Food and Agriculture Organization of the United Nations

Livestock transportation and slaughter practices

Practical guidelines for Asia and the Pacific region

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Overview

These guidelines apply the principles of animal welfare to the transport and slaughter process, to enable improvements in animal welfare to be initiated. The publication identifies the main animal welfare risks associated with livestock transport and slaughter, and presents guidelines on how to mitigate against the risks, encouraging continuous animal welfare improvement. It also presents an insight into the animal-based measures that can be used to objectively assess animal welfare. These guidelines were drawn up following the recent development of two regional publications on climate-smart livestock and backyard farming and slaughtering by the Food and Agriculture Organization of the United Nations (FAO) (2021a; 2021b).

Acknowledgements

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Abbreviations and acronyms

ASEL	Australian Standards for the Export of Livestock
FAO	Food and Agriculture Organization of the United Nations
SDGs	Sustainable Development Goals
WOAH	World Organisation for Animal Health

1. Introduction

1.1 Purpose of the guidelines

Live animals have been traded for thousands of years, from a simple exchange of animals between neighbours to modern trade in animals over vast distances. The nature of commercial livestock production and trade is such that livestock, at some point, undergo transportation from the farm of birth to a finishing system; to and from markets; to the abattoir or place of slaughter. Livestock production systems in Asia and the Pacific are becoming increasingly stratified, with several livestock movements or transfers between production and slaughter, however the vast majority of livestock are still farmed in a traditional manner. Reducing the number of steps and planning animal movement carefully can reduce the risk to animal health, animal welfare and foodborne disease. Reducing duration and frequency of transportation, whilst optimizing transportation conditions (and therefore improving animal welfare outcomes) will also invariably reduce greenhouse gas emissions.

These guidelines cover the transportation process for cattle, pigs, goats, sheep and poultry, with an emphasis on land transportation, following two guidelines on climate-smart livestock and backyard farming and slaughtering (FAO, 2021a; 2021b). It also examines how pre-slaughter treatment, stunning and slaughter can compromise animal welfare by exposing livestock to conditions that result in pain, fear and distress. The guidelines do not cover further processing once death has been confirmed.

Transportation is potentially hazardous for animals, regardless of whether travel is between or within countries, or by road, rail, air or sea. However, there are ways in which we can identify risks to animal welfare, and suggest suitable alternative conditions which would result in acceptable animal welfare outcomes.

1.2 Animal welfare and the United Nations Sustainable Development Goals

In 2015, the United Nations (UN) adopted a set of goals that present a future in 2030 without poverty and hunger, and safe from the worst effects of climate change and loss of biodiversity (United Nations, 2015). These Sustainable Development Goals (SDGs) have a wide scope; however, the welfare of animals is not mentioned directly. Nevertheless, there are obvious areas where animals play an important role in the context of sustainable development. These include food security, transport, employment and livelihoods as covered by SDGs 1, 2, 3, 5, 8, 12, 13, 15 and 17. Animal welfare and health also represent one of the four sustainability domains of the Global Agenda for Sustainable Livestock (GASL) to better focus actions in support of achieving the SDGs.

The One Welfare approach can contribute to the achievement of the SDGs as it addresses the idea that animal welfare decisions cannot be taken without concern for the broader impact on human well-being and the environment. Similarly, One Welfare also complements One Health, a concept adopted by the Global Animal Welfare Strategy (2017) of the World Organisation for Animal Health (WOAH, founded as OIE), which "recognizes that human health and animal health" are interdependent and bound to the health of the ecosystems in which they exist. Good animal welfare has a direct and indirect beneficial financial impact, helps to reduce poverty and has gender implications, as it is women who often care for livestock.

1.3 World Organisation for Animal Health

The World Organisation for Animal Health international guidelines for animal welfare are contained within the Terrestrial Animal Health Code (WOAH, 2021) (hereafter referred to as the WOAH Code). The WOAH Code describes the guiding principles based upon the five freedoms and the basic principles and minimum standards of welfare that are accepted by Member Countries. There are chapters within the WOAH Code that cover livestock transport by sea (Chapter 7.2), land (Chapter 7.3) and air (Chapter 7.4). These chapters describe various aspects which need to be taken into consideration before moving animals. They outline responsibilities, required competencies, planning the journey, management of the pre-journey period, loading, conditions during the journey, unloading and post-transportation handling, contingency measures and species-specific issues. There is also a chapter which focuses on the slaughter process (Chapter 7.5). Fundamental information from this publication is referenced throughout these guidelines.

Summary section 1: Introduction

This section presented an introduction to the guidelines. It included:

- An overview of the purpose of the guidelines.
- Insight into the relationship between animal welfare and the UN SDGs.
- An introduction to the Terrestrial Animal Health Code (WOAH, 2021).

2. Principles of animal welfare

2.1 Animal welfare definitions

There are many definitions of animal welfare, but an underlying principle of most of them is providing for an animal's physical and mental well-being (Hewson, 2003). Negative experiences should be avoided as much as possible and positive experiences encouraged. WOAH defines animal welfare as follows (2021):

> *Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and appropriate veterinary treatment, shelter, management and nutrition, humane handling and humane slaughter or killing. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment.*

The five freedoms, developed by the Farm Animal Welfare Committee (FAWC, previously known as Farm Animal Welfare Council) are timeless principles of animal welfare (Table 1). They represent a set of key animal welfare outcomes and the provisions needed to achieve these outcomes. The five freedoms have been used to create an approach to animal welfare assessment, which focuses on the outcomes in the animal itself, rather than just on the resources that we provide for it. The provisions associated with each of the five freedoms have also been recently refined – within a framework called the "Five Provisions of Animal Welfare" (Mellor, 2016) to include reference to the overall animal welfare aims.

Table 1. The five freedoms

Animal welfare outcome	Associated provisions	Welfare aims (Mellor, 2016)
1. Freedom from hunger and thirst	By ready access to a diet to maintain full health and vigour.	Minimize thirst and hunger and enable eating to be a pleasurable experience.
2. Freedom from discomfort	By providing a suitable environment, including shelter and a comfortable resting area.	Minimize discomfort and exposure and promote thermal, physical and other comforts.
3. Freedom from pain, injury and disease	By prevention or rapid diagnosis and treatment.	Minimize breathlessness, nausea, pain and other aversive experiences, and promote the pleasures of robustness, vigour, strength and well-coordinated physical activity.
4. Freedom to express normal behaviour	By providing sufficient space, proper facilities and company of the animal's own kind.	Minimize threats and unpleasant restrictions on behaviour and promote engagement in rewarding activities.
5. Freedom from fear and distress	By providing conditions and treatment which avoid mental suffering.	Promote various forms of comfort, pleasure, interest, confidence and a sense of control.

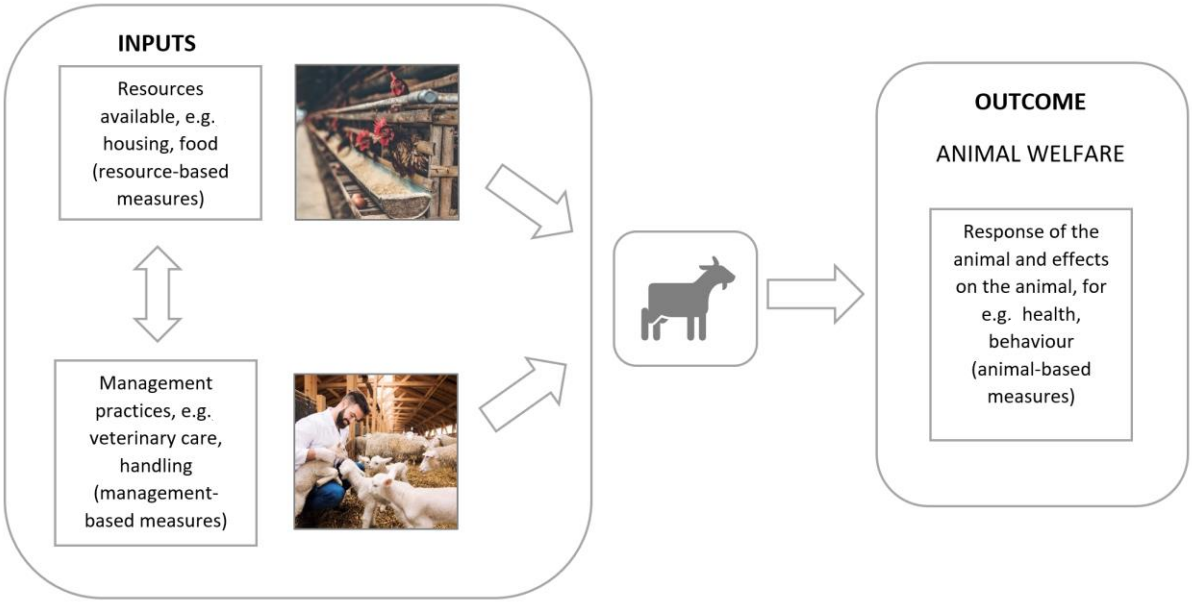
Source: Adapted from Mellor, D. J. 2016. Moving beyond the "Five Freedoms". MDPI Publishing https://www.mdpi.com/2076-2615/6/10/59; and the Farm Animal Welfare Committee (FAWC). 2009. FAWC Report on Farm Animal Welfare in Great Britain: Past, Present and Future.

2.2 Animal welfare assessment

Animal welfare is a scientific term that describes a measurable quality of life. The ideal measure of animal welfare should not only indicate the absence of negative affective states, but also the presence of positive affective states.

The factors that affect an animal's welfare include its physical environment and the resources available to the animal (determined using resource-based measures), such as space allowances and housing conditions, and the farm's management practices (determined using management-based measures), such as the provision of pain relief during husbandry procedures, veterinary treatment and animal handling methods. The interplay between available resources and management practices (inputs) and the animal's welfare state (outcome) is represented in Figure 1 (adapted from the European Food Safety Authority [EFSA], 2012a). The relationship between resources, management and the resulting welfare outcome forms the basis of many global animal welfare standards.
This principle can be used to evaluate all steps of livestock production, including transportation and slaughter.

Figure 1. Relationship between resource and management inputs and animal welfare outcome



Source: Adapted from the European Food Safety Authority (EFSA), 2012a Statement on the use of animal-based measures to assess the welfare of animals. EFSA Journal, 10(6).

2.3 Pain, fear and distress

Pain can be described as an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage (Sneddon *et al*., 2014). Pain is regulated by the nociceptive system, which functions similarly in all mammalian species and birds. Differences between animals can be found in their reactions to ending, avoiding and coping with pain. The expression of pain can vary between livestock species, with prey species often not showing obvious signs. During the transport process, pain can be caused by inappropriate handling during loading and unloading, and inappropriate infrastructure on the transport vehicle. During the slaughter process itself, pain can be caused by inappropriate handling and restraint, and during incorrect stunning and neck-cutting (if stunning is not used or the animal is stunned ineffectively).

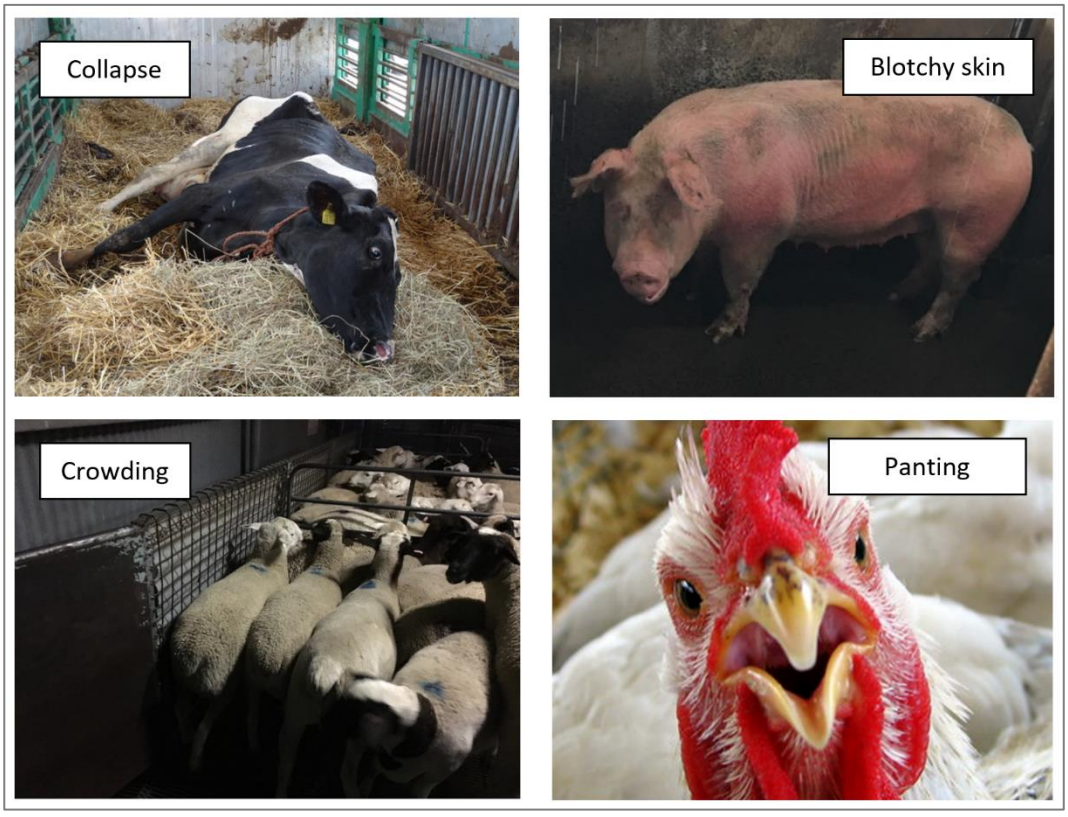
Fear is an unpleasant emotional state brought about by the perception of danger or potential danger. It involves physiological and behavioural changes that prepare the animal to cope with the situation. It can be a problem during the transportation and slaughter processes, when animals encounter novel or unexpected stimuli during confinement in vehicles, holding in lairage, handling and restraint. Many of the reactions of livestock towards humans are attributed to fear. The fear response can differ between species and animal type, causing increased agitation and activity in some animals (Table 2 and Figure 2).

Table 2. Signs of fear and distress in livestock

Cattle	Agitation, tail swishing, sweating, shaking, defecating, holding head high, vocalization, kicking, teeth-grinding, open-mouth breathing.
Goats	Holding head high, agitation, butting, persistent vocalization, open-mouth breathing.
Sheep	Agitation, butting, persistent vocalization, open-mouth breathing.
Pigs	Blotchy skin, muscle tremors, reluctance to move, shaking, open-mouth breathing, high-pitched vocalization, shaking, collapse.
Poultry	Wing flapping, piling, vocalization, tonic immobility, open-beak panting.

Source: Adapted from the European Food Safety Authority (EFSA), 2012a. Statement on the use of animal-based measures to assess the welfare of animals. EFSA Journal, 10(6); and Sneddon, L. U., Elwood, R. W., Adamo, S. A., & Leach, M. C. 2014. Defining and assessing animal pain. Animal Behaviour, 97, 201-212.

Figure 2. Photographic examples of signs of stress in livestock



The terms stress and distress are often both used to describe the response to, and impact of, the conditions that animals are exposed to. WOAH defines distress as the state of an animal that has been unable to adapt to factors which produce stress (stressors), which manifest as abnormal physiological or behavioural responses (WOAH, 2021). It can be described as either acute (short-term) or chronic (long-term), possibly resulting in pathological conditions, such as disease or even death. Common stressors associated with transportation include deprivation of food and water, heat, cold and overcrowding.

When exposed to a stressful situation, the sympathetic nervous system (SNS) is activated. Catecholamines are released increasing heart rate and respiratory rate, increasing blood flow and oxygen supply to muscles, and increasing the metabolic rate within cells. The animal may show an increase in breathing rate (and depth), muscle tremor and sweat production. The stress hormones, for example cortisol, are also produced and released by the adrenal cortex. Cortisol is one of the most widely used biomarkers to detect acute stress in livestock. Meat quality can also be affected by acute and chronic stress. After slaughter, the pH of the animal's muscles drops as glycogen is metabolized to lactic acid. If the animal is stressed at the time of slaughter (acute stress), the rate of pH decline increases, leading to a heat toughening situation in which meat tenderness, water-holding capacity and meat colour can be affected. If muscle glycogen is depleted during periods of chronic stress, for example during prolonged transportation, the ultimate pH (pHu) is high (>5.8), affecting meat tenderness, colour and water-holding capacity.

Summary section 2: Principles of animal welfare

This section presented an introduction to the guidelines. It included:

- A definition of animal welfare.
- An overview of the five freedoms.
- An introduction to animal welfare assessment and animal-based measures.
- The relationship between inputs (resources and management) and outputs (animal welfare outcome).
- An introduction to the concepts of pain, fear and distress.
- Signs of fear in livestock.
- Physiological signs of stress.

3. Introduction to the transportation of livestock

3.1 Methods of transportation

The methods used to move livestock are land transportation (by foot, road vehicle or rail), sea transportation and by air. There are inherent animal welfare risks associated with each method. These guidelines will primarily cover aspects of land transport, while referring to the specific characteristics and risks associated with transportation by sea. International guidance on sea and land transportation is provided by WOAH. The transportation of livestock by air is covered by the International Air Transport Association (IATA) Live Animals Regulations (LAR), which is recognized as the worldwide standard for transporting live animals by commercial airlines. There may also be additional specific legislations on animal transportation at national level, with conditions of transport being regulated by the animal welfare competent authority (veterinary authority or other governmental authority of a country).

3.1.1 Transport of livestock by land

Where animals are transported short distances, measures of short-term effects on animal welfare such as behavioural responses, injuries and carcass quality are often used. Ruminants, particularly sheep, tend to show less obvious signs of distress during road transport than other livestock species such as poultry. However, it is still likely to be an aversive experience. Conditions within road transport vehicles also determine the overall welfare impact on animals, with aspects such as driver competency, truck conditions, space allowance, noise, the ability to maintain balance, vibration and the thermal environment (as influenced by ventilation), and known stressors.

3.1.2 Transport of livestock by sea

Millions of livestock are exported annually by sea, with some journeys taking over a month for the animals to reach their destination. The WOAH Code (2021) contains detailed standards for the health and welfare of animals being moved across national boundaries. Transport by sea is often referred to as “short-haul” or “long-haul”, with some regulatory instruments providing an exact definition. Compared with journeys of a shorter duration, long-haul or long-distance transport by sea poses a unique set of animal welfare challenges determined by a range of animal, environmental and management factors. Evidence has shown that motion at sea can cause increased stress in sheep and pigs. One study showed that sheep that are exposed to side-to-side or up-and-down movements displayed an increase in stepping (balancing) behaviours, increased heart rate and reduced rumination; all these reactions are likely to be indicators of stress (Santurtun *et al*., 2015). During long-distance transport by sea, livestock are usually confined in group pens with access to feed and water (Figure 3).

Figure 3. Holding pen in a livestock ship used for long-distance transportation

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3.2 Process steps

The transportation of livestock is usually made up of the following process steps (described in Sections 4, 5 and 6):

- preparation for transport
- acclimatization and the withdrawal of food
- loading onto the vehicle
- confinement on the vehicle, with movement to the destination
- rest periods
- unloading from the vehicle

The transportation of animals should meet the standards outlined in the Terrestrial Animal Health Code (WOAH, 2021), observing requirements for the provision of feed and water, journey duration, weather conditions and rest periods. Within Australia, minimum rest periods are defined in the Australian Animal Welfare Standards and Guidelines for the Land Transport of Livestock (AHA, 2012) (Section 5.1). The rest time should provide animals with access to food, water and space to lie down before starting another journey. Animals should be transported only when they are fit and well enough to cope with the transport process (Section 4.1).

3.3 Risks to animal welfare during transport

The risk of poor animal welfare outcomes during transport is related to:

- the skills and knowledge of personnel involved in the transportation process;
- selection and preparation of the livestock for the journey;
- animal handling;
- loading and unloading;
- journey duration, food and water deprivation time;
- species and class of the livestock being transported;
- road conditions and terrain;
- weather conditions;
- vehicle and facility design and maintenance;
- space allowance on the vehicle;
- inability to observe the livestock during the journey and take necessary action.

These activities expose animals to stressors, resulting in poor welfare outcomes in the animal (Table 3).

Table 3. Stressors in livestock transport

Stressor	Effect
Confinement, noise, novelty	Fear
Mixing, overcrowding	Aggressive interactions, injury
Food and water withdrawal	Hunger, thirst, dehydration
Thermal conditions	Hyperthermia, hypothermia
Dust	Respiratory disease

Source: Adapted from World Organisation for Animal Health (WOAH, Founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris; and Animal Health Australia (AHA). 2012. Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock. Canberra.

Summary section 3: Introduction to the transportation of livestock

This section presented an introduction to the transportation of livestock. It included:

- An overview of the methods of transportation.
- An introduction to transport by land.
- An introduction to transport by sea.
- An overview of the process steps and the associated risks to animal welfare.

4. Preparation of livestock for transport

Livestock should be adequately prepared for any journey. Livestock stress during transportation can be thought of as cumulative, meaning that animals that are already stressed are likely to travel poorly. Preparing livestock for transportation can deliver a better animal welfare outcome, while reducing mortality and carcass quality problems, such as bruising. This section covers the key steps in preparing livestock for travel. It is usually the producer or consignor (person arranging transport) who is responsible for the welfare of animals prior to loading. The transporter or driver is usually responsible for the welfare of animals at the point of loading, during the journey and at the point of unloading.

4.1 Fitness to travel

Animals' capacity to cope with the transportation process varies with the species and physical state of animals being transported. It is important to exclude animals that are compromised by disease or injury. Livestock should not be loaded for transportation if it is likely that the animal will cope poorly with the journey as a result of injury, illness or physiological state (e.g. late pregnancy). Chapters 7.2, 7.3 and 7.4 of the Terrestrial Animal Health Code (WOAH, 2021) provide clear and detailed guidance on the assessment of an animal's fitness for the intended journey. Chapters 7.2 and 7.4 provide similar information, but in relation to the transport of animals by sea and air. Meat & Livestock Australia (MLA) have developed a useful "fit to load" guide to help livestock operators decide whether an animal is fit to be loaded for transport and for the entire journey (MLA, 2019). The "fit to load" guide is aimed at Australian production and transport system; however, it contains useful practical checklists and pictorial examples of animals that are not fit for transport. Table 4 provides a summary of the WOAH information on animals that are unfit to travel and aligns this with a basic checklist adapted from the MLA "fit to load" guide.

In poultry, the type and age of birds have an effect on their ability to cope with the transportation process. The presence of metabolic disease and injuries in both meat chickens and laying hens can be further exacerbated by poor handling during loading and inappropriate transport conditions. Inspection of poultry prior to transportation to identify diseased or ill birds is extremely important. If the animal is not fit to load then it must be treated and reassessed prior to future loading and transportation, transported under veterinary advice or euthanized.

Table 4. Summary of WOAH information on animals that are unfit to travel

WOAH Terrestrial Animal Health Code	Corresponding checklist – Is the animal fit to load?
Animals that are unfit to travel include: • those that are sick, injured, weak, disabled or fatigued; • those that are unable to stand unaided and bear weight on each leg; • those that are blind in both eyes; • those that cannot be moved without causing them additional suffering; • newborns with an unhealed navel; • pregnant animals which would be in the final 10 percent of their gestation period at the planned time of unloading; • females travelling without their young ones after giving birth within the previous 48 hours; • those whose body condition (for example, emaciated) would result in poor welfare because of the expected climatic conditions.	✓ Can the animal walk on all four legs? ✓ Is the animal free from visible signs of severe injury or distress or conditions likely to further compromise its welfare during transport? ✓ Is the animal strong enough to make the journey (i.e. not dehydrated or emaciated)? ✓ Can the animal see well enough to walk, load and travel without impairment or distress (e.g. it is not blind in both eyes)? ✓ Has it been confirmed that the animal is not in late pregnancy or too young to travel? ✓ Has the animal had adequate access to water prior to loading to meet the maximum time off water?

Source: Extracted from the World Organisation for Animal Health (WOAH, founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris, Chapter 7. 3; and Meat & Livestock Australia (MLA). 2019. Is the Animal Fit to Load? A national guide to the pre-transport selection and management of livestock. Revised edition 2019.

4.2 Acclimatization periods and withdrawal of food

For short journeys, particularly when livestock are being transported to slaughter, and during land transportation, it is common practice to withhold food (and sometimes water) prior to loading. The main objective of feed withdrawal is to reduce the probability of ingesta and faecal contamination of the carcass during processing. Depending on the time when food and water were withdrawn and the length of the journey, this may cause prolonged thirst and dehydration. In ruminants, the removal of water prior to land transportation poses little welfare risk, as long as the period of withdrawal and the climatic conditions do not result in dehydration. Without the additional stress of transport, sheep can be deprived of water for up to 72 hours in mild conditions (Cole, 2000); however, when environmental temperatures are high, dehydration can occur rapidly. In pigs, feed is often withheld for 24 hours prior to slaughter; however, for better animal welfare and meat quality, a time without feed of no longer than 12 hours is recommended (Acevedo-Giraldo *et al.*, 2020). Meat & Livestock Australia recommends that red meat livestock are held off feed for a period of 8 to 12 hours prior to transportation (MLA, 2019). It is important to note that time off water prior to loading is part of the maximum time off water for the intended journey. The period of feed withdrawal can impact production costs in terms of feed costs and loss of carcass weight as well as impact quality through carcass contamination. Although feed withdrawal is only a fraction of the total production to processing period, this process can present an opportunity for producers to increase yield, improve quality and reduce costs.

Prior to long journeys by sea, it is important to let livestock acclimatize to the feed they will be offered on-board the vessel. The 2021 Australian Standards for the Export of Livestock (ASEL) 3.2 require sheep and goats to spend around three to five days (depending on species and previous feed curfews) in a holding facility prior

to sea transport, where they are to be fed a ration equivalent in both form and composition to what they will be fed during the voyage.

4.3 Preparation for loading onto the transport vehicle for land transport

Loading onto the transport vehicle is known to cause physiological stress in livestock. It is important that highly stressful activities, for example shearing, dehorning or drenching, are not performed just before loading. Ear tagging before loading should be limited to those animals that have lost a tag and must be re-tagged for traceability purposes. Animals more accustomed to being handled by humans are likely to be less fearful of being loaded and transported (WOAH, 2021). Repeated humane handling of cattle during rearing and prior to transportation reduces their stress during the loading process (EFSA, 2004a; 2011). Methods of handling are covered in more detail in Section 7. It is recommended that, wherever possible, animals be kept in stable social groups (EFSA, 2004a; 2011). In the case of goats, groups should be kept stable and the introduction of new individuals should be monitored closely. It is important to keep horned and hornless goats separated on the transport vehicle.

GUIDELINES: Preparation of livestock for transport

- Inspect livestock carefully prior to loading to ensure they are fit for the intended journey.
- Prepare holding and loading facilities to ensure they are adequate.
- Maintain stable livestock groups.
- Always use low stress livestock handling techniques (see Section 7.1).
- Manage the time off feed and water, remembering that water should be available up to the point that livestock are loaded.
- Segregate livestock appropriately for loading and travel.
- If livestock need to be isolated during preparation for transport, ensure they are provided with vocal and visual contact with their group.
- Try to avoid undertaking any stressful husbandry procedures, including tagging, immediately before loading.

Summary section 4: Preparation of livestock for transport

This section covered the preparation of livestock for transportation. It included:

- Planning for the journey.
- An overview of fitness for the intended journey.
- A description of acclimatization and food withholding periods.
- Guidance on avoiding stressful situations prior to loading.
- The process of preparation for loading onto transport vehicles.

5. Transportation practices

5.1 Journey duration

The loading process and the initial part of the journey generally cause the peak stress response in livestock. However, after the initial physiological stressors of loading, increased transport duration may present further challenges to animal welfare. As the duration of the journey increases, animals may become more fatigued, particularly if they stand for long periods. The physiological effects of increasing transport duration by land (where feed and water are withheld) include increased live weight loss. However, some of the weight loss is likely to be gut fill, which can be recovered after feeding upon arrival at the destination. It is difficult to find data to support maximum journey times, applicable to transport types. There is little scientific research on the interaction of journey duration and journey experiences and direct impacts of journey duration on adverse welfare outcomes. As such, it is not possible to make evidence-based recommendations on the maximum journey duration for livestock. More emphasis should therefore be placed upon the actual journey conditions, rather than focus exclusively on duration. WOAH (2021) does not specify maximum journey times; however, it states that the amount of time animals spend on a journey should be kept to the minimum. The Australian Animal Welfare Standards and Guidelines for the Land Transport of Livestock stipulate the maximum time that livestock can be without water (Table 5).

Table 5. Maximum time off water and rest time

Species	Animal type	Maximum time off water (hours)	Minimum rest time (hours)
Cattle	Cattle >6 months	48	36
	Calves 30 days - 6 months	24	12
	Lactating cows with calves at foot	24	12
	Cows known to be more than 6 months pregnant, excluding the last 4 weeks	24	12
	Calves 5 to 30 days old travelling without mothers (12 hours max. journey)	18	N/A
Sheep	Sheep >4 months	48	36
	Lambs <3 months	28	12
	Ewes known to be more than 14 weeks pregnant, excluding the last 2 weeks	24	12
Goats	Goats >6 months	48	36
	Goats <6 months	28	12
	Goats known to be more than 14 weeks pregnant, excluding the last 2 weeks	24	12
Pigs	Grower/slaughter weight	24	12
	Lactating sows and piglets	12	12
	Weaners	12	12

Source: Animal Health Australia (AHA). 2012. Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock. Canberra.

5.2 Space allowance and stocking density

Space allowance (or stocking density) on the transport vehicle is one of the most important factors influencing animal welfare (Richert and Brumm, 2005). The WOAH Code (2021) does not provide specific space allowances, but recommends that the space allocated during land transportation be based on the need for livestock to lie down or stand during the journey. At commercial stocking densities, livestock are often reluctant to lie down. However, if they are provided with a greater space allowance, they spend more time lying down. At lower stocking densities care must be taken to ensure that animals can brace against each other and avoid significant movement in the vehicle. When calculating space allowance during land transportation of cattle, sheep and goats, an allometric equation relating size to body weight is recommended (Jones *et al.*, 2010). Where driving quality is good, animals at higher stocking densities are neither more nor less likely to fall or to be injured (EFSA, 2011). Floor space allowances should be increased by about 5 to 7 percent for horned cattle (EFSA, 2011). Providing sufficient floor space and head clearance for horned cattle allows them to move their heads at resting height without causing injuries to themselves and other animals in the group. Important factors to be considered in relation to space allowance and stocking density include noise produced by the vehicles or sudden noises that can startle animals and cause agitation, and vehicle movement that can affect the ability of the animals to maintain balance (up and down, side-to-side and forwards and backwards movements). Table 6 is an extract from the Australian Animal Welfare Standards and Guidelines for the Land Transport of Livestock (2012). It shows the recommended space allowances for livestock at different liveweights.

Table 6. Space allowance during land transport

Species	Liveweight (kg)	Minimum floor area (m^2/head) standing
Cattle	100	0.31
	150	0.42
	250	0.77
	350	0.98
	450	1.13
	550	1.34
	650	1.63
Sheep	20	0.17
	30	0.19
	40	0.22
	50	0.25
	60	0.29
Goats	20	0.15
	30	0.17
	40	0.22
	50	0.25
	60	0.28
Pigs	15	0.09
	25	0.12
	50	0.22
	75	0.29
	100	0.35
	200	0.61
	300	0.87

Source: Extracted from the Animal Health Australia (AHA). 2012. Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock. Canberra.

5.2.1 Space allowance during transport by sea (cattle, sheep and goats)

During long-distance transport by sea, space allowance needs to take into account an animal's ability to access necessary resources, such as feed, water and a lying area. The amount of space required, including headroom, depends on the livestock species, type and condition (e.g. pregnant, horned animals) and the length of the journey. Chapter 7.2 (Transport by Sea) of the WOAH Code (2021) requires that each animal is able to assume its natural position for transportation (including during loading and unloading) without coming into contact with the roof or upper deck of the vessel. When animals lie down, there should be enough space for every animal to adopt a normal lying posture simultaneously. It is also important that the pen density enable each animal to be observed regularly during the journey. The 2021 Australian Standards for the Export of Livestock 3.2 include space allowances for cattle, sheep and goats (Table 7) when being transported in the Asia-Pacific region and to the Middle East. It should be noted that this is the minimum pen space allocation for livestock transported by sea, which does not take into account the need to provide additional space for pregnant animals or for animals with horns.

Table 7. Space allowance during sea transport

Species	Live weight (kg)	Minimum pen area (m^2/head) - November to April	Minimum pen area (m^2/head) - May to October
Cattle	The minimum pen space allocations for cattle transported by sea are contained in a number of tables in the Australian Standards for Livestock Export (ASEL) depending on the port of origin and the time of year (see reference).		
Sheep	32	0.29	0.32
	40	0.34	0.38
	50	0.40	0.44
	60	0.45	0.49
Goats	30	0.28	0.31
	40	0.34	0.38
	50	0.39	0.44
	60	0.45	0.49

Source: Commonwealth of Australia. 2021. Australian Standards for the Export of Livestock 3.2. Australian Government. Department of Agriculture, Water and the Environment. Canberra, April.

5.3 Thermal environment

Transportation of any type involves exposing livestock to a change in their thermal environment. Establishing the impact of the thermal environment on animal welfare requires an understanding of the animal's thermoneutral zone. The thermoneutral zone is defined as "the range of ambient temperature at which temperature regulation is achieved only by control of sensible (dry) heat loss, i.e. without regulatory changes in metabolic heat production or evaporative heat loss" (IUPS Thermal Commission, 2001). In simple terms, this means the range temperature in which normal metabolism provides enough heat to maintain a constant body temperature in warm-blooded animals. At ambient temperatures outside of the thermoneutral zone, livestock need to maintain their body by employing strategies that balance heat production with heat loss (e.g. shivering will produce heat whereas panting will help the animal lose heat). Maintaining the thermoneutral zone can be influenced by several animal-related factors, such as:

- acclimatization (the process or result of becoming accustomed to a new climate or to new conditions);
- feed intake;
- the body condition of the animal;
- the type of hair coat (e.g. thick winter coat versus summer coat);
- whether the coat is wet, dry or muddy;
- pigmentation of the hide and hair (e.g. dark vs light-coloured animals).

When an animal is exposed to cold conditions (lower critical temperature) it will employ strategies to maintain its body temperature (e.g. shivering). Cold stress occurs when an animal is exposed to conditions below its lower critical temperature. As the ambient temperature rises, an animal's upper critical temperature will be reached. This is the ambient temperature above which thermoregulatory evaporative heat loss processes occur (e.g. panting). During extremely high ambient temperatures, an animal will struggle to lose excess body heat through evaporation (through panting). The situation can be exacerbated if humidity is high or air flow is low (e.g. no breeze).

Mortality caused by heat stress during land transport rarely occurs in cattle, sheep and goats, though adequate ventilation in the vehicle is essential. When a transport vehicle is stationary, the temperature inside usually rises within the stationary vehicle, increasing the risk of heat stress. Transporting animals during the cooler part of the day can also reduce the risk of heat stress and decrease mortalities.

During the transport of livestock by sea from cooler to warmer regions, heat stress can present a significant challenge. The 2021 ASEL 3.2 includes a requirement for a heat stress risk assessment (HSRA) which combines weather statistics, vessel parameters and animal heat tolerance factors to determine the optimal pen space allocation for livestock for a specified voyage and predicts the risk of mortality or heat stress.

Livestock experiencing heat stress may show some or all the signs of respiratory distress (panting and open-mouthed respiration), sweating, drooling (Figure 4), tongue out, head down, anxious eyes or a hunched posture. Action can include relocating animals to better ventilated areas, reducing the stocking rate in the pen, providing access to water, treating concurrent disease and spray wetting (Table 8). Cattle are generally more prone to heat stress than sheep or goats.

Figure 4. Signs of heat stress in cattle include excessive drooling (salivation)

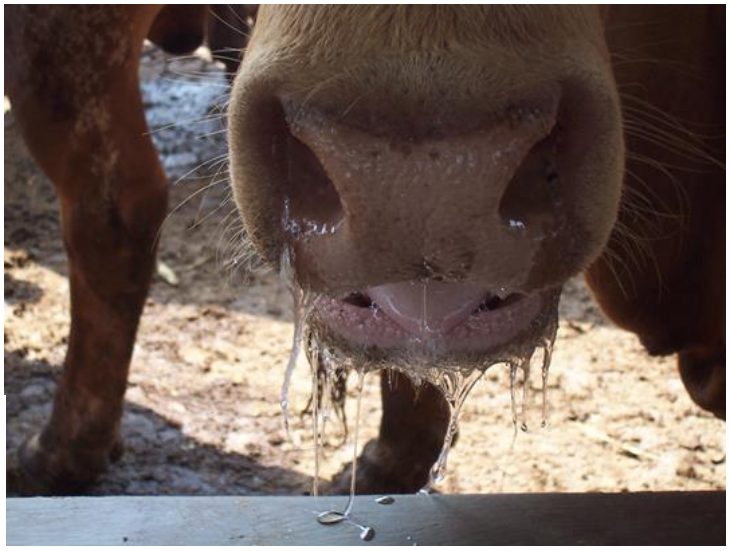

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Table 8. Wetting cattle during sea transport to alleviate heat stress

Spraying cattle with water can help alleviate heat stress when ventilation and air movement is good. The following points are important:

- start the spraying protocol when high risk weather conditions are predicted – sea or fresh water can be used;
- apply spray to the head and the neck;
- don't wet during ventilation failure or poor air movement;
- don't disturb the cattle if they are resting;
- don't use cold water (<25 °C);
- continue with spraying until respiratory stress has eased.

Poultry and pigs are very susceptible to heat stress during the transport process. The thermoneutral zone of chickens (within which the bird is thought to be comfortable and does not need to expend any effort to keep warm or lose heat) is thought to be around 20-25 °C. Thermal stress is influenced by bird weight, fat cover, feather cover as well as air movement, radiation (such as sunlight) and conduction (heat loss through contact with a surface, for example the transport crates). Birds may attempt to adjust their body temperature by altering their posture, for example spreading out their wings and standing when hot. Heat stress and mortality increases when birds are held in crates whose space allowance is inadequate for adopting these postures. Ambient temperatures above 17 °C during transportation and subsequent lairage have been shown to increase mortality in chickens held in crates. The upper limit in a transport container for meat chickens should be 24-25 °C assuming a relative humidity of 70 percent or higher (EFSA, 2011). Pigs also have an optimum temperature range, which lowers as the animal gets older and heavier. As such, the effects of heat stress are significantly more concerning for older finishing pigs and adult stock than for younger animals. A combination of cold ambient temperatures and wind speed can also create a significant risk of wind chill for pigs, with older cull animals being particularly susceptible. Indicators of inadequate thermal comfort can include observations of behaviours such as huddling, shivering, panting and colour of the skin. In slaughter weight pigs (approximately 80–120 kg), the thermoneutral zone varies between 15–28 °C at a humidity between 40 and 80 percent.

GUIDELINES: Transport practices

- When transporting poultry, adjust stocking densities in crates according to thermal conditions. For example, in hot conditions increase the space available to allow birds to spread their wings.
- Monitor temperature and, if possible, adjust environmental conditions, using fans and misting, if necessary.
- For cattle and sheep, calculate stocking densities according to an allometric equation relating size to body weight.
- Maintain adequate ventilation on the vehicle. This can be aided by keeping the vehicle moving and limiting times that the vehicle is stationary.
- During transport by sea, develop protocols for wetting cattle to alleviate heat stress.

5.4 Provision of feed and water

Weight loss during transportation is primarily attributed to dehydration (EFSA, 2011). This is particularly significant during long land journeys, when access to water is restricted to the time spent at rest stops. Water, feed and rest are essential to living animals also during transportation, however these needs vary considerably between species and depending on environmental and transportation conditions as well as previous feed and water patterns. Live weight loss, attributable to the withdrawal of food and water over the duration of the journey, was approximately 0.21 percent per hour in pigs (Richert and Brumm, 2005). The range of weight loss in pigs, even in short-term transport, is between 4 to 6 percent (Lambooij, 2014).
Sheep raised in arid environments are well adapted to minimize water loss in urine and faeces. Indigenous breeds balance their water requirements at a more economic level and therefore appear to cope better where water availability is limited (Schoeman and Visser, 1995). However, under conditions of heat stress, they thermoregulate by panting which increases the risk and the rate of dehydration.

Several studies have confirmed differences between sheep and goats in their water consumption and water conservation capacities, with goats better adapted to withstand dehydration than sheep under dry climatic conditions. For goats, the novel environment during pre-slaughter holding is likely to be a stronger stressor than feed and water deprivation. EFSA (2011) recommended that healthy adult sheep transported under good conditions can tolerate food and water deprivation up to 48 hours, but adult cattle should not be transported longer than 29 hours without food and water due to fatigue and physiological changes.

Under the Australian Animal Welfare Standards and Guidelines for the Land Transport of Livestock, the maximum time off water is 48 hours for cattle and goats over the age of six months and sheep over the age of four months. For adult pigs, the maximum time off water is 24 hours. Following this maximum time off water, livestock are required to be provided with a rest period (during which livestock are provided with water, feed and space to lie down) of 36 hours for cattle, sheep and goats, and 12 hours for pigs before starting another journey (Table 13).

During long distance transport by road, rest stops are sometimes mandated in regulatory requirements. The WOAH Code (2021) stated that a rest stop is an opportunity for livestock to be provided with feed and water, although it often requires livestock to be unloaded and reloaded, contributing to the compound stress of the journey. The value of short rest stops is also questionable, with some studies showing no clear improvements in welfare. Rest stops generally need to be above eight hours to provide animals with the opportunity to rest adequately (EFSA, 2011). The WOAH Code states that it is essential that the rest stops during long journeys are long enough to fulfil each animal's needs for feed and water. Livestock will often not readily drink water from unfamiliar sources in novel environments. Thus, during rest stops all livestock must be provided with access to water and allowed sufficient time to drink before a subsequent journey is resumed.

When livestock are transported by sea, feed and water is usually provided as much or as often as needed (*ad libitum*). However, inanition (refusal to eat) can occur in animals that do not adapt well to shipboard rations and is thought to be a primary cause of failure to thrive during the journey. Provisions such as increased access to feed, transition feeding prior to onboarding and decreasing stress (e.g. by providing more space and reducing competition for feed) may reduce the risk of inanition. The 2021 ASEL 3.2 addresses the issue of inappetence in livestock by including requirements for a feed transition period and on-board management of affected animals.

The quality of the feed ration and drinking water is also important. Livestock will refuse soiled drinking water (Figure 5), resulting in reduced water intake and possible thirst and dehydration. Therefore, troughs should be checked daily to ensure suitable drinking water is available.

Figure 5. Contaminated water trough

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Animal-based measures can be used to monitor animal behaviours during loading, transportation and unloading (Table 9). Assessment of animals during land transport may be difficult to undertake practically, however, pen-side assessments are an effective method for the appraisal of animal welfare outcomes during transport by sea. Behavioural observations, including descriptors of demeanour (aspects of animal behaviour and body language), have been shown to correlate with physiological markers during land transport studies (Fleming *et al*., 2016).

Table 9. Animal welfare monitoring during transport and unloading

Monitoring criteria	Method	Species	Target
Falls during loading and unloading	Occurs when an animal suddenly loses an upright position, and a part of the body other than the limbs touches the ground (NAMI, 2021). Falls can be assessed in the unloading area or during handling, when moving livestock to the stunning point.	All	<1%
Condition of livestock	Injury: severe conditions in pigs, cattle and sheep including broken legs, bleeding gashes, deep visible cuts and prolapses, cancer eye. Signs of heat stress: respiratory distress (panting and open-mouthed respiration), sweating, drooling, tongue out, head down, anxious eyes or a hunched posture. Signs of cold stress: shivering, huddling/crowing, lethargy, hunched posture, loss of coordination.	All	<3% of compromised animals on the vehicle (<1% is excellent) (NAMI, 2021)
Signs of overcrowding on the vehicle	Signs of overcrowding for pigs may include: piling, excessive squealing, open-mouthed respiration, excessive numbers of fatigued animals, injured animals, dead on arrival (DOA). Signs of overcrowding for cattle, sheep and goats may include: vocalization, animals not settled, animals unable to adopt normal posture, animals standing on each other, open-mouthed respiration, excessive number of fatigued animals, injured animals, dead on arrival.	All	If any overcrowding indicators are present, the auditor may assess the loading density based on applicable industry standards (NAMI, 2021)

Monitoring criteria	Method	Species	Target
Time taken for unloading to begin	Arrivals are managed such that livestock can be unloaded immediately and are not left on stationary vehicles. The vehicle should be kept moving (to improve ventilation) until it can be unloaded.	All	85% of vehicles unload within 60 minutes of arrival (>95% is excellent) (NAMI, 2021)

Source: Adapted from the North American Meat Institute (NAMI). 2021. NAMI Recommended handling guidelines and audit guide: A systematic approach to animal welfare.

GUIDELINES: Transport practices

- Plan journeys to limit the amount of time that livestock are confined on the transport vehicle.
- Ensure that scheduled rest stops provide animals with an opportunity to drink.
- When preparing livestock for transport by sea, ensure that a pre-transport period allowing effective transition to a shipboard ration is provided.
- During long distance transport by sea, ensure that livestock are provided with palatable feed and water.

Summary section 5: Transport practices

This section covered the different aspects of transportation and transport practices. It included:

- Details on the impact of journey duration.
- An overview of space allowance and the importance of using the correct stocking density.
- Calculation and adjustment of stocking density according to thermal conditions.
- An insight into the thermal environment and the impact on animal welfare.
- Guidance on the use of animal-based measures to assess heat stress in livestock.
- Information on the provision of food and water and rest stops.
- Guidance on the use of animal-based measures to monitor animals during loading, transportation and unloading.

6. Post-transportation processes

6.1 Unloading from the vehicle

After transportation to a slaughterhouse, livestock are unloaded, inspected and placed in a holding area (usually termed a “lairage”). During these processes they are exposed to a novel environment that presents different stimuli that can cause fear and stress. Unloading is often considered to be one of the most stressful stages of transportation for livestock and the stress experienced by the animal during this time is determined by the characteristics of the species and the individual, and how it responds to handling and the environment. Animals with excitable temperaments, such as those that have had little human contact, show more behavioural signs of stress during unloading and handling.

The physical unloading process may be assumed to be stressful, but in the case of sheep there seem to be no significant effects on some of the physiological indicators of stress such as plasma cortisol concentration. Sheep and goats are particularly adept at negotiating loading and unloading ramps (Figure 6), while cattle may need more time to unload. For sheep, the physical unloading process may be assumed to be stressful, but it appears that there are no significant effects on physiological indicators of stress such as plasma cortisol concentration or body temperature. Dogs are often used during the handling of sheep, reducing the need for direct intervention between the handler and the animals. However, the presence of a dog is stressful for sheep. Cattle are more likely to baulk during unloading when there are sharp contrasts than when there are either soft or no contrasts and the presence of the noisy truck can increase baulking. Cattle also slip more when the floor is wet or muddy. Pigs appear more reluctant to move when a steep ramp, an initial step associated with a moderate slope, or a wide angle of entrance are used. Past research studies have shown that a ramp slope >20 degrees leads to an increase in heart rate, cortisol concentration, baulking behaviour and handling time, hence it is often quoted as a maximum slope in standards and codes of practice. For heavier weight pigs, such as sows and boars, a reduction in the maximum ramp slope to 15 degrees is recommended.

Figure 6. Internal ramps in a livestock ship used for transporting sheep

6.2 Emergency slaughter

Livestock that have been severely injured during transport or are fatigued might only be identified during unloading. The handling and movement of these animals, particularly if they are unable to walk, will exacerbate their pain and distress. In these cases, the unloading of these animals by any means, including use of a trolley, should be avoided and emergency slaughter should be undertaken where the animals lie and at the earliest opportunity to minimize further suffering. The ideal method for emergency slaughter depends on the species and type of animal. A method that does not require a secondary procedure, such as pithing or bleeding, is often preferred, particularly if it is being performed on a vehicle or in the lairage. Pithing is a technique whereby the brainstem is physically destroyed by passing a metal rod through the shot hole and into the brain and down into the spinal column. It is important that stockpeople understand what to expect and can correctly identify and confirm death (Table 10). If any signs of consciousness, such as vocalization, spontaneous blinking or attempts to get up occur, a backup method of slaughter must be immediately applied.

Table 10. Checking for death

After emergency slaughter has been performed, it is vital that death is confirmed before the carcass is disposed. Check for the following signs of death:

- Absence of a corneal reflex: no blink when gently touching the eyeball.
- Absence of rhythmic breathing: no repeated air movement from nostrils; no breathing movements seen when looking at the chest and abdomen.
- Pupil fixed and dilated: no contraction of the pupil when the eye is opened.
- No jaw tone: no resistance when the jaws are parted and moved.
- Flaccid tongue: tongue flaccid when gently pulled; no curling of the tongue.

Source: Commonwealth of Australia. 2021. Australian Standards for the Export of Livestock 3.2. Australian Government. Department of Agriculture, Water and the Environment. Canberra, April.

Death is a process that does not occur immediately. It may take a while for the heart to stop beating and the body to stop moving. It is important not to mistake reflex motor activity, usually seen after death, as a sign of consciousness. This is a normal part of the death process and should not be seen as an indication of pain or distress.

GUIDELINES: Post-transportation processes

- Provide livestock with sufficient time to unload at their own pace.
- Inspect livestock during unloading for signs of injury, illness and fatigue.
- Ensure that equipment and facilities are available for emergency slaughter.
- If animals cannot walk, perform emergency slaughter where they lie rather than attempting to move them using a trolley or other equipment.
- After humane slaughter, check the animal to confirm death.

Summary section 6: Post-transportation processes

This section covered post-transportation processes. It included:

- A description of the unloading process and inspection requirements for livestock.
- Information on the use of emergency slaughter for sick and injured livestock.
- Guidance on how to confirm death after performing emergency slaughter.

7. Animal handling

Poor animal handling involves the frequent use of electric goads or forces livestock to move too quickly, or through unsuitable facilities, resulting in increased stress and poorer meat quality (Grandin, 2010).

Facilities and equipment can influence animal welfare outcomes in two main ways. They can i) present a risk of injury to animals; and ii) influence the effectiveness of how animals are handled and movement through the system. Scientific evidence demonstrates that stress during animal movement and the risk of physical injury can be mitigated by ensuring that handling facilities are well designed and operated. The WOAH Code (2021) describes several common distractions and presents examples of solutions that can be used to eliminate them (Table 11).

Table 11. Examples of distractions during animal handling

Examples of distractions during animal handling:

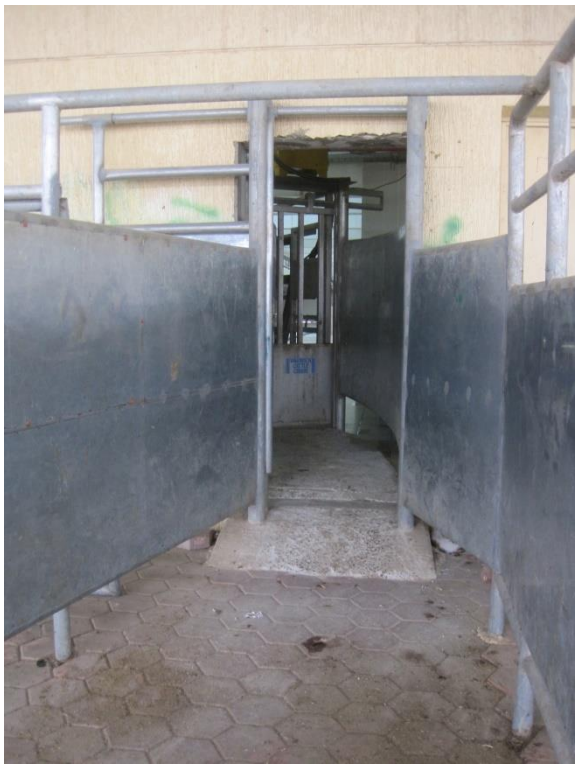
- reflections on shiny metal or wet floors;
- dark entrances to chutes, races, stun boxes or conveyor restrainers;
- animals seeing moving people or equipment up ahead;
- dead ends;
- chains or other loose objects hanging in chutes or on fences;
- uneven floors or a sudden drop in floor levels at the entrance to conveyor restrainers;
- sounds of air hissing from pneumatic equipment;
- clanging and banging of metal objects;
- air currents from fans or air curtains blowing into the face of animals.

Source: World Organisation for Animal Health (WOAH, founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris, Chapter 7.5.

Many guidelines around the world recommend non-slippery flooring, the elimination of obstacles and distraction and good lighting. Livestock tend to move better through a facility if visual distractions such as reflections on shiny metal, dangling chains, moving equipment or people up ahead are removed. Sharp contrasts, changes in lighting or light reflections are known to cause animals to baulk during handling. It has also been shown that insufficient light intensity (less than 160–215 lux) at the entrance of the stunning area increases the hesitancy of animals (Grandin, 2010). The use of different coloured lights to improve animal movement has been investigated, with anecdotal reports that green lighting reduces shadows on the floor and improves ease of handling.

Livestock are typically moved in groups from the lairage first and later in a single file for restraint and stunning (Figure 7). One of the most common mistakes is attempting to handle too large a group of animals. Livestock will enter a single file race more easily if crowd pens are not filled to capacity, allowing individuals space to adjust their position in preparation to follow a lead animal. Animals will move more willingly when they have visible and audible contact with each other. Handling an isolated animal can be difficult. A single animal that has been separated from the flock or herd will often become agitated while attempting to return to the group.

Figure 7. Cattle handling facility with single-file race leading up to restraint



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GUIDELINES: Animal handling facilities

- Ensure that flooring is non-slippery, easy to clean and kept clean. Flooring should be as flat and as even as possible across the whole lairage.
- Ensure that passageways are wide enough to allow animals to move in groups for as long as possible.
- Remove distractions from areas where livestock are being handled.
- Check the handling facilities for hazards, for example sharp edges and pointed objects, that could cause injury to livestock.
- Prevent or reduce sudden noise, such as shouting and banging of equipment.

Recent attention has focused on the actions of animal handlers themselves in optimizing animal welfare. Personnel involved in handling and moving animals should be competent and use species-specific behavioural principles to move livestock. The attitude and behaviour of animal handlers and their interactions with animals is known to influence the animals' physiological stress response and behaviour. When animal handlers feel that they have limited control over their actions or feel under time pressure they are prone to inappropriate handling behaviours. Also, if animal handlers believe that the facilities make livestock more difficult to handle, they are more likely to use handling tools, such as electric goads.

7.1 Low stress animal handling techniques

Handling animals requires an understanding of the animal's natural behaviour. Animal handlers must be able to interpret and anticipate this behaviour. A good understanding of animal behaviour enables the job to be completed more efficiently and improves handler safety. The following animal characteristics can influence animal behaviour and subsequent ease of handling by the stockperson:

- livestock senses and the manner in which livestock perceive and react to their environment;
- flight zone (see additional description below) and herding instinct;
- fear, stress and arousal as influenced by previous experiences;
- breed and temperament;
- behaviours associated with age and sex;
- dominance (within a herd).

Low stress animal handling involves the following key principles:

- position: the animal handler's position relative to the animal and the path that the handler wants the animal to take;
- pressure: when an animal handler moves into an animal's flight zone;
- movement: when an animal handler increases or decreases body movement to influence the movement of livestock.

Effective animal handlers would position themselves at the side of the animal. That allows them to influence the movement of the animal in the preferred direction. Applying pressure by moving into the flight zone causes the animal to move. Pressure can be applied by moving towards the animal, using animal handling tools, or by making a noise. The presence of too many people or poor facilities can increase pressure to unacceptable levels, causing an animal to panic. To prevent animals from becoming stressed, applied pressure must also be released by moving away from the animal and keeping quiet and still.

Animal handlers understand the behavioural principles of the flight zone and the point of balance for moving cattle, sheep and goats (WOAH, 2021). The flight zone is an important basic concept in livestock handling and uses the principles of pressure and release as previously reported. It can be described as an area of "personal space" around an animal. Flight zones vary between species and as a result of an animal's previous experiences (Grandin, 2016).

Poultry are generally fearful of human contact and handling itself can raise their stress levels (Wein *et al*., 2017). On-farm, fearfulness can potentially be reduced through appropriate habituation, however this may not be as significant during transportation and during pre-slaughter processes, when birds are exposed to many novel stimuli. In the Farmed Bird Welfare Science Review (Nicol *et al*., 2017), it was reported that meat chickens which experienced "pleasant" human contact (gentle stroking) showed reduced fear reactions to transportation compared to a control treatment (no contact). Studies have shown that picking birds up individually by their sides is ideal and better for bird welfare than catching methods that involve picking and holding birds by the legs, although this is not commercially viable in some countries with high labour costs.

GUIDELINES: Animal handling methods

- All animal handlers need to be competent (have the appropriate knowledge and skills to handle livestock) or work under supervision until competent.
- Use low stress livestock handling techniques, appropriate to the species of livestock being handled.
- Dogs are not to be used in close quarters with livestock and should be limited to open areas where animals have room to move away.
- Dogs are not to be used for pigs, calves or young animals (generally considered to be less than three months of age).
- Limit handling of poultry and carry birds in an upright position whenever possible.

7.2 Appropriate use of handling aids

Handling aids are often an essential part of livestock handling. They are meant to be an extension of the body and never to physically hit an animal. It is important that all stockpeople are trained in the correct use of these instruments. A variety of handling aids are available, and they are usually selected based on what is suitable for the animals being moved, the design of the system and any legal and commercial constraints.

Traditionally, sticks are the most common type of handling aid used by farmers and stockpeople. Although useful as an extension of the arm, their misuse has the potential to compromise animal welfare and quality. Where sticks are used, they must be light, only be made of wood and must not be modified in any way that could cause pain or injury to an animal. The use of polypropylene pipe as a handling aid must be avoided, as even a light tap on the animal can cause bruising below the skin.

An electric goad (or prodder) is a device designed to deliver an electric shock to livestock to make them move. There are legal restrictions on the use of electric goads in some countries and many assurance schemes prohibit or limit the use of electric goads particularly during transport, but also in the abattoir. The WOAH Code (2021) does not allow the use of electric goads on sheep.

Electric goads should only be used when other methods have proven unsuccessful. The WOAH Code recommends that only battery-operated goads be used and also states that electric goads should not be used on sheep and goats of any age, and very young animals. Electric goads must never be applied to the sensitive parts of the animal, such as the eyes, ears, nose, rectum, genitals or udder.

GUIDELINES: Appropriate use of an electric goad

- Electric goads must only be used on adult cattle (over three months of age).
- Electric goads must not be used on sheep or goats.
- Electric goads must only be used when livestock have room in which to move.
- Electric goads must only be used on the hindquarters.
- Electric goads must not be used on the sensitive parts of the animal (eyes, muzzle, anus, vulva, testes).
- When using an electric goad, you must follow regulation and workplace instructions.
- Electric goads must only be powered by battery or low voltage electricity.
- The application should be regulated to ensure that the shock delivered lasts no more than one second.
- Electric goads must not be applied multiple times on the same animal.

The WOAH Code (2021) lists handling principles for applying electric goads or other handling aids. It also prohibits the use of certain painful procedures, such as:

- whipping;
- kicking;
- tail twisting;
- use of nose twitches;
- pressure on eyes, ears or external genitalia;
- use of goads or other aids which cause pain and suffering (including large sticks, stick with sharp ends, lengths of metal piping, fencing wire or heavy leather belts;
- throwing and dragging animals (e.g. throwing animals from trucks).

Dogs are commonly used in Australian sheep abattoirs, reducing the need for direct intervention between the handler and the sheep. However, the presence of a dog is stressful for sheep. It has been recommended that dogs are not to be used in close quarters with sheep, and should be limited to pastures, large pens and other open areas where animals have room to move away (Grandin, 2010).

7.3 Monitoring handling

A simple monitoring system can be introduced to assess the effectiveness of the handling system, including the skill of the animal handler. Monitoring different animal-based measures associated with handling, such as vocalization and bellows helps to determine whether practices are improving. Reducing the use of electric goads will improve animal welfare. Applying an electric goad to an animal significantly raises its heart rate and many other physiological measures and affects product quality. The use of an electric goad should be recorded so that trends can be identified. Such records can help highlight any areas of the handling system that need improvement to facilitate the passive movement of animals through the system. Table 12 presents some animal welfare monitoring criteria and suggested targets that can be used.

Table 12. Animal welfare monitoring during handling

Monitoring criteria	Method	Species	Target
Falls	Occurs when an animal suddenly loses an upright position, and a part of the body other than the limbs touches the ground (NAMI, 2021). Falls can be assessed in the unloading area or during handling, when moving livestock to the stunning point.	All	<1%
Vocalization	Moo or bellow in cattle as a consequence of direct active handling in the race or crowd pen (NAMI, 2021). The assessment of vocalization during the handling of cattle is to be carried out when an individual animal is under active and direct handling. For example, during movement into the stun box.	Cattle	<3%
Use of electric goad	Touching an animal with an electric goad is counted, whether a shock is delivered or not. Do not count multiple applications of the goad on a single animal as individual events.	Cattle	<25%

Source: Adapted from the North American Meat Institute (NAMI). 2021. NAMI Recommended handling guidelines and audit guide: A systematic approach to animal welfare.

Summary section 7: Animal handling

This section covered animal handling. It included:

- A description of low-stress livestock handling practices.
- An overview of animal handler competency requirements.
- An insight into the impact of animal handling on animal welfare and the appropriate use of handling aids.
- Guidance on the correct procedures for the use of electric goads.
- An overview of prohibited handling procedures.
- Guidance on methods that can be used for monitoring handling, together with suggested acceptable targets.

8. Introduction to the slaughter process

The livestock slaughter process is usually made up of the following process steps (FAO, 2008):

- holding prior to slaughter;
- restraint;
- stunning;
- slaughter (sometimes referred to as sticking) and bleeding.

For the slaughter process to be humane, it is essential to render an animal immediately unconscious to pain, discomfort and distress. Details on basic slaughterhouse and abattoir development: options and designs for hygienic basic and medium-sized abattoirs and backyard farming and slaughtering have been described (FAO, 2008; 2021b).

The risk of poor animal welfare outcomes during the slaughter process is related to:

- competency of personnel involved in the slaughter process;
- animal handling;
- food and water deprivation time;
- species and class of the livestock being slaughtered;
- facility design and maintenance;
- space allowance in the lairage;
- washing livestock, for example using hoses;
- restraint for inspection and verification of identification;
- penning and social separation or mixing with unfamiliar animals;
- ability to observe the livestock during the holding period and take necessary action;
- restraint for stunning and slaughter;
- stunning and slaughter conditions.

The following sections cover each process step: identifying animal welfare risks and suggesting approaches that can be used to initiate animal welfare improvement.

9. Holding prior to slaughter

The term “lairaging” is used to describe the holding of animals in stalls, pens, covered areas or fields associated with the slaughter operation. It often represents the time between the animals being unloaded from the transport vehicle and being moved to slaughter. In the case of poultry, they may be held in containers on the vehicle during the lairage period. For some livestock species, the lairage may allow them to recover from some of the rigours of transportation, however this outcome is not evident in all livestock. General provisions for lairage conditions are detailed in Chapter 7.5 of the WOAH Code (2021). Conditions during the holding period will strongly influence the animal’s ability to rest, for example noise or activity in the area.

Several characteristics of the lairage environment must be considered during the design and operation of the lairage (Figure 8). These include space allowance, pen configuration, floor conditions (including bedding), food and water, cooling equipment, lighting, noise and holding duration. The lairage areas need to be free from any hazards that may cause injury to livestock during the holding period, or when they are being handled.

Figure 8. The lairage environment showing pen design and non-slippery flooring

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9.1 Lairage facilities

In the lairage, animals are usually provided with water, though it is more common to withhold food unless they are being held for a prolonged period. The WOAH Code (2021) recommends that animals held for longer than 12 hours should be fed, although a 24-hour period before feeding is undertaken is more typical. Lack of water provision as well as inappropriately designed or constructed drinking points that prevent continuous access to water can exacerbate thirst and dehydration. Feeding and drinking equipment should be designed and constructed to allow all animals to have access.

Space allowances in lairages must provide livestock with the opportunity to rest prior to slaughter. Studies of lying and drinking behaviours of livestock with different space allowances shows the more space provided, the more time animals spend lying down. For animals to actively drink whilst in the lairage, space allowances may need to be increased even further. For example, for sheep, the optimal space allowance to ensure adequate hydration for sheep may be greater than 1 m^2/head.

An abattoir is typically a noisy environment, with noise originating from machinery, handling facilities, animals and sometimes personnel. The noise levels in lairages are often greater than livestock might have been

accustomed to on a farm. Noises such as barking dogs, banging gates, whistles and rattles can have a negative effect on animal movement. Loud noises have been shown to increase stress responses in livestock, with intermittent sounds being more disturbing than continuous background noise.

The lairage environment should provide livestock with protection against adverse weather conditions. Heat stress is an important consideration for most livestock species during any holding period. If the lairage temperature is above an animal's thermoneutral zone (checked by measuring temperature and observing animal-based measures such as panting), action to cool animals should be undertaken. Low ambient temperatures in the lairage may lead to cold stress (as indicated by shivering and huddling behaviour). The provision of bedding material may help to alleviate the effects of the cold.

Placing poultry in a well-ventilated location, with protection from direct sunlight and inclement weather can prevent negative welfare consequences (Grilli *et al.*, 2015). Lighting is often kept at a low level in poultry lairages as it is thought to reduce bird activity in the crates. As cited in a recent review (Nicol, 2017), dim lighting (<5 lux) has been associated with reduced activity compared to brighter lighting (20–320 lux). The authors suggested that light intensity may be reduced in areas where birds are resting.

9.2 Holding duration

In terms of rest in the lairage prior to slaughter, there is an assumption that better welfare and meat quality outcomes in cattle, sheep and goats are associated with longer rest periods. This has been found to be the case in these species, but to a limited extent. It is difficult to draw firm conclusions on actual optimal lairage durations, and the interactions between transport duration and environmental conditions may well need to be taken into account. For cattle, most research suggests that lairage periods greater than 3 hours can be beneficial in terms of recovery, but lairage periods greater than 36 hours provide no further benefits. In sheep, a lairage period of 6 to 12 hours post transportation has resulted in better meat quality, whilst researchers have found that a duration of around 15 hours in an appropriate lairage facility enables sheep to fully recover from the stress of being transported. This information is summarized in Table 13. Animal-based measures, such as those shown in Table 14, can be used to assess the poultry welfare consequences of the holding period in the lairage.

Table 13. Optimal holding times prior to slaughter

Species	Lairage time
Cattle	>3 hours but <36 hours provides cattle with the opportunity to rest and recover if the conditions are appropriate.
Sheep and goats	6-12 hours post transportation has resulted in better meat quality in sheep. There is limited published research on the optimal lairage time for goats, however, it could be considered similar to that for sheep.
Pigs	1-3 hours deemed to be optimal time for welfare and quality. Above 24 hours has been shown to increase pork toughness (Zhen *et al.*, 2013).

Source: Commonwealth of Australia. 2021. Australian Standards for the Export of Livestock 3.2. Australian Government. Department of Agriculture, Water and the Environment. Canberra, April; and Zhen SB, Liu YR, Li XM, Ge KS, Chen H, Li C, et al. 2013. Effects of lairage time on welfare indicators, energy metabolism and meat quality of pigs in Beijing. Meat Science. 2013;93(2):287-91.

For poultry, that are usually held in their transport crates prior to slaughter, extending the time between catching and slaughter (that is, a combination of transport duration and holding time) has an impact on mortality. Increasing the time spent in crates above four hours was shown to increase the number of broiler chickens dead on arrival.

GUIDELINES: Holding prior to slaughter

- Unload livestock from transport vehicles as soon as they arrive at the facility.
- If livestock cannot be unloaded immediately, their condition needs to be monitored to ensure that action can be taken should they show signs of stress (particularly heat stress).
- Provide livestock with an environment in which they are thermally comfortable.
- If the temperature of the holding area is above an animal's thermoneutral zone, take action to cool livestock.
- Provide a lairage period and suitable holding conditions which allow livestock to recover from the stress of the transport process.
- For poultry, aim to keep the holding period as short as possible to reduce the mortality of birds in their crates.

Table 14. Animal-based measures for poultry in lairage

Measure	Cause of poor welfare
Death	Heat stress, cold stress
Panting: breathing with short, quick breaths with an open beak	Heat stress
Bunching together on one part of the available floor space	Fear
Piling: birds crowding against and on top of each other	Restriction of movement, cold stress
Presence of urates or orange cast on the floor of containers	Prolonged hunger

Source: European Food Safety Authority (EFSA). 2012a. Statement on the use of animal-based measures to assess the welfare of animals. EFSA Journal, 10(6).

Summary section 9: Holding prior to slaughter

This section covered the lairage environment and pre-slaughter handling. It included:

- A description of the lairage environment and its impact on animal welfare.
- An overview of appropriate lairage conditions, including space allowances and holding duration.
- Information on the thermal comfort of poultry in the lairage environment.
- Guidance on the use of animal-based measures for the assessment of poultry in the lairage.

10. Restraint procedure

10.1 Purpose and principles of restraint

The main purpose of restraint is to restrict the movement of the animal so that a procedure (stunning or bleeding) can be carried out accurately and effectively. The WOAH Code lists provisions for the restraint of animals (Table 15).

Table 15. Provisions related to restraint and containing animals

- provision of a non-slippery floor;
- avoidance of excessive pressure applied by restraining equipment that causes struggling or vocalization in animals;
- equipment engineered to reduce noise of air hissing and clanging metal;
- absence of sharp edges in restraining equipment that would harm animals;
- avoidance of jerking or sudden movement of restraining device.

Source: World Organisation for Animal Health (WOAH, founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris, Chapter 7.5.

The use of any restraining procedure will only achieve all the desired outcomes of the WOAH Code if it is performed by knowledgeable and skilled stockpeople and maintained to consistently ensure acceptable standards of animal welfare.

Traditional methods of restraint, used in small abattoirs with limited infrastructure, usually involve manual handling, the use of halters and casting. Cattle are usually led to the slaughter area using a halter or rope, which is then tied to a post, ring or rail. The halter is used to position the animal's head close to the floor and the handlers push the hindquarters to one side causing the animal to become unbalanced and fall to the ground. Often, the floor surface is smooth and cattle tend to slip, resulting in a fall to the ground with little or no coercion from the stockperson. Additional ropes are sometimes used to bind the legs and head and to aid positioning for slaughter. Binding the head and legs in this manner provides no real benefit in terms of animal manipulation and may actually increase levels of fear, stress and injury. With appropriate skills and knowledge, the traditional handling methods can be performed without inducing high levels of stress in cattle, though it is important that the prohibited methods of restraint are not used (Table 16).

The WOAH Code also specifically prohibits certain restraining methods that are considered to cause severe pain and distress (Table 16).

Table 16. Prohibited methods of restraint

Provisions relevant to restraining and containing animals:

- suspending or hoisting animals (other than poultry) by the feet or legs;
- indiscriminate and inappropriate use of stunning equipment;
- mechanical clamping of the legs or feet of the animals (other than shackles used in poultry and ostriches) as the sole method of restraint;
- breaking legs, cutting leg tendons or blinding animals in order to immobilize them;
- severing the spinal cord, for example using a puntilla or dagger to immobilize animals;
- using electric currents to immobilize animals, except for proper stunning.

Source: World Organisation for Animal Health (WOAH, founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris, Chapter 7.5.

The use of a box to restrain the animal can introduce more control to the restraint procedure and reduce overall levels of stress. Restraint boxes are usually categorized according to whether they provide active restraint (such as a neck yoke) or passive restraint (such as a shelf) of the animal's head. Group restraint is a form of passive restraint that is useful when stunning small stock (e.g. sheep, goats and young calves). Group restraint maintains animals in their social groups and reduces the need to handle individual animals and involves moving a manageable group of animals into a small pen. The limited space allows the stockperson to handle the animals effectively and apply the stunning equipment. Group restraint of sheep and goats to facilitate manual stunning is a common practice, particularly in small to medium-sized abattoirs.

10.2 The impact of restraint on animal welfare

Restraint, particularly when the animal is isolated from its conspecifics, can be extremely stressful for livestock. Restrainers are designed to allow livestock to maintain visual, tactile and audio contact with each other and can provide an improved solution. Sheep are reported to be calmer and show less distress or avoidance behaviours when presented to the stunning location using a v-restrainer (Figure 9) than when manually handled individually. The operation of v-restrainers does not require the animal to be rotated or have a head restraint applied. However, moving an animal into v-restraint can also have implications for animal welfare and is not necessarily a restraint solution that works for all facilities.

Restraint methods that keep animals in an upright position are generally favoured over those that require an animal to be inverted or laterally restrained. Research with sheep indicates that animals prefer being held in an upright position rather than being inverted. The use of active head restraint devices for cattle can be stressful for them. Cattle held in a poorly designed head restraining device exhibit higher cortisol levels than cattle stunned with their heads free. Animals remain calmer in head restraint devices when the body is also restrained. Figure 15 shows a simple restraining box for pigs, designed to hold a single animal for the application of the stunning method.

Figure 10. V-restrainer for sheep and goats

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Figure 9. Restraining box for individual pigs

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Prolonged restraint is stressful for animals, but strategies to minimize the negative impact on animal welfare can be implemented, such as facility design appropriate to the animals being handled, restraining the animal immediately before stunning, and using a blindfold or mask to quieten agitated animals. Struggling and escape behaviour is often indicative of excessive pressure, whether that be physical pressure applied by devices, or a stockperson applying pressure inside the animal's flight zone when it is unable to move away.

10.3 Restraint of poultry

A shackle line may be used for restraining poultry, which requires birds to be inverted and with their legs placed in metal shackles. The process of inversion and the compression of the birds' legs can result in pain and distress. Any pain experienced by birds during this process can be exacerbated further by the design of the shackle, rough handling, and the time period between shackling and stunning. Because of this, industry and customer standards have been set to limit the maximum time birds are kept in an attempt to reduce the impact the process has on the birds. However, research into the effect of shackling time on the welfare of the bird is limited. The WOAH Code (2021) recommends that the period of shackling is kept as short as possible and should not exceed the prescribed duration by even one minute. In smaller facilities, poultry may be restrained individually using a cone to hold the inverted bird. This has the benefit of providing additional support to the bird's body and reducing wing flapping.

GUIDELINES: The restraint procedure

- Ensure that the restraint method allows stunning and slaughter to be performed accurately and efficiently.
- Ensure that the design of the restraint equipment is suitable for the species and type of animal being restrained.
- Keep the restraint period as short as possible and only move animals into restraint when they can be stunned and slaughtered without delay.
- Use animal-based measures, such as "falling", "vocalization" (Figure 9) and "struggling behaviour" to monitor animals during restraint.
- In poultry, ensure that the design of the shackle allows for effective restraint without excessive compression of the legs.
- Keep the period of shackling as short as possible.

Summary section 10: The restraint procedure

This section covered the restraint procedure. It included:

- An overview of the purpose and principles of restraint.
- An insight into the impact of restraint on animal welfare.
- A description of the types of restraint for cattle, sheep, goats and pigs and the benefits of group restraint.
- A summary of the WOAH Terrestrial Animal Health Code provisions for restraint.
- A description of the restraint methods used for poultry.

11. Stunning

11.1 Purpose of stunning

Conscious livestock are capable of feeling pain and distress. The process of stunning livestock before slaughter induces unconsciousness which prevents animals from being exposed to any pain associated with the bleeding process. Stunning must induce a state of general unconsciousness until death occurs through the slaughter process (EFSA, 2004b). Fundamental to the definition of stunning is the meaning of "unconsciousness" which is defined as "a state of unawareness (loss of consciousness) in which there is temporary or permanent disruption to brain function" (Verhoeven *et al*., 2015).

The WOAH Terrestrial Animal Health Code (2021) defines stunning as:

> *…any mechanical, electrical, chemical or other procedure which causes immediate loss of consciousness; when used before slaughter, the loss of consciousness lasts until death from the slaughter process; in the absence of slaughter, the procedure would allow the animal to recover consciousness.*

For stunning methods that do not induce immediate unconsciousness, any alternative procedure should ensure: i) the absence of pain, distress and suffering until the onset of unconsciousness; and ii) that the animal remains unconscious and insensible until death. Stunning using gaseous methods falls into this category as unconsciousness is induced gradually. Under practical conditions, EFSA (2004b) has defined immediate (or instantaneous) as "unconsciousness occurring within 1 second" of the stun being applied.

Stunning methods are often referred to as "reversible" and "irreversible". Animals will regain consciousness after reversible methods if bleeding (or other killing method) is not performed. With methods regarded as "irreversible", the majority of animals will not recover from the stun if bleeding is not performed.

11.2 Stunning methods

11.2.1 Mechanical stunning

Mechanical stunning is a term often used to describe the application of a physical blow to the head to render an animal unconscious. The methods that are often used which fall into the category of mechanical stunning include:

- penetrative captive bolt
- non-penetrative captive bolt
- firearm (free projectile)
- blunt force trauma

The use of neck dislocation to kill poultry is also sometimes placed in this category. Penetrative captive bolt devices are designed to fire a retractable steel bolt through the cranium and into the brain of the animal, while non-penetrative devices are not designed to penetrate the skull. The desired outcome is for the bolt's impact on the skull to cause concussion and immediate unconsciousness (EFSA, 2004b). Structural damage to the brain may lead to the animal's quick death though this will vary depending on the extent of brain damage. Consequently, bleeding or some other secondary procedure should be used after an effective penetrative captive bolt stun.

Manual blunt force trauma is widely used in neonatal animals (particularly lambs and pigs). It is usually performed by holding the body or legs of the animal and delivering a percussive blow to the forehead with a hard object. Successful application of this method is dependent on the skill of the operator and their ability to

impart sufficient force to the blow. With sufficient force and accuracy, irrecoverable concussion is produced, however death is not guaranteed. Given this uncertainty around the outcome, it is recommended that the method only be used when other stunning methods are not available, and application of the percussive blow followed by bleeding. The probability of consistently achieving an immediate kill is low and there is a risk that poor application can lead to pain and distress to the animal.

Penetrative mechanical stunning is highly effective when correctly applied. The shot positions, as recommended by the WOAH Code (2021), appear to be most effective. The accuracy of the shot becomes more critical as animals mature, and also when using non-penetrative mechanical stunners. Also, usage of restraint equipment will improve shot accuracy. Non-penetrative stunning has a lower first-shot efficacy than penetrative mechanical stunning. Modern pneumatically-powered devices are as effective, perhaps even more so, than conventional cartridge-driven instruments.

The ability of captive bolt devices to deliver an effective stun is dependent on the velocity of the bolt, which can be reduced when poor maintenance can cause a build-up of carbon deposits, increasing friction when the bolt is fired. Similarly, poor maintenance of the recuperator sleeves can also reduce efficacy. Figure 11 shows the recuperator sleeves in a captive bolt device that has been used in an extremely humid environment. A grey sticky residue has built up around the recuperator sleeves due to inadequate cleaning. This residue prevents the recuperator sleeves from compressing fully upon firing, thus reducing the bolt's velocity and decreasing the likelihood of an effective stun.

Figure 11. Build-up of residue around the recuperator sleeves

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GUIDELINES: Mechanical stunning

- Select a mechanical stunning device and powerload that is appropriate for the species and type (for example sex, breed) of the animal being stunned.
- Inspect and test the equipment before use.
- Ensure that the mechanical stunning device is applied in the optimum position to improve the chance of achieving an effective stun.
- Ensure that a working backup stunner is immediately available at the point of stunning.
- Check the animals for signs of an effective stun. If in doubt, re-stun immediately.
- Dismantle, clean and lubricate captive bolt devices on a daily basis, even if they are used infrequently.

11.2.2 Electrical stunning

Electrical stunning is the passage of electric current through an animal's brain during stunning; it disrupts the brain's regular electrical activity and causes unconsciousness and epilepsy. This makes electrical stunning a humane method of rendering an animal immediately unconscious for a period that will allow death to occur through bleeding (EFSA, 2004b).

Two types of electrical stunning method are used commercially:

- electrical head only stunning, involving application of an electric current across the head;
- electrical head to body stunning, usually involving a head-to-body application of an electric current.

Depending on the frequency and amplitude of the electrical current applied, the stun will either be reversible (head-only application) or irreversible (head-to-body application that results in ventricular fibrillation).

In sheep, goats and pigs, the electrical current is usually manually applied across the head, using hand-held electrodes, while in cattle the electrical current is usually applied in an automatic system. Recent research into the electrical stunning of sheep has focused on optimizing stun parameters to ensure an effective stun without risking small haemorrhages throughout the muscle tissues, a carcass quality problem that may be associated with the use of higher electrical currents for smaller animals (Gregory, 2008). A minimum current of 1 A is recommended when stunning lambs and goats. For goat kids, lower currents may be more suitable to avoid blood splash in the carcass. Research has shown that 0.3 A resulted in epilepsy in goat kids, leading the authors to recommend that these current levels result in effective stunning (Llonch *et al.*, 2015). For pigs, the magnitude of the applied current should be 1.25–1.3 A at a low frequency (50 Hz) to meet the recommendations in published guidelines (WOAH, 2021). All electrical stunning equipment is potentially dangerous to the operator and other people in the vicinity. Particular care should be taken of the equipment, with regular checks and maintenance (each time it is used) carried out by a qualified electrician.

An animal's resistance to current flow is due to two factors: the tissues of the body and the nature of the contact between the electrodes and the skin. Keeping the resistance as low as possible will maximize the flow of electrical current, which can be achieved by applying electrodes in the correct position and maintaining constant pressure during the stun. Also, build-up of grease and dirt on the electrodes can create a high electrical resistance. Therefore, they should be cleaned regularly with a wire brush or similar after every 20 to 25 animals, and promptly replaced before they become worn out (Figure 12).

Electrical stunning of cattle is commonly used in New Zealand, although there are some concerns about their effect on meat quality when used in feedlot cattle. The systems available for cattle are generally suited to larger commercial abattoirs rather than small throughput facilities.

Figure 12. Worn and therefore unsuitable stunning electrodes

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GUIDELINES: Electrical head-only stunning

- Select electrical stunning equipment and electrical parameters appropriate for the species and type (for example size, age and sex) of the animal being stunned (Table 19).
- Inspect and test the equipment before use.
- Ensure that the stunning electrodes are applied in the position that spans the animal's brain to improve the chance of achieving an effective stun.
- Ensure that a working backup stunner is immediately available at the point of stunning.
- Check the animals for signs of an effective stun. If in doubt, re-stun immediately.
- Clean and maintain electrodes on a daily basis. Use a wire brush to clean electrodes between groups of animals.

11.2.3 Electrical water bath stunning of poultry

During stunning, electrical current passes from the electrode in the water bath through the bird to the shackle line. Water bath stunning systems can be differently designed, using a:

- deep bath of water (covering an electrode);
- shallow bath of water (covering an electrode); or
- wet electrode (wet plate system).

Electrical water bath systems used for chickens are usually designed to keep around 10 to 25 birds in contact with the water/electrode at the same time, depending on the length of the water bath, though they are usually smaller for other poultry species. In a multiple bird water bath stunning system, all the birds passing through the water bath will be exposed to a constant voltage. This means that the flow of electrical current through the bird is dependent on each bird's electrical resistance, where birds with a lower resistance receive more

current. Poor contact between the bird's legs and shackle also reduces the flow of current through the bird. There are inherent animal welfare risks associated with the use of an electrical water bath stunning system (Table 17).

Table 17. Welfare risks and compromises associated with electrical water bath stunning

- The birds are usually manually removed from their transport crates at speed which may increase the risk of rough handling prior to placement on the shackle.
- The birds are inverted which causes them stress and increases the likelihood of wing flapping.
- The shackle is likely to put pressure on the legs causing pain.
- The birds are at risk of painful pre-stun electric shocks as they approach the water bath.
- Agitated birds may occasionally struggle and avoid being electrically stunned.
- An electrical water bath system applies an electrical current to all birds simultaneously, meaning that the current delivered to each individual bird varies. This can result in some birds being ineffectively stunned.

Source: Nicol, C.J., Bouwsema, J., Caplen, G., Davies, A.C., Hockenhull, J., Lambton, S.L., Lines, J.A., Mullan, S., Weeks, C.A. 2017. Farmed Bird Welfare Science Review. Published by the Department of Economic Development, Jobs, Transport and Resources 1 Spring Street, Melbourne, Victoria, 3000.

In each electrical water bath system, birds could receive a pre-stun shock before they are stunned, and the risk could be greater at lower depths of immersion (for example with the wet plate system). Possible causes of pre-stun shocks are summarized in Table 18.

Table 18. Causes of pre-stun shocks

- A wet entry ramp that becomes electrified.
- Slow line speeds that allow the wing (or other part of the body) to enter the water before the head.
- Dipped shackle lines (where the bird descends too gradually and part of the body, for example the beak, enters the water first).
- Incorrect angle of the entry ramp.
- Birds agitated as they enter the water bath.
- Physical contact between birds on the shackle line, particularly if the birds are wet, leading to a shock from the adjacent bird.

Source: Humane Slaughter Association. 2015. Electrical Waterbath Stunning of Poultry. Humane Slaughter Association, The Old School. Brewhouse Hill Wheathampstead. Herts AL4 8AN, UK.

There is currently considerable debate among scientists about the reliability of criteria used to determine effective stunning when the current is applied to the whole bird in a water bath. The current could affect peripheral nerves and induce muscle paralysis in a bird that remains conscious. This is not the case with head-only applications.

GUIDELINES: Electrical water bath stunning of poultry

- Implement an effective shackle cleaning procedure that removes severed feet from the shackles, cleans any scale from the shackle and ensures that the shackles are wet.
- Implement procedures to ensure that injured birds and runt birds are not shackled.
- Use a shackling technique which ensures that birds are calm on the shackle line.
- Take measures to prevent birds from flapping on the shackle line, for example use of an effective breast comforter.
- Assess the prevalence of wing flapping on the line and aim to reduce the time that birds are shackled prior to stunning.
- Ensure that birds are settled on the line prior to the water bath, by removing causes of bird disturbance from the shackling line.
- Check for the occurrence of pre-stun shocks and adjust the set-up of the water bath at start-up and whenever there is a change in bird size.
- Raise and lower the bath as necessary to ensure that the head of the bird makes immediate contact with the electrode or electrified water.
- Ensure that the shackle is in good contact with the earth bar for the length of the water bath.
- When using constant voltage equipment, try to ensure that all birds receive similar current. This can be helped by ensuring that the equipment is capable of delivering high enough voltages to ensure resistance is broken down as quickly as possible.

Table 19 provides a useful summary of recommended stunning methods and the conditions required for an acceptable animal welfare outcome.

Table 19. Summary of recommended stunning methods and conditions of use

Stunning method	Species	Parameters	Recommended conditions
Non-penetrating percussive device	Cattle, sheep, goats and poultry	Follow manufacturer's recommendation for shot position and power.	Stun to stick interval: 20 seconds for cattle, sheep and goats (WOAH, 2021). Killing method for poultry: no recommended stun to stick interval.
Penetrating captive bolt	Cattle, sheep, pigs and goats	Follow manufacturer's recommendation for shot position and power.	Stun to stick interval: 60 seconds.
Free bullet	Cattle, sheep, pigs and goats	Use of correct shot position. Suitable as an emergency method as local laws allow.	Killing method: no recommended stun to stick interval.
Head-only electrical stunning	Cattle	Electrodes shall span the brain. Minimum current to produce an immediate stun.	Minimum applied current; Cattle: 1.5 A (WOAH, 2021). Calves: 1.0 A (WOAH, 2021). Stun to stick interval: 10 seconds (NAMI, 2021).
	Sheep and goats	Electrodes shall span the brain. Minimum current to produce an immediate stun.	Minimum applied current Sheep and goats: 1.0 A (WOAH, 2021). Lambs: 0.7 A (WOAH, 2021). Stun to stick interval: 10 seconds (NAMI, 2021).
	Pigs	Electrodes shall span the brain.	Minimum applied current.

Stunning method	Species	Parameters	Recommended conditions
		Minimum current to produce an immediate stun.	1.25 A (WOAH, 2021).
	Poultry	Electrodes shall span the brain. Minimum current to produce an immediate stun.	Meat chickens: 300–400 mA
Head to body electrical stun/kill	Cattle	Electrode shall span the brain and the heart. Minimum current to produce an immediate stun, to then be followed by cardiac arrest.	Minimum applied current (head electrodes). Cattle: 1.5 A (WOAH, 2021); Calves: 1.0 A (WOAH, 2021). There is no maximum stun to stick interval for stun/kill methods.
	Sheep and goats	Electrode shall span the brain and the heart. Minimum current to produce an immediate stun, to then be followed by cardiac arrest.	Minimum applied current (head electrodes). Sheep and goats: 1.0 A (WOAH, 2021). Lambs: 0.7 A (WOAH, 2021). There is no maximum stun to stick interval for stun/kill methods.
	Pigs	Electrode shall span the brain and the heart. Minimum current to produce an immediate stun, to then be followed by cardiac arrest.	Minimum applied current (head electrodes). 1.3 A (WOAH, 2021). There is no maximum stun to stick interval for stun/kill methods.
	Poultry	Electrode shall span the brain and the heart. Delivered in a water bath. Minimum current to produce an immediate stun, to then be followed by cardiac arrest.	Meat chickens: 100 mA per bird (at frequencies <200 Hz). 150 mA per bird (200-400 Hz). 200 mA per bird (400-1500 Hz); (WOAH, 2021).

Source: Extracted from the World Organisation for Animal Health (WOAH, founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris; and North American Meat Institute (NAMI). 2021. NAMI Recommended handling guidelines and audit guide: A systematic approach to animal welfare.

11.3 Assessment of effective stunning

To protect animal welfare at slaughter, it is important to assess the effectiveness of the stunning process by confirming that the animal remained unconscious right until its death. Table 20 presents a set of physical and behavioural indicators that may be used to assess the effectiveness of the different stunning methods (prior to neck-cutting).

Table 20. Assessment of effective stunning in red meat livestock - Physical and behavioural indicators

Stunning method	Physical activity	Breathing	Eyes	Head position after hoisting
Non-penetrating percussive device	Immediate collapse, followed by uncoordinated kicking.	Absent	No spontaneous blinking, eyes open, blank stare, no response to touch.	Hangs straight down, floppy.
Penetrating captive bolt	Immediate collapse, followed by uncoordinated kicking.	Absent	No spontaneous blinking, eyes open, blank stare, no response to touch.	Hangs straight down, floppy.
Free bullet	Immediate collapse, uncoordinated kicking may follow.	Absent	No spontaneous blinking, eyes open, blank stare, no	Hangs straight down, floppy.

			response to touch.	
Head-only electrical stunning	Induction of epileptic seizure where the animal collapses, becomes rigid (tonic phase), followed by gradual relaxation and uncoordinated kicking (clonic phase).	Absent, but livestock may show agonal gasping	Eyes may vibrate (nystagmus). May see downward movement of eyeballs. No spontaneous blinking.	Hangs straight down, floppy (after tonic phase). The neck/head of sheep may hang at an angle, but should be floppy.
Head to body electrical stun/kill	Animal collapses and becomes rigid (tonic phase), followed by gradual relaxation and no further movement.	Absent, but livestock may show agonal gasping	Eyes may vibrate (nystagmus). May see downward movement of eyeballs. No spontaneous blinking.	Hangs straight down, floppy (after tonic phase). The neck/head of sheep may hang at an angle, but should be floppy.

Source: Extracted from the World Organisation for Animal Health (WOAH, founded as OIE). 2021. Terrestrial Animal Health Code, OIE, Paris; and North American Meat Institute (NAMI). 2021. NAMI Recommended handling guidelines and audit guide: A systematic approach to animal welfare.

In poultry, the most reliable way to determine if a bird is unconscious is by assessing patterns of brain activity; however, this may not be a practical approach in an abattoir setting. The testing of brain-stem reflexes, such as rhythmic breathing or the nictitating membrane reflex may be used when appropriate electrical parameters are used (Table 19). However, when insufficient current is applied or higher frequencies are used, direct observations of rhythmic breathing and signs of epilepsy are not reliable indicators of unconsciousness because the current required to produce unconsciousness is higher than that needed to produce the physical signs in birds. Birds leaving the water bath may appear to be stunned though they are actually in electrically-induced paralysis. Therefore, it is very difficult to ascertain whether a bird is effectively stunned or not in a commercial setting.

Summary section 11: Stunning

This section covered the stunning process. It included:

- An introduction to the purpose and principles of the stunning process.
- A description of mechanical stunning methods.
- A description of head-only electrical stunning methods.
- A description of electrical water bath stunning of poultry.
- Information on the recommended parameters and stunning conditions.
- Guidance on the assessment of effective stunning.
- An insight into the difficulties in assessing effective stunning of poultry using physical and behavioural indicators.

12. Slaughter and bleeding processes

12.1 Slaughter method

The method used for slaughter (sometimes termed “sticking”), and consequently the blood vessels severed, varies between species of livestock. Slaughter methods either involve cutting the neck of the animal or performing a thoracic stick (which involves cutting the blood vessels close to the heart). Basic backyard slaughtering for smallholders has been described (FAO, 2021b). The WOAH Code (2021) emphasizes the importance of cutting both carotid arteries or the vessels from which they arise. When a transverse neck cut is used, the presence of “false aneurysm” or ”carotid ballooning”, where the cut end of the artery becomes blocked, can lead to reduced rate of bleeding and increase the risk of an animal that has been reversibly stunned regaining consciousness during exsanguination.

Cattle are bled either by the thoracic sticking method, where the knife is inserted into the base of the neck, close to the thoracic inlet severing the common carotid artery as it arises from the brachiocephalic trunk, or by a transverse neck cut below the jaw to sever both carotid arteries and jugular veins. The latter is preferred in some regions, however, from an animal welfare point of view, the thoracic sticking method is preferable. When stunning is used, a thoracic stick is also used when slaughtering pigs, with the knife being inserted in the midline of the neck at the depression in front of the breastbone. Sheep and goats are usually slaughtered using a transverse neck cut. When recoverable methods of stunning are used, it is recommended that the period of time between stunning and sticking (stun to stick interval) is kept as short as possible to reduce the risk of the animal recovering from the stun, with a maximum of 15 seconds being recommended for pigs, sheep and goats (EFSA, 2004b). In poultry, slaughter is performed by cutting the neck in the majority of large, commercial meat chicken abattoirs. This is performed using automatic equipment; with one or two rotating blades. In smaller facilities, necks are often cut manually.

To achieve the optimum bleed-out (rate and amount) and induce brain death as quickly as possible, both carotid arteries must be severed (Figure 13). Using a method which severs both carotid arteries is particularly important when reversible stunning methods are used (such as high frequency electrical stunning) (EFSA, 2004b). The blood vessels severed during neck-cutting can be checked practically using the techniques described in Table 21.

Figure 13. Ventral surface of a chicken’s neck showing the position of the carotid arteries

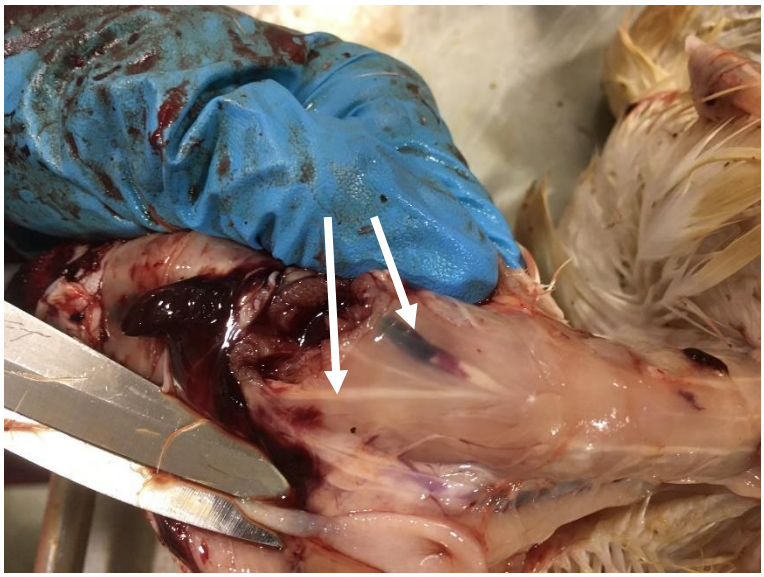

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Table 21. Practical monitoring of effective slaughter in poultry

- Perform a simple dissection of the neck to check that the carotid arteries have been severed.
- Check the time to loss of the nictitating membrane (corneal or palpebral reflex test) after neck-cutting. The shorter the time, the better the neck-cutting method.
- Monitor death before scalding using indicators including breathing, the corneal or palpebral reflex, pupil size and bleeding.

Source: The WOAH Terrestrial Animal Health Code, 2021; and FAO, 2021b. Backyard farming and slaughtering – Keeping tradition safe – Food safety technical toolkit for Asia and the Pacific No. 2. (Cobbold, R., Nampanya, S and Takeuchi, M), FAO-RAP, Bangkok. http://www.fao.org/3/cb4114en/cb4114en.pdf

12.2 Time to brain death

Cutting the blood vessels leads to a drop in blood pressure and interrupts the blood supply to the brain, reducing oxygenation and causing unconsciousness. The time to loss of consciousness and brain death in cattle can be variable depending on the slaughter method used. For all species, the optimum slaughter method, inducing the quickest time to brain death, involves the severance of both carotid arteries. Studies on rate and amount of bleed-out indicate that the stunning method used may influence the rate at which blood is lost rather than the total amount of blood lost (Kang and Sams, 1999).

In animals slaughtered using a transverse neck stick, without prior stunning, the time to unconsciousness as indicated by the animal's collapse has ranged from 20 seconds to over 60 seconds. Death of the animal can be confirmed when there is permanent absence of brainstem and activity ceases completely, indicated by the absence of breathing and eye reflexes, among other signs. After the incision of the blood vessels, no scalding carcass treatment or dressing procedures should be performed until all brain-stem reflexes have ceased.

GUIDELINES: Slaughter and bleeding

- Ensure that the slaughter methods used sever both carotid arteries or the vessels from which they arise.
- For the best welfare outcome, slaughter cattle and calves using a thoracic stick.
- Slaughter poultry using a complete ventral neck cut which severs both carotid arteries.
- Signs of death are to be confirmed before any further dressing procedure is performed.

Summary section 12: Slaughter and bleeding

This section covered the sticking and bleeding processes. It included:

- A description of the preferred slaughter methods used for different species, including the importance of severing the carotid arteries.
- Information on the effect of the slaughter method on the time to brain death.
- Guidance on methods that can be used to assess effective slaughter.

12.3 Slaughter without stunning

Published literature suggests that the act of slaughtering an animal without stunning it first may be painful to a conscious animal (Johnson *et al*., 2015). In addition, problems with restricted exsanguination as a result of false aneurysms can lead to sustained consciousness and increase the duration of the adverse welfare. Stunning prior to slaughter does not interfere with blood flow, and renders the animal unconscious during slaughter, thereby resulting in an acceptable animal welfare outcome. Although puntilla (a stab in the back of the neck to sever the spinal cord) is not recommended as a slaughter method by WOAH, it is still used in some countries. Studies have shown that animals are likely to remain conscious even after application of the method, confirming that it cannot achieve an acceptable animal welfare outcome (Tidswell *et al*., 1986).

If poultry are slaughtered without being stunned (rendered unconscious), the time to reach unconsciousness through bleeding is important, as birds will experience pain and distress until that point. Animals feel pain when the throat is cut without prior stunning. Any slaughter without stunning prior to the neck cut causes a poor welfare outcome.

13. Conclusions

Looking to the future, it is clear that increases in livestock production and efficiency will be required to meet the needs of a growing population. To this end, it is likely that there will be substantial changes in how livestock are transported and slaughtered. The impact of those methods on animal welfare will take on much greater significance, given the rise of societal expectations regarding animal welfare. Selection of the most appropriate method for use in any particular situation will require a case-by-case evaluation of aspects such as species of animal, availability of resources, operational capabilities, environmental considerations and personnel safety.

The principle that supervising and managing animals affects animal welfare is widely recognized within the livestock processing industry. Indeed, the stockperson may be the most influential factor affecting animal handling. Stockpeople require a range of well-developed husbandry skills and knowledge to effectively care for and manage livestock from arrival at the abattoir to slaughter. It has been realized that training stockpeople to improve human–animal interactions involves modification to their behaviour in addition to skills training. Practically, this involves stockpeople learning to behave in different ways by changing the beliefs and attitude that underpin their behaviour and then changing the behaviour itself. There is a clear, continuing need for the livestock processing industry to train their personnel to effectively care for and handle their stock.

Despite rapid technological advances in transport and slaughter practices, the stockperson will continue to play a pivotal role in the delivery of acceptable animal welfare outcomes. Improved animal welfare and livestock transportation will contribute to sustainable livestock development and food security; and supporting the Food and Agriculture Organization of the United Nations' (FAO) four betters (better production, better nutrition, a better environment and a better life). The four betters represent an organizing principle for how FAO intends to contribute directly to SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 10 (Reduced Inequalities) as well as to supporting achievement of the broader 2030 Agenda for Sustainable Development, which is crucial for attaining FAO's overall vision in the Asia-Pacific region and beyond.

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