the stunning area was 5% or less. In 94% of the beef plants and 86% of the pork plants, 0% of the animals fell during handling. The worst falling score in two plants was 2%. High standards could be attained by making simple changes. To improve welfare, plant managers did the following: improved stunner maintenance, installed non-slip floors in stun boxes and unloading ramps, and trained employees. To reduce balking and improve animal movement, the following modifications were made: illumination of dark race entrances, moving of lamps to eliminate reflections, reducing equipment noise, stopping employee yelling, installation of solid sides on races or shields to prevent animals from seeing activity outside the facility and elimination of air blowing in the faces of approaching animals. Employees were trained to use behavioral principles of animal handling such as the point of balance and the flight zone. The five numerically scored outcome measures in this audit are critical control points that can detect a variety of problems. They are 1) Percentage of animals stunned effectively with a single application of the stunner, 2) Percentage of animals falling during handling must be 1% or less to pass, 3) Percentage of pigs or cattle vocalizing (moo, bellow, squeal) in the stun box or while entering into the stun box must be 5% or less to pass. Do not use vocalization scoring for sheep, 4) Percentage of animals moved with an electric goad and 5) Percentage of animals rendered insensible before hoisting. Must be 100% to pass an audit. All scores are per animal. An animal is scored as either silent or as a vocalizer or stunned correctly with a single application or not stunned correctly. The audit also contains a list of banned practices that will result in an automatic failure. To maintain improvements in handling, some companies have installed video auditing that is monitored by auditors viewing it over the Internet. The outside auditors do numerical scoring at random times throughout the day. Video auditing over the Internet is an important new tool for improving welfare.

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EFFECTIVENESS OF CAPTIVE BOLT GUNS AS A KILLING METHOD WITHOUT EXSANGUINATION FOR HORNED AND UN-HORNED SHEEP

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There is a large amount of practical experience in using the captive bolt for stunning sheep for meat consumption, where sheep are bled after being shot. The current study will make welfare-based recommendations for gun-cartridge combinations and aiming points that will ensure death of the sheep (horned, unhorned, rams & ewes), without the need for either sticking or pithing. The findings will have application when it is necessary to kill sheep on farms for disease control or euthanasia purposes.

The initial study examined the pathophysiology of captive bolt injury to the brain using magnetic resonance imaging (MRI) and gross pathology in horned (n=18) and polled (n=19) ewes in order to (1) establish whether there are any differences between assessment of in situ brain injury based on MRI and assessment based on gross pathology of the brain after removal from the cranium, and (2) determine the pathophysiology of captive bolt injuries that do not produce insensibility leading to death. In a separate larger study, behavioural and reflex responses were examined with gross pathology in 610 animals (237 polled ewes, 152 horned ewes, 120 polled rams and 122 horned rams) with a variety of captive bolt-cartridge combinations.

The initial findings demonstrate the importance of marksmanship in determining success, with damage to the medulla (p=0.004), pons (p=0.001), midbrain (p=0.001) and thalamus (p=0.02) being most strongly associated with a deep level of concussion leading to death. Shooting horned rams was particularly challenging, partly because minor movements of the head at the time of shooting can result in deflection of the gun by the horns. High bolt velocities (>47 ms⁻¹) resulted in greater shattering of cranial bone producing smaller bone fragments that acted as secondary missiles within the brain. Lower bolt velocities (<42 ms⁻¹) resulted in larger bone fragments that travelled shorter distances creating less damage. Provisional recommendations for bolt velocity to achieve death without intervening recovery of consciousness in polled ewes, polled rams and horned rams are 43, 55 and 61 ms⁻¹ respectively, provided the shots are delivered accurately. In horned and polled animals a column of brain tissue was frequently extruded through the hole in the cranium created by the bolt. This might be caused by a suction-like effect during bolt withdrawal causing both damaged and undamaged tissue to be drawn into the trajectory of the bolt or it may be an effect of acutely increased intracranial pressure, or a combination of these factors. Either way, brain extrusion was associated with marked displacement of neural structures and may contribute to disturbed function.

STRESS AT SLAUGHTER IN CATTLE: ROLE OF REACTIVITY PROFILE AND ENVIRONMENTAL FACTORS

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During slaughter, cattle may be exposed to many potentially stress-inducing factors, of psychological and physical nature. A series of studies aimed to identify factors that may contribute significantly to the animal's stress status. In a first experiment, at the end of the fattening period, the reactivity profiles of 32 Normand cull cows were determined by exposing each individual to novelty, a human exposure and a social isolation test. Compared to the social isolation test, exposure to the human appeared more stressful as indicated by the longer time spent near the exit and the higher heart rates ($p < 0.05$). During subsequent slaughter, behavioural and physiological measurements and indicators of *post-mortem* (*pm*) Semitendinosus (ST) muscle metabolism were used to evaluate stress status of the cows. Stronger behavioural and physiological reactions during the slaughter procedure were associated with faster *pm* muscle metabolism. For example, cows that balked more when driven into the abattoir had warmer ST muscles ($r = 0.68$; $p = 0.01$) and lower pH 3h *pm* ($r = -0.60$; $p = 0.03$). Reactions during the exposure tests were also correlated with stress indicators at slaughter. A principal component analysis explained 65% of the variability in reactions during the tests and the slaughter procedure. The first and second axes were correlated with reactions to non familiarity and to social isolation, respectively. Both axes were correlated with stress indicators at slaughter, suggesting that these two aspects contribute significantly to the psychological stress at slaughter. A second experiment used a similar approach on young Angus, Limousin and Blond d'Aquitaine bulls. Blond d'Aquitaine bulls were more reactive to human exposure, a novel object and a sudden event (opening of an umbrella) than the other breeds. Indicators of *pm* muscle metabolism were correlated ($p < 0.05$) with stress reactions at slaughter, and with heart rates during the exposure tests. These two experiments indicate that for Normand cows and Angus, Limousin and Blond d'Aquitaine bulls stress reactivity at slaughter may be predicted from behavioural and physiological stress reactions during exposure tests. A third experiment assessed the effect of 30h food deprivation on stress reactivity. Compared to normally fed heifers, food deprived heifers were more reactive to human exposure and explored less ($p < 0.05$). Compared normally fed cows, food deprived cows showed stronger startle and fear responses ($p < 0.05$) in response to a sudden event (air blast on the nose). Overall, results show that in cattle, the general emotional reactivity profile and the physiological status of the moment explain part of their stress responses at slaughter.

ASSESSMENT OF THE RELATIVE WELFARE IMPACTS OF THREE GAS TREATMENTS FOR THE EUTHANASIA OF SUCKLING PIGLETS

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When euthanasia of sick or injured animals is required on animal welfare grounds, a method that induces minimal welfare compromise should be chosen. Blunt force trauma to the head is currently the most commonly employed means for on-farm euthanasia of pre-weaned piglets. When performed correctly, loss of consciousness is immediate, but the potential for delivery of sub-lethal blows, along with aesthetic unacceptability to many operators, has led to the need for alternative methods to be developed. The present study investigated the relative welfare impacts of the use of three different hypoxic gases or mixtures for euthanising suckling piglets. The gases were 100% carbon dioxide (CO₂), 100% argon (Ar) and a mixture of 40% CO₂: 60% argon (Ar/CO₂). Each gas was tested using male piglets, aged between 14 and 21 days (n=5). On each occasion a chamber was filled with the test gas and a piglet was placed inside. Throughout the experimental period, behavioural (escape attempts, vocalisation, loss of coordination, respiratory effort, convulsions) and physiological (electroencephalogram (EEG), electrocardiogram (ECG), respiratory rate) data were continuously recorded until death. In addition, plasma cortisol and adrenaline levels were determined before treatment and immediately following death. A welfare index was established to assess the relative welfare compromise induced by each gas treatment. The index included five behavioural measures observed in the period prior to apparent loss of consciousness, beyond which there was no further potential for welfare compromise. These measures were: latency to onset of convulsions, duration of escape behaviour, duration of increased respiratory effort, respiratory effort grade and duration of squealing. The sum of ranks for each animal across the 5 measures yielded a single score indicative of welfare compromise, with a lower score equating to less compromise. According to this index, CO₂ induced significantly greater welfare compromise (49.8 ± 2.77 , mean \pm SEM) than either Ar (35.2 ± 3.56), or Ar/ CO₂ (37.0 ± 0.89). These results suggest that 100% CO₂ is not an acceptable method for on-farm euthanasia of young pigs. Although argon and the mixture did not significantly differ in terms of welfare impact, times to loss of consciousness, isoelectric EEG and respiratory arrest were significantly shorter with Ar/ CO₂ than Ar ($p < 0.05$), making this potentially more useful from a practical standpoint. However, the degree of welfare compromise observed in all treatments suggests that other alternatives to manually applied blunt trauma should be investigated.

IDENTIFYING REASONS FOR STUNNING FAILURES IN SLAUGHTERHOUSES FOR CATTLE, SHEEP AND PIGS – A FIELD STUDY

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Checking the effectiveness of stunning was one of the major tasks when the authors evaluated the stunning process by request of the slaughterhouse management, retailers or the competent authorities in slaughterhouses in Germany, Switzerland and Austria between the years 2000 and 2010.

A total of 89 slaughterhouses for cattle, sheep and pigs were included in this study. In some slaughterhouses the evaluation was repeated after one or two years.

For every evaluation the technical premises of the stunning device, the execution by the personal and the clinical signs of the animals after stunning were recorded.

The evaluations for stunning of cattle include 49 in captive bolt and one in electrical stunning in a total number of 2000 cattle.

The investigations in sheep have been done on 208 sheep in 6 slaughterhouses using electrical stunning.

For pigs 103 evaluations in electrical (52) and CO₂ -stunning (51) covering in total 42.000 pigs (sows/piglets) had been made.

The main reasons for fail stunning were detected or at least estimated if not apparent. For each stunning method and species recommendations are given to avoid the occurrence of stunning failures.

VETERINARY CERTIFICATES FOR EMERGENCY OR CASUALTY SLAUGHTER BOVINES IN IRELAND: ARE THE WELFARE NEEDS OF CERTIFIED BOVINE ANIMALS ADEQUATELY PROTECTED?

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All emergency and casualty bovines in the Republic of Ireland that are deemed to be fit for human consumption must be accompanied to the slaughterhouse by an official veterinary certificate (VC). In a previous study, Cullinane et al. (2010) conducted a review of bovine cases consigned under veterinary certification to emergency and casualty slaughter in Ireland during 2006 to 2008. The current paper further evaluates these results, with emphasis on the period of validity, transport distance and transport conditions, and considers whether the current VC adequately protects the welfare needs of the certified bovine animal. Of 1,255 veterinary certificates, the mean time between certification and slaughter was 3 (minimum 0, maximum 452, median 1) days, with one fifth in excess of 3 days. The welfare of animals would be improved if each VC included a period of validity. The mean transport distance between farm and slaughterhouse was 27.2 km; 82.1% and 97.8% study animals were transported distances of no more than 40 and 100 km, respectively. In 27% of VCs, no slaughterhouse was designated; hence the transport distance was not limited. In 76.9% of all cases, the disability/injury related to the locomotory system, including 35.2% of these being animals with fractures. As well as stipulating maximum transport distances, these authors contend that VCs should also outline very specific conditions of transport, including bedding type and depth, and if deemed necessary some means of restraining the animal. The veterinary certification of ES and CS is a particularly important area for animal welfare, yet few studies of this type have been conducted previously. In future, veterinary certificates should clearly state a maximum period of validity between certification and slaughter, a maximum distance that the animal should be transported and a minimum level of comfort under which the animal must be transported. Historically in Ireland, there was no suitable non-transport alternative available to cattle producers wanting to salvage an otherwise healthy animal that had suffered an accident or injury resulting in acute pain. An alternative is now available, with the introduction of an on-farm emergency slaughter policy. All of the stakeholders must take responsibility to make this a viable option. The veterinary profession, both private and official, by adopting the recommendations of the current paper, are in a position to safe guard the welfare of the ES and CS bovine animals not subject to on farm slaughter.

IMPROVING THE POULTRY SHACKLE LINE

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The shackle line and multibird waterbath is widely used across the world for poultry slaughter. The major manufacturers of this equipment expect demand for this equipment outside from Europe to continue regardless of decisions made in Europe. Within Europe, medium and small processing plants lack credible alternatives and closure of these plants would significantly increase poultry transport distances to the detriment of poultry welfare.

The most significant welfare problems associated with the current design of the shackle lines and water-bath stunners are the pain caused by compression of the birds legs in the shackles, the stress caused by being inverted and suspended by the legs, poor or inadequate stunning caused by the commercial need to minimise carcass damage and poor water bath entry. Research will be described where some practical solutions to these problems were investigated. The aim is to identify solutions that individually or jointly could be retro-fitted to existing plants, or incorporated into the design of new small processing plants to improve poultry welfare.

These developments include compliant shackles that to avoid compressing the legs, a breast support conveyor to avoid the inverting and suspending the birds as they move from the hang-on point to the water-bath and a head- only water bath stunning system that facilitates a consistent and effective electric stun without causing carcass quality problems. These approaches have all been taken through a first stage of trials but need further trials and/or development before they can be introduced commercially.

The compliant shackles have operated for six months in a small processing plant without causing problems for the plant management. The breast support has been tested in a small broiler processing plant and is now used on two commercial turkey processing lines. Head only waterbath stunning has not yet moved beyond the experimental stage but trials show that it is capable of delivering an effective stun without compromising carcass quality.

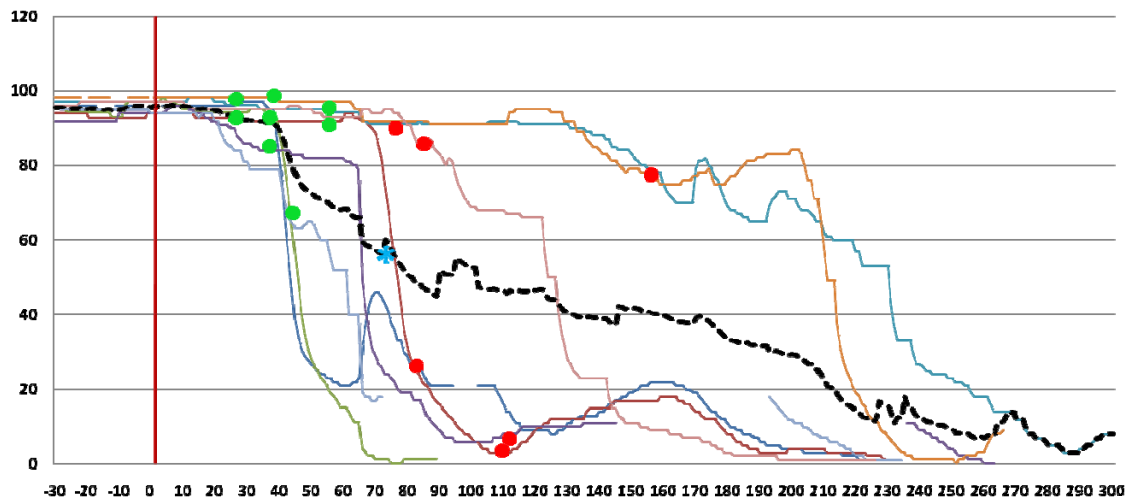
ASSESSMENT OF UNCONSCIOUSNESS DURING SLAUGHTER WITHOUT STUNNING IN LAMBS

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In non stunned animals the loss of consciousness during bleeding is not immediate. The aim of this study was to assess the brain activity of lambs with an index of consciousness (*IoC view*[®]; *Morpheus Medical*) given by the electroencephalogram (EEG) during religious slaughter without stunning and its correlation with the absence of physiological reflexes. *IoC view*[®] assesses consciousness by an algorithm that analyzes the EEG and gives an index from 0 (unconscious) to 100 (conscious). Eight lambs (Merino breed) of 20 to 25kg live weight were individually restrained in a stretcher and 3 skin electrodes were placed at the level of the frontal bone. The electrodes were connected to the *IoC view*[®]. Recording time started 2 minutes before sticking to get a basal *IoC* value of each animal. During bleeding presence of corneal reflex and rhythmic breathing each 10s were recorded until the brain death. The *IoC* values are presented in Figure 1. The disappearance of rhythmic breathing ranged between 31 and 60s after sticking and the average time to disappear was $43.8 \pm 4.20s$. Twelve seconds after the disappearance of the rhythmic breathing in the last animal, the average cerebral activity showed significant differences compared to the basal level (*IoC* = 60 ± 7.3 vs 95 ± 2.4). The time to disappear the corneal reflex ranged between 80s and 160s after sticking and the average time to disappear was $116.3 \pm 11.01s$. The lowest average *IoC* was reached 291s after sticking with a value of 2.1 ± 16.18 .

Figure 1. Time to disappear rhythmic breathing (green spot) and corneal reflex (red spot) in relation to the *IoC* of each animal and mean value (black line) after sticking (red line).



* Is showing the moment in which the mean *IoC* value is different (lower) than basal value.

ELECTRICAL STUNNING OF CAPTURED FISH

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Electrical stunning to protect welfare of food animals at slaughter is established for a range of farm animals. For fish, it is reported that when sufficient current is passed through the head, a general epileptiform insult will occur, which is recorded on an EEG. The epileptiform insult is indicative for loss of consciousness. Fish species specific specifications to achieve an instantaneous stun without recovery, should be based on EEG recordings.

It is known that electrical stunning of fish may lead to carcass damage. For Atlantic Salmon (*Salmo salar*) it is reported that so called “dry stunning” results in a very low incidence of damages. With “dry stunning”, a current is administered to a fish, after dewatering, via rows of positive plate electrodes and a conveyor belt as negative electrode.

Preliminary experiments performed by SINTEF with captured fish indicate that electrical stunning could allow for more rapid gutting and rinsing of fish onboard. Stunning of captured fish prior to killing could, therefore, increase the fish quality and at the same time protect welfare of fish at slaughter. The issue of electrical stunning of captured cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) onboard is one of the sub-objectives of a Norwegian project, led by SINTEF. This project started in 2010 and focuses on development and assessment of novel technologies onboard. In this project we assessed “dry stunning” of captured cod and haddock onboard of *Jan Mayen*. For the “dry stunning”, experimental equipment developed by the Norwegian manufacturer SeaSide was used. EEG recordings revealed that when on average 52 V_{rms} (100 Hz alternating current component, coupled with a direct current component) was applied across the electrodes for 1 s, sufficient current was passed through cod and haddock to provoke immediate loss of consciousness.

In 2009 a group of fishermen in the Netherlands decided to initiate a project on stunning of captured sole (*Solea solea*), turbot (*Psetta maxima*), plaice (*Pleuronectes platessa*), dab (*Limanda limanda*) and cod onboard. It is the view of these fishermen that sustainability of fisheries should also include welfare of captured fish. The Dutch project, which started in 2010, is managed by the company Scienta Nova. The first step is to establish conditions for “dry stunning” to achieve instantaneous loss of consciousness in plaice and dab.

COMPLICATIONS DURING HALAL SLAUGHTER AND SHECHITA IN CATTLE

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This paper summarises the findings from five studies in 8 countries on over 1500 cattle slaughtered commercially by the halal or shechita methods without stunning. It reports the number of cuts applied to the neck, the cutting methods and the frequency of complications during the bleeding period. Complications during the bleeding period occurred in some cattle and included (1) delay in the time to collapse, which was interpreted as late loss of consciousness, (2) premature arrest of bleeding from the carotid arteries due to false aneurysm formation, and (3) blood entering the respiratory tract during bleeding. These features are important as they determine or reflect the duration of consciousness following the cut and the potential for protracted suffering from wound nociception or blood irritating the respiratory tract.

When cattle were not restrained following the cut, they took on average 20 s to collapse. Fourteen % stood up again after an initial collapse, and 1.5 % took more than 4 min before their final collapse. Eight % took 60 s or longer to collapse, and those animals were more likely to have false aneurysms in the severed ends of the carotid arteries. False aneurysms, which were at least 3 cm in diameter, formed in the severed cardiac ends of the carotid arteries in 10 % of cattle slaughtered by halal or shechita. Some false aneurysms formed in the severed ends of the carotid arteries within 7 s of the cut, and in 10 % of the cattle blood flow came to a halt in one of the arteries within 10 s. On average the false aneurysms developed within 21 s. Nineteen % of cattle slaughtered by shechita and 58 % of cattle slaughtered by halal had blood lining the mucosa of the trachea. All animals had blood lining the glottis. In both situations there could be respiratory tract irritation from the blood.

It is proposed that severing the carotids at the position in the neck which corresponds to C1 will reduce the frequency of false aneurysm formation and subsequent arrested blood flow from the severed arteries, and it will deafferent the respiratory tract preventing the transmission of potentially unpleasant sensory signals associated with blood contaminating the upper and lower parts of the tract. Most cattle subjected to halal and shechita have the neck cut at a position which corresponds to C2 to C4, and changing to a cut at C1 could partly reduce the potential for suffering during slaughter without stunning.

WELFARE OF ANIMALS AND EMPLOYEES IN CONNECTION WITH SLAUGHTER OR EUTHANASIA OF ANIMALS

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Human awareness and skills constitute the one most important factor for the welfare of the animals in their care. We aim to study human-animal interaction and relationships between investments in human resources and animal care, assessed levels of employee subjective well-being (SWB) and animal welfare (AW), and the organisational efficiency at different workplaces where animals are handled and killed routinely. A three-year innovative collaboration between natural sciences, medicine, social sciences and humanities was initiated in 2009.

SWB refers to a person's evaluation of his/her life. It includes both a cognitive and an affective component. Different factors influence SWB, work place and job satisfaction being highly important. AW has been defined in various ways; the most general one states that AW occurs when the animal is in harmony with its environment. Research shows that AW is affected by the way animals are handled by humans, whose knowledge, attitudes and personalities are important factors. There are also studies showing positive effects of human-animal interaction on human well-being, and animals can be used in rehabilitation or treatment of physically and psychologically ill people.

In this study, staff and animals at abattoirs and animal laboratories in Sweden are studied. In both these types of workplaces there is frequent human-animal interaction of a particular kind. There are also many differences regarding e.g. gender distribution among employees, level of education, social standing, physical and mental work conditions and animal species. We hypothesise that there is a mutual dependency between employee SWB and AW at these workplaces, resulting in a virtuous or vicious circle. A healthy, satisfied and happy abattoir or laboratory employee is more likely to interact with his or her environment in a friendly way, and to treat fellow workers and animals well. A healthy, non-stressed and well-treated animal is easier to handle, and less likely to cause irritation and stress among the staff.

Data are collected through questionnaires, interviews, observations of humans and animals in interaction and a review of strategic company documents. Results from the study will be presented. These are expected to illustrate the importance and the impact of simultaneous focus on human well-being and animal welfare to reach a higher level of both in a production setting.

**Humane Slaughter Association Centenary International Symposium:
Recent Advances in the Welfare of Livestock at Slaughter**
30th June & 1st July, Portsmouth Historic Dockyard, Portsmouth, UK



THE ITALIAN APPROACH TO WELFARE DURING TRANSPORT OF DEERS BRED FOR MEAT: IMPLEMENTATION OF REGULATION (EC) 1/2005

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Introduction

In Italy, deers bred for human consumption are immobilised for transportation to other farms or to game reserves where they are shot and taken to a game handling establishment for post mortem inspection to commercialise their meat. Seldom, they are transported to the rare slaughterhouses authorised for game on the national territory.

Four terrestrial transports of less than eight hours, of 45 deers of the species *Cervus elaphus*, bred for meat, were observed over a period of four months during winter.

The aim of this study was to evaluate the implementation of Regulation (EC) 1/2005 in the transport of deers bred for meat.

Main Findings

The observed capture techniques such as darting, nets, and enclosures, provoked a high level of stress in the animals, which are bred in semi-intensive conditions and are unfamiliar with humans, engendering issues in the respect of European Regulations. Darting, although less invasive, created difficulties in the physical manipulation of the animals; furthermore, the specific legislation forbids the lifting of the animals' body parts. In game reserves, the impossibility to control the withdrawal periods limited the use of drugs.

Planning was crucial but variables related to environment, facilities, human management and animals influenced the duration of the operations, jeopardising the animals' welfare. The animals' reactions were rarely repeatable and could not be predicted. Cases of escape, traumas in animals and in humans, hyperthermia, and extreme stress were observed. Environmental and management factors such as inappropriate enclosures and land inclination created a risk both for animals and humans.

Loading and unloading represented important hazards for the inappropriateness of the means of transport used, which was not specific for deers and determined risks of falls, escape and traumas.

During the journey, the traumas observed were mainly caused by mixing of horned/unhorned animals and of young/adults. The journey duration was one of the main hazards; however journey times and stocking densities are not specified by law.

Management and experience were determinant for the success of the operations, as it was not possible to apply by analogy what were basic requirements for farm animals.

Conclusion

The stress due to human management, weather conditions, inadequacy of facilities and equipment, duration of operations and journey time, created circumstances in which the control of hazards was extremely difficult. The implementation of the legislation in force is partially complicated by its lack of specificity for the management and transport of farmed deers.

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WSPA AND APSRI HUMANE SLAUGHTER PROGRAMME IN CHINA – STEPS®

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Humane Slaughter programme is a project that has been developed and managed by the WSPA and APSRI who has jointly carried it out since 16th Dec. 2007. The training is based on the training needs analysis carried in China in 2007 by UK experts. Species specific textbooks and DVDs were produced based on the training needs analysis. Official website was developed to promote the training programme branded as STEPS® (www.steps.org.cn). Website was later on updated by an E-learning system. Other training supportive tools such as poker card sets with best practice humane slaughter images and basic rules were produced for entertainment and educational purposes. STEPs programme focuses on training provided to slaughterhouse staff, advising on legislation and guidelines and training and lectures provided to undergraduates.

Because of our effort, *Technical Code of Pig Humane Slaughter* drafted by us has been officially accepted by Chinese government and entered into force in 2009. We are still actively proposing other animal welfare related standards to the government. In field training, about 5000 staff and inspectors have been trained, from approximately 1100 slaughterhouses, 250 local governmental departments by now. Workshops for students and academics at ten universities/research institutes were carried out in last 2.5 years. We have provided advice to slaughterhouses with, and also helped university teachers add animal welfare related information into their curricula.

Main challenges we are facing now include need for equipment improvements, establishment of auditing system for retailers; promoting humane slaughter and animal welfare from market standpoint; enhancing propaganda and cooperation with more potential partners.

We want to make our training programme more flexible; reinforcing post-training evaluation visits and auditing in slaughterhouses; attracting more attention from local governments and slaughterhouse staff, working on implementation of governmental projects.

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CAPTIVE BOLT EUTHANASIA OF CATTLE: DETERMINATION OF OPTIMAL SHOT PLACEMENT AND EVALUATION OF THE CASH SPECIAL EUTHANIZER KIT FOR EUTHANASIA OF CATTLE

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Veterinarians and livestock producers have limited options for effective and humane euthanasia of cattle. Barbiturate euthanasia, gunshot, and captive bolt are currently available options. Captive bolt euthanasia is safer than gunshot and doesn't have the potential environmental hazards of barbiturates. However, it is generally recommended that captive bolt stunning be followed by a secondary means of euthanasia to ensure death. This may be problematic in a field setting, especially if large numbers of animals are involved.

The purpose of this study is to determine the effectiveness of the Cash Special Euthanizer for field euthanasia of cattle. Preliminary research has indicated a need for adjustment of shot placement when using a captive bolt for euthanasia. The currently recommended shot placement for stunning (the intersection of two lines drawn from the medial canthus to the opposite horn) is too rostral and doesn't consistently lead to disruption of the brainstem. Our preliminary work has shown that placing the shot 3-5 cm caudal to the standard location consistently leads to disruption of the cerebral cortex and brainstem in adult cattle. Euthanasia of approximately 20 adult cattle has shown that the Cash Special Euthanizer is highly effective when the shot is placed in a more caudal position.

This study will be conducted in two parts. Part one will determine the optimal shot placement for providing the highest chance of disrupting both the cerebral cortex and brainstem. Cadaver heads will receive a single shot in the standard location or in a more caudal position. The heads will undergo computed tomography scanning to evaluate the location and depth of bolt penetration. Following the CT scan, the brains will be formalin fixed and extracted for the assignment of a traumatic brain injury score.

The second part of the study will determine the effectiveness of the Cash Special Euthanizer for field euthanasia. Cattle requiring euthanasia will be shot and immediately assessed for signs of sensibility. Shot placement will be determined according to the results of part one of the study. Assessment will continue until a heart beat is no longer detected or ten minutes has elapsed, at which time concentrated potassium chloride will be administered intravenously.

Each part of the study will be repeated for adult, yearling, and neonatal cattle.

JOURNEY DURATION AND WELFARE OF PIGS TRANSPORTED TO SLAUGHTER IN THE UK

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On-going “Review of Council Regulation (EC) No 1/2005” on protection of animals during transport has reopened the debate on permissible journey durations for pigs. A Defra-funded study was carried out at two UK-based commercial pig abattoirs to assess the possible influence of journey time on welfare of pigs transported to slaughter. A total of 195 loads (deliveries) of pigs were observed between October 2009 and August 2010 covering winter and summer conditions, delivering 32,334 pigs from a variety of husbandry systems. Selection of loads to include in the study was semi-random. Journey durations of transports observed ranged between 59 minutes and 18.45 hours, with the majority being less than four hours. Pigs were observed being unloaded in order to assess incidence and severity of injuries and lameness. Where possible, behaviour of up to 61 pigs per load was then observed in a lairage pen for up to one hour. In addition, pH values were measured in the *Musculus glutaemus medius* 45 minutes and 24 hours post-slaughter from a representative sample of carcasses from most loads. Salivary cortisol was measured in sub-sets of pigs in one abattoir.

In total six pigs were dead on arrival (0.02%). Eighty-nine pigs were lame to the degree that they walked with difficulty or avoided putting weight on the affected limb. This was not related to journey duration. Eighty pigs were killed immediately upon arrival as casualty slaughters, though this included slaughter for declared injuries. Other main reasons for casualty slaughter included traumatic injury, lameness, ulcerated tailbites, heart attack, or rectal prolapse.

Behavioural analysis revealed that the first pig in each group observed started drinking within ten minutes of arrival, regardless of journey duration. Neither did duration affect incidences of aggressive behaviour in lairage. Pigs that had travelled more than eight hours did have a longer latency to rest than those that had travelled four hours or less. Although both pH₄₅ and pH₂₄ were influenced by differences in journey duration, this explained little of the variation in these measures. Levels of salivary cortisol increased linearly with journey duration.

Uniquely, this study combines behavioural and physical indicators of welfare in slaughter pigs to assess effects of journey duration under commercial conditions. From these data there is currently no indication that travel durations of up to 18.5 hours have an obviously negative effect on welfare of pigs transported to slaughter in the UK, although the implication of salivary cortisol levels at longer journeys needs further investigation.

LICENSING POULTRY GAS STUNNING SYSTEMS WITH REGARD TO ANIMAL WELFARE – INVESTIGATIONS UNDER PRACTICAL CONDITIONS

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CO₂-stunning for broilers is not permitted in Germany. However the competent authority can license a system for testing and during this testing phase scientific evaluation with regard to animal welfare is required. The approval procedure can be taken as an example for independent scientific support as required in the new European Council regulation (1099_2009, Art 20).

Evaluation of animal welfare under slaughter house conditions includes:

- a) Good welfare during bird supply to the system to reduce excitement and warrant a gentle induction of the stunning process,
- b) Scientifically based induction conditions and corresponding clinical appearance, which can be verified in practice,
- c) Sufficient depth of stunning assuring that in combination with given stun-stick interval and bleeding quality no animal regains consciousness before dying and
- d) Suitable process control and monitoring of welfare relevant parameters including possibilities for easy checks by the competent authority.

System 1: LINCO gas stunning system where broilers in their transport crates are lowered stepwise into a pit filled with CO₂ and exposed to slowly increasing CO₂ concentrations with total dwell times between 300 and 400 seconds depending on chicken weight (slaughter speed 9.000/h-12.000/h).

System 2: Stork PMT two phase gas stunning system (40% CO₂/30% O₂/30%N₂ for one minute/ 80% CO₂ for two minutes) where broilers are gently dipped onto a belt on which they pass through the gas atmospheres (slaughter speed 10.000/h-12.000/h).

System 3: Anglia Autoflow two phase CO₂-stunning system, where animals pass in their crates (slaughter speed 10.000/h-12.000/h). Results on this system are pending and will be included, provided affirmation of the company.

In system 1 and 2 video analysis of behaviour showed that birds are only exposed to high CO₂ - concentration (>40%) after being unconscious. Stunning effectiveness is very high but nevertheless single chicken are able to regain consciousness, especially if not bled correctly. Examples of evaluation of behaviour during induction will be given and animal welfare aspects (a-d) will be comparably depicted.

These field studies supplement the findings of laboratory experiments. Reliable monitoring points have been defined in each plant as minimum/maximum gas concentrations, minimum dwell times, maximum stun to stick intervals as well as control, monitoring and warning procedures relevant to the competent authority with regard to daily routine surveillance of animal welfare at stunning. CAS systems for broilers using less than 40% CO₂ until animals are unconscious, show obvious advantages compared to electrical stunning like abolishing of shackling and high stunning effectiveness.

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PAIN PERCEPTION AT SLAUGHTER

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Commercial slaughter of farm livestock usually employs an extensive incision that severs the soft tissues of the neck including the major blood vessels supplying and draining the brain. It is intended to cause a catastrophic decrease in cerebral blood flow with rapid onset of unconsciousness or insensibility. The tissues of the neck are innervated with nociceptive nerve fibres and their transection will cause a barrage of sensory impulses. Consciousness, and therefore the ability of the animal to feel pain and experience distress after the incision, may persist for 60 seconds or longer in cattle. These observations suggest that livestock may experience pain and distress during the period before they become insensible, but there have previously been no experimental techniques capable of assessing pain perception during this period.

Recent developments related to quantitative analysis of the electroencephalogram (EEG) have allowed the experience of pain to be assessed more directly than has hitherto been possible. Variables derived from the EEG of animals anaesthetized using our minimal anaesthesia model have been shown to respond to noxious stimulation in a similar manner as to when animals are conscious. This methodology has been used in a variety of applications including the evaluation of analgesic options for painful husbandry procedures and investigation of developmental aspects of the perception of pain.

We have now applied the minimal anaesthesia model to the question of the slaughter of calves by ventral-neck incision. A series of studies evaluated the magnitude of EEG response to the noxious stimulus of ventral neck incision and the physiological mechanisms that underlie this response. We also investigated the EEG effects of stunning by non-penetrating captive bolt and the ability of such stunning to ameliorate the response to ventral neck incision.

The results of these studies demonstrate clearly for the first time that the act of slaughter by ventral-neck incision is associated with noxious stimulation that would be expected to be painful in the period between the incision and subsequent loss of consciousness. These data provide further support for the value of stunning in preventing pain and distress in animals subjected to this procedure.

This paper will discuss the development of the minimal anaesthesia model and its adaptation for use in the investigation of slaughter by ventral neck incision as well as considering the contributions that these studies are making in the ongoing development of international policy concerning the slaughter of animals.

AVERSION TO THE INHALATION OF NITROGEN AND CARBON DIOXIDE MIXTURES COMPARED TO HIGH CONCENTRATIONS OF CARBON DIOXIDE FOR STUNNING RABBITS.

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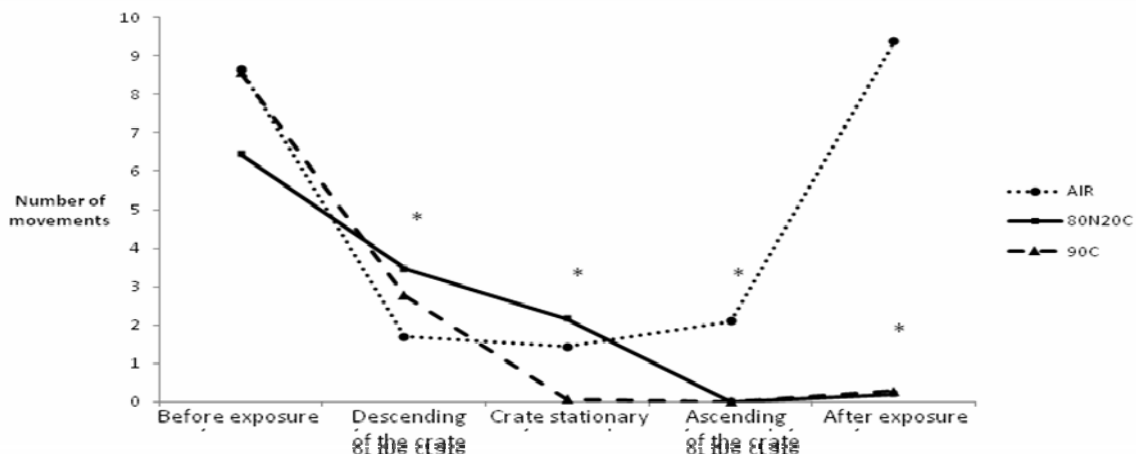
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Stunning by inhalation of nitrogen (N₂) and carbon dioxide (CO₂) mixtures have been stated to reduce aversion compared to high concentrations of CO₂ in pigs and poultry. The objective of the study was to assess the aversion to high concentrations of CO₂, 90% (90C), and an alternative gas mixture of 80% N₂ and 20% CO₂ (80N20C). The aversion was assessed in 120 rabbits using behavioural indicators and an open field tests. One group of 60 animals was exposed to the 90C and another one to 80N20C treatment. The study was carried out during two consecutive days. The first day, all rabbits descended in pairs to the pit with atmospheric air and their behaviour was recorded and used as control. The second day, rabbits were again introduced in pairs into the crate and descended into the pit, where they were exposed to the different gas treatments for 1 minute. The open field test and the assessment of the exploratory behaviour were recorded during the whole process (including two minutes before and after the exposure). During the exposure, signs of respiratory distress, loss of posture and muscular excitation were also assessed. The number of movements performed while the crate was descending, stationary and ascending are presented in Figure 1. In comparison to atmospheric air, animals submitted to both gas treatments showed a higher presence of respiratory distress. Respiratory distress was present in 97% of animals exposed to 90C whereas a 40% of animals exposed to 80N20C did so (p=0.0005). Muscular excitation during induction to unconsciousness occurred mainly in animals exposed to 80N20C compared to 90C (100% vs. 17%; p<0.0001) whereas muscular excitation during recovering occurred in a 100% of animals exposed to 90C in contrast to 0% of animals exposed to 80N20C. Mean time to recover posture was significantly lower in 80N20C than 90C (98.6s vs. 110s; p=0.0007). It is concluded that rabbits showed less signs of aversion to inhalation of 80N20C than 90C but more than inhalation of atmospheric air.

Figure 1. Number of movements performed on average on different periods in each gas



* shows significant differences between treatments in each period

STUN AND MEAT QUALITY OF SHEEP UNDER COMMERCIAL CONDITIONS

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Electrical head-only stunning is a widely used method in sheep slaughter. According to the recently adopted EU regulation on the protection of animals at the time of killing (Council regulation (EC) No 1099/2009), which includes minimum requirements to be met at slaughterhouses, a number of key parameters should be established to ensure efficient stunning when head-only stunning is applied on sheep and lambs. These include minimum current, minimum voltage, maximum frequency, minimum time of exposure, maximum stun-stick interval, and positioning of the electrodes.

There are numerous controlled experimental studies on the effect of current level on the stun quality and/or meat quality parameters in sheep and other species. Under commercial conditions, a number of factors can be expected to influence the stun. For example, high line speed and limitations related to the restraint facilities can result in suboptimal tong placement and tong maintenance, and the incoming animals vary in size, wool thickness and cleanliness.

To investigate the influence of currents level on stun and meat quality in practice, a study was carried out at a commercial slaughterhouse where hemorrhages ('blood splash') in the back muscles (*Longissimus dorsi*) were reported as a quality problem becoming increasingly common. The lambs, with an approximate live weight of 30 kg, were stunned applying head-only stunning using scissor type stunning tongs, conventional 50-Hz AC sine wave supply voltage, with an output of up to 230 V and a stunning cycle length of 10.5 seconds.

In total 198 lambs were randomly assigned to four groups with a current level of 0.6, 0.8, 1.0 and 1.25 A, respectively. For each lamb, the placement of the tongs was observed and classified as correct or incorrect. The stun quality was evaluated based on observations of the corneal reflex, eye movements, spontaneous breathing, head-righting reflex and kicking during the tonic phase.

A total of 58 % of the animals were stunned using an incorrect tong position and 31 % were insufficiently stunned. The effect of current level on the risk of poor stun quality was highly significant; using a current of 0.6 A increased the odds 21 times ($P < 0.0001$) compared to 1.25 A. Meat quality was analyzed in 196 carcasses, and 63 % of these displayed blood splash. There was no significant association between current level and blood splash ($P = 0.45$).

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THE USE OF A SINGLE EMPIRICAL OUTCOME MEASURE TO ASSESS WELFARE IN SLAUGHTER PLANTS: BETWEEN AND WITHIN SECTOR COMPARISONS OF THE SUPPLY BASE FOR A MAJOR RETAIL MULTIPLE

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Driven by the demands of increasing consumer awareness and an EU wide concern about farm animal welfare, major multinational retailers (who increasingly dominate sales within the various livestock sectors) have sought to provide assurances in respect of a general 'ethical accountability' and overall product quality. This has been achieved through stipulating supplier compliance with individual accredited assurance schemes and/or retailer specific inspection regimens.

Tesco Stores Ltd has historically adopted just such a two-fold approach for their own branded products. Consistency of the inspection process has been achieved for the last twelve years through the use of Integra Food Secure Ltd; an independent, UKAS accredited body whose inspectors are deployed globally throughout the Tesco supply base for the UK market.

When establishing supplier codes of practice, an inherent difficulty has been the need to move from a traditional risk based approach to food safety (that arguably places fairly limited emphasis on animal welfare *per se*) to one that adequately encapsulates key science-based welfare criteria. A limitation of the original Tesco/Integra inspection process was that net evaluation was based principally on the number of issues (non-conformances) identified rather than severity of any given issue and the subsequent implications for animal welfare. Successful precedent, using a critical control based approach, in the US red meat sector was used as a model to develop a cross-sector scoring system that identified issues based on welfare importance (upper/lower) and occurrence (isolated/ numerous/systematic). Coupled with a measure of the total number of non-conformances this is used to generate a single outcome measure linked to welfare; from lairage reception, up to the point of slaughter and onset of further dressing. Outcome status can be recorded as, 'Green' 'Amber' 'Red', (where the traffic light system denotes increasing frequency and/or severity of welfare related issues) or 'Blue' (indicating that the site is operating to best practice standards in terms of specified welfare- related procedures). The so-called BRAG status was recorded from over 300 individual inspections (include repeat site visits) carried out over a two year period in a range of red meat and poultry abattoirs in the UK, EU and a number of non-EU countries. Multivariate analysis demonstrates a general sustained improvement in assessed welfare standards based on BRAG status. This information will be discussed in the context of between and within sector variations (including limitations to achieving best practice status under current guidance) and any associated national trends.

HIGH EXPANSION GAS-FOAM: A HUMANE AGENT FOR EMERGENCY KILLING OF POULTRY?

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Disease control measures require poultry to be killed on farms to minimise the risk of transmission to other poultry, and in some cases to protect public health. We assessed the welfare implications for poultry of application of high expansion foam, intended as a gas delivery mechanism (i.e. not occluding the airway). Individual bird trials investigated the physiological and behavioural responses of broilers and hens to nitrogen filled foam. A novel small scale foam generator was used which was capable of producing foam with an expansion ratio of approximately 300:1. The birds were equipped with sensors and a logger to record cardiac and brain activity (electroencephalogram, EEG) and were exposed to foam in a 1m³ Perspex box. Behavioural responses to foam included headshakes and brief bouts of wing flapping, followed by ataxia/loss of posture and vigorous wing flapping characteristic of anoxic death. Loss of posture was seen on average 15.5s after submersion in hens but significantly earlier in broilers (9.2s). The average onset of vigorous wing flapping was 17.8s in hens and 15.3s in broilers. Mean time to motionless was significantly shorter in broilers (51.4s) compared to hens (65.2s). Based on EEG characteristics not compatible with consciousness, mean time to onset of unconsciousness was 30.1s in hens 17.6s in broilers. Post mortem examinations showed that the foam did not occlude the airway. The euthanasia achieved with anoxic foam was particularly rapid, due to the very low oxygen concentrations achieved in the foam (below 1%). Trials with ducks and turkeys produced similar results. Identical trials with carbon dioxide filled foam showed that its mode of action was anoxia. These trials provided proof of principle that submersion in anoxic foam is a highly effective and humane method of euthanasia. Further trials to scale up nitrogen filled foam application were carried out, focusing on foam delivery rate and the height of foam achieved over submerged birds before flapping onset. These trials showed that initial stocking density (40-50kg/m²) did not greatly affect the rate of foam destruction. Physiological data showed no significant differences compared to the results of laboratory studies on single birds. Thus, foam as deployed in these larger trials delivered a reliable and humane anoxic kill which was robust even at maximal stocking densities. Based on the results of these studies, an operating protocol (including design standard, application protocol, operating routine, monitoring points, foam depletion and bird removal instructions) have been produced.

REDUCTION OF STRESS REACTIONS OF LAMBS AT SLAUGHTER BY IMPROVING THEIR REACTIVITY TO HUMAN BEINGS.

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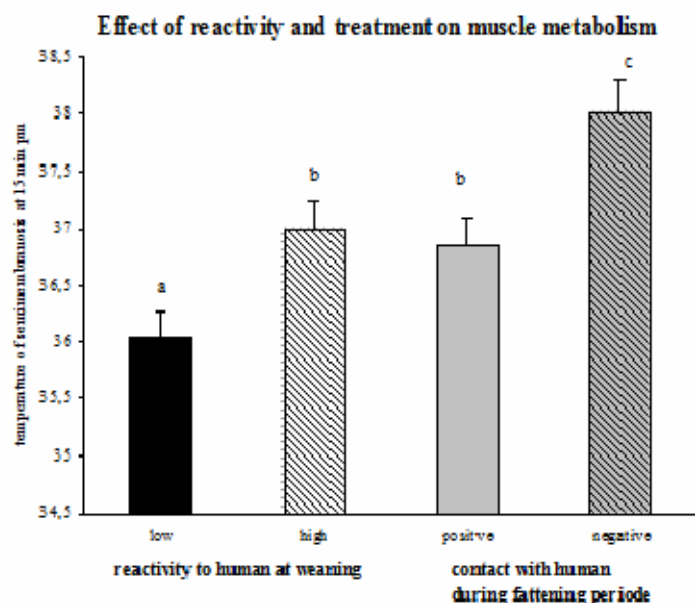
The slaughter period starts at the farm when animals are prepared for transport and ends when death is induced with the stunning and/or bleeding procedure. This period is associated with various potentially stress-inducing factors including physical constraints (e.g. transport, food deprivation) and psychological challenges, (e.g. human presence, unfamiliar environments). Stress reactions at slaughter can be reduced by diminishing the stressful aspects of the slaughter procedures. Other approaches may also be used. Stress reactions depend partly on the individual's propensity to interpret negatively environmental events. While it is well known that early emotional experiences may modulate later emotional reactivity of the individual, less is known of the effects of negative or positive emotional experiences occurring later in life. Such knowledge may help adapting farming practices to produce animals that are less reactive to the slaughter procedures.

The present study investigated in lambs (Romane breed) whether early positive experiences may reduce stress reactions at slaughter. Therefore, it assessed (i) whether reactivity to a human after weaning predicts reactivity at slaughter, and (ii) whether positive contacts with humans during fattening reduce reactions to slaughter procedures.

Reactivity to a human was evaluated after weaning in 121 lambs using a standardised test. The 40 most and 40 least reactive lambs were selected and reared in 4 groups balanced for reactivity scores. Two groups received negative contacts (automatic food distribution, abrupt and sudden handling) while the other two groups received positive contacts (manual food distribution, calm handling). In addition, 5 days a week an experimenter spent 1 hour quietly in each of the latter 2 groups, stroking those lambs that accepted. Two months later, reactivity to the human was again evaluated. Reactivity to the human at weaning was positively correlated with reactivity at the end of fattening ($F=20.54$, $p<0.0001$), indicating that lambs showed consistent differences. In addition, positive contacts during the fattening period reduced the reactivity to the human ($F=3.69$, $p=0.04$).

Following slaughter, muscles of lambs that after weaning were less reactive to the human were cooler (Fig. 1). Muscles of lambs of the positive contact groups were cooler ($F=5.45$, $p=0.02$) and had a slower pH decline ($F=7.45$, $p=0.008$). These characteristics are indicative of slower *post-mortem* muscle metabolism suggesting lower pre-slaughter stress levels.

Thus, reactivity of lambs to human presence after weaning can predict stress reactivity, including to the slaughter procedure. Positive experiences with humans during the fattening period may reduce stress reactions at slaughter.



THE WELFARE OF HORSES AT SLAUGHTER: THE DEVELOPMENT OF RECOMMENDED HANDLING GUIDELINES AND ANIMAL WELFARE ASSESSMENT TOOL FOR HORSES

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The horse meat industry is a vibrant part of Canadian agriculture including its export markets. Horses processed for human consumption generate at least \$50 million/year with annual exports of live horses to Japan at approximately \$16.9 million. According to the 2008 Alberta Horse Welfare Report ¹, Alberta exported a total of \$44.1 million worth of horse meat: \$25.8 m to Europe, \$15.8 m to Japan and \$2.3 m to other countries. As part of their mandate, the Horse Welfare Alliance of Canada recognized the need to develop animal handling and welfare assessing tools for the horse industry. They understood that as the horse processing industry continues to evolve, all must be done to ensure optimal care and show due diligence in regards to the welfare of horses at slaughter. This could only be achieved through the development of industry recognized guidelines, animal welfare assessments and education of all those involved in the process; this has been successfully accomplished in the other livestock industries.

The *Recommended Handling Guidelines and Animal Welfare Assessment Tool for Horses* was developed in consultation with leading animal welfare scientists, equine behaviorists and horse slaughter experts from across North America. The guidelines include behavior and handling of horses, facility design for optimal animal welfare at loading, unloading, lairage and within plant handling areas, transportation, and proper stunning, along with animal welfare assessment standards and forms. The standards utilize objective numerical scoring of the percentage of horses stunned correctly with one shot and the percentage of horses falling during handling.

The benefits of this guideline include consistent industry guidelines for the transport and processing of horses for meat, an animal welfare management tool for both the industry and third party assessors, a standardized tool to assess the welfare of horses during processing, concise standards for what is acceptable, positive messaging to the public and customers that this industry is responsible and care about the animals, and document factual information on the processing of horses in North America.

¹ Alberta Farm Animal Care, Alberta Horse Welfare Report (2008)

EQUIVALENCY BETWEEN EU AND THIRD COUNTRY STANDARDS FOR ANIMAL WELFARE AT SLAUGHTER (FINDINGS FROM INSPECTIONS OF THE FOOD AND VETERINARY OFFICE OF THE EUROPEAN COMMISSION)

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The Food and Veterinary Office is the inspection directorate of the European Commission's DG Health and Consumers, and has, since its inception, carried out checks of animal welfare at slaughter in both Member States of the European Union and in third countries.

While inspections in the Member States have included those where inspections were entirely focused on animal welfare at slaughter, the evaluation of this topic in third countries has been carried out at the same time as inspection of hygiene standards in EU approved establishments. Recommendations for action have been made where standards did not meet the minimum requirements of EU legislation in the case of Member States, or were not equivalent in the case of third countries. The reports of missions, to both Member States and third countries are published on the website of DG Health and Consumers:

http://ec.europa.eu/food/fvo/ir_search_en.cfm.

In 2011 the Food and Veterinary Office is carrying out a series of inspections to nine third countries which have significant meat exports to the EU. The missions are being carried out on a fact finding basis in order to compare current operations in EU approved slaughterhouses with the requirements which will apply from 1.1.2013 (Regulation 1099/2009). The results of these missions are presented and the findings discussed in relation to equivalency with EU legislation.

**Humane Slaughter Association Centenary International Symposium:
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