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GENETIC SELECTION FOR DOCILITY: A REVIEW

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ABSTRACT

Animal docility or temperament is an important trait in livestock as it has influence not only on the human safety and animal welfare but importantly also on the productivity of livestock farming enterprises. Poor temperament in livestock has been associated with reduced performance, health, and carcass quality. Docility is thus increasingly becoming a focus of many studies aiming at its inclusion in animal breeding programs. Most studies on docility and its association with production have shown that the trait (docility) exhibits moderate to large additive genetic variance which could be exploited in breeding programs. Docility could potentially be used as an indicator trait for economically important traits that are difficult to measure. Techniques for measuring docility are continually being refined and improved making it possible to accurately measure docility. Identification and selection of animals with a temperament that will improve their welfare and productivity within their production environment is becoming increasingly important.

Key words: docility; heritability; selection; temperament.

INTRODUCTION

Intense selection for increased production performance in animals is postulated to have resulted in increased problems with temperament, including increased aggressiveness during handling and more excited response to restraint (Grandin *et al.*, 1998). Aggressive behaviour or poor docility is considered a bad trait in farming operations and animals with such character are usually culled (Kenttamies *et al.*, 2006). Researchers and farmers are thus increasingly paying attention to livestock reactions during handling and use these to describe animal docility (Paranhos da Costa *et al.*, 2002) especially with emerging evidence that docility is not only correlated with ease of handling but also economically important traits. Animals remaining calm and docile during handling are considered to have a good temperament. Within a population, individuals show differences in behaviour, which are stable across time and situations (D'Eath *et al.*, 2009). Docility occurs across all types of production environments and includes maternal behaviour (Jarvis *et al.*, 2005), aggressiveness (D'Eath *et al.*, 2002a), social behaviors (Lovendahl *et al.*, 2005), reactions to humans (Barozzo *et al*., 2012; Burrow, 1997, Fordyce *et al.*,1998), feeding behaviours, daily activities and handling responses to new objects or situations (Yoder, 2010). Recent modifications in animal husbandry practices to reduce labour and increase herd size is resulting in less human contact and this consequently tends to increase poor temperament in animals (Holl *et al.*, 2010). Because of the reduced opportunities for animals to become familiar with humans, animals perceive handling as stressful (Brouček, 2008). Temperamental animals have generally been found to have reduced growth rates, poor carcass traits and poor immune function (Curley *et al.*, 2006b; Burdick *et al.*, 2011, Kadel *et al.*, 2006; Beckman *et al.*, 2008, Burrow, 2003; Breuer *et al.* 2000; Café *et al.*, 2011). Furthermore, temperamental animals are more easily stressed than their calmer herd mates (Curley *et al.*, 2008) and as a consequence more prone to disease infection. Selecting livestock to improve docility has positive benefits to improved animal performance in addition to improving human safety and animal welfare.

Docility has been found to be moderately heritable and therefore there is considerable scope for genetic improvement of the trait (Ferguson, 2006). Favourable genetic and phenotypic relationships between docility and meat quality, feedlot performance, ease of transport and some reproductive traits have been observed (Hamlyn-Hill, 2012) indicating that selection to improve docility will also result in genetic improvements in these traits. Unfortunately, docility is often overlooked in many countries especially developing countries.

Measurement of Docility: There are a number of methods for evaluating docility and these ranges from simple visual observations to assessments that require computerized techniques. These methods can be divided into restrained techniques, non-restrained techniques, and phenotypic evaluations (Cooke and Bohner, 2010b). The restrained techniques evaluate temperament when animals are physically restricted, such as in the squeeze chute while the non-restrained techniques evaluate animal docility based on their fear or aggressive response to humans when they are free to move within the evaluation area. The phenotypic evaluations account for external features of cattle that have been associated with temperament and are usually indirect measures of docility (Cooke, 2011). In cattle, the widely used methods are chute score, pen score and exit velocity. Chute and pen scores are considered subjective measures of temperament while exit velocity is considered an objective measurement (Vann *et al.*, 2011). Chute scores show the behaviour of the animal while confined in a chute and scored on the following scale (Grandin, 1993):

1: calm, no movement
2: restless, shifting
3: squirming, occasionally shaking of the crush
4: continuous vigorous movement and shaking of the crush
5: rearing, twisting of the body or violent struggling.

Pen score is a measurement in which cattle are separated into small groups of three to five and their reactivity to a human observed (Cooke, 2011). The scoring is also scored on a scale of 1 to 5.

1: unalarmed and unexcited animal that walks slowly away from the evaluator
2: slightly alarmed animal that trots away from the evaluator
3: moderately alarmed and excited animal that runs away from the evaluator
4: very alarmed and excited animal that runs with head held high and may charge the evaluator
5: animal very excited and aggressive in a manner that requires evasive actions by the evaluator to avoid contact.

Exit Velocity determines the velocity (m/s) at which an animal leaves a squeeze chute. The standard distance to measure velocity is over 6 feet. High velocity reflects poor level of docility (Burrow *et al.*, 1988). In some instances the exit velocity and pen score are averaged to obtain a temperament score. This score takes into consideration both the subjective and the objective perspectives (Curley *et al.*, 2006a). Hair whorl and eye white percentages have also been used as they have been found to correlated with level of docility (Cooke, 2011). In sheep, a 30 sec isolation test to measure temperament is used (Blache & Ferguson, 2005). In pigs, load score, scale score and vocal score are used as measures of temperament (Yoder, 2010).

Docility and Hormonal Responses: Given that temperament is a stress response trait, it is likely that the hypothalamic-pituitary-adrenal (HPA) axis plays a role in determining individual animal's responses to stress (Pugh *et al.*, 2011). The stress response is stimulated by a stressor and affects the body through activation of the HPA axis system and the sympathetic nervous system (Chrousos & Kino, 2005). Aguilera (1998) defines stressors as any internal or external stimuli or threat (physical, psychological, or chemical) that disrupts homeostasis. In response to this altered state, the stress response is activated in order to help the body cope with the threat and return to or maintain homeostasis (Burdick *et al.*, 2011).

Corticotropic releasing hormone (CRH) is released from the hypothalamus in response to stressors. The CRH then acts on the anterior pituitary causing the release of adrenocorticotropic hormone (ACTH) which elicits the production of glucocorticoids namely, cortisol from the cortex of the adrenal gland (Pugh *et al*., 2011) Glucocorticoids have been found to negatively affect growth by increasing the production of leptin which has been documented to reduce feed intake (Agarwal *et al.*, 2009). Glucocorticoids break down protein, glycogen, and fat to increase the amount of circulating glucose (Pugh *et al.*, 2011). An increase in circulating cortisol concentration also impairs the cell-mediated immunity of the animals by decreasing the number of macrophages, natural killer cells, T lymphoctyes, and cytokines (Jain *et al.*, 1991).

Positive correlations have been found in cattle between temperament and cortisol levels in the blood, suggesting that more excitable cattle are easily stressed (Curley *et al.*, 2008; Cooke *et al.*, 2009). In addition, cattle with excitable temperament also have altered metabolism and partitioning of nutrients in order to sustain the behavioural stress response, which results in further decreases in nutrient availability to support body functions (Cooke *et al.*, 2009). Hormones produced during a stress response, particularly cortisol, directly disrupt the physiological mechanisms that regulate reproduction in beef females, such as ovulation, conception, and establishment of pregnancy. Cows with calm temperament have reduced cortisol and greater blood concentrations of luteinizing hormone, the hormone required for puberty establishment and ovulation, compared to temperamental cows (Echternkamp, 1984). Increased corticosterone levels have been shown to retard growth in broiler chickens (Post *et al.*, 2003). Blood cortisol is positively correlated with temperament as measured by exit velocity (Otterman *et al*., 2013).

Breed Effects: A number of factors influence docility and these include breed effect, social environment, age, sex, production system and experience (Hoppe *et al.*, 2010; Burdick *et al.*, 2011). Only breed effects will be discussed, other factors that influence docility can be found in Hoppe (2008). Bos indicus and Bos indicus-crosses have been reported to be more temperamental than Bos taurus cattle (Burrow, 2001). Significant effects of breed have been observed in a study on Caracu breed (Bos taurus taurus) and Nelore, Gir and Guzerá (Bos Taurus indicus). Bos taurus taurus were found to be less reactive than Bos taurus indicus while among the Zebu breeds, Nelore were less reactive than Gir and Guzerá (Paranhos da Costa *et al.*, 2002). In a feedlot environment, results show that the British breeds (Angus-Hereford-cross and Hereford) steers were more nervous and had significantly lower average daily gains (and significantly higher morbidity over 85 days in the feedlot).

In a study on pigs, the Landrace breed was found to be more temperamental than the Duroc, Yorkshire and Chester White breeds while both Yorkshire and Chester were more temperamental when compared to the Duroc breed with the latter being the most docile amongst the studied pig breeds (Yoder, 2010). In a study on two dairy cattle breeds, the Jersey was found more docile than the Holstein-Fresian (Orban *et al.*, 2011). The Jersey breed had a score of 1.53 while the Holstein-Fresian had a score of 2.69. Crossbred animals have been noted to be less docile than purebreds (Schaeffer *et al*., 2011). In goats, the least temperament breed was Sanental followed by the Alpine, with the most temperamental being the selected Hungarian (Némethet *et al*., 2009).

Genetic response of docility and correlation with performance: Murphy (1999) found that Merino ewes divergently selected for temperament had a 10% higher lamb survival rate in twins compared with ewes from the 'nervous' flock. A study in sheep, heritability of ewe mothering temperament was found to be 0.39 indicating a moderate genetic component to this behavioural trait (Lennon *et al.*, 2009). Though moderately heritable, results of this suggest that if temperament is used as a selection criterion, there would be no correlated response in improved wool production nor litter survival. In a study by Blache and Bickell (2010), selection for temperament was demonstrated to affect the behaviour of the females during the mating period and in the early stages of gestation and had an effect on the survival of newborn lambs. The study showed that ewes with calm temperament had a greater ovulation rate than nervous ewes. More multiple gestations were observed in calm ewes than nervous ewes and ewes of calm temperament also carried more twin embryos than nervous ewes.

The heritability for docility score was estimated to be 0.22 in Angus heifers (Otterman *et al.*, 2013) indicating possibility of genetic selection for docility. In a study by Paranhos da Costa *et al.*, 2002, heritability estimates for temperament as measured by flight speed and agitation score were 0.35 and 0.34 respectively. Higher heritability estimates of 0.46 and 0.54 measured as flight speed have been reported in studies by Hearnshaw and Morris (1984) and Burrow *et al*. (1988) respectively. Fordyce *et al.* (1982) reported even higher heritability (0.67) for Zebu and European breeds. In a study by Sant'Anna *et al.*(2013) all temperament indicator traits showed large genetic variability to respond to selection and the use of flight speed could be used as a selection tool for fast genetic gain in Nelore cattle. Heritabilities of temperament in Japanese Black and Japanese Shorthorn cattle have been reported to be 0.45 and 0.67 respectively.

Kadel *et al.* (2006) showed that better temperament measured as flight time was genetically correlated with improved tenderness (i.e. lower shear force and higher tenderness scores), with genetic correlations of 0.42 and 0.33 between shear force and tenderness respectively. The study by Sullivan and Burnside (1988) showed that it is feasible to identify sires with significant differences in their daughters' handling and feeding behaviour. The study further suggested that selection on the basis of within-herd, farmer-rated milking behaviour evaluation, taken early in the heifer's lactation, would identify sires that leave predominantly quiet heifers that are easy to work with in the milking and handling process while sires that have high proofs for production, capacity and dairyness will tend to leave daughters that are aggressive during the feeding process.

Holl *et al.*, 2010 reported docility measured as activity score had a heritable genetic component and was genetically correlated with performance traits. Estimated genetic correlations between temperament and backfat measurements were negative, as was the genetic correlation of docility and body weight which indicated that selection for more docile animals would be expected to result in fatter, faster growing pigs. In a study by Yoder (2010), heritabilities ranging from 0.21 to 037 for vocal score were observed in various pig breeds. Genetic correlations between load score scale score and vocal score with backfat thickness, adjusted loin depth, days to 113.4 kilograms and estimated percent fat-free lean ranged from 0.78 to 0.56 indicating progress that can be achieved in performance traits if selection for temperament is practiced.

Cattle with calm temperaments have been found to have greater ADG (Burrow, 1997), poorer carcass quality (Scanga *et al.*, 1998; King *et al.*, 2006; Vann, 2006; Nkurumah *et al.*, 2007; Bates, 2011), poorer feed conversion rates (Voisinet *et al.*, 1997; Petherick *et al.*, 2002; Nkurumah *et al.*, 2007) and lower immune function (Fell *et al.*, 1999; Bates, 2011) than calm cattle. Docility measured as chute score was found to be positively correlated with first service AI conception rate in Angus heifers (Otterman *et al.*, 2013). Burrow and Dillon (1997) has reported heavier carcass weights in B. indicus crossbred cattle with slow flight speeds than those with fast flight speeds. Nkurumah *et al.*, (2007) have reported considerable genetic and phenotypic variation in beef cattle in measures of feeding behaviour and temperament, which are also related to measures of performance, FCR, and carcass merit.

Some Breed Associations that are now routinely considering docility in animal selection programs such as the Limousin Breed Association have seen remarkable improvement in temperament. Limousin cattle born in 1990 had an average docility EPD of about +1 and those born in 2007 averaged +15 (Hyde, 2003). Estimated docility heritability for the Limousin breed is estimated to be 0.4 (Hyde, 2003).

Conclusion: There is reliable evidence that docility has moderate to large genetic variation and thus can respond to selection pressure. Furthermore, temperament traits have been found to be positively correlated with performance traits in many livestock species. This further indicates that while temperament can be improved through direct selection, it may also be used to indirectly improve many economically important traits in various livestock species. Consideration of docility in breeding objectives has potential to improve the welfare of both animals and humans and the performance of livestock farming enterprises.

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