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EJACULATE PROPERTIES AND REPRODUCTIVE EFFICIENCY OF LARGE WHITE BOARS DURING EXPLOITATION

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Abstract: The main objective of this study was to assess the variability of ejaculate properties: volume of ejaculate (VOL, ml), sperm concentration (CON, spermatozoa/ml), total sperm count (NT) and the number of doses produced (NPD) per ejaculate under the influence of season, boar and the interval between two mounts. Reproductive efficiency of boars was analysed based on the farrowing rate (FR). The study included 341 ejaculates from seven Large White boars. Impact assessment was carried out by applying the GLM procedure of the statistical package SAS 9.1.3. The average values of VOL, CON, NT, NPD and FR were: 244.28 ml, 203.77x10^6 spermatozoa/ml, 43.48x10^9 spermatozoa, 17.39 doses and 67.58%. Ejaculate properties varied under the influence of season ($P<0.01$, $P<0.001$). The interval between two mounts did not affect only the variability of CON. The difference between the best and worst boars was 91.99x10^6 spermatozoa/ml of ejaculate ($P<0.001$). During summer VOL ejaculate was the lowest (191.36 ml). The highest NPD (19.04 doses) was produced during the autumn months, and during the same period the highest concentration of sperm was recorded (242.16x10^6 spermatozoa/ml). Regardless of the differences in the farrowing rate between boars not being statistically significant ($P=0.0882$), it is necessary to perform the ranking and promptly identify boars with farrowing rate below average.

Key words: boar, ejaculate, farrowing rate, rank, season

Introduction

Modern pig production is based on highly productive breeds with the use of modern technical and technological solutions and biotechnological methods in

breeding and reproduction. The success of artificial insemination depends largely on quantitative and qualitative properties of the ejaculate.

In the populations of pigs where a continuous selection is conducted, there is a tendency for better exploitation of boars, good production performance, which is reflected in obtaining the greatest possible number of doses per ejaculate of optimal fertile capability (*Savić et al., 2013a*). The volume of ejaculate, sperm concentration and sperm motility are characteristics/properties which determine the number of doses per ejaculate, fertility of doses and the number of sows that can be inseminated.

Variability of sperm properties is influenced by various genetic and non-genetic factors. Properties of the ejaculate vary under the influence of boars *(Savić et al., 2013b),* breed (*Okere et al., 2005; Wolf and Smital, 2009a*), season (*Kondracki et al., 2009; Kunowska-Slósarz and Makowska, 2011*), intensity of use or interval between two mounts (*Frangež et al., 2005; Wolf and Smital, 2009a; Smital, 2010*) and other factors.

Research by *Young et al. (2010)* shows that there are differences in farrowing rate between the 30 herds analyzed (54.7-92.4%), and the cause of such broad range is consequence of different procedures and technological operations carried out in herds. In the pig production, reproductive performance is assessed based on the farrowing rate, and the number of live born piglets, however, in the commercial sector boars of superior and inferior fertility are used (*Flowers, 2013*).

The aim of this study was to evaluate variability of ejaculate and reproductive efficiency of Large White boars during use in reproduction.

Material and Methods

The research was conducted on a reproduction farm, in the period from 2011 to 2012. Total of 341 ejaculates of 7 Large White boars were analyzed during two years of use in reproduction. In addition to the evaluation of ejaculate, also the reproductive efficiency boars was tested.

Sows were inseminated twice, and from a total of 919 matings, 602 farrowings were realized. Of the total number of analyzed ejaculates, 40 (11.73%) were unusable, so they were not evaluated. Reasons for ejaculates being considered unusable were different: dead sperm in the ejaculate, sperm motility subjectively estimated to be below 70%, the presence of impurities, etc.

Boars were housed in a separate facility, in boxes measuring 2×4 m, with partly slated concrete floor. The microclimate conditions in facility for boars were under automatic control. The animals were fed a balanced feed mixture, and fresh water was available to them *ad libitum.*

The impact of season was examined as the impact of a class: 1 (December, January, February), 2 (March, April, May), 3 (June, July, August) and 4

(September, October, November). The average interval between two mounts was 8.80 days. The research included: the volume of ejaculate (VOL, ml), sperm concentration (CON, $x10^6$ spermatozoa/ml), the total number of spermatozoa in the ejaculate (NT, $x10^9$ spermatozoa) and the number of doses produced (NPD). Reproductive efficiency of boars was investigated based on the farrowing rate (FR, %), which is calculated as the relative ratio between the number of farrowed sows in relation to the number of inseminated sows.

Taking of the ejaculate was performed using standard manual method, the introduction of mobile phantoms into boxes where boars are housed. The ejaculate volume was measured by graduated cylinder, with an accuracy of ±2 ml. The concentration of native sperm was evaluated by application of the photo-colorimeter. Dosages for insemination were standardized to a volume of 100 ml and 2.5 billion spermatozoa per dose. The total number of spermatozoa in the ejaculate was obtained by multiplying the sperm concentration by the volume of ejaculate.

Impact assessment was carried out by applying the General Linear Model procedure of the statistical package SAS 9.1.3 *(SAS Inst. Inc., 2002-2003)*, using the following model:

$$y_{ijk} = \mu + B_i + S_j + b(x_{ijk} - \bar{x}) + e_{ijk},$$

where: y_{ijk}- analysed property of the ejaculate, μ- general population average, B_i- the impact of boar (i=1,2,3,4,5,6,7), S_j- the impact of season (j=1,2,3,4), $b(x_{ijk}-\bar{x})$- linear regression impact of the interval between two consecutive mounts and e_{ijk}- random error.

The boars were ranked based on the value of the farrowing rate, by forming two groups of boars (with the farrowing rate above and below the general average). Comparison of Least Square Means (LSMeans) values of ejaculate properties and mean values of the farrowing rate was performed by t-test.

Results and Discussion

The basic statistical parameters are shown in Table 1. With regard to the values of the standard deviation, the ejaculate volume and sperm concentration exhibit a greatest variation with respect to other fertility traits.

Table 1. Basic statistical parameters of fertility traits

Fertility traits	Mean	SD
Volume of ejaculate (ml)	244.28	115.37
Concentration of sperm (x10^6 spermatozoa/ml)	203.77	97.11
Number of total spermatozoa (x10^9 spermatozoa)	43.48	18.57
Number of produced doses	17.39	7.43
Farrowing rate (%)	67.58	9.33

The influence of studied factors on the variability of the ejaculate properties is presented in Table 2. All the analysed properties of ejaculate varied under the influence of the season. In addition to micro-climate indicators, the impact of the season should be viewed through the duration of the photoperiod during the year, and expressed significance of the influences indicates to the need and obligation to include this factor in the models in the analysis of properties of ejaculate.

The results of this study are contrary to the study of *Savić et al. (2013b)* in which the ejaculate volume varied under the influence of boars, while the influence of the interval between two mounts was not significant. The effect of season on ejaculate properties identified in our study is in concordance with the findings of *Kondracki et al. (2009).*

Table 2. Effect of factors on variability of ejaculate traits

Ejaculate traits	Effect		
	Boars	Season	Interval between two consecutive mounts
Volume of ejaculate (ml)	ns	***	***
Concentration of sperm (x10^6 spermatozoa/ml)	***	***	ns
Number of total spermatozoa (x10^9 spermatozoa)	ns	**	*
Number of produced doses	ns	**	*

Significance: ns- not significant, *- P<0.05, **- P<0.01, ***- P<0.001

The differences between boars were recorded only in sperm concentration (Table 3). The difference between the best (ID number 1) and the worst boar (ID number 5) was 91.99x10^6 spermatozoa per millilitre of ejaculate. Since the animals were raised in the same facility, under the same conditions, these differences in phenotypic values of ejaculate concentration, are influenced by the individual characteristics of boars.

Table 3. Least square means (LSMeans) of ejaculate traits by boars

ID number of boar	LSMeans of ejaculate traits			
	VOL	CON	NT	NPD
1	217.31	242.24^{A}	47.47	18.99
2	229.98	$233.61^{a,Aa}$	42.83	17.13
3	216.16	$222.08^{a,Aa,c}$	43.97	17.59
4	264.68	$179.78^{B,b}$	43.75	17.50
5	279.02	$150.25^{B,Bb}$	33.87	13.55
6	244.63	$217.27^{a,Aa,e}$	43.77	17.51
7	240.70	$182.79^{B,d}$	40.13	16.05

VOL- volume of ejaculate (ml), CON- concentration of sperm ($x10^6$ spermatozoa/ml), NT- number of total spermatozoa ($x10^9$ spermatozoa), NPD- number of produced doses; Significance: ab, cd and de- P<0.05; AaBb- P<0.01; AB- P<0.001.

Comparison of LSM mean values for observed traits of ejaculate between seasons is presented in Table 4. During the summer (season 3) ejaculate VOL was the lowest, and the difference compared to the season 2 was -123.06 ml. During the summer, sperm concentration was above average, but the NT and NPD were below average, as a consequence of the low volume of ejaculate. Regardless of the fact that the boars were housed in controlled environment conditions, it is possible that higher temperatures during the summer months demonstrated a negative impact on quantitative sperm production. The highest NPD was produced during the autumn months (season 4), and during the same period the highest concentration of sperm was recorded. In comparison to season 2, during the autumn, the sperm concentration was higher by $86.23x10^6$ spermatozoa/ml. The reason for the highest concentration of sperm, the total number of spermatozoa in the ejaculate, and the number of doses during the autumn can be the stimulating effect of shortening of the photoperiod on neuro-humoral mechanism of sperm production.

Table 4. Least square means (LSMeans) of ejaculate traits by season

Season	Ejaculate traits			
	VOL	CON	NT	NPD
1 (December-February)	$234.04^{A,a}$	180.42^{A}	$37.49^{a,Aa}$	$15.00^{a,Aa}$
2 (March-May)	314.42^{B}	155.93^{A}	44.87^{b}	17.95^{b}
3 (June-August)	$191.36^{A,b}$	237.51^{B}	$39.06^{a,Aa}$	$15.62^{a,Aa}$
4 (September-November)	227.30^{A}	242.16^{B}	47.60^{Bb}	19.04^{Bb}
Population average	241.78	204.01	42.26	16.91

VOL- volume of ejaculate (ml), CON- concentration of sperm ($x10^6$ spermatozoa/ml), NT- number of total spermatozoa ($x10^9$ spermatozoa), NPD- number of produced doses; Significance: ab- P<0.05; AaBb- P<0.01; AB- P<0.001.

During the spring season the highest volume of ejaculate was determined (314.42 ml), as a result of negative correlation between volume and density and the

lowest concentration of sperm ($155.93x10^6$ spermatozoa/ml). The nature of this correlation is reported in many studies (*Wolf and Smital, 2009a; Wolf and Smital, 2009b; Kunowska-Slósarz and Makowska, 2011).* The results of our study are partly similar to the study of *Tomiyama et al. (2008),* who have, during the spring months, determined the highest volume and the lowest concentration, whereas during the autumn period, the volume of ejaculate was the lowest, with a maximum concentration of spermatozoa. Partial similarity exists also with the research of *Stančić et al. (2012)* who have recorded, during the period June-August and September-November, the average volume of ejaculate (213 and 232 ml) and the concentration of spermatozoa ($220x10^6$ and 210x106 spermatozoa/ml), while higher values were recorded in the period from December to February (293 ml, $319x10^6$ spermatozoa/ml) and March-May (285 ml, $284x10^6$ spermatozoa/ml). Contrary to the findings of the present study, *Okere et al. (2005), Kondracki et al. (2009), Wolf and Smital (2009a),* in the spring period, have determined the minimum volume of ejaculate from the tested breeds. This research is not consistent with the results of *Kunowska-Slósarz and Makowska (2011),* who have found, in the cold season (October and November), the highest volume and lowest density of ejaculate. Partial similarity exists with the research of *Rutten et al. (2000)* in which the lowest number of standardized doses is obtained from the semen in the summer period (26.3), and the highest in autumn (28.7), however, in our study, less doses per ejaculate were obtained.

Table 5 shows the ranking of boars according to the value of farrowing rate during the reproductive exploitation. The variation of the farrowing rate between boars ranged from 59.31 to 85.37%, which indicates a large difference in performance during use. Reproductive efficiency depends on several factors: boars, breeding season, sows with which boars are mated, weaning-oestrus interval, methods of insemination, sperm capacitive capabilities, etc.

Table 5. Rank of boar by farrowing rate

Rank of boar (ID number of boar)	Farrowing rate (%)	Group	P value
1 (5)	85.37	I	0.0882
2 (7)	72.22		
3 (4)	69.54		
4 (3)	66.30	II	
5 (2)	60.32		
6 (6)	60.00		
7 (1)	59.31		

Group I/II- Farrowing rate above/below the average (67.58%)

The difference in farrowing rate between the best (rank 1, ID number 5) and the worst boar (rank 7, ID number 1) was 26.06%. Regardless of the fact that the differences in the farrowing rate between boars were not statistically significant

(P=0.0882), it is necessary to rank and promptly identify boars with farrowing rate below average.

A broad interval of variation was found in the research of *Park (2013)* in which the farrowing rate on pig farms with pigs of Yorkshire genotype varied in the range 63.8-91.6%. The differences in the farrowing rate between boars are also due to the individual characteristics, so our research is in accordance with the results of *Ruiz-Sánchez et al. (2006)* who have found that the farrowing rates between boars range from 71 to 98%. The concordance is also present with the results of study by *Didion et al. (2009).* These researchers have determined the variation of farrowing rate in the range 38.9-82.7%, between 18 investigated boars.

Conclusion

The ejaculate properties vary under the influence of the season and the interval between two mounts. The differences in the concentration of sperm are influenced by the individual characteristics of boars. The mechanism of sperm production was strongly influenced by the season, primarily the negative impact of high summer temperatures and a possible stimulating effect of shortening of the photoperiod during the autumn. Control of productivity and ranking of boars based on the farrowing rate should be continuously carried out, regardless of the fact that in this experiment no statistically significant variation in the farrowing rate was determined between boars.

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Osobine ejakulata i reproduktivna efikasnost nerasta velikog jorkšira tokom iskorišćavanja

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Rezime

Osnovni cilj istraživanja bio je da se oceni varijabilnost osobina ejakulata: volumen ejakulata(VOL, ml), koncentracija sperme (CON, spermatozoida/ml), ukupan broj spermatozoida (NT) i broj proizvedenih doza (NPD) po ejakulatu pod uticajem nerasta, sezone i intervala izmedju dva skoka. Reproduktivna efikasnost

nerasta analizirana je na osnovu procenta prašenja (FR). Istraživanjem je bio obuhvaćen 341 ejakulat sedam nerasta velikog jorkšira. Ocena uticaja je izvršena primenom GLM procedure u statističkom paketu SAS 9.1.3. Prosečne vrednosti VOL, CON, NT, NPD i FR bile su: 244,28 ml, $203{,}77 \times 10^6$ spermatozoida/ml, $43{,}48 \times 10^9$ spermatozoida, 17,39 doza i 67,58%. Osobine ejakulata varirale su pod uticajem sezone ($P<0{,}01$; $P<0{,}001$). Interval između dva skoka nije uticao jedino na varijabilnost CON. Razlika izmedju najboljeg i najlošijeg nerasta bila je $91{,}99 \times 10^6$ spermatozoida/ml ejakulata ($P<0{,}001$). Tokom letnjih meseci VOL ejakulata bio je najmanji (191,36 ml). Najveći NPD (19,04 doza) proizveden je tokom jesenjih meseci, a tokom istog perioda bila je i najveća koncentracija sperme ($242{,}16 \times 10^6$ spermatozoida/ml). Bez obzira što razlike u procentu prašenja između nerasta nisu bile statistički značajne ($P=0{,}0882$), potrebno je vršiti rangiranje i pravovremeno identifikovati neraste sa procentom prašenja ispod proseka.

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