Effects of sex factor and bull lineage on behaviour of calves during ethological tests

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SUMMARY

The objective of this study was to investigate the effects of sex and bull lineage on calves` behavior showed in three ethological tests. Forty dairy calves sired by 3 bulls were used. The labyrinth tests were performed at the age of 119 days, novel arena tests were conducted at the 124th and 168th day. At the 130th day the social behavior during feeding was evaluated. We did not find any significant differences between genders in the labyrinth activities. Some activity times tended to be lower in the females. Heifer-calves spent less time standing at the labyrinth entrance part and tended shorter time to traverse the labyrinth than the bull-calves.

Bull-lineages differed significantly in the time of labyrinth leaving only. Calves sired by Bull 2 were the fastest in the labyrinth traversing (397.13±482.04 s) opposite to calves descended from Bull 1 and Bull 3 (722.58±372.01 s, 624.08±617.36 s) (P<0.001; 1:2**). Neither sexes nor bull-lineages differed during observations in novel arena. Heifer-calves tended be movable than bull-calves. The repeatability of ambulation behaviour between ages of 124 and 168 days was proved by significantly during the 1st minute and 5 minutes of the 1st test (r=0.3177*; r=0.2895*). We did not find any significant differences in social behavior. The win duel number tended to be higher in heifer-calves. The results of performed methods indicated that calves behavior is affected by the bull lineage factors in the labyrinth solving only.

Keywords: dairy calf, behavior, sex, bull lineage, labyrinth, novel arena, eating

INTRODUCTION

The use of modern housing systems instead of the conventional technology needs cattle resistant to stress and able to adapt to altered conditions of environment in coherence with new procedures and methods of

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dairy management (automatized feeding, robotization of milking). The individual reactions in various adverse situations can be used to predict the adaptability of animals to the breeding technology. These problems are rather pressing nowadays as modern husbandry is being promoted (Veissier and Le Neindre, 1989; Gonyou, 1994; Soch, 2005; Voriskova et al., 2010). Behavioral traits are largely determined by the environment, with little apparent genetic influence (Broucek et al., 2008; Broucek et al., 2011; Marsalek et al., 2008).

The ability to learn is important in all species because it allows the individual animal to adapt behaviorally to changes in its environment. In calves, such abilities are needed early in life as the animal learns features of its dam that strengthen the parent-offspring bond. The calf also learns, as do other animals, the features of the specie to which it will later direct its innate sexual responses (Kilgour et al., 1991; Arave et al., 1992; Veissier, 1993; Broucek et al., 2002). The speed and correctness of an animal in running through various types of labyrinths was used as a measure of animal intelligence and learning ability for a long time (Kilgour, 1987; Arave, 1996).

The ethological test, which measures animal activity or moved distance by individuals subjected to a novel arena, is used frequently in behavior studies (Broucek et al., 2000; Marsalek et al., 2005) and may indicate that the different factor effects on exploration are moderated by gender (Boissy and Bouissou, 1995). The novel arena test previously appears applicable also to temperament (Kilgour, 1987). Broucek et al. (2003) found that the number of grid crossings during the open-field test did not differ between the ages of 16 weeks and 18 months.

Cattle are highly adaptable and generally they respond well to modern farming practices. However, this adaptive ability can be overwhelmed. For instance, the intensification of animal housing and management can cause social disturbances resulting in behavioral problems, which in turn may affect productivity and welfare (Soch et al., 1997; Bouissou et al., 2001). Social constraints are of lesser importance for cattle reared in open rangelands or at pasture, although social relationships among animals in extensive husbandry may also have implications on productivity. On the other hand, social environment has positive effects on individual adjustments to the environment through social facilitation or learning (Bouissou, 1980; Creel and Albright, 1988; Boissy and Le Neindre, 1990). Early experience, including rearing conditions, influences social position in adulthood. Warnick et al. (1977) found that group-reared calves were dominant over individually reared and isolated calves. However, dominance relationships are not modified by deprivation of sight, and can be revealed by food competition tests under controlled conditions (Bouissou et al., 2001).

MATERIAL AND METHODS

Forty dairy calves (23 bull-calves and 17 heifer-calves) sired by 3 bulls (B1, n=12; B2, n=16; B3, n=12) were used in the experiment. They spent first four days of life with mother in individual pen. Calves were moved from the maternity barn into a calf barn with loose housing at the age of 5 days. They were fed the milk replacer from a bucket and weaned at the age of 56 days. After weaning all calves were kept in common pens.

The labyrinth learning was performed in the indoor space at the average age of 119 days (live body weight of 117.86 ± 20.32 kg). The labyrinth was constructed in the pen 16.4 × 4.5 m from steel fence 1.5 m high covered with a black plastic sheet. In the exit part was placed a red bucket with feed mixture. The calf was put into the labyrinth entrance and a door closed behind it. The calf was timed from when it entered the labyrinth until it got out. If the calf stood without movement in the enter part more than 3 minutes, it was forced gently to movement. The calf was allowed to eating for only a few seconds, whereupon it was lead out of the labyrinth to repeat the procedure. If the calf stands without movement more than 3 minutes in rear part of the labyrinth, it was taken out. On the first observation day the calves completed five runs, the first run was for training. There were evaluated 8 runs in total. Time to traverse of labyrinth was recorded from entering to the entering to exit. The behavior was recorded by a video camera.

The novel arena evaluation was performed twice, at the 124th and 168th day (live body weights of 125.04 ± 21.13 kg; 165.03 ± 24.55 kg). Calves were individually tested for 5 minutes in a novel arena 4.5 × 4.5 m divided in 9 quadrants. There were two buckets with concentrate mixture, red one in the left corner and green in the right corner. There were recorded the following activities: the start and end of any movement, the start and end of eating, the number of meals, the number of transgressed quadrants, the number of times the animal sniffed the ground and walls, the number of vocalizations, defecations and urinations. After 5 minutes was open the exit door. If the animal did not go out after 3 min it was drive out. Each calf was tested to four 5 min tests on 2 consecutive days.

The evaluation of the social behavior was made at the 130th day (live body weights of 132.00 ± 21.90 kg). The dominance order was assigned by recording calves concurrence during 1 h feeding on access to limited amounts of mixture in linear feeder. As concurrences types were recorded lick (tongue applied to other animal); sniff (nose put within 20 cm of the other animal for at least 2 sec; nuzzle (gently touch other animal or rub gently against other animal; threat; butt (ridges at top of head forcibly applied to other animal); push (side of head or shoulder forcibly applied to other animal); nudge (nose forcibly applied to other animal); displace (take up place at feeder forcibly so

that another individual moves back from the feeder); physical combat that resulted in a subordinate yielding space to an aggressor; turn away (response to approach or look by another individual which involves turning the head away or turning and walking away or diverting the path while walking so as to avoid the path of the other animal).

The dominance value was calculated by dividing the number of animals that a calf dominated (i.e. this calf displaced the other one at least twice as frequent as the other way around) by the number of animals a calf dominated plus the number of animals dominating the calf (Sambraus and Osterkorn, 1974). A mean dominance value of each animal was calculated by using the average of three observations. The win number (in percent) was calculated by dividing the number of win duels by the number of total duels multiplicities by 100.

The data were analyzed using a General Linear Model ANOVA by the statistical package STATISTIX, Version 9.0. The normality of data distribution was evaluated by the Wilk-Shapiro/Rankin Plot procedure. All data conformed to a normal distribution. Values are expressed as means ± SD.

The homogeneity of variance of the observed variables in groups, whose average values are being compared, was calculated by preliminary variance tests which determined whether the variability is equal. Bartlett's test for equality of variance tests was applied with an unequal size of samples. The ratio of the largest within-group variance over the smallest was also tested (Pearson and Hartley test).

Among-group comparisons of the behavior activities in each factor were analyzed using a General linear model ANOVA (General AOV/AOCV) - with the all effects considered as fixed effects and with error term as random effect distributed as $N \sim (0, \sigma^2)$ by model equation

$$y_{ij} = \mu + S_i + B_j + yi + e_{ij}$$

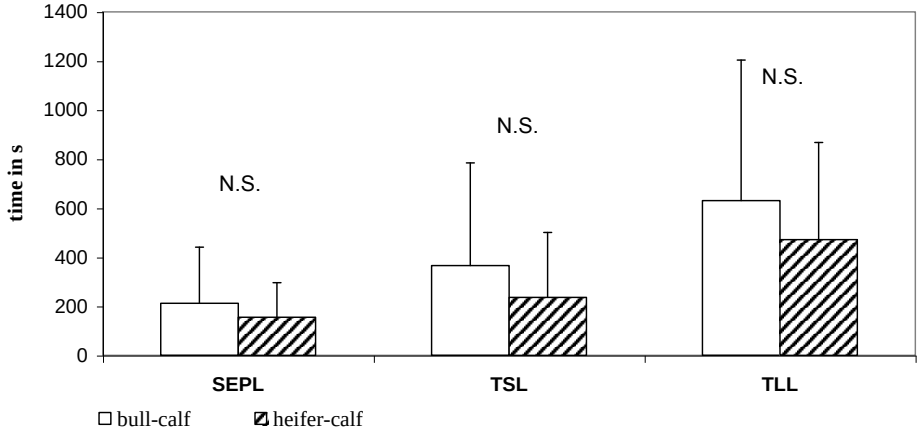
The dependent variables were ethological variables and the independent variables were factors the sex (factor S) and bull-lineage (factor B).

Significant differences among groups were tested by multiple comparisons of mean ranks. Tukey´s HSD method was used. The correlation coefficient (Pearson) was calculated.

RESULTS

At the present work, we did not find any significant differences in the majority of labyrinth activities either between genders or among bull-lineage groups. Some activity times tended to be lower in the females. Heifer-calves

spent less time standing at the labyrinth entrance part than the bull-calves (155.0±141.02 s vs. 211.87±229.16 s) at the labyrinth entrance part. Similar situation was in the total time of standing in entire labyrinth evaluation (236.0±265.23 s vs. 366.22±417.9 s). Heifer-calves took shorter time to traverse the labyrinth for all 8 runs than bull-calves (471.42±396.08 s vs. 630.43±573.41 s) (Figure 1). Bull-lineages differed significantly in the time of labyrinth leaving only. The fastest were in the labyrinth traversing calves originated from Bull2 (397.13±482.04 s). Calves descended from Bull1 and Bull3 (722.58±372.01 s, 624.08±617.36 s) crossed the labyrinth the slowest (P<0.001; 1:2**) (Figure 2).



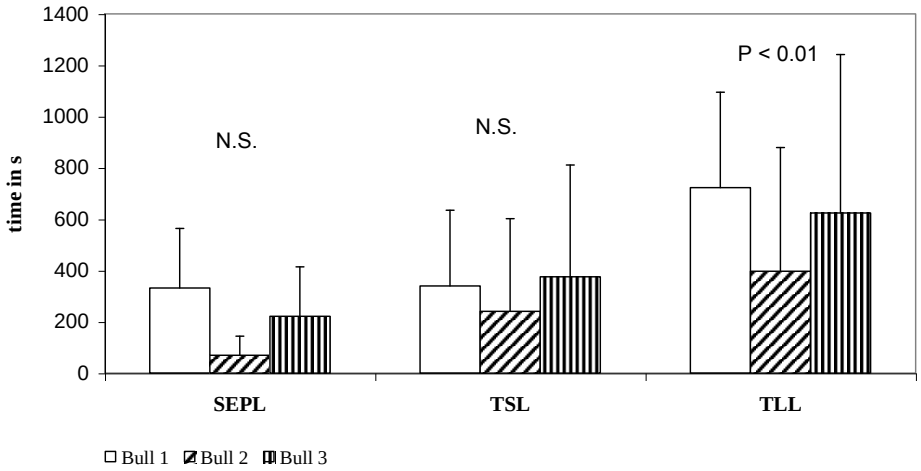
SEPL – standing in the enter part of labyrinth for both days; TSL – total standing in the labyrinth for both days; TLL – total leaving of labyrinth for both days
N.S. - non significant

Figure 1. Behaviour in the labyrinth according to sex factor

We did not found significant differences in ambulation behavior. Neither sexes nor bull-lineages differed during observations. Heifer-calves tended to be slightly quicker than bull-calves during both observations at 124th and 168th days of age. However, the number of transgressed quadrants was not differed during four novel arena tests at the age of 124 days (71.217±20.03 vs. 81.59±35.61) nor at the age of 168 days (86.09±25.66 vs. 90.23±23.41).

The repeatability of ambulation behaviour between ages of 124 and 168 days was proved by significant correlations of number of transgressed quadrants during the 1st minute of the 1st test (r=0.3177*) and during 5 minutes of the 1st test (r=0.2895*).

Bull-lineage had no significant effect on the movement in open-field arena. The highest number of transgressed quadrants during the both days was recorded in calves according to Bull2 (B1 73.08±14.41; B2 81.75±38.04, B3 70.0±21.56) at the age of 124 days, and also at the age of 168 days (B1 77.91±14.11; B2 92.00±25.39; B3 92.25±29.87). The ambulating time in the novel arena was between bull-lineage at the age of 124 days only slightly



SEPL – standing in the enter part of labyrinth for both days; TSL – total standing in the labyrinth for both days; TLL – total leaving of labyrinth for both days
N.S. - non significant

Figure 2. Behaviour in the labyrinth according to bull lineage

different (B1 156.33±27.77; B2 153.81±66.17; B3 146.25±36.58). At the age of 168 days were the speediest calves originated after Bull3 (B1 133.83±27.15; B2 157.38±51.70; B3 167.67±29.81; P≥0.05).

Similarly, we did not find any significant differences in social behaviour. The win duel number (in percentage) tended to be higher in heifer-calves (50.39 ± 29.89% vs. 44.49 ± 33.61%). In addition, the most successful, but not significantly, in this indicator were calves after Bull3 (47.35 ± 34.56%; 40.25 ± 27.29%; 55.63 ± 35.11%). Their social dominance index tended to increase on the first day of evaluation (0.49 ± 0.38, 0.39 ±0.27, 0.54 ± 0.37), too.

DISCUSSION

Developmental behavioural changes of adult cattle have not yet been thoroughly documented in dependence on the way of rearing at early age. Behaviour is partly genetically, and partly environmentally, determined. Our

research would provide data to help explain it. At the present work was showed that calves behaviour could differed according to bull-lineage factor. In the case of sex factor effect, we recorded only tendencies, no significant differences. Heifer-calves were speedier in the labyrinth traversing, and they walked and run more during both observations in novel arena.

Learning in the labyrinth can affect an animal's emotional behaviour also, but the influences of early learning on behaviour can occur in adulthood as well as in early life (Kilgour, 1987; Kukacka et al., 2002; Broucek et al., 2002). Veissier and Le Neindre (1989) concluded that soon after weaning as opposed to later on, spontaneous fear reactions are more overt and less physiological in nature and that learning is improved. Learning plays a role in other behaviours such as ingestive or exploration behaviour as the animal learns to discriminate between different aspects of its environment that are beneficial and those that are detrimental (Friend and Polan, 1974; Soch et al., 1999; Novak et al., 2000).

An early experience is for emotional reactions and calves preferences important (Fraser and Broom, 1997; Citek and Soch, 1994). Animals may be excessively fearful, cautious, or aggressive as a function of prenatal stress or maternal deprivation (Canali et al., 1986; Jones, 1997).

Novel space exploration familiarize the calves with key features of their surroundings; fear responses, such as innate orienting and startle responses, help the animal orientate itself towards changes in its environment and flee from danger. It all help the animal develop an understanding of its environment for future reference (Kondo et al., 1989; Corcum et al., 1994; Kosvanec et al., 1998; Soch et al., 1998). The lower level of ambulating behaviour at both ages may reflect a hider strategy in the responses of bull-calves to novel environments. However, the similarity in novel arena reactions between males and females at 124 and 168 days of age in the present experiment is not consistent with sex factor hypothesis, suggesting that there may be a sex influence on fear responses (Veissier et al., 1998; Broucek et al., 2008; Micinski et al., 2010).

The differences on behavioural tests were recorded at the factor of bull lineage, too. Especially, calves descended after Bull2 were the fastest in the labyrinth traversing. Positive correlation across ages suggested that repeatability of locomotor behaviour in the open-field test exists also 44 days later.

The ability of an animal to change its behaviour to cope better with environmental circumstances is due to learning. Genetic differences can affect the learning ability of different strains within a species (Veissier et al. (1998). Dairy cattle must learn to cope with environments vastly different from the habitats to which their ancestors were adapted. Hard floors, pen partitions, unwonted bedding, loud noises, overcrowding, heat, glaring or dimmed light,

unknown food are just a few of the unnatural environmental conditions imposed by domestication (Arave et al., 1992; Soch, 2005). The farm animals can probably be preconditioned to stressful situations. If such preconditioning to psychological stresses is to be economically achieved, farm animals must have the abilities to learn, adapt, and remember (Arave, 1996).

The heifer-calves tended be also successful in eating competition during access to limited amounts of feed. Results of regard social behaviour were not statistically different. It is very difficult to explain this phenomenon. It would be probably influence of different housing during rearing in group pen. However, both female and male used calves were kept in the same system during our experiment. Therefore, decreasing of social contacts by long stay in stabile environment may be a reason. Other argument, predictable feeding schedule not have to be very important for dairy cattle (Shipka and Arave, 1995; Uhrincat et al., 2007). However, when the calves are habitual to predictable feeding times, occasional deviations from that schedule may cause frustration when their expectations are not fulfilled (Johannesson and Ladewig, 2000).

Under modern, intensive husbandry, cattle are usually kept in groups of the similar age, both sexes together to the age of 6 months. The behaviour of herds with a natural sex ratio and age distribution has been little studied (Hall, 2002). Further, since animals of similar age and size are normally grouped together, it has been suggested that the negative effects of resource competition may be distributed across the group, and therefore difficult to detect of competitive behaviour differences. According to Reinhardt et al. (1978), older males have many more interactions with the other male calves, than do the female calves. Genetic influences on dominance have been demonstrated in several studies (Arave and Albright, 1976; Mench et al., 1990; Keyserlingk von et al., 2008). The results suggest that these sex-related differences in behaviour are apparent as early as 6 months of age.

The question of gender differences in temperament is arguably one of the most fundamental questions in gender differences research in the areas of personality and social behaviour (Grandin and Deesing, 1998). Temperament reflects biologically based emotional and behavioural consistencies that appear early in life and predict— often in conjunction with other factors— patterns and outcomes in numerous other domains such as psychopathology and personality (Hall, 2002). Generally, sexes may differ in the sensitivity of developing brain areas to stress hormones (Weinstock, 2007).

CONCLUSIONS

In conclusion the experiment indicates that calves labyrinth behavior is affected by the bull lineage factor. There is much scope for further investigation into the impacts of environment on the development of fear, exploratory and to better understand the learning ability, which are considered essential to welfare of dairy calves.

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REFERENCES

Arave, C.W., Albright, J.L., 1976. Social rank and physiological traits of dairy cows as influenced by changing group membership. J Dairy Sci. 59, 974-981.

Arave, C.W., Albright, J.L., Armstrong, D.V., 1992. Effects of isolation of calves on growth, behavior, and first lactation milk yield of Holstein cows. J Dairy Sci. 75, 3408-3415.

Arave, C.W., 1996. Assessing sensory capacity of animals using operant technology J. Anim. Sci., 74, 1996-2009.

Bouissou, M.F., 1980. Social relationships in domestic cattle under modern management techniques. Bull Zool. 47, 343-353.

Bouissou, M.F., Boissy, A., Le Neindre, P., Veissier, I., 2001.The Social Behaviour of Cattle, 113-145. In: Social Behaviour in Farm Animals. Edited by L. J. Keeling and H. W. Gonyou. Wallingford, Oxon, CABI Publishing, 406 p.

Boissy, A., Le Neindre, P., 1990. Social influences on the reactivity of heifers: Implications for learning abilities in operant conditioning. Appl Anim Behav Sci. 25, 149-165.

Boissy, A., Bouissou, M.F., 1995. Assessment of individual differences in behavioural reactions of heifers exposed to various fear-eliciting situations. Appl Anim Behav Sci. 46, 17-31.

Broucek, J., Uhrincat, M., Friend, T.H., Arave, C.W., 2000. Effect of rearing method of calves prior to weaning on subsequent open-field behavior at 28 week of Age. J Anim Sci. 78, Suppl. 1/J.Dairy Sci. 83, Suppl. 1, 35.

Broucek, J., Uhrincat, M., Arave, C.W., Friend, T.H., 2002. Effect of rearing methods of heifers during milk replacement period on their postweaning behavior in the maze. Acta Vet Brno. 71, 509-516.

Broucek, J., Kisac, P., Uhrincat, M., 2003. The effect of sire line on learning and locomotor behaviour of heifers. Czech J Anim Sci. 48, 387-394.

Broucek, J., Uhrincat, M., Soch, M., Kisac, P., 2008. Genetics of behaviour in cattle. Slovak Journal of Animal Science. 41, 166-172.

Broucek, J., Uhrincat, M., Hanus, A., 2011. Maintenance and competitive behaviour study in dairy calves. Slovak Journal of Animal Science. 44, 28-33.

Canali, E., Verga, M., Montagna, M., Baldi, A., 1986. Social interactions and induced behavioural reactions in milk-fed female calves. Appl Anim Behav Sci. 16, 207-215.

Citek, J., Soch, M. Zaklady odchovu telat; Institut vychovy a vzdelavani Ministerstva zemedelstvi CR v Praze, 1994, 34 p.

Corkum, M.J., Bate, L.A., Tennessen, T., 1994. Consequences of reduction of number of individual feeders on feeding behaviour and stress level of feedlot steers. Appl Anim Behav Sci. 41, 27-35.

Creel, S.R., Albright, J.L., 1988. The effects of neonatal social isolation on the behavior and endocrine function of Holstein calves. Appl Anim Behav Sci. 21, 293-306.

Fraser, A.F., Broom, D.M., 1997. Farm animal behaviour and welfare. CAB International, 437 p.

Friend, T.H., Polan, C.E., 1974. Social rank, feeding behavior, and free stall utilization by dairy cattle. J Dairy Sci. 57, 1214-1220.

Friend, T.H., Polan, C.E., 1978. Competitive order as a measure of social dominance in dairy cattle. Appl Anim Ethol. 4, 61-70.

Gonyou, H.W., 1994. Why the study of animal behavior is associated with the animal welfare issue. J Anim Sci. 72, 2171-2177.

Grandin T., Deesing M.J., 1998. Genetics and behavior during handling, restraint, and herding. In: T. Grandin (ed.), Genetics and the Behavior of Domestic Animals. Academic Press, Chapter 4, 113-144.

Hall S.J.G., 2002. Behaviour of cattle. In: P. Jensen (ed.), The Ethology of Domestic Animals: an Introductory Text. CAB International, 131-143.

Johannesson, T., Ladewig, J., 2000. The effect of irregular feeding times on the behaviour and growth of dairy calves. Appl Anim Behav Sci. 69, 103-111.

Jones, R.B., 1997. Fear and distress. In: Appleby, M.C., Hughes, B.O.: Animal welfare. CAB International, 198 Madison Ave., New York, NY 100016, USA, pp. 75-87.

Keyserlingk von, M.A.G., Olenick, D., Weary, D.M., 2008. Acute Behavioral Effects of Regrouping Dairy Cows. J Dairy Sci. 91, 1011-1016.

Kilgour, R., 1987. Learning and the training of farm animals. Veter Clinics of North America: Food Anim Practice. 3, 269-283.

Kilgour, R., Foster, T.M., Temple, W., Matthews, L.R., Bremner, K.J., 1991. Operant technology applied to solving farm animal problems. An assessment. Appl Anim Behav Sci. 30, 141-166.

Kondo, S., Sekine, J., Okubo, M., Asahida, Y., 1989. The effect of group size and space allowance on the agonistic and spacing behavior of cattle. Appl Anim Behav Sci. 24, 127-135.

Kosvanec, K., Rehout, V., Dvorak, J., Citek, J., Soch, M., Hajic, F., Kucerova, O., 1998. The program and results of breeding of gene resource of Bohemian Red Cattle Breeds. Czech J Anim Sci. 43, 9–10.

Kukacka, V., Soch, M., Marsalek, M., 2002. Reaction abilities of riders. Collection of Scientific Papers, Fakulty of Agriculture in Ceske Budejovice, Series for Animal Science, 19, 147-151.

Marsalek, M., Sedlackova, M., Secka, M., 2005. The influence of the age, sex and performance level of horses on their success in the show jumping competition. Journal of Central Evropean Agriculture. 6, 547-554.

Marsalek, M., Zednikova, J., Pesta, V., Kubesova, M., 2008. Holstein cattle reproduction in relation on milk yield and body condition score. Journal of Central Evropean Agriculture. 9, 624–628.

Mench, J.A., Swanson, J.C., Stricklin, W.R., 1990. Social stress and dominance among group members after mixing beef cows. Can J Anim Sci. 70, 345-354.

Micinski, J., Zwierchowski, G., Baranski, W., Golebiowska, M., Marsalek, M., 2010. Locomotor activity and daily milk yield of dairy cows during the perioestrous period in successive lactations. J Agrobiol. 27, 111-119.

Novak, P., Zabloudil, F., Soch, M., Venglovsky, J., 2000. Stable environment significant factor for the welfare and productivity of cows. Proceedings of the Xth International Congress on Animal Hygiene, Maastricht, 2-6 July 2000, Netherlands, Vol. 2, 1019-1024.

Reinhardt, V., Mutiso, F. M., Reinhardt, A., 1978. Social behavior and social relationships between female and male prepubertal bovine calves (Bos indicus). Appl Anim Ethol. 4, 43-54.

Sambraus, H.H., Osterkorn, K., 1974. The social stability in a herd of cattle. Z. Tierpsychol. 35, 418-424.

Shipka, M.P., Arave, C.W., 1995. Influence of extended manager lock-up on cow behavior and production factors in dairy cattle management. Proceedings of the Western Section of the American Society of Animal Science. 46, 84-87.

Soch, M., Kolarova, P., Rehout, V., Kosvanec, K., Hajic, F., Citek, J., 1997. Effect of dairy cows moving from tie-stall to loose housing system on their production and behaviour. Sbornik ZF JU Ceske Budejovice - zootechnicka rada, 14, 77-86.

Soch, M.; Kosvanec, K.; Rehout, V. Kadlec, J.; Novotny, D., 1998. Comparison of meat performance characteristics of bulls - crossbreeds F1 generation of Bohemian Red Cattle Breed x Bohemian Spotted Cattle Breed and bulls Bohemian Spotted Cattle Breed. Sbornik ZF JU Ceske Budejovice - zootechnicka rada. 15, 47-56.

Soch, M., Vrablikova, J., Travnicek, J., Matouskova, E., 1999. Welfare of farming animals. In: Ekologicke formy hospodarení v krajine; Acta Univer. Purkynianae, FZP UJEP Usti n. Labem, Czech Republic, pp. 106 - 111.

Soch, M. 2005. Effect of environment on selected indices of cattle welfare. University of South Bohemia, Ceske Budejovice, Czech Republic, 288 p.

Uhrincat, M., Tancin, V., Kisac, P., Hanus, A., Broucek, J. 2007. The effect of growth intensity of heifers till 15 months of age on their milk production during first lactation. Slovak Journal of Animal Science. 40, 83-88.

Veissier, I., Le Neindre, P., 1989. Weaning in calves: Its effects on social organization. Appl Anim Behav Sci. 24, 43-54.

Veissier, I., 1993. Observational learning in cattle. Appl Anim Behav Sci. 35, 235-243.

Veissier, I., Boissy, A., Nowak, R., Orgeur, P., Poindron, P., 1998. Ontogeny of social awareness in domestic herbivores. Appl Anim Behav Sci, 57, 233-245.

Voriskova, J., Marsalek, M., Slachta, M., Zednikova, J., Kobes, M., Kynkalova, P., 2010. Rearing beef cattle in submountainous and mountainous area of the Šumava region. Journal of Central European Agriculture. 11, 359-372.

Warnick, V.D., Arave, C.W., Mickelsen, C.H., 1977. Effects of group, individual and isolated rearing of calves on weight gain and behavior. J Dairy Sci. 60, 947-953.

Weinstock, M., 2007. Gender differences in the effects of prenatal stress on brain development and behaviour. Neurochem Res 32,1730–1740.