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EFFECT OF SOWS HOUSING MODE ON STRESS INDICATORS

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The research was accomplished on a farm with industrial housing of sows and on a family agricultural farm where sows are freely housed, outdoors. Twenty breeding sows from each farm were studied in this research.

The experiment was conducted aiming to compare housing of sows, as well as those factors affecting stress indicators.

For this purpose cortisol level was determined five days before farrowing, five days after farrowing and a day after weaning. Besides cortisol, other haematological parameters were determined in the blood, also.

Statistically significant higher concentration of cortisol was determined at five days before farrowing in sows housed freely compared to sows housed industrially ($p<0.05$).

Five days after farrowing and a day after weaning, concentrations of cortisol were lower in the blood of freely housed sows compared to industrially housed sows. However, the difference was not significant.

The level of cortisol determined in sows housed freely during pregnancy, and after dislocation into wedged farrowing departments, five days before farrowing, was significantly higher than in industrial sows. The aforesaid confirmed stress that can be induced by relocating the sows to a new location and wedged space.

The level of cortisol, determined in industrial sows was almost of equal values during the whole research, the fact being related to constant stress conditions.

Key words: sows, industrial housing, free fousing, stress, cortisol

INTRODUCTION

Pig production requires high technological standards in all breeding production phases, especially due to economic reasons. That is why keeping conditions can cause stress as an organism responds to harmful environmental stimulations (Topel and Christian, 1986).

Stress factors cause changes of homeostatic and physiological indicators, as well as changes in animal behaviour as the functions of physiological mechanisms they are regulated by, are violated.

Stress can be defined as a complex of reactions from the moment a stress factor affects an organism until the organism tries to either resist or adjust it (Hristov and Bešlin, 1991).

Stress reactions in pregnant sows lead to homeostatic changes whereby affecting breeding results. Changes in housing can cause a series of chemical and physiological alterations which reflect in altered behaviour such as irritation, fatigue or over heating. These are the consequences of small, but complex organism changes affecting the physical and psychical animal health (Santoro, 1996).

Various sow housing systems before and after parturition, as well as their behaviour within the system, have been recently researched (Barnett *et al*., 1985; Haskell, 1996; Arey and Sancha,1996; Pavičić *et al*., 2003; Damm *et al*., 2005).

Farrowing induced stress factors can cause damages from both the economic aspect and animal welfare. Namely, hormons in the stress period may affect reproductive activity (Hansen and Curtis, 1981), prolong parturition or even lead not only to higher piglet mortality rate, but sows can develop an aggressive reaction towards their own litter (Fraser, 1990). Low milk production leads to a higher mortality rate (De Passille and Rushen, 1989).

Higher free corticosteroid levels result in health reduction. This is the reason why subordinated animals have higher levels of glucocorticoids responsible for immunosuppressive effects (Roth, 1985; Kelley and Dantzer, 1990). Determination of plasma cortisol and adenocorticotrophic hormone (ACTH) by radioimmunologic methods enabled better understanding of the functions related to hypothalamus – pituitary gland – adrenalin stress response.

As for the afomentioned problems, housing conditions of sows in both industrial and family farm conditions were investigated.

Aiming to research the above-mentioned, sows of similar genetics and diet, but different housing conditions, were selected. The purpose of the trial was to determine whether transfer to a farrowing pen is stressful for sows prior to partus and is there a difference between measurable stress indices in the blood of sows housed industrially and those kept freely. Stress indicators were determined by the cortisol levels prior farrowing, five days after it and a day after piglets ablactation. Apart from cortisol, leucocytes, erytrocytes, hemoglobin, hematocrit, erythrocytes' volume, erythroctes' hemoglobin, hemoglobin level in erythrocytes, thrombocytes, eosinophils, segmented leucocytes, lymphocytes, monocytes and non-segmented leucocytes were also determined.

MATERIALS AND METHODS

Industrial housing mode

Sows used in the research were a part of the common farm technological process. Technological phases of sows production cycles are as follows: after

weaning sows are transferred from the farrowing pen into the admission pen in departments each housing five animals.

Having detected oestrus in the morning, sows are artificially inseminated by the testing boar for the first time at the same day in the afternoon, followed by the second insemination tomorrow morning. After admission has been accomplished the formed group is transported into a facility where they are kept individually, 45 to 50 days. A pregnancy control is conducted within this period. A group of 16 to 20 pregnant sows are moved into a sow pen and stay there not more than 5 days prior an expected parturition. Prior moving to a farrowing pen, sows are washed with a disinfectant added to warm water. The farrowing pen is, before sows are moved, mechanically cleaned, washed with hot water, dried and disinfected.

Piglets are weaned between 21st and 28th day of the age, depending on the loading and unloading dynamics of the farrowing pen. Sows selected for the trial were double crosses between Swedish Landrace and Large White. Twenty pregnant sows were used in this trial.

System of sows housing on family farms

Sows are kept in a group in an outdoor fenced place during the whole pregnancy period. Boars are kept separately in an isolated room, in individual cubicles. Few days prior farrowing, sows are moved to a farrowing pen i.e. into a solid facility consisting of 16 straw-rich departments used for farrowing. They stay into the facility until the time piglets are weaned which appears to be within 35 and 40 days of age. The piglets are dislocated into a rearing facility in six departments 4.0 x 6.0 m in size. These departments with a solid floor covered by straw are used for housing of piglets until they weigh approximately 30 kg. Thereon they are delivered to other producers for fattening. After piglets have been weaned, sows stay in the farrowing crate until the next oestrus occurs which is followed by the natural admission of the boar. After admission sows are returned to an exterior outlet. Approximately sixteen piglets (30 kg on the average) per sow are weaned annually. Sows selected for this trial were double crosses between Swedish landrace and Large white; German Landrace and Large White. Twenty reproductive sows were used in this trial.

Blood sampling

Blood (5 mL) was taken in EDTA vacutainer test tubes from the upper hollow vein (*vena cava cranialis*). The blood was taken three times: five days prior farrowing, five days after it and a day after ablactation. All three blood samplings were done in the morning hours.

Cortisol was determined by immunoenzymatic electrochemoluminescence (ECLIA method) on an automatic detector Elecsys Roche 2010. Each serum sample was determined two times and the mean value of these two measurings was used as the result.

Number of erythrocytes, leucocytes, thrombocytes, hemoglobin level and hematocrit were determined by the automatic counter Sysmex SF-3000. Blood smears were prepared for differential blood count determination. They were stained after Pappenheim and microscopically searched.

Statistical data processing

Obtained values of the observed indicators were processed by the computer program Statistica (Anonim., 2006). Mean value indicators for some traits were estimated by methods of descriptive statistics. Significant differences of hematologic indices of sows from industrial and free keeping were determined by a GLM model for repeated samples and tested by LSD *post hock* test.Case probability less than 5 % was designated as $p<0.05$, and less than 1% as $p<0.01$.

RESULTS

Compared results obtained via the three observed periods showed a statistically significant higher cortisol level five days prior farrowing in sows housed freely compared to industrially housed ones ($p<0.05$). Cortisol level was lower in sows housed freely in the other two periods, but no significant differences were determined ($p>0.05$, Table 1).

Table 1. Statistical indices for cortisol level values in sow serum of industrially and free housing, determined in designated periods

	Level of serum cortisol (nmol L^{-1})					
	five days prior farrowing		five days after farrowing		a day after ablactation	
	industrial housing	free housing	industrial housing	free housing	industrial housing	free housing
$\bar{x}$	87.87	107.14*	86.30	57.66	78.63	60.55
sd	57.75	23.68	56.99	14.36	38.65	22.37
x_{min}	35.21	87.36	25.20	43.90	40.45	31.16
x_{max}	212.75	156.80	194.90	88.22	135.75	89.70

Legend: $\bar{x}$ – arithmetic mean; sd – standard deviation; x_{min} – minimum mean values; x_{max} – maximum mean value; *$p<0.05$

Analysis of blood samples taken 5 days prior farrowing (Table 2) showed a significant ($p<0.01$) higher mean erythrocyte hemoglobin level (MCH) in the blood of the group of industrially housed sows compared to the mean erythrocyte hemoglobin level (MCH) in the blood of sows housed freely. Mean erythrocyte hemoglobin level (MCHC) in blood of the sows industrially housed is significantly ($p<0.05$) higher compared to the mean erythrocyte hemoglobin level (MCHC) in the blood of sows housed freely. Although the mean erythrocyte volume (MCV) in the blood of industrially housed sows is not significantly ($p>0.05$) higher, it is still considerably higher. The number of segmented neutrophils in the blood of sows housed freely is significantly ($p<0.05$) higher compared to segmented neutrophils in the blood of industrially housed sows.

Table 2. Blood indices of sows housed industrially and free five days prior farrowing

Indices	$\bar{x} \pm sd$	
	Industrial keeping	Free keeping
Leucocytes (x 10^9/L)	15.37± 3.87	15.29±2.62
Erythrocytes (x 10^{12}/L)	5.66± 0.75	5.89±0.35
Hemoglobin (g/L)	116.80±17.05	114.70±8.03
Hematocrit, (L/L)	0.36± 0.05	0.36±0.02
MCV (fl)	63.97± 2.85	61.87±2.31
MCH (pg)	20.62**± 0.89	19.49±0.82
MCHC (g/L)	322.10*± 5.09	314.90±6.24
Thrombocytes (x10^9/L)	193.60±46.17	158.40±105.34
Eosinophils	5.00± 4.37	2.80±1.48
Segmented neutrophils	41.80±13.43	53.80*±7.69
Lymphocytes	44.30±13.46	35.50±6.96
Monocytes	5.90± 1.73	6.30±4.08
Non-segmented neutrophils	2.90± 1.85	1.60±0.70

*p<0.05; **p<.01

Analysis of blood samples obtained 5 days after farrowing (Table 3) showed significantly higher values for the number of blood leucocytes, blood hemoglobin, non segmented blood neutrophils, mean blood erythrocyes (MCV), and mean concetration of blood erythrocytes hemoglobin (MCHC) in industrially housed sows.

Analysis of blood samples taken on the first day after ablactation (Table 4) showed statistically significantly ($p<0.05$) higher leucocytes count in blood of industrially housed sows compared to blood leucocytes in freely housed sows. Erythrocyte count in blood of freely housed sows is statistically very significantly ($p<0.01$) higher compared to erythrocytes in blood of industrially housed sows. Hemoglobin level in blood of freely housed sows is statistically significantly ($p<0.05$) higher compared to blood hemoglobin in industrially housed sows. Hematocrit value in blood of freely housed sows is statistically significantly ($p<0.05$) higher compared to hematocrit value in blood of industrially housed sows. Mean erythrocytes volume (MCV) in blood of industrially housed sows is statistically significantly ($p<0.05$) higher compared to mean erythrocyte volume (MCV) in blood of freely housed sows. Mean erythrocyte hemoglobin level (MCH) in blood of industrially housed sows is statistically very significantly ($p<0.01$) higher compared to mean erythrocyte hemoglobin level (MCH) in freely housed sows.

Table 3. Blood indices of sows housed industrially and free five days after farrowing

Indicators	$\bar{x} \pm sd$	
	Industrial housing	Free housing
Leucocytes (x 10^9/L)	17.08*± 2.10	14.60± 1.74
Erythrocytes (x 10^{12}/L)	5.63± 0.34	5.45± 0.50
Hemoglobin (g/L)	120.10*± 9.73	107.90± 9.59
Hematocrit (L/L)	0.38± 0.03	0.35± 0.03
MCV (fl)	66.67*± 2.41	63.91*± 3.01
MCH (pg)	21.31**± 0.63	19.83± 0.95
MCHC (g/L)	319.60**± 6.79	310.20± 6.86
Thrombocytes (x 10^9/L)	246.30±98.69	268.20±41.95
Eosinophils	7.00± 6.13	6.80± 2.82
Segmented neutrophils	46.10±10.58	44.30± 6.02
Lymphocytes	40.40±10.45	42.60± 4.53
Monocytes	4.20± 1.93	3.90± 1.20
Non-segmented neutrophils	2.71± 1.70	1.20± 0.42

*p<0.05; **p<0.01

Table 4. Blood indicators in industrially and freely housed sows a day after piglets ablactation

Indicators	$\bar{x} \pm sd$	
	Industrial housing	Free housing
Leucocytes (x 10^9/L)	19.03*±3.53	14.30± 4.37
Erythrocytes (x 10^{12}/L)	5.38± 0.36	6.14**± 0.57
Hemoglobin (g/L)	112.30± 8.00	119.30*± 6.60
Hematocrit (L/L)	0.35± 0.03	0.39*± 0.03
MCV (fl)	65.81*± 2.35	63.50± 2.37
MCH (pg)	20.86**± 0.80	19.51± 0.90
MCHC (g/L)	317.10**± 5.67	307.20± 6.96
Thrombocytes (x 10^9/L)	264.00**±38.36	180.20±73.82
Eosinophils	5.40± 2.37	7.33± 3.39
Segmented neutrophils	43.60± 5.48	45.11± 9.12
Lymphocytes	44.70± 6.27	41.44±10.33
Monocytes	4.30± 2.41	3.78± 2.95
Non-dsegmented neutrophils	2.00± 0.94	2.63± 2.00

*p<0.05; **p<0.01

MCHC level in blood of industrially housed sows is statistically very significantly ($p<0.01$) higher compared to MCHC in blood of freely housed sows. Thrombocytes count in blood of industrially housed sows is statistically very significantly ($p<0.01$) higher compared to thrombocytes count in blood of freely housed sows.

DISCUSSION

Freely housed sows, accommodated in crates showed instantly signs of agitation and frustration as described by Vestergaard and Hansen (1984) in their researches. They were restless and bit the wedges. Restlessness was getting increased as farrowing time was getting closer. This phenomenon would have been suppressed by preparing piglets nest if the sows had been freely housed. In natural conditions sows, searching for an adequate material, go as far as 200 meters from the place they make the nest. Industrial, closed system, can completely disturb indigenous need for making nest, thereby cause sows frustration. This is especially attributed by dislocating pregnant sows from group departments to crates for farrowing. Scientists proved that inability of making nest postpone maternal instinct in farrowed sows. It is considered as the first stress factor affecting a pregnant sow prior the parturition (Vučinić, 2006).

Arey and Brooke (2006) stated in their researches that these frustrations in sows produce a stress hormon such as cortisol. As the sows are getting older the stress is getting reduced. It is not possible to decrease the stress by putting straw on the farrow pen floor. What matters is that they are able to move, which is not the case here since they are wedged. This form of stress in sows also includes body bruises, slashes, scratches, exhaustion and increased body temperature.

Sows in industrial way of housing are also dislocated from a sow pen where they are housed in groups to a farrowing pen being housed individually wedged. In both cases sows respond stressfully. Cages are of metal construction that make sows impossible to move. Although wedges are made aiming to prevent pressings and to enable easier process of farrowing they are uncomfortable for sows. Researches found out that sows can suffer in this room since they are not able ro relax in a natural way (Jarvis *et al*., 1997). Sows are not able to turn round, assort with other sows, make nest and show their natural dung instinct far from the farrowing site.

Immediatelly after farrowing, piglets fight for suckling hierarchy. Each piglet fights for its udder place. They push, squeal and bite each other with sharp teeth. Unlike other animal species, piglets social hierarchy is formed immediatelly after farrowing, within 48 hours. It is already stabile in one week old piglets. The hierarchy depends on the teats position and piglets physical constitution. First pair of sow teats are known to provide more milk than others. Piglets suckling first pair of teats much better develop, compared to others. Since cortisol level is connected with extracting hormons which release gonadothropic hormons (GnRH), this can significantly affect sexual glands development (Rivier and Riviest, 1991).

Cortisol level in blood of sows being investigated ranged from 25.20 to 212.75 nmol L^{-1}. This finding is in consent to evidences of few authors. Kaneko (1997) stated that normal cortisol level pigs blood plasma is 82 ±3 nmol L^{-1}. Somewhat lower concentration of its value, approximatelly 18.9 +/- 3.9 nmol L^{-1} can be found in saliva (Schonreiter and Zanella, 2000). Hanon *et al*. (1990) determined, by radioimunological method, cortisol level within 49.7 and 218 nmol/L in pigs blood plasma.

Barnett *et al*. (1987) investigated cortisol level in plasma of sows housed in groups and those housed tied individually. They found out that there was no differennce in cortisol level between the aforementioned groups 24 hours after sows have been dislocated to a farrowing pen. In terms of housing mode and their accommodation of the first-farrowed sows, Cronin *et al*. (1991) monitored blood plasma cortisol level. They determined cortisol increase after dislocation from the group department into individual department of the farrowing pen, even when gilts were housed in the department longer than 28 days. Lawrence *et al*. (1994) found out that wedged sows in the farrowing pen department can induce stress in the pre-farrowing period. It was approved by an increased cortisol level during the parturition. Kadarmideen and Janss (2007), approved that concentrations can vary due to a genotype. They determined high heritability for cortisol being 0.40 - 0.70.

The conducted investigation was known for cortisol level with highest deviations five days prior farrowing. The most variable values were those of morning serum cortisol in sows from industrial housing mode (min 35.21-212.75 nmol L^{-1}). Still, cause of significant higher cortisol level in freely housed sows is likely changing of housing conditions. Namely, sows were, after being outdoor, transported to a farrowing crates, which caused stress occurrence. Not long after parturition (fifth day) cortisol level was lower in freely housed sows. It is probably due to more stabile neuroendocrine system which, during other production phases, was not so much stress-exposed while sows were transported in different departments compared to those in industrial housing mode (Kranendonk, 2006; Lawrence *et al*., 1994). The same authors stated that the same condition remained even after a month. The cortisol level was lower in freely housed sows regardless values ranged from minimum to maximum that charaacterized equally both groups of sows. It may be a consequence of leaving animals in the same department the first day after weaning when piglets were removed.

Although cortisol level was measured once it is likely matter of acute stress consequences after organism/environment interaction. To determine accurate evaluation of quality and nature of this stress, a daily cortisol extraction curve should be known. It is important since circadian rhythm will be desturbed depending on stress nature (Schonreiter and Zanella, 2000) or it will not change at all (Hillmann *et al*., 2007).

Žvorc *et al.* (2006) investigated health status of the herd during the sow's pregnant and lactation period by monitoring blood values. Attained results showed reducing number of erythrocytes, hematocrits, cell volume, leucocyte count and copper level in blood during the pregnancy period. Hemoglobin level

was reduced in the period of pregnancy and lactation. MCH level increased at the high stage of pregnancy and reduced during lactation period. Activity of alanine aminotransferase, level of sodium and inorganic phosphorous were reducing as pregnancy and lactation were coming to their final stage. The same period was characterized by statistically significant increase of glucose level.

Blood indices of sows controlled in the three periods ranged within referential limits in both groups of sows. The similar result was noted by Thorn (2000). Signs of negative i.e. stressful effects of housing were not determined in either group, being in accordance with findings of Hicks *et al*. (1998). Significantly higher total leucocyte counts were determined in sows from industrial keeping mode five days after farrowing and a day after ablactation. Lymphocytes portion was also higher in sows from industrial mode of housing except five days after farrowing when the ratio was opposite. However, no significant difference was determined. Non-segmented neutrophils appeared to be more in industrially housed sows. Indices of differential blood count show that there was no negative influence of stress, but industrially housed sows sows responded faster by activating first lines of defense - neutrophils. Increased number of segmented neutrophils five days prior farrowing in freely housed sows is a conseuence of changing housing conditions and increased number of available bacteria in farrowing pen indoor space. Erythrocyte constants are larger in industrially housed sows, likely because of iron metabolism and increased hemoglobin level. Namely, corticosteroids participate in maintaining serum iron within physiological limits whereas their increase may lead to rapid serum iron level.

CONCLUSIONS

Cortisl level was measured in sows' serums in the observed period. Higher cortisol level was determined five days prior farrowing in freely housed sows compared to those industrially housed ($p<0.05$). Five days after farrowing and a day after ablactating, cortisol level was higher in freely housed sows compared to ones housed industrially. However, there was no significant difference.

Cortisol level, determined in freely housed sows during their pregnancy, was significantly higher compared to industrially housed sows ($p<0.05$), while dislocating in farrowing crates five days before farrowing. It is confirmation of stress factors influence, induced by translocation into new environment and narrowed space.

Cortisol level, determined in industrially housed sows, was almost of equal values during the whole investigation. It indicates permanent weak stress status.

Blood indices of sows being controlled in the three periods have been within referential limits in both groups of sows and there was no statistically significant difference between these two groups.

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UTICAJ NAČINA UZGOJA KRMAČA NA INDIKATORE STRESA

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SADRŽAJ

U ovo istraživanje je bilo uključeno po dvadeset krmača sa farme sa industrijskim uzgojem i jedne domaće farme sa slobodnim ispustom. Osnovni cilj je bio da se ispita uticaj načina držanja krmača kao mogućeg faktora stresa. U ovu svrhu je određivan nivo kortizola pet dana pre prašenja i jedan dan posle zalučenja. Pored koncentracije kortizola određivane su vrednosti osnovnih hematoloških parametara.

Utvrđena je statistički značajno veća koncentracija kortizola, pet dana pre prašenja kod krmača sa domaćih farmi, nego kod onih koje potiču sa industrijskih farmi ($p<0,05$). Pet dana posle prašenja i jedan dan po zalučenju, koncentracija kortizola u krvi krmača sa domaćih farmi je bila niža kod krmača sa industrijskih farmi. Ova razlika nije bila statistički značajna. Nivo kortizola kod krmača sa domaćih farmi tokom bremenitosti i posle premeštanja u bokseve za prašenje, pet dana pre prašenja, je bio značajno veći nego kod industrijskih krmača. Ovo ukazuje na pojavu stresa usled premeštanja krmača u novo okruženje i izolovan prostor. Nivo kortizola, izmeren kod industrijskih krmača, je imao ujednačene vrednosti tokom celog perioda istraživanja usled konstantnog delovanja stresnih faktora.