Annex to the *EFSA Journal (2006) 326, 1-18. The w*elfare aspects of the main systems of stunning and killing applied to commercially farmed deer, goats, rabbits, ostriches, ducks, geese and quail.

SCIENTIFIC REPORT

"The welfare aspects of the main systems of stunning and killing applied to commercially farmed deer, goats, rabbits, ostriches, ducks, geese and quail"

(Question N° EFSA-Q-2005-005)

Adopted by the AHAW panel on 13th February 2006

Chapter 10 on food safety aspects, as adopted by

Biohazard panel on 17th -18th January 2006

INDEX

FIGURES

ABREVIATIONS

A: ampere

AC: alternating current

AHAW: EFSA scientific Panel on Animal Health and Welfare

AVMA: American Veterinary Medical Association

BGA: Bundesgesundheitsamt

BIOHAZ – EFSA scientific Panel on Biological Hazards

BSE: bovine spongiform encephalopathy

CNS: central nervous system

CWD: chronic wasting disease

DC: direct current

DFD: dark, firm, dry meat

EFSA: European Food Safety Authority

EEG: electroencephalogram

EC: European Community

ECG: electrocardiogram

ECoG: electrocorticogram

e.g.*:* abbreviation of *exempli gratia*, Latin for "for example"

et al.: abbreviation of *et alii*, Latin for "an others"

EU: European Union

FFTA: fast fourier transformation analysis

Hz: hertz

i.e.: abbreviation of "*id est"*, Latin for "it is", "in this case", "that is"

m: metre

mA: milliampere

min: minutes

mm: millimetre

Pcb: penetrative captive bolt

pers. comm.: personal communication

PSE: pale, soft, exudative meat

SVC: EU Scientific Veterinary Committee

SCAHAW: EU Scientific Committee on Animal Health and Animal Welfare

SD: standard deviation

sec: seconds

SEPs: somatosensory evoked potentials

SERs: somatosensory evoked responses

SSC: Scientific Steering Committee

TSE: transmissible spongiform encephalopathy

V: volts

vs: abbreviation of "*versus*", Latin for "against"

VEPs: visual evoked potentials

VERs: visual evoked responses

Ω: ohm

KΩ: K ohm

DEFINITIONS

Anoxia: depletion of oxygen in atmosphere or blood.

Aversion: a tendency to show behaviour to avoid or withdraw from a situation that is associated with a noxious stimulus.

Blood splashing: Occurs before or during the stunning and subsequent slaughter process when blood leaves the blood vessels due to an excessive blood pressure or damage to the vessels. It can be seen as small spots or bigger infiltration of whole muscles.

Chest sticking: severing major blood vessels in the chest by inserting a knife in front of the brisket or sternum (double cut: first the skin, then, with another knife, the vessels)

Clonic seizure: convulsions normally occurring as kicking or paddling movement of legs.

Consciousness: is the state of awareness of a normal animal when it can perceive stimuli from its external environment and respond in the normal behaviour of an awake individual.

Corneal reflex: blinking response to touching the eyeball.

Death: a physiological state of an animal, where respiration and blood circulation have ceased as the respiratory and circulatory centres in the *medulla oblongata* are irreversibly inactive. Due to the permanent absence of nutrients and oxygen in the brain, consciousness is irreversibly lost. In the context of application of stunning and killing methods, the main clinical signs seen are absence of respiration (and no gagging), absence of pulse and absence of corneal and palpebral reflex and presence of pupillary dilation, with the exception of rabbits.

Electrocorticogram: electrical activity of the brain usually recorded on the surface of the brain or dura (a membrane covering the brain).

Electroencephalogram: electrical activity of the brain usually recorded from the surface of the skull using non-invasive techniques.

Evoked potentials: Measurable electric response of the brain to an externally applied stimulus, *e.g.* auditory, visually or somatosensory stimuli.

Gagging or gasping: rudimentary respiratory activity occurring through mouth (oral breathing).

Generalised epilepsy: a pathological state of brain, involving both the cerebral hemispheres, occurring due to extreme neuronal synchrony leading to unconsciousness.

Humane: Treatment of animals in such a way that their welfare is good to a certain high degree. Humane killing implies that the treatment of the animals immediately before the killing procedure does not cause poor welfare and the procedure itself results in insensibility to pain and distress within a few sec or, in the case of gases, no poor welfare before insensibility.

Hypoxia: decrease in oxygen levels in atmosphere or blood.

Neck cutting: severing major blood vessels in the neck (skin and vessels cut simultaneously).

Period: the period of a given electric current frequency (Hz) is expressed in milliseconds and is calculated using the formula 1000 (milliseconds) divided by the frequency (Hz) of current. For example, electric currents of 50, 400 and 1500 Hz sine wave have periods of 20 (1000/50), 2.5 (1000/400) and 0.67 (1000/1500) milliseconds.

Seizure: convulsions that may occur with or without loss of consciousness or pathological EEG.

Slaughter: in this report, slaughter means the process of bleeding to induce death, usually by severing major blood vessels supplying oxygenated blood to the brain.

Sticking or bleeding: act of severing major blood vessels (also see neck cutting, chest sticking).

Stun / kill or stunning / killing: process of rendering animals unconscious first and then inducing death or achieving these simultaneously.

Stun or stunning: stunning before slaughter is a technical process subjected to each single animal to induce unconsciousness and insensibility in animals, so that slaughter can be performed without avoidable fear, anxiety, pain, suffering and distress. In most methods unconsciousness is induced immediately with the exception of controlled atmosphere stunning.

Stun-to-stick interval: the time interval between the induction of unconsciousness and sticking.

Tetanus: rigidity of the whole body usually with legs extended.

Tonic seizure: a state of tetanus occurring during generalised epilepsy.

Unconsciousness: Unconsciousness is a state of unawareness (loss of consciousness) in which there is temporary or permanent impairment of brain function and the individual is unable to respond to normal stimuli, including pain.

1. TERMS OF REFERENCE

1.1. Background

In response to a request from the Commission, the EFSA Panel on Animal Health and Welfare (AHAW) adopted on 15 June 2004 a scientific report and opinion related to welfare aspects of the main systems of stunning and killing the main commercial species of animals. This scientific report and opinion considered stunning and killing techniques that are applied to cattle, sheep, pigs, poultry (chickens and turkeys), horses and farmed fish, including methods applied in slaughterhouses and on-farm in disease control situations.

The outcome of this work (EFSA, 2004c) will assist the Commission with regard to possible future revisions of Community legislation[1] on the protection of animals at the time of slaughter or killing. However, Community legislation in this field also encompasses other species kept for farming purposes and therefore the Commission requested that an additional EFSA scientific opinion be prepared covering stunning and killing techniques applied to deer, goats, rabbits, ostriches, ducks, geese and quail. This scientific opinion should consider, in particular, the welfare aspects of the main systems of stunning and killing these commercially farmed species of animals, either in slaughterhouses or on-farm in disease control situations. Where relevant, the impact of the stunning/killing method used on the microbiological safety of the carcass as well as biosecurity considerations concerning methods used in disease control situations should also be considered.

1.2. Mandate

The Commission requested EFSA to issue a scientific opinion on the main systems of stunning and killing commercially farmed species of deer, goats, rabbits, ostriches, ducks, geese and quail, including systems used either in slaughterhouses or on-farm in disease control situations.

The scientific opinion should consider for each method described:

– the minimal conditions by which the method is likely to be efficient from the animal welfare point of view

– the criteria or procedures that could be used to check that the stunning or killing method has been effectively carried out

– the advantages and disadvantages of the method used in terms of animal welfare, taking into account the use of the method either in slaughterhouses or on-farm for disease control purposes

– where relevant, the impact of the stunning/killing method used on the microbiological safety of the carcase as well as biosecurity considerations concerning methods used in disease control situations.

1.3. Scope of Report

For basis background information and general information on existing methods, the present report refers to the chapters *'Scientific basis of consciousness and stunning'* and *'Available stunning and stun/killing methods and their use'* in the earlier report (EFSA, 2004c) and considers these as integral part of the present report.

The chapters on the different species in the present scientific report follow that of the earlier report and for each of the methods the following three areas are developed:

[1] Council Directive 93/119/EC OJ L340 p.21-34

- The minimal conditions by which the method is likely to be effective from the animal welfare point of view in field conditions;
- The criteria or procedures that could ensure that the stunning and the killing method is properly enforced;
- The advantages and disadvantages of the method used, taking into account the commercial/field conditions.

As in the earlier report, two separate contexts are considered: stunning and killing methods used in slaughterhouses and those used for disease control measures.

This report does not deal with killing of wild and feral animals.

2. PREAMBLE

2.1. Introduction

2.1.1. Considerations of stunning methods in this report:

This Scientific Report compliments an earlier report on stunning and slaughter (EFSA, 2004c) and includes species kept for farming purposes that were not dealt with in the previous report. These species are deer, goat, rabbit, ostrich, duck, goose and quail. Like the first report, the primary purpose of this report is to describe the main stunning and killing methods under commercial slaughterhouse or farm conditions in Europe, and to recommend procedures appropriate to the species and related minimum requirements such that unconsciousness and insensibility is induced without causing avoidable pain, suffering and distress. Where the mandate refers to stunning and slaughter in slaughterhouses or on-farm in disease control situations, slaughterhouse has to include facilities to process animals shot or otherwise killed on-farm for meat production.

Although it is recognised that, for instance, transport to the slaughterhouse, lairage conditions, pre-slaughter handling and restraint prior to stunning may cause serious welfare problems, the present report concentrates on the point of application of the stunning and killing techniques and will not consider in detail other preceding or subsequent procedures. However, it should be underlined that such management practices represent a crucial issue, particularly in case of deer stunning and slaughter. In fact, specific handling facilities and management procedures are required and described for deer (Yerex and Spiers, 1987; Haigh and Hudson, 1993; Diverio *et al.*, 1997; Matthews, 2000). Mobile slaughterhouses may be used to avoid poor welfare during animal transport. The slaughterhouse vehicle or vehicles may have facilities for stunning and killing, initial meat inspection, initial processing of animals shot or otherwise killed *in situ* and carcass transport.

It is recognised that the basis of unconscious and insensibility and the measures to assess those are vital to evaluate the effectiveness of the different methods applied. For some basic neurophysiology and measures of unconsciousness we refer to chapter 5 of the previous report (EFSA, 2004c). For a general overview of available stunning and killing methods and their underlying principles we refer to chapter 6 of that report.

Separate chapters consider available scientific data and specific aspects of stunning and killing methods for deer, goat, rabbit, ostrich, duck, goose and quail respectively. In general it appeared that published scientific information on slaughter and killing issues for these species was very scarce. Where specific scientific data are lacking, current practical applications are described in order to provide some relevant information. The stunning and killing methods are described with certain requirements for effective use necessary to safeguard animal welfare. Each section also considers possible parameters that can be used as monitoring points to ensure good stunning practice under commercial conditions to safeguard animal welfare. Advantages and disadvantages from an animal welfare point of view are listed. Killing methods for the purpose of disease control are considered for each species in a separate section.

Clearly it is important that all operators involved with stunning and slaughter are competent, properly trained and have a positive attitude towards the welfare of the animals. In the evaluation of the methods the working group expected that these requirements are fulfilled. The working group also assumed that the equipment used for stunning or killing is maintained in good working conditions and used according to the instructions of the manufacturer.

Since the mandate specifically addresses the impact (where relevant) of the stunning or killing method used on the microbiological safety of the carcass the parts in this scientific report related with it were developed under the responsibility of the EFSA Panel on biological hazards (BIOHAZ). Potential food safety implications are considered in Chapter 10.

On 10-11 January 2002, the Scientific Steering Committee (SSC, 2002) adopted an opinion on stunning methods and bovine spongiform encephalopathy (BSE) risks and in particular, the risk of dissemination of Central Nervous System (CNS) material via blood circulation to edible organs/tissues following the application of certain stunning methods. In its opinion, the SSC concluded that further research on stunning methods and their effects in regard to CNS material embolism and contamination of the carcass, especially in cattle, should be undertaken.

Two SSC reports (2001, 2002), considered the risk of CNS embolism associated with penetrating captive bolt stunning with air injection, as well as the risks associated with penetrating stunning followed by pithing, as particularly high. Consequently, the use of these stunning methods by the meat industry was banned based on related EU legislation (2001).

On the other hand, in the previous second SSC report (2002), the risk for CNS emboli associated with penetrating captive bolt stunning without pithing was not considered significant or sufficiently proven although this could not be excluded. Similarly, the risk for CNS emboli following non-penetrating and electrical stunning was considered as negligible.

Subsequently, BIOHAZ Scientific Panel reviewed results of more recent related studies and produced an updated Opinion (EFSA, 2004b). The main conclusion of this Opinion was that brain damage (contusion, laceration, haemorrhage, bone fragment intrusion) caused by both penetrating and non-penetrating captive bolt stunning in cattle, as well as that caused by penetrating captive bolt stunning in sheep, can result in occurrence of CNS tissue emboli in venous blood draining the head, with potential public health implications that cannot be ignored, although quantification of this public health risk is not possible due to a lack at present of available data. Consequently, the Opinion recommended that modifications of the current captive bolt stunning methods so as to prevent CNS embolism is required or, alternatively, the replacement of these methods should be investigated.

Biosecurity considerations are included where specific information on on–farm slaughter of diseased stock is described for each species.

Since the mandate requested the AHAW Scientific Panel to consider welfare, food safety and biosecurity aspects of stunning and killing methods, references to other issues such as occupational health, economic impact, social and religious aspects and product quality are not within the scope of this report. Nevertheless, for the information of the reader, some related points for potential future considerations are indicated below.

2.1.2. Occupational health aspects

Physical hazards

Risks for human operators may be directly related to the stunning or killing method, *e.g.* contact-firing captive bolt guns, manual electrical stunning or killing devices involving high voltages, or complex processes like water bath electrical stunning. Additional risks for operator safety relate to convulsions occurring after the application of certain stunning or killing methods. For instance, electrical head-only stunning induces tonic and clonic seizures, which are the outward symptoms of generalised epilepsy. The clonic (kicking) phase follows immediately after the tonic phase. Thus, from a worker safety point of view, sticking should be performed ideally whilst the animal is still in the tonic phase. Shackling of live poultry prior to stunning or killing using electrified water baths induces wing flapping and emission of dust and both of these have operator safety implications. Some methods of killing for disease control purposes, like a manually applied percussive blow on the head, are physically exhausting for personnel and therefore involve risks.

Neck dislocation and decapitation of poultry result in severe wing flapping which can be hazardous, especially when dealing with geese and ducks.

Chemical hazards

All gases used for stunning or killing can have a risk of poor health or death for humans and gases like carbon monoxide and gaseous form of cyanide can create a serious hazard to personnel.

Biological hazards

Some methods of killing for disease control involve more direct contact between human handlers and the birds, which may result in transmission of infective agents (*e.g.*, Avian Influenza). Penetrating captive bolt stunning methods may lead to direct (*e.g.* contaminated tools, leakage from stun wound, aerosols) exposure of the operator to CNS particles and potentially to prions, as described in chapter 10.

2.1.3. Economic aspects

The economic impact of different stunning and killing methods may normally be directly related to capital investment and running costs. For example, the investment in a marksman and high velocity rifle would be less than that for animal handling and restraint facilities, stockmen and licensed stunning and slaughter operatives within an abattoir. Animal welfare and food hygiene requirements may be inter-related and both of these can have economic consequences.

2.1.4. Product quality aspects

One of the main potentially negative effects of stunning on meat quality could be induction of the stress in animals during preparation for, or execution of, the stunning. This can result in reduced quality of the resultant meat *e.g.* pale, soft, exudative (PSE) or dark, firm, dry (DFD) meat in pigs or ruminants. The pH of DFD meat stays relatively high which can enhance the growth of the microflora including spoilage and pathogenic organisms during the meat storage. The former can shorten the commercial shelf life, whilst the latter can increase the associated microbial food safety risks, but these aspects are not addressed further in this Opinion. The frequencies of DFD (meat pH above 6.2 in *M. longissimus dorsi*) in venison have been estimated in Sweden (reindeer, *n=3,500*, Wiklund *et al.*, 1995) and New Zealand (red and fallow deer, *n=3,600*, Pollard *et al.*, 1999) to be 6% in reindeer, 1.5% in red deer and 1% in fallow deer venison.

In poultry, the application of high voltages during stunning has been associated with poor bleeding, broken bones (Gregory and Wilkins, 1989), exploded or damaged viscera, bruised wing joints and red wing tips (Heath, 1984), haemorrhages on the breast meat (Veerkamp and de Vries, 1983; Veerkamp, 1988) and split wishbones and separation of shoulder muscle tendons (Sams, 1996). There is a widespread belief within the poultry processing industry that the use of high stunning currents inevitably results in unacceptable levels of carcass damage (Bilgili, 1999). However, it has been demonstrated experimentally that stunning currents of up to 120 mA per bird are not responsible for any increases in the amount of carcass damage (Gregory and Wilkins, 1989). Head-only stunning in chickens, unlike water bath stunning, does not adversely affect carcass and meat quality provided the wing flapping is restricted. Similarly, anoxic killing may lead to increased wing damage in poultry (broilers and turkeys). Blood splashing may occur in electrically stunned animals, *e.g.* fallow deer, downgrading higher price cuts (Falepau and Mulley, 1998).

3. STUNNING AND KILLING METHODS FOR DEER

3.1. Introduction

Deer are members of the order Artiodactyla, suborder Pecora, superfamily Cervoidea and family Cervidae. Within Cervidae, the most common classification includes two major subfamilies, the Cervinae and Odocoileinae. Moose (*Alces alces*), reindeer and caribou (*R. tarandus*) and roe deer (*Capreolus capreolus*) lineages are considered within the Odocoileinae, whereas the muntjaks (*Muntiacus* spp.), fallow deer (*Dama dama*) and Red deer (*Cervus elaphus*) lineages within Cervinae (Cronin, 1994; Groves and Grubb, 1987; Gustafson, 1985; Bubenik, 1990).

The most up to date investigation on the distribution, management and status of wild Cervids in Europe and the previous USSR territories dates back to Sempèrè *et al.* (1994). Deer adaptive capacities allowed them to occupy different environments and to be kept under different farming systems, for almost 2000 years in Europe. Nowadays, the farmed deer industry has grown worldwide. The main deer types are red and fallow in Europe, Australia and New Zealand, with also some elk and white tailed deer in North America; and red, sika and elk in Asia (The Deer Farmer, 2005).

In Europe, the most common slaughtered species are reindeer (*Rangifer tarandus tarandus*), red deer (*Cervus elaphus*) and fallow deer (*Dama dama*). In fact, it has been estimated that the number of reindeer slaughtered in Europe (Sweden, Norway and Finland) are higher than the number of red deer. In a 2002 overview, it was concluded that the average number of reindeer slaughtered between 1994 and 2001 in Sweden, Norway and Finland were 56,065, 57,664 and 98,644 animals per year respectively (Wiklund *et al.*, 2002). Official statistics report that 48,275 reindeer were slaughtered in Sweden during the slaughter season of August 2003 to March 2004 (Swedish Board of Agriculture, 2005) and 106,316 in Finland (Finnish Reindeer Herder Association, 2005). The European Deer Farmers Association does not currently have any slaughter statistics available for farmed red deer and fallow deer within Europe (Solheim, pers. comm.).

In the past, the use of mobile slaughter plants has been exploited in different countries. These systems contained handling and stun/killing facilities which had the advantage that the animals could be driven in straight from their paddock and that *ante* and *post mortem* inspection could be carried out. In New Zealand, a mobile plant was evaluated as a way to reduce pre-slaughter handling but its use was soon dismissed since it proved to be economically impractical (Yerex, 1979; Seamer, 1986). Similarly, these systems have also been operated in Canada (Diversified Animal Management, 1997) and UK (Anonymous, 1993; Pollard *et al.*, 2002a).

In Sweden, fully equipped mobile slaughter plants have been used for reindeer since 1993, but many of these former primitive out-door slaughter sites were closed down (Wiklund, 1996). Nowadays, many of these fully equipped mobile slaughter plants have been converted into stationary abattoirs, and located near to a corral where the animals are unloaded after transport, and there individually captive bolt stunned/killed by an operator (Eva Wiklund, pers. comm.). The conversion from use of these mobile facilities to stationary abattoirs is a result of a combination of has been dismissed either for environmental (*i.e.* discharge of slaughter wastes, dropping from carcasses) and economical reasons. According to various reindeer herding districts in Sweden, about 300 since at least - 400 animals/day have to be processed at every slaughter occasion in to make all the system it affordable to bring a mobile facility out (Eva Wiklund, pers. comm.). At the present, new Swedish directives (National Food Administration, 1998) recommend that reindeer can be slaughtered only in specialised abattoirs, and that penetrative captive bolt stunning is the only approved technique for commercially slaughter them within EU (Wiklund, 1996).

It is recognised that some small additional costs may be necessary to prevent the very poor welfare that sometimes can occur during deer transport (EFSA, 2004d). In fact, pre-slaughter management, including transport, often represents one of the major concerns for deer welfare. However, it must also be taken into account that the animals' reaction to such procedures can vary greatly depending on their degree of tameness and thereby their manageability. In Sweden, reindeer have been subjected to a long process, over thousand of years, of selection and domestication which allow handling and transportation without undue distress, even if they are kept in a completely free-ranging system and not being fences. According to Swedish slaughter directives (National Food Administration, 1998), reindeer are considered as domestic animals and therefore the same slaughtering recommendations and rules given for other farm animals applies also to reindeer.

However, for red and fallow deer, in Europe there is a large variation in management systems and personal experience, ranging from very extensive farms in areas of marginal agricultural land to intensive units need to be considered. Some guidelines for differentiating deer according to their farming system need to be given in order to take in account such differences, which are of outmost importance in evaluating the impact of pre-slaughter management on deer welfare. As briefly indicated in the EFSA-AHAW Report on Animal Transport (2004d), Deer farms can be classified according to grazing density as extensive (1 head/ha), semi-extensive (from 1 to 3 head/ha, food integrations in winter and summer) or intensive (> 3 head/ha and regular feed supply). Another factor that differentiates deer farming is the type of management, which can vary from a very high level (1st Category Deer Farms, which are those provided with adequate fencing, paddocks and raceways connected to proper deer handling crushes where deer are routinely handled and can be individually captured), to 2nd Category farms with rudimental handling facilities, where deer are seldom captured as a group to very low standards (3rd Category Deer Farms) lacking of any form of deer handling facilities, and where the animals are collected only at slaughtering time, *i.e.* by nets or chasing them in a corral (Diverio *et al.*, 1997). This report recommends

that reindeer should be considered separately as a domestic species, whereas fallow and red deer should be treated according to their farming system.
According to the Australian Model Code of Practice for the Welfare of Farmed Deer (AAC-SCAW, 2002), effective and humane methods of killing deer include shooting with a firearm, electrical methodology or captive bolt pistol stunning, followed by immediate bleeding.

In European commercial plants, the most commonly used methods for stunning or killing deer are:

- Penetrating captive bolt pistol
- Electrical head-only stunning
- Free bullet

The use of a free bullet to shoot deer in the field can also be used (Smith and Dobson, 1990; Diverio *et al.*, 1998b; Pollard *et al.*, 2002b). In the initial systems of deer farming, shooting the deer in the field was the most common method of culling, and the majority of animals were butchered locally (Weeks, 2000). There is no evidence that the shooting of deer in view of other individuals causes poor welfare in the other deer present except for that caused by the presence of humans and the sound of the shot. However, since the recent expansion of deer farming, economic and meat hygiene reasons have resulted in the majority of farmed deer being transported to specific abattoirs for slaughter (Weeks, 2000). Appropriate methods of handling and transport had to be developed, taking into account the reactive and social nature of these recently farmed species.

Handling and restraint

The use of penetrative captive bolt and electrical stunning implies that animals have to be handled and restrained. Wilson (1999) stated that regular handling of deer can reduce the occurrence of pre-slaughter stress, since it improves the animal's ability to cope with management practices. Selection of tamer and calmer animals is suggested (Wilson, 1999), which is particularly relevant for fallow deer, since it has been demonstrated that they require very careful, slow handling as they are nervous and readily panic (Diverio *et al.*, 1998a; Pollard *et al.*, 2002a). Pre-slaughter handling was shown to increase stress and a high level of muscular exertion or damage in deer (Diverio *et al.*, 1993; 1998b; Wiklund, 1996; Carragher *et al.*, 1997; Grigor *et al.*, 1998; Pollard *et al.*, 2002a). Ecchymoses have been used as indicator of pre-slaughter stress in deer (Falepau and Mulley, 1998; Wilson, 1999).

The importance of the degree of tameness of the animals in their ability to tolerate stress has been also demonstrated in reindeer (Rehbinder, 1990; Wiklund, 1996). It should be noted that reindeer are a species that have been herded by the indigenous Saami people in Northern Europe for thousands of years, and that desired attributes in these animals (*e.g.* manageability) has been selected over a long time. In reindeer, a range of pre-slaughter handling factors and their effect on stress levels (n=3,500) have been studied. Recent studies have shown that the most stressful handling technique was the use of using a lasso when separating animals for slaughter, which depleted the muscle glycogen stores, produced high blood cortisol levels and high frequencies of abomasal lesions (Wiklund *et al.*, 1996; 1997). The loading and unloading from transport trucks have also been demonstrated to be particularly stressful for reindeer (Wiklund *et al.*, 2001).

Head-to-tail electro-immobilisation was assessed in red and red x wapiti hybrid deer but this restraint method was judged to be too stressful and therefore it was not recommended (Stafford and Mesken, 1992).

3.2. Mechanical Methods

3.2.1. Penetrating captive bolt

The Australian Model Code of Practice for the Welfare of Farmed Deer (AAC-SCAW, 2002) suggests the use of a penetrating captive bolt stunner, if used with a cartridge coded for the amount of power required for the species of animal being stunned. Tuckwell (2001) recommended the use of the captive bolt firearm from a frontal position.

From practical experience, the recommended site for captive bolt stunning of deer is "slightly lateral to the intersection of two lines drawn from the ear to the opposite antler base (or its equivalent position in a female) with the gun angled slightly forward." A diagram of this position is reported by DeerQA VP TC (2005). Another recommended shot position is at the intersection of imaginary lines drawn between the eye and the opposite ear.

A large range in the available energy is required to penetrate the skull of deer of different ages and sex (Blackmore, 1985; Blackmore *et al.*, 1993).

In the past, the slaughter of deer was only performed using penetrative captive bolt stunning (Blackmore and Delanay, 1988; Anonymous, 1991). Nowadays, this remains the only technique used for stunning reindeer in the EU (Wiklund, pers. comm.). However for other species of deer, alternative methods are used (AWAC, 1994; CARC, 1996; DeerQA VP TC, 2005).

3.2.1.1. Description of effective use

The animals are restrained in a stunning box in order to ensure correct application.

Based on practical experience, the recommended shot position is defined as slightly lateral to the intersection of two lines drawn from the ear to the opposite antler base or at the intersection of two imaginary lines drawn between the eye and the opposite ear.

Best practice would recommend a maximum stun to stick interval of 20 sec (AQIS, 1995).

3.2.1.2. Monitoring points

Effective penetrating captive bolt stunning is demonstrated by the following signs:

- Immediate loss of posture
- Short tonic phase, characterised by extension of the front legs, followed by jaw relaxation and mouth opening.
- Very little clonic activity.
- Absence of rhythmic breathing.
- The position of the eyeball is fixed.

3.2.1.3. Advantages

When the animal is properly restrained the method is effective.

3.2.1.4. Disadvantages associated to the use of captive bolt pistols

Handling and restraint is stressful and may cause severe welfare problems.

Deer of different age and sex require different bolt velocities for effective stunning.

3.2.2. Non-penetrating captive-bolt-stunning

According to the Australian Model Code of Practice for the Welfare of Farmed Deer (AAC-SCAW, 2002), the percussive stunner (non-penetrating) is not recommended. No scientific investigations are available.

3.2.3. Free bullet

Firearms are widely used for killing deer in the field. In some cases, shooting has been permitted for killing deer in commercial plants. The main advantage of shooting deer in the field is that it avoids the stress involved in pre-slaughter management practices. Red deer shot in the field showed low average plasma cortisol concentrations and muscle pH compared to deer herded on the farm or transported to the abattoir (Smith and Dobson, 1990). Pre-slaughter handling created moderate stress and high levels of muscle exertion and damage in commercially slaughtered red deer ($n=8$) compared to paddock-shot ones ($n=8$) (Pollard *et al.*, 2002a). However, muscle glycogen, pH and venison quality measurements showed only minor differences between treatments (Pollard *et al.*, 2002a). A study compared three different pre-slaughter management systems in fallow deer (shot at pasture, transported in small groups in wooden boxes and left overnight until shooting, or transported and held in lairage with food and water then moved to a slaughter area and shot) (Diverio *et al.*, 1998b). Results confirmed that field slaughter was the least stressful method despite the fact that some animals were trotting or running prior to being killed (Diverio *et al.*, 1998b).

From a welfare point of view, shooting deer in the field has been recognised, as the elective method of killing (Smith and Dobson, 1990; Diverio *et al.*, 1998b; Pollard *et al.*, 2002b). However, this technique cannot be used in all deer production systems, but it should be the only approved method for extensively managed red and fallow deer. As previously described, all reindeer in Sweden are slaughtered in approved facilities following the same rules and regulations as for other domestic species (National Food Administration, 1998) and field slaughter is not allowed. These regulations include ante mortem inspection and carcass inspection to safeguard food safety.

Shot positions for the use of firearms to the head in deer has been described (McAninch, 1993; CARC, 1996; Tuckwell, 2001; AAC-SCAW, 2002). The Australian Model Code of Practice for the Welfare of Farmed Deer (AAC-SCAW, 2002), indicates as a suitable firearm a .22 calibre rifle used at short range or a .32 calibre "humane killer", but not placed directly on the head. The direction for the line of fire is shown in a diagram (AAC-SCAW, 2002).

The recommended firearm position and shot direction for the humane killing of deer is also represented in the Canadian Code of Practice for the Care and Handling of Farmed deer (CARC, 1996) (see figures below). According to this guideline: "deer without antlers should be shot either from behind or from the front as described in the humane killing of deer with antlers or from the top of the head at a point high up on the head equal distance from the eyes and ears (Fig. 1 and 2). If the animal has antlers, the approach should be from the rear and the shot directed between the bases of the antlers towards the mouth (Fig. 3). Alternatively, the firearm can be aimed from the front just above the eyes on the midline, shooting towards the spine (Fig. 4)" (CARC, 1996).

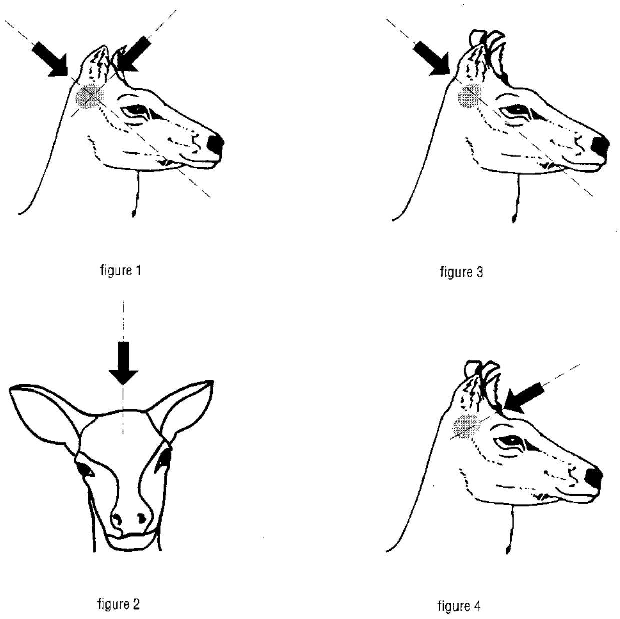

Figure 1 – 4: Recommended firearm position and shot direction for the humane killing of deer (CARC, 1996)

Tuckwell (2001) reported two alternate approaches to use with firearms:

i) "frontally, using the intersection point of the lines from the base of each ear to the opposite eye, and firing horizontally into the forehead;

ii) firing through the skull just behind the base of the antlers in the direction of the animal muzzle".

According to the report of the Scientific Veterinary Committee (SVC, 1997) "Reindeer with large antlers can be shot in a lateral position (temporal region) under the base of horns, between the outer canthus of the eye and the base of ear."

According to the same report (SVC, 1997) the restraint of deer to facilitate shooting can cause the animal to struggle. This can result in inaccurate shooting and be a threat to the personnel safety.

3.2.3.1. Description of effective use

Experienced and skilled operators with good firing expertise must aim and shoot to the head of the animals, in order to damage the brain and ensure death.

3.2.3.2. Monitoring points

- Immediate loss of posture
- Sometime rigid tonic extension of the front legs
- Very little clonic activity.
- Absence of rhythmic breathing.
- Pupil dilation

3.2.3.3. Advantages

Loss of consciousness is instantaneous if the projectile destroys major areas of the brain (AVMA, 2001).

It minimises the stress induced by handling and human contact (AVMA, 2001).

Shooting deer directly in the field has been proved to be very effective.

3.2.3.4. Disadvantages

Firearms are dangerous to personnel.

Under field conditions, it may be difficult to hit the target area (AVMA, 2001).

If not properly used, this method can injure but not kill the deer, with severe effects on deer welfare.

3.3. Electrical stunning and electrical killing methods

In order to apply electrical stunning equipment, deer have to be restrained to allow the electrodes to be applied in a position that spans the brain. For example, the characteristics of a restraining box for electrical stunning in red deer have been described (Blackmore *et al.*, 1993). The device consisted of a metal-sided box (2.0 m long, 0.42 m wide, 1.3 m deep), with a hinged metal floor, so that the stunned animals could be discharged from the bottom of the crate on to the slaughter floor. The openings were about 200 mm^2 and the top of the crate was covered by a metal mesh to prevent animals from escaping (Blackmore *et al.*, 1993). Tuckwell (1995) described a particular stun box for fallow deer: a box short enough to encourage the animals to put their head thought a small key hole' opening as the door is shut.

3.3.1. Electrical head-only stunning

Blackmore *et al.*, (1993) assessed the feasibility of electrical head-only stunning of deer in a number of trials. A first preliminary study was carried out which demonstrated that electrical contact could be maintained with animals restrained in a deer crush, for at least 1 second using a hand-set with fixed electrodes.

In a second experiment, 23 mature red deer were restrained in a stunning box, with reduced lighting, and electrically stunned using a conventional current-controlled apparatus for sheep, using a current of over 3A applied for a period between 0.5 and 2 sec. The hand-held electrodes consisted of two sharp prongs about 60mm apart mounted on a hand piece with a finger-operated switch (Blackmore *et al.*, 1993). The electrodes were placed on the head so they spanned the brain either laterally across the head in the region just rostral to the ears, or in a rostro-caudal direction over the frontal bones between the ears and the eyes. A satisfactory electrical stun was considered if the animal became rigid and lost posture.

No tonic spasms were recorded in electrically stunned red deer but four animals showed a tonic extension of the front legs for 5-10 sec. The animals appeared to be unconscious for at least 60 sec, but one showed signs of regaining consciousness (head rising) after 50 sec (Blackmore *et al.*, 1993).

Red deer reactions to being shot with a captive bolt were: rigid tetanic, extension of the front legs for up to 20 sec, pupil dilation, relaxation of the jaw and open mouth. Quivering of body muscles and some slight body movements for up to 70 sec after stunning were observed, whereas no clonic convulsions were recorded (Blackmore *et al.*, 1993).

During a third trial, the red deer electroencephalogram (EEG) activity elicited by head-only electrical stunning (50Hz, 400v open circuit, 1.3 A for 1 second in two animals and for 0.5 sec on other two animals) was monitored (Blackmore *et al.*, 1993). EEG recordings were carried out as described by Blackmore *et al.*, (1993), Cook *et al.*, (1992) and Bager *et al.*, (1990), with two additional electrodes to record heart activity (ECG).

In red deer, seizure activity (EEG amplitude greater than five times the pre-stun levels) took up to 6 sec to reach the "stormy" magnitude but it lasted for up to 60-120 sec after stunning. No differences between stun application times (0.5 and 1 second) were observed. No signs of ventricular fibrillation were recorded but heart rate increased.

Red and fallow deer were rendered unconscious for about 60 sec by electrical head-only stunning (Cook *et al.*, 1994). The duration of this stunned state was considered suitable for humane deer slaughtering, because it allowed time for death by exsanguinations to occur before consciousness could return (Stafford *et al.*, 2002).

Notwithstanding electrically stunned red deer showed a slower build-up of the typical epileptiform seizure compared with other animals (Cook *et al.*, 1992; Bager *et al.*, 1990), their EEGs patterns, suggested that electrical head-only stunning was suitable (Blackmore *et al.*, 1993). In order to cover the wide variation in the impedance of the heads of red deer depending to differences in skull thickness and hardness, currents of 0.6 to over 3 A, for a minimum duration of 0.5 sec, were used (Blackmore *et al.*, 1993). No attempts have been made to determine currents required to stun red deer of different sizes, ages and sexes. However, a 1.3 A current was considered as adequate to cover all eventualities for red deer (Blackmore *et al.*, 1993), as well as a 1.0 A current for fallow deer (Cook *et al.*, 1994).

The behavioural reactions of effective electrically stunned red deer differed from those observed in other ruminants for the absence or short duration of the initial tonic phase. This feature should be taken into account when using behavioural criteria to judge the effectiveness of a stun in this species. Such a response was also recorded in red deer shot with a captive bolt.

However, electrically stunned fallow deer reacted similarly to other farm animals, exhibiting an initial phase of body rigidity for 15-20 sec followed by paddling movements of all four legs (Cook *et al.*, 1994). Application of electric current (50 Hz, 400V open circuit) at 1.0A for 4 sec induced an epileptiform-like seizure (recorded by EEG) that lasted for 64 sec. Post stun behavioural reactions were a typical tonic limb, neck and head extension and body rigidity followed by a period of clonic activity developing about 20-30 sec after the stun. Tonic convulsions persisted up to 18-22 sec. The duration of unconsciousness in fallow deer was similar to that observed in red deer but was slightly longer than that seen in other domestic species and was characterized by the absence of a lag phase between the stun and the maximum amplitude of the seizure (Cook *et al.*, 1994). On average, the post stun period of insensibility persisted for about 60 sec (Cook *et al.*, 1994).

The supply of blood to the brain of red deer by the vertebral artery appears to be comparatively less than that in cattle (Nutman, pers. comm., reported by Blackmore *et al.*, 1993). Therefore, head-only electrical stunning of deer (red and fallow deer) was considered a humane procedure providing stun-to-stick times are no more than 20 sec (Blackmore *et al.*, 1993). This assumption is justified by the longer insensibility period (more than 60 sec) compared to other species and the presence of pupillary dilatation during this period.

In fallow deer, sensibility does not return during exsanguination if both carotid arteries are severed within 20 second of electrical stunning (Cook *et al.* 1994). Therefore it is not necessary to employ any form of head-to-body stunning to induce cardiac fibrillation and cerebral anoxia (Blackmore, 1996) to ensure optimum welfare.

According to the DeerQA VP TC, (2005) the following parameters are required for electrical head-only stunning deer: current: 1A minimum; voltage: 400V open circuit; duration: 1 second minimum.

3.3.1.1. Description of effective use

Deer are restrained in a stunning box to facilitate accurate application of electrodes and maintenance of the current flow.

Head only electrodes are applied in a position that spans the brain.

A minimum current of 1.3 A in red deer and 1.0 A in fallow deer is applied to induce immediate loss of consciousness (electrical stunning of reindeer is not in use).

Good electrical contact between the electrodes and the head should be maintained and the electrodes should be kept clean in order to ensure maximum current flow.

3.3.1.2. Monitoring points

Effective electric head-only stunning is demonstrated by the occurrence of the following signs:

- Immediate loss of posture
- The whole body becomes rigid. This tonic phase can be short or absent in red deer,
- Absence of rhythmic breathing
- Clonic activity characterised by violent four leg kicking, which last about 30-45 sec in red deer and about 20 sec in fallow deer.

3.3.1.3. Advantages

Immediate onset of insensibility if the head electrodes are firmly and properly applied. Application of currents between 0.6 and 1.3 A for 0.5 sec induces a period of reversible insensibility of more than 60 sec, which is 25% longer than in other farm animals (Blackmore, 1996).

In red deer, placing the electrodes either on the front, or on the back of the head seems to be equally effective.

3.3.1.4. Disadvantages

Most stunning boxes are not equipped with an adequate head restraint system, which may result in misapplication of the electrodes.

Since red deer, unlike fallow deer, do not show physical symptoms of an epileptiform seizure, the assessment of an effective stun in the abattoir could be more difficult.

The use of goads to coerce the animal into the stunning box will result in very poor welfare.

3.3.2. Electrical head-to-body killing method

With this method, the first two phases of an epileptiform fit as described for head-only electrical stunning should occur. However, the degree of clonic convulsions in the second phase is often reduced (AWAC, 1994).

Normal cardiac activity should immediately cease. Since in deer the manual palpation of the lower anterior chest to detect heart function can be difficult, the lack of cardiac activity can be assessed by a lack of pulsatile blood flow from the severed arteries (AWAC, 1994).

3.4. Specific methods which can be applied on-farm, including those for disease control purposes

On farm emergency killing of deer is needed in a number of circumstances. The selection of the most suitable killing method depends on the species to be killed, how accustomed they are to handling, their response to the presence of human beings, the presence and type of capture and handling systems available on the farm, and on the degree of deer expertise of the personnel involved with deer.

In most cases, the preferred method should be the use of a free bullet in the field. When proper capture and handling system are provided, and the animals are accustomed to them, the use of a captive-bolt stunning system followed by pithing can be applied.

In all cases, the same recommendations for their effective use, as well as the monitoring points described for pre-slaughter stunning can be applied.

4. STUNNING AND KILLING METHODS FOR GOATS

4.1. Introduction

The goat (*Capra hircus*), together with sheep, were among the earliest animals to be domesticated. Goat remains have been found at archaeological sites in western Asia, such as Jericho, Choga, Mami, Djeitun and Cayonu, which allows the domestication of the goats to be dated at between 6000 and 7000 B.C..

However, unlike sheep, their ancestry is fairly clear. The major contributor to modern goats is the Bezoar goat.

Unlike sheep, goats easily revert to feral or wild conditions given the opportunity. In fact, the only domestic species which will return to a wild state as rapidly as a goat is the domestic cat.

Sheep and goats are two of the most commonly farmed and economically important ungulates. In addition to providing meat and milk they produce wool. Goats are often herded in semi-arid areas where there is not enough grazing to support cattle.

There were approximately 7.4 million goats in the world with 1.8 million in the EU.

The most common methods for stunning and killing of goats in slaughterhouses are penetrating captive bolt and electrical stunning. An automatic electrical stunning system is also described.

4.2. Mechanical Stunning methods

4.2.1. Penetrating Captive bolt

When the captive bolt is powered by a blank cartridge, selection of the cartridge strength should be appropriate for the size of the animal (*i.e.* adult *vs* lambs). The manufacturer's recommendations should be followed. For effective stunning of hornless goats the captive bolt must be placed on the midline, in the middle of the forehead, just above the level of the eyes, aiming down along the angle of the neck. The proper site for horned goats is on the midline, just behind the bony ridge where the horns protrude, aiming toward the back of the chin (Hullinger and Stull, 1999) or at the cross-over point of two imaginary lines drawn between the base of the horns and the contra-lateral eyes (Troeger, 1990)

4.2.1.1. Description of effective use

The head is restrained to enable accurate placement of the gun.

The gun is fired using the recommended cartridge strength.

Bleeding is performed immediately after shot. Both common carotid arteries should be severed to keep the time to loss of brain responsiveness as short as possible.

4.2.1.2. Monitoring points

Effective captive bolt stunning produces the following signs:

- Immediate loss of posture
- Absence of rhythmic breathing
- The body becomes rigid (tonic phase)
- Clonic phase – uncontrolled physical activity
- The position of the eyeball is fixed.

4.2.1.3. Advantages

The stunning method appears to be effective, however, there is no published evidence to support this.

4.2.1.4. Disadvantages

The head of individual animals need to be restrained to enable accurate placement of the captive bolt gun.

4.3. Electrical stunning and electrical killing methods

4.3.1. Electrical head-only stunning

Head-only stunning of goats is carried out on individual animals. The electrodes are positioned between the eyes and the base of the ears on both sides of the head. The effect is characterised by a strong excitation of the cerebrospinal and the autonomic nervous system (Roos & Koopman, 1943). It is recommended to stun the goat with at least 1.0 A for 8 sec (Dayen, 2001).

In an automatic stunner, the restrainer runs until the animal makes contact with stunner head. At the end of the timed stun current application period, the stunner head opens up and the stun conveyor is run simultaneously to discharge the animal through a safety flange door down a chute to the sticking table. The stunner head is closed again and the cycle is repeated as required (Thornton, advertisement).

4.3.1.1. Description of effective use

The head is restrained to allow proper placement of electrodes.

The electrodes are positioned between the eyes and the base of the ears on both sides of the head.

A current of 1A at 50 Hz is applied.

4.3.1.2. Monitoring points

The following signs are displayed after an effective electrical stun:

- Immediate loss of posture
- Absence of rhythmic breathing
- The body becomes rigid (tonic phase)
- Clonic phase – uncontrolled physical activity

4.3.1.3. Advantages

Electrical stunning has been shown to produce immediate loss of consciousness in other species. However, research has not been published for goats.

4.3.1.4. Disadvantages

Electrode position: electrodes can be misplaced which will result in an ineffective stun. Maintaining good electrical contact with the skin may be difficult with hairy animals.

The use of this equipment to coerce (goad) the animal will result in very poor welfare.

4.3.2. Electrical head-to-body killing method

Electrical killing method is effective when it induces immediate unconsciousness and death by cardiac arrest. The electrodes must be placed in a position that spans both the brain and the heart (Hullinger and Stull, 1999). By analogy with sheep the recommended current to stun and kill the goat is at least 1A.

4.3.2.1. Description of effective use

The animal is restrained to allow proper placement of electrodes.

The electrodes are positioned to span the brain and heart.

A current of 1A at 50 Hz is applied.

4.3.2.2. Monitoring points

Effective electrical killing is demonstrated by the following signs:

- Immediate loss of posture
- Absence of rhythmic breathing
- Immediate onset of tonic and clonic spasms followed by relaxation after 10 to 15 sec.

4.3.2.3. Advantages

Electrical killing has been shown to produce immediate loss of consciousness and cardiac arrest in other species. However, research has not been published for goats.

4.3.2.4. Disadvantages

Electrode position: electrodes can be misplaced which will result in an ineffective stun and kill. Maintaining good electrical contact with the skin may be difficult with hairy animals.

The use of this equipment to coerce (goad) the animal will result in very poor welfare.

4.4. Specific methods which can be applied on-farm, including those for disease control purposes

4.5. The most common methods used to kill goats are given below:

- Captive bolt - Goats can be stunned by captive bolt and killed by pithing. The hole made in the skull leads some leaking of body fluids, brain tissue and possibly associated pathogens. When investigation is required for TSE this method (pithing) is not recommended.
- Electrical stun/kill - These methods require full animal restraint.
- Injection with anaesthetic drug – *e.g.* kill the animal with an i.v. injection (overdose of barbiturates).

5. STUNNING AND KILLING METHODS FOR RABBITS

5.1. Introduction

Domestic rabbits, which include breeds and crossbreeds of the European rabbit (*Oryctolagus cuniculus* L.), are farmed worldwide for meat, hair and fur production. They are also commonly used as laboratory animals, and increasingly as pet animals, in several European countries (Löliger, 1992).

Although the production is on the increase, rabbit meat is still a niche product within the European Union (Cavani and Petracci, 2004). It is regularly consumed and produced on a larger scale in only a few of the member states, foremost in France, Italy, Spain and Portugal. In these countries, the rabbit slaughtering process has been transformed. The large numbers of small abattoirs spread all over the territory and dealing with various species have been replaced by a few plants specialising in rabbit slaughter. In Spain 20 – 25 of the approximately 120 approved rabbit slaughter plants slaughter about 80-85% of the total production (about 110,000 – 120,000 tons per year) (Lopez, pers. comm.). Although in Italy approximately 300-400 authorised rabbit abattoirs exist only 50 of them slaughter about 90% of the total production (about 2,000,000 rabbits/week, for 50 week per year) (Salvi, pers. comm.). In Italy, over 56,000 rabbit farms produce a total of 7.4 million rabbits per year (ISTAT, 2003).

In other countries rabbit meat is regarded as rather exotic. In Germany only 215,000 rabbits underwent meat inspection in the whole of 2002 (Statistisches Bundesamt, 2003), and only one EU approved rabbit slaughter plant exists. While most of the rabbit meat consumed in Germany is produced on farm and directly marketed, in Spain for example direct marketing plays only a minor role.

In 1996 the average consumption of rabbit meat per year in the EU was less than 2kg per head (De La Puenta, 1996, quoted by Anil *et al.*, 2000). For most member states of the EU, however, no slaughter figures have been provided by EUROSTAT.

Rabbit production is increasing in some East European Countries (Hungary, the Czech Republic, Slovakia and Croatia) (Salvi, pers. comm.). Also in the old member states the integration of a large rabbit industry is becoming more important and the development of rabbit meat production is forcing processing plants to improve slaughter capacities by using high speed and more automated slaughter lines (Cavani et Petracci, 2004), thus increasing the risk of poor animal welfare as has been demonstrated in pigs (Warriss, 1994).

For commercial purposes mainly White New Zealand hybrids and cross-breeds are used, which are slaughtered at an age of 12-13 weeks corresponding to 2.5 – 2.7 kg live weight (Cavani, pers. comm.). In Spain Hybrids from selected French (HYPLUS and HYCOLE) or Spanish (UPV and IRTA) lines are predominantly used (Lopez, pers. comm.), in Italy, HYLA, HYCOLE and GRIMEAUD hybrids (2.5-3 kg) are used, in addition to local and lighter types, such as the Mediterranean rabbit (up to 2-2.2 kg) and the "Leprino della Tuscia". On the other hand, in Germany, an abundance of breeds and crosses are kept by hobby owners, slaughtering surplus stock in small quantities for their own consumption or direct marketing.

Traditionally, rabbits were slaughtered after the application of a blow to the head (using a stick or metal pipe or even the edge of the hand), with subsequent bleeding. This method is still widely used, especially for small quantities. However, where larger numbers are slaughtered methods have to be applied that depend less on manual expertise and more on automation to increase slaughter speed and guarantee uniform quality of the carcase. The main method used for stunning in commercial abattoirs is electrical stunning (Cavani, pers. comm.). However, gas stunning is used in one plant in Spain (Lopez, pers. comm.) and captive bolt stunning is sometimes carried out on farm in culling for disease control purposes in Italy (Salvi, pers. comm.).

Methods that have been traditionally used with small experimental rabbits like dislocation of the neck, decapitation (use of a guillotine), or applying an overdose of barbiturates are not recommended for use with commercial or emergency slaughter. They cannot ensure immediate or painless loss of consciousness, are not practical with high throughputs, or will lead to residues in the meat which are unacceptable from a food safety perspective.

Transcranial electric stimulation, *i.e.* applying magnetic fields to the brain, has recently shown to have some potential for the stunning of slaughter animals, as the use of this non-invasive technique in humans seems to be painless. To achieve a sufficiently lasting stun, however, seizure activity has to be induced. Moreover, this method requires high safety measures to protect the operator from accidental exposure to the magnetic field. Extensive fundamental research is needed before this technique might provide a viable alternative for stunning slaughter animals (Knight and Anil, 2003).

5.2. Mechanical Methods

Mechanical Methods for stunning rabbits are suitable for (and mainly used) with small slaughter numbers. Several cartridge or spring operated devices for penetrating captive bolt stunning are on the market and have to some degree been scientifically investigated. Free bullets seem not to be used with rabbits.

5.2.1. Penetrating captive-bolt stunning

There are cartridge operated and spring operated captive bolt guns on the market which are specifically designed for stunning small animals such as rabbits or waterfowl. Their use has been investigated and evaluated by the observation of the resulting clinical symptoms and examination of the damage inflicted to the skull and brain.

Figure 5: Spring operated captive bolt guns for stunning rabbits (Photo: I. Schuett-Abraham)

Dennis *et al.* (1988) investigated a penetrative captive bolt gun (suitable for stunning dogs but not otherwise described) in 5 healthy adult New Zealand White rabbits weighing between 2.5 and 5 kg. The bolt was forced into the brain by a .22 calibre blank cartridge. The rabbits were kept without restraint in sternal recumbency and the bolt placed directly on the skull at the intersection of lines drawn from the lateral canthus of each eye to the opposite ear, aiming towards the *medulla oblongata*.

Immediately following the shot, all animals collapsed and appeared to become immediately unconscious. The corneal reflex was abolished. Respiration ceased in four of five animals but was maintained in the fifth for about 1 min. Vocalisation occurred in one rabbit but was not further described, and it was not stated whether this rabbit was also the one that maintained respiration. Movement of the hind-limbs occurred in all animals, and extensor spasm of the limbs were observed in two animals, but the reaction was judged to be of reflex nature.

Holtzmann and Loeffler (1991) investigated one cartridge operated (6mm calibre blank cartridges) and two spring operated captive bolt guns in an un-stated number of commercially slaughtered rabbits of unknown breed and weight. The guns were positioned in compliance with the respective instructions from the manufacturers (recommended positions: 1. between the eyes, 2. at the intersection of lines connecting the eyes to the opposite ears, or 3. between the ears). Criteria for an effective stun (Riek, 1980) consisted of immediate loss of posture without righting movements, cessation of respiration, rigid and unresponsive pupils, and lack of aversive reactions to throat cutting.

Stunning effectiveness depended on the site of impact rather than on the make of the gun. Positioned between the eyes, the bolt would penetrate the olfactory bulb if applied at the sagittal suture and enter the orbita if applied paramedially, while positioned further rostrally it would hit the nasal cavity. Despite the lack of apparent brain damage in most of these cases the impact with the skull was sufficient to cause a short-lasting concussion. Throat cutting, however, triggered severe movements and animals shot into the nasal cavity or orbita also vocalized at this time. Shots applied to the intersection of the lines connecting the eyes with the opposite ears would hit the rostral cortex and were associated with apparent unconsciousness, however, the rabbits reacted with mild convulsive leg movements upon having their throats cut. Additionally, if the gun was positioned paramedially the bolt tended to slip off the convex bone surface and enter the soft tissues, leading only to temporary numbness. A lasting stun with no reaction to sticking was only achieved if the bolt was positioned on the midline between the ears where its impact would damage both cortex and brain stem.

Schuett-Abraham *et al.* (1992a) investigated the use of a spring operated captive bolt gun during the home slaughter of 45 fattened rabbits of mixed breed and sex, age 3 months to 3 years, with live weights of up to 4kg, and during the culling of 23 laboratory rabbits of mixed breed and sex, weighing around 3kg.

According to the manufacturer the gun developed an impact force equalling 26kg sufficient to drive the 5mm diameter bolt 27mm deep into the brain, the maximum penetration length of the bolt. The partly sloped bolt tip was fitted with an indentation measuring 2mm in diameter and 3.5mm in depth. The opposite end of the bolt was fitted with a handle with which the bolt could be fully retracted into the barrel until it latched, to thus manually cock the gun.

With a shot positioned close to the ears 100% of the home slaughtered rabbits were effectively stunned and 94% killed compared to only 63% effectively stunned and 25% killed if the bolt was positioned at the intersection of the lines connecting the eyes to the opposite ears. Moreover, in the remaining 12% that were shot in the latter positions the stun was ineffective. In the laboratory rabbits all shots were positioned as close to the ears as possible and produced an immediate tonic spasm which in some cases was associated with pronounced hyperextension of the animal's body (opisthotonus). Within 35 sec the tonic phase changed into clonic convulsions or faded directly into total relaxation. The shot irreversibly terminated the corneal reflex and respiration in 24 animals. In 8 animals the corneal reflex was lost while some gagging was observed between 30 and 95 sec after the shot. One animal, however, displayed rhythmic breathing despite the loss of corneal reflex.

A total of 8 rabbits vocalised during the shot. A conscious reaction to the penetrating bolt could be excluded as the stun was irreversible in all except one animal, which did not resume breathing until 65 sec after the shot. Vocalisation was produced by the sudden compression of the thoracic cavity at the onset of the tonic phase expelling air from the lungs, as has been discussed with poultry by Wormuth *et al.*, 1981.

In 19 of the rabbits blood leaked from the shot wound resulting in substantial blood loss in 3 animals. Apnotic animals became totally flaccid within 50 to 150 sec after the shot. A continuous blood flow was observed for 24 +/- 8 sec (mean +/- SD) in 18 rabbits bled within 2 min after the shot compared to 15 +/- 15 sec (mean +/- SD) in 13 rabbits bled between 2 to 5 min after the shot, although in the latter group blood flow could last for up to 45 sec in individuals. In contrast to other species the pupils appear not fully dilated in death but may remain semi-constricted, making it difficult to diagnose the death of the animal.

Although the skin holes suggested uniform positioning of the gun a post mortem revealed the corresponding holes in the skull to be scattered across the length and width of the left parietal bone. Apparently the gun had been moved by sliding the skin against the underlying bone. 16 of 17 rabbits shot paramedially on the parietal bone had been killed while one was temporarily stunned. Hitting a bone suture reduced the number of rabbits killed (7 out of 10) but still provided a lasting stun in the remainder. While at the sagittal sutures the bone thickness measured on average 3mm, at the paramedian its thickness was reduced to less than 2mm. No signs of impact were observed on the base of the skull.

No confirmation of stunning effectiveness by EEG could be found in the literature. However, it has been shown that:

- a correctly applied captive bolt shot has been proven to immediately extinguish the ability of the brain to respond to external stimuli in other species,

- this loss of function is accompanied by distinguished clinical signs (immediate loss of posture and onset of tonic rigidity, loss of corneal reflex, cessation of breathing) which are also clearly observed in rabbits, and

- with regard to the similarity of the bolt-inflicted damage and bleeding of the brain

It seems safe to assume by analogy to other species, that a correctly applied captive bolt shot will result also in rabbits in an immediate, deep and lasting stun.

To ensure that the bolt penetrates the brain and damages the brain stem, the muzzle of the gun has to be firmly held against the rabbit's head on the midline and between the ears or as close to them as possible. (Holtzmann and Loeffler, 1991; Holtzmann, 1991; Schuett-Abraham *et al.*, 1992a). With this position a deep and lasting stun can be achieved in nearly all rabbits and a stun/kill in most (Schuett-Abraham *et al.*, 1992a). Vocalisation observed at the moment of throat cutting indicates a poor stun (Dennis *et al.*, 1988; Holtzmann and Loeffler, 1991) while a single 'shriek' at the moment of the shot seems insignificant (Schuett-Abraham *et al.*, 1992a). As a kill cannot be guaranteed, the throat should be cut as soon as possible severing both carotid arteries (Schuett-Abraham *et al.*, 1992a).

5.2.1.1. Description of effective use

- The animal is restrained in sternal recumbency on a level surface by gripping its shoulder to allow accurate positioning of the gun.

- The barrel of the gun is held at right angles to the skull and the muzzle positioned slightly paramedially on the animal's head between or as close to its ears as possible.

5.2.1.2. Monitoring points

Effective captive bolt stunning is demonstrated by the following signs:

- Immediate loss of posture.

- Tonic seizure, resulting in hyperextension of the animals' body (opisthotonus), followed within about 35 sec by mild to severe clonic seizures and/or relaxation.

- Immediate and sustained absence of rhythmic breathing and absence of the corneal reflex (however, the latter could be due to severed reflex pathways).

5.2.1.3. Advantages

When correctly applied, with the animal properly restrained the penetrating captive bolt gun produces an effective stun.

This stunning method requires minimal training, is easy to apply and produces repeatable results whereas manual methods are less reliable (due to operator fatigue or emotional stress).

The devices are portable, and can be used for on-farm slaughter, and in case of emergencies.

5.2.1.4. Disadvantages

Restraint of the animal and proper presentation of its head may be difficult if rabbits are excited and struggling.

As the skin is only loosely attached to the skull the muzzle of the gun may shift after having been correctly positioned.

In case of misfired shots or delayed bleeding it is mandatory to immediately re-stun the animal. For this purpose a second device should always be at hand and ready to use.

Spring operated guns have to be manually cocked between shots while cartridge operated guns have to be reloaded. Both actions will slow down the slaughter speed. Therefore this effective method may be overlooked when implementing a stunning method in small-scale slaughter plants.

5.2.2. Non-penetrating captive-bolts

A blow to the back of the head with the edge of a hand or a wooden or metallic instrument has been the traditional method of stunning for home and other small scale slaughter of rabbits. In view of this, there is no reason to assume that commercially available non-penetrative captive bolt stunning devices developed for poultry would not also work well in rabbits. However, no publications were found to demonstrate this. Due to the lack of scientifically based data the subsequent recommendations follow empirical evidence.

5.2.2.1. Description of effective use

The rabbit is held by its hind legs. With a metal pipe, a wooden club or another suitable tool a blow is applied to the back of the rabbit's head just behind its ears. The blow has to be carried out with sufficient force to trigger concussion and dislocate the neck and the animal is bled without delay by severing both carotid arteries.

5.2.2.2. Monitoring points

- Immediate loss of posture.
- Tonic seizure, resulting in hyperextension of the animals' body (opisthotonus), followed by mild to severe clonic seizures and/or relaxation.
- Immediate and sustained absence of rhythmic breathing and absence of corneal reflex (however, the latter could be due to severed reflex pathways).

5.2.2.3. Advantages

- The method is suited for small slaughter numbers and in case of emergency slaughter or culling.
- As it needs no specially designed device a sufficiently heavy but easy to handle object (club, priest, piece of iron pipe) may be found on the spot.

5.2.2.4. Disadvantages

- As the blow has to be carried out with sufficient force to trigger concussion and dislocation of the neck it needs a skilled and determined operator.
- Operator fatigue can occur when large numbers of rabbits are stunned by this method.

5.3. Electrical Stunning and electrical stun / killing

Electrical stunning in rabbits has been applied since Phyllis Croft investigated its use in the 1950s. Today it is widely used in commercial rabbit slaughter plants. This method can be applied by using hand-held or wall-mounted V-shaped electrodes like those shown in Fig. 1a + b (Anil *et al.*, 1998, Maria *et al.*, 2001).

Figure 6 a + b: Electrical device for stunning rabbits (Photos: S. Diverio)

Few studies have investigated the use of electrical stunning of rabbits from a welfare point of view.

Anil *et al.* (1998) investigated the physical activity and reflex behaviour of 71 commercial rabbits of mixed sex (1.7 - 3.1kg) stunned in a commercial abattoir. The methods investigated were head-only applications of a 50Hz AC (sinusoidal waveform) at 100, 75 or 50 V for an average duration of 3-5 sec in 3 groups of 10 animals. In a second trial 4 groups of 10 rabbits each were stunned with 100 V or 50 Volts for 1 and for 3 sec. Following the stun the rabbits were placed on a table and their behaviour video-taped. Type and duration of spontaneous physical activity and the time to return of reflexes were measured from the video recording.

The variations in impedance of the rabbits' heads due to their fur were considerable and ranged from 300 Ω to more than 1500 Ω regardless of the voltage applied. Consequently, the currents ranged from 92-120mA at 50V, from 138 - 211mA at 75V, and from 154 - 279mA at 100V. (N.B. These data do not include 3 animals which failed to be stunned and were replaced!). Induction of a stun failed in 1 animal at 100V and in 2 animals at 50V. Where the stun was considered successful no significant differences were seen between the different voltages in terms of the duration of apparent insensibility. The lowest current received by an animal thought to be satisfactorily stunned was 140mA. Rhythmic breathing returned on average between 35 and 41 sec, a longer absence of rhythmic breathing found at the lower voltage. Corneal reflexes returned between 25 to 26 sec with no detectable correlation to voltage or stun duration. A response to a nose prick could be elicited within 44 to 55 sec and was correlated with the current flow duration.

The reaction patterns of the rabbits were corroborated by Maria *et al.* (2001) who also video-taped the behaviour upon stunning of 50 commercial white rabbits of mixed sex (around 2kg) for a maximum of 3 min. Groups of 10 rabbits were subjected different voltage / frequency combinations of a pulsed DC for 3 sec to 5 sec. The methods investigated were 49V at 179 Hz, 130V at 161Hz and at 1667Hz, and 19V at 161Hz and at 1667Hz. While voltage and frequency could be verified, it was not possible to record the amperage.

Two rabbits failed to be stunned by 19V and were replaced. After a stun that the authors considered successful the corneal reflex returned on average within 25 to 38 sec and was longest absent in the groups stunned at 130V. Rhythmic breathing ceased on average for between 26 and 33 sec and the duration of cessation showing no clear correlation with the stunning parameters. The response to nose prick was lost on average for 84 to 119 sec and tonic/clonic seizures lasted on average for 29 to 39 sec.

To verify the clinical assessment Anil *et al.* (2000) recorded the ECoG in 8 commercial rabbits (1.7 - 3.1kg). Bitemporal application of 100V of a 50Hz AC (sinusoidal waveform) for 1 sec resulted in the induction of typical Grand Mal epileptic activity in 6 rabbits, of which only two showed tonic/clonic seizures, the typical clinical sign for epilepsy in other species. The other four rabbits appeared "stunned and exhausted".

One rabbit that had received as little as 22mA failed to show epileptiform brain activity as well as physical signs of epilepsy, but its ECoG showed polyspike activity lasting for 13 sec, and loss of VER and SER lasting for 27 and 24 sec respectively, indicating at least a short period of insensibility.

Judging from the return of reflexes the stun lasted at least 22 sec and complete recovery was observed after 144 sec. Where evoked responses could be recorded SERs were lost following stunning and absent for 24 to 204 sec, while VERs were absent for 27 to at least 135 sec.

Regarding the broad variations of clinical symptoms in the electrically stunned rabbits, the often varying or unreported stunning conditions, the small number of animals in which the EEG was recorded, and the unclear correlation between clinical parameters and electrophysiological criteria of unconsciousness, scientifically based recommendations as to the minimum current for a sufficient stun in rabbits cannot be given. Further research including the recording of EEG/ECoG and EPs is necessary to clarify the situation.

Nevertheless, as the method is widely used in slaughter plants some recommendations need to be made to prevent misuse and to protect animal welfare.

5.3.1. Electrical Head-only stunning

The most common device for electrically stunning rabbits seems to be the wall-mounted V-type electrodes as described by Anil *et al.* (1998, 2000) and Maria *et al.* (2001) (Fig. 1a and 1b). Due to lack of scientific data the minimum current sufficient to stun all rabbits cannot be recommended.

In commercial plants, currents of 106 volts, with 1-4 A for 1 second, are used (Salvi, pers. comm.). Following head-only a stunning method, exsanguination is commonly carried out within 5-10 sec (stun-to sticking time), when the animals are still in the tonic phase (10-15 sec) and bleeding time was stated as 10-12 sec. Slaughterline speed ranges from 500 to 3000 rabbits/hour, depending on availability of staff. On the other hand, Cavani and Petracci (2004) reported that the use of 50-100 V for 2-3 sec prior to unilateral or bilateral neck cut as common practice, with bleeding times of 2-3 min.

5.3.1.1. Description of effective use

- To avoid pain as well as injury to the rabbit's back, the animal is restrained by one hand supporting its belly while the other is guiding the head by holding its ears.
- The head of the rabbit is placed in the V-shaped electrode in a way that allows for transcranial current flow. The electrodes need to connect between the outer corners of the eyes and the base of the ears thus spanning the brain.
- A minimum current to achieve a sufficiently deep and lasting stun in all rabbits cannot yet be recommended due to lack of evidence. However, currents of less than 140mA flowing for less than 3 sec, and driven by less than 100V have to be considered insufficient. Until the results of further research allow the statement of an adequate current to be described for rabbits, by analogy to head-only stunning of other species of similar size, 400 mA are recommended.
- Head-only stunning is fully reversible and will give only a short temporary stun, the animals need to be promptly bled by severing both carotid arteries.

5.3.1.2. Monitoring points

The most reliable sign of a successful induction of an electrical head-only stun is the cessation of rhythmic breathing.

Typical symptoms of an epileptic fit include immediate loss of posture and onset of the tonic phase, characterized by a tonic state of the body with the legs stretched out, and subsequent clonic convulsions with kicking of the fore and hind legs. However, these symptoms are observed in only a fraction of the animals, while others simply appear stunned and exhausted.

Other signs reported in some, but not all rabbits are excessive salivation, loss of corneal reflex for at least 20 sec, and lack of response to a nose prick for at least 30 sec.

5.3.1.3. Advantages

Immediate onset of unconsciousness upon correct application of sufficient current.

5.3.1.4. Disadvantages

There is a wide range in impedance to current flow due to the isolating properties of the rabbit's fur. This will result in a correspondingly wide range in achieved currents, with the consequent variation in the effectiveness of the stun.

The reported variations in the symptoms of an effective stun make reliable monitoring difficult.

Restraining the rabbit by holding its ears to facilitate the application of the current may compromise animal welfare if the weight of the rabbits is not properly supported.

Operator health and safety is an area for consideration, because the rabbits have to be stunned while manually held.

5.4. Gas mixtures for stunning and killing

Although the use of gas mixtures for stunning and killing of rabbits would reduce the stress of pre-slaughter handling and probably increase throughput in slaughter plants. However, its effect on the welfare of rabbits has not been scientifically investigated.

Investigations in several farm animal species (chicken, turkeys and pigs) demonstrated that inert gases like argon which induce unconsciousness from hypoxia do not trigger aversive reactions as the animals continue to breathe normally and do demonstrate escape behaviour. Therefore, the method is generally considered to be humane (EFSA, 2004c).

However, some caution has been expressed with regard to burrowing species which may show aversive reactions if exposed to high concentrations of inert gases (EFSA, 2005b). Given a free choice rats and mice evacuated an anoxic gas atmosphere after an average of 3 sec (Leach *et al.*, 2004; Niel and Weary, 2005). Accordingly, the Report requested further research to determine species-specific requirements for the use of hypoxic methods and recommended less aversive methods to be sought.

5.4.1. Carbon dioxide / air mixtures

Although carbon dioxide in high concentrations is widely used for the pre-slaughter stunning of pigs and poultry as well as the euthanasia of small laboratory animals like rodents and rabbits, exposure to the pungent gas has been recognized to often trigger severe aversive reactions during most experimental investigations. This led to the general recommendation to abandon its use in laboratory species, including rabbits (EFSA, 2005b).

Carbon dioxide had already previously been rejected as a method for killing experimental rabbits by the Swiss Federal Office for Veterinary Affairs (Bundesamt für Veterinärwesen, 1993) due to often observed severe reactions and excitations. In addition, a CEC DGXI working party investigating euthanasia methods applied in experimental animals did not recommend CO2 for the euthanasia of experimental rabbits because large individuals might experience distress while still conscious (CEC DGXI, 1993). The method was judged acceptable, however, by the AVMA Panel on Euthanasia (2000).

The recommendations for rabbits concerning their exposure to CO2 have mainly been extrapolated from research in rodents. Publications dealing with carbon dioxide stunning or killing of rabbits are scarce, originate mainly from observations made during trials experimenting with practical application, and are therefore not mentioned in the EFSA report (2005b).

Hertrampf and von Mickwitz (1979) reviewed experiments and observations published between 1928 and 1979. They concluded that rabbits were rather tolerant of carbon dioxide, but could be stunned if body size and breed were taken into account. In addition, stunning them in groups would avoid unnecessary stress. However, gas concentrations and times of exposure could not be recommended for lack of reliable data.

Dickel (1976) experimented with CO_2 stunning in a commercial slaughter plant by lowering rabbits individually into gas-filled containers. He judged a CO_2 concentration of 60-70% by volume to be optimal, as it achieved a reflexless narcosis within 20 to 25 sec after exposure. Higher carbon dioxide concentrations tended to kill, while concentrations below 50% were considered too slow in producing a reflexless stun. He also reported temporary breathlessness during exposure, and after 10 sec some rabbits showed mild excitations. The exposure was ended when the rabbits had reached the reflexless stage. The corneal reflex returned 20 to 25 sec after the end of the exposure, and the rabbits tried to right themselves.

Tholen (1987) described the empirical use of similar equipment in an East German rabbit slaughter plant. The cages were attached to a rotating drum and the rabbits exposed for 2 - 3 min to a mixture of unknown concentrations of carbon dioxide in air. Following stunning, the rabbits were shackled by a hind leg and bled by throat cut or decapitation.

Von Cranach *et al.* (1990) investigated CO_2 culling of laboratory rabbits and compiled data for this method. Exposure to 100% CO_2 (defined as import of 100% CO_2 into a closed system) took between 20 and 40 sec to render the animals unconscious and between 165 sec and 8 minutes to kill them. However, the rabbits did not go into lateral recumbency, a sign generally signalling loss of consciousness during gaseous stunning in other species.

Only one investigation quoted by Von Cranach *et al.* (1990) described the recording of the EEG of rabbits during exposure to an increased CO_2 content in the atmosphere. However, the only information presented was that the animals' EEG showed delta-waves when they became unconscious.

The presented observations and reports have only anecdotal status and therefore will not carry a science-based recommendation. While CO2 may be safely used to kill unconscious rabbits its use in conscious animals cannot be recommended unless the results of further investigations demonstrate that the aversiveness experienced by other species during the induction of CO2 stunning or killing is avoided in rabbits or will be so mild as to be outweighed by the welfare advantage of reduced handling.

5.5. Specific methods which can be applied on-farm, including those for disease control purposes

- Captive bolt guns are suitable for on-farm disease control unless the agent is highly contagious. The opening of the skull by the penetrating bolt often results in substantial blood loss from the bolt hole and is thus likely to spread the disease if the agent is present in blood.
- Where the spread of contagious diseases has to be avoided, non-penetrative percussion stunning (*e.g.* a blow to the head with a blunt instrument), the head-to-body application of an electrical current (sinusoidal AC at 50 Hz) of sufficient magnitude to stop the heart, or the use of gaseous stun/killing methods have to be preferred.
- Application of an anaesthetic drug (*e.g.* intravenous injection of an overdose of barbiturates) is also suitable for culling purposes (EFSA, 2005b). However, this method requires a comparatively high individual handling effort and would thus be applicable for small numbers only.

6. STUNNING AND KILLING METHODS FOR OSTRICHES

6.1. Introduction

Ostriches belong to only one species, known as *Struthio camelus*. Within this species four subdivisions are recognised: the North African Ostrich with pink neck and legs, the Masai

Ostrich or 'red' ostrich with red on their necks and legs, the Somali ostrich with deep blue heads and legs, and the Southern African Ostrich or 'blues' with bluish-grey necks and legs. The described differences are restricted to males. The South African 'Black' is a mixture of different breeds and sometimes known as *Struthio camelus domesticus*. Various crosses were made and resulted in a type of bird with largely improved feather quality (Paleari *et al.*, 1995; Sales and Oliver-Lyons, 1996).

Ostrich farming with tame birds probably started in the middle of the 19th century for the production of feathers. Early in the 20th century the production was strongly depressed and a revival was not seen until after the Second World War for the production of leather. In the nineteen-twenties a number of farmers began considering making biltong (dried meat products) from ostrich meat. This market grew slowly. In recent years the market for ostrich meat is growing, because ostrich meat has a low fat content and is considered a good alternative to other meats. South Africa and Israel are the countries with the greatest experience in slaughtering, meat processing and marketing techniques. However, they use different hybrids. In both countries the commercial production is well established, while in the EC production has started recently (Paleari *et al.,* 1995; Sales and Oliver-Lyons, 1996).

Presently, cross breeding experiments are conducted with "blacks", "reds" and "blues" to improve reproduction and carcass and meat quality. However, the "blacks" remain the meat ostrich for commercial purposes for the future, due the aggressive behaviour of the "reds" and "blues".

Some ostriches are stress susceptible, readily disturbed by humans and liable to injure themselves when making sudden movements in confined conditions (EFSA, 2004d). Where possible, "flighty" birds should not be transported, but similar to the recommendations for some species of deer, they should be slaughtered on-farm (EFSA, 2004d). Where ostriches are transported, their needs should be catered for and properly constructed handling facilities and transport vehicles should be used by suitably trained personnel (Wotton and Hewitt, 1999).

Careful documentation of any downgrading conditions found in the dressed carcass at the abattoir that could be related to handling / transport stress or trauma, would allow monitoring to take place that could lead to improvements in the systems and methods employed by the industry. This method of recording and investigating the basis for downgrading conditions has been shown to significantly improve live bird handling through a reduction in stress and trauma within the poultry industry (Wotton and Hewitt, 1999).

Ostriches are slaughtered at approximately 14 months of age to obtain optimal leather quality. However, for meat production the age may be 9 to 10 months. Pre-slaughter stress, including transportation, handling and 24 hours off feed, significantly increased live weight loss in ostriches; excessively high losses of 10 to 17% have been reported. Moreover birds are kept for 24 hours in small fenced areas with access to water before entering the abattoir. In practice ostriches are stunned by electrical methods using 80 to 90 V on the head or by captive bolt. After stunning they are shackled by both legs by chains hanging from the ends of an upturned horizontal bar. The animal is then subsequently lifted and bled. The time between stunning and sticking is generally about 60 sec. The preslaughter procedure is thought to be detrimental for the animal welfare and meat quality. According to the high ultimate pH, ostrich meat might be classified as an intermediate meat type between normal ($pH<5.8$) and dark, firm, dry meat (DFD; $pH>6.2$). Other results show that the decrease in pH is (very) limited, measured at 45 min and 18 h post mortem, which indicated DFD meat (Mellet, 1985; Paleari *et al.,* 1995; Morris *et al.,* 1995; Sales and Mellet, 1996; Sales and Oliver-Lyons).

Figure 7: Recommended position of the penetrative captive bolt for stunning of ostrich

6.2. Mechanical Stunning

6.2.1. Penetrative Captive bolt

Mechanical stunning of ostriches can be carried out successfully using a penetrating captive bolt. However, it is not known whether the stun is produced by physical destruction of neural tissue, bleeding of the brain or concussion. Parts of the skull overlying the hemispheres were found to be very thin (especially in Emus) and it is not known whether sufficient energy to produce concussion could be generated (Schütt-Abraham and Wormuth, 1995). For effective stunning of ostriches the captive bolt must be placed at the crossover point of imaginary lines drawn between the base of the ears and the contralateral eyes (Morris *et al.,* 1995; Paleari *et al.,* 1995; Sales and Mellet 1996; Sales and Oliver-Lyons, 1996). Another option is placing the captive bolt on the crown with the bolt in direction of the throat (Schütt-Abraham and Wormuth, 1995)

Recently a modified captive bolt method has been developed, in which air pressure was used to block post stun convulsions. To improve the prototype method for practical application a commercial air tacker was modified. The bolt of the original design was replaced by two needles, which penetrate the skin and skull at an angle of 15^{o} in a caudal direction. Both needles were provided with small holes, which allow air through in different directions. The stunning position was at the intersection of two imaginary lines drawn from the ear on one side to the inner corner of the eye on the other side. A trigger initiated the injection of compressed atmospheric air when the needles penetrate the skull, and the duration of air injection was electronically controlled. The duration of injection as well as the air pressure was adjusted to a shooting pressure of 8 bar and an air injection of 3 bar during 1.5 sec respectively. EEG investigations showed that this method was effective with ostriches (Lambooij *et al.,* 1999a, b).

It was hypothesised that in the captive needle pistol the compressed atmospheric air administered through the needle, placed more anterior on the ostriches' head, damaged higher brain regions to provide unconsciousness, while the other needle damaged the upper spinal cord to reduce post stun convulsions (Lambooij *et al.,* 1999a, b).

6.2.1.1. Description of effective use

The head is manually restrained.

The captive bolt is placed at the crossover point of imaginary lines drawn between the base of the ears and the contralateral eyes or on the crown with the bolt in the direction towards the throat.

Bleeding is performed immediately after the shot by severance of both common carotid arteries in the neck or the major blood vessels close to the heart.

6.2.1.2.Monitoring points

Effective captive bolt stunning produces the following signs:

- Immediate loss of posture
- Absence of rhythmic breathing
- The body becomes rigid (tonic phase)
- The position of the eyeball is fixed.
- Clonic phase – uncontrolled physical activity

6.2.1.3. Advantages

The stunning method is effective and mobile.

6.2.1.4. Disadvantages

The head of individual animals need to be manually restrained whilst maintaining operator safety.

The clonic spasms are severe and adversely affect operator safety and their ability to bleed the animal quickly.

The trajectory of the bolt must penetrate the mid-brain to effectively kill the ostrich (because of lack of evidence as to the mechanism for effective mechanical stunning).

6.3. Electrical Stunning

6.4. The passage of an electrical current through the brain of ostriches can result in effective stunning.

6.4.1. Head-only electrical stunning

Different electrical and mechanical stunning procedures were studied in ostriches to determine the effectiveness of the method (Lambooij *et al.,* 1999a). Fifty-eight South-African Black ostriches were equipped with EEG electrodes and stunned with 3 different electrical head-only methods. A general epileptiform insult on the EEG followed by recovery was observed in 20 ostriches. Another 8 animals died after recovery and 5 showed an iso-electric line and were killed by the application. The total duration of the insult was 25 ± 10 sec. The measured current was 463 ± 120 mA. In the second trial a constant current of 400 mA was administered to 13 ostriches. In 1 animal the electrodes were disconnected. Eight out of 12 animals showed a general epileptiform insult, 2 of them showed an iso-electric line and two did not show the characteristics of a general epileptiform insult. The total duration of the insult on the EEG was 21 ± 8 sec. The measured current was 365 ± 91 mA and the voltage 191 ± 27 V.

During the second stunning procedure 4 and 7 ostriches were stunned with 200 V (spiked electrodes) and 48 V (blunt electrodes), respectively, during approx. 6 sec. In this experiment all birds died following a head only application.

A study (Wotton and Sparrey, 2002) of the commercial stunning and slaughter of 783 ostriches in a Republic of South African abattoir revealed that a simple ostrich handling system, combined with a leg clamp applied during stunning current flow and operated by experienced ostrich slaughter men, resulted in a humane, efficient slaughter process. It was estimated that an electrical stunning current in excess of 400 milliamps at 50 Hz AC, applied to the head only, would prevent recovery in more than 90% of the ostriches, when bled within 60 sec from the start of stunning. The identification of rhythmic breathing movements indicate the first stages of recovery and is therefore an essential diagnostic 'tool' in recognising the effectiveness of the stunning treatment. The identification of rhythmic breathing movements in the ostrich after stunning is difficult because spinal reflexes, which produce contraction of limb muscles and result in almost rhythmic body movements, could easily be confused with breathing movements.

6.4.1.1.Description of effective use

The current is delivered via scissor-likestunning tongs with spiked electrodes for 3 to 6 sec. The electrodes are placed on the head between the eye and ear.

An effective head-only electrical stunning of ostriches occurs with a current of on average 500mA (~200 V). Due to the duration of the stunned state (25 sec), it is recommended (Lambooij *et al.,* 1999a) that for ostriches a short stun-stick interval be used or the animal should be killed by a current of long duration, for instance over 6 sec.

6.4.1.2.Monitoring points

- Immediate loss of posture
- Absence of rhythmic breathing
- The body becomes rigid (tonic phase)
- Clonic phase – uncontrolled physical activity which can be severe

6.4.1.3. Advantages

The stunning method permits the legs to be fixed during current application (tonic phase).

6.4.1.4. Disadvantages

The head of individual animals need to be restrained. The clonic phase can be severe and delay exsanguination.

The use of this equipment to coerce (goad) the animal will result in very poor welfare.

6.5. Specific methods which can be applied on-farm, including those for disease control purposes

6.6. The following methods can be used for on–farm casualty slaughter of ostriches:

- Captive bolt - ostriches can be stunned and may be killed by captive bolt.
- Electrical method – Application of stunning tongs to the head is followed by application across the chest to induce cardiac arrest.
- Injection with anaesthetic drug – *e.g.* kill the animal with an i.v. injection (overdose of barbiturates).

7. STUNNING AND KILLING METHODS FOR DUCKS

7.1. Introduction

Two main species of ducks are kept for breeding and slaughtering purposes in the European Union: Pekin ducks (*Anas platyrhinchos domestica*) and Muscovy ducks (*Cairina moschata*). Also crossbreds of these species (mule ducks) are produced for slaughter.

18 million ducks underwent meat inspection in Germany in 2002 (Statistisches Bundesamt, 2003). In the year 2003 approximately 74 million ducks were slaughtered in France, 9 million in Poland, and approximately 2 million in Denmark and Italy (EUROSTAT).

Ducks have been stunned prior to slaughter with a blow to the head or stunned electrically in a water bath stunner. More recently gas stunning methods for example exposure to argon or a carbon dioxide/argon mixture have been investigated.

The stun should last until death occurs either from anoxia or from bleeding. The time between sticking and loss of spontaneous or evoked brain activity was evaluated in anaesthetised and ventilated ducks, where loss of activity was from an approximated EEG signal reduction to 5% of its original values (Gregory and Wotton, 1986). Spontaneous brain activity was lost within 1 minute and evoked activity within 3 minutes upon bilateral severance of the carotid arteries and jugular veins. If the beak cut was used for bleeding the time to loss of spontaneous and evoked brain activity was tripled compared to bilateral severance of carotids and jugulars. If cardiac arrest was induced, however, the time was nearly halved (spontaneous ECoG was lost in less than 30 sec, and VEPs were lost in less than 2 min). Thus the quickest method to induce a loss of brain function in ducks is to simultaneously induce a cardiac arrest with the stun. Beyssen *et al.* (2004b) observed in ducks that bleeding without prior stunning led to loss of spontaneous activity in the brain after 50 to 70 sec.

The most common method for stunning ducks in commercial slaughter plants is the use of a water bath stunner. For small scale slaughter, especially on-farm stun/killing, mechanical devices have also been developed.

7.2. Mechanical Stunning

Mechanical stunning of ducks can be carried out where small numbers have to be slaughtered. Traditionally the duck is held at the base of the wings or by its feet and a blow to its head is administered with a blunt instrument. Few publications exist which deal with the welfare effects of mechanical stunning with ducks.

7.2.1. Penetrating Captive bolt

Research carried out in the Netherlands with broiler chickens and the use of a penetrating bolt with a diameter of 5 mm and a length of 25 mm (Hillebrand *et al.*, 1996), showed that penetrating captive bolt shooting can be effective in inducing unconsciousness in birds. However, results of investigations into the use of penetrative captive bolt guns with ducks are not available.

7.2.2. Non-penetrating Captive bolt

Hewitt developed and tested the effectiveness of a poultry casualty slaughter device for use in Ducks and Geese (Hewitt, 2000 and 2004). The percussive gun (figure 8 and 9) was shown to be effective at producing immediate unconsciousness and death with both ducks and geese.

Figure 8: Percussion stunner for poultry (Photo: Leisha Hewitt)

Figure 9: Convex head of percussion stunner for ducks (Photo: Leisha Hewitt)

7.2.2.1. Description of effective use

- A convex shaped head (figure 9) is used for ducks.
- The bird is restrained *e.g.* in a killing-cone.
- The head is restrained lightly by holding the beak.
- The muzzle is placed at right angles to the top of the bird's head (frontal bone) on the midline, before firing (as shown in figure 11 for geese).
- The bird's head is allowed to be propelled out of the hand upon firing. (There must be free movement of the bird's head after the percussive strike.)

7.2.2.2. Monitoring points

The following signs demonstrate effective percussive stunning:

- Uncontrolled and severe wing flapping.
- Immediate cessation of rhythmic breathing.
- Loss of neck tension.
- Leg flexion and extension.

7.2.2.3. Advantages

- In a properly restrained bird the method will produce an immediate and effective kill.
- The device is portable and can be used for on-farm or emergency slaughter.
- The risk of developing operator's fatigue with larger slaughter numbers is reduced compared to manual application of a blow to the head.

7.2.2.4. Disadvantages

- Restraint of the bird requires either additional equipment or a second operative to manually restrain the bird.

- Uncontrolled wing flapping can make assessment of the kill difficult.
- The method is not applicable to high throughput of large slaughter numbers.

7.3. Electrical Stunning and electrical stun / killing

An overview regarding the complex effects and interactions of stunning voltage, frequency and current in poultry is given in the previous EFSA report (2004c). The predominant method used for ducks is stun/killing in a water bath stunner.

Only few publications, however, are specifically viewing the welfare aspects of electrical stunning and stun/killing of ducks.

Schuett-Abraham *et al.* (1987a, b) estimated the voltage necessary to stun/kill 90% of a batch of Peking ducks within 3-4 sec of current flow (sinusoidal AC at 50 Hz) in a water bath stunner to be 208 V, resulting in currents of 130 mA or more. Stun/killed ducks showed irrevocable loss of corneal reflex and loss of muscle tension within 15 - 40 sec after the onset of current flow and could thus be distinguished from ducks that were only temporarily stunned. Prolongation of the current flow duration up to 12 sec did not improve the killing efficiency (Bundesgesundheitsamt, 1990; Knauer-Kraetzl, 1991). However, the investigations corroborated the recommendation that a minimum current of 130 mA (sinusoidal AC at 50 Hz) per bird was necessary to regularly trigger ventricular fibrillation during water bath stunning (Schütt-Abraham, 1995).

Gregory and Wilkins (1990) investigated electrical stun/killing of ducks in a commercial water bath stunner at 85, 150 or 250 mA (AC sinus 50 Hz). The ducks were less susceptible to a ventricular fibrillation than chickens or turkeys. 85 mA applied for 4 sec killed only 33% of the ducks. With 150 mA the stun/kill efficiency rose to 95%, but it took 250 mA to establish cardiac arrest in 99% of the ducks.

To achieve a good stun, the head of the ducks must be fully immersed in the electrically live water. Gregory and Wotton (1992) initiated ventricular fibrillation (judged by irrevocable loss of respiration and rapid relaxation of the body following the stun) in 9 out of 10 birds immersed for 4 sec in a water bath stunner by exposing each bird to a mean stunning current of 105mA. While 8 of 10 ducks, the heads of which had been fully immersed, lost VERs immediately after the stun for more than 20 sec, this was the case in only 3 of 10 ducks if only the bills and throats had been immersed. VERs returned for only a short time in fibrillating ducks before the birds became unresponsive. In the surviving ducks VERs were present immediately after the stun and persisted for at least 60 sec, demonstrating that the current bypassed the brain, if the head was not fully immersed and the bird would not be stunned.

Carcase damage in ducks has been of no major concern with electrical stun/killing methods with 50 Hz AC (S. Wotton, pers. comm.). Gregory and Wilkins (1990) found no relation between the stunning current and the incidence of red pygostyles, red wingtips, wing haemorrhaging, engorgement of the wing veins, breast and leg muscle haemorrhaging, and broken furcula and coracoids even if currents were used that induced ventricular fibrillation in all birds.

Also, there are no welfare, ethical, hygienical, or even legal reasons against using stun/killing methods for slaughter (Schütt-Abraham *et al.*, 1987b; Wormuth and Schütt-Abraham, 1986).

However, there is one publication that indicates that the livers of force-fed ducks may be affected (Beyssen *et al.*, 2004b). Also, in some Member States, *e.g.* France, they do not accept birds in which cardiac arrest has been induced prior to neck cutting (Beyssen *et al.*, 2004a). To avoid heart fibrillation some abattoirs have raised the current frequency. However, the current/frequency combinations which will reliably induce an effective stun in non-fibrillating ducks are not yet known.

Beyssen *et al.* (2004a) evaluated the effectiveness of water-bath applied constant currents at a higher frequency (600 Hz) by using Fast Fourier Transformation Analysis (FFTA), ECoG and SEPs. The stun was considered effective if an epileptic fit was generated, followed by a reduction in the electrical activity in the brain to less than 10% of the pre-stun level, and the abolition of SERs was observed. A constant current of 150 mA / 600 Hz applied for 4 sec was survived by 9 out of 10 male mule ducks. Only one bird, however, was effectively stunned, using the above criteria for up to 70 sec post stun. The SEPs were retained in 6 out of 9 ducks, in 4 of them throughout the post-stun period, and the total power never dropped to less than 60% of the initital values in 7 ducks. The authors concluded that electrical water bath stunning of ducks using 150 mA at 600 Hz was ineffective. Moreover, they suggested that the increase in total power content above 100% in the ECoG of 2 birds might indicate pain perception.

7.3.1. Water bath electrical stunning

The predominant method used for stunning ducks in the Member States of the EU is stun/killing in a water bath stunner. With electrical stunning in a water bath stunner the heart forms part of the circuit. Therefore, with frequencies between 50 and 90 Hz a stun/kill can be induced if the current exceeds the level for initiating ventricular fibrillation as well as for producing an epileptic fit.

7.3.1.1. Description of effective use

Described in the previous EFSA report (2004c) However, the minimum recommended current for the effective stunning of ducks is 130mA per bird at 50Hz AC.

7.3.1.2. Monitoring points

An effective electrical stun/kill will trigger the following symptoms:

- Immediate onset of tonic spasm
- Within 15 - 40 sec post-stun, full relaxation occurs due to loss of muscle tone, indicated by “spreading” of the neck plumage if ducks are inverted
- No rhythmic breathing
- No wing flapping during bleeding

7.3.1.3. Advantages

With an effective stun/kill in the water bath and with the heads fully immersed loss of consciousness will be immediate and irreversible.

7.3.1.4. Disadvantages

With incomplete immersion of the heads the stun is less effective care has thus to be taken to ensure complete immersion.

7.3.2. Electrical head-only Stunning

Only one paper was found to report the head-only stunning of ducks. Beyssen *et al.* (2004a) applied a constant current (sinusoidal AC at 50 Hz) to 45 ducks by firmly pressing tong-mounted spike electrodes to the ears of the birds after having doused their feathers with saline water. The investigated currents were 100, 200, 300, 400 or 600 mA applied for 4 sec. The birds were bled within 15 sec post-stun, severing the carotids and jugulars in their necks. Application of 100 mA was effective in only 1 out of 4 birds. Application of 200 - 400 mA failed to stun some birds, while some others regained consciousness before death from bleeding occurred. Only a 600 mA stun followed by bleeding rendered 7 birds unconscious until death. The clinical symptoms of an effective stun were described as a tonic phase, followed by a clonic phase during which the seizures were severe with 100 mA but decreased in force and duration with increasing current, and became mild and intermittent with 600 mA. Ventricular fibrillation was not observed, however, this was not surprising as the heart was excluded from the current pathway.

As the method has not been investigated by other research groups the following recommendations are solely based on this single report.

7.3.2.1. Description of effective use

- The duck is restrained, *e.g.* in a cone, and the feathers of its head are wetted.
- The electrodes of an electric tong are placed on the head spanning the brain.
- A constant current of not less than 600 mA (AC sinus 50 Hz) is applied for 4 sec.
- Immediately after the stun the bird is bled severing both carotid arteries and jugular veins.

7.3.2.2. Monitoring points

- Initial tonic phase (7-10 sec), followed by
- Mild and spaced-out convulsions (clonic phase), and
- Relaxation (exhaustion phase).

7.3.2.3. Advantages

If applied correctly and followed by quick bleeding the method is effective to trigger an immediate and lasting stun.

7.3.2.4. Disadvantages

- The method requires a short stun quick bleeding to ensure that the birds do not regain consciousness.
- Wing flapping during the clonic phase may impede proper application of the neck cut.
- The method requires handling of individual birds which renders it impractical for large throughput slaughterhouses.

7.4. Gas Stunning

Since ducks have some adaptation for diving and are adapted to cope with apneic periods while their head’s are immersed when feeding under water, concerns have been expressed as to the quick induction of unconsciousness by gaseous stunning, especially involving CO_2

(SCAHAW, 1998). However, Pekin ducks did not take longer to lose consciousness in an atmosphere of increasing CO_2 concentration than did turkeys, and the investigated parameters suggested a link between the loss of posture and the onset of unconsciousness (Gerritzen *et al.*, submitted) as had been found in other poultry species.

Raj *et al.* (1998) compared two different gas stunning/killing methods to an electrical stunning/killing method with respect to carcase damage and meat quality. 150 mule ducks were exposed within less than 5 sec to either 90% argon in air or 30% carbon dioxide in 60% argon (resulting in a mean oxygen content of around 2%), for 150 and 167 sec respectively. All birds were killed by the exposure. However, no information was given with respect to the induction phase, which from an animal welfare perspective is of the highest concern.

The effect of different exposure times at concentrations from 40-90% carbon dioxide was tested with ducks (A.B.M. Raj, pers. comm.). Six-minute exposure to 50% carbon dioxide failed to kill all ducks and those birds which survived the treatment vocalised within 20 sec and regained posture within 30 sec, after returning to atmospheric air. Three-minute exposure to 70% carbon dioxide resulted in the death of all ducks. However, as the exposure of the ducks to high concentrations of carbon dioxide produced aversion the method was not recommended.

7.4.1. Gas mixtures for stun / killing

According to research, ducks can be killed within 3 minutes by exposure to either 90% argon in air or a mixture of 30% carbon dioxide and 60% argon in air (Raj *et al.*, 1998).

The use of inert gases and certain gas mixtures is generally considered to be humane (EFSA 2004c, 2005b). However, this has not yet been sufficiently demonstrated for ducks. Thus some concerns remain on whether or not the induction phase is acceptable on welfare grounds.

7.4.1.1. Description of effective use

The ducks are lowered in crates into a container filled with the predetermined gas concentration of either 90% argon in air or 30% carbon dioxide and 60% argon in air and are exposed to this atmosphere for 3 minutes.

7.4.1.2. Monitoring points

- The bird is completely relaxed
- No rhythmic breathing or other brain–stem reflexes are observed

7.4.1.3. Advantages

The stress of shackling conscious birds is eliminated.

7.4.1.4. Disadvantages

- It may be difficult to maintain the gas concentrations required to ensure that every bird is stun/killed.
- Unconsciousness is not induced immediately, and it has not been demonstrated for ducks that the method quickly induces unconsciousness without causing undue stress.

7.5. Other methods

7.5.1. Cervical dislocation

Cervical dislocation, although used for on-farm killing purposes, is not a stunning method. By manual stretching, the neck is hyperextended and dorsally twisted to separate the first cervical vertebra from the skull (AVMA, 2001). Research in anaesthetised chickens demonstrated that it caused the spinal cord to break at the first cervical vertebra and greatly reduced the diameter of the carotid arteries. However, in a substantial number of birds the method failed to induce immediate loss of brain responsiveness, causing death from asphyxiation or ischemia (Gregory and Wotton, 1990). As the method requires considerable force to achieve cervical dislocation in large birds it is difficult to perform in practice. Death is not instantaneous, and the inflicted tissue damage may be perceived as painful. Therefore cervical dislocation should not replace pre-slaughter stunning in ducks, but only be used for killing stunned birds.

7.5.2. Decapitation

Decapitation is not a stunning method and does not result in instantaneous loss of brain responsiveness. Wormuth *et al.* (1981) could elicit the corneal reflex in the completely isolated heads of chickens for on average 23 sec, although a flat ECoG was recorded within a few sec. Gregory and Wotton (1986) demonstrated that brain activity in decapitated chickens lasted for longer than in these birds with a cardiac arrest. Therefore decapitation should not replace pre-slaughter stunning in ducks, but only be used for killing stunned birds.

Decapitation may compromise the biosecurity on the farm by the spillage of blood due to severe wing flapping of the headless body.

7.6. Specific methods which can be applied on-farm, including those for disease control purposes

The killing methods for ducks have not been sufficiently researched in this species. Therefore, culling for disease control purposes in ducks has to be carried out using methods recommended for other poultry species (EFSA, 2004c)

8. STUNNING AND KILLING METHODS FOR GEESE

8.1. Introduction

Reliable statistics for the slaughter of geese are not available for all member states of the EU however, in contrast to chickens, ducks and turkeys, geese meat is consumed mostly seasonally (Christmas and St Martin's Day). Subsequently, slaughter figures tend to peak towards the end of the year. For example, of approximately 700.000 geese slaughtered in France in 2003, about one third were slaughtered in December alone (EUROSTAT). Due to the demand for seasonal slaughter, specialised goose processing plants are very unusual in the EU and their slaughter often takes place in plants designed for other poultry species, predominantly chickens and turkeys.

8.2. Mechanical Stunning

8.2.1. Penetrating captive bolt equipment

Research carried out in the Netherlands with broiler chickens and the use of a penetrating bolt with a diameter of 5 mm and a length of 25 mm (Hillebrand *et al.,* 1996), showed that captive bolt shooting can be effective in inducing unconsciousness in birds. However, no publications on the evaluation of penetrative captive bolt guns with geese were found.

8.2.2. Non-penetrative captive bolt equipment

Very little research has been carried out on the welfare effects of mechanical stunning with geese however, DEFRA, UK have funded research to test the effectiveness of a poultry casualty slaughter device developed by Hewitt (2000) for use with Ducks and Geese (Hewitt, 2004). The percussive gun (figure 10) was shown to be effective at producing immediate unconsciousness and death with both ducks and geese.

Figure 10: Cartridge powered "Cash" Poultry Killer (Accles & Shelvoke Ltd., UK).

8.2.2.1. Description of effective use

- A convex shaped head is used for geese.
- The bird is restrained *e.g.* in a killing-cone.
- The head is restrained lightly by holding the beak.
- The muzzle is placed at right angles to the top of the bird's head (frontal bone) on the midline, before firing (as shown in figure 11 for geese).
- The bird's head is allowed to be propelled out of the hand upon firing. (There must be free movement of the bird's head after the percussive strike.)

Figure 11: the correct positioning of the "Cash" Poultry Killer for geese.

8.2.2.2. Monitoring points

The following signs demonstrate effective percussive stunning:

- Uncontrolled wing flapping.
- No rhythmic breathing following the percussive blow.
- No neck tension.
- Leg flexion and extension.

8.2.2.3. Advantages

When correctly applied and with the bird properly restrained, the percussive gun produces an immediate and effective stun/kill.

The devices are portable and can be used for on-farm or emergency slaughter.

8.2.2.4. Disadvantages

Restraint of the bird requires either additional equipment or a second operative to manually restrain the bird.

Uncontrolled wing flapping can make assessment of the stun/kill difficult.

8.2.3. Cervical dislocation

Cervical dislocation, although used for on-farm killing purposes, is not a stunning method. By manual stretching, the neck is hyperextended and dorsally twisted to separate the first cervical vertebra from the skull (AVMA, 2001). It severs the spinal cord and greatly reduces the diameter or promotes haemorrhage of the common carotid arteries, causing death from cerebral ischemia (Gregory and Wotton, 1990). The force necessary to achieve manual cervical dislocation in large birds like geese makes it difficult to perform in practice. As death from cerebral ischaemia is not instantaneous and the method may thus be painful for the bird cervical dislocation should not be used in place of pre-slaughter stunning with geese, but could be used for culling purposes in stunned birds.

8.2.4. Decapitation

Decapitation of poultry involves severing the neck, close to the head, by using a sharp instrument (Close *et al.,* 1996). Gregory and Wotton (1986) examined the process of decapitation of poultry and concluded that the shock of the process was not sufficient to render the chicken's brain instantly unresponsive and demonstrated that responses could be elicited for as long as 30 sec after decapitation. Therefore decapitation should not replace pre-slaughter stunning in geese, but only be used for killing stunned birds.

Decapitation can also be a major concern because the biosecurity on the farm can be compromised by the spillage of blood.

8.3. Electrical stunning or killing systems

Little research has been carried out into the welfare aspects of the stunning and slaughter of geese however, Schütt–Abraham *et al.,* (1987a) and Schütt–Abraham and Wormuth (1988) estimated the voltages at 50 Hz necessary to kill at least 90% of geese (V_{90}) during a 2-3 sec passage through a waterbath stunner. Their estimated V_{90} was 374 volts, at 197 mA giving a calculated impedance of 1.9 KΩ. They reported that the maximum current at 50 Hz that was survived by geese was 220 mA. Schütt–Abraham *et al.,* (1992b) showed that the resistance of the leg/shackle contact could not be improved by wetting the feet and that immersion depth had little effect on the impedance to current flow.

Fernandez, *et al.* (2003) examined the influence of waterbath stunning parameters on blood loss and quality aspects with geese. Unfortunately, the ability of the stunning current treatments tested to effectively stun the birds was not investigated however; they did note an effect on the reduction of impedance with increasing voltage with geese. Turcsan, *et al.* (2001) compared electrical stunning and controlled atmosphere stunning (CAS) on meat and liver quality of geese, which was improved with CAS. The authors did not report the welfare aspects of the stunning treatments. Turcsan, *et al.* (2003) investigated the influence of nine electrical stunning methods using various frequency and voltage combinations, on the presence of engorged blood vessels in goose liver. They concluded that the use of high-frequency currents gave considerable commercial advantages but again, welfare was not evaluated.

8.3.1. Head-only electrical stunning

There is no published evidence for the effective head-only stunning of geese and unpublished results with 110 volts AC at 50 Hz applied head-only using fixed spiked electrodes, failed to produce an effective stun (Wotton, pers. comm.). However, the method is preferred in some Member States for stunning small quantities of geese because the application of the current to the head, is more controlled than in a water bath stunner and the welfare implications of incomplete or non-immersion of the head, or premature electric shocks are avoided.

Head-only electrical stunning in geese using electric scissor-like tongs was investigated in 143 geese in 2 Lower Saxony abattoirs (Könnecke, 2001, pers. comm.). The geese originated from free-ranging flocks and were individually shackled prior to pre-slaughter stunning. The head of the goose was restrained manually by gripping the neck and the electrodes were immediately applied across the head in a position that spanned the brain (figure 12). The current was applied automatically by a proximity switch mounted on the tong arms. The duration of current flow - on average 10 sec - could be established from a lamp attached to the stunning transformer. Applying 180 Volts bitemporally produced 300mA within the first second of current flow. The initial impedance of 600 Ω decreased during the current flow to 120 Ω. Under optimal conditions (electrodes positioned on the eyes, sufficient pressure, clean electrodes) the current of 300 mA 50 Hz AC that had been recommended by the BGA could be achieved with as little as 120 Volts and was regularly obtained with 170 Volts.

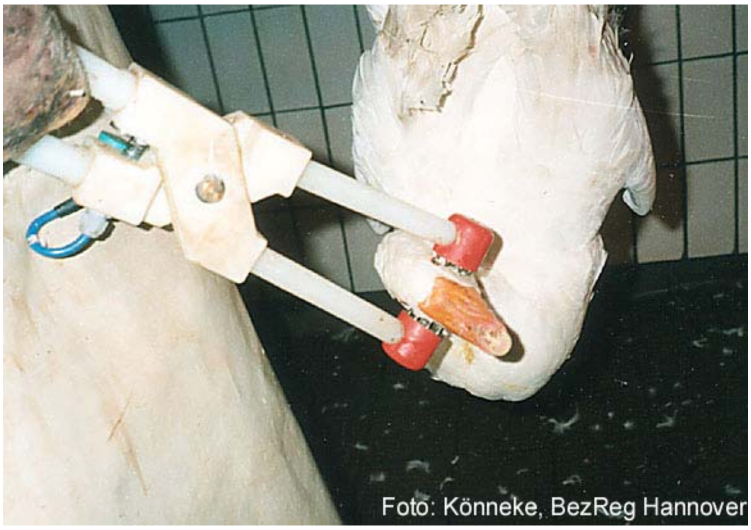

Figure 12: The application of electric scissor-like tongs to a goose.

8.3.2. Waterbath electrical stunning

Schuett–Abraham *et al.,* (1987a) and Schuett–Abraham and Wormuth (1988) assessed the effectiveness of electrical waterbath stunning of geese and determined the voltages at 50 Hz AC necessary to kill at least 90% of geese (V_{90}) during a 2-3 sec passage through a waterbath. Extrapolating from research in chicken (Wormuth *et al.*, 1981) and pigs (Hoenderken, 1978) they assumed that currents sufficient to fibrillate the heart would trigger an epileptic fit in all poultry provided the brain was included in the current pathway. They calculated V_{90} as 374 volts, at 197mA giving a calculated impedance of 1.9 KΩ. They also reported that the maximum current at 50 Hz AC that was survived by an individual goose was 220mA.

In 1990 the Working Group on Stunning of the German Federal Health Office (Bundesgesundheitsamt - BGA) investigated the effect of prolonged current flow and reduced voltages in a water bath stunner on electrical stunning of geese, using the Up-and-Down method (BGA, 1990). When 250 V was applied to geese in a waterbath stunner for between 4 and 12 sec, the average current in 52 birds was found to be 127 mA per bird (±19 SD). The highest current survived by a goose was 122 mA. All 25 geese that received >122 mA developed ventricular fibrillation. Increasing the duration of the current flow had no effect on the incidence of ventricular fibrillation but resulted in an increased current magnitude at the end of the application. The overall death rate in geese submitted to ≥120 mA was 97%. The average amperage in the surviving 7 geese was 105 mA (±11 SD) and the average amperage in the 45 geese experiencing ventricular fibrillation was 130 mA (±18 SD). Preceding investigations in a slaughter plant had shown that at the exit of the waterbath stunner, a positive corneal reflex was found in 4 of 50 geese (8%) when stunned with 360 V (average current = 225 mA). When 250 V (average current = 156 mA) was applied, 12 of 50 geese (24%) exhibited a positive corneal reflex (BGA, 1990, unpublished data). The impedance of the geese was calculated as 1.6 KΩ in the slaughter plant (where the legs of the geese had been sprayed with water), while in the laboratory experiments in dry conditions it was 2.0 KΩ. Based on these results the minimum recommended current to stun/kill geese was given as 130 mA per bird (Schütt-Abraham, 1999), the neurophysiological effect of this current level on brain function has not been investigated electrophysiologically.

8.3.2.1. Description of effective use

Described in the previous EFSA report (2004c). The minimum recommended current to stun and kill at 50 Hz AC is 130 mA per bird.

8.3.2.2. Monitoring points

Electrical waterbath stunning at 50 Hz AC will induce cardiac ventricular fibrillation in a proportion of geese, and hence, the usual tetanus seen at the exit of a water bath stunner will soon disappear and a total relaxation in the carcass will ensue. This can be recognised by the drooping of the wings immediately after the birds exit the waterbath. Geese that remain alive but stunned, will display the following symptoms that indicate a successful stun:

- Immediate onset of tonic seizure.

- Eyes wide open during tonic seizure.
- No rhythmic breathing.
- Clonic seizures occur as jerky movements of wings and legs.
- Eye reflexes must be absent when entering scald tank.

8.3.2.3. Advantages

If the waterbath stunning process is properly performed, it can be an effective method of stunning.

8.3.2.4. Disadvantages

The welfare implications of inverting and shackling large conscious birds are a disadvantage. The minimum amount of current necessary to ensure an effective stun in every bird has not been reliably established electrophysiologically in geese. Variation in electrical resistance from bird to bird and variation in the depth of immersion due to differences in bird size adversely affect the maintenance of good welfare conditions.

8.4. Gas mixtures for stunning and killing

Although the use of gas mixtures for the stunning and killing of geese would obviate the need for pre-stun shackling, which can be considered a welfare advantage, the application of carbon dioxide narcosis or anoxia with inert gasses has not been researched with geese. Therefore we are unable to make any recommendations until the methods have been investigated and reported in this species.

8.5. Specific methods which can be applied on-farm, including those for disease control purposes

The culling of geese for disease control purposes in geese has to be carried out using methods recommended for other poultry species (EFSA, 2004c) until methods for geese have been fully investigated.

9. STUNNING AND STUN / KILLING METHODS FOR QUAIL

9.1. Introduction

Quail are the smallest birds that are grown commercially for meat in the EU. There are about 40 different species however, only the Japanese quail (*Coturnix japonica*) has been successfully domesticated. The domestication of the European quail (*Coturnix coturnix*) has not been successful to date. Quail prefer covered and protected areas and spend much of their time either resting on the ground (sitting, standing, lying) or moving around, scratching and pecking, foraging or preening.

The worldwide production of quail has increased in recent years (Tservi-Gousi *et al.* 1999). In 1985 it was estimated that about 114.4 million quail were produced in France alone. This claim is backed by data that shows that in 1996, Label Rouge produced an estimated at 1.16 million birds, which was an increase of 12% over the previous year's production (Tservi-Gousi *et al.*, 1999).

The birds are highly susceptible to stress and research has been carried out to select more stress resistant genetic lines (Remington *et al.* 1998, Oguz *et al.* 1999). Results have shown an effect on some stress parameters in blood after selection trials for only three generations (Türkmut *et al.* 1999). Controlling conditions such as lighting regimes and light colour can have a considerable influence on the performance of quail; optimum growth performance was reached at the age of 5 weeks when green coloured light was applied, this was followed by results with white lighting and the poorest results were observed under red light (Sarica, 1998). This effect of lighting colour may reduce stress levels. Meat quality with quail is of high commercial importance and has been used as a parameter to indicate the effect of husbandry techniques. Therefore research was carried out to improve feeding and feed composition to reach optimal carcass quality with a high meat yield and low fat content (Shrivastav and Panda 1991).

Little information is reported on stunning, slaughter and/or killing. Quail are usually treated as a game species when they are slaughtered, *i.e.* they are processed without being bled (Gregory *et al.* 1991). Therefore, it is vital that quail experience a cardiac arrest at stunning if they are not to regain consciousness during subsequent processing. Quail were found very susceptible to ventricular fibrillation at stunning at currents between 45 to 110 mA (50 Hz). Experiments showed that currents as low as 45 mA were lethal to all birds (Gregory *et al.* 1991).

Tservi-Gousi *et al.* (1999) compared the effect of an electrical stunning method and the use of different gas mixtures (argon, carbon dioxide) on welfare and carcass quality of quail and concluded that the stunning/killing of quail in transport containers using gas mixtures such as 90 % argon in air or 30 % carbon dioxide and 60 % argon in air, in comparison with waterbath stunning systems, would not only help to alleviate potential welfare problems at slaughter but also improve carcass and meat quality. In particular the incidence of broken bones, bruises and haemorrhages were reduced.

9.2. Mechanical Stunning

Quail are usually killed by decapitation, dislocation of the neck (game) or by a blow to the head. There are regulations for the mechanical stunning of quail in different European states.

9.2.1. Percussive blow to the head

Percussion is carried out manually by a blow to the head. The Cash poultry killing device has been used to effectively stun/kill one-day old turkey poults therefore it is likely to be effective with quail.

9.2.1.1. Description of effective use

The quail is held by its legs/feet and a blow to the head is administered.

9.2.1.2. Monitoring points

The signs to recognize a successful mechanical stun are:

- Severe wing flapping occurs due to the damage to the brain.
- Absence of rhythmic breathing.
- Loss of corneal reflex.
- Gradual pupillary dilation.
- Absence of response to a painful stimulus.

9.2.1.3. Advantages

The use of mechanical stunning will result in the death of the bird provided the energy delivered to the skull is of sufficient magnitude

9.2.1.4. Disadvantages

An effective mechanical stunning method has not been developed for high throughput plants, therefore it can only be used on relatively small numbers.

9.2.2. Cervical dislocation

By manual stretching, the neck is hyperextended and dorsally twisted to separate the first cervical vertebra from the skull (AVMA, 2001). It severs the spinal cord and brain stem, and greatly reduces the diameter of the common carotid arteries, causing death from asphyxiation and cerebral ischemia (Gregory and Wotton, 1990). When carried out with force, it (inadvertently) leads to decapitation.

Mechanical neck crushing at the first cervical vertebra with a pair of pliers such as Semark pliers or the Burdizzo has been used as cervical dislocation. Neck crushing does not sever the common carotid arteries in chickens and does not reduce its diameter. Therefore, it does not cause cerebral ischemia and hence loss of consciousness. If the spinal cord is severed without stopping blood supply to the brain, it results in death from asphyxia (Gregory and Wotton, 1990).

Neck dislocation does not result in an effective stun therefore it should only be used as a killing method in a stunned bird.

9.2.3. Decapitation

Decapitation is only applied to poultry and involves severing the neck, close to the head, by using a sharp instrument (Close *et al.,* 1996). Research with chickens has shown that there may be visual evoked responses for up to 30 sec after decapitation (Gregory and Wotton, 1986). However, abolition of VEPs indicates brain death rather than loss of consciousness. It is worth mentioning again that neck dislocation inadvertently leads to decapitation. A major concern is the biosecurity on the farm that can be compromised by the spillage of blood.

Decapitation does not result in an effective stun therefore it should only be used as a killing method in a stunned bird.

9.3. Electrical stunning or killing systems

9.3.1. Water bath electrical stunning

Electrical stunning involves the use of a waterbath containing a 'live' electrode and the current flows through the bird to an earthed shackle and is universally practised as a method for stunning poultry (Tservensi-Gousi *et al.* 1999). Conventional quail processing methods do not include bleeding out the bird through neck cutting. Therefore the animals are killed in the waterbath by electrically induced ventricular fibrillation (cardiac arrest) rather than stunned and skinning must take place after brain death has occurred. The birds are killed in processing plants by cardiac arrest using a 50 Hz sinusoidal altering current (AC). Currents as low as 45 mA per quail are delivered with a 50 Hz sinusoidal AC. When the frequency of the stunning current waveform was increased, but applied at the same current level per bird, the incidence of cardiac arrest was reduced (Gregory *et al.* 1991). In spite of the fact that an effective stunning current has not been established for quail, a current greater than 45 mA per quail is considered sufficient (Tservensi- Gousi *et al.* 1999).

9.3.1.1. Description of effective use

Described in the previous EFSA report (2004c). The minimum recommended current to stun and kill quail at 50 Hz AC is 45mA per bird.

9.3.1.2. Monitoring points

- Relaxed carcass.
- No rhythmic breathing.
- Dilated pupils.

9.3.1.3. Advantages

Inducing cardiac ventricular fibrillation is the quickest method of producing brain death in birds. The bird welfare concerns associated with recovery of consciousness under water bath electrical stunning systems due to inadequate stunning and / or poor neck cutting will be eliminated.

9.3.1.4. Disadvantages

Some disadvantages of the electrical water bath stunning method (such as the welfare implications of shackling) also apply to water bath electrical stun/kill systems.

The amount of current necessary to induce cardiac ventricular fibrillation in quail may be less than that required to abolish brain responsiveness.

9.4. Gas mixtures for stun and killing

Various gas mixtures have been used to stun/kill quails. Subjective assessment has shown that when the birds are exposed to 90 % argon in air they lose posture after 9 sec, display a clonic phase between 15 and 24 sec and a tonic phase between 27 and 38 sec following exposure. From about 54 sec after the beginning of the stunning procedure, no movement is observed. In mixtures of 30 % carbon dioxide and 60 % argon in air, the respective times are very similar but with a significantly ($p<0.05$) prolonged tonic phase and a shorter clonic phase (not significant) (Tservensi- Gousi *et al.*, 1999).

9.4.1. Anoxic gas mixtures

The use of anoxic gas mixtures has been described before.

9.4.1.1. Description of effective use

Live quail can be conveyed into the gas mixtures in their transport crates.

9.4.1.2. Monitoring points

All the birds should be killed with the gas mixtures and under no circumstances should they show signs of recovery of consciousness. Adequate application of the method is indicated by:

- Completely relaxed carcass.
- No corneal or pupillary reflexes.
- No rhythmic breathing.
- Cardiac fibrillation.

9.4.1.3. Advantages

Gas stunning of quail can be successfully carried out by leaving the birds in the transport containers. This saves any manipulation and protects the birds from being handled, inverted and shackled. Gas stunning of quail in transport containers helps to reduce welfare problems.

9.4.1.4. Disadvantages

The identification of dead on arrivals has not proved a problem with the gas stun/killing of broilers and turkeys, therefore it is not envisaged that it would be a problem for quail.

The induction of anoxic convulsions after the birds have lost consciousness is not a welfare concern but does have consequences for carcass quality.

9.5. Specific methods which can be applied on-farm, including those for disease control purposes

The culling of quail for disease control purposes has to be carried out using methods recommended for other poultry species (EFSA, 2004c) because the killing methods for quail have not been sufficiently researched.

10. FOOD SAFETY IMPLICATIONS OF THE STUNNING METHODS

10.1. Food safety consideration

There are food safety concerns associated with some stunning methods used for animal species dealt with in this Opinion. Knowledge and data presently available are insufficient to quantify the food safety risks associated with those stunning methods but, for the purpose of this Opinion and based on the level of potential concern, they could be grouped into following:

10.1.1. Higher level, BSE-related potential food safety risks

Penetrating methods for stunning of goats

The main food safety concerns associated with penetrating captive bolt (Pcb) stunning of goats relates to potential for spread of CNS emboli into the general circulation and possibly to the edible tissues, with associated BSE-agent risks. The risks also include possible cross-contamination of other animals stunned with the same device. To date, no studies have been published on the occurrence of CNS emboli in Pcb-stunned goats, but the possibility cannot be excluded because analogue CNS embolism has been demonstrated in Pcb-stunned cattle and sheep (EFSA 2004b). Since TSEs, including BSE (Elioit *et al.*, 2005; EFSA, 2005a), affect goats, potential food safety risks associated with CNS embolism in sub-clinically infected goats cannot be ignored. It should be taken into account that goats with TSE infection in CNS also carry infectivity in the peripheral *i.e.* edible tissues (Heggebo *et al.*, 2002). Irrespective, Pcb stunning represents an additional risk factor including cross-contamination of other animals via the device. Consequently, penetrating captive-bolt stunning (and non-penetrating causing brain damage, if used at all) of goats could be assumed as carrying potential BSE-related food safety risks, that need to be treated with precaution.

10.1.2. Medium level, CWD-related potential food safety risks

Penetrating methods for stunning of deer

The main food safety concerns associated with Pcb stunning and free-bullet killing of deer relate to potential for spread of CNS emboli to the general circulation and possibly to the edible tissues, with associated TSE-agent risks. The risks also include possible cross-contamination of other animals stunned with the same device.

To date, no studies have been published on occurrence of CNS emboli in Pcb-stunned deer, but such a possibility cannot be excluded because analogue CNS embolism has been demonstrated in Pcb-stunned cattle and sheep (EFSA, 2004b). Since Chronic Wasting Disease (CWD; a form of Transmissible Spongiform Encephalopathy-TSE) affects deer, potential food safety risks with CNS embolism in sub-clinically infected deer must be taken into account.

CWD is an emerging prion disease of deer (*Odocoileus* species) and Rocky Mountain elk (*Cervus elaphus nelsoni*) (Williams *et al.*, 2002). The disease is presently confined to North America, and is not present in the EU. The risk of CWD transmission to humans following exposure to CWD-infected tissues is currently unknown. Two squirrel monkeys i.c. inoculated with brain tissue from a CWD-infected mule deer developed a progressive neurodegenerative disease (Marsh *et al.*, 2005). Brain tissue from those CWD-infected squirrel monkeys contained the abnormal isoform of the prion protein, PrP-res, and displayed spongiform degeneration. This was the first reported transmission of CWD to primates. However, direct comparison of the ability of the CWD agent to cause disease in squirrel monkeys (following experimental i.c. inoculation) with the susceptibility of humans to CWD infection is problematic and must be interpreted with caution, because squirrel monkeys may not be a good experimental model for assessing human susceptibility to animal prion diseases. In addition, oral exposure (the natural route of human exposure) to CWD of experimental animals is much less efficient at causing disease than i.c. inoculation. Overall, the results of this initial study must be considered preliminary, and the ability of CWD to cause disease in other primates by oral infection needs to be established to resolve the issue of susceptibility of humans to CWD infection. Although CWD-associated risks for humans may be low (Belay *et al.*, 2004), there is a need for further experimental and epidemiological research/surveys on the above issues and related recommendations of the previous EFSA Opinion on CWD (EFSA, 2004a) are still valid. To date, neither TSE nor BSE case in European cervids (farmed or wild) has been identified. Based on related EFSA Scientific Opinion (EFSA, 2004a), an EU-wide TSE/BSE survey in cervids is under preparation.

Overall, until further knowledge is accumulated, neither total absence of CNS embolism in Pcb-stunned deer, nor total absence of human health risks associated with exposure to the CWD agent, can be assumed. Consequently, penetrating (and non-penetrating causing brain damage, if used at all) captive-bolt stunning and free-bullet killing of deer cannot be assumed to carry no food safety risks.

10.1.3. Lower level, microbial contamination-related potential food safety risks

The two main potential food safety risks in this category are contamination of edible tissue with pathogenic microorganisms associated with: a) penetrating stunning of deer, goats, ostriches and rabbits; and b) water bath stunning of ducks, geese and quail, and

a. Penetrating stunning of deer, goats, ostriches and rabbits and microbial contamination

To date, no existence of CNS embolism and related TSE-related food safety concerns associated with Pcb-stunning of rabbits and ostriches have been documented. Rabbits have never been shown to harbour a natural TSE and seem to be protected by critical amino acid residues in their PrP that inhibit PrP^{SC} formation (Vorberg *et al.* 2003). In addition, experimental attempts to transmit TSE to rabbits failed (Barlow and Rennie, 1976; Gibbs and Gajdusek, 1973). In ostriches, a spongiform encephalopathy was described (Schoon *et al.*, 1991) but never shown to be TSE (Verwoerd, 2000).

When using penetrating captive bolt stunning methods, a potential concern is possible transfer of foodborne pathogens from the head skin (*i.e.* hair/feathers) and/or stunning device into the brain of deer, goats, ostriches and rabbits, and its further spread via circulation into edible tissues. Studies on the occurrence of such contamination with actual pathogens in these animal species under commercial conditions and studies on prevalence of pathogenic bacteria on their head skin/in brain are not available presently, but such risks cannot be entirely ignored. This is indirectly supported by studies in which Pcb-stunning-mediated contamination of edible tissues with marker microorganisms has been demonstrated in cattle (Daly *et al.*, 2001; Prendergast *et al.*, 2004) and sheep (Buncic *et al.*, 2002).

b. Electrical water bath stunning of birds and microbial contamination

The main food safety concerns associated with electrical stunning in a water bath of ducks, geese and quail are the possibility of aspiration of the stunner water by the birds (Gregory and Whittington, 1992) and subsequent contamination of the lung. Although information on the contamination of, and/or the fate of foodborne pathogens in, the stunning water baths is inadequate, the lung contamination with foodborne pathogens that may be present on birds' heads/feathers could be assumed to occur. Normally, lungs of slaughtered poultry are treated as inedible. However, if the contamination of lungs with pathogens indeed occurs, it is not known whether the pathogens are transferred to edible tissues of stunned birds. The risks probably cannot be excluded in birds dealt with in this Opinion (*i.e.* ducks, geese and quail), but the same also apply to other poultry species (*i.e.* broilers and turkeys) where electrical stunning bath method is used.

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13. ACKNOWLEDGEMENTS

We also would like to thank **Leisha Hewitt** for the proofreading.
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The declarations of conflicts of interest of all participants in this working group will be available on internet, in the EFSA web site (http://www.efsa.eu.int)