Journal of Veterinary Behavior 15 (2016) 50–55

Contents lists available at ScienceDirect

Journal of Veterinary Behavior

journal homepage: www.journalvetbehavior.com

Bovine Research

Effects of temperament on production and reproductive performances in Simmental dual-purpose cows

Ludovic Toma Cziszter [a,b], Dinu Gavojdian [a,*], Radu Neamt [a], Florin Neciu [a], Szilvia Kusza [c], Daniela-Elena Ilie [a]

[a] Research and Development Station for Bovine Arad, Academy for Agricultural and Forestry Sciences, Arad, Romania
[b] Department of Animal Production Engineering, Banat's University of Agricultural Sciences and Veterinary Medicine 'King Michael I', Timisoara, Romania
[c] Institute of Animal Science, Biotechnology and Nature Conservation, University of Debrecen, Debrecen, Hungary

ARTICLE INFO

Article history:
Received 3 June 2016
Received in revised form
11 August 2016
Accepted 18 August 2016
Available online 26 August 2016

Keywords:
animal welfare
behavioral reactivity
cattle
Simmental
selection traits

ABSTRACT

The aim of the current research was to evaluate the effects that temperament has on production and reproduction performances in Simmental dual-purpose cattle breed. Behavioral reactivity of cows significantly influenced ($P \leq 0.05$) the body weight, milk yield, fat yield, protein yield, protein content, and the calving interval of the cows included in the study-head, having more substantial effects ($P \leq 0.001$) on the milking speed and the number of steps per day, with calmer cows outperforming the nervous counterparts. However, temperament did not influence ($P > 0.05$) traits such as days open, number of inseminations per gestation, fat percentage, somatic cell count, body condition score, cleanliness of udder and cleanliness of hindquarter. Significant negative phenotypic correlations were found between temperament and cows body weight (−0.19), milk yield (−0.19), fat yield (−0.14), protein yield (−0.18), and milking speed (−0.18). Current results suggest that selection for calm temperaments will translate into increased milk, fat, and protein yields in Simmental cattle, as well as shorter the calving interval and improved milk ejection.

Introduction

Cattle (*Bos taurus*) have been undergoing human-managed selection ever since their original domestication 8,000-10,000 years ago (Loftus et al., 1994). Initially, selection was limited to docility and manageability; however, in the last 60-70 years, most of the breeding programs have been focused solely on the genetic improvement of production traits, such as milk yield and growth rates (Oltenacu and Broom, 2010). Nowadays, selection for a broader set of novel traits, such as health, longevity, feed efficiency, methane emissions, temperament, and functional traits, is becoming more widespread as producers and animal geneticists realize that high productivity cannot solely be maintained or improved without a more integrated approach on animal performance and welfare (Kramer et al., 2013; Haskell et al., 2014; Hietala et al., 2014). New functional traits are growing in importance because of recent declines in animal health and fitness caused by the intense selection for milk production (Egger-Danner et al., 2015).

Temperament in livestock species can be defined as the manner in which an individual reacts to a novel or challenging situation (Reale et al., 2000) and has been suggested as a useful tool for improving productivity in cattle (Ferguson and Warner, 2008; Cafe et al., 2011). In cattle, temperament is often described as an animal's response to handling or forced movement by humans (Haskell et al., 2014). Up-to-date, little information regarding heritability of behavioral traits is known; however, commercial dairy farms cull animals because of their poor temperaments (Berry et al., 2005). Previous investigations outlined the influence that temperament has on milk production (Breuer et al., 2000; Sutherland and Dowling, 2014), for meat quality and growth rates in beef and

* Address for reprint requests and correspondence: Dinu Gavojdian, Research and Development Station for Bovine Arad, Academy for Agricultural and Forestry Sciences, 310059 Arad, Romania. Tel: +40 723 375 804; Fax: +40 356 456 400.
E-mail address: gavojdian_dinu@animalsci-tm.ro (D. Gavojdian).

http://dx.doi.org/10.1016/j.jveb.2016.08.070

dual-purpose breeds (Reinhardt et al., 2009; Cafe et al., 2011; Turner et al., 2011), reproductive performance (Haile-Mariam et al., 2004; Sewalem et al., 2011), and longevity (Sewalem et al., 2010; Haskell et al., 2014) in cattle. Moreover, animals which are highly reactive to humans and handling exhibit poor adaptation to their environment and experience high levels of stress, reducing their level of welfare (Bickell et al., 2009; Gavojdian et al., 2015).

Cattle temperament is regarded to be low to moderately heritable, thus making it a suitable trait for genetic selection (Nkrumah et al., 2007; Barrozo et al., 2012), with significant breed disparities being reported (Haskell et al., 2014; Egger-Danner et al., 2015). In Simmental, the previous estimates on the heritability for handling scores range between 0.28 and 0.55 (Gauly et al., 2001; Hoppe et al., 2010).

The aim of the current research was to evaluate the effects that temperament has on production and reproduction performances in Simmental dual-purpose cattle breed.

Materials and methods

Use of animals and the procedures performed in this study were approved by the Scientific and Ethics Committee of the Research and Development Station for Bovine Arad of the Academy for Agricultural and Forestry Sciences, Decision no. 51 issued on November 11, 2015.

Animals and general management

The study was carried out at the Research and Development Station for Bovine Arad (46°10′36″N 21°18′4″E) Romania (altitude of site 107 m), where purebred dual-purpose Simmental cows, managed under loose system with zero grazing were included in the research herd.

The Simmental/Fleckvieh (national name Băltată românească) herd had been selected based on milk yield since 1981. Reproductive failure and age were the criteria normally used to define which cows would be culled. However, in some cases, low productivity, health, and udder problems were also considered. Cows taken in the study were between 1st and 8th lactation, with age and parity balanced within the herd and representing a diverse sampling of genetic lines (Austrian, German, and Romanian).

All animals were included in the Official Performance and Recording Scheme, being registered as a nucleus reference breeding herd, which produces and disseminates tested bulls for the national Artificial Insemination Stations. A data set from 198 animals and more than 3,560 records was analyzed for estimation of the effects that temperament has on production and reproduction outputs.

Cows were milked twice per day (starting at 5:30 and 17:30) in a "herringbone" milking parlor (2 sides × 14 units). The milking parlor was equipped with AfiMilk 3.076 A-DU software (Afikim, Israel). Furthermore, all cows were fitted with AfiTag pedometers (Afikim, Israel) for estrous and lameness detection.

Cows were kept on deep straw bedding, with a space allowance of 9 m^2 in the resting area and free access to water and outside paddocks. They received a daily feed ration of 15 kg of alfalfa and 15 kg of green fodder, 12 kg corn silage, 6 kg of alfalfa hay and 6 kg of concentrates starting spring till late autumn, and a ration of 15 kg alfalfa and 25 kg of corn silages, 6 kg of alfalfa hay and 6 kg of concentrates during winter. Cows were fed twice per day and had a feeding space allowance of 70-75 cm/head. Cows were housed in groups of 40-50 animals, according to their lactation stage and productivity.

The research activities were performed in accordance with the European Union's Directive for animal experimentation (Directive 2010/63/EU).

Temperament assessment

Temperament was assessed according to the "weigh crate" method described by Cafe et al. (2011) and Orban et al. (2011), a subjective restrained-method used to evaluate behavioral reactivity and fear response to handling in domestic ruminants. Temperament of cows was scored between 40 and 100 days after calving (in peak lactation). The measurements were taken when the cows were handled through the yards for other management or data collection related purposes. Temperament assessment was done in the paddock where cows wait for milking to take place, right before the afternoon milking for all animals, to avoid circadian behavioral variations. Cows were equally used to being handled to the test site and were not subject to prior handling procedures during that day (e.g., transrectal pregnancy control, vaccinations, regrouping). The 2 observers were placed at 3-3.5 m laterally to the weighing crate, to detect movements made by cows during the 30-second restrain period.

Behavior of animals was recorded using a 5-point score scale at weighing, while spending 30 seconds in the weighing crate: 1 calm, no movement; 2 calm with occasional movements; 3 moderately movements; 4 abrupt episodic movements; 5 permanent episodic movements.

Scoring was done individually by 2 observers and video-recorded for reevaluation, in case of a divergent scoring. Based on temperament scores given, cows were classified as either "calm" (scores 1 and 2), "moderate" (score 3), or "nervous" (scores 4 and 5).

Data collection and statistical analysis

ID tag number, milk yield per milking session (kg), milk duration (minutes), number of steps/interval (12 and 24 hours, between 2 milking sessions and per day), and milk conductivity (mS/cm) were recorded and collected daily using AfiMilk 3.076 A-DU software and hardware fitted in the milking parlor. Data were collected in a time interval of 72 hours (3 days) before the temperament evaluation. The number of steps was recorded during the daytime (from morning milking until the evening milking) and during the night time (from evening milking until the morning milking). Total number of steps performed by cows daily was obtained by adding the 2 values in each day of study, individually for each cow. The average milking speed (kg/min) was obtained by dividing the milk yield per milking to milk duration in minutes. For the purpose of this study, the averages during the 3 days were used for the number of steps during daytime, night, daily number of steps, and average milking speed.

Production and milk quality data (milk production, fat yield and percentage, protein yield and percentage, and the somatic cell count) were taken from the results of the official performance recordings, according to the standardized International Committee for Animal Recording (ICAR) guidelines (2012). The alternative milking at 4-week recording interval method was used for this purpose. Milk yield was standardized for normal lactation (305 days) and mature equivalent (cow's parity) using correction coefficients (Stanciu et al., 2005).

Body condition score (scores 0, regular body condition; 1, very lean; and 2, very fat), cleanliness of udder, and cleanliness of hindquarter (scores 0—no dirt or minor splashing or 2—separate or continuous plaques of dirt) were evaluated for each individual cow according to WelfareQuality® (2009) protocol for dual-purpose breeds, together with the body weight at the moment of the temperament assessment (40 to 100 days in lactation). Reproductive outputs of cows (days open, inseminations per gestation, and calving interval) were recorded by the research stations veterinarians.

Comparisons between the 3 temperament classes (calm, nervous, and moderate) for body weight, days open, inseminations per gestation, calving interval, milk yield, fat yield, fat percentage, protein yield, protein percentage, milking speed, somatic cell count, and number of steps were carried out using the one-way analysis of variance protocol, with categorical factor being considered the temperament of cows. Phenotypic correlations between temperament scores of cows on one hand and production and reproduction traits on the other hand were estimated using the analysis of variance described by Grosu and Oltenacu (2005).

Chi-square test of independence was performed to determine if cow temperament had an influence on the body condition score, cleanliness of udder, and cleanliness of hindquarters.

All the statistical inferences were carried out using Statistica software (StatSoft Inc., Tulsa, OK USA) (Hill and Lewicki, 2007). Decisions about the acceptance or rejection of statistical hypothesis have been made at the 0.05 level of significance.

Results and discussions

In general, the behavioral reactivity of cows (DF model = 2, DF residual = 195) significantly influenced the body weight (F = 4.36, $P = 0.014$), milk yield (F = 3.64, $P = 0.028$), milk fat yield (F = 3.70, $P = 0.026$), milk protein yield (F = 4.61, $P = 0.011$) and percentage (F = 4.66, $P = 0.011$), and the calving interval (F = 4.56, $P = 0.012$) of the cows included in the studied herd, having more substantial effects on the milking speed (F = 10.05, $P = 0.00007$) and the number of steps (F = 42.68, $P < 0.0000001$). However, temperament did not significantly influence traits such as days open (F = 0.29, $P = 0.749$), number of inseminations per gestation (F = 0.02, $P = 0.979$), milk fat percentage (F = 2.14, $P = 0.121$), and somatic cell count (F = 0.39, $P = 0.675$).

The average body weight for the Simmental herd was 589.7 kg (Table 1), with calmer cows outperforming significantly ($P \leq 0.05$) the moderate and nervous animals by 19.5 kg and 21.8 kg, respectively. No difference ($P > 0.05$) was observed between moderate and nervous temperaments. Overall, the body weight of cows was within the limits of the breed's standard of 550-650 kg (Acatincai, 2010); however, at the lower limit, taking into consideration that the Simmental is a dual-purpose breed, with the selection in Romania being mainly orientated for milk traits with 60%, followed by meat with 35% and fitness traits 5% (Perisic et al., 2009). As previously reported by Berry et al. (2003), genetic correlations between body weight and total lactation milk production are close to zero and negligible, as a result, focusing the selection scheme on milk yield would have a null or reduced effect on body weight gain within a breed.

Number of inseminations per gestation and days open were not influenced ($P > 0.05$) by the temperament (Table 1). Results from our study are in accordance with estimates for the breed reported by Muller et al. (2013) and Pantelic et al. (2011). Conversely to our results, Phocas et al. (2006) found significant genetic correlations showing that docile heifers had higher fertility than nervous heifers; however, this was limited, given that other reproductive outputs were not associated with temperament.

Calving interval was influenced by the temperament, with nervous animals having significantly higher intervals than their calm and moderate counterparts ($P \leq 0.05$ and $P \leq 0.01$, respectively). Results are similar to those reported by Riecka and Candrak (2011) for Holstein dairy cows and de Haas et al. (2013) for Simmental and other dual-purpose and beef breeds. To the best of our knowledge, this is the first report that shows the major implications of the behavioral reactivity on calving interval in cattle, of −40.5 days in calm versus nervous and −57.5 days in moderate versus nervous cows. The calving interval has an impact on reproductive outputs as well as on the farm related costs, as outlined by de Haas et al. (2013) with loss estimates of 1 €/cow/day.

Results on production data and the temperament implications on such traits are presented in Table 2. Average milk yield per 305 day of lactation in the studied herd was 5396.2 kg, consistent with reports of Jeretina et al. (2013) and Pantelic et al. (2011). Calmer cows had significantly ($P \leq 0.05$) higher milk yield compared to moderate (+316.4 kg) and nervous (+446.1 kg) animals. It was concluded that animals showing calm temperaments have higher milk yields, in accordance with previous records for the dairy breeds (Breuer et al., 2000; Haskell et al., 2014; Sutherland and Dowling, 2014). Given the current findings and implications, we recommend the incorporation of temperament as an independent trait in the selection index of the Simmental/Fleckvieh strain breeds.

Fat yield differed significantly ($P \leq 0.01$) between the calm and moderate temperaments, while between calm versus nervous and moderate versus nervous cows, the differences were not significant ($P > 0.05$). Oppositely, when it came to fat percentage from milk, significant ($P \leq 0.05$), differences were observed between moderate and nervous cows, with differences between calm versus moderate and calm versus nervous being not significant ($P > 0.05$). A similar pattern was observed for the protein yield, with significant ($P \leq 0.01$) differences being found between calm and moderate animals, while the differences between calm versus nervous, and moderate versus nervous were not significant ($P > 0.05$). Protein content was the lowest in moderate temperaments, significantly reduced compared to calm and nervous animals ($P \leq 0.05$ and $P \leq 0.01$, respectively).

Higher fat and protein content of milk in nervous animals could be attributed to the significantly lower milk yield in this group, given the significant negative correlations between milk production and fat and protein content from milk (Cziszter, 2003; Quist et al., 2008).

Data on milking speed, somatic cell count, and walking activity in cows are presented in Table 3. Stress induced by the human presence as well as the milking process itself in highly reactive cows can lead to milk ejection and milk let-down related problems (Bruckmaier, 2005). Given its importance, milk ejection rate or milking speed has been introduced as a secondary selection trait in many of the dairy breeds (Byskov et al., 2012).

Table 1
Least squares means (±SEM) for reproductive performances of cows based on their temperament

Temperament/trait	Body weight (kg)	Days open	Inseminations per gestation	Calving interval (days)
Cohort	589.7 ± 3.38	140.8 ± 5.48	1.72 ± 0.06	405.3 ± 5.36
Calm	597.5 ± 4.50[a]	138.9 ± 6.18[a]	1.73 ± 0.08[a]	405.5 ± 7.08[a]
Moderate	578.0 ± 5.48[b]	147.2 ± 12.49[a]	1.70 ± 0.13[a]	389.1 ± 7.66[a]
Nervous	575.7 ± 9.69[b]	134.8 ± 18.37[a]	1.71 ± 0.18[a]	446.6 ± 9.37[b]

SEM, standard error of the mean.
Column means with different superscript differ significantly at $P < 0.05$.

Table 2
Least squares means (±SEM) for productive performances of cows based on their temperament

Temperament/trait	Milk yield (kg/305 days)	Fat (kg/305 days)	Fat (%)	Protein (kg/305 days)	Protein (%)
Cohort	5396.2 ± 65.71	209.0 ± 2.49	3.89 ± 0.02	174.8 ± 2.09	3.24 ± 0.01
Calm	5531.4 ± 80.14[a]	214.0 ± 3.05[a]	3.88 ± 0.03[ab]	179.6 ± 2.49[a]	3.25 ± 0.02[a]
Moderate	5215.0 ± 129.04[b]	198.9 ± 4.54[b]	3.84 ± 0.05[a]	166.0 ± 4.22[b]	3.18 ± 0.02[b]
Nervous	5085.3 ± 207.68[b]	206.4 ± 9.06[ab]	4.05 ± 0.08[b]	169.3 ± 6.75[ab]	3.34 ± 0.04[a]

SEM, standard error of the mean.
Column means with different superscript differ significantly at $P < 0.05$.

In our study, an unclear pattern was observed, with moderately nervous animals having the lowest milking speed compared to both calm and nervous cows, differences were significant at $P \leq 0.001$ and $P \leq 0.05$, respectively. This tendency for the calmer cows to have a higher milking speed was reported by Szentleleki et al. (2015), while the reports from the same study give higher milking speed in Holstein cows, compared with the results from the present study.

Somatic cell count was not influenced ($P > 0.05$) by temperament, with results being in accordance with those published by Sewalem et al. (2011). Opposite results were reported by Orban et al. (2011) and Fulwider et al. (2007), which found that calmer and more docile Jersey and Holstein cows have lower somatic cell count in milk, compared to their nervous counterparts. The conflicting reports on the relationship between temperament and somatic cell count in the literature were mentioned as well by Haskell et al. (2014).

The 24-hour total number of steps and the number of steps between daytime and night-time intervals were significantly influenced by temperament ($P \leq 0.001$), with nervous cows taking roughly twice as many steps as the calm animals, regardless on the time interval. The circadian rhythm did not seem to influence the number of steps within the same timeframe across temperaments. A significant lower 24-hour total number of steps were reported by Maltz and Antler (2007); this might be attributed to the fact that the milking parlor during the present study was at roughly 200-m distance from the experimental barn, and cows had to walk twice per day to and from the milking parlor, while results from the aforementioned study were concerning walking activity of cows during late pregnancy, during their dry period.

Limited work has been done on correlations between temperament and other traits in dairy cattle, compared to beef breeds (Haskell et al., 2014), and even lesser studies are available on dual-purpose animals.

Significant phenotypic correlations were found between temperament and cows body weight (−0.19), milk yield (−0.19), fat yield (−0.14), and protein yield (−0.18). Results are in accordance with those previously reported by Cafe et al. (2011) for beef cattle, which found significant negative effects of more reactive temperaments on economically important traits in cattle, and in contrast with those published by Orban et al. (2011) concerning specialized dairy breeds. Thus, direct selection of cattle with calmer temperaments, and possibly the inclusion of this trait into the Simmental breeds selection index, and not only culling of cattle with extremely reactive temperaments, can improve overall productivity, animal's welfare, and safety of human handlers.

Opposite to the results found for fat and protein yields, correlations between behavioral reactivity of cows with milk fat and protein percentages were not correlated, with values of 0.07 and 0.02, respectively.

Somatic cells count was not correlated (0.00) with temperament in the Simmental breed. This result was conversely to previous finding of Orban et al. (2011), which reported positive moderate correlations for this trait with the temperament scores in Jersey and Holstein cows. This might be attributed to breed-related differences between temperaments, with dairy breeds having a higher behavioral reactivity propensity compared to beef or dual-purpose animals.

Milking speed was negatively correlated (−0.18) with the temperament of cows in the present study. In nervous cows, the milk ejection was slower, as outlined previously by Szentleleki et al. (2015) on a comparative research trial conducted on Holstein primiparous and multiparous cows.

Total number of steps per 24 hours, number of steps during the daytime interval, and the number of steps during the night-time interval have shown strong and positive correlations with temperament, of 0.55, 0.57, and 0.51, respectively. These results were opposite to those reported by Adamczyk et al. (2011) who found no correlation between dairy cows' temperament and their walking activity in the milking parlor.

Associations between temperament and reproductive traits in dairy cows are poorly studied but appear to be weak and variable (Haskell et al., 2014). No significant correlations were found between the Simmental cows temperament and reproduction traits such as days open (0.01), number of inseminations per gestation (−0.01), and the calving interval (0.08). These results are consistent with previous reports of Haile-Mariam et al. (2004) and Sewalem et al. (2011).

Body condition score, cleanliness of udder, and cleanliness of hindquarter evaluated according to WelfareQuality® protocol (2009) were not influenced ($P > 0.05$) by the cows temperament. To the best of our knowledge, no other study concerning the temperament effects on cleanliness in cattle exists up to this moment. We hypothesized, at the beginning of the study, that nervous cows would have a reduced degree of cleanliness of both udder and hindquarters, due to their more agitated nature, which

Table 3
Least squares means (±SEM) for milking speed, somatic cell count, and number of steps based on the behavioral reactivity of cows

Temperament/trait	Milking speed (kg/minute)	Somatic cell count (cells × 1.000/mL)	No. of steps/24 hours	No. of steps/daytime	No. of steps/night time
Cohort	2.15 ± 0.01	224.8 ± 28.15	4824.5 ± 157.62	2340.2 ± 65.73	2484.3 ± 97.40
Calm	2.21 ± 0.02[a]	233.8 ± 35.71[a]	3921.6 ± 134.66[a]	1956.6 ± 60.87[a]	1964.9 ± 83.17[a]
Moderate	2.03 ± 0.03[b]	188.1 ± 36.61[a]	5849.3 ± 279.43[b]	2765.8 ± 114.66[b]	3083.5 ± 176.89[b]
Nervous	2.17 ± 0.04[a]	268.7 ± 137.84[a]	7386.4 ± 644.37[c]	3453.5 ± 222.79[c]	3932.9 ± 431.72[c]

SEM, standard error of the mean.
Column means with different superscript differ significantly at $P < 0.05$.

would translate into a greater number of alternations between lying and standing positions during a 24-hour interval, compared to calmer animals. However, it was not the case, probably because these cows chose the cleanest places to lie down. In addition, the assumed hypothesis was not sustained because of the design of the resting area (deep straw bedding) that maintained a degree of dirtiness of udders and hindquarters, especially during rainy weather. Further studies are needed to evaluate the effects of bedding material and barn design on cleanliness of cows, given the practical implications on milk quality, udder health and animal welfare in general.

In the present study, cows with a calmer temperament had superior performances across a broad range of dairy production and reproduction outputs. "Weigh crate" temperament assessment method is simple to conduct on farm level, and its use could be encouraged by Simmental breeders' societies to allow selection for calmer temperaments or docility. Despite this, still relatively few published studies have described the relationships between temperament and commercially important traits in dual-purpose breeds and the biological mechanisms that underline these associations are not well known and evaluated up-to-date.

Conclusion

Correlations between temperament and production traits suggested that selection against animals that are highly reactive to improve welfare and ease of handling would not have detrimental impacts on productivity and reproductive outputs. Furthermore, significant correlations were found between cows' temperament and milk production traits. As a result, selection for calm temperaments should translate into increased milk, fat, and protein yields in Simmental/Fleckvieh cows, as well as shorter calving interval and improved milking ejection.

Acknowledgments

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS-UEFISCDI, project number PN-II-RU-TE-2014-4-1402. The idea for the article was conceived by Dinu Gavojdian. The experiments were designed by Daniela E. Ilie, Dinu Gavojdian, Szilvia Kusza, and Ludovic T. Cziszter. The experiments and data collection were performed by Radu I. Neamt and Florin Neciu. The data were analyzed by Ludovic T. Cziszter. The article was written by Dinu Gavojdian, Daniela E. Ilie, Szilvia Kusza, and Ludovic T. Cziszter.

Conflict of interest

The authors declare no conflict of interest.

References

Acatincai, S., 2010. Tehnologia Cresterii Bovinelor. Agroprint, Timisoara, Romania, pp. 167–170.
Adamczyk, K., Slania, A., Gil, Z., Felenczak, A., Bul, J., 2011. Relationships between milk performance and behaviour of cows under loose housing conditions. Ann. Anim. Sci. 11 (2), 283–293.
Barrozo, D., Buzanskas, M.E., Oliveira, J.A., Munari, D.P., Neves, H.H.R., Queiroz, S.A., 2012. Genetic parameters and environmental effects on temperament score and reproductive traits of Nellore cattle. Animal 6, 36–40.
Berry, D.P., Buckley, F., Dillon, P., Evans, R.D., Rath, M., Veerkamp, R.F., 2003. Genetic relationships among body condition score, body weight, milk yield, and fertility in dairy cows. J. Dairy Sci. 86 (6), 2193–2204.
Berry, D.P., Harris, B.L., Winkelman, A.M., Montgomerie, W., 2005. Phenotypic associations between traits other than production and longevity in New Zealand dairy cattle. J. Dairy Sci. 88, 2962–2974.
Bickell, S., Poindron, P., Nowak, R., Chadwick, A., Ferguson, D., Blache, D., 2009. Genotype rather than non-genetic behavioral transmission determines the temperament of Merino lambs. Anim. Welf. 18, 459–466.
Breuer, K., Hemsworth, P.H., Barnett, J.L., Matthews, L.R., Coleman, G.J., 2000. Behavioural response to humans and the productivity of commercial dairy cows. Appl. Anim. Behav. Sci. 66, 273–288.
Bruckmaier, R.M., 2005. Normal and disturbed milk ejection in dairy cows. Domest. Anim. Endocrinol. 29, 268–273.
Byskov, K., Buch, L.H., Aamand, G.P., 2012. Possibilities of implementing measures from automatic milking systems in routine evaluations of udder conformation and milking speed. Int. Bull. 46, 28–32.
Cafe, L.M., Robinson, D.L., Ferguson, D.M., McIntyre, B.L., Geesink, G.H., Greenwood, P.L., 2011. Cattle temperament: persistence of assessments and associations with productivity, efficiency, carcass and meat quality traits. J. Anim. Sci. 89, 1452–1465.
Cziszter, L.T., 2003. Dirijarea Functiei Glandei Mamare. Eurosampa, Timisoara, Romania, p. 126.
de Haas, Y., Veerkamp, R.F., Shalloo, L., Dillon, P., Kuipers, A., Klopcic, M., 2013. Economic values for yield, survival, calving interval and beef daily gain for three breeds in Slovenia. Livest. Sci. 157, 397–407.
Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes. OJ L276 (53), 33-79. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2010:276:FULL&from=EN. Accessed May 23, 2016.
Egger-Danner, C., Cole, J.B., Pryce, J.E., Gengler, N., Heringstad, B., Bradley, A., Stock, K.F., 2015. Invited review: overview of new traits and phenotyping strategies in dairy cattle with a focus on functional traits. Animal 9 (2), 191–207.
Ferguson, D.M., Warner, R.D., 2008. Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? Meat Sci. 80, 12–19.
Fulwider, W.K., Grandin, T., Rollin, B.E., Engle, T.E., Dalsted, N.L., Lamm, W.D., 2007. Survey of dairy management practices on one hundred thirteen North Central and North eastern United States dairies. J. Dairy Sci. 91, 1686–1692.
Gauly, M., Mathiak, H., Hoffmann, K., Kraus, M., Erhardt, G., 2001. Estimating genetic variability in temperamental traits in German Angus and Simmental cattle. Appl. Anim. Behav. Sci. 74, 109–119.
Gavojdian, D., Cziszter, L.T., Budai, C., Kusza, S., 2015. Effects of behavioral reactivity on production and reproduction traits in Dorper sheep breed. J. Vet. Behav. Clin. Appl. Res. 10, 365–368.
Grosu, H., Oltenacu, P.A., 2005. Programe de ameliorare genetica in zootehnie. Ceres, Bucharest, Romania, pp. 186–187.
Haile-Mariam, M., Bowman, P.J., Goddard, M.E., 2004. Genetic parameters of fertility traits and their correlation with production, type, workability, live weight, survival index, and cell count. Aust. J. Agric. Res. 55, 77–87.
Haskell, M.J., Simm, G., Turner, S.P., 2014. Genetic selection for temperament traits in dairy and beef cattle. Front. Genet. 5, 368.
Hietala, P., Wolfova, M., Wolf, J., Kantanen, J., Juga, J., 2014. Economic values of production and functional traits, including residual feed intake, in Finnish milk production. J. Dairy Sci. 97 (2), 1092–1106.
Hill, T., Lewicki, P., 2007. Statistics: Methods and Applications. StatSoft, Tulsa, OK.
Hoppe, S., Brandt, H.R., Konig, S., Erhardt, G., Gauly, M., 2010. Temperament traits of beef calves measured under field conditions and their relationships to performance. J. Anim. Sci. 88 (6), 1982–1989.
ICAR (International Committee for Animal Recording), 2012. International Agreement of Recording Practices. Available at: http://www.icar.org/pages/statutes.htm. Accessed May 23, 2016.
Jeretina, J., Babnik, D., Skorjanc, D., 2013. Modelling lactation curve standards for test-day milk yield in Holstein, Brown Swiss and Simmental cows. J. Anim. Plant Sci. 23 (3), 754–762.
Kramer, M., Erbe, M., Bapst, B., Bieber, A., Simianer, H., 2013. Estimation of genetic parameters for novel functional traits in Brown Swiss cattle. J. Dairy Sci. 96, 1–11.
Loftus, R.T., MacHugh, D.E., Bradley, D.G., Sharp, P.M., Cunningham, P., 1994. Evidence for two independent domestications of cattle. Proc. Natl. Acad. Sci. U. S. A. 91 (7), 2757–2761.
Maltz, E., Antler, A., 2007. A practical way to detect approaching calving of the dairy cow by a behaviour sensor. In: Cox, S. (Ed.), Precision Livestock Farming 07. Wageningen Academic Publishers, Wageningen, The Netherlands, pp. 141–146.
Muller, C.J.C., Potgieter, J.P., Cloete, S.W.P., Botha, J.A., 2013. Reproductive performance of Holstein and Fleckvieh x Holstein heifers and cows in a total mixed ration feeding system. Proc. Assoc. Advmt. Anim. Breed. Genet. 20, 439–443.
Nkrumah, J.D., Crews, D.H., Basarab, J.A., Price, M.A., Okine, E.K., Wang, Z., 2007. Genetic and phenotypic relationships of feeding behaviour and temperament with performance, feed efficiency, ultrasound and carcass merit of beef cattle. J. Anim. Sci. 85, 2382–2390.
Oltenacu, P.A., Broom, D.M., 2010. The impact of genetic selection for increased milk yield on the welfare of dairy cows. Anim. Welf. 19 (1), 39–49.
Orban, M., Gaal, K., Pajor, F., Szentleleki, A., Poti, P., Tozser, J., Gulyas, L., 2011. Effect of temperament of Jersey and Holstein Friesian cows on milk production traits and somatic cell count. Archiv. Tierz. 54 (6), 594–599.
Pantelic, V., Sretenovic, L., Ostojic-Andric, D., Trivunovic, S., Petrovic, M.M., Aleksic, S., Ruzic-Muslic, D., 2011. Heritability and genetic correlation of production and reproduction traits of Simmental cows. Afr. J. Biotechnol. 10 (36), 7117–7121.
Perisic, P., Skalicki, Z., Petrovic, M.M., Bogdanovic, V., Ruzic-Muslic, D., 2009. Simmental cattle breed in different production systems. Biotechnol. Anim. Husb. 25 (5-6), 315–326.

Phocas, F., Boivin, X., Sapa, J., Trillat, G., Boissy, A., Le Neindre, P., 2006. Genetic correlations between temperament and breeding traits in Limousin heifers. Anim. Sci. 82, 805–811.

Quist, M.A., LeBlanc, S.J., Hand, K.J., Lazenby, D., Miglior, F., Kelton, D.F., 2008. Milking-to-milking variability for milk yield, fat and protein percentage, and somatic cell count. J. Dairy Sci. 91 (9), 3412–3423.

Reale, D., Gallant, B.Y., Leblanc, M., Festa-Bianchet, M., 2000. Consistency of temperament in bighorn ewes and correlates with behavior and life history. Anim. Behav. 60, 589–597.

Reinhardt, C.D., Busby, W.D., Corah, L.R., 2009. Relationship of various incoming cattle traits with feed lot performance and carcass traits. J. Anim. Sci. 87, 3030–3042.

Riecka, Z., Candrak, J., 2011. Analysis of relationship between production and reproduction traits of Holstein cattle population in the Slovak Republic. Anim. Sci. Biotechnol. 44 (1), 332–336.

Sewalem, A., Miglior, F., Kistemaker, G.J., 2010. Analysis of the relationship between workability traits and functional longevity in Canadian dairy breeds. J. Dairy Sci. 93, 4359–4365.

Sewalem, A., Miglior, F., Kisteman, G.J., 2011. Genetic parameters of milking temperament and milking speed in Canadian Holsteins. J. Dairy Sci. 94, 512–516.

Stanciu, G., Acatincai, S., Cziszter, L., 2005. Tehnologia Cresterii Bovinelor - Lucrari Practice. Eurostampa, Timisoara, Romania, pp. 161–164.

Sutherland, M.A., Dowling, S.K., 2014. The relationship between responsiveness of first-lactation heifers to humans and the behavioural response to milking and milk production measures. J. Vet. Behav.: Clin. Appl. Res. 9, 30–33.

Szentleleki, A., Nagy, K., Szeplaki, K., Kekesi, K., Tozser, J., 2015. Behavioural responses of primiparous and multiparous dairy cows to the milking process over an entire lactation. Ann. Anim. Sci. 15 (1), 185–195.

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

Welfare Quality®, 2009. Welfare Quality® Assessment Protocol for Cattle. Welfare Quality® Consortium, Lelystad, Netherlands.