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Developing a welfare assessment protocol for Australian lot-fed cattle

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Lot feeding of cattle has gained momentum in recent years to improve efficiency in meeting market demands for high quality protein. Concurrently, societal concern for the welfare of animals raised in intensive farming systems has increased. Thus, the reporting of animal health and welfare measures is a key goal for the Australian cattle lot-fed industry. Although feedlots vary in location, climate, capacity, cattle genotype, and feeding programs, many welfare concerns are applicable across the industry. Despite this, no recognised standardised animal welfare assessment protocol exists for the Australian lot-fed industry. This study aimed to identify relevant measures to develop an assessment protocol, by identifying key welfare issues and their relevant measures, considering the validity, reliability, and practicality of each when applied to the feedlot context. An advisory model was derived after reviewing the relevant literature and five international protocols for the assessment of beef cattle (Welfare Quality®, AssureWel, US Beef Quality Assurance assessment tool, Canadian Feedlot Animal Care Assessment program, and an Australian Live Export industry protocol), followed by stakeholder consultation. A total of 109 measures were evaluated, with 99 environmental-, management-, resource- and animal-based measures being proposed. Piloting of the protocol on commercial feedlots will enable further refinement and validation, to provide an evidence-based, practical protocol to facilitate standardised monitoring of cattle welfare. Such a protocol could promote continued advances in animal welfare at a feedlot level and support a sustainable industry by addressing societal concerns.

KEYWORDS

feedlot, animal welfare, animal behaviour, animal-based outcomes, benchmarking

1 Introduction

Feedlots are specialised intensive systems designed to finish cattle for domestic and/or international markets and involve the confinement of cattle in open air pens to be fed high-energy diets (Ahola et al., 2018; Salvin et al., 2020). Lot feeding of cattle in Australia has gained momentum in recent years to meet market demands for a consistent supply of high eating quality beef (Greenwood et al., 2018; Greenwood, 2021), that reflects increased global demand (Gaughan and Sullivan, 2014). Between 2020 – 2021, over 1 million cattle were on-feed at any one point in Australian feedlots (MLA, 2021).

Alongside intensification, there is rising public and consumer concern within Australia for farm animal welfare (Taylor and Signal, 2009; Coleman, 2018). On a global scale, there is concern about the impact intensive systems have on animal welfare, with confinement and space restriction being of most concern (Clark et al., 2016; Coleman, 2018). Producers in the Australian red meat industry have also recently raised concerns regarding the negative perceptions of the public (Buddle et al., 2021), with industry stakeholders recognising there is a need to improve community engagement and transparency on welfare issues (RMAC, 2016; Coleman, 2018). There are obvious risks to market access, consumer and societal acceptance, and trust should producers fail to meet or exceed societal welfare expectations (reviewed by Fernandes et al., 2021). Outside of mandatory regulation, improvements in welfare standards and care of livestock are driven by the industry itself, and this must start with an understanding of welfare risks and an agreed means of measuring welfare. Importantly, increased reporting of animal health and welfare is a key priority for the beef industry (RMAC, 2019), as this may allow early identification and action to resolve any issue. However, a standardised welfare assessment protocol is not currently available to the Australian cattle lot-fed industry.

Several animal assessment protocols and welfare assurance/certification schemes have been developed in other countries for livestock that are production system and species specific (Main et al., 2014). A number of these address cattle welfare in extensive (AssureWel, 2010-2016a; AssureWel, 2010-2016b) and intensive systems (Welfare Quality®, 2009 Canadian Feedlot Animal Care Assessment Program (CFACA), 2018). Several protocols have also been developed for cattle under different systems (e.g., calf-cow operations; Simon et al., 2016; Kaurivi et al., 2020) or for specific stages of supply chains (e.g., sea transport; Dunston-Clarke et al., 2020, and slaughter; Losada-Espinosa et al., 2021). The diversity and breadth of measures available within these protocols are extensive because it is necessary to capture any aspects that may compromise the physical and psychological health of cattle. When evaluating the applicability to the Australian cattle lot-fed industry, careful consideration of measures is warranted as some may not be appropriate to the feedlot context.

The feedlot environment is an intensive form of cattle production and presents a number of welfare challenges including health, climate, housing, and the human-animal relationship (HAR) (reviewed by Salvin et al., 2020). Many of these welfare issues can be linked to: i) stress experienced prior to entry to the feedlot environment such as transport stress, including feed and water deprivation (Grandin and Callo, 2007), weaning (Arthington et al., 2008), and pregnancy status (Rademacher et al., 2015; Schwartzkopf-Genswein et al., 2018); ii) stress experienced during introduction to the feedlot which can result in metabolic disorders (González et al., 2012a), social stress (Tennessen et al., 1985; Sanderson et al., 2008), and disease susceptibility (Snowder et al., 2006); iii) variable climatic conditions and extremes, such as heat stress (Brown-Brandl et al., 2006a; Brown-Brandl et al., 2006b; Mader and Griffin, 2015; Grandin, 2016); or iv) physical environmental and/or management factors including housing conditions (Grandin, 2016; Macitelli et al., 2020), confinement (Blackshaw et al., 1997; Park et al., 2019a), and human-animal interactions (Grandin, 2016; Grandin, 2018; Salvin et al., 2020). An effective welfare assessment protocol would, therefore, need to consider all of these aspects.

The development of protocols for the assessment of cattle welfare under commercial conditions is challenging. Firstly, measures must be meaningful (valid) with respect to welfare, while being reliable and repeatable (Barnett and Hemsworth, 2009; Knierim and Winckler, 2009). It is vital, therefore, that the protocol also captures the possible cause(s) of compromised welfare (Waiblinger et al., 2001). Addressing the animal itself, not just the environment and management, is considered a fundamental component for successful welfare assessments (Barnett and Hemsworth, 1990; Main et al., 2003; Webster, 2005b; Barnett and Hemsworth, 2009; Knierim and Winckler, 2009; Main et al., 2014). Thus, a mix of animal outcomes, or outputs, and input measures are necessary. For a feedlot welfare assessment protocol to be successful, it should also address consumer priorities (e.g., ethical and humane treatment of animals, ability to express natural behaviour (Spooner et al., 2014; Coleman et al., 2016) as well as relevant state and national legislative requirements. Measures should be practical, easy and timely to capture (Waiblinger et al., 2001; Main et al., 2003). The recording of measures needs to be efficiently integrated into the feedlot system, with consideration of measures that may already be collected (e.g., feed, health records). Finally, to enable cross-sector use, a protocol must be versatile, flexible, and capture challenges that differ across feedlots due to variations in feedlot size (capacity, pen size and number), management and facility design, climate, and cattle genotype (breed), type (class and line) and feeding program (short, medium, and long). While challenging, the development of a comprehensive and practical welfare assessment protocol is important to successfully address societal concerns and achieve the industry's welfare goals.

This study aimed to identify suitable measures for a welfare assessment protocol applicable to the Australian cattle lot-fed industry. This was achieved by considering welfare protocols designed for beef cattle in the context of lot-fed cattle, and then adopting an advisory model to engage industry stakeholders to ensure all relevant issues were targeted in a practical manner. The purpose of such a protocol is two-fold. Firstly, to drive self-regulation and advances in animal welfare at a feedlot and national level. Secondly, to provide industry with an evidence-based system that

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could be used externally to facilitate transparency and engagement with consumers, acting to safeguard its social licence.

2 Materials and methods

This study adopted an advisory approach consisting of two steps to identify welfare measures applicable to the Australian cattle lot-fed industry. First, existing international beef cattle welfare protocols (*n* = 5), and industry resources (*n* = 3) were scrutinised by the authors alongside relevant scientific literature to develop a list of welfare measures suitable for inclusion in a protocol. Second, this list was further refined after consultation with industry stakeholders. To ensure a comprehensive assessment of animal welfare, the four principles outlined by the Welfare Quality® (Welfare Quality®, 2009) were adopted. Each measure pre-selected as relevant was classified under one of the following: Good Feeding, Good Housing, Good Health, and Appropriate Behaviour. The existing beef cattle welfare assessment protocols reviewed included the Welfare Quality® on-farm and at slaughterhouse protocols (Welfare Quality®, 2009), AssureWel Beef Cattle protocol (AssureWel, 2010-2016a), the US Beef Quality Assurance (BQA) assessment tool ((BQA), 2010), Canadian Feedlot Animal Care Assessment Program ((CFACA), 2018), and the proposed welfare protocol for the Australian live export of feeder and slaughter cattle (Dunston-Clarke et al., 2020). The National Feedlot Accreditation Scheme ((NFAS), 2021), the MLA 'fit to load guide' (MLA, 2019) and the Australian Animal Welfare Standards and Guidelines for Cattle (Animal Health Australia, 2016), were also reviewed, ensuring that information relating specifically to the Australian industry were considered. Measures relevant to all aspects of the feedlot system, including animal handling and stockpersonship, and transport (loading and unloading), were considered.

A list of 109 measures were initially identified as potentially applicable to welfare assessments of lot-fed cattle; Good Feeding (*n* = 20); Good Housing (*n* = 35), Good Health (*n* = 37) and Appropriate Behaviour (*n* = 17) (Table 1). Many measures (*n* = 44; Table 1) were developed or adapted for application within a feedlot context, such as those to capture feedlot specific environment and management factors (e.g., animal source, use of prostaglandins, days on feed), or to address specific issues (e.g., acidosis for feed related issues, approach test for quantifying the human-animal relationship, drinking behaviour to address heat stress). The protocol was then reviewed by an advisory board consisting of animal welfare scientists and industry stakeholders, who considered each metric for its applicability and feasibility to the Australian feedlot context. Measures that were not deemed to meet these requirements were excluded, and additional measures considered relevant by stakeholders were identified and incorporated into the protocol. In

TABLE 1 Welfare measures from existing international protocols, industry resources and scientific literature in beef cattle.

Welfare principle	Welfare measure	Existing animal welfare assessment protocol					Industry resources and scientific literature
		AssureWel	Beef Quality Assurance	Canadian Feedlot Animal Care Assessment Program	Welfare Quality®	Live Export Protocol	
Good Feeding (*n* = 20)	*Output measure*						
	Body weight						✓
	Body condition score	✓		✓	✓	✓	
	Feeding behaviour score					✓	
	Drinking behaviour score						✓
	Input measure						
	Ration number						✓
	Ration type			✓			
	Ration MMEF						✓
	Feeding program						✓
	Days on feed						✓
	Feed contamination		✓	✓		✓	
	Slick bunks[¥]		✓	✓	✓	✓	
	Feed bunk access/length					✓	
	Water trough/s no.				✓	✓	

(Continued)

TABLE 1 Continued

Welfare principle	Welfare measure	Existing animal welfare assessment protocol					Industry resources and scientific literature
		AssureWel	Beef Quality Assurance	Canadian Feedlot Animal Care Assessment Program	Welfare Quality®	Live Export Protocol	
	Water trough access/ length				✓	✓	
	Water trough circumference						✓
	Position of water trough						✓
	Water functionality				✓	✓	
	Water trough temperature			✓			
	Water trough contamination		✓		✓	✓	
	Frequency of trough cleaning						✓
Good Housing (n = 35)	*Output measure*						
	Coat cleanliness	✓		✓	✓	✓	
	Panting score	✓			✓	✓	
	Shivering						✓
	Huddling						✓
	Grouped						✓
	Animals caught in pen structures						✓
	Escaped animals						✓
	Input measure						
	Pen base structure						✓
	Manure/mud depth		✓	✓		✓	
	Manure consistency					✓	
	Pen cleaning frequency						✓
	Animal present in pen during cleaning						✓
	Ammonia			✓		✓	
	Structures in pens			✓		✓	
	Slope of pen						✓
	Wet-bulb globe temperature			✓		✓	
	Dry bulb temperature			✓		✓	
	Relative humidity					✓	
	Solar radiation						✓
	Precipitation			✓			
	Wind speed						✓
	Stocking density		✓	✓	✓	✓	

(Continued)

TABLE 1 Continued

Welfare principle	Welfare measure	Existing animal welfare assessment protocol					Industry resources and scientific literature
		AssureWel	Beef Quality Assurance	Canadian Feedlot Animal Care Assessment Program	Welfare Quality®	Live Export Protocol	
	Number of animals in pen				✓	✓	
	Horned animals	✓					
	Length of horns					✓	
	Tipped horns						✓
	Animal source						✓
	Time to fill pen/lot						✓
	Mixing						✓
	Breed	✓			✓	✓	
	Class	✓		✓		✓	
	Average pen weight at induction						✓
	Coat colour						✓
	Facility generated noise						✓
	Pen noise					✓	
Good Health (*n* = 37)	*Output measures*						
	Animals that should be moved to hospital pen	✓		✓			
	Births and abortions	✓		✓		✓	
	Treatment pulls					✓	
	Unfit to load at exit						✓
	Case fatality rate						✓
	Mortality/euthanasia	✓		✓	✓	✓	
	Wound/lesion	✓		✓	✓	✓	
	Abscess						✓
	Hair loss/rub marks	✓			✓	✓	
	Non-ambulatory			✓	✓	✓	
	Swelling	✓		✓	✓	✓	
	Lame	✓		✓	✓	✓	
	Haematoma						✓
	Nasal discharge	✓			✓	✓	
	Coughing	✓			✓	✓	
	Sneezing					✓	
	Respiratory distress	✓		✓	✓	✓	
	Ocular discharge	✓			✓	✓	
	Ocular lesions					✓	
	Ocular cancer						✓

(Continued)

TABLE 1 Continued

Welfare principle	Welfare measure	Existing animal welfare assessment protocol					Industry resources and scientific literature
		AssureWel	Beef Quality Assurance	Canadian Feedlot Animal Care Assessment Program	Welfare Quality®	Live Export Protocol	
	Pink eye					✓	
	Belching					✓	
	Bloat			✓	✓	✓	
	Acidosis						✓
	Hollow sides					✓	
	Roughage regurgitation						✓
	Water belly						✓
	Urogenital infection						✓
	Diarrhoea				✓	✓	
	Prolapse of rectum/ pizzle/vagina			✓			
	Dystocia				✓		
	Trace mineral deficiencies						✓
	Vitamin deficiencies						✓
	Abattoir report data						✓
	Input measures						
	Use of prostaglandins/ steroids						✓
	Frequency of pen checks			✓			
	Routine health treatment at induction			✓	✓		
Appropriate Behaviour (n = 17)	*Output measures*						
	Posture			✓	✓	✓	
	Ethogram				✓	✓	
	Approach test						✓
	Reactivity index					✓	
	Demeanour				✓	✓	
	Crush agitation						✓
	Crush exit speed						✓
	Crush exit		✓				
	Slips		✓	✓	✓*		
	Falls		✓	✓	✓*		
	Electric prodder use		✓	✓	✓*		
	Handling aid use			✓	✓*		
	Use of dogs			✓			
	Mis-caught animals in crush		✓	✓			

(Continued)

TABLE 1 Continued

Welfare principle	Welfare measure	Existing animal welfare assessment protocol					Industry resources and scientific literature
		AssureWel	Beef Quality Assurance	Canadian Feedlot Animal Care Assessment Program	Welfare Quality®	Live Export Protocol	
	Vocalisations		✓	✓	✓*		
	Staff generated noise						✓
	Animal flow through facility				✓*		

*Captured under Welfare Quality ® for fattening cattle at slaughterhouse only. ¥A "slick bunk" feeding strategy attempts to match intake to appetite (Collings et al., 2011).
Purple indicates measures to assess stockpersonship and human-animal relationship.

some cases where a measure failed to meet stakeholder inclusion but was considered necessary by the authors, it was retained to ensure a comprehensive assessment of welfare. This resulted in measures that were novel to the feedlot context being retained (e.g., demeanour, reactivity index). For these measures, future pilot testing will ultimately determine their practicality and validity.

3 Results

The advisory process resulted in a protocol containing 99 measures identified as applicable to the Australian cattle lot-fed industry. These measures were categorised by location of collection: Pen-side assessment (Good Feeding = 14, Good Housing = 28, Good Health = 11, and Appropriate Behaviour = 5, Total = 57; Table 2): Yard assessment (Good Housing = 4, Good Health = 2, Appropriate Behaviour = 18, Total = 24; Table 3): and Transport assessment (Good Feeding = 1, Good Housing = 5, Good Health = 5, and Appropriate Behaviour = 6, Total = 17; Table 4). These measures and their method of collection are shown in Tables 2 – 4.

Of the 109 potential measures evaluated by the advisory board, 51 were deemed not to meet applicability and practicality requirements and were excluded. Overall, 9 Good Feeding, 15 Good Housing, 25 Good Health and 2 Appropriate Behaviour measures were excluded in this process (Table 5). The main reasons for exclusion were that a measure was i) not applicable to the feedlot context, ii) not practical to capture, iii) were adequately captured by another measure, or iv) the level of detail captured was not considered necessary by stakeholders. An additional 41 measures that were not included in the initial measure list, but were considered relevant to stakeholders were identified and incorporated. This included the same measures captured repeatedly at different locations; both Yard and Transport assessments (e.g., handling aid use, electric prodder use, electric prodder in hand but not used, slips, falls, use of dogs), and in all three assessments (e.g., panting score, cattle shivering). Overall, a total of 13, 12 and 16 additional measures were incorporated in the proposed Pen-side, Yard, and Transport assessment protocols, respectively, with the reason for inclusion detailed in Table 6. For measures where several collection methods were evident in the literature, multiple measures were proposed (e.g., coat cleanliness, pen manure pad integrity measures; Table 6).

4 Discussion

This study identified 109 measures suitable for a cattle welfare assessment protocol, 99 of which were determined appropriate for the assessment of feedlot cattle in three key areas; Pen-side, Yard, and Transport. These protocols addressed the four Welfare Quality® welfare principles; Good Feeding, Good Housing, Good Health, and Appropriate Behaviour.

4.1 Proposed measures to address 'good feeding'

The management of feed and water is important, with adequate accessibility and quality of these resources being fundamental to animal welfare (Appleby and Waran, 1997). Our Pen-side protocol contained animal output measures that were considered appropriate for assessment from outside of the pen (body condition score (BCS), feeding behaviour score (FBS), drinking behaviour and faecal pat consistency) in addition to several resource- and management-measures, including feed contamination, feed bunk length, water trough number, water trough access, water trough contamination, and water trough fill.

Feedlot rations are developed in conjunction with nutritionists to meet requirements and reduce metabolic issues (Salvin et al., 2020), and there is a clear management focus on the delivery and monitoring of feed at a pen level in feedlots. Furthermore, considerable literature focuses on the nutritional management of cattle within the feedlot setting (e.g., Duff and Galyean, 2007; Nagaraja and Lechtenberg, 2007). However, fulfilment of the basic needs of an animal, in this case food, does not necessarily guarantee good welfare (Webster, 2005b). To address this, inclusion of animal output measures such as FBS that captures short-term feeding and BCS that captures medium- to long-term feeding were proposed in our protocol. FBS is a novel animal-based measure to inform on hunger status, social competition for food and response

TABLE 2 Proposed Pen-side assessment protocol for the Australian cattle let-fed industry by welfare principle.

Good Feeding (*n* = 14)	Good Housing (*n* = 28)	Good Health (*n* = 11)	Appropriate Behaviour (*n* = 5)
Output measures - Body condition score (BCS; description of majority of pen = score 1–5) - Feeding behaviour score (FBS; not observed/ disinterested/keen/pushing and competitive; % per category) - Drinking behaviour (description of majority of pen = score 1–5)* *Input measures* - Feeding program (short/short-medium/ medium/long) - Days on feed (days) - Feed out time - Feed contamination (score 1–4) - Feed bunk length (m) - Slick bunks - Water trough/s (no.) - Water trough/s length (m) - Water trough contamination (score 1–5) - Water trough fill (score 1–4) - Faecal pat consistency (description of majority of pen = score 1–5)	*Output measures* - Coat cleanliness 1 score (score 1–10) - Coat cleanliness 2 score (score 1–5) - Panting score (score 1–4.5; % per score)* - Shivering (%)# - Huddling (%)# - Grouped (dispersed/grouped at feeder/at water/under shade or not at resource; % per category) - Agitation associated with flies (Y/N, if Y = %) *Input measures* - Pen type (home/hospital) - Head in pen (no.) - Pen size (m^2) – to calculate stocking density (m^2/head) - Pen surface (description of pen = sandy/clay/rocky/gravel) - Surface moisture (score 1–3) - Mud depth (score 1–5) - Animal mud depth (score 1–4) - Structures in pen - Enrichment (Y/N, if Y = comment) - Cloud cover (%) - Dry bulb temperature (°C) - Web bulb globe temperature (°C) - Relative humidity (%) - Precipitation (mm) - Wind speed (km/hr) - Temperature humidity index (THI) - Heat Load Index (HLI) - Mixing (Y/N) - Breed - Class (sex) - Coat colour (grey or white/red/red and white/black/black and white/spotted)	*Output measures* - Births and abortions (no.)^ - Treatment pulls (no. and reason)^ - Case fatality rate (no.)^ - Mortality/euthanasia (no.)^ - Abattoir report data^ - Lame (no.) - Non–ambulatory (no.) - Nasal discharge (no.) - Coughing (no.) - Ocular discharge (no.) - Ill–thrifty (no.) & reason for ill–thrift	*Output measures* - Posture (standing/lying lateral/ lying sternal in shade vs. sun; %) - Ethogram (eating/drinking/ ruminating/walking/positive social/ negative social/self–groom/ abnormal/engaged/resting/vigilant; % per category) - Approach test (No reaction/ look/retreat/approach and sniff; % head at feeder per category at human approach) - Reactivity index (No reaction/ look/stand up/retreat/approach; %) - Demeanour (10 descriptive terms = score 0–100 per term)

*Measure collected only if Panting Score 2 or above observed.
#Measure collected only if cold stress conditions (windy and/or cold) observed.
^Measure collected at a feedlot level.
Unless specified, measures were recorded at the pen level.

to thermal stress, and was first proposed for use in the live export industry (Dunston-Clarke et al., 2020). While feedlot pens are designed to give most if not all cattle access to feed simultaneously, the assessment of both resource-based and animal output measures of Good Feeding is important and may be useful in the identification of possible issues. For example, crowding or competition at feed troughs may indicate stocking density is too high, or that the feed bunks were void of feed for too long and action may be needed to manage welfare outcomes.

BCS is a commonly used measure of feeding that is easy to collect under field conditions and was included in four of the five reviewed beef cattle protocols. BCS offers a subjective assessment of body reserves (subcutaneous fat and muscular reserves) independent of frame-size, thus providing valuable information regarding nutrient intake relative to the animals' requirements (overall nutrition status) (Roche et al., 2004; Kenyon et al., 2014). The monitoring of BCS at feedlot would be useful to identify cattle in poor condition with low body reserves (emaciated) or 'poor doers' (captured under ill-thrifty animals in Good Health), the implication of which is inadequate nutrition informing on feed and animal management. Equally, the monitoring of heavy (fat or obese) cattle may also be useful as these cattle not seen in other points within the beef cattle supply chain (e.g., calf-cow operations, live exports), are present at feedlots. Weight or excess fat cover in cattle is a risk factor for heat stress (Brown-Brandl et al., 2006a; Dikmen et al., 2012), hoof disease (Schöpke et al., 2013), slips and falls during unloading (Gregory, 2008), and lameness (Wells et al., 1993). Heavier cattle may also be harder to move within facilities or require additional care when handling to manage risks of injury to staff and animal, which have both welfare and profitability impacts. From a management perspective, these risks may be harder to mitigate, and as such the pushing of cattle to extreme weight may not be ideal. Recording BCS may inform on other measures that identify animals in a negative welfare state (e.g., animals unfit to load by industry standards), aiding animal management efforts (e.g., feed management).

The accessibility and quality of water, alongside the appropriate management of water during climatic extremes, is an important welfare consideration in feedlots (Animal Health Australia, 2016; Salvin et al., 2020). From a welfare and legal perspective, it is vital to

TABLE 3 Proposed Yard assessment protocol for the Australian cattle lot-fed industry by welfare principle.

Good Feeding	Good Housing (*n* = 4)	Good Health (*n* = 2)	Appropriate Behaviour* (*n* = 18)
None	*Output measures* - Panting score (score 1 – 4.5; % per score) - Cattle shivering (no.) *Input measures* - Stocking density (m^2/head) - Shade access (Y/N if Y = % cover)	*Output measures* - Lame (no.) *Input measures* - Routine health treatment at induction (comment)	*Output measures* - Cattle slapped/hit, or tails twisted (no.) - Handling aid use (no.) - Electric prodder use (no.) - Electric prodder in hand but not used (no.) - Mis-caught (no.) - Slips (no.) - Falls (no.) - Choking (no.) - Sleepers (no.) - Running/jumping out of crush at release (no.) - Fell at release from crush (no.) - Coat cleanliness (score 1 – 10) - Vocalisation (no.) - Animal flow through facility (score 1 – 3) - Animal flow when moving to/from home pen (score 1 – 3) *Input measures* - Staff generated noise (score 1 – 3) - Facility generated noise (score 1 – 3) - Use of dogs (Y/N if Y = indicate whether appropriate)

*Human-animal relationship which incorporates appropriate handling and stockpersonship is captured under the welfare principle Appropriate behaviour.
Colour indicates type and location of assessment; Blue – captured in holding yards, Purple – captured in race, Orange – captured in crush, and Black – facility/infrastructure measure. Unless specified, measures were recorded at the animal level.

ensure that all cattle have access to water (Animal Health Australia, 2016; Grandin, 2016), particularly during heat stress conditions, when cattle have higher water requirements (Arias and Mader, 2011). Thus, measures to indicate good water accessibility were included in our protocol (e.g., water trough number, water trough length, water trough fill, and time off water for transported cattle). The provision of clean water is essential for good welfare (Grandin, 2016), and is reported to influence water intake in feedlot cattle (Sparke et al., 2001; Schütz et al., 2019), thus water contamination and temperature are important to assess.

Animal-based measures for water availability and utilisation were not present in any of the welfare protocols reviewed. Previous protocols focused on input (resource- and management-based) measures to assess Good Feeding, reflecting the ease of collection under field conditions and reliability of such measures (Main et al., 2001; Rushen et al., 2011). However, animal output based measures are needed to provide a direct assessment of animal welfare (Main et al., 2001; Webster et al., 2004). Therefore, a drinking behaviour measure was created to capture pen-level crowding around water trough(s). During periods of heat stress, cattle alter their behaviour, increasing water intake (Arias and Mader, 2011), standing over water troughs (Sparke et al., 2001), and seeking shade created by troughs (Mitlöhner et al., 2001; Castaneda et al., 2004; Lees et al., 2020). As only a small number of cattle are able to access water trough(s) at any one time, monitoring cattle drinking behaviour, particularly when heat stress conditions are occurring or expected is paramount. Crowding may be an indicator of poor welfare as it indicates that there are cattle that are thirsty but are unable to access water. Such observations can inform management decisions, ensuring appropriate and prompt action is taken, such as providing additional water points. The monitoring of water accessibility and quality measures is important from both a welfare and management perspective.

TABLE 4 Proposed Transport assessment protocol for the Australian cattle lot-fed industry by measure type.

Good Feeding (*n* = 1)	Good Housing (*n* = 5)	Good Health (*n* = 5)	Appropriate Behaviour* (*n* = 6)
Input measures - Time off water (h)	*Output measures* - Panting score (score 1 – 4.5; % per score) - Cattle shivering (no.) *Input measures* - Loading density (m^2/head) - Stock crate free from sharp edges, holes etc. (Y/N, if N = comment) - Truck well aligned (Y/N if N = comment)	*Output measures* - Animals unfit for transport (no.) - Animal unfit for transport on arrival (no.) - Animal dead on arrival (no.) - Tender-footed animals (no.) *Input measures* - Average weight (kg)	*Output measures* - Handling aid use (no.) - Electric prodder use (no.) - Electric prodder in hand but not used (no.) - Slips (no.) - Falls (no.) *Input measures* - Use of dogs (Y/N if Y = indicate whether appropriate)

*Human-animal relationship which incorporates appropriate handling and stockpersonship is captured under the welfare principle Appropriate behaviour.
Colour indicates measures captured by transport event type; Blue – loading measures only, Orange – unloading measures only, and Black – both loading and unloading events. Unless specified, measures were recorded at the animal level.

TABLE 5 Pen-side welfare measures by welfare principle excluded from proposed protocol based on stakeholder deliberation.

Good Feeding (*n* = 9)	Good Housing (*n* = 15)	Good Health (*n* = 25)	Appropriate Behaviour (*n* = 2)
Output measures - Body weight *Input measures* - Ration number - Ration type - Ration MMEF - Water trough circumference - Position of water trough/s - Water functionality - Water trough temperature - Water trough cleaning frequency	*Output measures* - Animals caught in pen structures - Escaped animals *Input measures* - Manure consistency - Pen cleaning frequency - Animals present in pen during cleaning - Ammonia - Slope of pen - Solar radiation - Horned animals - Length of horns - Tipped horns - Animal source - Time to fill pen/lot - Average pen weight at induction - Pen noise	*Output measures* - Animals that should be moved to hospital pen - Wound/lesion - Abscess - Hair loss/rub marks - Swelling - Haematoma - Sneezing - Respiratory distress - Ocular lesions - Ocular cancer - Pink eye - Belching - Bloat - Acidosis - Hollow sides - Roughage regurgitation - Water belly - Urogenital infection - Diarrhoea - Prolapse of rectum/pizzle/vagina - Dystocia - Trace mineral deficiencies - Vitamin deficiencies *Input measures* - Use of prostaglandins/steroids - Frequency of pen checks	*Output measures* - Crush agitation - Crush exit speed

4.2 Proposed measures to address 'good housing'

Good Housing in our Pen-side, Yard, and Transport protocols includes the assessment of pen condition and environment, with measures selected to inform both cattle comfort and thermal challenge. Animal output measures of coat cleanliness, panting score, shivering, huddling, grouped, and agitation associated with flies were included, with input measures necessary to inform these output measures also captured (e.g., head in pen, stocking and loading density, surface moisture, mud depth, access to shade, WBGT, breed, class, and coat colour).

Thermal challenge, particularly heat stress, is considered a major welfare issue in feedlot cattle (Salvin et al., 2020). The thermal environment, including temperature, humidity, solar radiation, air flow, and precipitation all directly impact cattle comfort and their ability to effectively thermoregulate (Mader et al., 2006; Gaughan et al., 2008; Grandin, 2016). Heat stress can lead to decreased feed intake and efficiency, cattle discomfort, and death in extreme cases (Brown-Brandl et al., 2006b; Mader and Griffin, 2015; Tucker et al., 2015; Grandin, 2016). Panting score is an animal-based measure of heat stress widely used in cattle and is routinely assessed under feedlot conditions (Mader and Griffin, 2015; Lees et al., 2020). The assessment of cattle demeanour (proposed under Appropriate Behaviour) offers further direct assessment of the impact of thermal challenge on cattle and is both simple and time efficient. For example, observations of demeanour together with panting scores are reported to capture animal responses to heat under live export conditions (Willis et al., 2021b). Stockperson stock appraisal skills may benefit from routine assessment of animal demeanour, improving awareness and sensitivity to how animals are coping with their environment and the identification of issues such as thermal stress. With the incidence of heat stress in feedlot cattle influenced by several factors, including climate, water accessibility, shade, breed, coat colour, weight, diet, and current health status (Brown-Brandl et al., 2006a; Tucker et al., 2015; Grandin, 2016; Salvin et al., 2020), the collection of this input data is vital to inform output measures.

The reviewed international cattle welfare protocols currently do not include animal-based measures to quantify cold stress in cattle, therefore, the assessment of shivering and huddling at a pen level was developed and proposed in the Pen-side, Yard, and Transport protocols. This was deemed important as some feedlots are located in southern Australia and can experience cold winter conditions. There is a heavy focus by industry on heat stress; however, the impact of cold stress on cattle thermal comfort and welfare needs to be considered. Evidence from US feedlots shows that cold stress impacts production and behaviour (Gonyou et al., 1979), and if not appropriately managed can result in mortalities (Belasco et al., 2015). Cattle are reported to huddle under heat stress conditions (Gaughan et al., 2010; Lees et al., 2020), and both huddle and/or shiver under cold stress conditions (Gonyou et al., 1979; Graunke et al., 2011). Recording these behaviours is considered simple and would better inform stakeholders on the impact of cold stress on cattle comfort and welfare, and provide insight into intervention points and the effectiveness of management strategies which could include use of bedding, temporary wind breaks, and/or feed management (Mader, 2003; Mader and Griffin, 2015; Tucker et al., 2015).

TABLE 6 Additional welfare measures included in the proposed protocols (Pen-side, Yard, and Transport) based on stakeholder deliberation and manuscript review.

Assessment protocol	Welfare principle	Welfare measure	Measure type	Collection method	Reason for inclusion
Pen-side	Good Feeding	Feed out time	Input	hh:mm	Additional measure to inform cattle behaviour, specifically ethogram and demeanour measures. Important to aid interpretation of outcome measures.
		Water trough fill	Input	Score 1 – 4	Additional and more direct measure for water availability and utilisation not considered in existing protocols. Considered particularly important to inform water availability under thermal stress conditions.
		Faecal pat consistency	Output	Description of majority of pen = score 1 – 5	More straightforward collection method of diarrhoea at a pen level, offering an assessment of manure consistency as well. Informs on cattle nutrition and management as diarrhoea is associated with diseases that are important in feedlot cattle, such as acidosis (Parkinson et al., 2010).
	Good Housing	Coat cleanliness score 2	Output	Score 1 – 5	Alternative measure to coat cleanliness score 1 to inform pen conditions and health (diarrhoea). Simplified 5-point scale proposed to reduce assessment burden; originally proposed in the 2000 draft for the Clean Livestock Assessment Scheme (for details see; Tucker and Klepper (2005)).
		Agitation associated with flies	Output	Agitation associated with flies evident? (Y/N; if Y = %)	Identified by stakeholders as a specific issue in the feedlot context not considered in existing protocols. Nuisance flies can disrupt behaviour and reduce animal welfare (Machtinger et al., 2021), thus capture was deemed necessary.
		Enrichment	Input	Enrichment present? (Y/N; if Y = comment)	Identified as a specific subject in the feedlot context not considered in existing protocols. The provision of enrichment is an inherently positive welfare outcome. The provision of effective environmental enrichment has the potential to reduce aggressive behaviour in feedlot cattle (Park et al., 2019b), and may reduce boredom and frustration (Nawroth et al., 2019). Capture is important to inform on cattle behaviour and capture positive welfare outcomes.
		Pen type	Input	Description of pen = home/ hospital	Additional measure to capture that not all pens at feedlots are standard home pens, with hospital pens routinely used to manage unwell cattle. Pens can also vary from a housing standpoint being different in pen size, pen environment and resources, and management, and should be assessed in the protocol.
		Surface moisture	Input	Score 1 – 3	Alternative measures to mud depth to inform pen manure pad integrity. Two alternative collection methods are proposed on the basis of practicality and perceived ease of collection. Piloting to determine most appropriate collection method.
		Animal mud depth	Input	Score 1 – 4	
		Cloud cover	Input	Percentage (%) cloud cover	Additional measure to give an indication on the amount of sun exposure and thus environmental conditions cattle experience.
		Temperature humidity index (THI)	Input	THI calculation from weather data	Additional measure designed to inform on environmental conditions cattle experience, specifically heat stress conditions; previously used as an indicator and predictor of heat stress in Australian feedlots (MLA, 2006).
		Heat load index (HLI)	Input	HLI calculation from weather data	Alternative measure to THI to inform on environmental conditions cattle experience, specifically heat stress conditions. This measure incorporates solar radiation and wind speed and therefore is considered a more accurate indicator and predictor of cattle heat stress than THI (Thornton et al., 2021).
	Good Health	Ill-thrifty	Output	No. & reason for ill-thrift	Additional outcome measure designed to capture 'poor doers'. Proposed under Live Export Protocol reviewed but not initially pre-selected in the protocol for feedlot cattle due to comprehensive list of morbidities included instead (Table 1).
Yard	Good Housing	Panting score	Output	Score 1 – 4.5; % per score	Additional measure to capture more detailed assessment of animal outcomes related to thermal challenge during handling within the feedlot context not initially considered in the Yard assessment.
		Cattle shivering	Output	No.	Additional measure to capture more detailed assessment of animal outcomes related to thermal challenge during handling within the feedlot context not initially considered in the Yard assessment.
		Coat cleanliness score 1	Output	Score 1 – 10	Additional measure suggested during manuscript review to supplement Pen-side recordings of coat cleanliness.

(Continued)

TABLE 6 Continued

Assessment protocol	Welfare principle	Welfare measure	Measure type	Collection method	Reason for inclusion
		Stocking density	Input	m^2/head	Additional measure considered important to capture appropriate management of stock during routine handling not initially considered under the Yard assessment.
		Shade access	Input	Shade available in holding yards? (Y/N; if Y = % cover)	Additional measure to give an indication on the amount of sun exposure in holding yard facilities and thus environmental conditions cattle experience during routine handling.
	Good Health	Lameness	Output		Additional measure suggested during manuscript review to supplement Pen-side recordings of lameness.
	Appropriate Behaviour*	Cattle slapped/hit, or tails twisted	Output	No.	Additional measure to capture aversive handling, a negative welfare outcome, to provide indication of improvements in handling over time. Aversive handling causes stress and/or fear in cattle, which may also result in increased risk of slips and falls and/or injury as reasoned by (Minka and Ayo, 2007; Bourguet et al., 2011; Doyle and Moran, 2015).
		Electric prodder in hand but not used	Output	No.	Identified as a specific issue during handling not considered in existing protocols. The premise that having the prodder in hand with the intention of using as a handling aid (non-electric prodder or as extension of arm) is more likely to result in inappropriate use. From a welfare perspective, it is considered best practice for electric prodders only be picked up and used when required, then put back down immediately, thus not being held constantly or used as a primary driving/handling aid (Grandin, 2007).
		Choking	Output	No.	Identified by stakeholders as a specific issue during handling not considered in existing protocols. Additional measures to capture inappropriate restraint of cattle during handling in the crush.
		Sleepers^	Output	No.	
		Fell at release from crush	Output	No.	Additional measure to capture a more aversive animal outcome than already captured by the collection of the crush exit measure (no. running/jumping out of crush at release). Proposed under BQA yard assessment ((BQA), 2010), and included following stakeholder feedback.
		Animal flow when moving to/ from home pen	Output	Score 1 – 3	Additional measure to capture a further aspect of animal handling within the feedlot context not initially considered; movement within the premises such as between home pen and yards not simply within the yard environment. Not considered in existing protocols.
Transport	Good Housing	Panting score	Output	Score 1 – 4.5; % per score	The assessment of handling and condition of cattle associated with transport at feedlot entry was highlighted by stakeholders as an area in need of further assessment. Consequently, the assessment of animal handling and facilities was expanded to include a detailed assessment of trucking events, both loading and unloading. These measures are incorporated to capture: i) Compliance with legislation (e.g., time off water; (Animal Health Australia, 2012)) and industry standards (e.g., unfit for transport; (MLA, 2019), ii) Recognised welfare issues associated with transport (e.g., tender-footed/ lame animals; (Grandin, 2001; González et al., 2012b), iii) Animal handling as outlined in the Yard and Pen-side assessments, and/or iv) Additional important risk factors identified under existing welfare audits/ protocols designed specifically for transport and abattoir (e.g., truck alignment and condition of stock crate;(Grandin 2013)).
		Cattle shivering	Output	No.	
		Loading density	Input	m^2/head	
		Time off water	Input	Time of water (h)	
		Stock crate free from sharp edges, holes etc.	Input	Stock crate free from sharp edges, holes etc.? (Y/N; if N = comment)	
		Truck well aligned	Input	Truck well aligned before cattle loading/ unloading? (Y/ N; if N = comment)	
	Good Health	Animal unfit for transport on arrival	Output	No.	

(Continued)

TABLE 6 Continued

Assessment protocol	Welfare principle	Welfare measure	Measure type	Collection method	Reason for inclusion
		Animal dead on arrival	Output	No.	
		Tender-footed animals	Output	No.	
		Average weight	Input	Average weight of cattle on truck (kg)	
	Appropriate Behaviour	Handling aid use	Output	No.	
		Electric prodder use	Output	No.	
		Electric prodder in hand but not used	Output	No.	
		Slips	Output	No.	
		Falls	Output	No.	
		Use of dogs	Input	Dogs used? (Y/N; if Y = indicate whether appropriate)	

*Human-animal relationship which incorporates appropriate handling and stockpersonship is captured under the welfare principle Appropriate behaviour.
^An animal that goes down in the crush and becomes unconscious but gains consciousness again.

Mud has been identified as one of the top three welfare problems in cattle feedlots, particularly in areas of high rainfall (Grandin, 2016). High mud levels have been reported to impact resting behaviour and cattle comfort (Muller et al., 1996; Fisher et al., 2003; Tucker et al., 2015; Chen et al., 2017), and is associated with increased risk of lameness (Stokka et al., 2001; Marti et al., 2016) and heat stress through contributions to humidity in hot conditions (Petrov, 2007; Tucker et al., 2015; Salvin et al., 2020). Lying behaviour and the number of steps taken have been shown to be reduced in beef cattle confined to a surface with a high mud depth within a feedlot (Dickson et al., 2022). Measures of coat cleanliness are routinely employed as an indirect evaluation of environment (sanitation) and comfort in cattle and was included in all but one of the protocols reviewed. Overall, coat cleanliness can inform on pen surface, indicating muddy conditions or whether a dry area for lying is available (Hauge et al., 2012; Grandin, 2016; Chen et al., 2017). The maintenance of facilities and targeted pen surface management are vital to control mud and cattle cleanliness (Mader, 2003; Mader and Griffin, 2015; Grandin, 2016). Therefore, measures which assess manure pad integrity (e.g., surface moisture, mud depth or animal mud depth measures) should be recorded, and relevant management practices (e.g., stocking density) and environmental measures (e.g., precipitation) should be monitored. Importantly, even when good pen surface management practices are employed, pens can still get muddy (Grandin, 2016). Hence, monitoring cattle lying behaviour (captured as posture in Appropriate Behaviour) and cleanliness in the Pen-side and Yard assessments would be informative.

4.3 Proposed measures to address 'good health'

Animal health is central to animal welfare and forms a vital component of the proposed protocol. Routine daily pen walks/rides by feedlot staff in Australian feedlots ensure that cattle health is monitored, and appropriate treatment action is taken where required. Here, important health issues relevant to the feedlot context are prioritised for further standardised formal recording at a pen level in the Pen-side protocol (lameness, non-ambulatory animals, nasal discharge, coughing, ocular discharge, ill-thrift), and within the Yard (lameness) and Transport protocols (animals unfit for transport, animals unfit for transport on arrival, animals dead on arrival, tender-footed animals). Additional measures of Good Health available for assessment at a feedlot level from readily accessible records were also considered (routine husbandry practices, births/abortions, treatment pulls, case fatality rate, mortality/euthanasia, abattoir report data).

Mortality represents the ultimate endpoint of compromised welfare and potentially poor welfare management (Colditz et al., 2014), and is an informative indicator of welfare under commercial conditions. Four of the protocols evaluated included a measure for cattle mortality, however, they considered only mortality at its endpoint, reporting the percentage of animals that died and/or were euthanised, regardless of cause (Welfare Quality®, 2009). Importantly, identifying the cause of death is considered a vital element of a successful welfare assessment protocol (Waiblinger et al., 2001). This enables action to safeguard welfare rather than simply reporting the status quo. Hence, the collection of more detailed mortality measures, including cause and case fatality rate following treatment, were proposed to be captured at a feedlot level. In addition to mortality, other measures of importance to be collected at a feedlot level included routine husbandry practices, births and abortions, treatment pulls, and abattoir report data.

Lameness, injury, and respiratory illnesses (e.g., Bovine Respiratory Disease (BRD)) are common and important issues in feedlot cattle (Salvin et al., 2020), and could reflect the suitability of the pen environment, feed and animal management, and stockpersonship. For example, pen condition and pen surface are considered as the two most common factors contributing to lameness caused by infection in feedlot cattle, followed by weather patterns and handling (Terrell et al., 2013). BRD is a major cause of morbidity and mortality in feedlot cattle (Perkins, 2013; Vogel et al., 2015), with age, stress at entry to feedlot environment (e.g., weaning, transport), immune status, nutritional status, climate and management (e.g., stocking density) important risk factors in feedlot cattle (Snowder et al., 2006; Duff and Galyean, 2007). Cattle requiring treatment for illness or injury likely experience negative welfare and to capture this, signs of these common health issues in cattle are included in the proposed protocol (lameness, nasal discharge, coughing). The collection and reporting of such information in a more targeted, routine, and standardised manner will inform on Good Health and would be beneficial. For example, the routine recording of nasal discharge and coughing at a pen level may have the added benefit of improving the accuracy of BRD diagnosis by pen walkers/riders, which is considered poor (~ 60%) (White and Renter, 2009). Overall, the Pen-side protocol captures several major health concerns applicable to feedlots, providing information valuable from both welfare assessment and management standpoints.

Cattle unfit to load at exit, unfit for transport at arrival, and dead-on-arrival in the Transport protocol, and lameness in the Yard protocol, represent additional measures of Good Health proposed here. The presence of animals that are unfit to load represents an assessment of moderate to severe health issues at the point of exit from feedlot, with the welfare of cattle unfit to load likely to be compromised (e.g., non-weight bearing lame, severe injury, or severe distress) (Animal Health Australia, 2012). The MLA 'fit to load guide' (MLA, 2019) is available to producers to ensure the relevant legislative standards (Animal Health Australia, 2012) are met and best practice animal welfare is achieved. Cattle are routinely passed through the yards for drafting into lots for transport within weeks to days of exit from the feedlot prior to loading on trucks. This represents a practical time to collect valuable information captured in the Yard and Transport protocols proposed, including the formal recording of unfit, tender-footed, and lame animals.

It has been suggested that many on-farm welfare issues (e.g., cleanliness, ease of handling) can be assessed at the abattoir (Grandin, 2017; Knock and Carroll, 2019). While it is generally considered that 'lead' indicators, those that facilitate corrective or preventative actions to be taken, are most informative from a welfare perspective (Barnett and Hemsworth, 2009), the benefit of 'lag' indicators such as those that could be assessed at the abattoir should not be overlooked. The collection of this data could capture issues that have been missed including injuries and bruises (Grandin, 2017; Knock and Carroll, 2019) or issues that may not be apparent externally such as liver abscesses (Galyean and Rivera, 2003) or pneumonic (lung) lesions (Fernández et al., 2020). This information could then be used to inform targeted action at the feedlot. For example, consistent reports of liver abscesses could indicate ruminal acidosis, suggesting that current feed management needs to be reviewed (Nagaraja and Chengappa, 1998; Galyean and Rivera, 2003). In this way, data from received in abattoir feedback can be applied to refine management, thus advancing animal welfare at a feedlot level.

4.4 Proposed measures to address 'appropriate behaviour'

Behaviour has an important role in the diagnosis and early detection of health issues at feedlots (e.g., diagnosis of BRD (White and Renter, 2009)), and behavioural measures are recognised as meaningful indicators of welfare across numerous production industries and systems (Mench and Mason, 1997; Mench, 1998; Webster, 2005a). The Pen-side protocol prioritises the behavioural observation of cattle in their home pen environment, capturing both positive and negative behaviours (through posture and activity), to provide a direct assessment of welfare outcomes. The assessment of cattle demeanour in the Pen-side protocol also offers a valuable assessment of both positive and negative welfare and mental state within a single measure. The assessment of animal handling and Human-animal relationship (HAR) in all three protocols is considered an advantage of this protocol, with the collection of several output (e.g., Pen-side; approach test, reactivity index, Yard and Transport; cattle slapped/hit or tails twisted, handling aid/electric prodder use, mis-caught, slips, falls, choking, animal flow through facility and to/from home pen; see Table 3 and Table 4 for details), and relevant input measures (e.g., staff generated noise, facility generated noise and/or use of dogs).

Both antagonistic social behaviours (e.g., displacement, aggression) and abnormal behaviours (e.g., buller syndrome, tongue rolling) can be observed in feedlot cattle (Blackshaw et al., 1997; Mitlohner et al., 2002; Gonzalez et al., 2008; Val-Laillet et al., 2009). While it is important to recognise that many factors influence behaviour (e.g., DOF, health status, climate, stocking density), the observation of negative behaviours can relate to competition and social stress, indicating that the social environment may be unstable (e.g., inadequate resource availability (Gonzalez et al., 2008; Val-Laillet et al., 2009)), or that animals lack adequate stimulation (Park et al., 2019a). Conversely, the absence or low incidence of these behaviours could be considered as an indication of neutral or positive welfare states. For these reasons, measures to capture negative social and abnormal behaviour are presented in the Pen-side protocol (see Table 2 for details).

The identification of measures of positive welfare is considered extremely valuable in on-farm monitoring protocols (Farm Animal

Welfare Council, 2009; Webster, 2011; Edgar et al., 2013). The collection of information indicating that animals are experiencing a positive welfare state is paramount to the assessment of quality of life (see Mattiello et al., 2019). The assessment of positive welfare here involved measuring maintenance behaviours (e.g., self-grooming, resting, lying, ruminating), positive social behaviours (e.g., allogrooming, social play), and positive interactions with the environment (e.g., engaged; object play, locomotor play, exploration) listed in the ethogram and posture measures. Allogrooming, play (social and non-social), self-grooming and behavioural synchrony are indicators of positive welfare in cattle (Napolitano et al., 2009). For example, cattle naturally display synchrony in their feeding, resting/lying and ruminating behaviours (Rook and Huckle, 1995; Stoye et al., 2012; Tuomisto et al., 2019). High levels of synchrony in lying and ruminating behaviours may indicate comfort, social stability and/or that space allowance and stocking density are appropriate to avoid competition (see Napolitano et al., 2009; Asher and Collins, 2012). However, as indicators of positive welfare, some of these behaviours have limitations. For example, cattle may also demonstrate grooming when parasitised (ectoparasites including flies, ticks, lice) or when dirty (Napolitano et al., 2009), therefore high frequencies of these behaviours and consideration of these outputs with other measures may be required. Further, the use of pen infrastructure (e.g., fence posts, water troughs and/or enrichment) for grooming may damage the pen which could lead to injury or escape, a concern for welfare and management. These behaviours may also occur infrequently (e.g., allogrooming; (Napolitano et al., 2009) so careful consideration surrounding the most appropriate time for recording is required. For example, there is some evidence that allogrooming in cattle occurs in higher frequency during periods of feeding and overnight (Val-Laillet et al., 2009). For these reasons, measures to capture positive behaviour and mental state would be beneficial at feedlots; however, care should be given when interpreting these behaviours as indicators of positive welfare.

In addition to assessing quantitative measures of positive behaviour, the assessment of cattle demeanour is considered a particular advantage in the Pen-side protocol. Assessments of animal demeanour or body language offer a qualitative, whole animal assessment that is useful for the interpretation of welfare measures (Wemelsfelder et al., 2000; Wemelsfelder and Lawrence, 2001; Wemelsfelder, 2007), and are quick to capture compared to other behavioural measures (Knierim and Winckler, 2009). This is important under commercial conditions, with collection burden a major limitation to the use of behavioural measures (Barrell, 2019). The assessment of demeanour using Qualitative Behavioural Assessment (QBA) principals is considered valuable under commercial conditions, particularly to assess positive state (Boissy et al., 2007; Rutherford et al., 2012; Murphy et al., 2014; Fleming et al., 2016). Two of the reviewed protocols incorporate QBA which involves a panel of observers scoring the behavioural expression of cattle using a predetermined list of descriptive terms (Table 7). A modified-QBA, or 'demeanour' was proposed in the Pen-side protocol which includes one stockperson observing cattle real-time scoring four positive (curious, content, lively, settled), four negative (agitated, dull, nervous, uncomfortable) and two neutral terms (active, alert) (Table 7). Importantly, producers in the Australian red meat industry believe that assessing animal welfare is an innate ability they possess (Buddle et al., 2021). Scoring animal demeanour could be considered fundamentally similar to this, capturing what a good stockperson does when they survey their livestock in a formal, numerical manner (Fleming et al., 2016). The application of including demeanour to feedlots is novel; however, the full QBA approach has been validated in cattle under numerous contexts (see; Rousing and Wemelsfelder, 2006; Brscic et al., 2010; Stockman et al., 2013; de Boyer des Roches et al., 2018; Vindevoghel et al., 2019; Rizzuto et al., 2020), with the modified-QBA (demeanour) approach recently reported useful and valid for welfare assessment within the Australian live export industry (Willis et al., 2021a; Willis et al., 2021b). At feedlots, demeanour may provide evidence of positive affective state, and an early indicator of issues, such as thermal stress, ill-health, and unstable social housing, allowing earlier mitigation than otherwise would be possible. It would also aid in the interpretation of other measures, informing on how cattle are coping under certain conditions, allowing users to more easily interpret animal welfare states. In these ways, the assessment of cattle demeanour pen-side would be valuable; however, piloting under feedlot conditions is required.

Our protocols contain many measures of animal handling and the human-animal relationship (HAR). The quality of the HAR is widely considered an important factor that impacts animal welfare (Hemsworth, 2003; Waiblinger et al., 2006; Hemsworth and Coleman, 2011). In feedlots, good stockpersonship is an essential component of good cattle welfare (Grandin, 2016), and handling can influence cattle's fear of humans (Breuer et al., 2003; Petherick et al., 2009a; Petherick et al., 2009b). Recording cattle responses to handling (e.g., slips, falls, crush exit) and human resource use (e.g., use of electric prodders and handling aids, noise, mis-caught animals) informs on stockpersonship, animal stress (Grandin, 1993; Fell et al., 1999; King et al., 2006; Anderson and Miller, 2019), the design of the yards, and can be used to demonstrate improvements in handling practices over time (Grandin, 2016; Grandin, 2018). Feedlot cattle are routinely drafted through the yards and crush for treatments, performance weighing and/or immediately prior to transport, which represent important opportunities to easily and unobtrusively assess HAR. For example, poor flow through yards results when animals refuse to move forward or attempt to back up or turn around; thus, an assessment of animal flow can indicate that there are problems with facilities and/or handling (Grandin, 2018).

An assessment of HAR is also included in the Pen-side protocol. Observations concerning the reactions of cattle to an approaching human are commonly used to assess HAR and inform on how animals perceive humans, and whether this changes over time (Waiblinger et al., 2006). The incorporation of the 'Reactivity Index' measure used in the Live Export Protocol (Dunston-Clarke et al., 2020) was considered to be most suitable to pen-side collection at feedlots. The capture of this information pen-side ensured that HAR is considered at all applicable points within the feedlot system

TABLE 7 Descriptive terms used for Qualitative Behavioural Assessment (QBA) by existing cattle welfare assessment protocols and those proposed with definitions in the proposed feedlot protocol.

Term	Welfare Quality®	Live Export Protocol	Proposed Feedlot Protocol	Definition in Proposed Feedlot Protocol
Active	✓	✓	✓	Energetic, lively, busy body movement and actions
Agitated	✓	✓	✓	Restless, uneasy, reactive, nervous movement
Alert		✓	✓	Wide awake, fully aware, attentive, vigilant, engaged with surroundings, ready to react
Anxious		✓		
Apathetic	✓			
Bored	✓			
Calm	✓			
Curious			✓	Positive interest, questioning and inquisitive towards surroundings, actively exploring and engaging with environment
Content	✓	✓	✓	Above means met, state of satisfaction, contentment in life situation, appeased, happy, in control and at ease
Depressed	✓			
Dull		✓	✓	Lacking interest, dispirited or wearied, slow moving, may include an element of being unwell
Fearful	✓			
Friendly	✓			
Frustrated	✓	✓		
Happy	✓	✓		
Indifferent	✓			
Inquisitive	✓	✓		
Irritable	✓			
Listless		✓		
Lively	✓		✓	Animated, energetic, excited, eager, enthusiastic, playful, positively engaged with surroundings
Nervous			✓	Anxious, alarmed, worried, tense, unsure, unable to settle, reactive to stimuli, vigilant or watchful
Playful	✓			
Positively occupied	✓			
Relaxed	✓			
Settled		✓	✓	Quiet, calm, relaxed and resting
Sociable	✓			
Uneasy	✓			
Uncomfortable		✓	✓	Showing signs of physical discomfort, uneasy, or irritation

and the lack of this could be considered a limitation in previous protocols. Importantly, cattle responses to humans are influenced by social context, the surrounding environment, the novelty of human exposure and type (Grignard et al., 2000) and loud machine and human noise (Weeks, 2008). Thus, these measures should be considered when observations of cattle are made Pen-side and also during handling (e.g., Yard and Transport protocols). Any measure based on the observation of cattle both pen-side and in the yards must be feasible to capture in a fast-paced environment and integrate within the feedlot system efficiently. The collection of those measures proposed is considered to achieve this; however, piloting will ultimately determine the practicality of these measures.

4.5 Additional measures included in the proposed protocol based on stakeholder engagement

The proposed protocol includes 41 additional measures identified as suitable for inclusion (Table 6), with 28 of these incorporated at the request of stakeholders and during manuscript review for a more comprehensive assessment of transport (loading, unloading) and animal handling than initially proposed and the remaining 13 were added to capture issues relevant to feedlots. For example, nuisance flies and their impact on cattle was identified as a specific seasonal problem due to the abundance of food and ideal breeding conditions (Urech et al., 2004). Flies can disrupt behaviour and reduce animal welfare (Machtinger et al., 2021), thus the measure was incorporated in the Pen-side protocol. Likewise, it was deemed necessary to incorporate a measure of 'ill-thrifty' animals to capture 'poor doers' that may have a poor demeanour (e.g., dull), have hollow sides or suboptimal body condition and/or poor coat condition. This addition is not anticipated to have a marked impact on assessment burden as it can be captured during pen walks/rides. Other measures were included as alternative methods to capture relevant information, either offering collection of information in a simpler manner than initially proposed (e.g., faecal pat consistency vs. diarrhoea), or one that was more familiar to feedlot staff, thus considered more easily understood and adoptable (e.g., THI vs. HLI). Regarding measures of coat cleanliness and pen manure pad integrity, multiple methods of measurement were determined necessary to identify the most appropriate for use in a feedlot context. Pilot testing will determine the most appropriate measures to capture this information.

4.6 Measures excluded from the proposed protocol based on stakeholder engagement

A total of 51 measures were excluded during the advisory process. Engagement with industry stakeholders and animal welfare scientists ensured that issues relevant to all stakeholders were addressed, ensuring measure feasibility and practicality were considered (Sørensen and Fraser, 2010). Some tools to assess animal welfare developed in a research capacity may be too complex for practical use (Grandin, 2018), thus this step is considered vital in developing a successful protocol. Overall, the main reasons for exclusion were related to feasibility and practicality. For example, of the extensive list of potential health issues proposed under Good Health (n = 27; Table 1), 22 (81.4%) were excluded from observations in the Pen-side protocol on the basis of stakeholder feedback but retained at a feedlot level collected from feedlot records (see Table 5). In light of the difficulty in identifying many of these health issues accurately when pen-side (e.g., acidosis) and the time to collect data, it was considered more appropriate to prioritise the formal collection of indicators of BRD (e.g., nasal discharge, coughing) and injury (e.g., lameness, non-ambulatory). This approach was deemed more comprehensive than collecting disease incidence data from only a sample of pens, with the added benefit of minimising assessment burden during pen-side assessments. Likewise, although measures of water temperature are included in four of the reviewed protocols, they were excluded here due to stakeholder concern that the time needed to manually assess them was prohibitive. Perhaps with advances in automated water monitoring systems in the future these measures may be feasible. Deliberation by the advisory board also identified measures not applicable to the feedlot environment (e.g., ammonia), or as is the case for those measures under Good Feeding relating to rations (ration number, ration type, ration MMEF), not considered pertinent to include in a feedlot welfare assessment. The reason behind these exclusions was the fact that feedlots are considered to inherently address nutritional requirements at an appropriate level because diets are specially formulated with nutritionists and carefully managed. In addition, several measures were considered by stakeholders to capture duplicative information and discussion determined which of these was most appropriate for inclusion. For example, for the Yard protocol, crush agitation and crush exit speed measures were argued to provide the same evidence to inform HAR as the crush exit measure, the latter of which was identified as the easiest to capture by feedlots, thus retained under Appropriate Behaviour. Likewise, the collection of the water trough number, water trough length and water trough fill measures were considered sufficient to inform water accessibility resulting in the exclusion of water trough circumference, position of water trough/s and water functionality measures from Good Feeding.

4.7 The consideration of existing feedlot data

Consultation with industry stakeholders indicated that 46 (46.5%) of the revised list of proposed measures are presently collected at feedlots to some extent. This means that the data is either readily accessible in the proposed format (e.g., days on feed, breed, mortalities, climatic data) or the data is presently collected in a different form (e.g., panting scores, slick bunks, water trough fill, health data). For those in the latter category, careful consideration during the advisory process was given as to how measures could be obtained without feedlot staff being required to collect duplicative information which would strain resources or be viewed as intrusive. Pilot testing will determine whether those measures presently collected can be easily transferred to the collection method proposed. Aligning data collection methods with those already collected at feedlot means that the protocol is considerate of resources (staff time and labour), and it is likely that the monitoring will not impede on normal staff responsibilities.

4.8 Next steps: pilot testing and industry adoption

The proposed protocol appears practical and feasible within the feedlot context. The next step is to pilot test the protocol on representative feedlot premises across Australia to further refine the measures and their collection methods. The final selection of measures to be included will ultimately be a trade-off between comprehensiveness and validity, and practicality under commercial feedlot conditions. The piloting, which is currently underway, will further develop the protocol, answering many questions vital to ultimate adoption and success, including:

- Validation of measures novel to the feedlot context (e.g., drinking behaviour, reactivity index measures).
- Removal of measures that are uninformative or provide duplicative information.
- Identification of measures in need of further modification to suit collection within a feedlot.
- Use of records: Are feedlot records collected and stored in a manner that allows easy direct retrieval and transfer as suggested above?
- Timing of pen-side assessments: What is the best and appropriate time of day to capture relevant information (e.g., behaviour measures)? Are repeated measurements of some measures required (e.g., increased frequency of the monitoring of panting score and drinking behaviour under heat stress conditions)?
- Frequency of assessment: How many times per year is enough to prove ongoing standards and/or improvements in animal welfare?
- Sample size: How many pen assessments, transport and handling event assessments per feedlot is appropriate?
- Time to complete assessments: How long do assessments take? Do assessments fit in with the feedlot personnel jobs efficiently?
- Creation of training materials to allow for standardised collection of measures and to address potential concerns with assessor bias.

5 Conclusion

The development and adoption of a welfare assessment protocol at a national level represents an opportunity for the Australian cattle lot-fed industry to pro-actively address public concerns surrounding animal welfare. As such, this study identified 99 suitable measures for inclusion in a welfare assessment protocol for lot-fed cattle in Australia, including an array of management-, resource-, environmental- and animal-based measures, considered both valuable and practical for use in feedlots. Care was taken to ensure all relevant feedlot welfare issues and the management and environmental factors that influence these were considered under the Pen-side, Yard, and Transport protocols. Assessing welfare at feedlots can be a considerable challenge due to the complex nature of both feedlot enterprises and animal welfare itself. The next step is to pilot this protocol on representative feedlot premises across Australia to further refine measures. The result of this process would be a versatile tool that provides the foundation for the on-going, standardised, monitoring of cattle welfare. This would ultimately benefit the industry by providing an evidence-based, transparent approach to benchmark animal welfare at a national level, thus addressing societal and industry concerns. It would also encourage continual improvements, the benefit of which is the long-term stability and sustainability of the industry.

Data availability statement

The original contributions presented in the study are included in the article and supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ET: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing– original draft, Writing– review & editing. ED–C: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Writing– review & editing. DB: Investigation, Methodology, Writing– review & editing. EJ: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Writing– review & editing. BL: Conceptualization, Writing– review & editing. AB: Conceptualization, Funding acquisition, Investigation, Writing– review & editing. DM: Conceptualization, Writing– review & editing. TC: Conceptualization, Funding acquisition, Investigation, Supervision, Writing– review & editing. AF: Conceptualization, Funding acquisition, Investigation, Supervision, Writing– review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Ahola, J. K., Wagner, J. J., and Engle, T. E. (2018). "An overview of the segments of the beef cattle industry and animal welfare implications of beef industry practices," in *The welfare of cattle*. Eds. T. E. Engle, D. J. Klingborg and B. E. Rollin (Boca Raton: CRC Press), 173–179.

Anderson, F., and Miller, D. (2019). *The impact of handling conditions and new environments on the stress of cattle (P.PIP.0743)* (North Sydney, Australia: Meat and Livestock Australia).

Animal Health Australia (2016) *Australian animal welfare standards and guidelines for cattle* (Canberra, Australia: Animal Health Australia). Available at: http://www.animalwelfarestandards.net.au/cattle/ (Accessed April 28, 2018).

Animal Health Australia (2012). *Australian animal welfare standards and guidelines — Land transport of livestock. 1 ed* (Canberra: Animal Health Australia).

Appleby, M. C., and Waran, N. K. (1997). "Physical conditions," in *Animal welfare*. Eds. M. C. Appleby and B. O. Hughes (UK: CAB International), 177–190.

Arias, R. A., and Mader, T. L. (2011). Environmental factors affecting daily water intake on cattle finished in feedlots. *J. Anim. Sci.* 89 (1), 245–251. doi: 10.2527/jas.2010-3014

Arthington, J. D., Qiu, X., Cooke, R. F., Vendramini, J. M. B., Araujo, D. B., Chase, C. C. Jr., et al. (2008). Effects of preshipping management on measures of stress and performance of beef steers during feedlot receiving1. *J. Anim. Sci.* 86 (8), 2016–2023. doi: 10.2527/jas.2008-0968

Asher, L., and Collins, L. M. (2012). Assessing synchrony in groups: Are you measuring what you think you are measuring? *Appl. Anim. Behav. Sci.* 138 (3), 162–169. doi: 10.1016/j.applanim.2012.02.004

AssureWel (2010-2016a) *Beef cattle*. Available at: http://www.assurewel.org/beefcattle (Accessed 9 October 2020).

AssureWel (2010-2016b) *Dairy cows*. Available at: https://www.assurewel.org/dairycows (Accessed 9 October 2020).

Barnett, J. L., and Hemsworth, P. H. (1990). The validity of physiological and behavioural measures of animal welfare. *Appl. Anim. Behav. Sci.* 25, 177–187. doi: 10.1016/0168-1591(90)90079-S

Barnett, J. L., and Hemsworth, P. H. (2009). Welfare monitoring schemes: using research to safeguard welfare of animals on the farm. *J. Appl. Anim. Welfare Sci.* 12 (2), 114–131. doi: 10.1080/10888700902719856

Barrell, G. K. (2019). An appraisal of methods for measuring welfare of grazing ruminants. *Front. Veterinary Sci.* 6 (289). doi: 10.3389/fvets.2019.00289

(BQA) (2010) *Beef Quality Assurance manual*. Available at: https://www.bqa.org/resources/manuals (Accessed 9 October 2020).

Belasco, E. J., Cheng, Y., and Schroeder, T. C. (2015). The impact of extreme weather on cattle feeding profits. *J. Agric. Resource Economics* 40 (2), 285–305. doi: 10.22004/ag.econ.206597

Blackshaw, J. K., Blackshaw, A. W., and McGlone, J. J. (1997). Buller steer syndrome review. *Appl. Anim. Behav. Sci.* 54 (2), 97–108. doi: 10.1016/S0168-1591(96)01170-7

Boissy, A., Manteuffel, G., Jensen, M. B., Moe, R. O., Spruijt, B., Keeling, L. J., et al. (2007). Assessment of positive emotions in animals to improve their welfare. *Physiol. Behav.* 92 (3), 375–397. doi: 10.1016/j.physbeh.2007.02.003

Bourguet, C., Deiss, V., Tannugi, C. C., and Terlouw, E. M. C. (2011). Behavioural and physiological reactions of cattle in a commercial abattoir: Relationships with organisational aspects of the abattoir and animal characteristics. *Meat Sci.* 88 (1), 158–168. doi: 10.1016/j.meatsci.2010.12.017

Breuer, K., Hemsworth, P. H., and Coleman, G. J. (2003). The effect of positive or negative handling on the behavioural and physiological responses of nonlactating heifers. *Appl. Anim. Behav. Sci.* 84 (1), 3–22. doi: 10.1016/S0168-1591(03)00146-1

Brown-Brandl, T. M., Eigenberg, R. A., and Nienaber, J. A. (2006a). Heat stress risk factors of feedlot heifers. *Livestock Sci.* 105 (1), 57–68. doi: 10.1016/j.livsci.2006.04.025

Brown-Brandl, T. M., Nienaber, J. A., Eigenberg, R. A., Mader, T. L., Morrow, J. L., and Dailey, J. W. (2006b). Comparison of heat tolerance of feedlot heifers of different breeds. *Livestock Sci.* 105 (1), 19–26. doi: 10.1016/j.livsci.2006.04.012

Brscic, M., Wemelsfelder, F., Tessitore, E., Gottardo, F., Cozzi, G., and Van Reenen, C. G. (2010). Welfare assessment: correlations and integration between a Qualitative Behavioural Assessment and a clinical/health protocol applied in veal calves farms. *Ital. J. Anim. Sci.* 8 (2s), 601. doi: 10.4081/ijas.2009.s2.601

Buddle, E. A., Bray, H. J., and Ankeny, R. A. (2021). "Of course we care!": A qualitative exploration of Australian livestock producers' understandings of farm animal welfare issues. *J. Rural Stud.* 83, 50–59. doi: 10.1016/j.jrurstud.2021.02.024

(CFACA) (2018) *Canadian feedlot animal care assessment program. Instructions, standards and common audit tool* (Alberta, Canada). Available at: https://www.cattlefeeders.ca/wp-content/uploads/2016/04/Recommended-Feedlot-Animal-Care-Assessment-Guide-PAACO-approved-January-2016A.pdf (Accessed 11 October 2020).

Castaneda, C. A., Sakaguchi, Y., and Gaughan, J. B. (2004). Relationships between climatic conditions and the behaviour of feedlot cattle. *Anim. Production Aust.* 1 (1), 33–36. doi: 10.1071/SA0401009

Chen, J. M., Stull, C. L., Ledgerwood, D. N., and Tucker, C. B. (2017). Muddy conditions reduce hygiene and lying time in dairy cattle and increase time spent on concrete. *J. Dairy Sci.* 100 (3), 2090–2103. doi: 10.3168/jds.2016-11972

Clark, B., Stewart, G. B., Panzone, L. A., Kyriazakis, I., and Frewer, L. J. (2016). A systematic review of public attitudes, perceptions and behaviours towards production diseases associated with farm animal welfare. *J. Agric. Environ. Ethics* 29 (3), 455–478. doi: 10.1007/s10806-016-9615-x

Colditz, I. G., Ferguson, D. M., Collins, T., Matthews, L., and Hemsworth, P. H. (2014). A prototype tool to enable farmers to measure and improve the welfare performance of the farm animal enterprise: the unified field index. *Anim. (Basel)* 4 (3), 446–462. doi: 10.3390/ani4030446

Coleman, G. (2018). Public animal welfare discussions and outlooks in Australia. *Anim. Front.* 8 (1), 14–19. doi: 10.1093/af/vfx004

Coleman, G., Jongman, E., Greenfield, L., and Hemsworth, P. (2016). Farmer and public attitudes toward lamb finishing systems. *J. Appl. Anim. Welfare Sci.* 19 (2), 198–209. doi: 10.1080/10888705.2015.1127766

Collings, L. K. M., Weary, D. M., Chapinal, N., and von Keyserlingk, M. A. G. (2011). Temporal feed restriction and overstocking increase competition for feed by dairy cattle. *J. Dairy Sci.* 94 (11), 5480–5486. doi: 10.3168/jds.2011-4370

de Boyer des Roches, A., Lussert, A., Faure, M., Herry, V., Rainard, P., Durand, D., et al. (2018). Dairy cows under experimentally-induced Escherichia coli mastitis show negative emotional states assessed through Qualitative Behaviour Assessment. *Appl. Anim. Behav. Sci.* 206, 1–11. doi: 10.1016/j.applanim.2018.06.004

Dickson, E. J., Campbell, D. L. M., Monk, J. E., Lea, J. M., Colditz, I. G., and Lee, C. (2022). Increasing mud levels in a feedlot influences beef cattle behaviours but not preference for feedlot or pasture environments. *Appl. Anim. Behav. Sci.* 254, 105718–105728. doi: 10.1016/j.applanim.2022.105718

Dikmen, S., Ustuner, H., and Orman, A. (2012). The effect of body weight on some welfare indicators in feedlot cattle in a hot environment. *Int. J. Biometeorology* 56 (2), 297–303. doi: 10.1007/s00484-011-0433-6

Doyle, R., and Moran, J. (2015). "Cattle behaviour," in *Understanding dairy cow behaviour to improve their welfare on asian farms* (Clayton South VIC Australia: CSIRO Publishing), 37–67.

Duff, G. C., and Galyean, M. L. (2007). BOARD-INVITED REVIEW: Recent advances in management of highly stressed, newly received feedlot cattle. *J. Anim. Sci.* 85 (3), 823–840. doi: 10.2527/jas.2006-501

Dunston-Clarke, E., Willis, R. S., Fleming, P. A., Barnes, A. L., Miller, D. W., and Collins, T. (2020). Developing an animal welfare assessment protocol for livestock transported by sea. *Animals* 10 (4), 705–721. doi: 10.3390/ani10040705

Edgar, J. L., Mullan, S. M., Pritchard, J. C., McFarlane, U. J. C., and Main, D. C. J. (2013). Towards a 'Good life' for farm animals: development of a resource tier framework to achieve positive welfare for laying hens. *Animals* 3 (3), 584–605. doi: 10.3390/ani3030584

Farm Animal Welfare Council (2009) *Farm animal welfare in great britain: past, present and future* (UK: Department for Envrionment Food & Rural Affairs). Available at: https://www.gov.uk/government/publications/fawc-report-on-farm-animal-welfare-in-great-britain-past-present-and-future (Accessed 9 June 2021).

Fell, L. R., Colditz, I. G., Walker, K. H., and Watson, D. L. (1999). Associations between temperament, performance and immune function in cattle entering a commercial feedlot. *Aust. J. Exp. Agric.* 39 (7), 795–802. doi: 10.1071/EA99027

Fernandes, J. N., Hemsworth, P. H., Coleman, G. J., and Tilbrook, A. J. (2021). Costs and benefits of improving farm animal welfare. *Agriculture* 11 (2), 104. doi: 10.3390/agriculture11020104

Fernández, M., Ferreras, M. D. C., Giráldez, F. J., Benavides, J., and Pérez, V. (2020). Production significance of bovine respiratory disease lesions in slaughtered beef cattle. *Animals: an Open Access J. MDPI* 10 (10), 1770. doi: 10.3390/ani10101770

Fisher, A. D., Stewart, M., Verkerk, G. A., Morrow, C. J., and Matthews, L. R. (2003). The effects of surface type on lying behaviour and stress responses of dairy cows during periodic weather-induced removal from pasture. *Appl. Anim. Behav. Sci.* 81 (1), 1–11. doi: 10.1016/S0168-1591(02)00240-X

Fleming, P. A., Clarke, T., Wickham, S. L., Stockman, C. A., Barnes, A. L., Collins, T., et al. (2016). The contribution of qualitative behavioural assessment to appraisal of livestock welfare. *Anim. Production Sci.* 56 (10), 1569–1578. doi: 10.1071/AN15101

Galyean, M. L., and Rivera, J. D. (2003). Nutritionally related disorders affecting feedlot cattle. *Can. J. Anim. Sci.* 83 (1), 13–20. doi: 10.4141/a02-061

Gaughan, J. B., Bonner, S., Loxton, I., Mader, T. L., Lisle, A., and Lawrence, R. (2010). Effect of shade on body temperature and performance of feedlot steers. *J. Anim. Sci.* 88 (12), 4056–4067. doi: 10.2527/jas.2010-2987

Gaughan, J. B., Mader, T. L., Holt, S. M., and Lisle, A. (2008). A new heat load index for feedlot cattle. *J. Anim. Sci.* 86 (1), 226–234. doi: 10.2527/jas.2007-0305

Gaughan, J. B., and Sullivan, M. L. (2014). "Australian feedlot industry," in *Beef cattle production and trade*. Eds. D. J. Cottle and L. P. Kahn (Victoria, Australia: CSIRO Publishing), 205–233.

Gonyou, H. W., Christopherson, R. J., and Young, B. A. (1979). Effects of cold temperature and winter conditions on some aspects of behaviour of feedlot cattle. *Appl. Anim. Ethology* 5 (2), 113–124. doi: 10.1016/0304-3762(79)90083-X

Gonzalez, L. A., Ferret, A., Manteca, X., Ruiz-de-la-Torre, J. L., Calsamiglia, S., Devant, M., et al. (2008). Performance, behavior, and welfare of Friesian heifers housed in pens with two, four, and eight individuals per concentrate feeding place. *J. Anim. Sci.* 86 (6), 1446–1458. doi: 10.2527/jas.2007-0675

González, L. A., Manteca, X., Calsamiglia, S., Schwartzkopf-Genswein, K. S., and Ferret, A. (2012a). Ruminal acidosis in feedlot cattle: Interplay between feed ingredients, rumen function and feeding behavior (a review). *Anim. Feed Sci. Technol.* 172 (1), 66–79. doi: 10.1016/j.anifeedsci.2011.12.009

González, L. A., Schwartzkopf-Genswein, K. S., Bryan, M., Silasi, R., and Brown, F. (2012b). Relationships between transport conditions and welfare outcomes during commercial long haul transport of cattle in North America. *J. Anim. Sci.* 90 (10), 3640–3651. doi: 10.2527/jas.2011-4796

Grandin, T. (1993). Behavioral agitation during handling of cattle is persistent over time. *Appl. Anim. Behav. Sci.* 36 (1), 1–9. doi: 10.1016/0168-1591(93)90094-6

Grandin, T. (2001). Perspectives on transportation issues: The importance of having physically fit cattle and pigs. *J. Anim. Sci.* 79 (suppl_E), E201–E207. doi: 10.2527/jas2001.79E-SupplE201x

Grandin, T. (2007). "Behavioural principles of handling cattle and other grazing animals under extensive conditions," in *Livestock handling and transport*, *3rd edition*. Ed. T. Grandin (Wallingford, UK: CAB International), 44–64.

Grandin, T. (2016). Evaluation of the welfare of cattle housed in outdoor feedlot pens. *Veterinary Anim. Sci.* 1-2, 23–28. doi: 10.1016/j.vas.2016.11.001

Grandin, T. (2017). On-farm conditions that compromise animal welfare that can be monitored at the slaughter plant. *Meat Sci.* 132, 52–58. doi: 10.1016/j.meatsci.2017.05.004

Grandin, T. (2018). Livestock-handling assessments to improve the welfare of cattle, pigs and sheep. *Anim. Production Sci.* 58 (3), 403–407. doi: 10.1071/AN16800

Grandin, T., and Callo, C. (2007). "Cattle transport," in *Livestock handling and transport*, *3rd Edition ed*. Ed. T. Grandin (UK: CAB International), 134–154.

Grandin, T. (2013). *Recommended animal handling guidelines and audit guide: a systematic approach to animal welfare. 1 ed* (Washington, DC USA: American Meat Institure Animal Welfare Commitee).

Graunke, K. L., Schuster, T., and Lidfors, L. M. (2011). Influence of weather on the behaviour of outdoor-wintered beef cattle in Scandinavia. *Livestock Sci.* 136 (2), 247–255. doi: 10.1016/j.livsci.2010.09.018

Greenwood, P. L. (2021). Review: An overview of beef production from pasture and feedlot globally, as demand for beef and the need for sustainable practices increase. *Animal* 15, 100295. doi: 10.1016/j.animal.2021.100295

Greenwood, P. L., Gardner, G. E., and Ferguson, D. M. (2018). Current situation and future prospects for the Australian beef industry–A review. *Asian - Australas. J. Anim. Sci.* 31, 992–1006. doi: 10.5713/ajas.18.0090

Gregory, N. G. (2008). Animal welfare at markets and during transport and slaughter. *Meat Sci.* 80 (1), 2–11. doi: 10.1016/j.meatsci.2008.05.019

Grignard, L., Boissy, A., Boivin, X., Garel, J. P., and Le Neindre, P. (2000). The social environment influences the behavioural responses of beef cattle to handling. *Appl. Anim. Behav. Sci.* 68 (1), 1–11. doi: 10.1016/S0168-1591(00)00085-X

Hauge, S. J., Kielland, C., Ringdal, G., Skjerve, E., and Nafstad, O. (2012). Factors associated with cattle cleanliness on Norwegian dairy farms. *J. Dairy Sci.* 95 (5), 2485–2496. doi: 10.3168/jds.2011-4786

Hemsworth, P. H. (2003). Human–animal interactions in livestock production. *Appl. Anim. Behav. Sci.* 81 (3), 185–198. doi: 10.1016/S0168-1591(02)00280-0

Hemsworth, P. H., and Coleman, G. J. (2011). *Human-livestock interactions: the stockperson and the productivity and welfare of intensively farmed animals* (Wallingford, UK: Cambridge, MA: CABI).

Kaurivi, Y. B., Laven, R., Hickson, R., Parkinson, T., and Stafford, K. (2020). Developing an animal welfare assessment protocol for cows in extensive beef cow–calf systems in New Zealand. Part 1: assessing the feasibility of identified animal welfare assessment measures. *Animals* 10 (9), 1597. doi: 10.3390/ani10091597

Kenyon, P. R., Maloney, S. K., and Blache, D. (2014). Review of sheep body condition score in relation to production characteristics. *New Z. J. Agric. Res.* 57 (1), 38–64. doi: 10.1080/00288233.2013.857698

King, D. A., Schuehle Pfeiffer, C. E., Randel, R. D., Welsh, T. H., Oliphint, R. A., Baird, B. E., et al. (2006). Influence of animal temperament and stress responsiveness on the carcass quality and beef tenderness of feedlot cattle. *Meat Sci.* 74 (3), 546–556. doi: 10.1016/j.meatsci.2006.05.004

Knierim, U., and Winckler, C. (2009). On-farm welfare assessment in cattle: validity, reliability and feasibility issues and future perspectives with special regard to the welfare quality(R) approach. *Anim. Welfare* 18, 451–458. doi: 10.1017/S0962728600000865

Knock, M., and Carroll, G. A. (2019). The potential of post-mortem carcass assessments in reflecting the welfare of beef and dairy cattle. *Animals* 9 (11), 959. doi: 10.3390/ani9110959

Lees, A. M., Lees, J. C., Sejian, V., Sullivan, M. L., and Gaughan, J. B. (2020). Influence of shade on panting score and behavioural responses of *Bos taurus* and *Bos indicus* feedlot cattle to heat load. *Anim. Production Sci.* 60 (2), 305–315. doi: 10.1071/AN19013

Losada-Espinosa, N., Estévez-Moreno, L. X., Bautista-Fernández, M., Galindo, F., Salem, A. Z. M., and MIranda-de la Lama, G. C. (2021). Cattle welfare assessment at the slaughterhouse level: Integrated risk profiles based on the animal's origin, pre-slaughter logistics, and iceberg indicators. *Prev. Veterinary Med.* 197, 105513. doi: 10.1016/j.prevetmed.2021.105513

Machtinger, E. T., Gerry, A. C., Murillo, A. C., and Talley, J. L. (2021). Filth fly impacts to animal production in the United States and associated research and extension needs. *J. Integrated Pest Manage.* 12 (1), 41. doi: 10.1093/jipm/pmab026

Macitelli, F., Braga, J. S., Gellatly, D., and Paranhos da Costa, M. J. R. (2020). Reduced space in outdoor feedlot impacts beef cattle welfare. *Animal* 14 (12), 2588–2597. doi: 10.1017/S1751731120001652

Mader, T. L. (2003). Environmental stress in confined beef cattle 1. *J. Anim. Sci.* 81 (14), E110–E119. doi: 10.2527/2003.8114_suppl_2E110x

Mader, T. L., Davis, M. S., and Brown-Brandl, T. (2006). Environmental factors influencing heat stress in feedlot cattle. *J. Anim. Sci.* 84 (3), 712–719. doi: 10.2527/2006.843712x

Mader, T. L., and Griffin, D. (2015). Management of cattle exposed to adverse environmental conditions. *Veterinary Clinics North America: Food Anim. Pract.* 31 (2), 247–258. doi: 10.1016/j.cvfa.2015.03.006

Main, D. C. J., Kent, J. P., Wemelsfelder, F., Ofner, E., and Tuyttens, F. A. M. (2003). Applications for methods of on-farm welfare assessment. *Anim. Welfare* 12 (4), 523–528. doi: 10.1017/S0962728600026129

Main, D. C. J., Mullan, S., Atkinson, C., Cooper, M., Wrathall, J. H. M., and Blokhuis, H. J. (2014). Best practice framework for animal welfare certification schemes. *Trends Food Sci. Technol.* 37 (2), 127–136. doi: 10.1016/j.tifs.2014.03.009

Main, D. C. J., Webster, A. J. F., and Green, L. E. (2001). Animal welfare assessment in farm assurance schemes. *Acta Agriculturae Scandinavica Section A — Anim. Sci.* 51 (sup030), 108–113. doi: 10.1080/090647001316923171

Marti, S., Janzen, E. D., Orsel, K., Jelinski, M. J., Dorin, L. C., Pajor, E., et al. (2016). Risk factors associated with lameness severity in feedlot cattle. *J. Anim. Sci.* 94 (suppl_5), 38–39. doi: 10.2527/jam2016-0083

Mattiello, S., Battini, M., De Rosa, G., Napolitano, F., and Dwyer, C. (2019). How can we assess positive welfare in ruminants? *Animals* 9 (10), 758–785. doi: 10.3390/ani9100758

Mench, J. (1998). Why it is important to understand animal behavior. *Institute Lab. Anim. Res. J.* 39 (1), 20–26. doi: 10.1093/ilar.39.1.20

Mench, J. A., and Mason, G. J. (1997). "Behaviour," in *Animal welfare*. Eds. M. C. Appleby and B. O. Hughes (UK: CAB International), 127–141.

Minka, N. S., and Ayo, J. O. (2007). Effects of loading behaviour and road transport stress on traumatic injuries in cattle transported by road during the hot-dry season. *Livestock Sci.* 107 (1), 91–95. doi: 10.1016/j.livsci.2006.10.013

Mitlohner, F. M., Galyean, M. L., and McGlone, J. J. (2002). Shade effects on performance, carcass traits, physiology, and behavior of heat-stressed feedlot heifers. *J. Anim. Sci.* 80 (8), 2043–2050. doi: 10.2527/2002.8082043x

Mitlöhner, F. M., Morrow, J. L., Dailey, J. W., Wilson, S. C., Galyean, M. L., Miller, M. F., et al. (2001). Shade and water misting effects on behavior, physiology, performance, and carcass traits of heat-stressed feedlot cattle. *J. Anim. Sci.* 79 (9), 2327–2335. doi: 10.2527/2001.7992327x

MLA (2006). *Tips & tools feedlots: Heat load in feedlot cattle* (North Sydney, NSW: Meat & Livestock Australia).

MLA (2019). *Is the animal fit to load? A national guide to the pre-transport selection and management of livestock* (North Sydney, NSW: Meat & Livestock Australia Ltd).

MLA (2021) *Australian Cattle on feed - National Calendar year*. Available at: https://statistics.mla.com.au/Report/List (Accessed 1 March 2023).

Muller, C. J. C., Botha, J. A., and Smith, W. A. (1996). Effect of confinement area on production, physiological parameters and behaviour of Friesian cows during winter in a temperate climate. *South Afr. J. Anim. Sci.* 26 (1), 1–5.

Murphy, E., Nordquist, R. E., and van der Staay, F. J. (2014). A review of behavioural methods to study emotion and mood in pigs, Sus scrofa. *Appl. Anim. Behav. Sci.* 159, 9–28. doi: 10.1016/j.applanim.2014.08.002

Nagaraja, T. G., and Chengappa, M. M. (1998). Liver abscesses in feedlot cattle: a review. *J. Anim. Sci.* 76 (1), 287–298. doi: 10.2527/1998.761287x

Nagaraja, T. G., and Lechtenberg, K. F. (2007). Acidosis in feedlot cattle. *Veterinary Clinics North America: Food Anim. Pract.* 23 (2), 333–350. doi: 10.1016/j.cvfa.2007.04.002

Napolitano, F., Knierim, U., Grass, F., and De Rosa, G. (2009). Positive indicators of cattle welfare and their applicability to on-farm protocols. *Ital. J. Anim. Sci.* 8 (sup1), 355–365. doi: 10.4081/ijas.2009.s1.355

(NFAS) (2021). *National feedlot accreditation scheme handbook. Rules and standards of accreditation 2021* (Murarrie QLD Australia: AUS-MEAT Limited).

Nawroth, C., Langbein, J., Coulon, M., Gabor, V., Oesterwind, S., Benz-Schwarzburg, J., et al. (2019). Farm animal cognition—linking behavior, welfare and ethics. *Front. Veterinary Sci.* 6. doi: 10.3389/fvets.2019.00024

Park, R. M., Bova, R., Jennings, J. S., and Daigle, C. L. (2019a). 8 Environment enrichment reduces aggression and stereotypic behaviors in feedlot steers. *J. Anim. Sci.* 97 (Supplement_1), 13–14. doi: 10.1093/jas/skz053.030

Park, R. M., Jennings, J. S., and Daigle, C. L. (2019b). Impact of environmental enrichment on feedlot steer productivity and aggression. *J. Anim. Sci.* 97 (Supplement_3), 226–226. doi: 10.1093/jas/skz258.460

Parkinson, T. J., Vermunt, J. J., and Malmo, J. (2010). *Diseases of cattle in australasia.* (Wellington, New Zealand: New Zealand Veterinary Association Foundation for Continuing Education).

Perkins, N. (2013). *Animal health survey of the Australian feedlot industr). MLA final report P.PSH.0547* (North Sydney, NSW: Meat & Livestock Australia Ltd).

Petherick, J. C., Doogan, V. J., Holroyd, R. G., Olsson, P., and Venus, B. K. (2009a). Quality of handling and holding yard environment, and beef cattle temperament: 1. Relationships with flight speed and fear of humans. *Appl. Anim. Behav. Sci.* 120 (1), 18–27. doi: 10.1016/j.applanim.2009.05.008

Petherick, J. C., Doogan, V. J., Venus, B. K., Holroyd, R. G., and Olsson, P. (2009b). Quality of handling and holding yard environment, and beef cattle temperament: 2. Consequences for stress and productivity. *Appl. Anim. Behav. Sci.* 120 (1), 28–38. doi: 10.1016/j.applanim.2009.05.009

Petrov, R. (2007). *The microclimate of Australian cattle feedlots* (University of Southern Queensland: Master of Engineering).

Rademacher, R. D., Warr, B. N., and Booker, C. W. (2015). Management of pregnant heifers in the feedlot. *Veterinary Clinics North America: Food Anim. Pract.* 31 (2), 209–228. doi: 10.1016/j.cvfa.2015.03.003

Rizzuto, S., Evans, D., Wilson, B., and McGreevy, P. (2020). Exploring the use of a qualitative behavioural assessment approach to assess emotional state of calves in rodeos. *Animals* 10 (1), 113. doi: 10.3390/ani10010113

RMAC (2016) *Meat industry strategic plan: MISP 2020, including outlook to 2030* (Australia: Red Meat Advisory Council Limited). Available at: https://www.mla.com.au/globalassets/mla-corporate/generic/about-mla/misp-2020.pdf (Accessed 11 October 2022).

RMAC (2019) *Red meat 2030* (Australia: Red Meat Advisory Council Limited). Available at: http://rmac.com.au/wp-content/uploads/2021/05/RedMeat2030.pdf (Accessed 11 October 2022).

Roche, J. R., Dillon, P. G., Stockdale, C. R., Baumgard, L. H., and VanBaale, M. J. (2004). Relationships among international body condition scoring systems. *J. Dairy Sci.* 87 (9), 3076–3079. doi: 10.3168/jds.S0022-0302(04)73441-4

Rook, A. J., and Huckle, C. A. (1995). Synchronization of ingestive behaviour by grazing dairy cows. *Anim. Sci.* 60 (1), 25–30. doi: 10.1017/S1357729800008092

Rousing, T., and Wemelsfelder, F. (2006). Qualitative assessment of social behaviour of dairy cows housed in loose housing systems. *Appl. Anim. Behav. Sci.* 101 (1-2), 40–53. doi: 10.1016/j.applanim.2005.12.009

Rushen, J., Butterworth, A., and Swanson, J. C. (2011). ANIMAL BEHAVIOR AND WELL-BEING SYMPOSIUM: Farm animal welfare assurance: Science and application1. *J. Anim. Sci.* 89 (4), 1219–1228. doi: 10.2527/jas.2010-3589

Rutherford, K. M., Donald, R. D., Lawrence, A. B., and Wemelsfelder, F. (2012). Qualitative Behavioural Assessment of emotionality in pigs. *Appl. Anim. Behav. Sci.* 139 (3-4), 218–224. doi: 10.1016/j.applanim.2012.04.004

Salvin, H. E., Lees, A. M., Cafe, L. M., Colditz, I. G., and Lee, C. (2020). Welfare of beef cattle in Australian feedlots: a review of the risks and measures. *Anim. Production Sci.* 60 (13), 1569–1590. doi: 10.1071/AN19621

Sanderson, M. W., Dargatz, D. A., and Wagner, B. A. (2008). Risk factors for initial respiratory disease in United States' feedlots based on producer-collected daily morbidity counts. *Can. Veterinary J.* 49 (4), 373–378.

Schöpke, K., Weidling, S., Pijl, R., and Swalve, H. H. (2013). Relationships between bovine hoof disorders, body condition traits, and test-day yields. *J. Dairy Sci.* 96 (1), 679–689. doi: 10.3168/jds.2012-5728

Schütz, K. E., Huddart, F. J., and Cox, N. R. (2019). Manure contamination of drinking water influences dairy cattle water intake and preference. *Appl. Anim. Behav. Sci.* 217, 16–20. doi: 10.1016/j.applanim.2019.05.005

Schwartzkopf-Genswein, K., Gellatly, D., and Janzen, E. (2018). "Welfare issues in feedlot cattle," in *The welfare of cattle*. Eds. T. E. Engle, D. J. Klingborg and B. E. Rollin (Boca Raton: CRC Press), 211–234.

Simon, G. E., Hoar, B. R., and Tucker, C. B. (2016). Assessing cow–calf welfare. Part 1: Benchmarking beef cow health and behavior, handling; and management, facilities, and producer perspectives. *J. Anim. Sci.* 94 (8), 3476–3487. doi: 10.2527/jas.2016-0308

Snowder, G. D., Van Vleck, L. D., Cundiff, L. V., and Bennett, G. L. (2006). Bovine respiratory disease in feedlot cattle: Environmental, genetic, and economic factors. *J. Anim. Sci.* 84 (8), 1999–2008. doi: 10.2527/jas.2006-046

Sørensen, J. T., and Fraser, D. (2010). On-farm welfare assessment for regulatory purposes: Issues and possible solutions. *Livestock Sci.* 131 (1), 1–7. doi: 10.1016/j.livsci.2010.02.025

Sparke, E. J., Young, B. A., Gaughan, J. B., Holt, M., and Goodwin, P. J. (2001). *Heat load in feedlot cattle (FLOT.307)* (North Sydney, Australia: Meat and Livestock Australia).

Spooner, J. M., Schuppli, C. A., and Fraser, D. (2014). Attitudes of Canadian citizens toward farm animal welfare: A qualitative study. *Livestock Sci.* 163, 150–158. doi: 10.1016/j.livsci.2014.02.011

Stockman, C. A., Collins, T., Barnes, A. L., Miller, D., Wickham, S. L., Beatty, D. T., et al. (2013). Flooring and driving conditions during road transport influence the behavioural expression of cattle. *Appl. Anim. Behav. Sci.* 143 (1), 18–30. doi: 10.1016/j.applanim.2012.11.003

Stokka, G. L., Lechtenberg, K., Edwards, T., MacGregor, S., Voss, K., Griffin, D., et al. (2001). Lameness in feedlot cattle. *Veterinary Clinics North America: Food Anim. Pract.* 17 (1), 189–207. doi: 10.1016/S0749-0720(15)30062-1

Stoye, S., Porter, M. A., and Stamp Dawkins, M. (2012). Synchronized lying in cattle in relation to time of day. *Livestock Sci.* 149 (1), 70–73. doi: 10.1016/j.livsci.2012.06.028

Taylor, N., and Signal, T. D. (2009). Willingness to pay: Australian consumers and "On the farm" Welfare. *J. Appl. Anim. Welfare Sci.* 12 (4), 345–359. doi: 10.1080/10888700903163658

Tennessen, T., Price, M. A., and Berg, R. T. (1985). The social interactions of young bulls and steers after re-grouping. *Appl. Anim. Behav. Sci.* 14 (1), 37–47. doi: 10.1016/0168-1591(85)90036-X

Terrell, S. P., Thomson, D. U., Reinhardt, C. D., Apley, M. D., Larson, C. K., and Stackhouse-Lawson, K. R. (2013). Perception of lameness management, education, and effects on animal welfare of feedlot cattle by consulting nutritionists, veterinarians, and feedlot managers. *Bovine Practitioner* 48 (1), 53–60. doi: 10.21423/bovine-vol48no1p53-60

Thornton, P., Nelson, G., Mayberry, D., and Herrero, M. (2021). Increases in extreme heat stress in domesticated livestock species during the twenty-first century. *Global Change Biol.* 27 (22), 5762–5772. doi: 10.1111/gcb.15825

Tucker, C. B., Coetzee, J. F., Stookey, J. M., Thomson, D. U., Grandin, T., and Schwartzkopf-Genswein, K. S. (2015). Beef cattle welfare in the USA: identification of priorities for future research. *Anim. Health Res. Rev.* 16 (2), 107–124. doi: 10.1017/S1466252315000171

Tucker, R., and Klepper, K. (2005). *Review of on-farm food safety best practice (PRMS.075)* (North Sydney, Australia: Meat and Livestock Australia).

Tuomisto, L., Huuskonen, A., Jauhiainen, L., and Mononen, J. (2019). Finishing bulls have more synchronised behaviour in pastures than in pens. *Appl. Anim. Behav. Sci.* 213, 26–32. doi: 10.1016/j.applanim.2019.02.007

Urech, R., Green, P. E., Skerman, A. G., Elson-Harris, M. M., Hogsette, J. A., Bright, R. L., et al. (2004). *Management of nuisance fly populations on cattle feedlots (FLOT.306)* (North Sydney, NSW: Meat & Livestock Australia).

Val-Laillet, D., Guesdon, V., von Keyserlingk, M. A. G., de Passillé, A. M., and Rushen, J. (2009). Allogrooming in cattle: Relationships between social preferences, feeding displacements and social dominance. *Appl. Anim. Behav. Sci.* 116 (2), 141–149. doi: 10.1016/j.applanim.2008.08.005

Vindevoghel, T. V., Fleming, P. A., Hyndman, T. H., Musk, G. C., Laurence, M., and Collins, T. (2019). Qualitative Behavioural Assessment of Bos indicus cattle after surgical castration. *Appl. Anim. Behav. Sci.* 211, 95–102. doi: 10.1016/j.applanim.2018.11.004

Vogel, G. J., Bokenkroger, C. D., Rutten-Ramos, S. C., and Bargen, J. L. (2015). A Retrospective evaluation of animal mortality in US feedlots: Rate, timing, and cause of death. *Bovine Practitioner* 49 (2), 113–123. doi: 10.21423/bovine-vol49no2p113-123

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.-V., Janczak, A. M., Visser, E. K., et al. (2006). Assessing the human–animal relationship in farmed species: A critical review. *Appl. Anim. Behav. Sci.* 101 (3), 185–242. doi: 10.1016/j.applanim.2006.02.001

Waiblinger, S., Knierim, U., and Winckler, C. (2001). The development of an epidemiologically based on-farm welfare assessment system for use with dairy cows. *Acta Agriculturae Scandinavica Section A — Anim. Sci.* 51 (sup030), 73–77. doi: 10.1080/090647001316923108

Webster, J. (2005a). *Animal Welfare: Limping Towards Eden: A practical approach to redressing the problem of our dominion over the animals* (UK: Blackwell Publishing).

Webster, J. (2005b). The assessment and implementation of animal welfare: theory into practice. *Rev. Scientifique Technique (International Office Epizootics)* 24 (2), 723.

Webster, J. (2011). *Management and welfare of farm animals: UFAW farm handbook* (Chicehester, West Sussex, UK: Wiley-Blackwell).

Webster, A. J. F., Main, D. C. J., and Whay, H. R. (2004). Welfare assessment: indices from clinical observation. *Anim. Welfare* 13, S93–S98. doi: 10.1017/S0962728600014421

Weeks, C. A. (2008). A review of welfare in cattle, sheep and pig lairages, with emphasis on stocking rates, ventilation and noise. *Anim. Welfare* 17 (3), 275–284. doi: 10.1017/S096272860003219X

Welfare Quality® (2009) *Welfare Quality® assessment protocol for cattle* (Welfare Quality® ConsortiumLelystad, Netherlands). Available at: http://www.welfarequality.net/en-us/reports/assessment-protocols/ (Accessed 9 October 2020).

Wells, S. J., Trent, A. M., Marsh, W. E., McGovern, P. G., and Robinson, R. A. (1993). Individual cow risk factors for clinical lameness in lactating dairy cows. *Prev. Veterinary Med.* 17 (1), 95–109. doi: 10.1016/0167-5877(93)90059-3

Wemelsfelder, F. (2007). How animals communicate quality of life: the qualitative assessment of behaviour. *Anim. Welfare* 16 (S1), 25-31. doi: 10.1017/S0962728600031699

Wemelsfelder, F., Hunter, A. E., Mendl, M., and Lawrence, A. B. (2000). The spontaneous qualitative assessment of behavioural expressions in pigs: first explorations of a novel methodology for integrative animal welfare measurement. *Appl. Anim. Behav. Sci.* 67, 193–215. doi: 10.1016/S0168-1591(99)00093-3

Wemelsfelder, F., and Lawrence, A. B. (2001). Qualitative assessment of animal behaviour as an on-farm welfare-monitoring tool. *Acta Agriculturae Scandinavica Section A - Anim. Sci.* 51 (sup30), 21–25. doi: 10.1080/090647001300004763

White, B. J., and Renter, D. G. (2009). Bayesian estimation of the performance of using clinical observations and harvest lung lesions for diagnosing bovine respiratory disease in post-weaned beef calves. *J. Veterinary Diagn. Invest.* 21 (4), 446–453. doi: 10.1177/104063870902100405

Willis, R. S., Fleming, P. A., Dunston-Clarke, E. J., Barnes, A. L., Miller, D. W., and Collins, T. (2021a). Animal welfare indicators for sheep during sea transport: Monitoring health and behaviour. *Appl. Anim. Behav. Sci.* 240, 105354–105365. doi: 10.1016/j.applanim.2021.105354

Willis, R. S., Fleming, P. A., Dunston-Clarke, E. J., Barnes, A. L., Miller, D. W., and Collins, T. (2021b). Animal welfare indicators for sheep during sea transport: The effect of voyage day and time of day. *Appl. Anim. Behav. Sci.* 238, 105304–105315. doi: 10.1016/j.applanim.2021.105304