BILL E. KUNKLE INTERDISCIPLINARY BEEF SYMPOSIUM: Temperament and acclimation to human handling influence growth, health, and reproductive responses in *Bos taurus* and *Bos indicus* cattle[1]

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ABSTRACT: Temperament in cattle is defined as the fear-related behavioral responses when exposed to human handling. Our group evaluates cattle temperament using 1) chute score on a 1 to 5 scale that increases according to excitable behavior during restraint in a squeeze chute, 2) exit velocity (speed of an animal exiting the squeeze chute), 3) exit score (dividing cattle according to exit velocity into quintiles using a 1 to 5 scale where 1 = cattle in the slowest quintile and 5 = cattle in the fastest quintile), and 4) temperament score (average of chute and exit scores). Subsequently, cattle are assigned a temperament type of adequate temperament (ADQ; temperament score ≤ 3) or excitable temperament (EXC; temperament score > 3). To assess the impacts of temperament on various beef production systems, our group associated these evaluation criteria with productive, reproductive, and health characteristics of *Bos taurus* and *Bos indicus*-influenced cattle. As expected, EXC cattle had greater plasma cortisol vs. ADQ cattle during handling, independent of breed type (*B. indicus* × *B. taurus*, $P < 0.01$; *B. taurus*, $P < 0.01$; *B. indicus*, $P = 0.04$) or age (cows, $P < 0.01$; heifers or steers, $P < 0.01$). In regards to reproduction, EXC females had reduced annual pregnancy rates vs. ADQ cohorts across breed types (*B. taurus*, $P = 0.03$; *B. indicus*, $P = 0.05$). Moreover, *B. taurus* EXC cows also had decreased calving rate ($P = 0.04$), weaning rate ($P = 0.09$), and kilograms of calf weaned/cow exposed to breeding ($P = 0.08$) vs. ADQ cohorts. In regards to feedlot cattle, *B. indicus* EXC steers had reduced ADG ($P = 0.02$) and G:F ($P = 0.03$) during a 109-d finishing period compared with ADQ cohorts. *Bos taurus* EXC cattle had reduced weaning BW ($P = 0.04$), greater acute-phase protein response on feedlot entry ($P \leq 0.05$), impaired feedlot receiving ADG ($P = 0.05$), and reduced carcass weight ($P = 0.07$) vs. ADQ cohorts. Acclimating *B. indicus* × *B. taurus* or *B. taurus* heifers to human handling improved temperament ($P \leq 0.02$), reduced plasma cortisol ($P < 0.01$), and hastened puberty attainment ($P \leq 0.02$). However, no benefits were observed when mature cows or feeder cattle were acclimated to human handling. In conclusion, temperament impacts productive, reproductive, and health characteristics of beef cattle independent of breed type. Hence, strategies to improve herd temperament are imperative for optimal production efficiency of beef operations based on *B. taurus* and *B. indicus*-influenced cattle.

Key words: beef cattle, performance, reproduction, temperament

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INTRODUCTION

Temperament is defined as the fear-related behavioral responses of cattle when exposed to human handling (Fordyce et al., 1988). In other words, as cattle temperament becomes more excitable, their reaction to human contact or other handling procedures becomes more aggressive and/or fearful. Generally, beef producers consider temperament to be an important trait when selecting cattle (Elder et al., 1980), particularly due to its moderate heritability (Shrode and Hammack,

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1971; Fordyce et al., 1988) and relevance to personnel security and animal welfare (Grandin, 1994). Moreover, numerous research studies also demonstrated that cattle temperament directly impacts production traits, including growth (Voisinet et al., 1997b), immune responses (Burdick et al., 2011a), carcass quality (Voisinet et al., 1997a), and reproduction (Cooke et al., 2009a, 2012a). Therefore, evaluating cattle for temperament can be used as a management decision tool to enhance overall safety and productivity in beef cattle operations.

Cattle temperament is influenced by genetic and environmental factors such as sex, age, and handling management (Fordyce et al., 1988; Voisinet et al., 1997b). Breed type is another factor that largely influences cattle temperament. *Bos indicus*-influenced cattle are more excitable than *Bos taurus* cattle (Hearnshaw and Morris, 1984; Fordyce et al., 1988), although excitable temperament is frequently detected among *B. taurus* breeds, particularly in young cattle (Morris et al., 1994). Cattle reared in extensive systems are also often more aggressive compared with cattle reared in intensive operations because of less frequent interaction with humans (Fordyce et al., 1985). Accordingly, our research group has focused on productive, reproductive, and welfare implications of cattle temperament in extensive beef production systems based on *B. taurus* and *B. indicus*-influenced cattle.

Evaluating Temperament in Beef Cattle

Cattle temperament can be evaluated by several methods (Cooke, 2009). These include restrained techniques such as chute score and nonrestrained techniques such as exit velocity and pen score (Burrow and Corbet, 2000) as well as phenotypic evaluations such as hair whorl position on the forehead and percentage of eye white exposed in the evaluated animal (Lanier et al., 2001; Core et al., 2009). However, our group has focused on chute score and exit velocity, which have been shown to be reliable (Boivin et al., 1992; Grandin, 1993; Curley et al., 2006) and relatively simple techniques to be completed during routine cattle processing, such as weaning or AI.

We evaluate chute score based on a 5-point scale while the evaluated animal is restrained in a squeeze chute where 1 = calm with no movement; 2 = restless movements; 3 = frequent movement with vocalization; 4 = constant movement, vocalization, and shaking of the chute; and 5 = violent and continuous struggling. Exit velocity is assessed immediately after the evaluated animal is released from the squeeze chute by measuring rate of travel over a 1.9-m distance with an infrared sensor (FarmTek Inc., North Wylie, TX). In addition, evaluated animals are divided in quintiles according to their exit velocity and assigned an exit score from 1 to 5 (1 = cattle within the slowest quintile and 5 = cattle within the fastest quintile). Individual temperament scores are then calculated by averaging chute score and exit score. Subsequently, animals are classified according to the temperament score as having adequate temperament (temperament score ≤ 3) or excitable temperament (temperament score > 3). This latter criteria was developed based on research from our group indicating that moderate temperament (such as temperament scores 2 and 3) does not substantially impair production traits (Cooke et al., 2009a, 2011, 2012a) but may be warranted for cattle to cope with the challenges associated with extensive production systems (Wieckert, 1971; Flörcke and Grandin, 2013).

Stress and Excitable Temperament

Cattle with excitable temperament may have reduced feed intake compared with cohorts with adequate temperament (Fox et al., 2004; Nkrumah et al., 2007), which can be attributed to increased vigilant behavior when excitable cattle are near humans (Welp et al., 2004). Second, several genes that may be responsible for cattle temperament have been identified (Schmutz et al., 2001; Wegenhoft, 2005; Boldt, 2008), indicating that interactions among these genes with those regulating production traits are possible and should be investigated. Finally, cattle with excitable temperaments have heightened stress-related physiological responses compared with calmer cohorts when handled by humans (Burdick et al., 2011b).

Stress response is defined as the reaction of an animal to internal and external factors that influence its homeostasis (Moberg, 2000), and animals unable to cope with these factors are classified as stressed (Dobson and Smith, 2000). Based on this concept, the fearful and/or aggressive responses expressed by excitable cattle during human handling can be attributed to their inability to cope with this situation and, therefore, classified as a stress response. Accordingly, excitable cattle typically experience changes in their neuroendocrine system and hypothalamic–pituitary–adrenal axis that culminates with increased synthesis of cortisol, which is considered paramount to the neuroendocrine stress response (Sapolsky et al., 2000). More specifically, several studies from others (Stahringer et al., 1990; Fell et al., 1999; Curley et al., 2006) and our group (Table 1) reported that cattle with excitable temperaments have greater circulating cortisol concentrations during handling compared with cohorts with adequate temperament. It is worth mentioning that the aforementioned studies evaluated *B. taurus* and *B. indicus*-influenced cattle from different ages and genders and across intensive and extensive systems. Hence, excitable temperaments have been positively associated with neuroendocrine stress reactions independent of breed type, age category, and production system.

Table 1. Plasma cortisol concentrations (ng/mL) in cattle during handling, according to temperament and within breed type, age, and gender (adapted from Cooke et al., 2009a,b, 2012a; Francisco et al., 2012b)[1]

Item	Adequate	Excitable	SEM	*P*-value
Bos indicus				
Steers	16.7	19.6	1.4	0.04
B. indicus × *Bos taurus*				
Heifers	45.5	57.9	2.1	<0.01
Cows	30.7	42.4	0.7	<0.01
B. taurus				
Heifers	32.1	41.8	2.3	<0.01
Cows	17.8	22.7	0.8	<0.01

[1]Cattle temperament was evaluated concurrently with blood collection via chute score and exit velocity. Exit velocity was divided into quintiles and cattle assigned with a score from 1 to 5 (exit score: 1 = slowest animals and 5 = fastest animals). Individual chute and exit scores were averaged for calculation of temperament score. Cattle were classified according to temperament score as adequate temperament (temperament score ≤ 3) or excitable temperament (temperament score > 3).

Table 2. Reproductive performance of beef cows according to temperament (adapted from Cooke et al., 2011, 2012a)[1]

Item	Adequate	Excitable	SEM	*P*-value
Bos indicus				
Pregnancy rate, %	42.8	35.3	2.8	0.05
Bos taurus				
Pregnancy rate, %	94.6	88.7	1.9	0.03
Calving rate, %	91.8	85.0	2.2	0.04
Weaning rate, %	89.9	83.9	2.3	0.09
Calf weaning BW, kg	248	247	6	0.71
Calf wt. weaned/cow exposed to breeding, kg	223	207	6	0.08

[1]Cattle temperament was evaluated via chute score and exit velocity at the beginning of the breeding season. *Bos taurus* cows were assigned to fixed-time AI followed by a 50-d bull breeding, whereas *B. indicus* cows were assigned to a fixed-time AI protocol only. Exit velocity was divided into quintiles and cattle assigned with a score from 1 to 5 (exit score: 1 = slowest animals and 5 = fastest animals). Individual chute and exit scores were averaged for calculation of temperament score. Cattle were classified according to temperament score as adequate temperament (temperament score ≤ 3) or excitable temperament (temperament score > 3).

The hormones produced during a neuroendocrine stress reaction influence several traits in cattle, such as growth, immune response, and reproductive function (Fell et al., 1999; Dobson et al., 2001). As an example, elevated circulating cortisol concentrations stimulate body fat and skeletal muscle catabolism (Nelson and Cox, 2005), impair function of the somatotropic axis (Elsasser et al., 1997; Maciel et al., 2001), elicit acute-phase reactions (Cooke et al., 2012b), lead to immunosuppression (Kelley, 1988), and reduce gonadotropin activity and ovarian steroidogenesis in females (Da Rosa and Wagner, 1981; Li and Wagner, 1983). Collectively, these results corroborate that one of the main mechanisms by which excitable temperament impacts productive and welfare traits in beef cattle is via the neuroendocrine stress reaction, which has been the focus of our and other research groups when evaluating the impacts of cattle temperament on beef production systems.

TEMPERAMENT AND BEEF CATTLE PRODUCTION

Reproductive Performance of Beef Females

As an initial attempt to associate temperament and reproduction in beef females, Plasse et al. (1970) classified *B. indicus* heifers according to temperament score (1 = calm, 2 = moderate, and 3 = excitable temperament) and reproductive score (heifers with inadequate reproductive performance received the greatest scores). These authors reported that temperament score was positively correlated with reproductive scores and negatively correlated with duration of estrus and suggested that consideration of temperament in selection programs might have a positive influence on the reproductive efficiency of the cowherd. However, the practical effects of excitable temperament on reproductive function of beef females still needed further investigation. Hence, our research group recently assessed the impacts of temperament on reproductive performance of *B. taurus* and *B. indicus*-influenced cows (Cooke et al., 2009a, 2011, 2012a).

Cooke et al. (2009a) evaluated temperament at the beginning of the breeding season in Braford cows exposed to bulls for 90 d and Brahman × British cows assigned to fixed-time AI and subsequently exposed to bulls for 90 d. Probability of pregnancy during the breeding season was negatively associated with temperament score, independent of breed and reproductive management. Similarly, Cooke et al. (2011) evaluated temperament in Nelore cows assigned to a fixed-time AI protocol and reported that cows with excitable temperament had reduced pregnancy rates compared with cohorts with adequate temperament (Table 2). More recently, Cooke et al. (2012a) evaluated temperament at the beginning of the breeding season in Angus × Hereford cows exposed to bulls for 50 d or cohorts assigned to fixed-time AI and subsequently exposed to bulls for 50 d. Cows with excitable temperament had reduced pregnancy rate, calving rate, weaning rate, and kilograms of calf weaned/cow exposed compared with cows with adequate temperament (Table 2), indicating that excitable temperament not only impairs reproductive performance but also overall production efficiency in cow–calf systems. Collectively, these results demonstrated that cows with excitable temperament had reduced reproductive performance compared with cohorts with adequate temperament. Such

Table 3. Feedlot performance of beef cattle according to temperament (adapted from Francisco et al., 2012a,b)[1]

Item	Adequate	Excitable	SEM	*P*-value
Bos indicus				
Feedlot ADG, kg/d	1.30	1.05	0.10	0.02
Feedlot DMI, kg/d	9.3	8.8	0.3	0.14
Feedlot G:F, g/kg	138	119	8	0.03
No. of bruises/carcass	0.62	1.32	0.26	0.05
Bos taurus				
Weaning BW, kg	204	197	2	0.04
BW and feedlot entry, kg	219	213	2	0.09
Growing lot ADG, kg/d	1.08	1.09	0.01	0.51
Finishing lot ADG, kg/d	1.85	1.80	0.02	0.21
BW at slaughter, kg	587	576	5	0.09
HCW	370	362	3	0.09

[1]Cattle temperament was evaluated via chute score and exit velocity at feedlot entry (Francisco et al., 2012b) or weaning (Francisco et al., 2012a). Exit velocity was divided into quintiles and cattle assigned with a score from 1 to 5 (exit score: 1 = slowest animals and 5 = fastest animals). Individual chute and exit scores were averaged for calculation of temperament score. Cattle were classified according to temperament score as adequate temperament (temperament score ≤ 3) or excitable temperament (temperament score > 3).

outcomes were independent of breed type (*B. taurus* and *B. indicus*-influenced cattle), reproductive management (AI, natural breeding, or both), and perhaps nutritional status because cow BCS at the beginning of the breeding season was not affected by temperament (Cooke et al., 2009a, 2011, 2012a). Plasma cortisol concentrations were greater in cows with excitable temperament (Table 1; Cooke et al., 2009a, 2012a), which indicates that their decreased pregnancy rates could be attributed to neuroendocrine stress responses stimulated by handling for estrus synchronization and AI (Dobson et al., 2001). However, the same decrease in reproductive performance was observed in excitable cows assigned to natural breeding only, with no human interaction or handling to stimulate neuroendocrine stress responses during the breeding season. Therefore, additional mechanisms associating temperament and reproduction in beef females, including postconception effects and potential genetic and innate deficiencies within the reproductive system of excitable cows, warrant further investigation (Cooke et al., 2012a).

Performance, Health, and Carcass Quality of Feedlot Cattle

The vast majority of research conducted to date evaluating the impacts of cattle temperament on beef production systems focused on overall feedlot performance of *B. taurus* and *B. indicus*-influenced cattle. These efforts concluded that cattle with excitable temperament have impaired feedlot ADG (Voisinet et al., 1997b; Cafe et al., 2011; Turner et al., 2011), often explained by reduced DMI (Fox et al., 2004; Nkrumah et al., 2007) and feed efficiency (Petherick et al., 2002) as well as reduced carcass quality (Voisinet et al., 1997a; King et al., 2006; Cafe et al., 2011), compared with cohorts with adequate temperament. Accordingly, we also demonstrated that *B. indicus* steers with excitable temperament had reduced ADG and G:F during a 109-d feedlot period and greater incidence of carcass bruises at slaughter (Francisco et al., 2012b; Table 3). Francisco et al. (2012a) reported that *B. taurus* feeder cattle with excitable temperament had reduced BW at weaning and feedlot entry as well as HCW compared with cohorts with adequate temperament (Table 3). These latter results were novel, indicating that temperament impacted cattle BW throughout their productive lives and were independent of the dam's temperament given that calf weaning BW was similar among cows with excitable or adequate temperament (Table 2; Cooke et al., 2012a).

The negative impacts of excitable temperament on feedlot performance and carcass attributes have also been attributed to neuroendocrine stress reactions, particularly because feedlot cattle are constantly exposed to human interaction. We and others also documented that feedlot cattle with excitable temperament have greater circulating cortisol concentrations compared with cohorts with adequate temperament (Fell et al., 1999; Francisco et al., 2012b). In addition, excitable cattle also have heightened inflammatory and acute-phase responses following a stress stimulus (Hulbert et al., 2009), which may partially explain the reduced feedlot performance of excitable cattle (Voisinet et al., 1997b; Cafe et al., 2011; Turner et al., 2011) given that the magnitude of the acute-phase response on feedlot entry is negatively associated with cattle health, DMI, and growth performance (Berry et al., 2004; Qiu et al., 2007; Araujo et al., 2010). Accordingly, we demonstrated that steers with excitable temperament had greater plasma haptoglobin and ceruloplasmin responses following road transport and feedlot entry as well as reduced ADG during feedlot receiving compared with cohorts with adequate temperament (Fig. 1; Francisco et al., 2012a).

Collectively, these results indicate that excitable temperament also impacts overall productivity of feeder cattle, including *B. taurus* and *B. indicus*-influenced cattle in various feedlot conditions. Similarly to reproductive traits, these outcomes were mainly associated with reduced feed intake and increased neuroendocrine stress reactions in excitable cattle. However, potential interactions among genes regulating cattle temperament and productive traits, such as feed efficiency and carcass characteristics, warrants investigation.

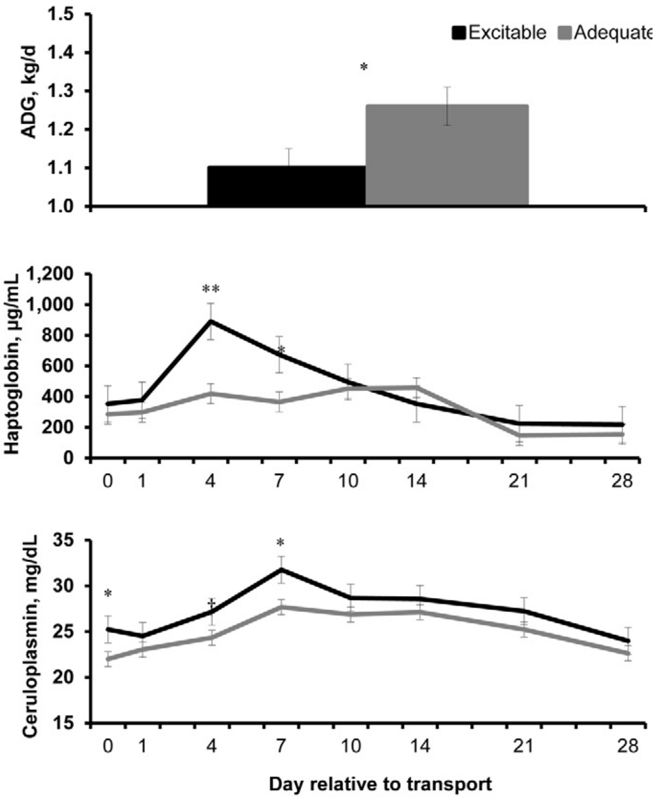

Figure 1. Average daily gain and plasma concentrations of haptoglobin and ceruloplasmin during feedlot receiving (d 1 to 28) of steers according to temperament, which was evaluated via chute score and exit velocity on d 0 (before 24-h road transport). Exit velocity was divided into quintiles and cattle assigned with a score from 1 to 5 (exit score: 1 = slowest and 5 = fastest steers). Chute and exit scores were averaged for calculation of temperament score. Steers were classified according to temperament score as adequate temperament (temperament score ≤ 3) or excitable temperament (temperament score > 3). Treatment comparison: **P* ≤ 0.05; ***P* < 0.01. Adapted from Francisco et al. (2012a).

MODIFYING TEMPERAMENT OF THE HERD

Based on the aforementioned research results, managing beef herds for adequate temperament is imperative for personnel and animal welfare as well as optimal production efficiency in beef operations. These include adoption of cattle temperament in selection and culling criteria and acclimation of young cattle to human handling.

Selecting Cattle for Temperament

The most direct approach to manage temperament of beef herds is by including this trait as a criterion when selecting sires, dams, and replacement heifers, particularly due to its moderate heritability (Shrode and Hammack, 1971; Fordyce et al., 1988). In addition, culling of excitable and unproductive cows and heifers that do not become pregnant during the annual breeding season will also benefit temperament and productive efficiency of the herd. Based on our results (Cooke et al., 2009a, 2011), reproductive performance of cows with temperament scores of 2 or 3 was not substantially reduced compared with cohorts with a temperament score of 1. Hence, we proposed that temperament score ≤ 3 is an adequate selection criterion to optimize productive efficiency of cowherds without impairing their ability to cope with the challenges associated with extensive production systems, such as presence of predators (Flörcke and Grandin, 2013) and ability to search and compete for feed resources (Wieckert, 1971). Nevertheless, additional research is required to determine the optimal temperament for beef cattle within different environments, breeds, and production systems.

Acclimating Cattle to Human Handling

Frequent exposure of young cattle to human handling has been shown to improve their temperament and alleviate neuroendocrine stress responses associated with handling stress (Jago et al., 1999; Krohn et al., 2001; Curley et al., 2006). As an example, Echternkamp (1984) reported that mature Hereford cows previously acclimated to physical restrain for blood collection had reduced plasma concentrations of cortisol and increased pulsatility and mean concentrations of LH compared with those of cohorts with no previous acclimation. Accordingly, we conducted a series of experiments to determine if acclimating *B. taurus* and *B. indicus*-influenced cattle to human handling would benefit their temperament and production traits (Cooke et al., 2009a,b, 2012a; Francisco et al., 2012a).

Cooke et al. (2009b) exposed Braford and Brahman × Angus replacement heifers whereas Cooke et al. (2012a) exposed Angus × Hereford replacement heifers to a 28-d human acclimation process within 45 d after weaning. In both experiments, acclimated heifers were processed through a handling facility 3 times weekly for 4 wk, whereas nonacclimated heifers remained undisturbed on pasture. Cooke et al. (2009b) reported that acclimated heifers had reduced growth rates compared with nonacclimated heifers and attributed this outcome to additional exercise and potential disruption in grazing patterns due to the acclimation process (Table 4). Cooke et al. (2012a) reported similar growth rates between acclimated and nonacclimated groups given that heifers were maintained on pastures near the handling facility (Table 4), which reduced the additional exercise required by the acclimation process. In both studies, the acclimated heifers had improved temperament traits, reduced plasma cortisol concentrations (Table 4), and hastened attainment of puberty compared with nonacclimated cohorts (Fig. 2). Based on these results, we concluded that increasing the frequency of which replacement heifers are exposed to human interaction is

Table 4. Effects of acclimation to human handling on temperament and productive traits of beef cattle (adapted from Cooke et al., 2009a,b, 2012a, and Francisco et al., 2012a)[1]

Item	Acclimated	Nonacclimated	SEM	*P*-value
Bos indicus × *Bos taurus* heifers				
Plasma cortisol after acclimation, ng/mL	37.8	50.5	1.6	<0.01
Chute score after acclimation	1.37	1.84	0.09	<0.01
ADG until breeding season, kg/d	0.50	0.58	0.01	<0.01
B. taurus heifers				
Plasma cortisol after acclimation, ng/mL	26.1	32.8	1.9	0.01
ADG until breeding season, kg/d	0.47	0.46	0.01	0.37
Exit velocity at breeding season, m/s	2.10	2.56	0.14	0.02
B. taurus steers				
ADG during acclimation BW, kg	0.32	0.38	0.05	0.36
Plasma cortisol after acclimation, ng/mL	20.0	25.3	1.6	0.02
Temperament score after acclimation	2.22	2.63	0.12	0.02
ADG during feedlot receiving, kg/d	1.13	1.32	0.04	<0.01
DMI during feedlot receiving, kg/d	7.09	7.40	0.11	0.07
G:F during feedlot receiving, g/kg	166	185	6	0.03

[1]Cattle were assigned or not to a 28-d human acclimation process within 45 d after weaning. Acclimated cattle were processed through a handling facility (heifers = 3x weekly, steers = twice weekly) for 4 wk, whereas nonacclimated cohorts remained undisturbed on pasture. Cattle temperament was evaluated via chute score and exit velocity. Exit velocity was divided into quintiles and cattle assigned with a score from 1 to 5 (exit score: 1 = slowest animals and 5 = fastest animals). Individual chute and exit scores were averaged for calculation of temperament score.

a management tool that can improve their temperament and reproductive development.

No benefits were observed when mature *B. indicus*-influenced cows (Cooke et al., 2009a) or *B. taurus* feeder cattle (Francisco et al., 2012a) were exposed to acclimation processes. Cooke et al. (2009a) exposed Braford and Brahman × Angus cows to human interaction twice weekly for 180 d before the breeding season and reported that this acclimation process did not effectively impact cow temperament, neuroendocrine

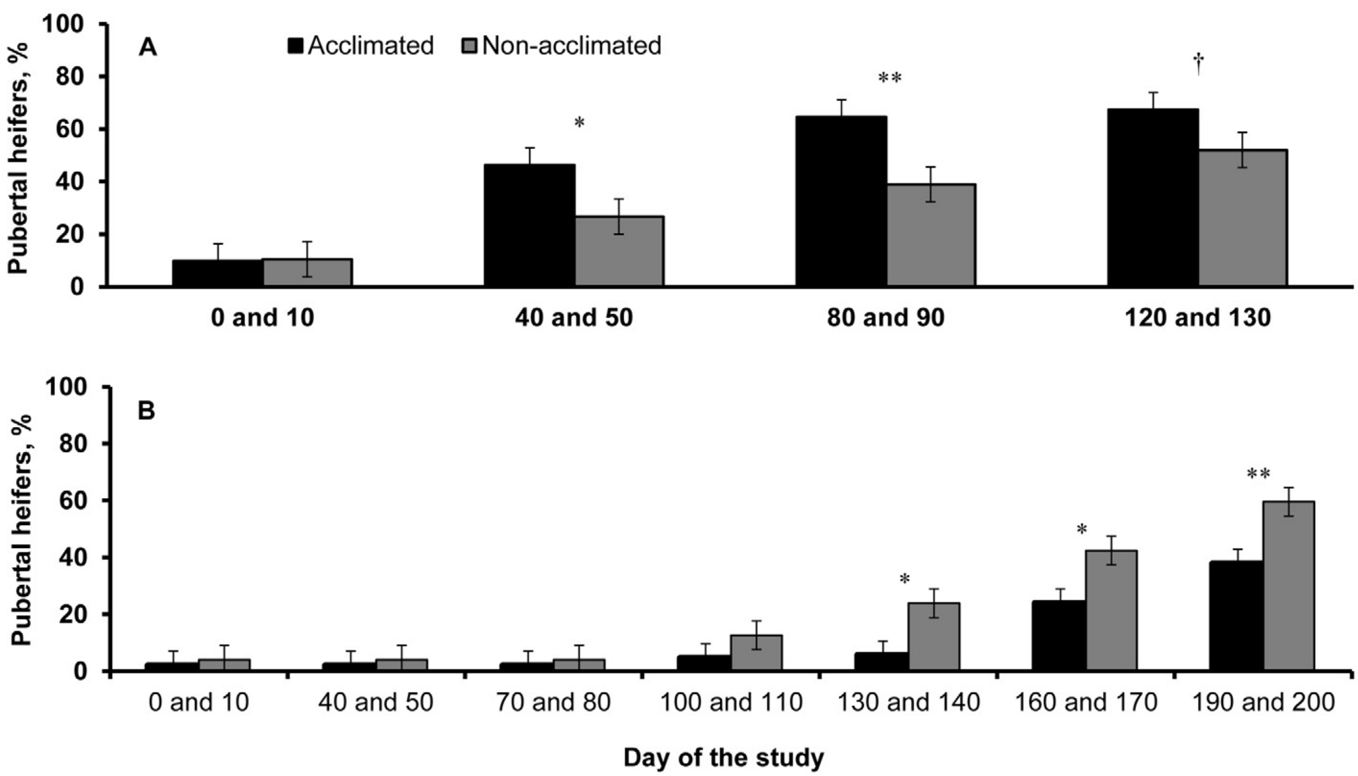

Figure 2. Puberty attainment of *Bos indicus* × *Bos taurus* (panel A) and *B. taurus* (panel B) heifers exposed or not to a 28-d human acclimation process within 45 d after weaning. Acclimated heifers were processed through a handling facility 3 times weekly for 4 wk, whereas nonacclimated cohorts remained undisturbed on pasture (d 10 to 40 of each experiment). Treatment comparison within days: †$P = 0.10$; *$P \leq 0.05$; **$P < 0.01$. Adapted from Cooke et al. (2009b) and Cooke et al. (2012a).

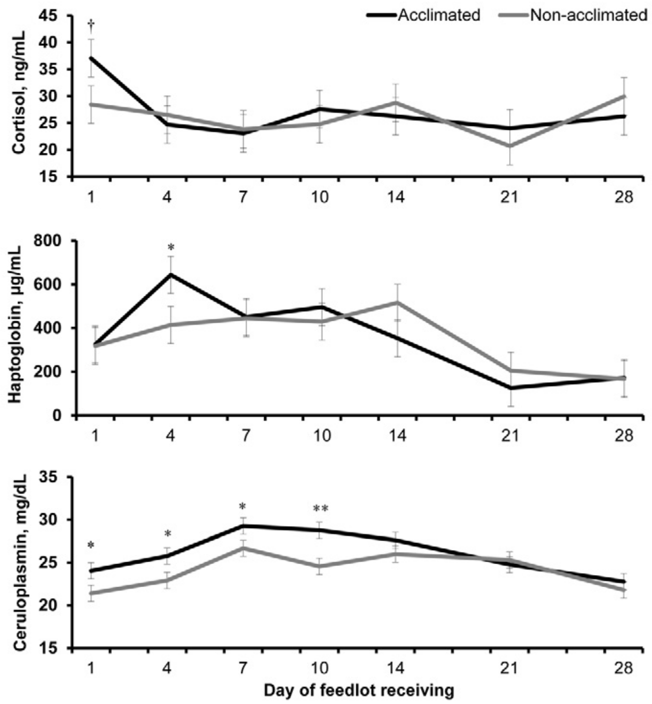

Figure 3. Plasma concentrations of cortisol, haptoglobin, and ceruloplasmin during feedlot receiving (d 1 to 28) of beef steers exposed (acclimated) or not (nonacclimated) to handling acclimation procedures and transported for 24 h for 1,200 km (d 0 to d 1). Acclimated steers were processed through a handling facility twice weekly for 4 wk, whereas nonacclimated cohorts remained undisturbed on pasture (d –28 to –1 of the experiment). Treatment comparison within day: *$P \leq 0.05$; **$P < 0.01$. Adapted from Francisco et al. (2012a).

stress reactions, or reproductive performance. It was suggested that mature cattle may not acclimate to human handling as well as younger animals (Cooke et al., 2009a). Moreover, exposing the mature cowherd to such procedures is likely impractical in extensive cow–calf production systems (Cooke et al., 2009a). Francisco et al. (2012a) exposed Angus × Hereford steers to a 28-d acclimation process, similar to Cooke et al. (2012b), beginning 35 d after weaning. After the end of the acclimation period, steers were assigned to a 28-d feedlot receiving study. Francisco et al. (2012a) reported that acclimated steers had reduced temperament score and plasma cortisol concentrations compared with nonacclimated cohorts after the end of the acclimation period (Table 4). However, acclimated steers had reduced ADG, G:F, and DMI (Table 4) as well as heightened stress-induced cortisol and acute-phase protein responses (Fig. 3) during feedlot receiving compared with nonacclimated cohorts. Hence, acclimation to human handling after weaning and before transport to feedlot, such as during a preconditioning program, was detrimental to feedlot performance of *B. taurus* feeder cattle.

Table 5. Temperament score and plasma cortisol of beef cows from wolf-naïve (CON) and wolf-experienced origins (WLF) subjected to a simulated wolf encounter (adapted from Cooke et al., 2013)[1,2,3]

Item	WLF	CON	SEM	*P*-value
Temperament score				
Presimulation	2.97	2.08	0.12	<0.01
Postsimulation	3.37	2.05	0.12	<0.01
Change[3]	0.40	–0.04	0.10	0.01
Covariately adjusted[4]	3.06	2.34	0.09	<0.01
Plasma cortisol, ng/mL				
Presimulation	17.9	13.1	1.5	0.04
Postsimulation	23.7	14.6	1.5	<0.01
Change[3]	5.8	1.5	0.8	<0.01
Covariately adjusted[4]	21.8	16.3	0.7	<0.01

[1]Simulated wolf encounter consisted described by Cooke et al. (2013). Cattle temperament was evaluated via chute score and exit velocity, whereas blood samples were collected before (presimulation) and immediately after (postsimulation assessment) the simulated wolf encounter.

[2]Exit velocity was divided into quintiles and cattle assigned with a score from 1 to 5 (exit score: 1 = slowest animals and 5 = fastest animals). Individual chute and exit scores were averaged for calculation of temperament score.

[3]Calculated by subtracting presimulation values from postsimulation values.

[4]Postsimulation values covariately adjusted to presimulation values.

Presence of Predators: Impacts on Cattle Temperament

Cattle temperament may also be impacted by other factors besides human interaction, including presence of predators (Creel and Christianson, 2008). More specifically, fear of predation may increase cattle excitability and subsequent neuroendocrine stress reactions (Laporte et al., 2010; Boonstra, 2013). Due to the recent increases in wolf populations, incidence of cattle–wolf interaction, and cattle predation by wolves in the northwestern United States, we recently investigated if wolf presence near cattle herds alters temperament and neuroendocrine stress responses, particularly in cattle from herds previously predated by wolves (Cooke et al., 2013). In that study, beef cows from wolf-naïve and wolf-experienced origins were subjected to a simulated wolf encounter, which included olfactory (i.e., wolf urine), auditory (i.e., prerecorded wolf howls), and visual (i.e., domestic canines physically similar to wolves) stimuli. Cooke et al. (2013) reported that the wolf simulation process increased temperament score and plasma cortisol concentration in wolf-experienced cows but not in wolf-naïve cows (Table 5). Therefore, presence of wolf packs near cattle herds may negatively impact beef production systems via predatory activities and subsequent death and injury of animals as well as by increasing excitability and inducing neuroendocrine stress responses when packs are in close proximity to previously predated herds

SUMMARY AND CONCLUSIONS

In conclusion, the research results compiled in this manuscript demonstrate that cattle temperament impacts reproductive efficiency of females as well as growth, health, and carcass quality of growing cattle and, hence, overall productivity of beef systems based on *B. taurus* and *B. indicus* cattle. These outcomes were mainly associated with neuroendocrine stress reactions, although potential interactions among genes regulating cattle temperament and productive traits are possible and warrant investigation. Nevertheless, strategies to improve the temperament of beef herds, including temperament as a selection or culling criterion and acclimation of young cattle to human interaction, are imperative for optimal production efficiency of beef operations based on *B. taurus* and *B. indicus*-influenced cattle.

LITERATURE CITED

Araujo, D. B., R. F. Cooke, G. R. Hansen, C. R. Staples, and J. D. Arthington. 2010. Effects of rumen-protected polyunsaturated fatty acid supplementation on performance and physiological responses of growing cattle following transportation and feedlot entry. J. Anim. Sci. 87:4125–4132.

Berry, B. A., A. W. Confer, C. R. Krehbiel, D. R. Gill, R. A. Smith, and M. Montelongo. 2004. Effects of dietary energy and starch concentrations for newly received feedlot calves: II. Acute-phase protein response. J. Anim. Sci. 82:845–850.

Boivin, X., P. Le Neindre, J. M. Chupin, J. P. Garel, and G. Trillat. 1992. Influence of breed and early management on ease of handling and open-field behavior of cattle. Appl. Anim. Behav. Sci. 32:313–323.

Boldt, C. R. 2008. A study of cattle disposition: Exploring QTL associated with temperament. University Undergraduate Research Fellows, Texas A&M University, College Station, TX.

Boonstra, R. 2013. Reality as the leading cause of stress: Rethinking the impact of chronic stress in nature. Funct. Ecol. 27:11–23.

Burdick, N. C., J. A. Carroll, L. E. Hulbert, J. W. Dailey, M. A. Ballou, R. R. Randel, S. T. Willard, R. C. Vann, and T. H. Welsh Jr. 2011a. Temperament influences endotoxin-induced changes in rectal temperature, sickness behavior, and plasma epinephrine concentrations in bulls. Innate Immun. 17:355–364.

Burdick, N. C., R. D. Randel, J. A. Carroll, and T. H. Welsh. 2011b. Interactions between temperament, stress, and immune function in cattle. Int. J. Zool. 2011:1–9.

Burrow, H. M., and N. J. Corbet. 2000. Genetic and environmental factors affecting temperament of zebu and zebu-derived beef cattle grazed at pasture in the tropics. Aust. J. Agric. Res. 51:155–162.

Cafe, L. M., D. L. Robinson, D. M. Ferguson, B. L. McIntyre, G. H. Geesink, and P. L. Greenwood. 2011. Cattle temperament: Persistence of assessments and associations with productivity, efficiency, carcass and meat quality traits. J. Anim. Sci. 89:1452–1465.

Cooke, R. F. 2009. Evaluating temperament in beef cattle. Oregon State University - Beef Cattle Sciences/Beef Cattle Library, BEEF041. http://beefcattle.ans.oregonstate.edu/html/publications/documents/BEEF021-TemperamentandPerformancex_000.pdf. (Accessed 20 April 2014.)

Cooke, R. F., J. D. Arthington, D. B. Araujo, and G. C. Lamb. 2009a. Effects of acclimation to human interaction on performance, temperament, physiological responses, and pregnancy rates of Brahman-crossbred cows. J. Anim. Sci. 87:4125–4132.

Cooke, R. F., J. D. Arthington, B. R. Austin, and J. V. Yelich. 2009b. Effects of acclimation to handling on performance, reproductive, and physiological responses of Brahman-crossbred heifers. J. Anim. Sci. 87:3403–3412.

Cooke, R. F., D. W. Bohnert, B. I. Cappellozza, C. J. Mueller, and T. DelCurto. 2012a. Effects of temperament and acclimation to handling on reproductive performance of *Bos taurus* beef females. J. Anim. Sci. 90:3547–3555.

Cooke, R. F., D. W. Bohnert, M. Meneghetti, T. C. Losi, and J. L. M. Vasconcelos. 2011. Effects of temperament on pregnancy rates to fixed-timed AI in *Bos indicus* beef cows. Livest. Sci. 142:108–113.

Cooke, R. F., D. W. Bohnert, M. M. Reis, and B. I. Cappellozza. 2013. Impact of previous exposure to wolves on temperament and physiological responses of beef cattle following a simulated wolf encounter. J. Anim. Sci. 91:5905–5911.

Cooke, R. F., J. A. Carroll, J. Dailey, B. I. Cappellozza, and D. W. Bohnert. 2012b. Bovine acute-phase response following different doses of corticotrophin-release hormone challenge. J. Anim. Sci. 90:2337–2344.

Core, S., T. Widowski, G. Mason, and S. Miller. 2009. Eye white percentage as a predictor of temperament in beef cattle. J. Anim. Sci. 87:2168–2174.

Creel, S., and D. Christianson. 2008. Relationships between direct predation and risk effects. Trends Ecol. Evol. 23:194–201.

Curley, K. O., Jr., J. C. Paschal, T. H. Welsh Jr., and R. D. Randel. 2006. Technical note: Exit velocity as a measure of cattle temperament is repeatable and associated with serum concentration of cortisol in Brahman bulls. J. Anim. Sci. 84:3100–3103.

Da Rosa, G. O., and W. C. Wagner. 1981. Adrenal-gonad interactions in cattle. Corpus luteum function in intact and adrenalectomized heifers. J. Anim. Sci. 52:1098–1105.

Dobson, H., and R. F. Smith. 2000. What is stress, and how does it affect reproduction? Anim. Reprod. Sci. 60–61:743–752.

Dobson, H., J. E. Tebble, R. F. Smith, and W. R. Ward. 2001. Is stress really all that important? Theriogenology 55:65–73.

Echternkamp, S. E. 1984. Relationship between LH and cortisol in acutely stressed beef cows. Theriogenology 22:305–311.

Elder, J. K., J. F. Kearnan, K. S. Waters, G. H. Dunwell, F. R. Emmerson, S. G. Knott, and R. S. Morris. 1980. A survey concerning cattle tick control in Queensland. 4. Use of resistant cattle and pasture spelling. Aust. Vet. J. 56:219–223.

Elsasser, T. H., S. Kahl, N. C. Steele, and T. S. Rumsey. 1997. Nutritional modulation of somatotropic axis-cytokine relationships in cattle: A brief review. Comp. Biochem. Physiol. 116:209–221.

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

Flörcke, C., and T. Grandin. 2013. Loss of anti-predator behaviors in cattle and the increased predation losses by wolves in the northern Rocky Mountains. Open J. Anim. Sci. 3:248–253.

Fordyce, G. E., R. M. Dodt, and J. R. Wythes. 1988. Cattle temperaments in extensive beef herds in northern Queensland. 1. Factors affecting temperament. Aust. J. Exp. Agric. 28:683–687.

Fordyce, G., M. E. Goddard, R. Tyler, G. Williams, and M. A. Toleman. 1985. Temperament and bruising of *Bos indicus* cross cattle. Aust. J. Exp. Agric. 25:283–288.

Fox, J. T., G. E. Carstens, E. G. Brown, M. B. White, S. A. Woods, T. H. Welsh Jr., J. W. Holloway, B. G. Warrington, R. D. Randel, D. W. Forrest, and D. K. Lunt. 2004. Residual feed intake of growing bulls and relationships with temperament, fertility and performance traits. J. Anim. Sci. 82(Suppl. 2.):6 (Abstr.).

Francisco, C. L., R. F. Cooke, R. S. Marques, R. R. Mills, and D. W. Bohnert. 2012a. Effects of temperament and acclimation to handling on feedlot performance of *Bos taurus* feeder cattle originated from a rangeland-based cow-calf system. J. Anim. Sci. 90:5067–5077.

Francisco, C. L., A. M. Jorge, F. D. Rezende, A. Schmidek, J. M. B. Benatti, M. H. Faria, E. Oba, and R. F. Cooke. 2012b. Effects of temperament on physiological responses, feedlot performance, and carcass characteristics of Nelore steers. J. Anim. Sci. 90(E-Suppl. 3):427 (Abstr.).

Grandin, T. 1993. Behavioral agitation during handling of cattle is persistent over time. Appl. Anim. Behav. Sci. 36:1–9.

Grandin, T. 1994. Solving livestock handling problems. Vet. Med. 89:989–998.

Hearnshaw, H., and C. A. Morris. 1984. Genetic and environmental effects on a temperament score in beef cattle. Aust. J. Agric. Res. 35:723–733.

Hulbert, L. E., J. A. Carroll, N. Burdick, J. W. Dailey, L. Caldwell, R. Vann, M. Ballou, T. Welsh Jr., and R. Randel. 2009. Influence of temperament on inflammatory cytokine responses of cattle to a lipopolysaccharide (LPS) challenge. J. Anim. Sci. 87(E-Suppl. 3):11. (Abstr.).

Jago, J. G., C. C. Krohn, and L. R. Matthews. 1999. The influence of feeding and handling on the development of the human–animal interactions in young cattle. Appl. Anim. Behav. Sci. 62:137–151.

Kelley, K. W. 1988. Cross-talk between the immune and endocrine systems. J. Anim. Sci. 66:2095–2108.

King, D. A., C. E. S. Pfeiffer, R. D. Randel, T. H. Welsh Jr., R. A. Oliphint, B. E. Baird, K. O. Curley Jr., R. C. Vann, D. S. Hale, and J. W. Savell. 2006. Influence of animal temperament and stress responsiveness on the carcass quality and beef tenderness of feedlot cattle. Meat Sci. 74:546–556.

Krohn, C. C., J. G. Jago, and X. Boivin. 2001. The effect of early handling on the socialisation of young calves to humans. Appl. Anim. Behav. Sci. 74:121–133.

Lanier, J., T. Grandin, R. Green, D. Avery, and K. McGee. 2001. A note on hair whorl position and cattle temperament in the auction ring. Appl. Anim. Behav. Sci. 73:93–101.

Laporte, I., T. B. Muhly, J. A. Pitt, M. Alexander, and M. Musiani. 2010. Effects of wolves on elk and cattle behaviors: Implications for livestock production and wolf conservation. PLoS ONE 5:e11954.

Li, P. S., and W. C. Wagner. 1983. In vivo and in vitro studies on the effect of adrenocorticotropic hormone or cortisol on the pituitary response to gonadotropin releasing hormone. Biol. Reprod. 29:25–37.

Maciel, S. M., C. S. Chamberlain, R. P. Wettemann, and L. J. Spicer. 2001. Dexamethasone influences endocrine and ovarian function in dairy cattle. J. Dairy Sci. 84:1998–2009.

Moberg, G. P. 2000. Biological response to stress: Implications for animal welfare. In: G. P. Moberg and J. A. Mench, editors, The biology of animal stress: Basic principles and implications for animal welfare. CAB International, Oxon, UK. p. 1–21.

Morris, C. A., N. G. Cullen, R. Kilgour, and K. J. Bremner. 1994. Some genetic factors affecting temperament in *Bos taurus* cattle. N. Z. J. Agric. Res. 37:167–175.

Nelson, D. L., and M. M. Cox. 2005. Lehninger principles of biochemistry. 4th ed. W. H. Freeman and Company, New York, NY.

Nkrumah, J. D., D. H. Crews Jr., J. A. Basarab, M. A. Price, E. K. Okine, Z. Wang, C. Li, and S. S. Moore. 2007. Genetic and phenotypic relationships of feeding behavior and temperament with performance, feed efficiency, ultrasound, and carcass merit of beef cattle. J. Anim. Sci. 85:2382–2390.

Petherick, J. C., R. G. Holroyd, V. J. Doogan, and B. K. Venus. 2002. Productivity, carcass and meat quality of lot-fed *Bos indicus* cross steers grouped according to temperament. Anim. Prod. Sci. 42:389–398.

Plasse, D., A. C. Warnick, and M. Koger. 1970. Reproductive behavior of *Bos indicus* females in a subtropical environment. IV. Length of estrous cycle, duration of estrus, time of ovulation, fertilization and embryo survival in grade Brahman heifers. J. Anim. Sci. 30:63–72.

Qiu, X., J. D. Arthington, D. G. Riley, C. C. Chase Jr., W. A. Phillips, S. W. Coleman, and T. A. Olson. 2007. Genetic effects on acute phase protein response to the stresses of weaning and transportation in beef calves. J. Anim. Sci. 85:2367–2374.

Sapolsky, R. M., L. M. Romero, and A. U. Munck. 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocr. Rev. 21:55–89.

Schmutz, S. M., J. M. Stookey, D. C. Winkelman-Sim, C. S. Waltz, Y. Plante, and F. C. Buchanan. 2001. A QTL study of cattle behavioral traits in embryo transfer families. J. Hered. 92:290–292.

Shrode, R. R., and S. P. Hammack. 1971. Chute behavior of yearling beef cattle. J. Anim. Sci. 33:193 (Abstr.).

Stahringer, R. C., R. D. Randel, and D. A. Neuendorff. 1990. Effects of naloxone and animal temperament on serum luteinizing-hormone and cortisol concentrations in seasonally anestrous Brahman heifers. Theriogenology 34:393–406.

Turner, S. P., E. A. Navajas, J. J. Hyslop, D. W. Ross, R. I. Richardson, N. Prieto, and M. Bell. 2011. Associations between response to handling and growth and meat quality in frequently handled *Bos taurus* beef cattle. J. Anim. Sci. 89:4239–4248.

Voisinet, B. D., T. Grandin, S. F. O'Connor, J. D. Tatum, and M. J. Deesing. 1997a. *Bos indicus*-cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. Meat Sci. 46:367–377.

Voisinet, B. D., T. Grandin, J. D. Tatum, S. F. O'Connor, and J. J. Struthers. 1997b. Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. J. Anim. Sci. 75:892–896.

Wegenhoft, M. A. 2005. Locating quantitative trait loci associated with disposition in cattle. University Undergraduate Research Fellows, Texas A&M University, College Station, TX.

Welp, T., J. Rushen, D. L. Kramer, M. Festa-Bianchet, and A. M. B. de Passillé. 2004. Vigilance as a measure of fear in dairy cattle. Appl. Anim. Behav. Sci. 87:1–13.

Wieckert, D. A. 1971. Social behavior in farm animals. J. Anim. Sci. 32:1274–1277.