

Comparative assessment of reproductive capacity of boar-sires depending on the breed and season

O. S. Miroshnikova , S. V. Naumenko 

State Biotechnological University, Alchevsky Str., 44, Kharkiv, 61002, Ukraine

Article info

Received 19.09.2022

Received in revised form

24.10.2022

Accepted 25.10.2022

Correspondence author

Svitlana Naumenko

Tel.: +38-097-984-27-62

E-mail: frolka001@gmail.com

2022 Miroshnikova O. and Naumenko S. This is an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.



Contents

1. Introduction	23
2. Materials and methods	24
3. Results and discussion	24
4. Conclusions	27
References	27

Abstract

The article highlights the results of the reproductive capacity of different breeds of boar sires in the farms of eastern, southern, and central regions of Ukraine in dynamics over three years are given. It represented the influence of the year's season on sperm quality by estimating the ejaculate volume, concentration, and motility of sperm of boars-sires of the different breeds and their hybrids. Data were also calculated on the culling of ejaculates of boar sires of various breeds for the years 2019–2021 in the dynamics. In a comparative aspect, the indicators were analyzed by the following genotypes: Large White, Ukrainian Meat, Landrace, Duroc, Yorkshire, and synthetic line Makster. The reproductive capacity of boars was within the limits of the indicators for the elite and first classes. However, specific differences were observed between boars of different breeds, which were constant and took place during the three studied years. The difference in the concentration of sperm in the ejaculates of the Ukrainian Meat breed gradually decreased starting from 2019 and was the smallest in 2021. The highest ejaculate volume was found in boars of the Ukrainian meat breed ($310.9 \pm 113.2 \text{ cm}^3$), and the sperm concentration was the highest in boar sires of the Large White breed ($215.7 \pm 83.5 \text{ million/cm}^3$). On the other side, hybrids of the Large White breed had low indicators compared to other groups of animals (Large White \times Yorkshire – $184.2 \pm 68.5 \text{ million/cm}^3$, Large White \times Makster – $189.0 \pm 59.7 \text{ million/cm}^3$). Sperm motility did not undergo significant breed differences: the average annual indicator of motility was 7.6 ± 0.09 points, and it was the highest in the winter period (8.6 ± 0.11 points), however, for the established variances; the dilution was used 1.65–3.58 times and a high percentage of unusable sperm (15.4–29.4 % of the total amount) was established in a large number of samples. According to the results of the annual analysis of the sperm production of boars, a high degree of culling of ejaculates was established for various reasons (high level of sperm agglutination (52.3–74.0 %), low concentration of germ cells (14.5–29.8 %), presence of foreign impurities (5.8–12.4 %). The highest percentage of culling was in summer (20.3 %). Thus, the obtained results showed the breed and seasonal characteristics of the reproductive capacity of breeding boars.

Keywords: boar-sires, reproductive capacity, ejaculate, agglutination.

Citation:

Miroshnikova, O. S., & Naumenko, S. V. (2022). Comparative assessment of reproductive capacity of boar-sires depending on the breed and season. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 5(3), 23–28.

1. Introduction

Because boars are a smaller component of the leading herd and perform an equally important function, special requirements are imposed on their selection. At the same time, it is necessary to create such conditions for boar sires that would contribute to the complete disclosure of their genetic potential. An animal as a living organism should be considered in inseparable unity with the environment. Paratypic factors make it possible to realize the genotype within the taxon, and therefore the technological conditions should be such that it is possible to obtain the maximum amount of appropriate products from farm animals (Yeste et al., 2017; Fair & Romero-Aguirregomez, 2019; Khalak et al., 2020; 2021; Martin-Hidalgo et al., 2022).

Many factors affect the productivity of boar sires. Boar productivity indicators, as a group of labile traits, undergo changes depending on their age, breed, season of the year,

the intensity of use, levels of feeding and maintenance, etc. The influence of external factors on the productivity of boar sires is significantly exacerbated when used in industrial conditions. In turn, this affects the productivity of sows and, later on, the efficiency of the industry as a whole (Gao et al., 2018; Czubaszek et al., 2019; Martysuk et al., 2021; Basioura et al., 2021).

The implementation of the influence of factors of various origins on spermatogenesis and the reproduction function of males is regulated by hormonal and metabolic processes, leading among which are the influence of active forms of oxygen and the protective function of the antioxidant system. Most authors believe that obtaining valuable offspring is possible under the comprehensive application of reproductive technologies (early clinical examination, use of preventive measures, artificial insemination, etc.) (Hurtado de Llera et al., 2016; Khoi et al., 2021).

Of course, information about the dynamics of sperm quality indicators in different seasonal periods of producers of different origins is essential in the selection and technical programs of pig breeding. In this context, in the comparative evaluation of different combinations of animals, it is necessary to study the productivity of sires involved in obtaining various breed combinations. In addition to the lifetime assessment and determination of the quality class of boars, when selecting them for the formation of combinations, it is necessary to carry out a comprehensive assessment of their sperm production. This especially applies to their previous and subsequent productive periods (Rodríguez-Gil & Bonet, 2016; Morrel, 2019; Ge et al., 2021). The purpose of the research: is to determine the reproductive capacity of different breeds of boar sires in the dynamics over three years for the comparative assessment of its breed and seasonal characteristics.

2. Materials and methods

The study of the sperm of boar sires was carried out at the centers of artificial insemination at the farms of eastern, southern, and central regions of Ukraine and on animals belonging to private individuals of the specified regions and Kharkiv city.

Boar-sires were kept at the farms under sanitary, hygienic, and technological conditions. The mode of use of boars is one sampling in four days. Sperm was carried out following the current veterinary and sanitary rules of operation of artificial insemination centers. Before obtaining sperm, all boars were treated with warm water under the shower, with water supplied from all sides of the animal's body. Collec-

tion and evaluation of semen from boars in all seasons of the year were carried out at their full constitutional maturity and sexual development, starting from 10 months old.

To evaluate the reproductive capacity of boar sires in dynamics over three years, data on the six groups of animal breeds and their hybrids were estimated: Large white breed (1), Ukrainian Meat (2), Large White×Yorkshire (3), Landrace (4), Large White×Makster (5), Duroc (6).

All the experimental involvement and slaughter of animals were conducted according to the requirements of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes (Strasburg, 1985) and the Order of the First National Congress of the Bioethics (Kyiv, 2001).

Statistical processing of experimental results to determine biometric indicators (average values and their errors, comparison of average values according to the Student's criterion) was done using the *Microsoft Excel* program.

3. Results and discussion

Sperm motility is a qualitative component characterizing sperm production of sires. The general dynamics of the spermatozoa motility of boars of different genotypes are shown in Figure 1. From the obtained data, it can be seen that during the 2019–2021 years, significant differences in sperm motility among all experimental groups of boars were not observed. The reproductive capacity of boar sires was at the level of the elite record and first classes. During the 2019, 2020, and 2021 years the score of sperm motility ranged from 6.73 – 7.82, 6.77 – 8.0, and 7.06 – 7.76 points, respectively.

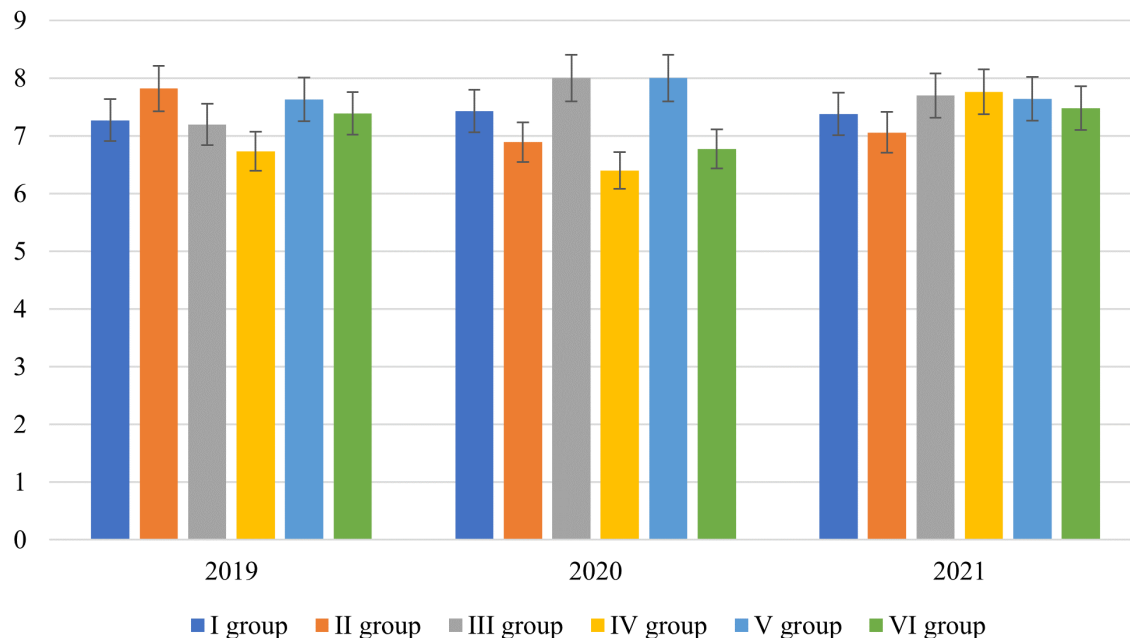


Fig. 1. Dynamics of changes in spermatozoa motility in the boars' ejaculates

Among the quantitative indicators characterizing sperm quality, the important trait is the volume of ejaculation. Many researchers note that the volume of semen of boars has high variability and ranges from 150 to 500 cm³ (Luther & Waberski, 2019; Shostia et al., 2021). It should be noted that the variability of this indicator is determined by many factors, among which the leading ones are the age of the

breeder, the resistance of his organism, and the use of feed additives (Kuster & Althouse, 2016; Shaoyong et al., 2019; Czubaszek et al., 2020).

Volume significantly affects the number of semen doses diluted and prepared for insemination: 8–10 doses or 5–6 doses are obtained with a large or low volume of sperm,

respectively. The general dynamics of the volume of ejaculates of boars of different genotypes are shown in Figure 2.

The largest volume of ejaculate was found in boars of the Ukrainian meat breed during three years 326.18 cm³ (2019), 289.29 cm³ (2020), and 317.29 cm³ (2021). Other breeds of boars had average indicators of ejaculate volume ranging from 191.51 to 289.18 cm³.

The following picture shows the dynamics of sperm concentration in the boars' ejaculates (Figure 3). The concentration of boar semen of the Large White breed remained high for three years and prevailed over the other genotypes in 2019–2020 (214.16 and 239.23 million/cm³). Also, there is no straight-line correlation between the volume and concentration of sperm.

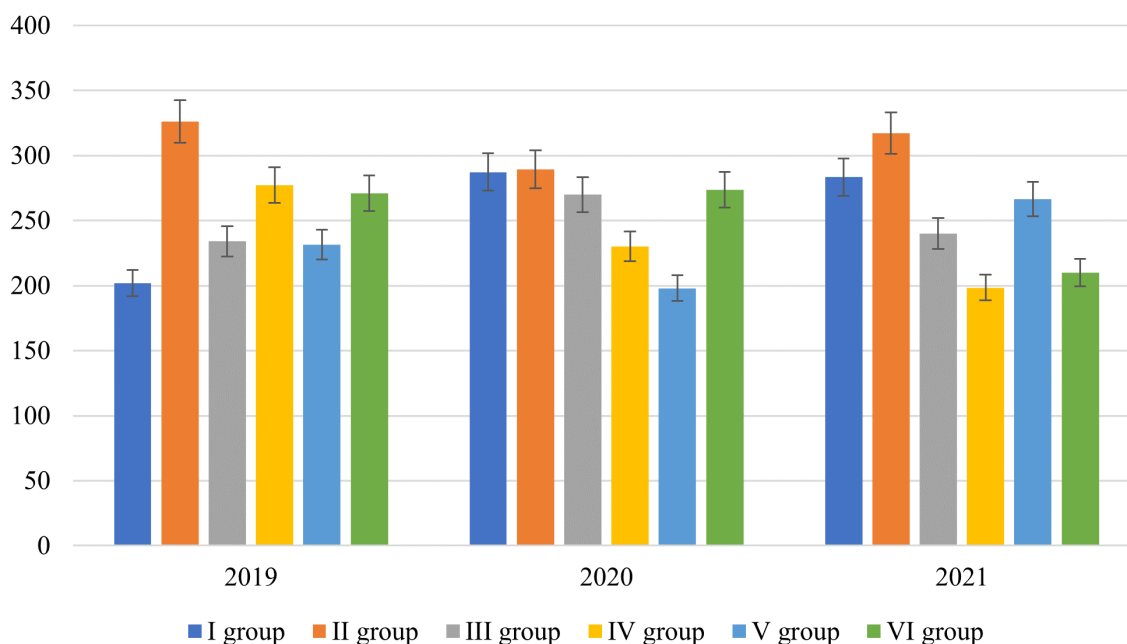


Fig. 2. Dynamics of changes in boars' ejaculate volume

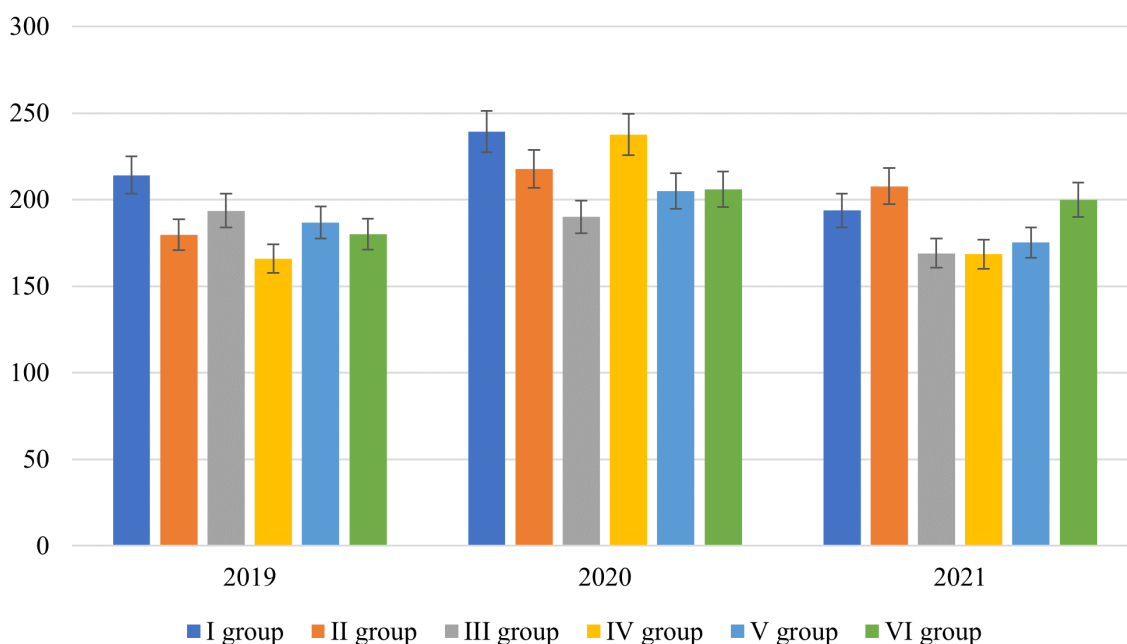


Fig. 3. Dynamics of changes in boars' sperm concentration

The sperm concentration of the Large White boars was the highest among the studied groups, while its hybrids (Large White × Yorkshire, Large White × Makster) were characterized by low values. In general, the reduced dynamics of sperm productivity indicators in 2019–2021 are consistent with previously obtained data for other breeds and hybrids of boars, which determines the need to apply correc-

tive factors (Koshevoy et al., 2021; Zhukova & Naumenko, 2022).

Artificial insemination is economically feasible only under the conditions of obtaining valuable ejaculates. Even slight variations in the sperm motility, concentration, and volume of ejaculate contribute to a significant decrease in the profitability of the industry due to the high number of rejected samples and, mainly, due to the impossibility of

dilution with special diluents. The indicators of sperm productivity of the studied breeds of boar sires for 2019–2021 are summarized in [table 1](#). The data in [table 1](#) shows that the degree of dilution of ejaculates ranged from 1.65 to

3.58 times. Such a discrepancy determines the possibility of impregnating a different number of sows and obtaining a different number of offspring, which will determine the economic efficiency of using artificial insemination.

Table 1
Features of the sperm productivity of boar sires for 2019–2021

Year	Indicator	Animal groups:					
		I	II	III	IV	V	VI
2019	Semen dilution, times	2.78 ± 1.33	1.97 ± 0.68	2.30 ± 1.41	1.90 ± 0.86	2.19 ± 0.87	1.99 ± 0.82
	Unusable sperm, %	9.16	1.76	10.71	16.83	4.61	7.66
2020	Semen dilution, times	3.58 ± 1.22	2.79 ± 1.33	2.50 ± 0.50	3.50 ± 1.43	2.20 ± 1.08	2.55 ± 1.06
	Unusable sperm, %	7.14	13.89	0.00	20.00	0.00	15.38
2021	Semen dilution, times	2.27 ± 1.21	2.63 ± 1.36	1.65 ± 0.12	1.73 ± 0.53	1.88 ± 0.44	2.58 ± 0.17
	Unusable sperm, %	10.26	29.41	3.70	2.94	6.67	4.35

On the other hand, a low amount of unsuitable sperm (up to 4.6 %) was observed in only 38.9 % of the examined ejaculates. In comparison, more than 20 % had a high level of culling (up to 29.4 % of the total). Therefore, considerable attention should be paid to qualitative indicators of boars' sperm to ensure the industry's high profitability. In addition, along with common indicators, foreign researchers pay attention to the importance of sperm metabolism for preserving the mitochondrial activity of sperm and their activity in the genital passages of the female, as well as after

insemination with chilled and frozen-thawed sperm ([Holt & Satake, 2018](#); [Nesci et al., 2020](#)).

An annual analysis of the sperm production of boar sires showed a high degree of culling of ejaculates for various reasons, especially in summer – 20.3 % ([Table 2](#)). The highest percentage of ejaculates with a high level of sperm agglutination was also in the summer – 74.03 %, at the same time as ejaculates with a low sperm concentration, only 16.9 % of the total number of culling.

Table 2
Prevalence of the main factors of culling of boar sires' ejaculates depending on the season

Indicators	Winter (n = 51)	Spring (n = 49)	Summer (n = 66)	Autumn (n = 53)	Total
The total number of obtained ejaculates	622	591	803	642	2658
Adequate ejaculates, %	82.9	89.8	79.7	83.8	84.0
Culled ejaculates, %	17.1	10.2	20.3	16.3	16.0
<i>including:</i>					
with low sperm concentration, %	14.5	29.8	16.9	18.0	18.6
with impurities (blood, pus, urine), %	12.4	11.2	5.8	7.5	8.8
with high sperm agglutination, %	66.9	52.3	74.0	72.8	68.4
with necrospemia, %	5.5	5.1	2.5	1.7	3.5
with azoospermia, %	0.7	1.7	0.82	0	0.7

The low concentration of sperm and the presence of foreign impurities had great importance in the elimination of ejaculates of boar sires. However, the leading factor of sperm unsuitability was a high degree of germ cell agglutination (52.3–74.0 %). This phenomenon arises due to an increase in the number of sperm antibodies and the development of infectious diseases, which are accompanied by changes in the proteomic profile of spermatozoa ([Parrilla et al., 2019](#); [Martín-Hidalgo et al., 2020](#); [Kroh et al., 2022](#)).

It must be assumed that the high and uncomfortable summer temperature adversely affects the sperm-forming function of sires. Therefore, ensuring and complying with comfortable sanitary and hygienic conditions and the maintenance of producers is an integral attribute of modern, efficient technologies in pig breeding. It was also estab-

lished that boar sires who produced higher volumes of ejaculates were characterized by higher sexual activity.

In addition, it was established the presence of variations of sperm motility of the boar-sires depending on the season ([Fig. 4](#)). The motility of spermatozoa reached the highest values in winter (8.6 ± 0.11 points), in spring and autumn, it ranged between 7.2–7.3 points, and it was significantly reduced in summer. Note that the average annual mobility index was 7.6 ± 0.09 points.

Prospects for further research are the determination of the effect of correction of the reproduction function of boars with antioxidant components, taking into account breed and seasonal features according to biochemical and morphological parameters ([Feugang et al., 2019](#); [Koshevoy et al., 2022](#)).

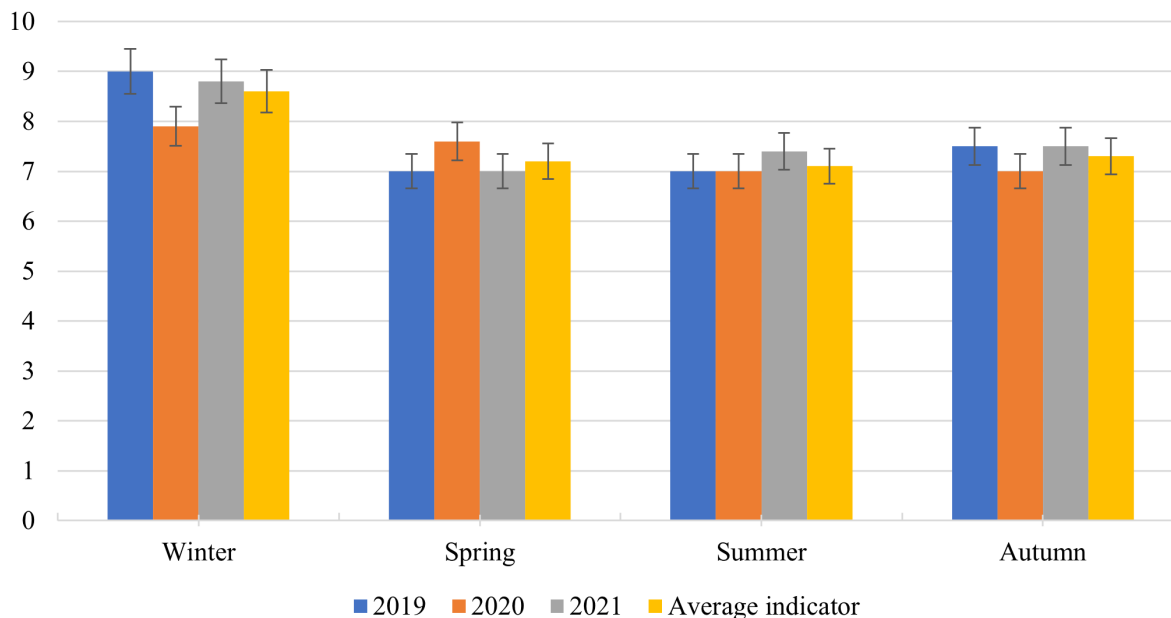


Fig. 4. Dynamics of changes in sperm motility of boar sires depending on the season

4. Conclusions

1. The production quality of boars semen was within the limits of indicators for the elite and first classes, but specific differences were observed between sires of different breeds. These differences were constant and took place during the three studied years: the highest volume of ejaculate was established in boars of the Ukrainian Meat breed ($310.9 \pm 113.2 \text{ cm}^3$), and the sperm concentration was the highest in boars of the Large White breed ($215.7 \pm 83.5 \text{ million/cm}^3$), while the hybrids of this breed had low indicators compared to other groups of animals (Large White \times Yorkshire – $184.2 \pm 68.5 \text{ million/cm}^3$, Large White \times Makster – $189.0 \pm 59.7 \text{ million/cm}^3$).

2. Sperm motility did not undergo significant breed differences: the average index of annual motility was 7.6 ± 0.09 points, and it was the highest in winter (8.6 ± 0.11 points); we note that for the established variations, the degrees of semen dilution was 1.65–3.58 times, while a high percentage of unusable sperm was established (15.4–29.4 % of the total number of samples).

3. According to the results of the annual analysis of the sperm quality of boar sires, a high degree of ejaculate culling by various reasons was established, the most common of which were: high level of sperm agglutination (52.3–74.0 %), low concentration of germ cells (14.5–29.8 %), the presence of foreign impurities (5.8–12.4 %), etc. The increase in the abovementioned changes had a pronounced seasonality: the highest culling percentage was observed in summer (20.3 %).

Conflict of interest

The authors claim that there is no conflict of interest.

References

Basioura, A., Tsousis, G., Boscus, C. M., & Tsakmakidis, I. A. (2021). Efficiency of three boar sperm enrichment techniques. *Reproduction in domestic animals = Zuchthygiene*, 56(8), 1148–1151. [\[Crossref\]](#) [\[Google Scholar\]](#)

Czubaszek, M., Andraszek, K., & Banaszewska, D. (2020). Influence of the age of the individual on the stability of boar sperm genetic material. *Theriogenology*, 147, 176–182. [\[Crossref\]](#) [\[Google Scholar\]](#)

Czubaszek, M., Andraszek, K., Banaszewska, D., & Walczak-Jędrzejowska, R. (2019). The effect of the staining technique on morphological and morphometric parameters of boar sperm. *PloS one*, 14(3), e0214243. [\[Crossref\]](#) [\[Google Scholar\]](#)

Fair, S., & Romero-Aguirregomezcorta, J. (2019). Implications of boar sperm kinematics and rheotaxis for fertility after preservation. *Theriogenology*, 137, 15–22. [\[Crossref\]](#) [\[Google Scholar\]](#)

Feugang, J. M., Rhoads, C. E., Mustapha, P. A., Tardif, S., Parrish, J. J., Willard, S. T., & Ryan, P. L. (2019). Treatment of boar sperm with nanoparticles for improved fertility. *Theriogenology*, 137, 75–81. [\[Crossref\]](#) [\[Google Scholar\]](#)

Gao, H., Gao, Y., Yang, C., Dong, D., Yang, J., Peng, G., Peng, J., Wang, Y., Pan, C., & Dong, W. (2018). Influence of outer membrane vesicles of *Proteus mirabilis* isolated from boar semen on sperm function. *Veterinary microbiology*, 224, 34–42. [\[Crossref\]](#) [\[Google Scholar\]](#)

Ge, C., Feng, N., Hu, C., Tang, Y., Li, X., & Wang, X. (2021). Transwell isolation and difference analysis of capacitated boar sperm proteins based on the iTRAQ technique. *Theriogenology*, 168, 13–24. [\[Crossref\]](#) [\[Google Scholar\]](#)

Holt, W. V., & Satake, N. (2018). Making the most of sperm activation responses: experiments with boar spermatozoa and bicarbonate. *Reproduction, fertility, and development*, 30(6), 842–849. [\[Crossref\]](#) [\[Google Scholar\]](#)

Hurtado de Llera, A., Martin-Hidalgo, D., Gil, M. C., Garcia-Marin, L. J., & Bragado, M. J. (2016). New insights into transduction pathways that regulate boar sperm function. *Theriogenology*, 85(1), 12–20. [\[Crossref\]](#) [\[Google Scholar\]](#)

Khalak, V., Guttyj, B., Bordun, O., Ilchenko, M., & Horchanok, A. (2020). Effect of blood serum enzymes on meat qualities of piglet productivity. *Ukrainian Journal of Ecology*, 10(1), 158–161. [\[Article\]](#) [\[Google Scholar\]](#)

- Khalak, V., Gutyj, B., Bordun, O., Horchanok, A., Ilchenko, M., Smyslov, S., Kuzmenko, O., Lytvynshchenko, L. (2020). Development and reproductive qualities of sows of different breeds: innovative and traditional methods of assessment. *Ukrainian Journal of Ecology*, 10(2), 356–360. [\[Article\]](#) [\[Google Scholar\]](#)
- Khalak, V., Gutyj, B., Stadnytska, O., Shuvar, I., Balkovskiy, V., Korpita, H., Shuvar, A., & Bordun, O. (2021). Breeding value and productivity of sows of the Large White breed. *Ukrainian Journal of Ecology*, 11(1), 319–324. [\[Article\]](#) [\[Google Scholar\]](#)
- Khoi, H. X., Shimizu, K., Yoneda, Y., Minagawa, I., Abe, Y., Kuwabara, Y., Sasanami, T., & Kohsaka, T. (2021). Monitoring the reactive oxygen species in spermatozoa during liquid storage of boar semen and its correlation with sperm motility, free thiol content, and seasonality. *Andrologia*, 53(11), e14237. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Koshevoy, V. I., Naumenko, S. V., Klochkov, V. K., & Yefimova, S. L. (2021). The use of gadolinium orthovanadate nanoparticles for the correction of reproductive ability in boars under oxidative stress. *Ukrainian Journal of Veterinary Sciences*, 12(2), 74–82. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Koshevoy, V., Naumenko, S., Skliarov, P., Syniahovska, K., Vikulina, G., Klochkov, V., & Yefimova, S. (2022). Effect of gadolinium orthovanadate nanoparticles on male rabbits' reproductive performance under oxidative stress. *World's Veterinary Journal*, 12(3), 296–303. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Kroh, P. D., Braun, B. C., Liu, F., Müller, P., & Müller, K. (2022). Boar spermadhesin AWN: novel insights in its binding behavior and localization on sperm. *Biology of reproduction*, 106(4), 775–791. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Kuster, C. E., & Althouse, G. C. (2016). The impact of bacteriospermia on boar sperm storage and reproductive performance. *Theriogenology*, 85(1), 21–26. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Luther, A. M., & Waberski, D. (2019). In vitro aging of boar spermatozoa: role of sperm proximity and seminal plasma. *Andrology*, 7(3), 382–390. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Martín-Hidalgo, D., Macías-García, B., & González-Fernández, L. (2022). Influence of different cellular concentrations of boar sperm suspensions on the induction of capacitation and acrosome reaction. *The Journal of reproduction and development*, 68(1), 68–73. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Martín-Hidalgo, D., Macías-García, B., García-Marín, L. J., Bragado, M. J., & González-Fernández, L. (2020). Boar spermatozoa proteomic profile varies in sperm collected during the summer and winter. *Animal reproduction science*, 219, 106513. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Martysjuk, T. V., Gutyj, B. V., & Khalak, V. I. (2021). System of antioxidant protection of the body of piglets under the action of feed additive “Butaselmevit-plus”. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 4(2), 38–43. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Morrell J. M. (2019). Effect of colloid centrifugation on boar sperm quality during storage and function in in vitro fertilization. *Theriogenology*, 137, 122–126. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Nesci, S., Spinaci, M., Galeati, G., Nerozzi, C., Pagliarani, A., Algieri, C., Tamanini, C., & Bucci, D. (2020). Sperm function and mitochondrial activity: An insight on boar sperm metabolism. *Theriogenology*, 144, 82–88. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Parrilla, I., Perez-Patiño, C., Li, J., Barranco, I., Padilla, L., Rodríguez-Martínez, H., Martínez, E. A., & Roca, J. (2019). Boar semen proteomics and sperm preservation. *Theriogenology*, 137, 23–29. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Rodríguez-Gil, J. E., & Bonet, S. (2016). Current knowledge on boar sperm metabolism: Comparison with other mammalian species. *Theriogenology*, 85(1), 4–11. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Shaoyong, W., Li, Q., Ren, Z., Xiao, J., Diao, Z., Yang, G., & Pang, W. (2019). Effects of kojic acid on boar sperm quality and anti-bacterial activity during liquid preservation at 17°C. *Theriogenology*, 140, 124–135. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Shostia, A. M., Siabro, A. S., Kovalchuk, I. I., Krasnoshchok, O. O., Chukhlib, Ye. B., & Bereznytskyi, V. I. (2021). Prooksydantno-antyoksydantnyi homeostaz u spermi knuriv-plidnykiv pid chas vzhivannia riznykh kormovykh dobavok. *Visnyk Poltavskoi derzhavnoi aharnoi akademii*, 2, 181–187. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Yeste, M., Rodríguez-Gil, J. E., & Bonet, S. (2017). Artificial insemination with frozen-thawed boar sperm. *Molecular reproduction and development*, 84(9), 802–813. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Zhukova, I. O., & Naumenko, S. V. (2022). Assessment of the influence of N-acetylcysteine *in vivo* on sperm quality and hormone balance in boars. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Veterinary Sciences*, 24(108), 107–111. [\[Crossref\]](#) [\[Google Scholar\]](#)