REPRODUCTIVE
BIOLOGY

Sperm morphology of cattle and domestic pigs

Stanisław Kondracki[1], Dorota Banaszewska, Anna Wysokińska, Joanna Chomicz
Department of Bioegineering and Animal Breeding, University of Podlasie, Siedlce, Poland

Received: 2 October 2005; accepted: 19 December 2005

SUMMARY

Sperm morphology was evaluated (using Blom classification) in 44 ejaculates of 11 bulls and 44 ejaculates of 11 boars. Significant differences in sperm morphology were found between bulls and boars. In addition, the correlations between frequency of morphological changes and morphometrical traits of boar spermatozoa were demonstrated. More morphological anomalies of spermatozoa were recorded in ejaculates containing longer spermatozoa. *Reproductive Biology 2006* ***6*** *Suppl. 2:99–104*.
Key words: boars, bulls, sperm morphology differences

INTRODUCTION

The importance of artificial insemination (AI) and its extensive usage in reproduction of many farm animal species, demands more efficient meth-

[1]Corresponding author: Department of Bioegineering and Animal Breeding, University of Podlasie, 14 Prusa Str, 08-110 Siedlce, Poland; e-mail: sk@ap.siedlce.pl

ods for semen use. Morphometrical traits, relative to spermatozoal measurements and shape may be helpful for evaluating semen usefulness to AI. Sperm dimensions and shapes may affect semen fertilizing ability. Sperm dimensions are characterized by large inter- and within-species variabilities [2, 5, 12-14]. The relationship between spermatozoal measurements and male fertility is well documented [4, 6, 8, 17]. In this study, an attempt was made to estimate differences in sperm morphological traits of boar and bull ejaculates used in AI.

MATERIALS AND METHODS

Ejaculates were collected from 11 bulls (n=44) of Black-and- White breed (6.5-7.5 years old) and from 11 boars (n=44) of Polish Landrace breed (1.5-2.5 years old). Mean ejaculate quality parameters were as follows: for bulls - ejaculate volume 8.3 ml, sperm concentration 1.344×10^9 ml^{-1}, and sperm motility 74% and for boars - ejaculate volume 270 ml, sperm concentration 0.440×10^9 ml^{-1}, and sperm motility 79.4%. Slides were prepared and stained according to the method described by Kondracki et al. [11] and evaluated under Nikon E-400 microscope using immersion lens with 100 times magnification. Sperm morphology was evaluated according to Blom [3] classification (Screen Measurement v. 4.1). Measurements of spermatozoa were as follows: the spermatozoon head's area, length, and the width; the spermatozoon flagellum's length; and the spermatozoon's total length. The results of morphometrical measurements were used to calculate indexes of spermatozoal morphology. Sperm characteristics were compared using the analysis of variance. Differences between means were compared using the t-Student`s test.

RESULTS AND DISCUSSION

Differences in the size and shape of spermatozoa of both species were found (tab. 1). Bull spermatozoa had higher measurements than boar sper-

Table 1. Morphometric traits of sperm of bulls and boars

Specification		Bulls	Boars
Head area (μm²)	$\bar{x}$	43.19 A*	40.00 B
	SD	4.47	1.49
Head length (μm)	$\bar{x}$	10.11A	9.17B
	SD	0.57	0.41
Head width (μm)	$\bar{x}$	5.21A	4.69B
	SD	0.43	0.20
Flagellum length (μm)	$\bar{x}$	60.10A	44.11B
	SD	4.02	3.45
Total length (μm)	$\bar{x}$	70.21A	53.28B
	SD	4.25	3.72
Head width / head length (%)	$\bar{x}$	51.55	51.17
	SD	4.13	2.40
Head length / total length (%)	$\bar{x}$	14.44A	17.26B
	SD	0.96	0.90
Head length / flagellum length (%)	$\bar{x}$	16.89A	20.88B
	SD	1.33	1.33
Head area / total length (%)	$\bar{x}$	61.72A	75.38B
	SD	7.21	5.20

*means bearing different superscripts differ significantly at $p \leq 0.01$

matozoa. Differences between bulls and boars in the shape of the spermatozoon head were insignificant, due to similar spermatozoon head width/head length ratio in both species. However, boar spermatozoa were characterized by higher head length/flagellum length ratio and higher head length/total length of spermatozoon ratio than those of bull spermatozoa. A higher area of spermatozoon head/total length of spermatozoon ratio of boar spermatozoa than that of bull spermatozoa was also found. Both bull and boar semen was of good quality, and the frequency of spermatozoa with major abnormalities neither exceeded 1% nor differed significantly between species (tab. 2).

Correlations between morphological changes and some morphometrical traits of boar spermatozoa were found (tab. 3), including significant positive correlations between the following parameters: the flagellum length and the total spermatozoon length, the percentage of main

Table 2. Percentage of sperm abnormalities in semen of bulls and boars

Specification	Bulls	Boars
Spermatozoa of normal morphology (%)	96.30^{A}*	93.88^{B}
Spermatozoa with major abnormalities (%)	0.88	0.90
underdeveloped	0.11	0.06
pear shaped head	0.10^{a}	0.03^{b}
narrow base	0.15	0.09
proximal droplet	0.02^{A}	0.25^{B}
Dags defect	0.20	0.32
other major abnormalities	0.30^{A}	0.15^{B}
Spermatozoa with minor abnormalities (%)	2.82^{A}	5.22^{B}
free heads	1.18^{A}	0.22^{B}
distal droplets	0.08^{A}	2.01^{B}
simple bent tail	1.37^{A}	2.86^{B}
terminally coiled tail	0.15	0.08
other minor abnormalities	0.03^{a}	0.05^{b}

*means bearing different superscripts differ significantly at $p \leq 0.01$ (capital letters) or $p \leq 0.05$ (small letters)

Table 3. Correlation coefficients between morphometric traits of spermatozoa and parameters of sperm morphology in ejaculates of boars

Parameters of perm morphology Morphometric traits of sperm	Normal morphology	Major abnormalities	Minor abnormalities
Head area (μm^2)	- 0.05	0.07	0.10
Head length (µm)	0.11	0.22	0.30*
Head width (µm)	- 0.08	0.16	0.12
Flagellum length (µm)	- 0.13	0.37*	0.48*
Total length (µm)	- 0.11	0.37*	0.48*
Head width / head length (%)	- 0.21	- 0.05	- 0.18
Head length / total length (%)	0.25	- 0.32*	- 0.40*
Head length / flagellum length (%)	0.25	- 0.33*	- 0.40*
Head area / total length (%)	0.08	- 0.34*	- 0.45*

*$p \leq 0.05$

abnormalities (r=0.37) and secondary abnormalities (r=0.48), as well as the length of the spermatozoon head and the percentage of secondary abnormalities (r=0.30). Moreover, significant, but negative, correlations (from –0.32 to –0.44) were found as well between the percentage of main and secondary abnormalities and the morphological indexes containing the flagellum length or the total spermatozoon length in the indexes.

Our results indicated considerable differences in spermatozoal morphology in cattle and domestic pigs, as well as a relatively large variation of the traits within particular species. Morrow and Gage [13] found higher values of morphological measurements in bull spermatozoa than those in boars. It was found that the variability of head dimensions in bulls is related to abnormal chromatin structure [15]. The changes in the chromatin structure of spermatozoa isolated from the bull scrotum are linked with an increase in morphologically abnormal spermatozoa [10].

Differences in the shape of spermatozoal head were not found in this study, however, bull spermatozoa were longer than boar spermatozoa. According to Gomendio and Rodan [7] longer spermatozoa in mammals could be an adaptation to sperm competition. These authors showed that the sperm length is positively correlated with the sperm motility. Dependences between the measurements of spermatozoal head and fertility were also found [1]. According to Hirai et al. [9] boar spermatozoa of high fertility are characterized by smaller and shorter heads than boar spermatozoa of weak fertilization efficiency. Spermatozoal measurements like their survival and motility are factors essential for semen selection within female reproductive tract [16].

In conclusion, we found considerable and statistically significant differences in spermatozoal morphology in bulls and boars. Bull spermatozoa were larger than boars. Correlations between the frequency of morphological changes and morphometrical traits of boar spermatozoa were found as well. More morphological anomalies of spermatozoa in ejaculates containing longer spermatozoa were also recorded.

REFERENCES

1. Azis N, Fear S, Taylor C, Kingsland CR, Lewis-Jones I **1998** Human sperm head morphometric distribution and its influence on human fertility. *Fertility and Sterility* **70** 883-891.
2. Ball BA, Mohammed HO **1995** Morphometry of stallion spermatozoa by computer-assisted image analysis. *Theriogenology* **44** 367-377.
3. Blom E **1981** The morphological estimation of the spermatozoa defects of bull II. The proposal of new classification of spermatozoa defects (in Polish). *Medycyna Weterynaryjna* **37** 239-242.
4. Casey PJ, Gravance CG, Davis RO, Chabot DD, Liu IKM **1997** Morphometric differences in sperm head dimensions of fertile and subfertile stallions. *Theriogenology* **47** 575-582.
5. Dahlbom M, Andersson M, Vierula M, Alanko M **1997** Morphometry of normal and teratozoospermic canine sperm heads using an image analyzer: work in progress. *Theriogenology* **48** 687-698.
6. Gage MJG, Morrow EH **2003** Experimental evidence for the evolution of numerous, tiny sperm via sperm competition. *Current Biology* **13** 754-757.
7. Gomendio M, Roldan ERS **1991** Sperm competition influences sperm size in mammals. *Proceedings of the Royal Society of London Series B – Biological Science* **243** 181-185.
8. Gravance CG, Liu IKM, Davis RO, Hughes JP, Casey PJ **1996** Quantification of normal head morphometry of stallion spermatozoa. *Journal of Reproduction and Fertility* **108** 41-46.
9. Hirai M, Boersma A, Hoeflich A, Wolf E, Föll J, Aumüller R, Braun AJ **2001** Objectively measured sperm motility and sperm head morphometry in boars (*Sus scrofa*): Relation to fertility and seminal plasma growth factors. *Journal of Andrology* **22** 104-110.
10. Karabinus DK, Vogler CJ, Saacke RG, Evenson DP **1997** Chromatin structural changes in sperm after scrotal insulation in Holstein bulls. *Journal of Andrology* **18** 549-555.
11. Kondracki S, Banaszewska D, Mielnicka C **2005** The effect of age on the morphometric sperm traits of domestic pig (Sus scrofa domestica). *Cellular and Molecular Biology Letters* **10** 3-13.
12. Morrow EH, Gage MJG **2000** The evolution of sperm length in moths. *Proceedings of the Royal Society of London Series B – Biological Science* **267** 307-313.
13. Morrow EH, Gage MJG **2001** Consistent significant variation between individual males in spermatozoal morphometry. *Journal of Zoology* **254** 147-153.
14. Rijsselaere T, Van Soom A, Hoflack G, Maes D, Kruif A **2004** Automated sperm morphometry and morphology analysis of canine semen by the Hamilton-Thorne analyzer. *Theriogenology* **62** 1292-1306.
15. Sailer BL, Jost LK, Evenson DP **1996** Sperm head morphometry related to abnormal chromatin structure and fertility. *Cytometry* **24** 167-173.
16. Snook RR **2005** Sperm competition: not playing by the numbers. *Trends in Ecology and Evolution* **20** 46-53.
17. Sukcharoen N, Sithipravej T, Promvienghai S, Chinpilas V, Boomkasemsanti W **1998** Sperm morphology evaluated by computer (IVOS) cannot predict the fertilization rate in vitro after intracytoplasmic sperm injection. *Fertility and Sterility* **69** 564-568.