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INFLUENCE OF FARMING SYSTEMS ON INDICATORS OF BEEF CALVES GROWTH

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ABSTRACT

The aim of this study was to evaluate growth ability of Charolais calves in different systems of farming. The observations were performed in period of 8 years (2007 - 2014) in one herd, which was transiting from conventional to ecological farming system. Period from 2007 to 2010 was of conventional character, 2010 to 2012 transition phase, and from 2012 to 2014 ecological phase. This transfer is directly linked to changes in cow´s welfare and nutrition. Growth ability (live weight at birth, 120, and 210 days of age, average daily gain from birth to 120, from birth to 210, and from 120 to 210 days of age) of 518 Charolais calves was measured. Statistical analyses were performed using SAS 9.3 software, GLM procedure. The model equations contend effect of sex, number of parity, month of calves birth and type of farming system. Difference in birth weight of calves between farming systems was small and insignificant. This fact may be due to breeding system focused on easy calving. Increase of values measured in different age and average daily gains were statistical significant ($P < 0.05$) between conventional and ecological farming. The increase of parameters of weight and average daily gain could be largely connected with genetic progress in Charolais population in Czech Republic and following good selection of bulls to insemination and natural breeding. Nevertheless, the transition from conventional to ecological farming system did not affected growth ability of beef cattle negatively and, in contrary, results of growth improved farm economy.

Key words: Charolais; live weight; gain; calves; breeding system

INTRODUCTION

Breeding of beef is a constantly developing sector in the Czech Republic. The basic aspects of good economic results in beef cattle herds are a good fertility of cows and an excellent growth of their progeny. The growth ability of calves are affected by many factors, such as breed of cattle (Krupa et al., 2005), sex (Stádník et al., 2008), nutrition (Mandell et al., 1997; Priolo et al., 2001), age of cows (Roffeis & Muench, 2007), parity (Toušová et al., 2014), month of birth (Dadi et al., 2002), type of beef cattle production system (Younie, 2001; Sato et al., 2005) and others. Charolais is the most favored beef cattle breed in the Czech Republic. Beef cattle are usually kept in one of two common types of production systems: conventional and ecological (Wileman et al., 2009). These systems differ in quality and quantity of fodder and feed ratio (Skládanka & Veselý, 2007), as well as in welfare of the cattle (e.g. use of some systems of conventional housing is forbidden in ecological system) (Capper, 2012). Some authors (Fernández & Woodward, 1999; Glanc et al., 2015) observed lower daily gain and final slaughter weight achived in organic farming system. Also differences in economy of organic farming are mentioned in number of studies, for example Gillespie and Nehring (2013). The aim of this study was to compare systems of farming and evaluate their effect on outputs in beef cattle herds.

MATERIALS AND METHODS

This study was performed during 8 years period (from 2007 to 2014) in one herd with Charolais cattle. During this period, the farm underwent the transition from conventional to ecological farming system. Period from 2007 to 2010 was of conventional character, transition phase took place from 2010 to 2012, followed by ecological phase from 2012 to 2014. The dataset has included 518 calves born during 8 years. Weight after birth, weight at 120 days of age, weight at 210 days of age, daily gain from birth to 120 days of age, daily gain from birth to 210 days of age, and daily gain from 120 to 210 days of age were evaluated as indicators of growth performance in the herd. Statistical evaluation was performed using SAS software (SAS/STAT® 9,3, 2011), ANOVA method (GLM procedure). Akaike Information Criterion was used for the best model determination. The model equation included sex of calves, parity, month of birth, and period of farming system.

The Tukey-Kramer method was applied for comparison and evaluation of significant differences between least square means. Significance levels $P < 0.05$ and $P < 0.01$ were used to evaluate the differences between groups.

RESULTS AND DISCUSSION

The results are shown in Tab 1 and 2. The results show that sex affects all considered parameters of growth. Statistically significantly higher weights and daily gains were observed in bulls. Similar results were observed in study of Stádník et al. (2008). The parity had an effect on weight in 120 and in 210 days of age, on daily gain to 120 days of age and on daily gain since birth to 210 days of age. The statistically significantly highest values were recorded in progeny of cows giving birth on fourth and fifth occasion. This is in accordance with study of Toušová et al. (2014). The effect of the month of birth had statistically insignificant effect on all characteristics observed since birth to 120 days of age. The highest weights after birth were obtained in calves born in August (36.29 kg), and in contrary the lowest in those born in November (32.60 kg). The weight in 120 days of age and daily gain to 120 days of age were highest in calves born in January (175.99 kg; 1,090.93 g/day) and lowest in calves born in December (158.58 kg; 1,035.75 g/day). There were found some statistically significant effects of the month of birth on characteristics observed from 120 to 210 days of age. The weight in 210 days was statistically significantly superior ($P < 0.05$) in calves born in February (283.86 kg) over calves born in May (257.06 kg) and June (256.37 kg). The same calves shown also significant differences ($P < 0.05$) in daily gain since birth to 210 days (1,191.32 g/day in February over 1,066.53 g/day in May and 1,062.89 g/day in June) and daily gain since 120 to 210 days (1,254.08 g/day in February over 1,058,57 g in May and 1,023.79 g in June). The effects of other months of birth were statistically insignificant ($P > 0.05$). These results confirmed importance of winter season of calving.

The season affects growth performance of calves in spring and summer pasture period in accordance with results of Krupa et al. (2005) and Stádník et al. (2008).

There were found no statistically significant differences (P > 0.05) in weight after birth between the systems of farming. This fact may be due to breeding system focused on easy calving during the whole time of this study. On the other hand, statistically significant (P < 0.01) higher weight in 120 days was observed in calves born in ecological system of farming compare to those born in conventional system (+14.50 kg). Similar statistically significant (P < 0.01) effect was counted for daily gain since birth to 120 days of age (+117.27 g in favor of ecological farming). The statistically significant (P < 0.05) change was recorded in the weight of calves in 210 days and in their daily gain since birth to 210 days of age, where the weights increased in the ecological system (+12.76 to +13.29 kg) a daily gains (+64.51 to +64.70 g/day). The daily gain between 120 and 210 days of age was statistically significantly (P < 0.05) highest in the period of transition (1,190.17 g).

Tab 1. Results obtained using procedure GLM (ANOVA)

effect	level	Live weight at birth	Live weight at 120 days	Average daily gain to 120 days
		LSM ± SE	LSM ± SE	LSM ± SE
Sex	bulls	34,33 ± 0,463^{A}	170,48 ± 3,484^{a}	1137,68 ± 27,945^{a}
	heifers	33,17 ± 0,432^{B}	163,69 ± 3,254^{b}	1086,48 ± 26,102^{b}
parity	1	33,45 ± 0,614	153,34 ± 4,627^{a}	993,35 ± 37,114^{A,a}
	2	33,60 ± 0,613	166,46 ± 4,615	1104,83 ± 37,022
	3	33,42 ± 0,652	169,66 ± 4,910^{b}	1134,10 ± 39,387^{b}
	4	33,03 ± 0,678	172,45 ± 5,110^{b}	1161,16 ± 40,992^{B}
	5	34,30 ± 0,656	170,76 ± 4,941^{b}	1154,83 ± 39,635
	6	34,44 ± 0,598	165,95 ± 4,502	1096,11 ± 36,111
	7	34,09 ± 0,653	170,60 ± 4,919^{b}	1138,12 ± 39,458
	8 and more	33,67 ± 0,555	167,45 ± 4,180	1114,11 ± 33,528
month of birth	January	33,65 ± 0,759	175,99 ± 5,714	1190,93 ± 45,832
	February	33,69 ± 0,519	168,99 ± 3,909	1144,25 ± 31,352
	March	33,67 ± 0,302	170,78 ± 2,272	1141,52 ± 18,224
	April	33,68 ± 0,380	171,62 ± 2,864	1148,89 ± 22,973
	May	33,09 ± 0,551	161,72 ± 4,152	1072,51 ± 33,307
	June	33,17 ± 0,546	164,20 ± 4,116	1092,21 ± 33,014
	August	36,29 ± 1,043	171,25 ± 7,854	1126,62 ± 63,000
	November	32,60 ± 2,771	160,63 ± 20,877	1056,01 ± 167,47
	December	33,91 ± 1,792	158,58 ± 13,502	1035,75 ± 108,31
Farming system	conventional	34,11 ± 0,452	160,08 ± 3,406^{A}	1055,78 ± 27,319^{A}
	transition	33,29 ± 0,521	166,59 ± 3,928	1107,40 ± 31,506
	ecological	33,85 ± 0,509	174,58 ± 3,832^{B}	1173,05 ± 30,734^{B}

A-B …, P < 0.01; a-b…, P < 0.05.

The increase of parameters of weight and daily gain are probably caused by genetic progress in Charolais population in Czech Republic and following good selection of bulls to insemination and natural breeding. Fernández & Woodward (1999) and Glanc et al. (2015) observed lower daily gain and live weight in organic farming compared to conventional system. These findings are in contrary with our results. This fact also may be caused by using different breeds, different environmental condition and definition of organic and commercial farming in USA.

Tab 2. Results obtained using procedure GLM (ANOVA)

effect	level	Live weight at 210 days	Average daily gain to 210 days	Average daily gain between 120 and 210 days of age
		LSM ± SE	LSM ± SE	LSM ± SE
Sex	bulls	282,64 ± 4,994^{A}	1182,45 ± 23,698^{A}	1242,14 ± 34,457^{A}
	heifers	255,78 ± 4,665^{B}	1060.05 ± 22,137^{B}	1024,82 ± 32,185^{B}
parity	1	246,62 ± 6,632^{A,a}	1015,10 ± 31,475^{A,a}	1044,10 ± 45,763
	2	269,31 ± 6,616^{b}	1122,43 ± 31,398^{b}	1145,90 ± 45,650
	3	273,80 ± 7,039^{B}	1144,68 ± 33,403^{B}	1158,77 ± 48,566
	4	275,23 ± 7,325^{B}	1153,34 ± 34,764^{B}	1142,92 ± 50,545
	5	279,63 ± 7,083^{B}	1168,23 ± 33,613^{B}	1186,10 ± 48,871
	6	266,36 ± 6,453	1104,40 ± 30,624	1115,46 ± 44,526
	7	272,77 ± 7,051^{b}	1136,59 ± 33,463^{b}	1134,55 ± 48,653
	8 and more	269,97 ± 5,992^{b}	1125,23 ± 28,434^{b}	1140.05 ± 41,342
month of birth	January	284,79 ± 8,190	1195,92 ± 38,869	1202,56 ± 56,513
	February	283,86 ± 5,603^{a}	1191,32 ± 26,589^{a}	1254,08 ± 38,659^{A,a}
	March	274,12 ± 3,257	1145,02 ± 15,455	1149,69 ± 22,470
	April	273,98 ± 4,105	1144,26 ± 19,482	1138,09 ± 28,326
	May	257,06 ± 5,952^{b}	1066,53 ± 28,247^{b}	1058,57 ± 41,069^{b}
	June	256,37 ± 5,900^{b}	1062,89 ± 27,998^{b}	1023,79 ± 40,707^{B}
	August	275,44 ± 11,258	1138,79 ± 53,428	1155,01 ± 77,681
	November	268,34 ± 29,927	1122,53 ± 142,020	1211,23 ± 206,49
	December	248,95 ± 19,355	1023,99 ± 91,852	1008,30 ± 133,550
Farming system	conventional	260,53 ± 4,882^{a}	1078,18 ± 23,168^{a}	1108,06 ± 33,685^{a}
	transition	273,29 ± 5,630^{b}	1142,88 ± 26,719^{b}	1190,17 ± 38,848^{b,c}
	ecological	273,82 ± 5,492^{b}	1142,69 ± 26,065^{b}	1102,21 ± 37,896^{d}

A-B …, P < 0.01; a-b…, P < 0.05,

CONCLUSION

The change from conventional to ecological farming system had positive effect on all parameters of growth excluding weight in birth and daily gain between 120 and 210 days. The transition to ecological system of cattle breeding does not decrease parameters of growth and economical results conditioned by parameters of growth. The growth ability of beef calves to weaning is influenced by a number of factors. Farmers are recommended to secure quality of nutrition and animal welfare to reach maximal growth performance of beef calves and maximal economic results of beef production.

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HEAT STRESSED HOLSTEIN HEIFERS - THRESHOLD DETERMINATION IN CENTRAL CROATIA

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ABSTRACT

In the light of increasingly rapid climate change worldwide, and with the purpose of reduction of financial losses of dairy farmers and enabling the sustainable farming, the necessity of implementation of breeding values for heat resistance in breeding strategies, have become more and more pronounced. Estimation of breeding values requires determination of THI threshold value. Therefore, the objective of this research was to determine the THI threshold value for Holstein heifers in environmental conditions in Central Croatia. With that purpose individual test-day records of Holstein heifers with records of ambient temperature and relative humidity in the barns collected in regular milk recording from January 2006 to December 2012 were analysed. The THI threshold values for daily milk yield were determined by least square analyses of variance for each given THI value (from 65 to 76) using the PROC MIXED (SAS). The THI ≥ 65 cause significant change in Holstein heifers' daily production. Significant decrease of daily milk yield was observed at THI = 65 with estimated drop from 0.087 till 0.254 kg milk/day (THI from 65 – 76). The THI = 65, as the lowest value at which significant decrease in daily milk yield was determined was taken as the threshold value for Holstein heifers in Central Croatia.

Key words: Holstein heifers, heat stress, temperature-humidity index, threshold, Central Croatia.

INTRODUCTION

In the last few decades, we have witnessed more expressed and increasingly rapid climate change worldwide. Meaning, that in regions that at the time are not characterized as extreme climate conditions, in future dairy cattle will be exposed to the unfavourable climatic conditions (IPCC, 2007). In accordance with this forecast, Reiczigel et al. (2009) in Hungary determined increase of heat stress days/year (temperature-humidity index – THI > 68) from 5 to 17 in a period of 30 years. In dairy cattle breeding in indoor housing, the optimal microclimate conditions in the barns are necessary for the realization of the productive potential of individual cows. The interrelation between ambient temperature and relative humidity is important from the aspect of animal welfare, reproduction and finally profitability of dairy farm. Any extreme combination is potentially harmful. In environment with low temperature and high humidity, cows increase heat production and consume more feed in order to compensate body energy losses. When the animal is overheated, high humidity may lead to infections of respiratory tract or udder. On the other hand, high temperature and low relative humidity may dehydrate mucous membranes thus increasing vulnerability to viruses and bacteria (Romaniuk and Overby, 2005).

The combination of high temperature and high relative humidity has the most detrimental effect through inducing heat stress in cows. Under heat stress conditions, lactating cows tend to reduce their dry matter intake (DMI) and milk production (West et al., 1999). Moreover, besides milk production heat stress is associated with changes in milk composition, somatic cell counts (SCC) and mastitis frequencies (Bouraoui et al., 2002.; Collier et al., 2012; Correa-Calderon et al., 2004; Ravagnolo et al, 2000.; St-Pierre et al., 2003; West, 2003). Additionally, deteriorate effect on reproductive performances was also observed (Bohmanova et al., 2007; Ravagnolo et al., 2000). Numerous studies showed that the high producing cows are much more susceptible to heat stress than low producing cows (Bohmanova, 2006; Collier et al. 2006). Kadzere et al. (2002) suggested that, due to intensive genetic selection for milk production, the thermoregulation physiology of a cow have been changed. The high producing cows have larger frames and larger gastrointestinal tracts which allow digestion of more feed and result in more metabolic heat which consequently reduce cow's ability to maintain normal temperature at unfavourable conditions. Finally, high producing cows experience heat stress earlier than low producing since the thermoneutral zone of high producing cows is at lower temperatures. The most common measure of heat stress in dairy cows is the temperature-humidity index (THI) that present combination of ambient temperature and relative humidity and is a useful and easy way to assess the risk of heat stress (Kibler, 1964). Du Preez et al. (1990a, b) determined that milk production and feed intake is affected by heat stress when THI values are higher than 72. Bouraoui et al. (2002) put the threshold on 69, while Bernabucci et al. (2010) as well as Collier et al. (2012) on 68. Vitali et al. (2009) suggested that the risk of cow's death starts to increase when THI reaches 80. The significant decrease of daily milk traits (yield and contents) was also determined in Croatian environmental conditions with highest decline during summer period in Eastern and Mediterranean Croatia (Gantner et al., 2011). In many dairy-producing areas of the world heat stress condition represent a significant financial burden, for example in the USA between $897 million and $1,500 million per year (St-Pierre et al., 2003). There are many methods to decrease the impact of heat stress including the shading, cooling, nutrition (Kadzere et al., 2002; West, 2003) and selection for resistance on heat stress (Bohmanova, 2006). Ravagnolo et al. (2000) determine antagonistic relationship between cow's production and heat tolerance implying deteriorate effect of selection on productivity on cow's resistance to heat stress. The high yielding Holstein cows in Israel is good example that selection on production could be successful in terms of heat stress (Aharoni et al., 1999). Implementation of breeding values for heat resistance in breeding strategies would certainly reduce financial losses of dairy farmers and enable sustainable farming. Estimation of breeding values requires determination of THI threshold value. Therefore, the objective of this research was to determine the THI threshold value for Holstein heifers in environmental conditions in Central Croatia.

MATERIALS AND METHODS

Individual test-day records of Holstein heifers collected in regular milk recording performed by alternative milk recording method from January 2006 to December 2012 in Central Croatia were used for the analysis. Monthly, at each recording, milk yields were measured during the evening or morning milkings. Additionally, at each recording, ambient temperature and relative humidity in the barns were recorded. Logical control of milk data was performed according to ICAR standards (2003). Daily temperature-humidity index (THI) was calculated using the equation by Kibler (1964):

$$THI = 1.8 * Ta - (1 - RH)(Ta - 14.3) + 32$$

where Ta is average temperature in degrees Celsius and RH is relative humidity as a fraction of the unit. Records with lactation stage in (< 6 days and > 305 days), age at calving in (< 21 and > 36 months), missing or parity > 1, and missing or nonsense Ta and RH value were deleted from dataset. Data, provided by the Croatian Agricultural Agency, after logical control consisted of 153,305 test-day records from 21453 heifers reared on 1,750 farms in Croatia. Variability of ambient temperature (Ta) and relative humidity (RH) per recording year in Central Croatia is presented in Table 1.

Table 1. Descriptive statistics of ambient temperature (Ta) and relative humidity (RH) measured during the milk recording regarding the recording year in Central Croatia

Recording	**Ambient temperature (°C)**					**Relative humidity (%)**				
year	Mean	SD	CV	Min	Max	Mean	SD	CV	Min	Max
2006	17.0	7.28	42.7	-8.0	40.0	69.8	10.35	14.8	30.0	99.0
2007	16.6	6.72	40.4	-3.0	39.0	70.0	10.80	15.4	30.0	97.0
2008	16.2	6.80	41.8	-7.0	39.0	69.7	11.20	16.1	30.0	99.0
2009	16.6	7.21	43.4	-7.0	39.0	70.1	10.46	14.9	30.0	97.0
2010	15.2	7.36	48.5	-5.0	40.0	72.6	10.35	14.3	30.0	97.0
2011	16.2	7.99	49.4	-3.0	40.0	70.6	9.82	13.9	31.0	99.0
2012	16.1	7.87	48.9	-8.0	39.0	71.1	10.12	14.2	31.0	98.0

The THI threshold values for daily milk yield were determined by least square analyses of variance for each given THI value (from 65 to 76) using the PROC MIXED procedure in SAS (SAS Institute Inc., 2000). Following mixed model was used:

$$y_{ijklmn} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3 \ln(305/d_i) + b_4 \ln^2(305/d_i) + S_j + A_k + T_l + e_{ijklmn}$$

where y_{ijklm} = estimated daily milk yield; μ = intercept; b_1, b_2, b_3, b_4 = regression coefficients; d_i = days in milk (i = 6 to 305 day); S_j = fixed effect of calving season class j (j = 1/2006 to 12/2012); A_k = fixed effect of age at calving class k (k = 21 to 36 month), T_i = fixed effect of THI class (l = 0 (*normal condition – values under the given threshold*) or 1 (*heat stress condition – values equal and above the given threshold*)), and e_{ijklm} = residual. The significance of the differences between the THI classes were tested by Scheffe's method of multiple comparisons. The lowest threshold value at which significant differences in milk yield was determined, was taken as the threshold value.

RESULTS AND DISCUSSION

Maximum daily relative humidity and ambient temperature measured during the milk recording in summer period in years 2006 – 2012 are presented in figure 1.

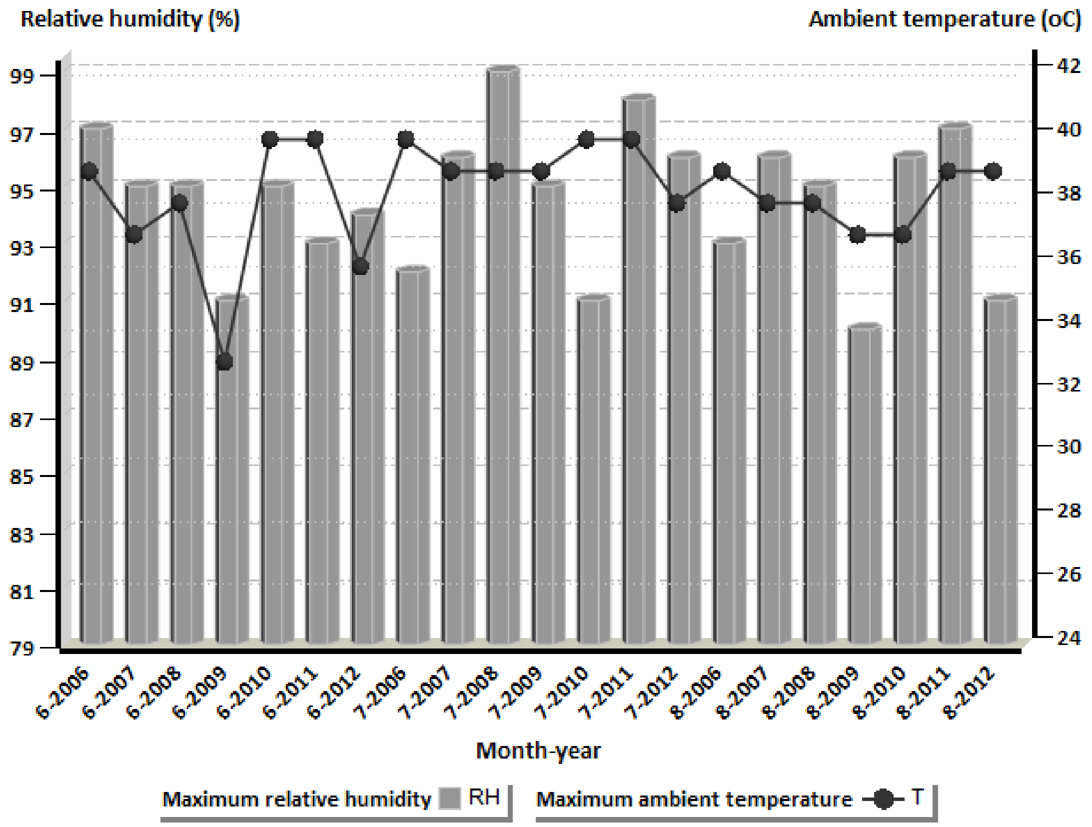

Figure 1 Maximum daily relative humidity and ambient temperature measured during milk recording

Least square means from analysis of variances regarding the fixed effect of THI class (0, 1) on daily milk yield are shown in Table 2. Environmental conditions in the barns with THI values in 65 caused significant, but small (0.087 kg/day) difference in daily production of Holstein heifers. Statistically highly significant decrease of daily milk yield was observed when THI value in the barns was above 65 that is in interval from 66 – 76, when, estimated drop in milk yield was from 0.157 till 0.254 kg/day. Highest decrease was determined in environmental condition characterised with THI = 68. The lowest value at which significant differences in milk yield was determined, was taken as the threshold value. Therefore, in environmental conditions in Central Croatia, as threshold value for Holstein heifers 65 was set. Significant drop in daily production of dairy cattle at the same THI value was also determined by Bernabucci et al. (2010) and Collier et al. (2012). Bouraoui et al. (2002) in a Mediterranean climate observed decrease in milk production of dairy cows in condition characterised with THI ≥ 69. In the environmental conditions of Eastern Croatia that characterise more extreme weather comparable to the Central, THI threshold value for the first parity Holsteins was set to 68, with the highest drop of 0.716 kg/day if THI =74 (Gantner et al., 2015).

Du Preez et al. (1990a, b) determined that dairy cows in Southern African conditions are affected by heat stress when THI values are higher than 72. The significant decrease of daily milk yield when THI ≥ 72 was also determined in Croatian and Mediterranean Croatia (Gantner et al., 2011). Bohmanova et al. (2007) in USA determined different threshold values regarding the region (72 in Georgia, and 74 in Arizona). The difference between determined threshold values could be due to better adapted cows, farm management or special housing characteristics.

Table 2. Least square means of daily milk yield regarding the given threshold value

ThHo	Ls0	Ls1	Estimated difference
THI65	**18.20 ± 0.098**	**18.11 ± 0.100**	**0.087 ± 0.038***
THI66	18.24 ± 0.098	18.00 ± 0.101	0.245 ± 0.039***
THI67	18.23 ± 0.098	18.01 ± 0.101	0.219 ± 0.040***
THI68	18.23 ± 0.097	17.98 ± 0.102	0.254 ± 0.041***
THI69	18.22 ± 0.097	18.01 ± 0.102	0.208 ± 0.042***
THI70	18.21 ± 0.097	18.01 ± 0.103	0.203 ± 0.043***
THI71	18.21 ± 0.097	17.99 ± 0.104	0.220 ± 0.045***
THI72	18.20 ± 0.097	17.98 ± 0.105	0.222 ± 0.046***
THI73	18.20 ± 0.097	17.97 ± 0.106	0.230 ± 0.048***
THI74	18.20 ± 0.097	17.98 ± 0.107	0.218 ± 0.051***
THI75	18.19 ± 0.097	18.03 ± 0.108	0.157 ± 0.054**
THI76	18.19 ± 0.097	18.00 ± 0.111	0.189 ± 0.058**

* ThHo – given threshold value; 0 – class under, and 1 – class above the given threshold value

CONCLUSION

Based on analysed data it could be concluded that THI ≥ 65 cause significant change in Holstein heifers' daily production. Significant decrease of daily milk yield was observed at THI = 65 with estimated drop from 0.087 till 0.254 kg milk/day (THI from 65 – 76). The THI = 65, as the lowest value at which significant decrease in daily milk yield was determined was taken as the threshold value for Holstein heifers in Central Croatia.

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MICROCLIMATE PARAMETERS AND VENTILATION INSIDE THE BARNS IN THE LOWLAND REGION OF BOSNIA AND HERZEGOVINA

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ABSTRACT

Purpose of this paper is analysis of microclimate parameters in dairy cow barns in Bosnia and Herzegovina (Republic of Srpska), and examine the impact of the ventilation on the microclimate inside the barns. The study included 38 dairy barns in the lowland region of Bosnia and Herzegovina (Republic of Srpska), during the winter season. The following microclimate parameters were measured: air temperature, relative humidity of air, air velocity and concentration of gases (NH_3 and CO_2). Statistically significant correlations were determined between NH_3 concentration and air temperature (P<0,001) and between temperature and concentration of CO_2 (P<0,05). Also, are established positive and statistical significant correlation between manure gases (NH_3 and CO_2). The research has also shown that the average concentration of CO_2 in relation to the open area in the barn statistically significant (P<0,05).

Key words: dairy cow barns, microclimate parameters, ventilation

INTRODUCTION

Microclimate and ventilation is important factor that identify quality of air in livestock buildings. Particularly in terms of removing harmful gases and ensure thermal comfort and control environment by ventilation. Such ventilation affects indoor microclimate parameters and assists the maintenance of a comfortable environment for dairy cattle (Teye, 2008). In the barns is necessary to provide the optimal microclimatic conditions, because those have a major influence on health, welfare and production of dairy cows, and thus the profitability of dairy production.

In order to achieve better production results in modern cattle production, we must ensure optimal conditions for the animals. The key role in this has barn and microclimate conditions (Mijić, 2013). When it is about housing of dairy cattle in Bosnia and Herzegovina (Republic of Srpska), there are a big differences between the regions, breeders, traditional breeding of cattle, breeding methods and economic opportunities of producers to invest in the system of dairy cattle breeding (Erbez et al., 2015).

Therefore, the aim of this study was to determine the microclimate parameters in the barns and obtained results compare with standards or similar research, and determine the relationship between investigated microclimate parameters. Analysis of microclimate parameters in relation to the representation of open space on the side walls of the barns, which affect the quality of housing in the certain number of cattle barns in Bosnia and Herzegovina (Republic of Srpska) were analyzed.

MATERIAL AND METHODS

The research was conducted at 38 dairy cattle barns in the area of 10 municipalities in lowland region of Bosnia and Herzegovina (Republic of Srpska). The investigations were carried out in the period from December 5th, 2013 to March 15th, 2014, in the winter, because cows were kept tied in the barns during the cold season (pasturing in the rest of the year). Next microclimatic parameters were measured: air temperature, relative humidity of air, air velocity and concentration of gases (NH_3 and CO_2). The air temperature and relative humidity were measured using Thermo Anemometer PCE-423, temperature and air velocity measured by Anemometer PCE-AM82 and stable gases measured by IBRID MX6 device.

The calculation to define the percentage of open area to the total surface of barns, take the openings on the side walls of barns.

The descriptive statistical indicators were calculated (mean, standard deviation, standard error of arithmetic mean, coefficient of variation, minimum and maximum) for the measured parameters. The Pearson correlation coefficient (r) between parameters of microclimate were also calculated.

RESULTS AND DISCUSSION

The descriptive statistical analysis for investigated microclimate parameters are presented in table 1.

Tab.1. Average values and variability of microclimate conditions in the investigated dairy barns

Microclimatic parameters	$\overline{X}$	$S\bar{x}$	Sd	CV (%)	Variations	
					Min.	Max.
Temperature (^{o}C)	11.18	0.53	3.32	29.7	3.1	17.5
Relative humidity (%)	76.22	1.45	8.94	11.72	57.1	92.9
Air flow velocity (m/s)	0.12	0.02	0.14	116.6	0.01	0.67
Ammonia (ppm)	1.39	0.12	0.74	53.23	0	3
Carbon dioxide (ppm)	871.57	53.69	330.75	37.94	390	1690

Air temperature in the barn ranged from 3.1 to 17.5°C, which means that the temperature was optimal for dairy cows. Relative humidity had a value of 57.1 to 92.9 %, with an average of 76.22 %. The relative humidity in dairy housing should not vary more than between 40 and 80 % (DIN 18910, 2004), while Hristov (2002) suggested that the optimum humidity for cows is 50 to 75 %. Average values of humidity were the optimum values, but maximal value of relative humidity exceeded the recommended values. In a study conducted by Popescu et al. (2010) in Transylvanian dairy barns, the relative humidity varied from 59.2 % to 98.65 %. The same authors state that high relative humidity during the cold seasons is a major problem in most of the dairy buildings, as well as the relative humidity in the dairy buildings exceeded the recommended values when the ventilation was inadequate. The air velocity had a mean value of 0.12 m/s, wasn't in accordance with the recommendation for dairy cattle barns. According to the EFSA recommendation air velocity in barns for cattle should be about 0.2 m/s in winter and 0.6 m/s in summer. The ammonia concentrations varied from 0 to 3 ppm. Average values of CO_2 were in the range of 390 to 1690 ppm, which indicates

that these values were below the threshold limit value of 3000 ppm. In a study conducted by Teye et al. (2007) in dairy cows' barns in Finland and Estonia, the concentration of carbon dioxide was from 522 to 1678 ppm.
We also studied the correlations between the investigated parameters of microclimate. Statistical significant and positive correlation were demonstrated between the air temperature and the ammonia concentration (P<0.001), and between the temperature and carbon dioxide (P<0.05) (table 2).

Tab. 2. Results of correlation strenght examination between single investigated microclimate parameters

Microclimatic parameters	P value	Correlation coefficient	The strength of association
T (^oC) – RH (%)	0.077^{NS}	0.48	No
T (^oC) – V (m/s)	0.075^{NS}	0.5	No
T (^oC) - NH_3 (ppm)	0.550***	4.23	Strong
T (^oC) - CO_2(ppm)	0.355*	2.36	Weak
RH (%) – V (m/s)	-0.288^{NS}	1.92	No
RH (%) – NH_3 (ppm)	-0.038^{NS}	0.23	No
RH (%) – CO_2 (ppm)	0.217^{NS}	1.35	Very weak
V (m/s) – NH_3 (ppm)	0.241^{NS}	1.5	Very weak
V (m/s) – CO_2 (ppm)	0.208^{NS}	1.90	Very weak
NH_3 (ppm) - CO_2 (ppm)	0.435**	2.9	Medium

***P<0.001; **P<0.01; *P<0.05; ^{NS}P>0.05
T^o- temperature of the air; RH – relative humidity of the air; V-air flow velocity; NH_3 – ammonia concentration; CO_2- carbon dioxide concentration

It is to conclude that with increasing temperature of the air inside the barn, increases the concentrations of manure gases, in particular the ammonia. Wu et al. (2012) state that the concentration of ammonia in naturaly ventilated barns in mostly influenced by temperature and air movement. This fact is confirmed by the study conducted by Popescu et al. (2010), according to which there a significant correlation between the ammonia concentration and temperature, and air movement velocity inside the barn. Also, that supports the research of Herbut and Angrecka (2014) who observed a significant correlation between air temperature and ammonia concentration and this correlation was most noticeable in winter. According to Romaniuk and Mazur (2014) is established positive correlation between ammonia concentration and internal temperature.

Tab. 3. Analysis of variance microclimate parameters in relation to the representation of open space on the side walls of barns

Source of variation	**d.f.**	**SS**	**MS**	F_{exp}
The air temperature				
Treatments	4	16.13	4.03	0.32^{NS}
Error	33	404.47	12.25	
Relative humidity of the air				

Treatments Error	4 33	614.8 2426.4	153.70 73.53	2.09^{NS}
Air flow velocity				
Treatments Error	4 33	0.05 0.71	0.012 0.021	0.57^{NS}
Ammonia concentration				
Treatments Error	4 33	2.25 18.83	0.56 0.57	0.98^{NS}
Carbon dioxide concentration				
Treatments Error	4 33	1244028.33 2913076.93	311007.08 88275.05	3.52^{*}

*P<0.05

Positive and statistical significant correlation (P<0.05) is established between manure gases (NH_3 and CO_2). According to Hristov (2002) when ventilation is inadequate, especially in the morning, high ammonia concentrations are accompanied by high concentrations of carbon dioxide in the air barns.
In table 3 is presented statistically significant difference between examined microclimate parameters, determined by analysis of variance and considered in relation to the various solutions natural ventilation of investigated barns.

Based on the analysis of variance, is confirmed that the concentration of carbon dioxide was significantly influenced by the representation of open space in relation to the total area of barns. Thereby, it was confirmed that insufficient ventilation air exchange inside the barn causes increased concentration of CO_2. Also, according to Mijić (2013) carbon dioxide can be used to assess the effectiveness of the ventilation system, as well as when the ventilation in the barn are insufficient or inadequate, are increased the concentration of harmful gases. The concentration of carbon dioxide depends on the type of building, ventilation system and livestock density. In summer the concentration of carbon dioxide is lower than in the winter due to opening windows and doors, and higher rates of ventilation (Hristov, 2002).

CONCLUSION

Based on the exposed results of the research can be concluded that the investigated barns have relatively favorable microclimate. Only is required to improve the natural ventilation of the existing barns in terms to provide sufficient circulation of fresh air.

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PRODUCTION OF DAIRY COWS AT DIFFERENT ENVIRONMENTAL CLIMATIC PARAMETERS

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ABSTRACT:
Cattle have a constant body temperature, which held up to a certain limit. Due to changing ambient climatic parameters (temperature, humidity, THI index), can lead to certain consequences which have a deleterious effect on the health of the animals, and even can cause death of the animal. The assumption of this research was that the environmental climatic parameters have an impact on cows in milk production.
The study involved 50 Holstein cows, which were divided in the same building and in the two groups: the first (n = 25) = 30 kg milk and 2 (n = 25) = 30 and more kg of milk. The results showed that the surface temperature of the body was measured on the left side of the body cows (area rumen) increased no matter what was the level of milk production. However, the surface temperature of the udder measured from the back of the cows showed a different trend. The temperature of the udder of the cow in the first (with a milk production of less than 30 kg) was constant (average of 34.95 ° C), in contrast to the other groups of cows (with a milk production of 30 kg or more), where the surface temperature is increased as the udder increased and THI index in the barn.
The increase in metabolic activity in animals (such as dairy cows) and leads to an increase in surface heat in certain parts of the body, and what is even more pronounced when the animals are in inadequate surroundings or barn that is not adapted to cows with high milk production.
Key words: dairy cows, environmental, climatic parameters, THI index

INTRODUCTION
Cattle belong to homeothermic animals, or those their body temperature up to certain limits can be maintained constant. The relatively constant temperature is required for operating the vital and manufacturing processes. It is necessary to maintain a balance between heat production and heat emission to the environment (Richter et al., 2006). The body temperature of cows is influenced by different factors: varies with the stage of lactation, milk production (Bohman, 2006), and shows the highest increase after feeding (Yousef, 1985). In addition, also the climatic conditions affect the amount of body temperature. Cattle, like most homeothermic animals, produce excess heat, which must be released into the environment. The skin, which makes the link between the environment and the heat, maintains the balance between heat production of the body and its immediate surroundings. In this way it can meet the physiological needs of the body. Therefore, the infrared thermography suitable diagnostic tool for the detection of all types of diseases, which are in any way

related to changes in blood flow (Voice, 2008). Khalifa (2003) states that in cases when the ambient temperature falls below the lower critical temperature, cattle trying to maintain their body temperature to increase metabolic activity and trembling. However, with the increase in ambient temperature above the critical temperature the body tries to balance the load imposed and increased perspiration and a reduction in metabolic heat production. The higher the ambient temperature, then it takes more energy for thermoregulation. This mechanism is important because animals in this way prevents the increase of their own body temperature. For Holstein cows to the area where the ambient temperature is between 23-26°C (Igone et al., 1992; Hahn, 1999). With increasing temperature the body tries to reduce heat production. This makes the reduction of food intake, but consequently leads to the decrease in production (West, 2003). If these mechanisms are not sufficient, body temperature begins to rise and then can lead to hyperthermia (Robertshaw, 1981). Temperatures of between 42 and 43°C can lead to heat stroke, which in most cases fatal ends (Jessen, 2000). For dairy cows the temperature range of thermal neutrality is different, depending on the author. So Bianca (1971) and Yousef (1985) in the field of thermal neutrality state ambient temperature from 0 to 16°C, Heidenreich et al. (2004) of 4 to 16°C, while Małków-Nerge et al. (2005) report from -7 to 17°C.

The aim of this study was to measure the value of the most important climatic parameters in the barn, milk producing cows that reside in this area, the body temperature of cows on certain parts of the body, and to determine how these climatic parameters in the barn affect cows with different heights of milk production.

MATERIALS AND METHODS

The study was conducted on a Holstein dairy farm in Eastern Croatia. Cows, in accordance to the daily milk production, were divided into two groups: Group 1 (n = 25) with a daily production <30 kg of milk (13 to 29.99 kg) and Group 2 (n = 25) with a daily production of >= 30 kg of milk (30 to 53.50 kg). The farm is a modern concept of building: free grazing, semi-open type. Milking was performed by robots Lely Astronaut A4 automatic milking. The period of study was from 10.06.2013 to 31.03.2014. The daily measures of milk yield was available for analysis. Temperature (T) and humidity (H) in the barn were measured with digital device "Data Logger PCE-HT71". Temperature-humidity index (THI) was calculated according to Kibler (1964). The data on external climate parameters are taken from the Meteorological and Hydrological Service of the Republic of Croatian. The measurements of the surface temperature of the cow's body was measured by the thermo camera Flir i7 brand and from a distance of 2 m. Cows were measured from the left side (area rumen) and on the area of the udder from the rear cows. To process the thermal images software Flir QR was used. For statistical analysis of the data GLM procedure of SAS statistical program was used.

RESULTS AND DISCUSSION

Air temperature in the barn during the study (Table 1) ranged in interval from 2.9 to 28.3°C, with an average value of 20.71 °C. Optimal temperatures according to some sources (Bianca, 1971; Heidenreich et al. 2004) suggest that the average temperature in our research was above the recommended. The temperature of the udder from the cow's rear side measured by the thermal camera had an average value of 35.32 °C, while the temperature of the cow's body measured from the left side (area of the rumen) was slightly lower and amounted to 33.05 °C. The average daily milk production was 30.42 kg.

Table 1. Basic statistics of the investigated parameters (n=50)

Variable	Unit	Mean	Std Dev	Min	Max
Air temperature in barn	°C	20.71	7.60	2.90	28.30
Humidity in barn	%	63.16	12.16	46.80	89.90
THI in barn	-	66.21	11.19	38.40	78.10
Air temperature outside barns	°C	19.75	7.92	-2.50	29.20
Humidity outside barns	%	54.22	15.72	38.00	96.00
THI outside barns	-	63.99	10.95	28.17	7622
Surface temperature of the body left by cows	°C	33.05	2.70	26.60	37.00
Surface temperature of the udder - viewed from behind	°C	35.32	1.34	30.60	37.20
Average daily milk production	kg	30.42	9.45	13.00	53.50

Table 2 shows the Lsmeans values determined for the first and second group, and the significance of the differences between compared groups. The average daily milk production in the first group was 23.22 kg, while in the second group was 37.63 kg. Among these groups, a highly significant difference (P <0.001) for the average daily milk production was found. Highly significant differences (P <0.001) were also found for the other tested parameters (surface temperature of the body with the left hand and the surface temperature of the udder from the rear of the cow).

Table 2. Lsmeans and the differences between the experimental groups

Variable	Unit	1. group (< 30 kg of milk)		2. group (=> 30 kg of milk)		Difference
		Mean	Std Dev	Mean	Std Dev	
Average daily milk production	kg	23.22	5.31	37.63	6.76	***
Surface temperature of the body left by cows	°C	32.52	2.99	33.58	2.31	***
Surface temperature of the udder - viewed from behind	°C	34.95	1.63	35.70	0.84	***

*** P<0,001

Figure 1 presents a first group of cows with daily milk production lower than 30 kg. The measured surface temperature of the body on the left side of the cows increased as increased THI index in the barn. However, these cows did not change the surface temperature of the udder. Figure 2 refers to a group of cows with daily milk production equal and higher than 30 kg. In these cows, increase of THI index was followed by the increase of the surface temperature of the body to the left, as the temperature of the udder. This phenomenon of rising temperatures comment by certainly with increasing milk production comes to higher metabolic processes that occur due consequently to an increase in temperature. Speakman and Król (2010) state that the heat is actually a by-product of metabolic processes. It has different values, depending on what the animal is doing. Thus, the warm-blooded animal production of low heat when the animals are in the basal state or elevated in animals that have a high production. This fact explains the situation that was found in this research.

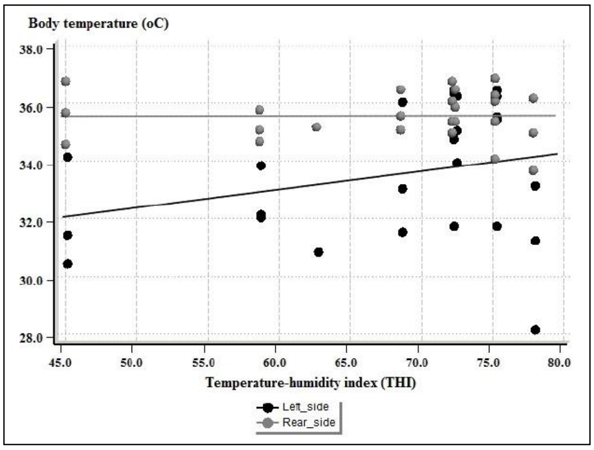

Figure 1. The temperature of the body of cows (°C) with daily production <30 kg of milk at different values of THI in the barn

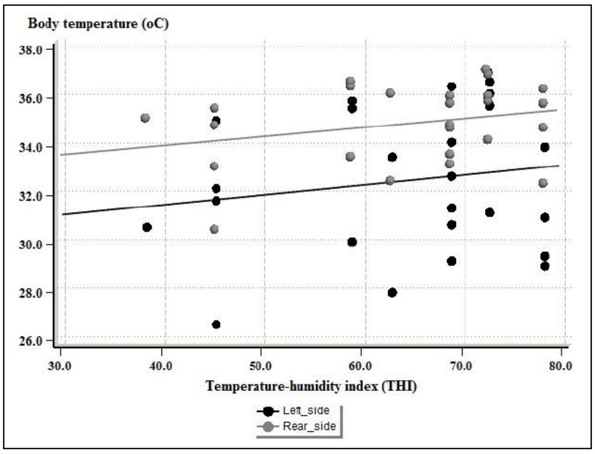

Figure 2. Temperature bodies cows (°C) with daily production => 30 kg of milk at different values of THI in the barn

CONCLUSION

Based on the research it could be concluded that the environmental climatic parameters affecting the animals and their environment in which they reside. This is especially true in highly productive animals, such as dairy cows, which most of their productive life staying indoors or in adequate conditions. Climate change is more and more pronounced, therefore, with purpose of a successful production, and ensuring the animal welfare, object adaptation is needed. Additionally, it will be needed to introduce additional measures to overcome the period with increased temperature, humidity or THI index.

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THE EFFECT OF TEMPERATURES ON THE BEHAVIOUR OF CZECH FLECKVIEH COWS

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ABSTRACT

A group of 98 Czech Fleckvieh cows (one section) was observed over the period of one year with the aim to determine the variation in their milk performance and behaviour at cowshed different cowshed temperatures. Behaviour were recorded once a week (on the same day) at 10:00. Periods of 8 weeks with the highest temperature (hot period – H) and of 8 weeks with the lowest temperature (cold period – L) were then compared. The cows were housed in one section (1/4 of the total capacity) of the free-cubicle shed and where the cubicles were distributed into three rows. Row A (32 cubicles) was close to the feeding plateau, row B (33 cubicles) was in the centre and row C (38 cubicles) was peripheral, close to the side wall. The cowshed temperature was monitored on a daily basis and the mean temperature was 23.2 °C in the hot period and -1.7°C in the cold period, relative humidity 60.2 % (H) and 74.6 % (L) and THI 69.4 (H) and 33.4 (L). The behaviour of the cows was recorded 1568 times, showing them mostly lying down (1037) or standing (531). The cows tended to prefer lying down on their left sides (594 observations) as opposed to their right sides (443).

Key words: Czech Fleckvieh, temperature, behaviour, cows, lying, standing

INTRODUCTION

Although the process of domestication brought about a number of important, even essential, changes in farm animal performance, the environmental requirements of animals remained relatively invariable throughout their phylogenesis. The impact of environmental factors on domesticated animals is extremely complex and difficult to define. The more the original environmental conditions change, the greater the responsibility of the breeder to provide adequately for animals' needs (Chládek, 2004).

Cowshed microclimate is, together with nutrition, type of housing and animal handling, one of the main factors affecting the animal. It affects cows' well-being and performance and subsequently herd performance and profitability. Cowshed microclimate is defined in terms of air temperature, relative humidity, air velocity and the presence of various components – gasses, dust, microorganisms, etc. (Matějka, 1995).

According to Bílek (2002) cowshed temperature is the most important factor. The negative impact of high temperature is heightened by air humidity Koukal (2001). With increasing relative humidity, heat tolerance and stress resistance of cows decrease (Doležal et al., 2003). The Temperature-Humidity Index (THI) is used to describe the combined effects of temperature and relative humidity (West, 2003).

The time spent lying down is an indicator of the housing quality and a comfortable laying-down area is therefore one of the most important housing design criteria for dairy cows (Ito et al., 2009). The amount of time spent comfortably laying down is fundamental for cows’ welfare (Thorne, 2008). It can be extended by various means, e.g. through the provision of additional bedding (Colam-Ainsworth, 1989; Drissler, 2005). The quality of cubicle surface, the number of cubicles and the area available for each cow are important characteristics affecting laying behaviour (Fregonesi et al., 2007). In order to maintain a good level of welfare of cows it is essential to analyse and understand their behavioural responses to cowshed microclimate changes, including the impact of low and high temperatures on the general behaviour and performance of cows.

MATERIAL AND METHODS

The primary objective of the experiment was to assess the effects of low and high cowshed temperatures on the behaviour of Czech Fleckvieh cows. Observations were recorded on a private farm GenAgro Ricany a.s. (Czech Republic; geographic coordinates 49°12´30.370´´N, 16°23´43.092´´E). The observed section (1/4 of the cowshed) included 103 comfortable cubicles arranged into three rows (see Figure 1.) Row A (32 cubicles) was the closest to the feeding plateau, row B (33 cubicles) was in the middle of the section and row C (38 cubicles) was situated peripherally, close to the side wall. Some other experiments described by Erbez et al. (2012) and Javorova et al. (2014) were carried out in this cowshed.

The average number of cows housed in the observed section was 98 and in various days in milk (30d and more) and lactation number (1^{st} to 8^{th}). The average milk yield was about 28.1 kg per cow per day. There were no dry cows. The data on milk yield consistency and days of milk were recorded on the test days using the milking parlour software FASTOS 2000.

Data were collected over a period of one year (from the 1^{st} June to 31^{st} May). Behaviour were monitored once a week, always on the same day, at 10.00. Then data from the 8 hottest (H) and 8 coldest (L) weeks were compared. The behaviour was described as the number of cows standing or lying down, the number of cows lying down on their left or right side. The microclimate characteristics (air temperature and relative humidity) were recorded by HOBO data loggers which were distributed throughout the cowshed. Their detailed placement and function were described in Erbez et al. (2012). THI values were calculated using the following equation (Hahn, 1999):

$$THI = 0.8\ tdb + (tdb - 14.4) * RH/100 + 46.4$$

Where:

tdb = cowshed temperature

RH = relative humidity

The calculated values were statistically evaluated by GLM procedure (to test for mean) and chi-square test (Statistica 10.0).

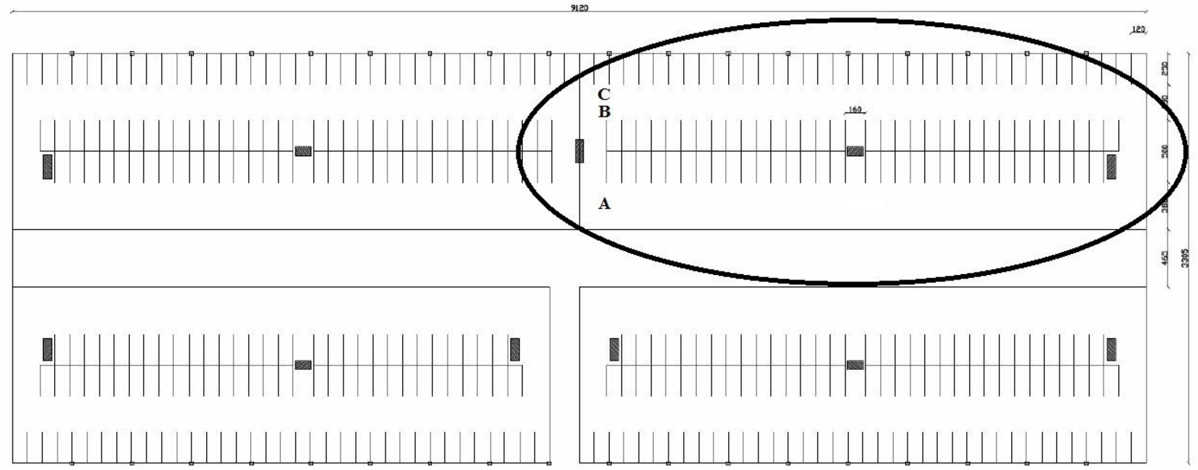

Figure 1: The scheme of the observed section

RESULTS AND DISCUSSION

The differences in the frequency of lying down and standing

The cowshed microclimatic characteristics (temperature, relative humidity and THI) are presented in **Table I**. Mean values of the characteristics were +23.2 ºC, 60.2 % and 69.4 in H period (high temperature) and -1.7 ºC, 74.6 % and 33.4 in L period (low temperature). The differences between H and L periods were statistically highly significant. According to Erbez et al. (2012) heat stress develops at temperatures of +21 ºC and higher. The upper temperature limit recorded in this study was +2.2 ºC (+23.2 ºC) higher than this threshold temperature value indicated in literature.

The milk yield, lactation number and days in milk of in H and L periods and the differences in the frequency of lying down and standing behaviour of the cows are presented in **Table II**.

The number of observations recorded in hot and cold periods (H and L) were equal – 784 observations in each group. The recorded cow behaviour shows that cows were lying down (1037 observations) or standing (531 observations). The cows preferred lying down (1037 observations which makes up 66% of the total number) to standing and the milk yield of the cows lying down was non-significantly higher (by 0.6 kg milk) compared to the standing cows (531 observations). The lactation number was greater in the cows lying down but no statistical differences were found in days in milk and milk yield between the laying and standing cows.

The effect of temperature on laterality (preference of one side of the body over another) of cows' lying down behaviour, milk yield, lactation number and days in milk are described in **Table III**.

The total number of observations was 1 037. The cows preferring laying on their left sides produced significantly more milk (by 0.9 kg) and were of higher lactation number than the cows showing preference for laying on their right sides. There was no difference among the stages of lactation. Cows showed preference for lying down on their left sides in both hot and cold periods. The combination of laterality and cowshed temperature showed that cows showing preference for lying on their left sides produced more milk in both periods.

Table I Climatic characteristics measured inside the cowshed

Period and climatic characteristics			Period		
			High	Low	Sig.
Temperature (°C)	avg.	10.8	23.2	-1.7	**
	min.	*-9.4*	*21.0*	*-9.4*	
	max.	*26.8*	*26.8*	*1.9*	
Relative humidity (%)	avg.	67.1	60.2	74.6	**
	min.	*46.9*	*46.9*	*48.4*	
	max.	*96.1*	*67.4*	*96.1*	
THI	avg.	51.4	69.4	33.4	**
	min.	*26.3*	*66.0*	*26.3*	
	max.	*74.9*	*74.9*	*39.6*	

*Within the column (Sig.), values marked with * and ** differ (P < 0.05) and (P < 0.01), respectively or the difference is not significant (NS)*
Within the row, values marked with different letters a, b, c, differ significantly

Cows spend on average 13 hours per day (h/d) laying down (Houpt, 1998). Tucker et al. (2004) specified the range between 9.4 – 14.7 h/d. In adverse conditions cows tend to spend more time standing than laying down, are more susceptible to health problems and produce less milk (Thorne, 2008). According to O'Driscolla et al. (2009) cows spend more time laying down in winter than in summer in any kind of housing arrangement. Vecera et al. (2012) also found greater numbers of cows laying down in colder periods compared to cows standing. A non-significant tendency regarding the preference of left side corresponds with the results of Hrouz et al. (2007), who found that 53 – 70 % of the observed cows preferred to rest on their left sides. Tucker et al. (2009) also observed left-side laterality in loose-housed dry cows; however the authors admitted that cows in pens or on pasture may exhibit no laterality when laying down. Although the cows show no overall preference of side as a group, there might be strong individual preferences (Gibbons et al., 2012).

Table II, Milk production, lactation number and days in milk of cows during H and L periods; differences in lying and standing

Period and row	n / avg.	Period			Lying x standing			Period x lying and standing					
Number and parameter		High	Low	Sig.	Laying	Standing	Sig.	High x Lie	High x Stand	Low x Lie	Low x Stand	Sig.	Sig. of inter.
Number	1568	784	784		1037	531		518	266	519	265		
Milk production (kg/cow/day)	28.9	30.4^{A}	27.4^{B}	**	29.1	28.5	NS	30.6	30.0	27.6	27.0	NS	NS
Lactation number (l/cow)	3.12	3.21^{A}	3.02^{B}	**	3.18^{a}	2.99^{b}	*	3.25	3.15	3.12	2.84	NS	NS
Days in milk (days/cow)	129.2	131.5	126.9	NS	130.4	126.9	NS	133.1	128.4	127.7	125.3	NS	NS

*Within the column, values marked with * and ** differ (P < 0.05) and (P < 0.01), respectively or the difference is not significant (NS)*

Within the row, values marked with different letters a, b, c, differ significantly

Table III, Milk production, lactation number and days in milk of cows during H and L periods; lying laterality

Period and row	n / avg.	Period			Side			Period x lying laterality					
Number and parameter		High	Low	Sig.	Left	Right	Sig.	High x Left	High x Right	Low x Left	Low x Right	Sig.	Sig. of inter.
Number	1037	518	519		594	443		293	225	301	218		
Milk production (kg/cow/day)	29.1	30.6^{A}	27.5^{B}	**	29.5^{a}	28.6^{b}	*	31.1	30.0	27.8	27.0	NS	NS
Lactation number (l/cow)	3.18	3.26^{A}	3.10^{B}	**	3.19^{a}	3.17^{b}	*	3.16	3.37	3.22	2.97	*	*
Days in milk (day/cow)	130.4	133.5	126.8	NS	131.5	128.9	NS	130.6	136.4	132.4	121.3	NS	NS

*Within the column, values marked with * and ** differ (P < 0.05) and (P < 0.01), respectively or the difference is not significant (NS)*

Within the row, values marked with different letters a, b, c, differ significantly

Zejdova et al. (2011) reported that older cows (4th lactation number and older) lay on the left side more often than younger cows (2nd and 3rd lactation). A greater milk yield in cows preferring the left side (Vecera et al., 2012) might be due to the anatomical differences in the left and right lung. A greater respiration capacity of the right lung allows better lung ventilation in cows lying on their left side. Presumably, there are more factors affecting laterality but the specific anatomy of adult ruminants is likely to be the main cause. This presumption was supported by Phillips (2002) who claimed that calves show no laterality because their rumen has not been developed and they are not forced to rest in the sternal position.
The findings of this study do not conclusively prove the anticipated negative impact of high temperatures on milk yield with Czech Fleckvieh cows. Findings do however suggest that high temperatures negatively affected milk yield in Holstein dairy cows, due to their greater sensitivity to heat stress (e.g. in Zejdova et al., 2011).

CONCLUSIONS

The findings reported in this study suggest important variations in behaviour of cows associated with high and low cowshed temperatures. Cows with a tendency to laying down were older (greater consistency) than the cows with a preference for standing and tended to produce more milk (a non-significant difference). Cows showing preference for laying down on their left sides produced more milk and were older than the cows laying down on their right sides.

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EFFECT OF CERTAIN BARN CONSTRUCTION CHARACTERISTICS ON INDOOR CLIMATE STATUS IN DAIRY BARNS IN BOSNIA AND HEREGOVINA

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ABSTRACT

The aim of this field study was to describe climatic status in dairy barns in lowland and in mountainous regions of BiH, and to examine correlations between chosen housing parameters and indoor climate. Totally 76 herds were visited once by a team of trained observers in 18 municipalities in Bosnia and Herzegovina. All barns in mountain region had tie-stall housing system (MH), while 30 barns in lowland regions had tie-stall system (LTS) and 8 of those loose housing (LLH) with or without cubicles. Presence of CO2 was quite different between groups, the average lowest was found in LLH and it was 627.5 ppm (ranging from 390 – 890), in LTS 936.7 (390-1690), in MH 1105.7 (390-5390). The highest measures roof temperatures were at LTS, and the average was 12.7, while in LLH were 10.49, MH 11.14 and AF 11.70. Mean floor area per animal for all farms was 6 m2/animal, in MH 6.4, LTS 5.4 and LLH 6 m2/animal. Mean barn volume for all farms was 27.9 m3/animal, in MH 25.5, LTS 26.5 and LLH 44.2 m3/animal. Average barn height was 3.6 m for AF, 5.7 m for LLH, 4 m for LTS and 2.8 meters for MH. The negative correlations between construction environment parameters was found for all combinations except for the air velocity in LTS barns. Some of the construction parameters could help in overall estimation of the housing quality in dairy cattle barns.

Key words: dairy cattle, construction of the barn, carbon dioxide, ammonia, air velocity

INTRODUCTION

Housing potentially provides protection from aversive climatic conditions (Legrand et al., 2009), but depending on housing quality it may also exacerbate extremes (Phillips, et al., 2013). Housing conditions and management are important factors affecting the health of dairy cows and other aspects of their welfare. Housing, including thermal conditions, has multifactorial consequences that can affect cow welfare and health. The relationship between the animal and its environment determines the degree to which an animal remains in thermal equilibrium with its environment

(Finch, 1976). Poor building design and unsuitable microclimate may result in thermal stress or diseases, resulting in decreased productivity and risks to their welfare (Charles, 1981; Cena and Clark, 1981). Poor ventilation may also increase the relative air humidity or concentrations of gases like carbon dioxide and ammonia. Humidity in animal houses originates from direct evaporation from the animals, their breathing or by evaporation from urine and faces (Charles, 1981; Cena and Clark, 1981). Even low concentrations of ammonia are considered to endanger health (Danuser et al., 1988; Brautbar et al., 2003). BiH dairy sector is still based mostly on small scale farms. Loza (2014) found that as much as 75.8% of the commercial dairy herds in BiH are smaller than 5 cows, and majority of the farms have tie-stall housing system.

Hence, the aim of this field study was to describe climatic status in dairy barns in lowland and in mountainous regions of BiH, and to examine correlations between chosen housing parameters and indoor climate.

MATERIALS AND METHODS

The research was carried out in the period from December 5th, 2013 to March 15th, 2014 and 76 herds were visited once by a team of trained observers in 18 municipalities in Bosnia and Herzegovina. Farms were randomly selected from the database of Register of agricultural Producers (www.apif.net), from which half of the herds (n=38) were selected from a geographical area lower than 300 meter above sea level (lowland herds) and the other half of the herds (n=38) were selected from a geographical area above 600 meter above sea level (mountain herds). All barns in mountain region had tie-stall housing system (MH), while 30 barns in lowland regions had tie-stall system (LTS) and 8 of those loose housing with or without cubicles (LLH). Mean herd size of all farms (AF) were 11.9 dairy cows (range 5-107), in MH was 11.9 dairy cows (range 5 to 74), LTS barns accommodated 16.2 dairy cows in average (range 6-54) and LLH herds had 51.4 dairy cows (range 21-107). A systematic protocol was used to record data on each farm. This protocol was an adapted version of that one used in the Norwegian KUBYGG-project (Simensen et al, 2010). The dimensions of visited objects were measured by laser distance meter (LDM50, PCE instruments, UK). Based on these numbers, area per animal (not accessible space) and total air volume per animal was calculated. Farm height was always measured at the highest point of the barn from inside. Temperature and air humidity was measured using Thermo anemometer PCE-423 (PCE Instruments, UK), and from those parameters was calculated THI. Air velocity was also measured by PCE-423. Carbon dioxide (CO_2) and ammonia (NH_3) were measured in the center of each building using IBRID MX6 (Industrial Scientific Corporation, USA). Roof temperature was measured by Infrared laser thermometer PCE-777 (PCE Instruments, UK).

For the statistical analyses, herd was the statistical unit. Based on the recorded data from multiple animals per herd, herd means was first calculated and then used in the analyses. Then were done correlations of the between selected indoor climate parameters (and housing parameters of the barn.

RESULTS AND DISCUSSION

The THI was lowest in MH and was 48.6, then LLH 50.2, LTS 53.6 and at AF 50.94, and those values were not extreme, as EFSA (2009) suggested that cows are subject of discomfort when THI exceeds 75. There were not detected some higher concentration of NH_3, and on those were from 0 – 3 ppm. Presence of CO_2 was quite different between groups, the average lowest was found in LLH and it was

627.5 ppm (ranging from 390 – 890), in LTS 936.7 (390-1690), in MH 1105.7 (390-5390) and at AF was 988.68. The highest presence of CO_2 was detected in MH farms, and was 5390 ppm. EFSA (2009) suggested that cows are adversely affected by gas concentrations in dairy cow houses exceeding: ammonia 10 ppm, H2S a measurable amount e.g. 0.5 ppm, carbon dioxide 3000 ppm. The highest measures roof temperatures were at LTS, and the average was 12.7, while in LLH were 10.49, MH 11.14 and AF 11.70. Mean floor area per animal for all farms was 6 m^2/animal, in MH 6.4, LTS 5.4 and LLH 6 m^2/animal. Mean barn volume for all farms was 27.9 m^3/animal, in MH 25.5, LTS 26.5 and LLH 44.2 m^3/animal. Average barn height was 3.6 m for AF, 5.7 m for LLH, 4 m for LTS and 2.8 meters for MH.

Correlations

In next tables there are shown correlations between selected construction parameters of barns height (in further text: height), area per head in m^2 (A/H) and volume per head in m^3 (V/H), on one side and temperature humidity index (THI), air velocity, NH_3, CO_2 and roof temperature (roof T), on the other side.

All farms

Tab. 1. Correlation between chosen parameters at AF

N=76	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,0406 p=0,728	0,1822 p=0,115	0,1111 p=0,339	-0,1869 p=0,106	-0,2446 p=0,033
A/H	-0,1511 p=0,193	0,0819 p=0,482	-0,0423 p=0,717	-0,0091 p=0,938	-0,3335 p=0,003
V/H	-0,1424 p=0,220	0,1100 p=0,344	0,0030 p=0,979	-0,1022 p=0,380	-0,3337 p=0,003

When all groups were joined and analyzed as one group (AF), the height was negatively correlated with THI and CO_2 (table 1). Correlations of barn height for AF stalls and examined microclimate parameters are of negligible for THI to very weak for air velocity, CO_2 and NH_3. The highest correlation coefficient was recorded between building height and the temperature of the roof, with the emphasis that the correlation is negative, which is logical. The height of building, the space allowance also contributes to air quality and thus welfare by its association with air volume (EFSA, 2009). Correlations between A/H and microclimate parameters are of negligible to weak. A negative correlation was observed between (A/H, THI, NH3 and CO2), except when the air velocity. The highest negative correlation was observed between the A/H and the roof T. V/H was negatively correlated to THI and CO2 Roof T, and positive correlation was observed at air velocity and NH3. As in the previous two cases, the highest negative correlation was observed between V/H and the roof T.

Loose housing lowland

The height of the barns LLH showed a negative correlation for THI, air velocity, NH3 and roof T (Tab. 2). A strong negative correlation was found for THI, indicating that the size of the object directly influences the temperature comfort dairy cows. A strong negative correlation was found for air velocity parameter. This could be explained by the building's structure. In these barns height was usually higher than in other groups, windows are usually placed at higher altitudes (under the roof) and air velocity measurements were done at the level of heads of animals. Correlation coefficients between the A/H and microclimatic parameters THI, NH_3 and roof T were in negative relations (Tab. 2). Positive correlations were between A/H and air velocity and CO_2. Correlation with CO_2 is negligible, and to the air velocity is weak. Comparing air velocity correlations between construction parameters for AF and LLH, we can notice higher correlations in loose housing farms, what could be effect of higher available area per head and more space for air circulations.

Tab. 2. Correlation between chosen parameters at LLH

N=8	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,7120 p=0,048	-0,8274 p=0,011	-0,2866 p=0,491	0,0753 p=0,859	-0,1041 p=0,806
A/H	-0,0391 p=0,927	0,2717 p=0,515	-0,0389 p=0,927	0,0821 p=0,847	-0,2970 p=0,475
V/H	-0,4458 p=0,268	-0,3181 p=0,443	-0,1200 p=0,777	0,1542 p=0,715	-0,2136 p=0,611

Negative correlations were found between V/H and air velocity, NH3 and roof T. For NH_3 and roof T correlations were negative and very weak, for the air velocity was low, and the T and THI medium negative. The very weak positive correlation between A/H and CO_2, could be result of higher percent of decomposition of organic matter (straw) in those barns, as straw lies longer at the barns, comparing to tie-stalls in both regions bellow 300 m.a.s.l. and above 600 m.a.s.l., and also there is more straw used in those types of barns (Tab. 5).

Tie-stalls lowland

The negative correlations between construction environment parameters was found for all combinations except for the air velocity in LTS barns (Tab. 3). The largest negative correlations were observed between the parameters of construction facilities and the concentration of CO_2 and roof T. When it comes to the negative correlations between CO_2 and design characteristics of the studied objects/stables, it provides information that higher space per head, reduces the concentration of CO_2, as well as the roof T.

Tab. 3, Correlation between chosen parameters at LTS

N=30	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,0253 p=0,894	0,2048 p=0,278	-0,0015 p=0,994	-0,1531 p=0,419	-0,2657 p=0,156
A/H	-0,1720 p=0,364	0,0131 p=0,945	-0,1857 p=0,326	-0,4526 p=0,012	-0,3449 p=0,062
V/H	-0,1735 p=0,359	0,1682 p=0,374	-0,1329 p=0,484	-0,3831 p=0,037	-0,3955 p=0,031

Pedersen, S. and Sällvik, K. (2002) suggested that lower calculated ventilation increased measured CO_2. Results from this research showed also that spacious animal room could help in dispersion of CO_2. Air velocity has positive but very weak correlation with barn construction parameters and seems all are related to barn indoor environment (Tab. 3).

Mountain farms

Correlations between constructional parameters of MH (Tab. 4) showed negative correlations with THI. The highest negative correlations were observed ($p < 0.05$) for the roof T, which indicates the close connection between the total available space for animals and a roof T. The air velocity shows in relation to the construction solutions very weak positive correlation, and suggest that the flow increases with the increase of usable space in the barn. The correlations between CO_2 and certain characteristics of the objects were negligible.

Tab.4, Correlation between chosen parameters at MH

N=38	*THI*	*Air velocity*	*NH3 ppm*	*CO2 ppm*	*Roof T*
HEIGHT	-0,2050 p=0,217	0,1721 p=0,301	0,1240 p=0,458	-0,0849 p=0,612	-0,4416 p=0,006
A/H	-0,1068 p=0,523	0,1362 p=0,415	0,0943 p=0,573	0,0474 p=0,778	-0,3228 p=0,048
V/H	-0,1082 p=0,518	0,1285 p=0,442	0,0899 p=0,592	-0,0408 p=0,808	-0,3526 p=0,030

CONCLUSIONS

Conducted research showed that there are differences between housing systems and building approach among three groups of barns/farms, low land group housing barns, lowland tie-barns and mountain barns. Some of the construction parameters could help in overall estimation of the housing quality in dairy cattle barns.

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THE SIZE OF THE FARM AND ITS INFLUENCE AT CLEANLINESS OF THE COWS AND MILK HYGIENE

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ABSTRACT

For animals the sense of physical comfort is necessary (physical comfort). When animals feel physically comfortable, it means that every part of their bodies is in harmony with the surrounding area. Therefore, the farms are usually build in accordance with the number of cattle that will be hold in designed facilities, which provide a higher degree of cows cleanliness. Cleanliness of cows is important in order to produce hygienically clean milk and to achieve the cattle welfare of dairy cows too. Cleanliness of animals mostly depends on what kind of object they are placed in. Hygienically proper milk includes the number of microorganisms up to 100,000 / ml and the number of somatic cells to 400,000 / ml, which are regulated by the "Regulations on quality of fresh raw milk." For this research farms are divided into three groups according to the number of cows. The first group included the number of cows from 1 to 9, the second group included 10 to 19, and a third group 20 or more cows. The aim of this paper is to examine whether there is an influence of the size of farms (number of cows) on the subjective cow cleanliness and hygienic quality of milk.

Key words: cow cleanliness, somatic cells, bacteria, the number of cows

INTRODUCTION

The main objective that has to be realize while projecting stalls for cows is to provide the appropriate accommodation, such as comfort, favourable microclimate, feeding, milking and manure evacuation (Čobić and Antov, 1996). The European Commission for Food Safety gave the corresponding recommendations for keeping dairy cows that farmers have to respect in order to achieve good production and also achieve the welfare of dairy cows (European Food Safety Agency, 2009).

Cleanliness of cows is important in order to produce hygienically proper milk and to achieve the welfare of dairy cows too. Cleanliness of animals mostly depends on what kind of object they are placed in. To produce milk of good chemical and microbiological composition, it is necessary to provide conditions for milking, and to carry out milking properly. Disinfection of teats after milking, as only protection, especially in a shorter period of time does not prevent from new cases of mastitis (Hristov and Reljic, 2004). Besides daily cleaning, it is preferably at least once a year to make a thorough cleaning of the entire barn, and then painting (Regional Office for Europe and Central Asia Food and Agriculture Organization of the United Nations, 2013).

Hygienically proper milk includes the number of microorganisms up to 100,000 / ml and the number of somatic cells to 400,000 / ml, which are regulated by the "Regulations on quality of fresh raw milk." Every increase in the number of somatic cells in milk above 100,000 / ml is connected with a decrease in milk production, and it has an impact on the quality of milk products (Katic, 2007). High bacterial levels in milk, whether originating from the cow or the environment, substantially affect the quality, safety, and consumer acceptance of milk and dairy-derived products (Piepers et al, 2014). The aim of this paper is to examine whether there is an influence of the size of farms (number of cows) on the subjective cow cleanliness and hygienic quality of milk.

MATERIALS AND METHODS

On the territory of Bosnia and Herzegovina a group of researchers in the period from 05.12.2013 to 15.03.2014 made an investigation within the project named "Evaluation of the welfare and quality of accommodation dairy cows in Bosnia and Herzegovina". This research was aimed to examine the quality of accommodation for dairy cows in Republic of Srpska, Bosnia and Herzegovina. Research was conducted on 76 farms that are owned by registered agricultural producers.

On the special scheme that was used for the evaluation of cow`s hygiene, was assessed five cows on each farm. That pattern contained: the number of cows, rump appearance, appearance hooves, changes on body parts (scratches, swelling, open wounds, parts without hair), and schematic drawings of cows with ratings for thighs, legs, udder, stomach left and right side and schematic view of the back of the cow. Legs, stomach and thighs are usually the dirtiest part of the cow`s body that are located in the barn while the udder is usually cleaner because it is cleaned daily because of milking. Considering with previous statements, these regions are the most critical at these farms where we specifically determined purity: thighs and legs on the left and right sides, udder and belly also within left and right side, as well as the back of the cows in particular. These marks are numbered on a scale from 1 to 4. Mark 1 means that cow is clean, grade 2 some dirty, grade 3 dirty while score 4 indicates a very dirty cow.

Marks for cow cleanliness are rated from 1 till 4 (Ruud et al, 2010)

Cow cleanliness score	1 (clean)	2 (some dirt)	3 (dirty)	4 (very dirty)
Rear				
Thigh				
Leg				
Udder				
Belly				

Schematic representation

RESULTS AND DISCUSSION

The results of this research show that number of cows has not significant influence on subjective cleanliness and hygiene of milk (number of somatic cells and bacteria). For this research farms are divided into three groups according to the number of cows. The first group included 1 to 9 cows, the second group included of 10 to 19 cows and the third group included 20 or more cows.

Table 1, Descriptive analysis for subjectively cleanliness related to cows number

Statistical parameters	$\bar{X}$	***S***	***Sx***	***CV***	***min***	***Max***
First Group	2.10	0.56	0.12	26.67	1.2	3.4
Second Group	2.08	0.76	0.14	36.54	1	3.6
Third Group	1.97	0.68	0.20	34.51	1.2	3.2
Average	2.05	0.67	0.15	32.57	1.13	3.4

Average amount of subjectively cleanliness for first cows group was 2.10. The smallest average value of subjectively cleanliness for first group was 1.2 whereas the largest average value was 3.4. Average amount of subjectively cleanliness for second cows group was 2.08. The smallest average value of subjectively cleanliness for second group was 1 whereas the largest average value was 3.6. Average amount of subjectively cleanliness for third cows group was 1.97. The smallest average value of subjectively cleanliness for third group was 1.2 whereas the largest average value was 3.2. Average amount of coefficient of variation for all cows groups was 32.57.

Table 2, F test for subjetively cleanliness in comparison with number of cows.

Number of heads	$\bar{X}$	F calculated	F tabularly	
			0.05	0.01
First group	2.10	0.15	3.15	4.98
Second group	2.08			
Third group	1.97			

Average mark of subjectivaly cleanliness for 1st group of cows is 2,10 for 2nd 2,08 and for third group 1,97. Calculated value of F test is not statistically significant in terms of subjectively cleanliness of cows.

Average number of somatic cells for first group of cows was 233,794. The smallest average number of somatic cells in milk for first group of cows was 11,101 whereas the biggest number of somatic cells was 1044,003. Average number of somatic cells for second group of cows was 155,304. The smallest average number of somatic cells in milk for second group of cows was 7,781 whereas the biggest number of somatic cells was 895,689.

Table 3, Descriptive analysis for number of somatic cells related to number of cows

Statistical parameters	$\bar{X}$	S	*Sx*	*CV*	*min*	*Max*
First Group	233,794	287,210	61,233	122,85	11,101	1044,003
Second Group	155,304	190,572	36,014	122,70	7,781	895,689
Third Group	160,588	133,886	38,649	83,37	28,488	436,160
Average	183,229	203,890	45,299	109,64	15,790	791,951

Average number of somatic cells for third group of cows was 160,588. The smallest average number of somatic cells in milk for first group of cows was 28,488 whereas the biggest number of somatic cells was 436,160. Average amount of somatic cells for all cows groups was 109,64.

Table 4, F test for number of somatic cells related to number of cows

Number of heads	$\bar{X}$	F calculated	F tabularly	
			0,05	0,01
First group	233,794	0.85	3.15	4.98
Second group	155,304			
Third group	160,588			

Average number of somatic cells in milk for 1st group of cows is 233,794 for second group 155,304 and for third group 160,588. Calculated F test is not statistically significant for number of cows when we talk about number of somatic cells in milk.

Table 5, Descriptive analysis for number of bacteria in comparison with number of cows

Statistical parameters	$\bar{X}$	S	*Sx*	*CV*	*min*	*Max*
First Group	58,602	69,897	14,902	119,28	7,351	319,976
Second Group	81,824	205,033	38,747	250,58	4,076	1099,015
Third Group	32,704	25,201	7,275	77,05	9,606	100,466
Average	57,710	100,044	20,308	148,97	7,011	506,486

Average number of bacteria for first group of cows was 58,602. The smallest average number of bacteria in milk for first group of cows was 7,351 whereas the biggest average number of bacteria was 319,976. Average number of bacteria for second group of cows was 81,824. The smallest average number of bacteria in milk for second group of cows was 4,076 whereas the biggest average number of bacteria was 1099,015. Average number of bacteria for third group of cows was 32,704. The smallest average number of bacteria in milk for third group of cows was 9,606 whereas the biggest average number of bacteria was 100,466. Average amount of bacteria for all cows groups was 148,97.

Table 6, F test for number of bacteria in comparison with number of cows

Number of heads	$\bar{X}$	F calculated	F tabularly	
			0,05	0,01
First group	58602.14	0.50	3.15	4.98
Second group	81824.27			
Third group	32704.71			

Average number of bacteria in milk for 1st group of cows amounts 58602. 14 for 2nd group is 81824. 27 and for third group is 32704.71. Calculated value of F test is not statistically significant if we talk about number of bacteria in milk.

CONCLUSION

In recent times dairy cows are selected by level of production. In that way it is necessary to provide adequate housing conditions. Good conditions will have positive effects on their health, and good quality of milk too.

The results that we have obtained show that the number of cows has no influence on subjective cleanliness of cows. It has been observed that in all three types of farms have approximately the same rank of cow`s hygiene. Results also showed that there is no significant influence of the number of cows on the hygienic quality of milk. Properly managing as well as cleaning stalls and cows guarantees a high quality of milk.

ANNOTATION

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CHARACTERISCS OF INDOOR MICROCLIMATE STATUS IN GOAT BARNS IN BOSNIA AND HERZEGOVINA

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ABSTRACT
The aim of this paper is to explain microclimatic indicators in the winter inside buildings for of goat housing in Bosnia and Herzegovina. Data processed in this paper were collected from ten goat farms which are deployed throughout Bosnia and Herzegovina. In the housing facilities for goats for whose were determined the microclimate status, the average temperature was in the range of optimal values. Average airflow in facilities for goats in Bosnia and Herzegovina was below the 0.2 m/s during the winter period. The average relative humidity in the goat barns in Bosnia and Herzegovina ranged permitted values. The average determined concentration of ammonia in the air barn goat farm is located above the allowable limit. On based of established levels of CO 2 in goat barns in Kozara region of Bosnia and Herzegovina could be concluded that there is above the allowable limit. Reducing the levels of harmful gases in the facilities may be required in increasing the air change in buildings either natural or artificial ventilation.

Key words: goats, housing, winter, microclimate, gases

INTRODUCTION

The goat is a kind of domestic animal that produces products such as milk, meat necessary for human nutrition, quality leather and sackcloth of which are used in clothes production, but also other things and manure that is used to improve soil fertility. Goat husbandry nowadays is characterized by three production systems: extensive, semi-intensive and intensive. Extensive system is characterized by low investment in facilities for goats. Goats are placed in inappropriate facilities during the winter and feed on shadows with minimum of available concentrate feedstuffs. Breeds held in this way belong to the group of primitive or natural breeds. Semi intensive way of goat housing and breeding implies something greater investment in facilities for the animals and complete diet. Breeds kept in this way belong to the group of crossbreeds between primitive and noble breeds, and can be bred noble breeds, which in this case achieved lower production. Intensive way of goat's breeding, means the keeping of animals throughout the year within the buildings in which construction was invested more resources. Farms for intense way of goat production in its composition have all necessary facilities intended for smooth production technology. Goat breeds that are grown in this system it belongs to the group of noble race whose expression of genetic potential, in particular for the milk or meat production and those need necessary balanced diet. In order to preserve the health of animals, and therefore production, while keeping goats inside buildings, regardless of the breeding system is necessary to ensure adequate microclimate. Elements of microclimate prevailing in barns for goat housing define the environment in which the goats will spend its lifetime. It could be said that optimum microclimatic conditions, with their actions have beneficial effects on health of the animals, better feed utilization, and favorable metabolism and finally allow maximum delivery of planned production results. In practice, especially in extensive and semi-intensive way of goat breeding is not given enough importance to microclimate conditions inside buildings, what affects negatively the health and productivity of animals, which cannot be tolerated in intensive production.

The aim of this paper is to explain microclimatic indicators in the winter inside buildings for of goat housing in Bosnia and Herzegovina.

MATERIALS AND METHODS

Data processed in this paper were collected from ten goat farms which are deployed throughout Bosnia and Herzegovina. Two farms were located on the route Sarajevo - Žepa, five farms are located in the Western Herzegovina in the area of municipalities Tomislavgrad and Široki Brijeg and three farms are around city of Banja Luka. Farms have had more than 50 goats belonging to the different production systems of goat production. Buildings that housed goats were purpose-built for that purpose or were adapted for keeping goats. Data that were taken on farms are: the dimensions of buildings, number and surface of windows, no ventilation Aperture on the walls and on the roof, the temperature inside the building, the temperature of the reservoir, the roof temperature, relative humidity, carbon dioxide concentration, the concentration of ammonia, lighting and air flow inside the building.

All dimensions in barns were measured by laser meter PCE-LDM 50 laser Measuring range from 0.05 to 50.0 m with tolerance of 1.5 mm. Temperature and relative humidity were obtained using thermal anemometer PCE – 423. Thermo-anemometer is one of the basic equipment for the measurement of microclimate and ventilation control, and is characterized by high resolution and a wide range of applications. The device has a telescopic probe on the end that enables the measurement in difficult access areas. Air velocity was measured by an anemometer PCE-AM 82. With this instrument there were measured the temperature inside the buildings as a control indicator. Airflow speed is expressed in m/s and temperature in ^{0} C. The concentration of stable gas was measured using the IBRID MX6. This instrument is a universal detector of up to 6 different gases in simulative memory data and operating software. Signaling of IBRID MX 6 devices is performed over a loud beep with an accompanying flashing display. The instrument gives a signal to a low or high level. IBRID MX 6 machine has an optional electric pump, which provides that before entering the area, to check the concentration of greenhouse gas emissions that are already in it. The suction pump allows the connection pipe length up to 30 m for intake of air into the instrument and detection of gases. The device has its own memory where data is stored by the given parameters. Before measuring of gases the device was calibrated and values where actually zero values, and values showed in this paper means amounts of gases above normal atmosphere concentration of those. The intensity of light within buildings is measured by the instrument PCE-MLM 1 LUX meter whose measuring range goes up to 40,000 lux. The resolution of the instrument is 1 lux, and its accuracy ranges from 5% if the luminous intensity of less than 10,000 lux, or in the range of 10% if the luminous intensity is greater than 10,000 lux.

The data obtained by the monitored parameters were processed on the basis of statistical methods and are calculated arithmetic mean, standard deviation, standard error of the arithmetic mean, variation coefficient and the minimum and maximum tolerances.

RESULTS AND DISCUSSION

Goat farms on which were measured microclimate parameters are belonging to all agro-ecological zones that are represented in Bosnia and Herzegovina. Farms were built of hard materials such as brick and block, to objects made of wood. Table 1 provides data on the size of objects and the number of animals in them.

Table 1. Number of goats and housing surface in visited barns

Category/ statistical indicators	X	S	SX	V	Min. Max.
Goat	112.7	47.96	16,00	42,55	35 180
Capricorn	3.5	2.12	0.80	60,60	1 7
The surface/animal	2.39	1.37	0.45	57,25	0.70 4.31

On all farms goats were kept in the loose housing system. Animal room inside the object are divided into several pens. Number of pens is dependent on the size of the building and the number of goats located in the facility. Depending on the size of the box the number of goats in the same ranged from 5 to 30. The resulting average area per goat is above satisfactory surface ranging from 1.2 to 1.5 m^2 per animal. Larger size of living space than recommended can be explained by the time when they took data from farms. Kidding of goats in our agro ecological conditions begins in early February and ends by the beginning of March, and the measurement of microclimate parameters was performed in the second half of January. Counting that living space which was provided for kid was 0.25 to 0.30 m^2, we can conclude that the population of goats by objects moving in the normal range.

Table 2. Microclimate indicators inside goat barns

Indicators microclimate	X	With	With $_X$	V	Min. Max.
Temperature, ^{0}C	11,47	2.15	0.71	18,38	6.00 14.00
Temperature of bed of ^{0} C	13,00	2.75	0.91	21,16	8.00 17.40
The temperature of the roof, ^{0} C	12,01	2.17	0.72	18,04	8.10 14.80
The air flow, m / s	0,039	0.03	0.01	86.65	0.01 0.11
RH of air,%	69.95	13,99	4.67	20,01	58.00 92.00
Light, lux	38.78	48,23	20.38	124.34	0.20 158.00
NH_3 ppm	2.13	0.92	0.35	43,52	1.00 3.00
CO_2 %	0.1	0.02	0.01	22.90	0.08 0.14

The goat breeders of high yielding goats should be aware of the microclimate inside buildings because those goats are sensitive to low temperatures, drafts and moisture. So for these reasons to have healthy and highly productive goats in barns, favorable microclimate conditions must be provided. Table 2 provides information on the microclimate inside visited barns of goats in Bosnia and Herzegovina.

The microclimate parameters are important indicators of air quality in the housing facilities for goats. Inside the facilities it is necessary to provide appropriate microclimate conditions, no whose largely depends the health and welfare of the animals, so as poorly ventilated barns with stale air, are inadequate environment for the skin. In addition microclimate in barns has a big influence on milk production, because any deviation levels of certain microclimate indicators than those recommended could result in reducing milk production. Goat which have below the cool litter, which was served cold food and water, will less time spend lying and resting on the contrary it will stand more, will shiver and waste energy. From these goats breeder will get lower production, they will get sick more often, especially on respiratory organs and udder diseases. Goats that are located in facilities where there is high temperature losses of appetite and food consumption and consequently reduce milk production. As we see, both extremes, low and high temperature inside the facilities has the final outcome of reducing the production and health damage goats. The corresponding temperature is in the range of 5 ^{0}C to 27 ^{0}C, while the optimum temperature range of 10 ^{0}C to 15 ^{0}C in the accommodation facilities of adult goats. For kids preferred temperature is slightly higher, and it is moving in the intervals of 12 ^{0}C to 27 ^{0}C, and optimum in the range from 18 ^{0}C to 20 ^{0}C within barn (Simović and Kojic, 1981). However a study by Bøe et al. (2007) measuring thyroxine (T4) indicates that goats adapt within 2 days to an ambient air temperature of 128C. Cold, uninsulated housing is commonly used for dairy goats in Canada, Sweden and Norway (Bøe and Ehrlenbruch, 2012). In the housing facilities for goats for whose were determined the microclimate status, the average temperature was in the range of optimal values. Temperature of lying surfaces and the temperature of the roof had higher average value than the temperature inside the building, what has logical explanation. In all the facilities where they lay there were deep litter, which retains heat, besides the warm air is lighter and goes to the roof of objects and the heat same.

Livestock facilities should protect the animals from adverse weather conditions and to provide good health, well-being and productivity of animals. This is possible only if the object is technologically well equipped, functional and has a good structural solutions, which largely determines the microclimate conditions inside buildings (Marciniak, 2014). Already in the design phase of buildings it is to plan appropriate exchange between object and surroundings, which is achieved by designing adequate ventilation. All visited farms used natural ventilation, only one had in addition to natural and artificial ventilation. Ventilation of the building is necessary because in order to make exchange of the polluted indoor air with fresh coming from the outside. Inadequate ventilation can cause adverse health effects on goat, if it manifests as a directed flow, which are directly exposed to the skin. A strong draft can cause-negative consequences, especially on the health of goats, and if the intake air have much lower temperature than the temperature of the air that is in the animal room and the goat body. Depending on the breed and categories of animals air velocity should to be limited to 0.2 m/s, and only during the summer, when are higher temperatures this can reach as 0.5 m/s. Average airflow in facilities for goats in Bosnia and Herzegovina was below the 0.2 m/s during the winter period. This air flow was expected, as in the period of investigation the outside temperatures were quite low. Ventilation in the winter, especially when outside temperatures are low, should be minimal, just to remove the polluted air, while ventilation in the summer should be a maximum with a view to eject excess heat from buildings.

Humidity inside goat barns depends on the humidity of air entering the barn, either natural or artificial ventilation, and humidity that occurs within buildings. Humidity inside buildings may originate from the animals through breathing and evaporation from urine and feces. Relative humidity inside goat barns should range from 40% to 80% (FAO, 1988). High humidity range air in animal housing hinders normal body moisture and heat exchange with the environment, causes diseases of the skin and mucous membranes, appear cold and soiling of the body and on the other hand, low humidity range causes increased amounts of dust floating in the air, which causes dryness and inflammation respiratory mucosa, and by itself causes great loss of moisture by evaporation, and the constant feeling of thirst (Radivojevic, 2005). The average relative humidity in the goat barns in Bosnia and Herzegovina ranged permitted values. Szulc and Rezeznik (2007) reported that high humidity in winter increases the feeling of cold, and in order at the optimal temperature (15 ^{0} C) optimal relative humidity was 75%. In addition, the same authors report that high temperatures and low relative humidity causes dry mucous membranes of animals, which makes them vulnerable to infection.

During the day, the interior lighting of the largest number of visited barns achieves natural light. In order to ensure enough daylight, and in addition to ventilation, windows should cover from 8 to 10% of the total floor and wall area. The windows through which one gets the most of daylight are set so that light falls goats on its back, in addition to plans to crib should be well illuminated. At the present time in the intensive system of goat breeding are increasingly practiced by the application of artificial lighting.

The presence of gas in the barn relates to the level of carbon dioxide (CO_{2}), ammonia (NH_3), hydrogen sulfide (H_2S) and methane (CH_4) in the barn air. The presence of sulfur-hydrogen and methane in the stable air can be recorded over the limit very rare. In the intensive livestock harmful gases accumulate in the barn air, originating from the same metabolically processes that occur in animals or feedstuffs for goats. Goats secrete themselves breathing gases, as well as gases generated by fermentation and decomposition of organic matter from feed and manure. The fermentation and decomposition of organic matter in stables was particularly emphasized during the summer, when decomposition processes are accelerated under the influence of high temperatures, although the same effects can occur in the winter, when it comes to maintaining a favorable temperature barn air, and when ventilation rate is reduced to a minimum (Radivojevic 2005).

Ammonia is a strong irritant gas, odor, is toxic in animal housing, and it is formed by decomposition of feces and urine. Ammonia concentration above the permissible values in the animal room air irritates the mucous membranes of the respiratory tract. The increased concentration of ammonia in facilities may occur due to unclear deposits of feces and bedding straw. Ammonia is much lighter than air, so it is in the upper layer of animal room air (Radivojevic, 2005). The concentration of ammonia in the barns depends on the type of stalls, the number of animals in the house, and on the external factors such as temperature, humidity and air flow. In addition to these factors on the level of ammonia in the buildings affected by additional ventilation, types of mats and frequency of cleaning stalls (Groot Koerkamp et al., 1998; Wathes et al., 1998). Also, wet conditions, it is to increase the relative humidity or humidity of bedding material, increase the rate of generation of ammonia (Hristov, 2002). The presence of ammonia in the barn air is allowed in concentrations up to 0.15 l / m ^{3} or 0,015% by volume, or 150 ppm. The average determined concentration of ammonia in the air barn goat farm is located bellow the allowable limit. That in the buildings was present inadequate ventilation confirms the very low speed of the airflow, which is far below the speed limit for winter conditions of 0.2 m/s.

The concentration of CO_2 in the stables for animals depends on the building structure, the number of animals accommodated, technical characteristics and functionality of the ventilation system. Carbon dioxide is collected at the floor of the object because it has a larger specific weight than air. Due to its solubility in water, occurs when in ceiling area when it is bound to water vapor, which is warmer and lighter than air, so for these reasons is moving toward a ceiling in the barns. In the German Standard (DIN 18910, 1992) carbon dioxide is regarded as an indicator of ventilation intensity in animal housing and a carbon dioxide level of 0.3 % should not be exceeded. However, if add the atmosphere CO_2 to average values of CO_2 measured in visited goat barns, still those were half lower bellow limit (0,14%).

CONCLUSION

Goat production in Bosnia and Herzegovina is in a form of expansion for the reason that there are favorable conditions for goat breeding, and goat offers high-quality and high-grade products for human consumption. In addition itself goat production is profitable, perhaps at this moment more profitable than other branches of livestock production. Goat production is based on noble races, balanced diet and adequate housing. Noble breed of goats intended for high milk production are kept in an intensive way in buildings designed in detail for the purpose by technological activities and respect animal welfare. On the base of conducted investigation, seems most of the farmers take care on housing quality of kept animals, however in some barns ventilation systems should be advanced.

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PROFESSIONAL OPINION

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SYSTEM OF ACTIVE STABLING FOR HORSES

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ABSTRACT

Horses are animals, which are naturally accustomed to all day movement and grazing with their herd. But the typical modern stabling of horses usually looks like so that a horse is 23 hours per day in a box alone. The welfare of horses is very bad in such case, but it is very comfortable for its keepers. Now, a new technology is available on market presenting a compromise for both sides - for the horses and for the human. 'System of active stabling' allows the horses to move freely in paddock and stable area. Each horse has a chip which communicates with the sensors placed on the requisite point and it also sends information to the operating computer. Feeding is done by feeding stations, in which a number and composition of the feed can be set for each individual animal. Thus, breeder has always a review available of how much his horse walked or how much of feed ate. And he has the option to direct horse choice, too.

Key words: horse, active stabling, welfare, feeding station.

INTRODUCTION

In today's time, welfare of dairy cows is often better than in the case of the horses. Cows in free stalls can to move freely, maintain social contacts, eat or rest whenever they want and if milking is carry on by automatic milking robot, then we can say that they had "flexible working time". But when we look at the typical stabling of horses, it usually looks like so that a horse is 23 hours per day in a box alone (in the worst case even tethered in a stall) and it is taken by its rider to the hippodrome for one hour. If it is lucky and it can walk into the paddock, but it has a strictly defined "timetable", usually there. It is the best thing you can make for your horse – to give it all day free movement at the pasture. More and more breeders become aware of this fact, most of them succumb to their own comfort usually, when they knows that whenever they will come into the stables, they will find their horse to wait for them at its place - just to clean, to gear and to ride. As well as, people oppose to longterm stay of horse with the herd in the paddock because then they loses track of what feed ration ingest by their pet actually. They are afraid that the expensive granules were eaten by the extraneous pony and that (perhaps due to the more dominant individuals in the group) their horses did not had enough hay.

MATERIALS AND METHODS

“System of active stabling” allows the horses to move freely. To make the system function optimally, is necessary to have in addition to stable a space where horses can move and where the feeding points may be placed, watering places, etc. Each horse has a chip (on foot or in a mane) which communicates with the sensors placed on the requisite point and, of course, it also sends information to the operating computer. Thus, breeder has always a review available of how much his horse walked or how much of feed ate.

Feeding is done by a “Compident horse” stations, in which a number and composition of the feed can be set for each individual animal (it is possible to combine up to eight loose and one liquid feed). An animal gets (or does not get) a food according to a set parameters after entering to the feeding station. The natural position of the cattle-bin near the floor leads to the fact that horses receive the feed with bowed head and they do not gollup - this has an impact on the natural and smooth function of the digestive tract. In another place of the paddock, there is a station with a roughage placed (it is possible to use a bales or a loose material), waterhole, housing area, pasture, etc. Thanks to the area segmentation and a distance of the individual "points of interest" horses are forced into a natural activity that is similar to their behavior in the nature. But abreast with it, their owner has the option to direct horse choice, because animals must go through a selective computer-controlled points. For example, during the spring an access can be restricted to a rich and nutritious pasture for horses with a tendency to be fatty and allowed them to an area where only a hay is available instead. In the contrast, there will be an access granded for old horses or for individuals in a bad condition (to those rich and nutritious pastures) for which is such grazing desirable. Thus, feeding horses and other activities are controlled without the animals being forced to do something violently. It is proved that horses in the “System of active stabling” walked at average of 10–15km, which is significantly higher in comparison with the classic egress. Basically, it is the equivalent of the popular "paddock paradise", but system of active stabling has the advantage that although the horse decides for himself what it will do, the breeder can peacefully regulate its activity and also have an overview.

Moreover, a constituent advantage of the system is a fact that it reduces the workforce, which leads to a better working effectiveness. For example, in a stable in Austria, the only stable-girl manages daily care of thirty horses in three hours approximately, without her being revised and horses being suffered. Thank to this measurement, practically, horses care of themselves and so, the keeper may work especially with a cleaning and with replenishing reservoir in the feeding station, but first and foremost, he can also oversee the operation of the system. The saving of the feed is great, too – because there is no undue waste. Sophisticated feeding box “Compident horse” won an award for innovation at last year's Equitana exhibition.

CONCLUSION

“System of active stabling” contributing to a health and well-being of the horses, filling their natural needs while reducing demands on a labor and on a feeding and leads to a better working effectiveness. Acquisition price of this system is no higher than the classic boxing stables for 20 horses. Innovative stabling system is already quite common in Austria with several dozen "active" stables, or in German and Switzerland – there the completed projects exceed 100.

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TECHNOLOGICAL DEVELOPMENT IN THE NORWEGIAN DAIRY SECTOR

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HISTORY

Arable land is covering less than 3% of the total area of Norway, and is partly situated north from the Arctic Circle. The remaining part is mainly forests and mountains. The history of the Norwegian people and agriculture was hence a history about poverty. Before the industrial revolution in the middle of the 17th century, the population lived on small farms where they grew what they needed for their self-sufficiency. Farmers made their own farm buildings and equipment according to their own ideas and regional traditions. The buildings were small, specialized and normally had a short lifespan. Typical building materials were timber and stone. Indoor climate was far from good. The total workload was high, however, the work force was large as a lot of people lived on the farms.From approx. 1850 a big change took place in Norway as industrial products became available. A lot of people moved to the cities (or immigrated to USA) to live from industry or trade. The cities became a new market for agricultural products, the farmers got an income (as cash) and could buy "modern" factory built farm equipment. As people left the countryside for a better life (!?) in the city, farmers also had to select more efficient solutions to be able to run their farms with less hands involved. The monetary housekeeping also made it possible to loan money. Loan money was invested in more robust buildings, better solutions, e.g. for taking care of the manure and for storing food etc. As these buildings were more expensive, different productions were gathered in fewer buildings. What was called the "unity building" became the new standard. In those buildings, the manure was typically stored in the cellar, animals were kept on the main floor, and food was stored above there again. The gravity became the farmers "helping hand". A great improvement in work load, animal welfare, hygiene and production was achieved, and traditional housing methods were soon forgotten, however, the debt increased.In the years after world war II, the spread of electricity and combustion motors made room for another change; mechanization replacing manual work and gravity. Milking machines replaced hand milking, and feed and manure work were mechanized using mass-produced equipment.Today mechanization has developed into automation, and at the same time market forces has multiplied production volumes. The unity barn is also replaced with wide one-level buildings. The normal situation today, is also that one person is normally running several farms. Hence, to raise new buildings the work load is too big for the farmer, and the result is that he have to buy both building materials as well as hands to build – and the debt is increasing even more…

REGULATIONS

In Norway there is a lot of regulations. Two central acts are; *the Building act* with detailed *technical regulations*, and the *Animal welfare act* with species specific regulations. The first animal welfare act in Norway came in 1935 with an aim to "avoid animal abusement". In 1974 it was revised, and the aim was to "avoid unnecessary suffering". The focus in present version from 2010 is to "prevent and ensure animal welfare". Detailed demands regarding cattle housing are found in the *Regulation on keeping cattle*. Regulations regarding construction of a farm building are similar to all other types of commercial buildings.

HOUSING

Norwegian herds are medium sized (mean: 25 dairy cows), and are traditionally kept in tie stall barns. As late as 10 years ago, approx. 10 % of the herds were housed in traditional tie stall barns. The typical solution was an insulated building with mechanical ventilation, the cows tied with the head facing a central feed bunk, and the young stock housed on a fully slatted floor system above the manure storage. New regulations on keeping cattle (2004), demands loose housing for all animals (within 2024), soft flooring in the cubicles, outdoor exercise, and solid floors for heifers. Today approx. 50% of the cows are loose housed - typically using a free stall system. Fully insulated insulated buildings is still the most prevalent type of building, however, there is a trend towards more use of wood and "low insulated" constructions.

MILKING

As new regulations has "forced" farmers to renew their housing systems, normally mechanization has also been updated. In tie stall barns cows are normally milked using a pipeline milking system. Older loose house barns were typically with herringbone or tandem milking parlors, hoever, loose housing was not very common until 2000-2002. At that time the first automatic milking systems (AMS) were also introduced in Norway. As Norway is a high cost country, and we had suitable herd sizes, AMS systems soon became very popular. Today close to 100 % of new (or remodeled) barns are ending up with AMS systems. There are 1500 AMS herds in Norway (out of totally 9500 dairy herds), meaning that approx. every third cow in Norway is actually automatically milked today.

FEEDING

Because of long winters, it is necessary to store half of the food needed throughout a year. Hay based storing was replaced by roughage stored in silos after World War II. This was the most frequent solution from the 1950s and until approx. late 1990s. With a more "expansive" agriculture policy, the herd size increased and round baling became more and more popular. All that use of plastic is not very cheap, but it is a time effective method for storing food. Hence today approx. 2/3 of the silage is stored in round bales. Feeding systems have likewise changed from simple electrical delivery wagons, to more automated rail based "cut-and deliver" systems. Today there is a trend towards more TMR systems. However, due to our arctic climate, most farmers have just grass and concentrate – and e.g. no maize etc.

MANURE

Due to the climate, there is also a lack of straw for use as bedding. There are access to some sawdust or turf, however it is also associated with considerable costs. The last century the solution have been a slatted floor solution. The manure from the animals went through the slatted floor (slats 35-40 mm) and beams 13-15 cm) and ended in a manure storage in the cellar underneath the animals. As herds became larger, the problem with ammonia and hydrogen sulphide emissions became more evident. New regulations from 2004 therefore demands "gas tight" connections between manure storage and the animal room. Mechanical scraping systems have been common since the 1960s, and they still are. A survey from 2006 found that in general, farmers were less satisfied with their manure systems, and the majority used more than one hour per day for cleaning out manure. The trend today is to use scraping robots at the top of slatted floors.

FUTURE???

The 2015 dairy barn is actually working quite well, however, improvements will always be possible. One trend is towards animal welfare solutions, e.g. with separation in more groups, with specialized "looser cow" departments (for calving, lame cows etc). The move from mechanical to automation is also evident. In addition, new surveillance systems are entering the barns, e.g. pedometers, climate warning etc. The problem regarding financing all the equipment is, however, also more and more evident. I guess that the "hunt" for animal friendly, time efficient AND cheap solutions will continue!

LIVESTOCK HOUSING CONFERENCE

Conference "Livestock housing", organized by the Faculty of Agriculture, University of Banja Luka, Faculty of Agriculture from Bosnia and Herzegovina, University of Life Sciences in As and the Hedmark College University both from Norway. The conference was held from 20 to 22 October, 2015 at the Spa - Hotel Kardial, Teslić, Republic of Srpska, Bosnia and Herzegovina (http://www.banja-vrucica.com/en/book/hotel-kardial/).
The goal of the Conference was that participants present its research and studies in the form of papers and presentations. Those studies and researches were related with next topics: climate change and livestock, animal welfare, production and housing of farm animals, modern technologies in function of proper housing and similar.

Photo 2 (back side), Goat farm, Tomislavgrad

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