EFFECTS OF GENDER AND SIRE LINE ON DAIRY CATTLE BEHAVIOUR IN DIFFERENT ENVIRONMENT

Jan Broucek[1]*, Michal Uhrincat[1], Miloslav Soch[2], Anton Hanus[1], Peter Tongel[1]
[1]*Animal Production Research Centre Nitra, Slovak Republic*
[2]*University of South Bohemia in Ceske Budejovice, Czech Republic*

Corresponding author: Assoc. Prof. Eng. Jan Broucek, DrSc.
Animal Production Research Centre Nitra, Hlohovská 2, 951 41 Lužianky, Slovak Republic
Phone: + 421 37 654 6280; Fax: + 421 37 654 6483; E-mail: broucek@cvzv.sk

Abstract. The purpose of this study was to investigate the effects of gender, and sire on behaviour of dairy cattle. The study included 40 animals (23 males and 17 females) which descended from 3 sires. An open-field test was applied to animals aged 12 months kept in a 10 x 10 m arena marked off into 9 squares. A manger was placed in square 8. The animals were exposed to isolation and silence on the first day, and to an unfamiliar person sitting in square 4 on the second day. On the first day of observation, heifers were more mobile than hogs. The number of grid crossings during the first 5 minutes of the 1st run on the first day and the movement time on the second day ($P<0.05$) were statistically different for different sire lineage groups. In terms of human presence, a significant difference between genders was recorded in the time of staying at the 4th square border and frequency of staying in square 4 ($P<0.05$). The genotype significantly influenced the vocalization ($P<0.001$). The results of used behavioural tests indicated that locomotor behaviour and relationship to humans are affected by the gender and sire lineage of cattle.

Keywords: cattle, behaviour, relation to human, gender, sire.

LYTIES IR PROTĖVIŲ ĮTAKA GALVIJŲ ELGSENAI SKIRTINGOMIS LAIKYMO SĄLYGOMIS

Jan Broucek[1]*, Michal Uhrincat[1], Miloslav Soch[2], Anton Hanus[1], Peter Tongel[1]
[1]*Gyvulininkystės mokslų centras, 92-949 Nitra, Hlohovská 2, Slovakijos Respublika*
[2]*Pietų Bohemijos universitetas, CZ - 370 05 Česke Budejovicai, Branisovská 31, Čekijos Respublika*

Santrauka. Tyrimo tikslas – nustatyti lyties ir protėvių įtaką galvijų elgsenai skirtingomis laikymo sąlygomis. Bandymo metu tirta trijų skirtingų protėvių 40 galvijų (23 buliukų ir 17 telyčių). 12 mėn. gyvuliai buvo laikomi palaidi devyniuose atviruose atskiruose garduose, kurių bendras plotas 10x10 m. Ėdžios pastatytos aštuntame garde. Izoliuoti tyloje gyvuliai buvo laikomi pirmą bandymo dieną. Antrą bandymo dieną ketvirtajame garde buvo lokalizuotas pašalinis asmuo. Pirmą stebėjimo dieną telyčios judėjo aktyviau už buliukus. Skirtingų protėvių galvijų judėjimas pirmąją ir antrąją bandymo dieną buvo statistiškai skirtingas ($p<0,05$). Galvijų reakcija į pašalinį asmenį taip pat reikšmingai skyrėsi priklausomai nuo galvijų lyties ($p<0,05$). Balso reakcijai (baubimui) reikšmingą įtaką darė genotipas ($p<0,001$). Tyrimų rezultatai patvirtino ankstesnius duomenis apie tai, kad lytis ir protėviai daro įtaką galvijų elgsenai ir reakcijai į pašalinius asmenis skirtingomis laikymo sąlygomis.

Raktažodžiai: galvijas, elgsena, ryšys su žmogumi, gimine, reproduktoriumi.

Introduction. In the European Union, there is an increasing public concern about animal welfare from the social, political, ethical and scientific viewpoint. In these countries a number of consumers is influenced by ethical concerns rather than cost with high interests in farming and the associated animal welfare standards (Soch, 2005). They demand high quality livestock products obtained by methods where animal welfare is also considered. Welfare includes many aspects (Soch, 2005). In the last decades, farm animal breeding has improved. The implementation of new technologies into cattle husbandry has resulted in high increases of efficiency (Kulpys et al., 2010). Unfortunately, intensive animal husbandry systems may be associated with poor animal welfare. Many animals used as replacements for dairy herds are kept in inconvenient housing conditions (Soch et al., 1997; Voriskova et al., 2010; Kartal et al., 2011).

The open-field test is often used for evaluation of adaptation of isolated animal to a new environment (Boivin et al., 1992; Passilé de et al., 1995; Kukacka et al., 2002). Responses in an open-field test can be diverse involving: freezing when scared, locomotor activity, excretion, and vocalization and escape attempts (Canali et al., 1986; Sisto and Friend, 2001; Jensen et al., 2004; Marsalek et al., 2005; Micinski et al., 2010).

The general public, farmers and governmental officers are concerned about the welfare of animals controlled by people. There is an interest in the influence of human–animal interactions during transportation of animals. In this context, some authors reported that gentling and repeated tactile, visual and auditory contact with a human makes animals easier to handle and reduce fear response

of cattle in relation to an approaching human (Goddard et al., 2000; Boivin et al., 2009).

Little information is available on the effect of gender and sire lineage on behaviour in an unknown environment (Kilgour, 1998; Kosvanec et al., 1998; Soch et al., 1998; Broucek et al., 2008). Some authors indicated that there are differences between genotypes in the cattle locomotor behaviour and approachability and reactivity towards humans (Broucek et al., 2003; Hemsworth et al., 2009; Broucek et al., 2011b). A number of reports have suggested that the farm environment and management could influence the behaviour of animals in a variety of ways, including their responses to potentially stressful situations (Dellmeier et al., 1990; Goddard et al., 2000).

The aim of this study was to test hypotheses that the locomotor behaviour in open-field tests and relation to human are impacted by the gender and sire lineage of cattle.

Materials and methods. We assessed 40 Holstein cattle (23 males and 17 females) descended from 3 bulls (Sire 1, n=12; Sire 2, n=16; Sire 3, n=12). The distribution of males/females within sires was following: Sire 1 (6 + 6), Sire 2 (12 + 4), Sire 3 (5 + 7). The animals were kept in pens of loose housing. The experiment and all tests were performed under the same conditions at the experimental farm of the institute.

The open field test was carried out in the ethological laboratory at the age and live body weight of 354.74 ± 39.03 days and 329.60 ± 33.45 kg. The facility comprised a small barn section for 10 animals, a laboratory and open field arena. The arena is a room of 10x10 m, where a door and an observation window are the only openings. The concrete floor is divided by white lines into 9 equal squares. By the wall opposite the observation window (square 8) there was a feeder into which 0.5 kg of granulated concentrated mixture for each animal was put before testing. Each animal was subjected to four 10 min runs on 2 consecutive days. The data of locomotor behaviour were scored during each minute from 10 min test: number of grid crossings (whenever the animal crossed the square with front feet over a line), movement time (the start and end of any movement were recorded, time of movement was calculated).

After testing of each animal, the arena was carefully cleaned by flushing with water. The animals were exposed to isolation and silence in the first two tests, and to an unfamiliar person sitting on square 4 (by the wall on the right side) in the third and fourth tests. This person was not initiating any contact with animal. During the open field test, the duration and frequency of contacts with the person was recorded. The behaviour was analysed, either directly from a monitor screen (using a portable computer) or from a video tape afterwards, using a stop watch.

The data were analyzed using by the statistical package STATISTIX, Version 9.0 (Anonymous, 2009). The normality of data distribution was evaluated by the Wilk-Shapiro/Rankin Plot procedure. All data conformed to a normal distribution. Among-group comparisons of the behaviour 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 by model equation

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

The dependent variables were ethological variables and the independed variables were factors the gender and sire lineage.

Significant differences among groups (gender, sire lineage) were tested by multiple comparisons of mean ranks.Tukey´s HSD method was used. Significant differences between groups were tested by Comparisons of Mean Ranks. Values are expressed as means ± SE.

Results. No significant differences were found between male and female gender in locomotor behaviour. On the first day of observation, heifers were more mobile than bulls (Table 1). The numbe rof grid crossing significantly differed among sire lineages during the first 5 minutes of the 1st run on the first day (23.83±3.09; 36.44±2.68; 32.07±3.01; $P<0.05$). We also found a significant difference in movement time on the second day (58.50±5.26 s; 64.29±4.55 s; 78.36±5.54 s; $P<0.05$). The shortest movement time on both days was observed in animals descended from Sire 1 (Table 2).

Table 1. **Locomotor behaviour during open-field tests according to gender on both days** (mean ± SE)

Grid crossing (number)	Gender		P
	Male	Female	
1st min, 1st run	8.85±0.71	10.29±0.83	ns
5 min, 1st run	27.47±2.23	34.22±2.60	ns
1st day	47.21±3.96	53.89±4.61	ns
2nd day	37.45±2.31	36.91±2.68	ns
Movement time (s)			
1st run, 1st day	46.09±3.35	54.90±3.89	ns
1st day	83.30±6.04	88.12±7.03	ns
2nd day	71.21±3.80	62.89±4.42	ns

Male, N = 23; Female, N = 17; ns, not significant.

Table 2. **Locomotor behaviour during open-field tests according to sire lineage on both days** (mean ± SE)

Grid crossing (number)	Sire			P	
	1	2	3		
1st min, 1st run	7.83±0.98	11.17±0.85	9.71±0.91	ns	
5 min, 1st run	23.83±3.09	36.44±2.68	32.27±3.01	0.0163*	
1st day	42.00±5.49	56.79±4.75	52.86±5.09	ns	
2nd day	35.92±3.19	36.74±2.77	38.88±3.49	ns	
Movement time (s)					
1st run, 1st day	41.17±4.63	55.39±4.01	54.93±4.60	ns	
1st day	75.33±8.37	92.21±7.24	89.60±8.31	ns	
2nd day	58.50±5.26	64.29±4.55	78.36±5.56	0.0336*	1:3*

Sire 1, N = 12; Sire 2, N = 16; Sire 3, N = 12; ns, not significant

Table 3. **Activities in relation to a human according to gender on the second day** (mean ± SE)

Time of staying in 4th square (s)	Gender		P
	Male	Female	
1st run	20.01±5.09	34.79±5.72	ns
2nd run	13.27±4.96	19.83±5.58	ns
Time of staying on 4th square border (s)			
1st run	5.32±1.21	9.17±1.36	0.0452*
2nd run	3.48±1.27	2.85±1.42	ns
Mooing number			
1st run	17.15±2.07	13.57±2.33	ns
2nd run	22.71±2.28	17.78±2.57	ns

Male, N = 23; Female, N = 17; ns, not significant.

Table 4. **Activities in relation to a human according to sire lineage on the second day** (mean ± SE)

Time of staying in 4th square (s)	Sire			P	
	1	2	3		
1st run	21.00±6.73	28.69±6.15	32.52±6.77	ns	
2nd run	11.16±6.57	18.70±6.00	19.78±6.60	ns	
Time of staying on 4th square border (s)					
1st run	8.25±1.60	4.90±1.46	8.59±1.61	ns	
2nd run	5.75±1.67	0.78±1.53	2.97±1.68	ns	
Mooing number					
1st run	17.33±2.74	19.29±2.51	9.46±2.76	0.0358*	2:3*
2nd run	21.08±3.03	29.08±2.76	10.58±3.04	0.0004***	2:3***

Sire 1, N = 12; Sire 2, N = 16; Sire 3, N = 12; ns, not significant.

Table 5. **Activities in relation to human behaviour according to gender on the second day** (mean ± SE)

Frequency of staying in 4th square (s)	Gender		P
	Male	Female	
1st run	2.44±0.76	5.19±0.85	0.0242*
2nd run	1.23±0.43	2.54±0.48	ns
Frequency of staying on 4th square border (s)			
1st run	0.75±0.16	1.19±0.18	ns
2nd run	0.22±0.09	0.47±0.19	ns

Male, N = 23; Female, N = 17; ns, not significant.

No significant differences were recorded in the time and frequency of staying in square No. 8 (where manger was placed), or in frequency of concentrate eating and sniffing. During all tests, heifers spent less time on feeding on the concentrate.

There were no differences among sex groups in the time of staying in square 4 where an unfamiliar person was sitting, but slightly higher values were recorded in heifers. Significant difference was recorded at the first run in the time of staying on the 4th square border in gender comparison (5.32±1.21 s vs. 9.17±1.36 s; P<0.05). Contact behaviour, measured by the frequency and length of sniffing of the person was not different. Vocalization was better pronounced in bulls (Table 3).

Times of staying in square 4 and stay on the 4th square border were not differed amoung sire lineage groups. The genotype only significantly influenced the number of mooings. Cattle originated from Sire 2 vocalized most during both 10 minutes runs (17.33±2.74, 19.29±2.51, 9.46±2.76, P<0.05; 21.08±3.03, 29.08±2.76, 10.58±3.04, P<0.001)(Table 4).

Frequencies of staying on the 4th square border were not significant nor at one`s observed factor, frequency of staying in square 4 during the 1st run in gender comparison only (2.44±0.76 vs. 5.19±0.85; P<0.05) (Tables 5 and 6).

Table 6. **Activities in relation to human behaviour according to sire lineage on the second day** (mean ± SE)

Frequency of staying in 4th square (s)	Sire			P
	1	2	3	
1st run	2.00±1.01	4.18±0.92	5.27±1.01	ns
2nd run	1.66±0.57	2.01±0.52	1.97±0.57	ns
Frequency of staying on 4th square border (s)				
1st run	0.75±0.21	1.11±0.19	1.05±0.21	ns
2nd run	0.50±0.26	0.19±0.11	0.33±0.14	ns

Sire 1, N = 12; Sire 2, N = 16; Sire 3, N = 12; ns, not significant.

Discussion. The specific aim of this study was to test hypotesis that behaviour of dairy cattle is determined by the gender and origin after father. Age, lactation stage, experience, sex, breed and handling are the major factors that influenced the temperament and its relationship to an environment adjustment of animals in farming systems (Soch et al., 1999; Soch, 2005; Antanaitis et al., 2010).

In the present study, it was determined that heifers moved more actively in the open-field arena. Similar results were obtained by Broucek et al. (2011b) observing the same animals at a younger age. This may be due either to an effect of age, a response to habituation or both. Also Hafez (1975), Kilgour (1998), and Goddard et al. (2000) reported that behaviour of ruminants differed according to gender**.**

Some studies have reported a significant gender effect on temperament traits (Hafez, 1975; Broucek et al., 2008). Females are always more excitable or difficult to handle; heifers had higher temperament scores than their steers, who were more docile than heifers (Grandin and Deesing, 1998).

In our previous work we pointed out that ambulant behaviour was influenced by genotype (Broucek et al., 2011b). The sire lineage influences a large part of the population so its genetic qualities are effective as a stabilization factor (Marsalek et al., 2008; Jukna et al., 2010). The sire is effective in the herd during a relatively short period, so the complex of factors to which its offspring are exposed during rearing should not be of such variability (Hall, 2002; Broucek et al., 2008).

The entire genetical adaptability of the population can be important (Soch et al., 1998; Broucek et al., 2011a). Kovalcik et al. (1988) compared the behaviour of mothers and their daughters in open-field tests and they found that the total time of motion was significantly longer in mothers; younger daughters had higher locomotor activity than older ones. Significant differences were found in the evaluation of four genetic sire lines (Kovalcikova et al., 1988). The open-field behaviour resulted from two factors: their level of general activity and their disturbance in response to novelty (Passilé de et al., 1995).

Changes in agricultural policy and financial support to agriculture in the European Union are resulting in an intensification of animal husbandry systems with a reduction in the amount of interaction between animals and humans. However, it is an advantage for farmers trying to save their working time (Goddard et al., 2000; Boivin et al., 2009). It is generally accepted that the behaviour of cattle and their owners is closely related (Rushen et al., 2001).

In the present work, the reaction to unfamiliar person was studied. Heifers spent more time near an unfamiliar person then bulls. The differences between bulls and heifers most probably are a reflection of the temperament of the animals. It would mean that the movement of the animals in the arena reflected their agitation when placed in a threatening environment (Kilgour, 1998). This movement should be considered for investigatory behaviour. The presence of unfamiliar person as an object of curiosity is transmitted to the animal through visual pathway (Hafez, 1975). When the object is reached,

sniffing or licking follows.

In the presence of humans, bulls mooed more than heifers. They were probably more nervous. Grandin and Deesing (1998) suggest that intense selection for productivity traits has resulted in nervous and aggressive animals that are difficult to handle. Vocalising occurs in conditions when social partners are separated. It is just the case of the open field arena. Vocalizations reflect a social search or social separation. Although the environment was not totally unknown to our animals, they were ethologically tested in small open-field arena at an age of 16 and 25 weeks (Broucek et al., 2011b); human presence was the new factor. It is however interesting to note that the bulls produced more numerous vocalizations.

Genotype had a significant effect on the comunication behaviour expressed by the vocalization. The groups of different sires can react differently. It can indicate that there may be differences in their capacity for adaptation. Cattle sired by various fathers develop differently in their patterns of motor activity as measured by total number of squares crossed and numbers of central and peripheral squares (Canali et al., 1986).

However, while it is clear that genetic differences lie at the basis of the variance between animals in tameness, the mechanisms of these genetic divergences have not been investigated in detail. Despite the distinct effects of genetics on animals' fear of people, there is much evidence that the responses of farm animals to people are affected by their experience, especially the way they are handled (Hemsworth et al., 2009).

Some cattle can be neophobic, and the appearance of unfamiliar people may develop orienting responses and fear (Hemsworth and Coleman, 1998). In this study, habituation of these responses occurred during the last run when the animals were for the second time exposed to people.

Conclusion. The results of used behavioural tests indicated that locomotor behaviour and relationship to humans are affected by the gender and sire lineage of cattle. Further work needs to be conducted on the differences among genotypes in human–animal interactions.

Acknowledgement. This work was supported by the Slovak Research and Development Agency under the contract No. APVV-0632-10.

References

1. Anonymous. STATISTIX 9 for Windows. User's Manual. Analytical Software, Tallahasee, FL, USA. ISBN 978-1-881789-07-9. 2009. 454 p.

2. Antanaitis R., Žilaitis V., Juozaitienė V., Žiogas V. Impact of health status of cows, season and stages of lactacion on daily walking activity, milk yields, conductivity and body weight, Veterinarija ir Zootechnika. 2010. T. 49 (71). P. 3–7.

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

4. Boivin X., Gilard F., Egal D. The effect of early human contact and the separation method from the dam on responses of beef calves to humans, Appl. Anim. Behav. Sci. 2009. 120. P. 132–139.

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

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

7. Broucek J., Uhrincat M., Hanus A. Maintenance and competitive behaviour study in dairy calves, Slovak J. Anim. Sci. 2011a. 44. P. 28–33.

8. Broucek J., Uhrincat M., Hanus A. Learning and locomotor behaviour study of dairy calves kept in group housing, Slovak J. Anim. Sci. 2011b. 44. P. 72–77.

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

10. Dellmeier G., Friend T. H., Gbur E .E. Effects of changing housing on open-field behaviour of calves, Appl. Anim. Behav. Sci. 1990. 26. P. 215–230.

11. Goddard P. J., Fawcett A. R., MacDonald A. J., Reid H. W. The behavioural, physiological and immunological responses of lambs from two rearing systems and two genotypes to exposure to humans, Appl. Anim. Behav. Sci. 2000. 66. P. 305–321.

12. Grandin T., Deesing M. J. Genetics and behaviour during handling, restraint, and herding. In: T. Grandin (ed.) Genetics and the Behaviour of Domestic Animals. Academic Press. 1998. Chapter 4, P. 113–144.

13. Hafez E. S. E. The behaviour of domestic animals. In: E.S.E. Hafez (ed.) Bailiere Tindall, London. 1975. 544 p.

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

15. Hemsworth P. H., Coleman G. J. Human-Livestock Interactions. The Stockperson and the Productivity and Welfare of Intensively-farmed Animals. CAB International. Wallingford, Oxon, UK. 1998. 152 p.

16. Hemsworth, P. H., Barnett, J. L., Coleman, G. J. The integration of human-animal relations into animal welfare monitoring, Animal Welfare. 2009. 18. P. 335–345.

17. Jensen M. B., Tuomisto L., Pedersen L. J. Locomotor behaviour in dairy calves, the use of demand functions to assess the effect of deprivation, Appl. Anim. Behav. Sci. 2004. 86. P. 3–14.

18. Jukna C., Jukna V., Korsukovas A., Pečiulaitienė N. The influence of beef breeds bulls on Lithuanian black-and-white cattle production and quality, Veterinarija ir Zootechnika. 2010. T. 49 (71). P. 50-54.

19. Kartal T. Z., Yanar M. Effect of floor types on the growth performance and some behavioural traits of brown swiss calves, Veterinarija ir Zootechnika. 2011. 55 (77). P. 20–24.

20. Kilgour R. J. Arena behaviour is a possible selection criterion for lamb-rearing ability; it can be measured in young rams and ewes, Appl. Anim. Behav. Sci. 1998. 57. P. 81–89.

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

22. Kovalcikova M., Kovalcik K., Broucek J. The effects of the bull on the reactions and adaptibility of the daughters in behavioural tests, Zivoc. Vyr. 1988. 33. P. 201–209.

23. Kovalcik K., Kovalcikova M., Broucek J. Interbreed differences in the responses of first - calvers to artificially induced stress conditions, Sci. agric. bohemoslov. 1988. 20. P. 203–209.

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

25. Kulpys J., Januškevičius A., Černauskienė J. Investigation of a new raising technology feeding calves on milk, Veterinarija ir Zootechnika. 2010. 50 (72). P. 48–53.

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

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

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

29. Passilé de A.M., Rushen J., Martin F. Interpreting the behaviour of calves in an open-field test: a factor analysis, Appl. Anim. Behav. Sci. 1995. 45. P. 201–213.

30. Rushen J., Passillé de A. M., Munksgaard L., Tanida H. People as social factors in the world of farm animals. In: Social Behaviour in Farm Animals (L.J. Keeling and H.W. Gonyou, Eds.). CABI Publishing, NY, USA, 2001. P. 353–372.

31. Sisto A. M., Friend T. H. The effect of confinement on motivation to exercise in young dairy calves, Appl. Anim. Behav. Sci. 2001. 73. P. 83–91.

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

33. Soch M., Kosvanec K., Rehout V., Kadlec J., Novotny D. Comparison of meat performance characteristics of bulls - crossbreeds F_1 generation of Bohemian Red Cattle Breed x Bohemian Spotted Cattle Breed and bulls Bohemian Spotted Cattle Breed, Sbornik ZF JU Ceske Budejovice - zootechnicka rada. 1998. 15. P. 47–56.

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

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

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

Received 17 October 2011
Accepted 20 March 2013