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Fertility of hybrid sows inseminated with east Balkan boar semen: a step towards developing a new hybrid

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Abstract

The present study aims to evaluate the fertility and reproductive performance of hybrid sows inseminated with semen from East Balkan boar (EBS), as part of an experimental artificial insemination program. A total of 472 hybrid sows were inseminated with semen from 10 EBS boars, and their reproductive traits were analyzed. The conception rate was high (92%), exceeding the average values for industrial pig farming (85%), indicating satisfactory reproductive performance following the use of East Balkan boar semen. The average litter size was 12.3 piglets, of which 9.6 were live-born and 2.5 were stillborn. Seasonality affected both litter size and piglet survival, with summer farrowings producing higher litters but also higher neonatal mortality. Differences among individual boars were observed, with some demonstrating superior reproductive performance. The results provide information on reproductive outcome following the use of East Balkan boars in hybrid sow insemination.

Keywords: sow fertility, boar influence, autochthonous breed, artificial insemination, swine hybridization

INTRODUCTION

The East Balkan pig (*Sus scrofa*) is an autochthonous Bulgarian breed with a long historical tradition, adapted to pasture-based farming in the forested regions of the Eastern Balkan Mountains and Strandzha Mountains. In recent decades, the breed population has significantly declined, approaching critically low levels. This trend has been attributed to factors such as pig farming industrialization and diseases – African Swine Fever (ASF).

Preservation of local pig breeds has gained increasing scientific interest due to breeds genetic specificity and adaptation to extensive production systems. According to Kasprzyk & Walenia (2023), maintaining local breeds as a genetic reservoir supports conventional animal husbandry by offering potential adaptability to changing environmental conditions and production demands.

Autochthonous pig breeds have been extensively reviewed in the literature, mainly in relation to their biological, reproductive and production characteristics, as well as their role as genetic resources in breeding activities. Kasprzyk & Walenia (2023) discuss native pig breeds primarily in the context of breeding strategies aimed at maintaining genetic diversity, particularly in low-input or alternative production systems, without considering them as replacements for conventional commercial lines. In Bulgaria, the East Balkan pig has been described with specific biological and reproductive features, including lower prolificacy compared to modern industrial breeds, but with distinct adaptive and production traits (Stoykov et al., 2011; Marchev et al., 2018). This highlights the need for studies focused on reproductive parameters when using boars of the East Balkan pig breed.

The experiments were conducted at "Industrial pig farm Golyamo Vranovo Invest" (IPGVI) where artificial insemination of hybrid sows with semen from East Balkan boars was performed under field conditions. The present study evaluates reproductive performance in hybrid sows inseminated with semen from boars of the EBS breed. The analysis focuses on conception rate and litter characteristics, including total number of piglets born, live-born, stillborn, and mummified fetuses.

The study evaluates key reproductive traits in hybrid sows inseminated with semen from 10 East Balkan boars. The goal is to assess the influence of the sire on conception rate and litter parameters such as total piglets born, live-born, stillborn, and mummified fetuses. It has been reported that the breed of the boar played a significant role in determining litter size, conception rate, and the incidence of stillbirths and mummified fetuses (Pedersen et al., 2019).

The aim of the present study is to analyze the results from experimental artificial insemination of hybrid sows with semen from EBS boars. The obtained results may contribute to a better understanding of reproductive outcomes following the use of East Balkan boars in hybrid sow insemination.

MATERIALS AND METHODS

The experimental crossbreeding of East Balkan pigs with commercial breeds was conducted at the IPGVI farm. The breeding boars were raised in a nucleus herd of purebred EBS in the town of Kyustendil. The animals were acquired for breeding and preservation purposes by the Executive Agency for Selection and Reproduction in Animal Husbandry (EASRAH). An experimental crossbreeding program involving East Balkan boars and commercial hybrid sows was initiated, with the primary objective of evaluating reproductive performance of the animals involved.

A total of 472 hybrid sows were included in the study, housed at the IPGVI farm under a group pen system. The study covered a period of one year (October 2023 – October 2024). The parental breeds used for the development of the hybrid sows are part of a breeding program currently under patent application and therefore cannot be disclosed at this stage for confidentiality reasons.

Artificial insemination was performed using special intrauterine catheters, which improve conception rates. For estrus synchronization in sexually mature sows, ALTRESYN 4 mg/ml oral solution (Ceva Santé Animale, France) containing altrenogest was used. The product was administered orally once daily at a dose of 20 mg altrenogest (equivalent to 5 ml ALTRESYN) per animal for 10 consecutive days. The product was evenly distributed over the individual feed ration just before feeding. After the last ALTRESYN application, the sows were monitored for estrus signs. Insemination was performed when clear behavioral signs of estrus were observed, typically between 3 to 5 days after treatment cessation. The product was administered with a special dispenser ensuring an exact 5 ml dose per full press. All safety precautions related to hormonal products were observed.

Semen Handling and insemination procedure

Ejaculates were collected, evaluated, and diluted at the nucleus farm in Kyustendil. The semen was transported in a cooled container at a temperature of 15–17°C and warmed to 35°C before insemination. Each semen dose contained 3.0–5.0 $\times 10^9$ spermatozoa, with a minimum of 70% motility and morphological abnormalities less than 20%. The dose volume was 80 ml. The procedure involved restraining the sow, cleaning the external vulva, and inserting a specialized catheter through the cervix into the uterus. The semen was administered slowly over 1–2 minutes via gravity flow or gentle pressure. After insemination, sows were kept calm for at least 30 minutes. Pregnancy was confirmed by ultrasound 35 days after insemination.

Statistical analysis

The following reproductive traits were studied: total number of piglets born, number of stillborn piglets, number of weaned piglets, presence of mummified fetuses at farrowing, and the influence of certain factors (boar and season of farrowing) on these parameters.

The data were analyzed using the specialized statistical software SPSS (IBM, v.24).

For analytical purposes, F-criteria and significance levels were calculated at three levels: $p < 0.05$, $p < 0.01$, $p < 0.001$. Various models were applied to analyze specific reproductive parameters as follows:

$Yijkl = \mu + Si + eijl$

$Yijl = \mu + Bj + eijl$

$Yijkl = \mu + Si + Bj + SBij + eijkl$

where:

μ – overall mean constant, Si – fixed effect of farrowing season (i = 4; spring: March to May, summer: June to August, autumn: September to November, winter: December to February), Bj – fixed effect of boar (j = 10 different boars), SBij – random interaction effect between farrowing season and boar, eijkl – residual variance

RESULTS AND DISCUSSION

The reproductive performance of sows is influenced by numerous factors, including paternal genetics, semen quality, and insemination technique. The boar plays a key role in determining litter size, conception rate, and the proportion of stillborn and mummified fetuses (Pedersen et al., 2019; Nevrkla et al., 2021; Kramarenko et al., 2024;). The sire as a factor has a measurable, though limited, effect on reproductive traits of sows (Cieleń & Sell-Kubiak, 2024; Barquero, 2021). Semen quality is significantly correlated with conception success and litter size (Myromslien et al., 2019). Another important prerequisite for high reproductive outcomes in sows is the optimization of the insemination process (Lucca et al., 2020). Contemporary approaches emphasize the importance of selecting boars with good ejaculate characteristics and applying precise artificial insemination methods to enhance reproductive efficiency (Mellagi, 2023; Knox, 2016).

The conducted analysis of variance revealed that the season significantly influenced litter size ($p < 0.01$), number of live-born piglets ($p < 0.01$), and number of stillborn piglets ($p < 0.01$). This suggests that the season, as a composite factor including temperature, nutrition, photoperiod, etc., can affect reproductive outcomes. The sire, as an independent factor, did not reach statistical significance ($p > 0.05$), indicating that individual differences among boars were not a significant factor for these traits.

Table 1. Influence of boar and season on reproductive traits of hybrid sows.

Model	Factor	F- criteria and level of significance				
		Total born	Live-born	Stillborn	Mummified	Conception rate (%)
1	Boar	1.535	1.568	1.326	1.0404	-
2	Season	3.860**	3.432**	3.092**	1.535	-
3	Boar	1.294	1.345	1.191	1.458	-
	Season of mating	3.390*	4.271**	1.827	2.455*	-
	Boar * Season of mating	1.054	1.138	0.895	1.649*	-
4	Boar	-	-	-	-	0.207*
5	Season	-	-	-	-	5.516***

However, analyzing the sire's effect within each season revealed a significant influence on the number of mummified fetuses ($p < 0.05$), indicating variable reproductive results across seasons for individual boars. The conception rate was primarily affected by season ($p < 0.001$), while the effect of boar on this trait was relatively weak but still significant ($p < 0.05$).

The conception rate in sows depends on semen quality, the number of viable spermatozoa, and sperm motility. According to Reckinger et al. (2025), certain boars consistently show high fertility, while others have lower conception rates despite similar semen quality.

The total number of born piglets varied from 10.87 to 13.38 (Table 2), depending on the boar used for insemination. The highest values were observed for boar 23 (13.38 ± 1.086) and boar 19 (13.27 ± 0.82), while the lowest average litter sizes were reported for boar 1 (10.87 ± 0.865) and boar 25 (10.96 ± 0.712). On the other hand, the highest percentage of live-born piglets was recorded for boars 1, 17, and 29 (Figure 1), where this indicator exceeded 80% of the total born. For boars 18, 19, 20, and 21, the proportion of live-born was lower, corresponding to an increased share of stillborn and mummified fetuses.

Although the percentage of mummified fetuses was relatively low for all boars, the highest value was observed for boar 28, which also showed the highest absolute number of mummified fetuses (0.60 ± 0.15). For the other boars, this value was minimal and barely noticeable in the graph.

Table 2. Influence of boars on some reproductive traits

Traits / Boar	Total born	Live-born	Mummified fetuses	Stillborn piglets
1	10.87 ± 0.865	8.791 ± 0.518	0,064 ± 0.088	2.02 ± 0.418
17	12.89 ± 0.75	10.09 ± 0.449	0.067 ± 0.076	2.731 ± 0.363
18	12.65 ± 1.226	9.45 ± 0.734	0.292 ± 0.125	2.909 ± 0.593
19	13.27 ± 0.82	10.24 ± 0.491	0.210 ± 0.083	2.82 ± 0.397
20	12.99 ± 0.704	9.858 ± 0.421	0.111 ± 0.072	3.017 ± 0.34
21	12.72 ± 0.705	9.702 ± 0.422	0.146 ± 0.072	2.869 ± 0.341
23	13.38 ± 1.086	10.33 ± 0.65	0.246 ± 0.110	2.799 ± 0.525
25	10.96 ± 0.712	8.667 ± 0.427	0.144 ± 0.072	2.154 ± 0.345
28	12.37 ± 1.497	9.547 ± 0.896	0.600± 0.152	2.225 ± 0.724
29	11.34 ± 0.899	9.436 ± 0.538	0.182 ± 0.091	1.727 ± 0.435

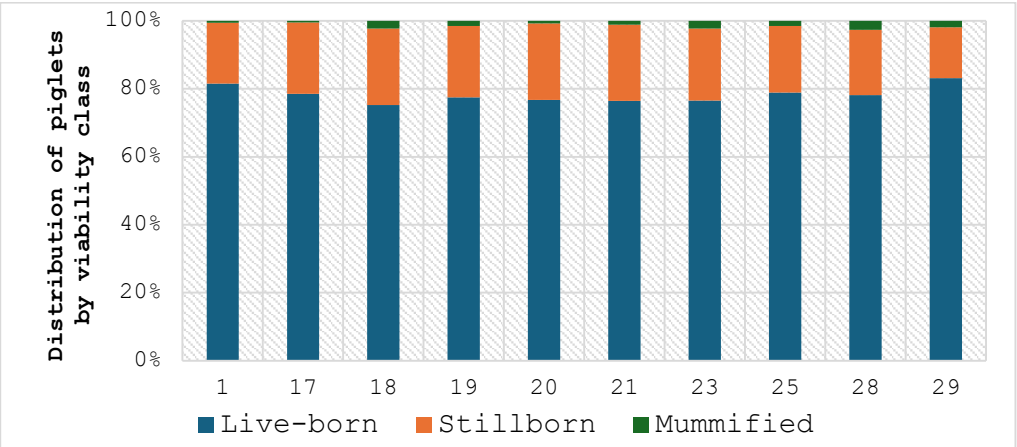

Figure 1. Distribution of piglets by viability class depending on the sire

The number of stillborn piglets also varied significantly, with the lowest values reported for boar 29 (1.73 ± 0.44) and boar 28 (2.23 ± 0.72), and the highest for boar 20 (3.02 ± 0.34).

The graph confirms the trend of differences in litter parameters across sires. Some boars, such as 1 and 29, are distinguished by a high proportion of live-born and low loss rates, while boars 18, 20, and 28 show higher levels of stillborn and mummified fetuses.

The analysis of reproductive performance in sows across different seasons revealed significant variation in litter size, piglet mortality, and conception rate. The highest average number of total piglets born was recorded during summer (13.65 ± 0.52), while the lowest was during autumn (11.42 ± 0.5). In terms of live-born piglets, the highest mean was reported in summer (10.32 ±0.31) and the lowest in autumn (8.98 ±0.3). Neonatal mortality was highest in summer (3.12 ±0.25), and lowest in autumn (2.23 ± 0.24). The number of mummified fetuses showed minor seasonal differences, with slightly higher values during summer and autumn compared to spring and winter.

These results are consistent with other studies. Auvigne et al. (2010) reported that sow fertility decreases by 3–7% during summer months, mainly due to heat stress. Similarly, Piñán et al. (2021) observed seasonal fluctuations in farrowing rate and litter size, with declines during summer and early autumn. Chu (2005) noted that the stillbirth rate is higher in summer and lower in autumn. All these studies confirm that sow fertility and reproductive efficiency is high during cooler months and decline in summer, underscoring the seasonal impact on reproductive performance in pigs.

Table 3. Litter size, piglet mortality and conception rate in saws, depending on the season

Litter trait	Season	N	Mean	± SE	± SD
Total born piglets	Spring	85	11.87	0.572	5.351
	Summer	104	13.65	0.517	5.335
	Autumn	113	11.42	0.496	5.056
	Winter	130	11.75	0.462	5.347
Live born piglets	Spring	85	9.318	0.344	3.310
	Summer	104	10.32	0.311	3.057
	Autumn	113	8.982	0.298	3.108
	Winter	130	9.423	0.278	3.213
Stillborn	Spring	85	2.471	0.275	2.467
	Summer	104	3.125	0.248	2.827
	Autumn	113	2.230	0.238	2.295
	Winter	130	2.215	0.222	2.518
Mummified	Spring	85	0.082	0.059	0.352
	Summer	104	0.212	0.053	0.634
	Autumn	113	0.212	0.051	0.661
	Winter	130	0.115	0.048	0.443

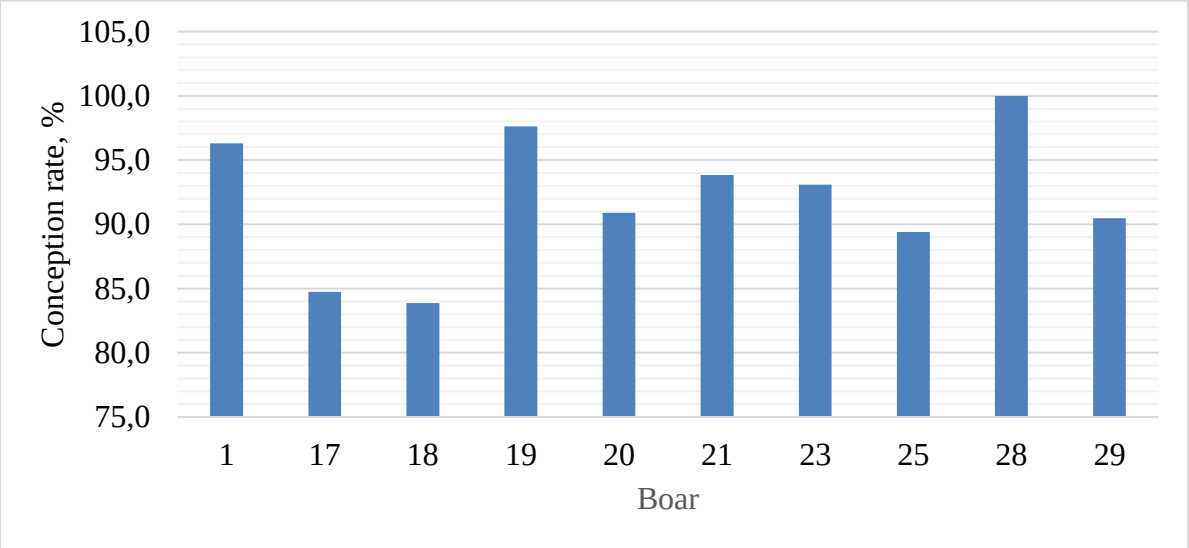

Figure 2. Influence of boars on conception rate of hybrid sows

Figure 2 presents the conception rate in hybrid sows depending on the breeding boar. Substantial variation was observed among sires, with the highest conception rate recorded for boar 28 (100%), and the lowest for boars 17 and 18 (83–84%). High values were also estimated for boars 1 and 19 (95–97%), suggesting genetic or physiological advantages in the reproductive performance of these animals.

Differences in conception rates among boars may result from various factors, including semen quality, sperm morphology and motility, as well as individual characteristics of the inseminated sows. According to Piñán et al. (2021), reproductive success in artificial insemination is influenced not only by boar fertility but also by insemination techniques and environmental conditions.

These results highlight the importance of individual boar selection in breeding programs and the need to monitor semen quality to optimize reproductive outcomes. The reproductive performance of the boars included in this study – in terms of qualitative and quantitative semen traits – is currently under further investigation.

In the studied hybrid sows (Table 4), inseminated with semen from East Balkan boars, relatively good reproductive performance was observed. The conception rate of 92.03%, indicated that 9 of 10 inseminated sows conceived and farrowed successfully. This rate is considered high, given that the average conception rate in industrial farms is typically around 85%, with the best-performing operations reaching 90%. Therefore, the observed 92% exceeds typical industry benchmarks, indicating good fertility of the cross (F1 sows × EBS boars).

Regarding fertility, the average total number of piglets born (12.3) represents a moderately large litter (Table 4). Of these, 9.6 were live-born, 2.5 stillborn, and 0.2 were mummified fetuses. Thus, live-born piglets represented approximately 78% of total births, while stillborn accounted for about 20%. Nevrkla et al. (2021) report an average of 12.4 to 14.1 live-born piglets per litter and 0.94 to 2.4 stillborn, with total litter size ranging from 13.6 at first parity to 16.9 at third parity. In the present study, the values (9.6 live-born out of 12.3 total) are lower, reflecting a known fertility trade-off when using EBS boars. However, it should be noted that purebred East Balkan pigs typically produce only 6–8 live-born piglets (Marchev et al., 2018).

Table 4. Overall reproductive traits in hybrid sows, artificially inseminated with EBS boars

Trait	N	Mean	± SE	± SD
Conception rate (%)	472	92.03	1.392	27.88
Total born piglets per litter, n	432	12.29	0.305	5.322
Live-born piglets, n	432	9.576	0.183	3.195
Stillborn piglets, n	432	2.512	0.148	2.549
Mummified fetuses, n	432	0.205	0.031	0.543

An average of 2.5 stillborn piglets per litter represents a notably high rate – over 20%. Literature suggests that typically only 7–8% of piglets are stillborn (approximately 0.9 per litter of 12), and optimal values are below 6% (Merck Veterinary Manual, 2025). Even in high-producing sows with very high litters (15–17 total), an average of about 1.0 stillborn piglet per litter (5–6%) is observed (van den Bosch, 2022). In comparison, using standard industrial boars such as Duroc is observed approximately 12.3 live-born piglets out of 13.8 total, with about 1.35 stillborn (~10%) (Nevrkla et al., 2021). For the Pietrain breed, which is known for its higher stillbirth risk, 2.8 out of 16.6 total (17%) stillborn are recorded– still lower than the 20% observed in the current study. This highlights that crossbreeding with EBS, in some cases can result in a relatively high proportion of stillborn piglets. However, the number of mummified fetuses (0.2 per litter or 1.6%) is low and comparable with typical values (1.0%–2.99%) (Merck Veterinary Manual, 2025), indicating that early embryonic mortality was not a serious issue. The main piglet losses occurred during or shortly before farrowing (late fetal mortality).

CONCLUSIONS

The conception rate in hybrid sows inseminated with East Balkan boars was 92.03%. This demonstrates that, despite their autochthonous origin, EBS boars can be effectively used in reproductive programs with industrial sows. The average number of piglets born per litter was 12.29, of which 9.58 were live-born (78%), 2.51 were stillborn (20.4%), and 0.2 (1.6%) were mummified. Season had a significant effect on reproductive parameters. In summer, the highest average number of born piglets was recorded (13.65), along with the highest number of stillborn piglets (3.12). Conversely, in autumn, the lowest total number of piglets (11.42) and lowest neonatal mortality (2.23) were observed. Individual boars had varying effects on litter traits. For example, boars 1 and 29 showed high conception rates (>96%) and low stillbirth rates (<15%), while boar 28 achieved 100% conception but had the highest share of mummified fetuses (0.6). Further analysis of genetic and physiological factors influencing reproductive outcomes is needed. The high conception rates in some boars, contrasted by increased stillbirth and mummification rates in others, point to potential genetic incompatibilities or physiological limitations. Future studies should include a detailed assessment of semen quality and the impact of specific genetic markers on reproductive performance.

REFERENCES

Auvigne, V., Leneveu, P., Jehannin, C., Peltoniemi, O., & E. Sallé, (2010). Seasonal infertility in sows: A five-year field study to analyze the relative roles of heat stress and photoperiod. *Theriogenology*, 74(1), 60–66. https://doi.org/10.1016/j.theriogenology.2009.12.019

Barquero, V., Roldan, E. R. S., Soler, C., Vargas-Leitón, B., Sevilla, F., Camacho,

M., & Valverde, A. (2021). Relationship between fertility traits and kinematics in clusters of boar ejaculates. Biology, 10(7), 595. https://doi.org/10.3390/biology10070595

Chu, M. X. (2005). Statistical analysis of stillbirths in different genotypes of sows. *Asian-Australasian Journal of Animal Sciences*, 18(10), 1475–1478. https://doi.org/10.5713/ajas.2005.1475

Cieleń, G., & Sell-Kubiak, E. (2024). Importance and variability of the paternal component in sow reproductive traits. Journal of Applied Genetics, 65(4), 853–866. https://doi.org/10.1007/s13353-024-00910-y

Kasprzyk, A., Walenia, A. (2023). Native pig breeds as a source of biodiversity – breeding and economic aspects. *Agriculture*, 13, 1528. https://doi.org/10.3390/agriculture13081528

Knox, R. V. (2016). Artificial insemination in pigs today. *Theriogenology*, 85(1), 83–93. https://doi.org/10.1016/j.theriogenology.2015.07.009

Kramarenko, A. S., Karatieieva, O. I., Liuta, I. M., & Kramarenko, S. S. (2024). Genetic and non-genetic factors influencing piglet stillbirth risk. Regulatory Mechanisms in Biosystems, 15(4), 875–881. https://doi.org/10.15421/0224126

Lucca, M. S., da Rosa Ulguim, R., Bortolozzo, F. P., Wentz, I., Rocha, J. C., de Souza, M. C. D., Escobar, R. V., Calderam, K., de Quadros, P. I., & Marcos, R. A. (2020). Reproductive performance of sows inseminated with semen doses stored for up to seven days in long-term extender in a field condition. *Animal Reproduction*, 17(1), e20190121. https://doi.org/10.21451/1984-3143-AR2019-0121

Marchev, Y., Doneva, R., & Dimitrova, D. (2018). East Balkan swine – autochthonous Bulgarian pig breed. In: Proceedings of the X Simposio Internacional sobre el Cerdo Mediterráneo. *Cordoba, Spain, Archivos de Zootecnia*. 61-65. https://dialnet.unirioja.es/descarga/articulo/6537150.pdf

Mellagi, A. P. G., Will, K. J., Quirino, M., Bustamante-Filho, I. C., Ulguim, R. da R., & Bortolozzo, F. P. (2023). Update on artificial insemination: Semen, techniques, and sow fertility. *Molecular Reproduction and Development*, 90(7), 601–611. https://doi.org/10.1002/mrd.23643

Merck Veterinary Manual. (n.d.). *Measures of reproductive performance in swine relative to industry averages*. Merck & Co., Inc. Retrieved from https://www.merckvetmanual.com/multimedia/table/measures-of-reproductive-performance-in-swine-relative-to-industry-averages

Myromslien, F. D., Tremoen, N. H., Andersen-Ranberg, I., Fransplass, R., Stenseth, E. B., Zeremichael, T. T., van Son, M., Grindflek, E., & Gaustad, A. H. (2019). Sperm DNA integrity in Landrace and Duroc boar semen and its relationship to litter size. *Reproduction in Domestic Animals*, 54(2), 160–166. https://doi.org/10.1111/rda.13322

Nevrkla P, Lujka J, Kopec T, Horký P, Filipčík R, Hadaš Z, Střechová V. (2021). Combined Effect of Sow Parity and Terminal Boar on Losses of Piglets and Pre-Weaning Growth Intensity of Piglets. *Animals*, 11(11), 3287. https://doi.org/10.3390/ani11113287

Pedersen MLM, Velander IH, Nielsen MBF, Lundeheim N, Nielsen B. (2019). Duroc boars have lower progeny mortality and lower fertility than Pietrain boars. *Translational Animal Science*, 3(2), 885-892. https://doi.org/10.1093/tas/txz036

Piñán, J., Martinez-Pastor, F., Alegre, B., Maj, M., Kirkwood, R. N., Domínguez, J. C., &

Manjarín, R. (2021). The Suinfort® semen supplement counters seasonal infertility in Iberian sows. Animals, 11(11), 3176. https://doi.org/10.3390/ani11113176

Reckinger, F., Luther, A-M., Riesenbeck, A., Sitzenstock, F., Wassmuth, R., & Waberski, D. (2025). Fertility with cervical insemination and boar effects using hypothermic stored semen, *Theriogenology*, 236, 45-51. https://doi.org/10.1016/j.theriogenology.2025.01.025

Stoykov, A., Dimov, D., Palova, N., Zapryanova, I., Pavlenko, M., Ivanova-Peneva, S., & K. Kulev, (2011). Shte spasim li Iztochnobalkanskata svinya ot izchezvane (Will we save the East Balkan pig from extinction) [In Bulgarian]. *Zhivotnovadni Nauki* (*Animal Science*), 48(4), 72–78. https://animalscience-bg.org/page/bg/details.php?article_id=1005

van den Bosch, M., van de Linde, I. B., Kemp, B., & van den Brand, H. (2022). Disentangling litter size and farrowing duration effects on piglet stillbirth, acid-base blood parameters and pre-weaning mortality. *Frontiers in veterinary science*, 9, 836202. https://doi.org/10.3389/fvets.2022.836202