

THESIS

BENCHMARKING ANIMAL HANDLING OUTCOMES AND ANALYZING IMPACTING
FACTORS ON COW-CALF OPERATIONS

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ABSTRACT

BENCHMARKING ANIMAL HANDLING OUTCOMES AND ANALYZING IMPACTING FACTORS ON COW-CALF OPERATIONS

Animal handling is an important part of the cattle industry; proper handling of animals can improve animal welfare and increase consumer confidence. One way handling is assessed on cow-calf operations is through producer education programs, such as the Beef Quality Assurance (BQA) program. A part of these producer education programs is assessing animal handling outcomes. However, there has not been much research into the occurrence and implication of cow handling outcomes. The objectives of this study were to: 1) quantify handling outcomes on cow-calf operations in the United States and 2) investigate potential factors that may influence these outcomes. An assessment was developed by refining existing BQA Cow-Calf program outcome definitions in addition to questions about animal factors, facilities, and management factors. Handling outcomes observed included: Prod Use, Miscatch, Vocalization, Jump, Slip/Stumble, Fall and Run. A total of 76 cow-calf operations were sampled in 24 states (Central, $n = 17$; East, $n = 30$; West, $n = 29$), with herd sizes ranging from 10 head to more than 5,000 head. Observations occurred during processing of either cows or yearling heifers through a cattle chute restraint system, regardless of procedure being performed. With herds less than 100 head, all cows or yearling heifers were observed as they moved through the single file alley, into the chute, and upon exiting the chute for a distance of three body lengths. On operations greater than 100 head, a maximum of 100 contiguous head were observed. Results indicate that most participants were BQA trained (70%) and had crossbred herds (63%) with a Docile temperament

(57%) and had Daily Visual Contact with their herds (47%). The mean observations for Prod Use (18.1% ± 28.9), Miscatch (2.5% ± 5.1), and Fall (2.5% ± 4.2) exceeded the upper limit of BQA standards. The BQA threshold for Prod Use is 10%, Miscatch is 0%, and Fall is 2%. Vocalization (3.8% ± 7.6), Jump (7.5% ± 9.9), Run (7.7% ± 13.8), and Slip/Stumble (6.3% ± 9.1) were within BQA thresholds (5%, 25%¹, and 10% respectively). Prod Use had the greatest number of impacting factors including BQA status, Herd Size Group, Temperament, and Visual Contact while Miscatch, Vocalization, and Fall all had single impacting factors (Region, Temperament, Visual Contact, respectively). Visual Contact and Temperament had an association with the majority of outcomes. Future research should focus more in-depth on specific factors and the variety contained within and on the role of veterinarians in handling outcome frequencies.

¹ The observations for Jump and Run have a combined threshold total of 25% or fewer occurrences in the herd.

TABLE OF CONTENTS

ABSTRACT.....	ii
LIST OF TABLES.....	v
LIST OF FIGURES.....	vi
LITERATURE REVIEW.....	1
INTRODUCTION.....	1
ANIMAL WELFARE FRAMEWORKS.....	4
ASSESSING ANIMAL WELFARE-ANIMAL, RESOURCE, AND MANAGEMENT-BASED OUTCOMES.....	6
ANIMAL-BASED OUTCOMES.....	6
RESOURCE-BASED OUTCOMES.....	7
MANAGEMENT-BASED OUTCOMES.....	8
ANIMAL HANDLING.....	9
APPLICATION ON FARM.....	10
ASSESSMENT OF ANIMAL HANDLING.....	11
BQA.....	11
BQA ANIMAL HANDLING MEASUREMENTS.....	12
IMPACTING FACTORS ON ANIMAL HANDLING.....	15
LITERATURE CITED.....	18
BENCHMARKING ANIMAL HANDLING OUTCOMES ON COW-CALF OPERATIONS..	29
SUMMARY.....	29
INTRODUCTION.....	30
METHODS.....	34
COW-CALF OPERATION SELECTION.....	34
OBSERVER SELECTION AND TRAINING.....	35
CATTLE HANDLING OBSERVATIONS.....	35
STATISTICAL ANALYSIS.....	37
RESULTS.....	39
OPERATION CHARACTERISTICS.....	39
HANDLING OUTCOME FREQUENCIES.....	40
CORRELATIONS.....	40
OUTCOMES AND PREDICTORS.....	41
PROD USE.....	41
MISCATCH.....	41
VOCALIZATION.....	42
JUMP.....	42
SLIP/STUMBLE.....	42
FALL.....	43
RUN.....	43
DISCUSSION.....	44
CONCLUSION.....	54
LITERATURE CITED.....	66

LIST OF TABLES

Table 1	Handling outcome definitions.....	55
Table 2	Predictors and different levels for the sample population	56
Table 3	Summary of animal handling outcomes for sample population	58
Table 4	Spearman correlations exhibiting the relationships between handling outcomes for the sample	59
Table 5	Summary of animal handling outcomes and predictors based on Aikake Information Criterion	60

LIST OF FIGURES

Figure 1	Association of temperament and outcome frequencies	61
Figure 2	Association of visual contact and outcome frequencies	62
Figure3	Association of herd size group and outcome frequencies	63
Figure 4	Average prod use by BQA and visual contact	64
Figure 5	Association of region and outcome frequencies	65

CHAPTER I

LITERATURE REVIEW

INTRODUCTION

Cattle production is a major economic force in American agriculture, generating the largest share of total cash receipts for agricultural commodities in the United States (Economic Research Service, 2021). In addition to the critical economic role that the agricultural industry has (ERS, 2021), cattle production has historically been an integral component of the western American identity. Although an inexact slice of history (Library of Congress, 2021), popular American mythos routinely includes images of vast ranches, cowboys, and cattle (Chow, 2019; Stars, 1998). Despite or possibly due to the images' permeation in popular imagery, cattle production and beef consumption are not under a cover of inviolability but rather have become increasingly scrutinized by consumers in respect to not only human and environmental health, but progressively animal welfare (Croney & Anthony, 2010; Fernandes, et al., 2021; Kehlbecher, et al, 2012; Mench, 2008; Stull et al., 2005). The segments of the cattle supply chain that have traditionally received the most attention with regards to humane treatment of livestock, are packing plants and dairies; these operations having been the focus of various exposés and investigations (Croney & Anthony, 2010; Grandin, 2014). However, other factions of the cattle production industry are rapidly attracting notice i.e., feedyards and cow-calf operations. Studies addressing feedlot cattle have looked at different facets of welfare including animal handling, behavior, health, and environmental factors at feedlots (Edwards-Callaway, et al., 2017; 2021; Mader, et al., 2006; Mitlöhner, et al., 2002; Woiwode & Grandin, 2014). In the cow-calf sector, common management practices such as branding, castration, and dehorning are increasingly

becoming an area of focus for researchers (M'hamdi et al., 2013; Marti et al., 2017; Petherick et al., 2014; Schwartzkopf-Genswein et al., 1998; Stafford & Mellor, 2011; Tucker et al., 2014) and consumers (Clark et al., 2016; McKendree et al., 2018; Philips et al., 2009; Zuliani et al., 2018). However, when producers are surveyed about these factors on cow-calf operations, they tend to rank these concerns lower than the general public does (Kling-Eveillard et al., 2015; Martin et al., 2019; 2019; McKendree et al., 2018).

To address these animal welfare concerns with how cattle are being raised on the myriad of operation types, various verification programs have been created and implemented across the cattle supply chain (Edwards-Callaway, 2018; Eicher, 2006; Fraser, 2006; Hewson, 2003; Stull, et al., 2005). The North American Meat Institute (NAMI, 2022), in addition to federal regulations such as the Humane Slaughter Act 1978, address the packer segment of the supply chain while the National Cattlemen's Beef Association (NCBA) Beef Quality Assurance (BQA) program provides guidance for feedlots, transporters, and stockers (BQA, 2019c; 2021a; 2021b). The cow-calf segment of the supply chain has a plethora of programs addressing animal welfare including BQA, Global Animal Partnership (GAP), Animal Welfare Approved by AGA (AWA), and Certified Humane (HFAC), among others (Wade, 2018; USDA, 2020). All the aforementioned programs, with the exception of BQA, have an associated meat label for their verification programs (Wade, 2018). However, BQA remains a more widespread industry program with over 580,000 active certifications (J. Fitzsimmons, personal communication), and endorsement from large packers (Cargill, 2020; JBS, 2022; Tyson, 2022) and feedlots (Woiwode et al, 2016; Woiwode & Grandin, 2014). The prevalence of BQA is likely due to it being an industry-based education program created to involve a large number of people and no cost for entry.

A key component of these various cattle care programs is the adoption of low-stress handling as a best management practice for cattle producers. This increased focus on good stockmanship provides not only benefits for the animals but the caretakers as well (Ceballos et al., 2018; Grandin, 1999; Hemsworth & Coleman, 2011; Noffsinger and Locatelli, 2004). However, due to the expansive nature and inherent variety of cow-calf operations and producers (e.g. operation size, breed type, location within the United States, etc.; APHIS, 2017), it can be difficult to apply a broad-brush approach to standards and have effective outreach to encourage adoption (Simon et al, 2016). The cow-calf segment contains the greatest amount of independent owners as compared to the consolidation of feedlots and packers (National Agriculture Statistics Service [NASS], 2017). This variety of owners in turn creates the opportunity for the greatest diversity in management, facilities, and practices in the cow-calf segment. This diversity then presents the subsequent challenges of how to reliably assess the standards of an applied verification program along with how to address the impacts of various factors present at cattle processing that are not necessarily captured by solely measuring outcomes. These presented challenges have created a vacuum in the current literature about welfare challenges present on cow-calf ranches, with a particular focus on animal handling and stockmanship.

ANIMAL WELFARE FRAMEWORKS

Animal welfare is not a new consideration for livestock production but rather an evolving concept as values change and new research specific to managing and improving cattle welfare emerges (McKendree et al., 2018; Fernandes et al., 2021; Fraser, 2009; Weary & Robbins, 2019). Traditionally, assessing welfare involved observing morbidity and mortality (Noffsinger & Locatelli, 2004). However, as public perceptions towards farm animal welfare changed, two frameworks were developed and are commonly used for applying animal welfare concepts across all animals are The Five Freedoms (Brambell, 1965; Elischer et al., 2019; McCulloch, 2013; Mellor, 2016; Poletto & Hötzel, 2014) and Fraser's Three Circles (Broom, 2011; Fraser et al., 1997; Fraser, 2008; Weary & Robbins, 2019). Despite these two frameworks increasingly transitioning out of academic circles into wider industry application (Weary & Robbins, 2019), performance and health indicators often remain the standard for industry purposes (Hoy & Verga, 2006; Kelly & Janzen, 1986; Turner & Dwyer, 2007).

In the debate of how to measure animal welfare a common critique of assessing an animal's mental and emotional state, is that it is too subjective to be reliably measured (Broom, 1991; Hewson, 2003; Kniriem & Winkler, 2009; McLaren & Appleyard, 2019). Therefore, health parameters such as morbidity and mortality have traditionally been used by the cattle industry to measure success in production practices (Noffsinger & Locatelli, 2004) with a more recent focus on other physical parameters such as gain of the live animal and meat quality (Boykin et al., 2017; del campo et al., 2021; Hagenmaier et al., 2016; Sonoda et al., 2017). Health parameters are integral parts of both The Five Freedoms (Farm Animal Welfare Committee, 2009) and Fraser's Three Circles (Fraser et al., 1997) but due to their easily quantifiable nature, they have been traditionally focused on for reporting and analysis. The

number of animals who have died, have lesions, have bruising, etc are more easily captured. The limitations of utilizing only health parameters such as mortality and morbidity are that they do not address the totality of the animal's experience including affective state, which is integral to animal welfare (Fraser, 2006, Jirkof et al., 2019; Stull et al., 2006; Webster, 2003) and push the beef industry further out of step with consumers (Croney & Anthony, 2010; Fernandes et al., 2021; Kehlbacher et al., 2012; McKendree et al., 2014; 2018; Mench, 2008).

The Five Freedoms originated in England, where spurred by citizen concern, a commission headed by Roger Brambell was formed to review current intensive livestock practices. Known as the "Brambell Commission", this group released a report in 1965 stating that animals should have the freedom to stand up, lie down, turn around, groom themselves, and stretch their limbs (Brambell, 1965; Elischer, 2019; McCulloch, 2013). These findings were then codified into the Five Freedoms by the Farm Animal Welfare Council (FAWC) in 1979 (Elischer, 2019). The list of Five Freedoms are as follows: 1) Freedom from hunger and thirst 2) Freedom from discomfort 3) Freedom from pain injury and disease 4) Freedom to express normal behavior and 5) Freedom from fear and distress (Farm Animal Welfare Committee, 2009; Elischer, 2019; McCulloch, 2013). These freedoms, while having been integrated into subsequent animal welfare frameworks, legislative actions and best management practices, have received criticism for focusing on the negative side of welfare and for being too non-prescriptive and general in their language (McCulloch, 2013; Mellor; 2016). The general language used in the Five Freedoms and the focus on the negative i.e., "freedom from...", sets a minimum that must be met rather than providing a beneficial existence. Despite its limitations, the Five Freedoms have been foundational in establishing standards for livestock animal welfare.

The next major framework, Fraser's Three Circles, often used in the evaluation of animal welfare, was crafted partially against the backdrop of the Five Freedoms and its influence on the field of animal welfare in the following decades. Fraser et al. (1997), sought to create one cohesive model for assessing animal welfare that incorporated three concerns of animals in captivity: living natural lives, feeling well, and having satisfactory health with functioning physiological and behavioral systems. These concerns became formalized into the model of overlapping circles of biologic functioning, affective states, and natural living (Fraser, 2009; Fraser et al., 1997). Fraser's framework, while useful, also contains an inherent limitation in actual application. It can be very difficult to balance needs in the three areas as they can often be contradictory; optimal fulfillment of one welfare criteria area can lead to suboptimal fulfillment in another (Croney & Anthony, 2010; Etim et al., 2014; Lassen et al., 2006; Weary & Robbins, 2019). For example, it can be stated that a chicken has a natural behavior of seeking food outdoors by pecking the ground cover (natural living), however, in being outdoors the chicken is now more susceptible to predation and disease (health) (Grandin, 2020).

ASSESSING ANIMAL WELFARE-ANIMAL, RESOURCE, AND MANAGEMENT-BASED

OUTCOMES

Within the three frameworks listed above, there are several different measures used to assess animal welfare. These measures largely fall under three categories: animal-based, resource-based, or management-based outcome measurements.

Animal-Based Outcomes

Animal-based outcomes directly record aspects of the animals themselves and are critical parts of animal welfare assessments (Grandin, 1998; Hewson, 2003). These types of outcomes

are direct measures of an animal's welfare as they are made via direct observations of various animal characteristics (Grandin, 2010; Knierim and Winckler, 2009; Miele et al., 2011; Webster, 2005). Animal-based outcome measurements can be species specific i.e. missing feathers in poultry (Global Animal Partnership, 2020) and tail biting in swine (Pork Quality Assessment Plus, 2019) and vary by production setting and third-party requirements. For animal-based outcomes in beef cattle, actions such as vocalizing, slipping, and falling are commonly measured as parts of on-farm and in-plant animal handling assessments (BQA, 2019a; NAMI, 2021). Animal-based outcomes are useful in that these measures can provide information about potential issues in the animal's environment.

Disadvantages in using this type of outcome lie in the reliability and repeatability of measurements. Some animal-based outcomes are easy to measure such as a steer slipping on the ramp (Uetake et al., 2008). Others are more qualitative and can be difficult to assess (Hewson, 2003; Webster, 2005) such as amount of mud on a hide (Mijares et al., 2021). Several studies performed have found either or both reasonable reliability and repeatability (Czycholl et al., 2016; Czycholl et al., 2019a; Czycholl et al., 2019b; Friedrich et al., 2019; Flower and Weary, 2005; Gardenier et al., 2021; Parham et al., 2019) for several measurements but have found that other animal-based outcomes are difficult to assess, especially in herds (Friedrich et al., 2019)

Resource-Based Outcomes

These outcomes directly measure the resources that animals need and that are part of their environment i.e., pen density, minimum trailer sizes, food and water availability, number of animals per feed and water trough, maximum amount of particulates in the air, etc (BQA, 2019a; 2019b; 2019c; 2021a; 2021b; NAMI, 2021; PQAPlus, 2019). As with the use of the previously mentioned health parameters, resource-based outcomes provide the advantage of being easily

measured (Knierim & Winckler, 2009) and ensure at least a minimum standard of provision (Keeling, 2005; Noffsinger & Locatelli, 2004). However, focusing solely on assessing resources provides an incomplete picture of animal welfare (Fraser, 2006; Weary & Robbins, 2019) as resource-based parameters themselves are not measuring animal welfare; they are identifying potential risks within the environment that could impact an animal's welfare (Grandin, 2020).

Management-Based Outcomes

Another area of outcome-based measurements entail management-based parameters. There are numerous measurements that fit within his category. Some commonly assessed in cattle care programs, these parameters include emergency action plans, documenting employee training, herd health plans, and written evidence of veterinary-client-patient-relationships (VCPRs) (BQA, 2019a; Wade, 2018). Emergency actions plans can prevent further mortality and morbidity (BQA, 2019a; Hanthorn et l., 2021; Rethhorst, 2018), which can improve health and affective state welfare parameters. Employee training has been shown to improve animal welfare through better handling (Coleman & Hemsworth, 2014; Edwards-Callaway, 2018; Grandin, 1996; 2012; Hemsworth & Coleman, 2009; Sorge et al., 2014). Herd health plans and VCPRs additionally affect animal welfare by preventing disease, treating disease, and mitigating pain (Dewell, 2021; Paton, 2013; Sibley, 2010).

ANIMAL HANDLING

Beef cattle typically begin their lives on extensively managed farms known as cow-calf operations. On a cow-calf operation, cows will be restrained and subject to handling by stockpeople for both medical and reproductive procedures. Medical procedures include vaccinations, supplementation, parasite control (Penn State 2014; APHIS, 2009), and acute injury treatment (Jean & Anderson, 2014). Reproductive procedures include pelvic

measurement, artificial insemination, and pregnancy checking (APHIS 1998; Bekele et al., 2016; Wiltbank et al., 1961).

Low stress handling for animals during this time has been adopted as a best practice (BQA, 2019a; 2019b). Low stress handling is the incorporation of natural livestock behaviors and senses in the management of animals in production settings (Grandin, 2007). Alternately known as good stockmanship, this practice lies at the junction of not only providing benefits for the animals (Grandin; Hemsworth & Coleman 2011; Leon et al, 2020; Boivin et al., 2003) but caretakers as well (Grandin, 1999; Hemsworth, 2004, Coleman & Hemsworth, 2014; Edwards-Callaway, 2018; Noffsinger & Locatelli, 2004.).

Most notably associated with Temple Grandin, low stress handling is a holistic practice that incorporates facets of the handler's body language including body positioning, angle, distance, timing, and pressure (Grandin, 2007; Noffsinger & Locatelli, 2004) with the animal. Additionally, considerable focus is put on the minimization of distractions in handling areas and specific aspects of facility design (Grandin, 1980; 1998). By working with an animal's instincts and natural behaviors, the animal will remain calmer (Hemsworth; 2003; Ceballos et al., 2017; Grandin, 1998) which is tied to an improved animal welfare (Broom et al., 1993; Moberg, 2000; Moberg & Mench, 2000), productivity (Hemsworth 2003; Leon et al., 2020; Grandin; Daigle & Ridge 2018), and worker outcomes (Grandin, 1997; Ceballos et al., 2017, Noffsinger & Locatelli, 2004).

Cumulatively, low stress handling is critical over an animal's lifetime as domesticated species' previous handling experiences influence their reaction to current handling situations (Andrade et al., 2001; De Jonge et al., 2000; Grandin & Shively, 2015; Hemsworth 2003; Hemsworth & Coleman 2010; Parham et al., 2019; Rybarczyk et al., 2001;). As these studies

state, the impact of both chronic and acute stress or lack thereof has effects on both livestock welfare and worker safety. To realize the positive benefits of low stress handling, stockpeople must be trained in the application of low stress handling techniques (Boivin et al., 2003; Burton et al., 2012; Ceballos et al., 2017; Coleman & Hemsworth, 2014; Daigle & Ridge, 2018; Edwards-Callaway, 2018; Grandin, 1996; 2012; Hemsworth 2003; Hemsworth and Coleman, 2009; 2010; Leon et al., 2020; Sorge et al., 2014).

Application On Farm

Temple Grandin has long been recognized as a foremost source on animal handling and has produced several works about low stress handling (Grandin, 1989; 1999; 2008; 2014; 2017). Specific aspects of low stress handling include stockpeople moving slowly and quietly while using animals' flight zones and point of balance rather than physical contact to move them. The flight zone is the space around an animal where intrusion into it by the handler will cause the animal to move away while exit from it by the handler will cause the animal to not move but rather turn to face the handler. The size of the flight zone is specific to each animal; tamer animals will have a smaller flight zone where the stockperson has to get closer to the animal to trigger movement whereas the reverse is true for an animal less acclimated to human contact. The point of balance is located around the animal's shoulder where the handler's position in relation to the point of balance will cause the animal to move in a direction opposite and away from the handler. Additional aspects of low stress handling include letting fearful, agitated animals return to a state of calm before handling again, reducing noises such as yelling while moving animals, reducing or removing visual distractions such as hanging chains and shadows, and using handling tools appropriately (Grandin, 1999).

ASSESSMENT OF ANIMAL HANDLING

The practice of low-stress handling is included as a best management practice in the aforementioned cattle care programs (BQA, GAP, AWC, AHC) as a standard component to address the welfare of livestock in a production setting (Wade, 2018). The assessment of animal handling is largely captured by measuring animal-based outcomes (Grandin, 2010; 2020). Having a measurement strategy to determine the efficacy of animal handling is critical in being able to evaluate handling and to make adjustments when necessary (Grandin, 1998; 2007; 2010; 2020).

BQA

One of the most widespread cattle care programs used throughout the beef segment of the livestock industry is the Beef Quality Assurance Program (BQA, J. Fitzsimmons, personal communication, September 13, 2021). Originating over forty years ago, BQA is a nationally coordinated program that is dispersed to individual states for implementation (BQA, 2019b). As stated by BQA, their mission is two-fold; to help producers realize greater profit from the animals they produce through quality, safety, and consistency of end product and to promote consumer confidence within the beef industry. To accomplish this mission, BQA has programs addressing transporters, feedlots, backgrounders and stockers, and cow-calf operations (BQA, 2019a; 2019b; 2019c; 2021a; 2021b; Woiwode & Grandin, 2014; Simon et al., 2016). These various sub-programs within BQA consist of trainings with respective training materials followed by on-site assessments for feedlots, stocker, and cow-calf operations to achieve certification. BQA assessments record both resource and animal-based outcomes (BQA, 2019b).

The particular animal-based outcomes measured during the BQA assessment of a cow-calf operation occur during movement of cattle through a restraint chute. The outcomes

measured are prod use, miscatch, vocalizing, stumbling or tripping, falling, jumping, and running. According to BQA (2019a), prod use is defined as discharging electric current while in contact with the animal. A miscatch is when the animal being in any position other than with its head fully outside of the chute and the balance of the body within the chute, or if an animal is caught in the tail/back gate and not released. Vocalizing occurs when cattle make an audible noise following improper restraint but prior to occurrence of a procedure. Stumbling or tripping is defined as an animal contacting the ground with a knee. Falling occurs when the animal's torso/belly touches the ground. There is no BQA definition of jumping while running is defined as not being trotting or loping.

BQA Animal Handling Measurements

Animal handling outcomes measured during the BQA Cow-Calf Assessment are miscatches, prod use, vocalizing, stumbling or tripping, falling, jumping, and running. Miscatches and prod use are direct measurements of handling performed by stockpeople on animals while vocalizing, stumbling or tripping, falling, jumping, and running are indirect measurements of handling and overall welfare. Other industry animal handling assessments incorporate select outcomes as well into their assessments (NAMI, 2021; PQAPlus, 2019). Studies analyzing these outcomes have occurred at feedlots (Woiwode & Grandin, 2014) and on cow-calf operations (Simon et al., 2016). Both studies found outcomes that were performed in excess of BQA thresholds.

A miscatch occurs when a procedure is performed on an animal when that animal is either not securely held with its head entirely outside the chute with the remainder of its body inside the chute or when two animals are caught in the chute at the same time i.e. one animal caught in the head gate and the following animal is caught in the tail gate (BQA, 2019a). This

measurement is important as restraint in a chute can induce a high stress response in animals (Chen et al., 2016; Grandin, 1993; Grandin & Shively, 2015) and even pressure applied over an animal's body can down regulate the stress response (Grandin, 1993a). An improperly caught animal can experience undue additional stress which in turn creates welfare, handling, and worker safety issues (Grandin, 1993b). Limited studies have been performed looking at miscatch rates but these studies have reported rates on cow-calf operations (14.5%) that exceeded thresholds set in BQA standards (Simon et al., 2016) while those at feedlots indicated lower rates of miscatch than reported on cow-calf operations (2.2%) but still in excess of BQA program guidelines (Woiwode & Grandin, 2014).

Electric prods are used as a driving aid to move cattle and prod use occurs with the application of an electric prod, whether charged or not, to an animal (BQA, 2019a; NAMI, 2020). However, the issue of prod usage remains controversial. Several third-party verification programs ban the use of electric prods (Wade, 2018) as there is some indication of it being an aversive experience to cattle (Grandin, 1998; 2001) while some studies indicate no lasting effect if used judiciously according to industry guidelines (BQA, 2019a; NAMI, 2021; Smith et al, 1998). It has been noted that there is an ability to over use prods as a handling tool (Grandin, 2001) but here is little research conducted around to what degree of pain cattle feel from prods, the ethics of applying pain to animals with the purpose of moving them and the efficacy of prod usage compared to other handling tools. This might be due to ethical considerations in performing animal research in recreating aversive and possibly long-lasting pain.

Cattle are a herd species and as such very commonly communicate back and forth with each other (BQA, 2019a; Schnaider et al., 2021). These communications through vocalization relay a variety of internal and external information (Grandin, 2001; Manteuffel et al., 2004;

Schön et al., 2007; Watts & Stookey, 1999; 2000). However, when vocalizations are recorded during the BQA assessment, it occurs only while the animal has been caught in the restraint chute but before any procedure is initiated on the animal (BQA, 2019a). Recording vocalizations during this specific period immediately following restraint but before the onset of a procedure has the purpose of trying to capture any response to pain or discomfort caused by the chute or handler to the animal and not the procedure itself. Chute issues can range from sharp edges to excessive pressure in the case of hydraulic chutes (Grandin, 1998; 2001). A minimal amount of animals vocalizing during a handling event, can be attributed to individual animal differences rather than issue with a chute. However, a higher percentage of recorded vocalizations can indicate an issue with the chute.

As the pressure on the restraint chute is released and the head gate opens, observations are made for any incidences of stumbling, tripping, or falling as the animal exits the chute. Stumbling and tripping occur when an animal contacts the ground with its knee while falling occurs when an animal's belly or torso contact the ground (BQA, 2019a). Slipping, stumbling, tripping, and falling can cause acute distress for animals and can result in injury (Benson and Mason, 2009; Grandin, 1998). Excessive amounts recorded of these outcomes can indicate an issue with issue the footing within the chute or immediately outside of it (Benson & Mason, 2009; Grandin, 1998). Despite being included as a parameter in cattle care programs (BQA, 2019a; NAMI, 2021), there is little research on the effect of slipping on cattle welfare. One study to analyze slipping was Uetake et al. (2008) who recognized that increased slipping due to ramp conditions can cause poor welfare due to injury.

Jumping and running are also outcomes measured upon release of the animal from a chute. Jumping and running do not have clear definitions within the BQA assessment but

running is slightly defined by not being trotting or loping (BQA, 2019a). These outcomes are typically measured as overall indications of temperament and internal state (Blanco, et al., 2009; Burrow, 2001; Fordyce, et al., 1985; Grandin, 1993, 2010; Lima et al., 2018; Sant'Anna et al., 2013). These actions are indicative of escape behaviors which in turn is indicative of a fear response towards humans.

Impacting Factors on Animal Handling

Processing of cattle on cow-calf operations occurs in a very dynamic space (Simon et al., 2016). Therefore, it can be difficult to quantify the various factors that affect animal-, resource-, and management-based outcome measurements. These background factors include such varied aspects as facility construction, frequency of animal handling, type of procedure the animal is undergoing, herd size, breed, and region (Simon et al., 2016).

In general, facilities for cattle handling in the United States typically include a corral system involving a large holding pen, a smaller crowd pen, an alley way, and a chute. From once to several times a year, cattle are typically restrained in a chute device for the aforementioned medical and reproductive activities (Grandin 1998; Grandin & Shively 2015). On cow-calf operations in the United States, there are commonly found at least one of three types of chutes: self-catch, manual, or hydraulic. Within each style, there are variations including the presence of brisket bars, neck extenders, covered sides, and removable panels. All chutes involve the capture of an animal's neck in a gate to limit the animal's movement during procedures. Some styles of chute also allow for compression on the animal's sides to further limit movement. Restraint can in itself be stressful and auditory and visual distraction should be minimized to reduce that stress (Andrade et al., 2001; Chen et al., 2016; Grandin, 1993a; 1998). Stress from restraint can also be reduced by the frequency of positive or neutral experiences an animal has in a chute (Andrade et

al., 2001; Grandin, 1993a; Grandin & Shively, 2015; Parham et al., 2019). Overall, increased handling with positive outcomes reduces fear in animals and makes them easier to handle subsequently. Conversely, previous negative handling experiences and extremely infrequent handling result in difficulties for moving animals (Boivin et al., 1998; Hemsworth and Barnett, 2000; Lensink et al., 2000; Rault et al., 2020; Rybarczyk et al., 2001; Schmeid et al., 2008; Waiblinger et al., 2004). An animal's behavior in the chute is affected by a combination of facility design and previous handling experiences.

An animal's level of stress in the chute is also impacted by the procedure the animal is undergoing. Some procedures are considered painful and invasive such as dehorning (Kling-Eveillard et al., 2015; Stafford and Mellor, 2011; Stock et al., 2013) and castrating (Capucille et al., 2002; Coetzee, 2013; Moya et al., 2014; Stafford & Mellor et al., 2005). Others, such as ear tagging, are viewed as minimally invasive and thus, minimally aversive (Temple Grandin, personal communication, 2017) but studies have indicated that ear tagging is also a painful procedure (Lomax et al., 2017; Schnaider et al., 2022; Steagall et al., 2021). While a common practice on cow-calf operations, there is a dearth of research on pain and stress associated with pregnancy checking. Another factor with lacking research is the possible effect on stress levels of multiple procedures being performed on an animal in a single handling event i.e. pregnancy checking, vaccination, ear-tagging, and branding.

There is limited research on herd size effects on cattle in extensive systems. Studies have mostly focused on disease transmission (Alonso-Andicoberry et al., 2001; Beggs et al., 2019; Brooks-Pollock, E., & Keeling, 2009; Rowlands et al., 1983) and breeding (Sasaki et al., 2016) with mixed findings on effect of herd size. One study to look at the impacts of herd size on overall welfare was Gieseke et al. (2018), which reported that inferences about overall welfare

cannot be gathered from solely herd size due to the various other factors that impact welfare. There is limited research on impacts caused by varying herd sizes on cow-calf operations. Multiple studies have been performed analyzing the relationship between breed and temperament finding distinct breed differences in temperament levels (Burrow et al., 1988; Hearnshaw & Morris, 1984; Fordyce et al., 1982; Morris et al., 1994). Additionally, temperament and handling have been analyzed with studies indicating that more agitated levels of temperament increase handling difficulties (Blanco, et al., 2009; Burrow, 2001; Fordyce, et al., 1985; Grandin, 1993, 2010; Sant'Anna et al., 2013). Animals with an elevated temperament i.e. agitated, perform more escape behaviors and can be aggressive towards handlers. However, little research has been done looking at breed effects on different parameters of animal handling. Boivin et al. (1992) found that breed did not have a significant effect on handling.

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CHAPTER 2

BENCHMARKING ANIMAL HANDLING OUTCOMES AND IMPACTING FACTORS ON COW-CALF OPERATIONS

SUMMARY

The objectives of this study were to: 1) quantify handling outcomes on cow-calf operations in the United States and 2) investigate potential factors that may influence these outcomes. An assessment was developed by refining existing BQA Cow-Calf program outcome definitions in addition to questions about animal factors, facilities, and management factors. Handling outcomes observed included: Prod Use, Miscatch, Vocalization, Jump, Slip/Stumble, Fall and Run. A total of 76 cow-calf operations were sampled in 24 states (Central, $n = 17$; East, $n = 30$; West, $n = 29$), with herd sizes ranging from 10 head to more than 5,000 head.

Observations occurred during processing of either cows or yearling heifers through a cattle chute restraint system, regardless of procedure being performed. With herds less than 100 head, all cows or yearling heifers were observed as they moved through the single file alley, into the chute, and upon exiting the chute for a distance of three body lengths. On operations greater than 100 head, a maximum of 100 contiguous head were observed. Results indicate that most participants were BQA trained (70%) and had crossbred herds (63%) with a Docile temperament (57%) and had Daily Visual Contact with their herds (47%). The mean observations for Prod Use ($18.1\% \pm 28.9$), Miscatch ($2.5\% \pm 5.1$), and Fall ($2.5\% \pm 4.2$) exceeded the upper limit of BQA standards. The BQA threshold for Prod Use is 10%, Miscatch is 0%, and Fall is 2%. Vocalization ($3.8\% \pm 7.6$), Jump ($7.5\% \pm 9.9$), Run ($7.7\% \pm 13.8$), and Slip/Stumble ($6.3\% \pm$

9.1) were within BQA thresholds (5%, 25%², and 10% respectively). Prod Use had the greatest number of impacting factors including BQA status, Herd Size Group, Temperament, and Visual Contact while Miscatch, Vocalization, and Fall all had single impacting factors (Region, Temperament, Visual Contact, respectively). Visual Contact and Temperament had an association with the majority of outcomes. Challenges encountered included recruiting participants, attempting to capture appropriate impacting factors, and schedule logistics. Future research should focus more in-depth on specific factors and the variety contained within and on the role of veterinarians in handling outcome frequencies.

INTRODUCTION

Consumers are becoming increasingly invested in animal welfare (Croney & Anthony, 2010; Kehlbacher, et al, 2012; Stull et al., 2005). Several studies have indicated that certain segments of the public in developed nations are willing to pay for what they perceive are products associated with improved animal welfare (Fernandes et al., 2021; Kehlbacher, et al., 2012; Mench, 2008; Olynk et al., 2021). These products can often be identified by the use of verified labels on the product packaging indicating producer compliance with third-party animal care verification programs (Eicher, 2006; Fraser, 2006). Concerned consumers can also affect legislation regarding livestock husbandry practices by successfully petitioning legislation to mandate conditions such as space requirements for living conditions (Coleman, 2018; Croney & Anthony, 2010; Chang, 2021; McKendree, et al., 2018; Mench, 2008). However, this increased consumer concern with animal welfare is concurrent with the consumer having less connection than ever before to animal agriculture but increased exposure through media to certain husbandry

² The observations for Jump and Run have a combined threshold total of 25% or fewer occurrences in the herd.

practices (Grandin, 2014), often through undercover recordings of animal abuse (Croney & Anthony, 2010). A 2014 survey by McKendree, et al. of 798 American households was performed to investigate relationships between household characteristics and concern with animal welfare along with sources used to find information about animal welfare. This survey indicated that most participants did not have a primary source of animal welfare information and those participants that did most often turned to animal rights organizations (McKendree, et al., 2014). Livestock welfare is an emotive issue (Kehlbacher et al., 2012) and animal rights organizations can focus on or misrepresent current industry standard practices to generate strong emotions in consumers (Freeman, 2010; People for Ethical Treatment of Animals [PETA], 2022).

Despite the fact that cattle care programs have existed in the United States prior to the rising concern about animal welfare in agriculture (BQA, 2019; NAMI 2022), this increased pressure has led to the creation of various new assurance and verification programs across the cattle supply chain and incorporation of animal handling parameters into existing ones (Edwards-Callaway, 2018; Eicher, 2006; Fraser, 2006; Hewson, 2003; Stull, et al., 2005). The processing segment of the industry utilizes the North American Meat Institute (NAMI) animal care and handling guidelines (NAMI, 2021) which third party organizations use to audit packing plants. The feedlot industry largely ascribes to the Beef Quality Assurance (BQA) Feedlot Audit (BQA, 2019; Woiwode & Grandin, 2014). Beef Quality Assurance additionally has programs for transporters and backgrounders/stockers (BQA, 2019). The cow-calf segment has several programs available to participate in including the Global Animal Partnership, Certified Humane and, BQA (BQA, 2019; Wade, 2018). However, only some of these programs come with verified labels. A third-party verification program can provide a USDA approved label to be put on a

meat or other animal product verifying that a producer has successfully met that program's requirements regarding animal welfare practices (Eicher, 2006). While a verified label can return a premium on a product, there is an associated cost to the producer to participate that they may not realize a return on (Eicher, 2006; Escobar and Demeritt, 2017; Fernandes et al., 2021). This can create a barrier to entry for producers. Participation in BQA can have fewer associated costs and still entail producers meet certain animal handling parameters. However, it is difficult for producers to communicate with consumers about their on-farm animal welfare practices without having any marker on the end product for consumers to see (Kehlbacher et al., 2012).

Communication between cattle producers and consumers is hindered by being on opposite ends of the supply chain (Connexus Cattle, 2014) and often having different knowledge bases and experience with livestock practices in general (Grandin, 2014). With over 580,000 individuals with active certifications (J. Fitzsimmons, personal communication, September 13, 2021), the program's animal handling guidelines, specifically the Cow-Calf Assessment (BQA, 2019), are a critical resource for the industry.

Animal handling is often a key component in various audits and verification programs throughout the cattle supply chain. Animal handling outcomes such as prod use, vocalization, and slipping are measured because they can be indicative of stockmanship and facilities which can both have an impact on animal welfare (Edward-Callaway, 2018; Grandin, 2010; Hewson, 2003). The measurement of animal handling outcomes for audits has been successfully applied across feedlots (Woiwode and Grandin, 2014) and packing plants (Grandin, 1998). However, the cow-calf segment has not as readily adopted these measurements, in part due to the fact that requirements for third party audits as seen in the other sectors is not as extensive.

Firstly, the expansive nature of the cow-calf segment (USDA, 2017) creates difficulties in outreach to cattle owners about animal handling program guidelines. Subsequently, there are then difficulties in adequately evaluating and reevaluating those standards of animal handling (Simon et al., 2016). These difficulties have created an issue of limited information about the occurrence rates of some of these animal handling outcomes on cow-calf operations and how different factors such as facility design, seasonal weather, handling amounts, and stockperson training may impact the outcomes (Simon et al., 2016).

Surveys have been utilized to gather cow-calf producer perspectives and self-reported practices performed about animal handling and welfare (Martin, et al., 2018; 2019; McKendree et al., 2018) but to the author's knowledge, the only research to assess animal handling on cow-calf operations through observation has been Simon et al., (2016). The authors were able to collect the incidences of outcomes measured in the BQA program including electric prod use, miscatch, and vocalizations along with management factors such as training and herd health management. While able to capture a range of different factors such as herd size, age of operation, and amount of visual contact, the study was unable to capture other factors such as differences in management styles, weather and landscape, and other regional differences as the study was performed in only one state during one season.

A component of cattle care programs involves evaluating animal handling through quantifying animal-based outcomes and setting thresholds for acceptable incidences of these outcomes. Benchmarking of thresholds is a critical part of an assessment scheme to ensure compliance and generate public trust in the scheme (Huxley et al., 2004). Despite this, little research has been conducted about the value and practicality of these thresholds and the various factors that could affect them on cow-calf operations. To gain insight into how these thresholds

are currently being applied, the objectives for this study were to: 1) summarize animal handling outcomes on cow-calf operations and 2) determine which factors, such as Region, BQA Certification Status, or overall Herd Size impact outcome frequencies.

METHODS

Cow-Calf Operation Selection.

The recruitment process for cow-calf operations for this study involved an initial reach out to numerous National Cattlemen's Beef Association (NCBA) staff, State Beef Quality Assurance (BQA) coordinators, county extension agents, university professors, veterinarians, trade-publications and trade organizations along with networking in the local community and at conventions. The effort dedicated to finding potential participating operations was extensive and a considerable number of contacts were made by a group of collaborating individuals. From these sources, a list of potential producers was compiled and contacted to inquire about interest and availability in participating in the study.

Selection criteria for the cow-calf operations were limited specifically to having a minimum of ten total head of cows and/or yearling heifers and the use of a cattle restraint chute during the observational period. Calves, steers, and bulls were not observed for this study. A numerically even sampling was attempted across all states included in the NAHMS Beef study (2017).

Observer Selection and Training.

Due to various logistical factors including number of cow-calf operations and the vast geographical range of this study, 9 total observers were selected for this study with 1 primary

observer selected to perform the majority of ranch visits. All observers had previous experience with assessing cattle handling outcomes in a professional capacity as either an extension agent, veterinarian, or other industry/academic position. Each observer was provided with a training module to be completed before their first ranch visit. The module consisted of 2 main parts: written definitions of handling outcomes and temperament with labeled video examples of handling outcomes provided by National BQA staff and a simulated mock cow-calf operation visit with 47 videos of cows being processed through the chute and a data sheet to record observations of handling outcomes.

Cattle Handling Observations.

Operations were visited between September 2020 and November 2021. Each visit occurred over a 1-day period with a single trained observer recording cattle handling outcomes during processing. The exact location of the observer varied by operation, but the observer stood at a position to be able to watch the animals moving through the single file alley and into and out of the chute. When breeding boxes were used, the observer would move from multiple locations to observe the focal cow as she moved from the single file alley into the chute and then out of the chute and breeding box.

At operations processing more than 9 but less than 100 cows, observations were made on all cows. At operations processing greater than 100 cows, observations were made on a contiguous group of 100 cows. One hundred head was chosen as the upper limit for observations to remain consistent with the BQA Cow-Calf Assessment (2019). The majority of observations were made on animals at the entrance of the chute, upon initial restraint, during restraint, and upon exit including three body lengths of space after the chute. Prod use was measured in the

single file alley in the lead up to the chute and overall temperament was measured throughout the processing of the cattle. Criteria for assessing the observed handling outcomes were derived from the existing BQA Cow-Calf Assessment (2019) with the addition of a measurement for trotting and a category to capture the event of a cow maintaining a position not fully upright for a majority of her time in the chute (i.e., supporting her weight on her front two cannon bones rather than hooves). The presence (or absence) of each handling outcome was recorded for each individual animal. A list with definitions of the handling outcomes criteria can be found in Table 1.

For analysis, each operation was assigned to a region based upon the state it was located: West (AZ, CA, CO, ID, MT, NM, NV, OR, WA, WY, UT), Central (IA, IL, KN, MN, MO, ND, NE, OK, SD, TX, WI), and East (AL, AR, CT, DE, FL, KY, GA, IN, LA, MA, MD, ME, MI, MS, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WV) (NAHMS, 2017). Each operation was additionally assigned to a category based upon total herd size. These herd size categories were derived from the 2017 Ag Census data (USDA, 2017). Animal factors recorded included breed, temperament, and procedure being performed. The breed of each herd was recorded as either purebred or crossbred, as reported by the owner. A herd was classified as crossbred if the herd consisted of multiple purebred animals from various breeds and animals with mixed breed lineage. Temperament scores, based upon the Beef Improvement Federation guidelines (BIF, 2018) were assigned on a herd level. A separate category of Mixed was created to address herds that were equally distributed across adjacent temperament scores. Type of procedure and number of unique procedures performed on a focal animal during restraint was recorded. Facility information that was recorded included chute style (hydraulic, manual, or self-catch), facility construction material of the pens and alleyways (metal, mixed, or wood), and the ground

material at the exit of the chute (cement, rubber, or earth). Management factors that were recorded included BQA certification status, type and number of handling implements used, total amount of stockpeople engaged in handling cows, distraction presence and type at observed handling event, and the average frequency that producers and/or workers interacted with animals both physically through handling in a chute and through visual contact without any physical contact (Table 2). Due to the variability in conditions on cow-calf operations, observers additionally recorded any extra pertinent information or observations not captured elsewhere on the data sheet.

Statistical Analysis.

Data were analyzed using R Statistical Software (v4.1.2; R Core Team, 2021). For analysis we explored the data, collected on a per operation basis, using several summary statistics. The incidences of observed handling outcomes were computed on a percentage basis per operation and summarized (mean, median, min, max, and sd). Observation totals for each predictor level were calculated across all operations. Correlations were calculated between all handling outcomes using Spearman's rank correlation coefficients due to non-linearity of data based on diagnostic graphing. The outcomes of Down and Trot were not included for any further analysis due to their absence in BQA guidelines (2019).

One-way analysis of variance (ANOVA) models were used to analyze the relationship between outcomes (Prod Use, Miscatch, Vocalizing, Jumping, Stumble/Trip, Running, and Falling) and predictor variables (BQA Certification, Breed, Chute style, Distractions, Exit Material, Herd Size Group, Number of Handling Aids, Number of Stockpeople, Procedure Type, Region, Temperament, Times Handled through the Chute, and Visual Contact Amount) (v3.0.12;

Fox and Weisberg, 2019). All outcomes were square root transformed to satisfy modeling assumptions. Predictors were selected for each outcome in the ANOVA analysis based upon previous subject matter knowledge. Predictors were excluded from further analysis if they were found to not have a relationship (p -value > 0.05) with handling outcomes. The predictors excluded were the Number and Type of Procedures, Facility Construction Material, Flooring at Chute Exit, Handling Implements Utilized, Number of Stockpeople Handling the Cows, Distractions, and the Average Number of Times the Producer Works their Herd through the Chute During a Calendar Year.

Significant predictors from the one-way ANOVA models ($P < 0.05$) were analyzed for relationships amongst each other. Relationships between predictors were analyzed using contingency tables and by performing Pearson's Chi-square test of independence. Many of the predictor variables were found to be related to one another.

We used model selection to explore multi-predictor ANOVA models. Model selection for multiple regression was based upon Aikake Information Criterion (AIC) (MuMIn v1.43.17; Dohoo et al., 2009; Windmeyer et al., 2014). Models with the lowest AIC were selected as the final model and used for further analysis. Final models were analyzed using Type III F-tests. Models with response variables that did not meet ANOVA assumptions were analyzed using the Kruskal-Wallis test (v4.1.2; R Core Team, 2021). These outcomes were Miscatch, Vocalizing, and Falling. Regression models were fit with pairwise interactions between several predictors. However, due to missing observations or association between predictors, the majority of predictor pairs were unable to be analyzed.

Pairwise comparisons were calculated for all parametric models using estimated marginal means (emmeans v1.7.1.1; Length, 2021). Pairwise comparisons for non-parametric models were calculated using the Wilcoxon rank sum test with Benjamini-Hochberg adjustment (v4.1.2; R Core Team, 2021).

RESULTS

Operation Characteristics.

A total of 81 operations were recruited from across the United States, representing 24 states. Five operations were removed from final analysis because the total number of cows and/or yearling heifers being processed during the observational period was fewer than 10 cows. A total of 76 operations were used for analysis.

Operation characteristics are found in Table 2. The percentage of operations by Region were: West (n = 29, 38.2%), Central (17, 22.4%), and East (30, 39.5%). Herd size of participating operations ranged from 10 head to greater than 5,000 head. Herd sizes were divided into categories based upon total head: 10-49 (n = 12, 15.8%), 50-99 (21, 27.6%), 100-199 (9, 11.8%), 200-499 (17, 22.4%), and 500+ (15, 19.7%). The majority of herds were crossbred (n = 48, 63.2%); there were 28 purebred herds (36.8%) sampled including Black Angus, Red Angus, Hereford, and British White. Overall Temperament of the observed animals was recorded as Docile (n = 43, 56%), Restless (15, 19.7%), Nervous (7, 9.2%), Flighty (3, 3.9%), Aggressive (2, 2.6%), Very Aggressive (1, 1.3%), or Mixed (2, 2.6%). The majority of operations had at least one BQA trained individual (n = 53, 69.7%) but not all operations did (18, 23.7%) while some were either unsure or declined to answer (5, 6.6%). Chute Style was recorded as Hydraulic (n = 26, 34.2%), Manual (33, 43.4%), or Self-Catch (14, 18.4%). Finally, Visual Contact between the

herd and stockpeople and/or owners was recorded as Daily (n = 36, 47.4%), Weekly (22, 28.9%), 1-2x per month (7, 9.2%), or 2-6x per year (7, 9.2%).

Handling Outcome Frequencies.

Table 3 includes a summary of animal handling outcomes. Mean Prod Use was $18.1\% \pm 28.9$. This observed mean exceeds the acceptable BQA threshold ($<10\%$) for prod usage. Mean Miscatch was $2.62\% \pm 5.14$, which also exceeds the BQA threshold of 0% Miscatch. Percentage of Vocalization, Jump, Slip/Stumble, and Run were all within acceptable BQA thresholds. The mean of Fall ($2.5\% \pm 4.24$) slightly exceeds the acceptable BQA threshold of less than 2.0% falls. The mean, median, and range of Down and Trot are also provided but have no established acceptable thresholds for these outcomes.

Correlations

Spearman rank correlations are presented in Table 4. The majority of outcomes had a negligible correlation with each other (0 to 0.30) (Hinkle and Weirsman, 2003). Trot and Prod Use were moderately correlated ($0.54; P < 0.05$). Also moderately correlated, were Jump and Run ($0.50; P < 0.05$). Lowly correlated outcomes (0.3 to 0.5) included Fall and Slip/Stumble ($0.45; P < 0.05$), Trot and Jump ($0.45; P < 0.05$), Trot and Run ($0.44; P < 0.05$), Jump and Slip/Stumble ($0.42; P < 0.05$), Prod Use and Jump ($0.38; P < 0.05$), Prod Use and Fall ($0.36; P < 0.05$), and Prod Use and Run ($0.34; P < 0.05$).

Outcomes and Predictors

Prod Use

Overall, the observed frequencies of Prod Use were influenced by the predictors Visual Contact ($P = 0.027$), Temperament ($P = 0.001$), Herd Size Group ($P = 0.072$) and BQA Status ($P = 0.104$) (Table 5). A difference between Visual Contact levels occurred between the 2-6 times per year category ($48.2\% \pm 13.8$) with both Weekly contact ($17.4\% \pm 6.26$, $P = 0.025$) and Daily contact ($6.92\% \pm 2.91$, $P = 0.030$) categories (fig.1). There was a difference in Prod Use between the Flighty (8.0% , SE: ± 8) and the Very Aggressive (92.0% , na) Temperament categories ($P = 0.015$) and the Nervous ($3.4\% \pm 1.72$) and Very Aggressive categories (92.0% , na, $P = 0.045$). Additionally, there was evidence of a marginal difference ($P = 0.065$) in Prod Use between the Flighty ($8.0\% \pm 8$) and Aggressive ($41.8\% \pm 10.2$) categories (fig.2). There was a marginal difference in Prod Use between herds 10-49 head ($9.12\% \pm 8.1$) and herds with 500 + head ($35.0\% \pm 9.25$, $P = 0.059$) (fig.3). There was no difference between BQA Certification levels in mean prod usage ($P = 0.104$). Observed prod usage was additionally influenced by the interaction of Visual Contact and BQA Certification Status ($P = 0.009$) (fig.4). A difference between certification statuses was identified in herds that had Weekly visual contact ($P = 0.002$; Yes: $6.49\% \pm 4.33$; No: $40.8\% \pm 14.3$) and herds that had visual contact 2-6 times per year ($P = 0.057$) ($87.3\% \pm 10.3$)($32.6\% \pm 13.2$) (fig.5).

Miscatch

The only predictor with an association with the rate of Miscatch was the Region where the operation was located ($P = 0.019$) (Table 5). Pairwise comparisons identified differences in Miscatch percentage ($P = 0.023$) between Central (4.04% SE ± 1.91) and East ($1.17\% \pm 0.42$). There was also a difference ($P = 0.044$) between East ($1.17\% \pm 0.42$) and West ($2.97\% \pm 0.906$) Regions (fig.5).

Vocalization

Vocalization also was found to have only one significant predictor, which was Temperament ($P = 0.002$) (Table 5). There was a difference in Vocalization between the Docile ($1.43\% \text{ SE} \pm 0.62$) and Flighty temperament categories ($22.5\% \pm 13.5$, $P = 0.014$) with a marginal difference ($P = 0.058$) between the Docile and Aggressive temperament categories ($20.8\% \pm 5.84$) (fig.2).

Jump

The incidences of Jump observed on operations were influenced by the factors of Herd Size Group ($P = 0.002$), Region ($P = 0.006$), and Visual Contact ($P = 0.018$) (Table 5). There was evidence of differences between herds in the 500+ head category ($13.7\% \text{ SE} \pm 3.23$) and herds in the 10-49 head category ($3.27\% \pm 1.45$, $P = 0.009$) and in the 50-99 head category ($2.91\% \pm 0.95$, $P = 0.017$). Additionally, herds greater than 500 head had a marginal difference in mean rates of jumping with herds 100-199 head ($4.52\% \pm 2.74$, $P = 0.056$) (fig.3). Differences in Jump were observed between the operations in the Central region ($2.86\% \pm 1.26$) and operations in the East ($7.31\% \pm 2.07$, $P = 0.004$) and West ($10.8\% \pm 2.12$, $P = 0.014$) (fig.5). In addition, there was evidence for a difference in rates of Jump between herds that had Daily visual contact ($3.87\% \pm 1.03$) and herds that had visual contact 2-6 times per year ($18.1\% \pm 5.54$, $P = 0.017$) (fig.1).

Slip/Stumble

Predictors that impacted the rate of Slip/Stumble were Chute Style ($P = 0.001$) and Visual Contact ($P = 0.123$) (Table 5). There was evidence that self-catch chutes (2.03% , $\text{SE} \pm 1.38$) differed in their rates of Slip/Stumble from hydraulic chutes (8.13% , ± 1.61 , $P = 0.001$) and

manual chutes ($4.86\% \pm 0.026$, 1.11). However, there was no difference ($P > 0.05$) in mean rates of Slip/Stumble between herds experiencing different frequencies of Visual Contact with caretakers (fig.1).

Fall

The rate of Fall was impacted by only one of the recorded predictors, Visual Contact ($P = 0.002$) (Table 5). Pairwise comparisons identified differences between herds that had visual contact 2-6 times per year ($7.72\% \text{ SE} \pm 2.41$) and herds that had Daily contact ($1.32\% \pm 0.43$, $P = 0.005$). In addition, there was a difference (0.009) between herds that had visual contact 2-6 times per year ($7.72\% \pm 2.41$) with herds that had Weekly contact ($2.0\% \pm 0.97$) (fig.1).

Run

The frequencies of Run were impacted by Visual Contact ($P = 0.004$) (fig.1) and the overall Temperament of the herd (0.053) (fig.2). Pairwise comparisons showed differences between herds who had visual contact 2-6 times per year ($21.6\% \text{ SE} \pm 5.51$) both with herds that had Daily contact ($2.24\% \pm 0.58$, $P = 0.002$) and Weekly contact ($5.62\% \pm 1.73$, 0.029). Pairwise comparisons additionally showed marginal differences in Run between Restless herds ($6.98\% \pm 3.24$) and Flighty herds ($38.7\% \pm 11.5$, $P = 0.059$). Restless herds also had a marginal difference with Aggressive herds ($44.3\% \pm 27.3$, 0.093).

DISCUSSION

There is limited research on animal handling on cow-calf operations. A possible cause is that the extensive knowledge base around low-stress animal handling practices is an amalgamation of scientific principles and general husbandry experience (BQA, 2019; Gill, et al.,

2013; Grandin, 2017; 2019). Therefore, the purpose of this study was to summarize animal handling outcomes on cow-calf operations across the United States and to both benchmark animal handling on a national scale and determine any impacting factors that may influence on-farm animal handling. Currently, the BQA Cow-Calf Assessment program guidelines (BQA, 2019) are widely used as the standard for animal handling on cow-calf-operations. This study found that rates of Prod Use, Miscatch, and Fall occurred exceeded BQA standards. Rates of Vocalization, Jump, Slip/Stumble, Run were within the standards in the Cow-Calf Assessment (BQA, 2019). Additionally, this study found that there are several factors that impact animal handling on cow-calf operations.

Prior to this study, Simon et. al., (2016) quantified animal handling on cow-calf operations located within California. Similar to Simon et al., (2016), the current study found that incidences of Prod Use exceeded the acceptable BQA threshold (<10.0%). This is in contrast to Woiwode & Grandin (2014) observing only 5.5% Prod Use at feedlots. However, it was a minority of operations within the current study population that were driving this finding (n = 26, 34%). Despite the majority of operations meeting BQA guidelines for Prod Use (n =50, 66% were below 10%), the substantial size of operations that displayed Prod Use in excess of BQA thresholds (n = 26, 34%) deserve attention; there were 13 operations that had prod usage rates greater than 50%. Also, in line with Simon et al. (2016), mean rates of Miscatch exceeded BQA standards (2.6% vs. 0%) with almost half of operations in this study exceeding the standards (n = 34, 45%). In contrast to Simon et al. (2016), who reported a 0.9% fall frequency, in the current study mean incidences of Fall slightly exceeded BQA thresholds (2.5 % vs. <2.0%) with 23 operations (30%) exceeding the Fall threshold. Possible explanations for these outcomes

exceeding BQA thresholds are explained further in the description of each outcomes' impacting factors.

While not included in further analysis, Trot (n = 65, 86%) and Down (45, 59%) were frequently observed. During project planning, it was observed that interobserver consensus of Run was lower than for other outcomes. Additionally, there was confusion on how to classify the behavior where cows rest on their front shins during pregnancy checking. Therefore, Trot and Down were added to data collection with the intent of improving reliability between observers. The authors hoped to improve observer reliability that by making an observer identify differences between Down and Fall and Trot and Run. For example, one observer might interpret an animal's action as a run whereas another thinks it is just a quick walk, resulting in inconsistent reporting and program application (Knierim & Winckler, 2009)

Observed frequencies for Slip/stumble (6.3%), Jump (add) and Run (7.7%) were within BQA guidelines (<10.0% and <25.0%, respectively). This is in line with Slip/Stumble frequencies (4.7%) and Run frequencies (12.8%) reported by Simon et al. (2016) but in stark difference to Woiwode & Grandin (2014), who reported a Run frequency of 30.7% at feedlots. Simon et al. (2016) reported Vocalization frequencies slightly in excess of BQA thresholds (5.2% vs <5.0%) and in the current study observed frequencies of Vocalization were within acceptable BQA levels (3.8%). During animal handling assessments, vocalization is not scored during the actual procedure that is occurring (e.g., pregnancy checking, vaccinations, branding, etc.) and individuals not familiar with animal handling auditing may not realize this distinction. Anecdotally, vocalizing may occur during procedures but as shown by the results of this study, cows do not often vocalize in response to the handling or restraint specifically, which is what is scored during an assessment.

Visual Contact had an association with 5 out of 7 of the handling outcomes assessed in this study. This is consistent with studies that have reported that visual contact can result in calmer cattle (Grandin, 1993; Hemsworth & Barnett, 2000). Increased visual contact with humans can lower animals' fear response to humans, thus making them calmer. Interestingly, though, the amount of handling (measured as the amount animals were physically handled through the chute in a calendar year) in this study did not have an association with any of the animal handling outcomes. This finding seems to contradict studies indicating that repeated chute handling can acclimate animals to that handling event (Andrade et al., 2001; Grandin & Shively, 2015; Parham et al., 2019). This could be due to the fact that the majority of study participants (n = 52, 68%) reported handling their cattle through the chute less than 6 times per year, far fewer than amounts in previous research that tend to focus on more frequent handling events. On operations that reported Daily Visual Contact with their herds, there were lower rates of most outcomes. This finding is consistent with previous studies that indicate domesticated animals possibly utilize human interactions in any form to generate schemas about their environment and caretakers (Boivin et al., 1998; Lensink et al., 2000; Rault et al., 2020; Rybarczyk et al., 2001; Schmeid et al., 2008; Waiblinger et al., 2004). There is a growing interest to understand this connection between animal and caretakers (Rault et al., 2020). The current study suggests that human interaction not involving physical contact can impact cattle behavior. On several cow-calf operations, handling through the chute typically occurs in seasonal spring and fall clusters based around breeding (Larson & White, 2016) but cattle may interact with humans more frequently throughout the year during herd health checks, movement between pastures, and being fed hay in the winter. Logistically, certain management systems do not allow for frequent visual contact with cow herds so future research should focus on the minimum

amount of visual contact needed to cause a change in animal behavior during handling.

Additionally, operations may work with cattle using different techniques, such as in a car or ATV, on foot or on horseback; future studies exploring aspects of visual contact that are meaningful could examine impacts of these different approaches to cattle handling. It should be noted that Prod Use, Jump, Slip/Stumble, and Run all had multiple impacting factors (not just visual contact) and therefore and it might be more feasible to focus future extension efforts on additional influential factors when and if increasing visual contact with herds is not practical.

Temperament had an association with 3 out of 7 outcomes: Prod Use, Vocalization, and Run. In this study, an observed trend was that an increase in Temperament level from Docile to Very Aggressive coincided with increased frequencies of handling outcomes. For example, Docile herds displayed less Vocalization and fewer instances of Run than herds that were categorized as any other Temperament category. This finding is in accordance with previous studies indicating that increasingly aggressive behavior makes handling more difficult, can increase worker injuries and can lead to decreased production attributes due to the relationship between temperament and fear response to humans (Blanco, et al., 2009; Burrow, 2001; Fordyce, et al., 1985; Grandin, 1993, 2010; Sant'Anna et al., 2013). An increased fear response in cattle can result in escape behaviors during handling. Behaviors such as vocalization and running are examples of escape behavior. Thus, the importance of Temperament selection in certain breeding and genetic improvement initiatives has been recognized (Chang et al., 2020; Friedrich et al., 2015; Parham et al., 2019; Phocas et al., 2016). One such initiative is the Temperament scoring scale used in this study, created by the Beef Improvement Federation (BIF, 2020). By selecting animals with calmer temperaments escape behaviors are decreased and productivity measures increase (Grandin & Deesing, 2014). An exception to the trend between Temperament levels and

outcome frequency is Prod Use, for which herds in the Nervous and Flighty temperament categories experienced lower mean incidences of prod usage as compared to all other Temperament categories. One potential explanation for this finding is that nervous or flighty animals may move quickly through the handling facilities not needing to be persuaded with handling tools or too much handling pressure, ultimately resulting in lower electric prod use. This reasoning would also explain the increased rates of Run associated with the increase in Temperament score. However, as indicated by this study, the number of factors impacting Prod Use demonstrate the complexity of explaining prod usage on cow-calf operations. A limitation on the use of Temperament scoring in this study is the small selection of herds in the Temperament categories of Aggressive (n = 2, 0.03%) and Very Aggressive (1, 0.01%). Future research should attempt to recruit more herds in the Aggressive and Very Aggressive temperament categories to be able further explore how differences in temperament can impact Prod Use.

Herd Size Group (fig.3) was found to have an association with rates of Prod Use and Jump. Greater frequencies for both outcomes were observed on operations with larger herds sizes (200-499 and 500+ head). Larger herds can often result in a greater ratio of animals per stockperson and land needed to support animals (Beggs, et al., 2018). Combined with this study's findings on the inverse relationship between outcome frequencies and level of Visual Contact, these studies could explain the differences in observed frequencies and herd sizes. It is logistically more difficult to interact with every animal in a larger herd as it requires more labor and the animals are often on larger expanses of range land. Therefore, future research should focus on what is the minimum amount of visual contact needed to cause a change in animal

behavior during handling and if there are associations with how the cattle see the caretaker, i.e. in a car, ATV, on horseback, or on foot.

Region (fig. 5) had an association with Miscatch and Jump. There were significant differences between regions in outcome frequencies but not enough information related to management processes and procedures was captured in this study to necessarily explain the reasoning behind these differences. This link should be further investigated to see if there are region specific attributes such as different management procedures and/or approaches that could affect handling outcomes.

An interesting take-away from this study is the absence of an association between BQA Certification Status and handling outcomes. This could be linked to the fact that the majority of participants either were currently or previously certified. This study defined positive BQA Certification as having ever been BQA trained. Five individuals (0.09%) identified that they had received the training greater than 3 years ago. Additional studies could implement operation sampling schemes that recruit both BQA and non-BQA certified individuals across some of the other important predictors, such as visual contact, temperament of herds and region. A possible confounding factor in determining the impact of BQA Status on outcomes are the multiple instances of mean frequencies of handling outcomes in excess of BQA thresholds occurring on BQA certified operations and vice versa for non-BQA certified operations. For example, while no significant differences were found between BQA Statuses, positive BQA Certification Status appeared to coincide with a reduction in mean Prod Use. However, 13 operations (17%) with certified individuals exceeded BQA thresholds for Prod Use. This could be possibly addressed by refining the outcome definitions listed in the Cow-Calf Assessment (BQA, 2019) and ensuring standardization in on-site assessments by BQA personnel. Additionally, increased focus

on handling aids can be included in BQA training materials to ensure consistent messaging about proper usage.

The single outcome affected by Chute Style was Slip/Stumble. There were significant differences between self-catch style chutes with both manual and hydraulic chutes. Self-catch chutes had the greatest observed instances of Slip/Stumble, however, the fewest amount of observed chutes were self-catch. The greater rates of Slip/Stumble in self-catch chutes may be due to the structure of the chute. Observed self-catch chutes were typically smaller than hydraulic or manual chutes and more cattle were observed having difficulty exiting this style of chute due to their body size, requiring greater force on the part of the animal to exit. This greater force could have result in increased Slip/Stumble as the animal contacts the ground outside of the chute. Interestingly, ground material at the exit of the chute was not found to have an impact on Slip/Stumble. This could be due to the fact that studies addressing slipping often occur on areas of slick concrete or ramps at slaughter plants or during transport (Grandin, 1998; Gregory et al., 2009; Uetake et al., 2008), whereas in this study the majority of exit materials were rubber mats or earth (n = 61, 80%).

In addition to measured predictors, many qualitative observations were recorded during the operation visits. Many of the noted observations included instances of inappropriate handling implement usage. Inappropriate prod usage as defined by both BQA (2019) and NAMI (2021) guidelines is no prod should be applied to sensitive areas such as the vulva, face, and/or udder or on non-ambulatory cattle. Multiple instances were recorded of applying the electric prod to a sensitive area and/or on downed animals in the crowd pen, alleyway, and chute. While there are no stated upper limits on amount of times an electric prod can be applied to a single animal in BQA (2019) or NAMI (2021) guidelines, multiple instances (n = 9, 12%) were recorded of

animals receiving more than five prods with amounts exceeding 10 prods per animal being observed. This could be an area for future analysis and setting a threshold for prod use per animal in future guidelines; thresholds of this nature could also apply to feedlot and slaughter plant scenarios as specific guidelines do not currently exist. Non-electric handling aids were also observed being applied with excessive force and to sensitive areas. Beef Quality Assurance guidelines state that animals should not be struck with handling aids (BQA, 2019), nor should they be kicked. These observations occurred on operations that had individuals that were both BQA-certified and those that did not.

Although the intent of this study was not to evaluate facility design, the observers had many opportunities to watch cattle move through different types of handling facilities. Facility components that were captured in this study included Chute Style, Facility Material, and Material at Exit of Chute, however, only Chute Style had an association with an outcome, Slip/Stumble. Observers identified some challenges with facility design, based on their anecdotal observations, including: alleys that were too wide, alleys with large gaps, chutes that were not secured to the alleyway, and chutes that were too small for the current herd. These identified facility challenges could cause animals to turn around, escape, and balk, making handling more difficult. Due to the large variety in facility design aspects, focus should be on creating a system to categorize design aspects to better analyze any relationships between outcomes and facilities. Individuals who perform BQA assessments can assist in this process by making observations on facilities and perhaps creating visual examples to aid in training and continuing education.

Another category included observations made during teaching procedures between veterinarians and veterinary students or between family members. Empirical learning is a critical part of veterinary science and as ranching is often a family business, a critical part of showing

younger family members husbandry procedures. However, in learning, procedures on animals often took longer or were repeated multiple times which potentially could have affect the outcomes of Jump, Slip/Stumble, Run, and Fall and should be investigated further.

The final category of observer observations involved veterinarians and veterinary staff interactions with cattle. A few observations were made about individuals handling cattle roughly, which can impact outcome frequencies. Veterinarians are increasingly expected to uphold animal welfare principles (Edwards, 2004; Hewson, 2003) but animal welfare concepts have traditionally not been a focus in veterinary school curricula (de Boo & Knight, 2005; Yeates, 2012). Additionally, veterinarians are not only a critical part of cattle care by attending to and balancing the needs of the animals and producers, but increasingly, expectations of the general public (Sumner et al., 2018; 2018; 2020). However, studies have consistently shown a wide variety of attitudes and empathy towards animals among veterinarians and the effects that has on their assessment of animal pain and treatment (Norrington et al., 2014; Paul, E. S., & Podberscek, 2000; Schoenfeld-Tacher et al., 2017). As producers are often very limited with selection of large animal veterinarians, especially in rural areas (National Institute of Food and Agriculture [NIFA], 2020), future research into veterinarian perspectives on large animal handling should be conducted along with evaluation of future opportunities for continuing education about animal welfare and handling topics.

Logistics for coordinating this study were extremely difficult; this was similarly reported in Simon et al. (2016). Recruiting operations to participate in this project was challenging as it included several steps before an operation visit could occur (e.g., contacting industry professionals to assist with recruitment, gathering contact information for potential operations, reaching out directly to operations and coordinating processing schedules). One limitation unique

to the timing of this study was limitations related to the COVID-19 pandemic which included scheduling delays and hesitancy to host visitors on-farm. Additionally, as the majority of cattle processing occurs outdoors, inclement weather impacted visits along with the seasonal grouping of operations performing herd checks. These limitations should be considered when designing future research endeavors requiring extensive visits to cow-calf operations across the United States.

As the outcomes of Prod Use, Jump, Run, Slip/Stumble had multiple predictors, this could indicate that the outcomes of Miscatch, Vocalize, and Fall might as well. As discussed in the Simon et al., (2016) study, there is a large magnitude of variety across cow-calf operations in terms of management practices and facilities. While this current study recorded several factors to analyze for any impacts (n = 16), there are still relevant factors that were not captured such as how often the cattle had been handled prior to observation period, experience levels of handlers, and facility effects such as size of alleyway and presence of overhead coverage. Future research on these outcomes should be conducted to help illustrate why the mean rates of Miscatch (2.0%) and Fall (2.5%) both exceeded BQA thresholds (0%, 2.0%). Additionally, future research should focus on analyzing the relationships between the significant predictors.

CONCLUSION

This study found that mean incidences of Prod Use, Miscatch, and Fall all exceeded thresholds set in the BQA Cow-Calf Assessment. However, the mean incidences for Vocalization, Jump, Slip/Stumble, Fall, and Run were all within BQA thresholds. Impacting factors were uncovered for all outcomes with Prod Use, Jump, Slip/Stumble, and Run all having multiple impacting factors. In addition to the quantified impacting factors, observations that

could impact animal handling outcomes were also recorded. Due to limitations set by difficult scheduling logistics, initial sampling goals were unmet. Future research should be focused on analyzing in greater depth the variety of factors present on cow-calf operations.

Table 1. Definitions of cow handling outcomes.

Outcomes	Definitions
Prod Use	The touching of an animal with an electric prod whether energized or not. Prod use is counted only once per animal even if the prod contacts the animal twice.
Miscatch	Performing any processing activity on an animal in any position where the animal is not firmly and safely secured in the chute according to manufacturers' guidance. An animal caught in the tail gate and an animal caught in the headgate counts as a miscatch.
Vocalization	Any audible vocalization (moo, bellow) after chute restraint has been initiated but before processing activity occurs.
Down	Any position other than fully upright for majority of time in chute. A deliberate movement of the cow in her body position, not an involuntary fall.
Jump	Upon release from the chute, the animal deliberately bends front knees with front lower joints (pasterns) tucked under the animal and/or tucked back legs. Straight leg vertical jumps should also be considered as an additional form.
Slip/Stumble	Lost contact between a foot and the ground in a non-walking manner and/or a portion of the animal's leg (front or rear) other than foot (knee/hock) contacts the ground. The animal's topline will drop with sudden motion.
Fall	A sudden loss in upright position and any body part other than the feet touch the ground.
Trot	A gait of moderate speed that is in between a walk and a run.
Run	Sustained, fast paced movement with elevated tailhead when exiting the chute lasting at least 3 strides.

Table 2. Predictors and different levels for the sample population (n = 76).

Predictor	Predictor Levels	Operations (n)
BQA Status	Yes	53
	No	18
	NA	5
Breed	Purebred	28
	Crossbred	48
Chute Style	Hydraulic	26
	Manual	33
	Self-catch	14
	Mixed	1
	NA	2
Herd Size	10-49	12
	50-99	21
	100-199	9
	200-499	17
	500+	15
	NA	2
Region¹	Central	17
	East	30
	West	29
Times Visual Contact	Daily	36
	Weekly	22
	1-2x Per Month	7
	2-6x Per Year	7
	NA	4
Temperament²	Docile	43
	Restless	15
	Nervous	7
	Flighty	3
	Aggressive	2
	Very Aggressive	1
	Mixed	2

¹**West** (AZ, CA, CO, ID, MT, NM, NV, OR, WA, WY, UT) **Central** (IA, IL, KN, MN, MO, ND, NE, OK, SD, TX, WI) **East** (AL, AR, CT, DE, FL, KY, GA, IN, LA, MA, MD, ME, MI, MS, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WV) (NAHMS 2017)

²**Docile.** Mild disposition. Gentle and easily handled. Stands and moves slowly during processing. Undisturbed, settled, somewhat dull. Does not pull on headgate when in chute. Exits chute calmly. **Restless.** Quieter than average, but may be stubborn during processing. May try to back out of chute or pull back on headgate. Some flicking of tail. Exits chute promptly. **Nervous.** Typical temperament is manageable, but nervous and impatient. A moderate amount of struggling, movement and tail flicking. Repeated pushing and pulling on headgate. Exits chute briskly. **Flighty** (Wild). Jumpy and out of control, quivers and struggles violently. May bellow and froth at the mouth. Continuous tail flicking. Defecates and urinates during processing. Frantically runs fence line and may jump when penned individually. Exhibits long flight distance and exits chute wildly. **Aggressive.** May be similar to Flighty, but with added aggressive behavior, fearfulness, extreme agitation, and continuous movement which may include jumping and bellowing while in chute. Exits chute frantically and may exhibit attack behavior when handled alone. **Very**

Aggressive. Extremely aggressive temperament. Thrashes about or attacks wildly when confined in small, tight places. Pronounced attack behavior. (Beef Improvement Federation 2018) **Mixed.** This is an additional category added to describe herds that equally displayed behaviors of two sequential temperaments.

Table 3. Summary of animal handling outcomes for sample population (n = 76).

Animal Handling Outcomes Frequency (%)									
Measurement	Prod Use	Miscatch	Vocalization	Down	Jump	Slip/ Stumble	Fall	Trot	Run
Min	0	0	0	0	0	0	0	0	0
Max	100	30.8	36.0	64.0	38.0	42.9	19.0	67.0	71.7
Mean	18.1	2.6	3.8	7.5	7.5	6.3	2.5	21.0	7.7
Median	2.78	0	0	2.39	3.0	3.0	0	18.6	2.06
sd	28.9	5.1	7.6	12.7	10.0	9.1	4.2	18.5	13.8
BQA³	10.0	0	5.0	- ⁴	25.0 ⁵	10.0	2.0	- ⁴	25.0 ⁵
Operations above thresholds (n)	34 (26)	46 (35)	21 (16)	-	19.7 (15 ⁴)	23.7 (18)	31.6 (24)	-	19.7 (15 ⁴)

³Beef Quality Assurance Cow-Calf assessment thresholds. Acceptable frequencies are below the listed numerical threshold (BQA 2019).

⁴There are no established thresholds for these outcomes in BQA Cow-Calf Assessment (BQA 2019).

⁵The handling outcomes of Jump and Run must have a combined total less than 25.0% to be within acceptable levels (BQA 2019).

Table 4. Spearman correlations exhibiting the relationships between handling outcomes for the sample population (n = 76).

Outcome	Prod Use	Miscatch	Vocalization	Down	Jump	Slip/ Stumble	Fall	Trot	Run
r									
p¹									
Prod Use	1.0	0.21 **	0.19 **	0.14	0.38 *	0.19 **	0.36 *	0.54 *	0.34 *
Miscatch		1.0	0.11	0.10	0.21 **	0.28 *	0.12	0.26 *	0.21 **
Vocalization			1.0	0.06	0.24 *	0.05	0.01	0.19	0.21 **
Down				1.0	0.05	-0.07	0.00	0.20	0.04
Jump					1.0	0.42 *	0.18	0.45 *	0.50 *
Slip/Stumble						1.0	0.45 *	0.25 *	0.22 **
Fall							1.0	0.36 *	0.27 *
Trot								1.0	0.44 *
Run									1.0

¹*indicates p-value <0.05
 **indicates p-value 0.05-0.10.

Table 5. Summary of animal handling outcomes and predictors based on Aikake Information Criterion (AIC).

Outcomes	Predictors					
	BQA status	Chute style	Herd size group	Region	Temperament	Visual contact
Prod Use	X		X		X	X
Miscatch				X		
Vocalization					X	
Jump			X	X		X
Slip/Stumble		X				X
Fall						X
Run					X	X

Association of Visual Contact and Outcome Frequencies

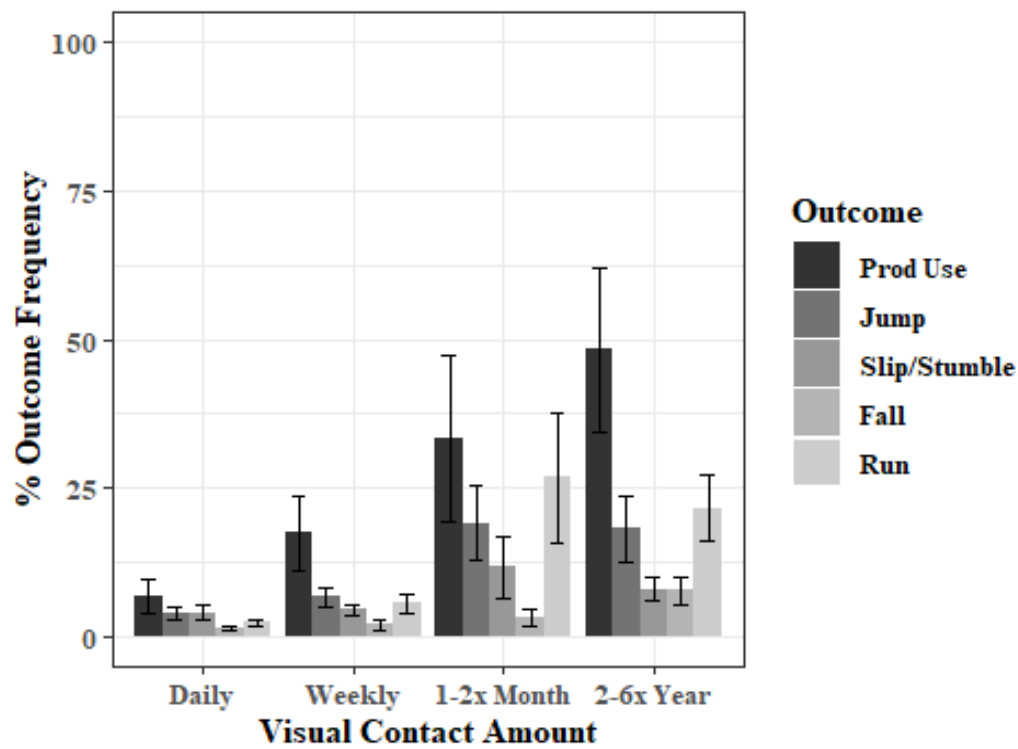


Figure 1. Frequencies (Mean \pm SEM) of animal handling outcomes by Visual Contact category as reported by ranch operator ($n = 68$). Outcomes included were associated with Visual Contact Amount based on AIC model selection.

Association of Herd Temperament Score and Outcome Frequencies

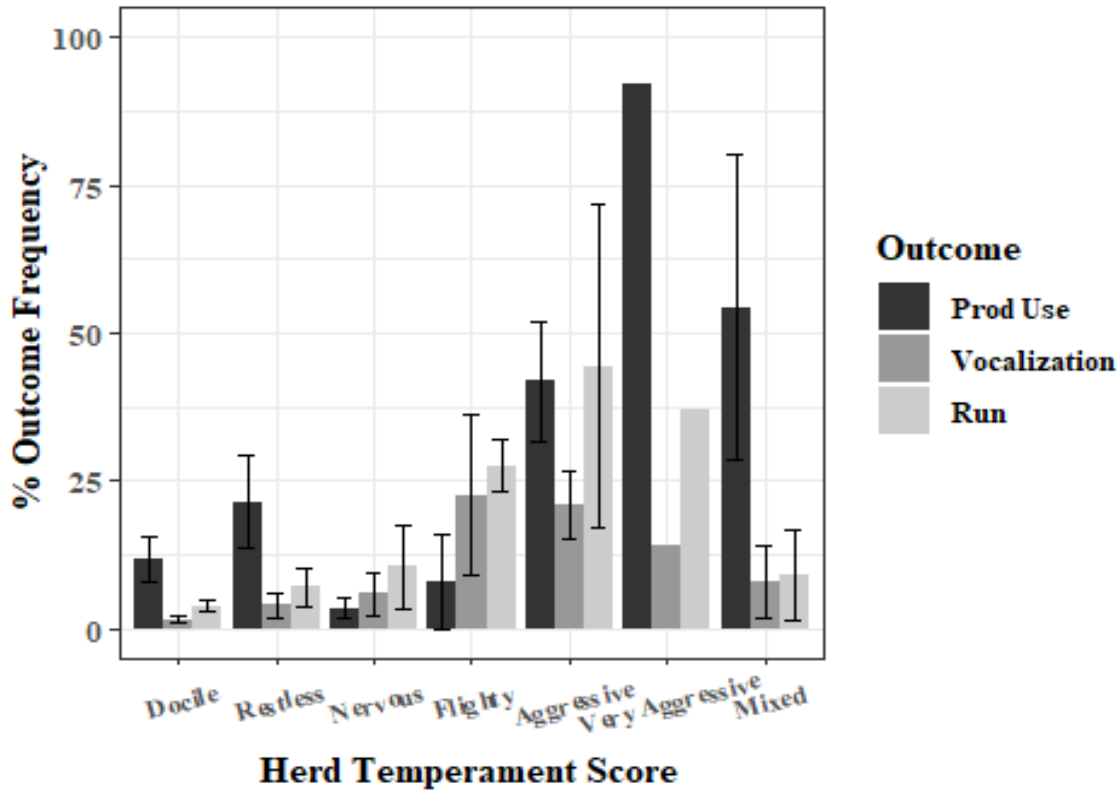


Figure 2. Frequencies (Mean \pm SEM) of animal handling outcomes by Temperament category as reported by observer ($n = 68$). SEM not reported for Very Aggressive due to limited sample size ($n = 1$). Temperament was scored on herd level and was based on Beef Improvement Federation guidelines (BIF 2020). Outcomes included were associated with Herd Temperament Score based on AIC model selection.

Association of Herd Size Group and Outcome Frequencies

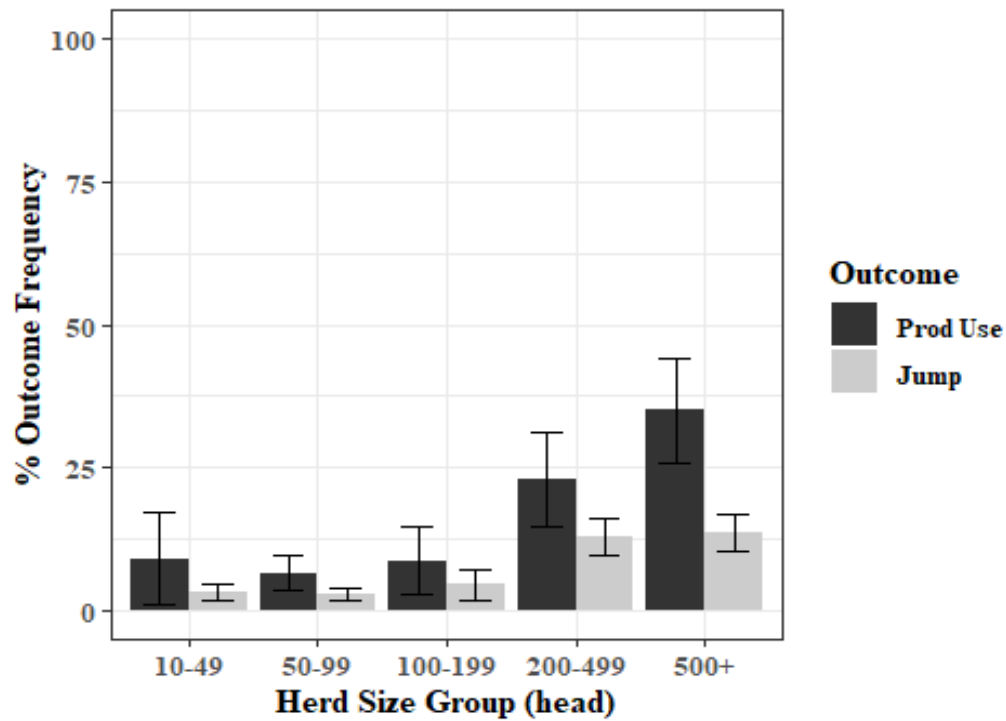


Figure 3. Frequencies (Mean \pm SEM) of animal handling outcomes by Herd Size category as reported by ranch observer (n = 68). Outcomes included were associated with Herd Size Group based on AIC model selection.

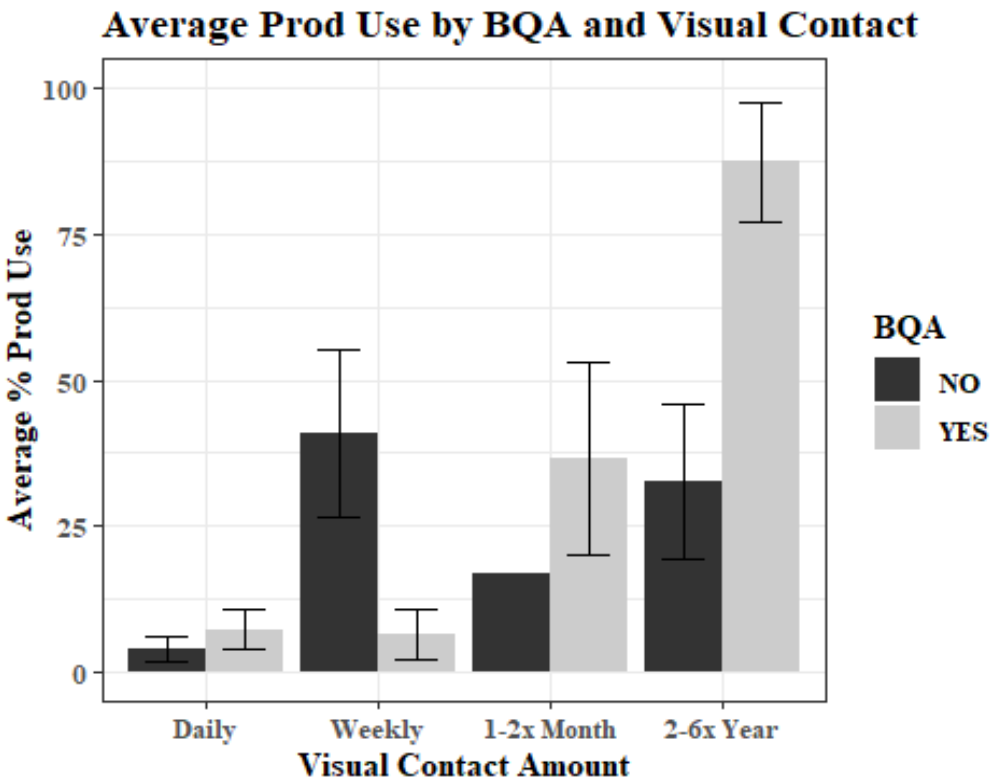


Figure 4. Frequencies (Mean \pm SEM) of Prod Use by interaction of Visual Contact and BQA Certification Status Temperament categories as reported by ranch operator (n = 65). The outcome included was associated with the interaction of BQA Certification Status and Visual Contact based on AIC model selection.

Association of Region and Outcome Frequency

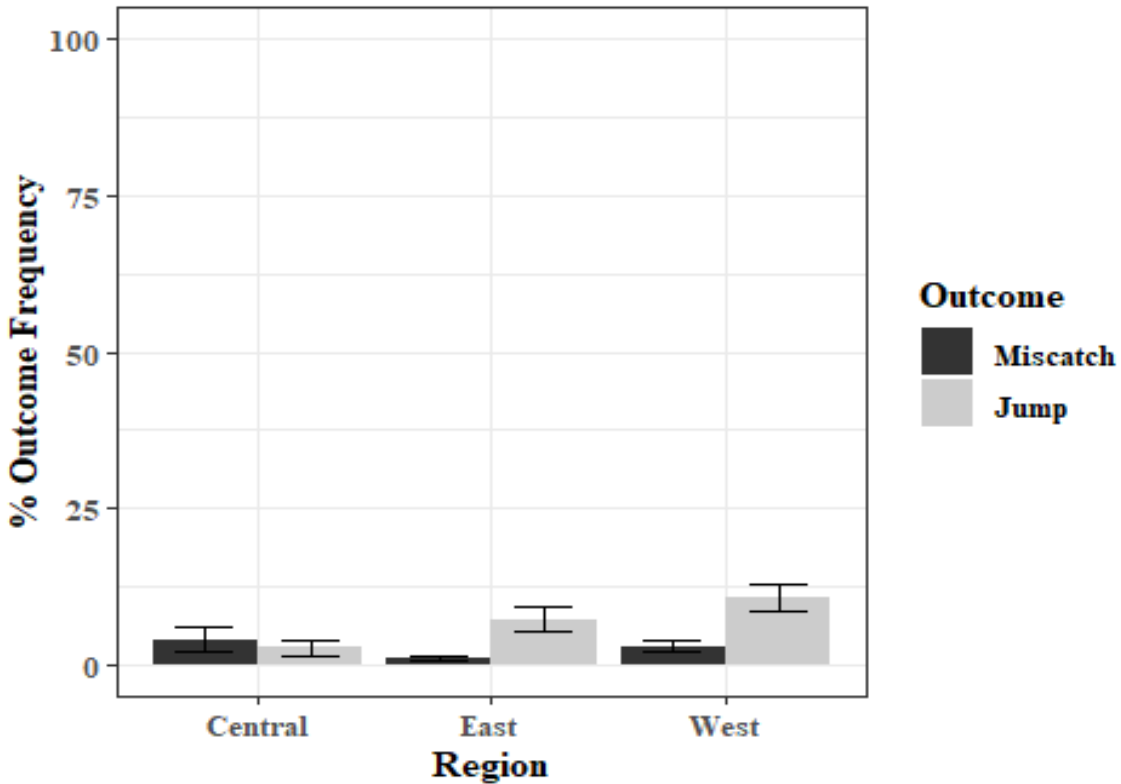


Figure 5. Frequencies (Mean \pm SEM) of animal handling outcomes by Region category as reported by observer (n = 68). Outcomes included were associated with Region based on AIC model selection. Regions were classified as follows: **West** (AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, WA, WY, UT) **Central** (IA, IL, KS, MN, MO, ND, NE, OK, SD, TX, WI) **East** (AL, AR, CT, DE, FL, KY, GA, IN, LA, MA, MD, ME, MI, MS, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, VT, WV) (NAHMS 2017).

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