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FERTILITY OF BOARS – WHAT IS IMPORTANT TO KNOW

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Review paper

Abstract: The most important part in reproductive management is the control of boar fertility. A common division of fertility traits is on the: *in vitro* (sperm traits) and *in vivo* (return rate, farrowing rate and litter size traits) fertility. In many studies were found differences between breed in the both groups of fertility traits. Variability of sperm traits of boars during the reproductive exploitation is influenced by various genetic (boar, breed) and paragenetic factors/effects (age, season, intensity of use). Good libido is desirable characteristics in boars, but the knowlegde of the correlation of libido and boar fertility traits are limited. Also, there is no standardised procedure or methods for the estimation of libido of the boars. The permanent ranking of boars according to the reproductive efficiency should be performing. Good reproductive management implies the timely identification of boars with the low fertility (or close to the average).

Key words: boar, artificial insemination, sperm traits, libido, reproductive efficiency

Introduction

A large number of descendants produced by boar at an annual level requires a permanent control of its fertility and timely culling of the animals whose performance is below the population or herds average. The application of artificial insemination requires fast and accurate estimation of boar breeding value on the basis of libido, sperm evaluation, success of insemination and the litter size. The boar fertility traits are represented by *in vitro* (sperm traits) and *in vivo* (reproductive efficiency and litter size) fertility. In selected pig populations the boars remain in reproduction from 6 to 8 months on average. In a review of the results realised by a number of artificial insemination centres, *Robinson and Buhr (2005)* state the following most frequent reasons for replacement of boars: genetic reasons (20-45%), sperm quality (10-30%), libido (1-21%), physical health (13-60%) and other reasons (10-20%).

The research results obtained by *Feitsma (2009)* showed that variability of litter size was from 4-7% caused by sperm components, 10% by sow genotype, 10% by herds and 17% by parity. In pig populations where continuos selection is being conducted there is a tendency to use the boars of good production performances in the best way possible what is reflected in obtaining as more doses per ejaculate of optimal fertilising capacity as possible *(Savić et al., 2013b).*

The size of litter varies among the boars, when insemination doses contain the same number of spermatozoa, while an increase of the number of spermatozoa at insemination has a positive effect on the number of live-born piglets particularly in the interval of $1\text{-}3x10^9$ spermatozoa *(Flowers, 2002)*. Farrowing rate and litter size are important traits of the economy of pig breeding industry. A litter size is a low heritable trait and variability of this trait depends in a highest degree on the environmental factors. Number of piglets in litter depends on a sow's genetic potential, but it is thought that boars determine constitution and vitality of fruits and piglets influencing the number of prenatal, perinatal and postnatal losses *(Petrović, 1990)*. According to the research of *Ruiz-Sánchez et al. (2006)* there are some differences between the boars regarding the percentage of determined pregnancies on the 30^{th} day after insemination (73-98%), farrowing rate (71-98%) and total number of born piglets (8.8-12.0 piglets). The boars are being selected mostly on the traits having a primary economic importance such as the rate of liveweight gain or the age at certain body mass, bacon thickness and productivity of their daughters, report *Robinson and Buhr (2005)*.

The control of boars productivity is an important segment of reproductive management so the objective of this research is the effect of evaluation of the most important factors on boar fertility. In addition, this research will partly answer the question whether sexual drive (libido) can have some influence on fertility in boars.

Sperm traits

Evaluation of sperm traits is a standard procedure in the application of artificial insemination. Various factors like boar, breed, age, season, intensity of use have been evidenced to show effect on these traits.

An important step in improving a pig population is a production and exploitation of boar sperm of high genetic potential, good productive performances and high fertilising capacity. Sperm fertilising capacity depends on a larger number of traits. The most important quantitative and qualitative traits of ejaculate are: volume of ejaculate, density or concentration of sperm, motility, percent of abnormal spermatozoa, total number of spermatozoa and number of functional spermatozoa, vitality of spermatozoa and number of doses produced per ejaculate.

A precise determination of concentration, volume and percent of live spermatozoa is very important for the evalution of maximal dilution of sperm which can be used either for artificial insemination or for a number of sows which can be inseminated *(Kanokwan, 2011).* Sperm concentration, volume of ejaculate and motility of spermatozoa are the most important factors which determine the number and fertility of doses produced per one jump *(Savić et al., 2013b).* The choice of extender in the process of preparation of doses for insemination can have an effect on fertility. The results of the research of *Berg et al. (2014)* show differences in the farrowing rate and total number of live piglets at birth of 2.5% and 0.6 piglets which occurred as a result of application of different types of extenders.

Effect of breed

An average manifestation and variability of the boar sperm traits depend on a breed. The research by *Borg et al. (1993)* shows breed differences in body mass, size of testicles, number of spermatozoa per ejaculate and volume of ejaculate. In their research, *Wierzbicki et al. (2010)* determined the differences in all ejaculate traits among 10 examined boar genotypes.

Table 1 shows parameters of quantitative and qualitative traits of boar ejaculate per breed in accordance with the results obtained in different studies. The lowest volume of ejaculate (VOL) and the highest sperm concentration (CON) were determined in Duroc breed boars while the highest volume was determined in LWxP cross-bred boars.

Table 1. Ejaculate traits per breed

Traits	*Wolf and Smital (2009b)*						*Wolf and Smital (2009a)*		*Wolf (2010)*	
	Pure breed			Cross-breed			Pure breed		Pure breed	
	D	LW^s	P	DxLW	DxP	LWxP	LW	L	L	LW
VOL	200	270	275	236	241	282	276	273	276	275
CON	491	401	453	431	445	407	430	422	418	428
MO	73.6	76.6	76.8	71.6	74.2	76.6	76.0	75.6	75.8	76.2
AB	10.8	11.2	11.8	13.1	10.8	10.8	11.4	11.2	11.2	11.5
NT	93.7	101.3	118.7	95.1	102.1	107.4	112	107	108	111
NF	61.5	69.3	80.3	59.1	67.5	73.8	75.5	72.6	72.9	75.2

D- Duroc, LW- Large White (^{s}-sire line), P- Pietrain, L- Landrace, LW- Large White, VOL- Volume of ejaculate *(ml),* CON- Sperm concentration *($x10^3$ spermatozoa/mm^3)*, MO- motility *(%),* AB- percentage of abnormal spermatozoa *(%),* NT- total number of spermatozoa *($x10^9$ spermatozoa)*, NF- number of functional spermatozoa *($x10^9$ spermatozoa)*

Pietrain boars had a large volume of ejaculate, high concentration of sperm, the largest percent of motility of spermatozoa (MO) with the largest number of functional spermatozoa (NF=80.3x10^9) what enables obtaining a larger number of fertilising doses for insemination from one ejaculate. Percent of motile spermatozoa is in all genotypes more or less similar and ranges in the interval from 71.6 to 76.8%. Cross-breds boars DxLW had the worst parameters of the sperm traits with the lowest motility, highest percent of abnormal spermatozoa and smallest number of functional spermatozoa determined.

In the research of *Smital (2009)* significant differences existed in all examined sperm traits with maximum differences between analysed breeds (Czech meaty pig, Duroc, Hampshire, Landrace, Great White, Czech Great White, Pietrain and their different cross-breds) being: 95 ml (VOL), 109 x10^3/mm^3 (CON), 9% (MO), 1.6% (AB), 24x10^9 (NT) and 19x10^9 (corrected number of spermatozoa).

The research of *Stanić et al. (2003)* showed differences in sperm traits existing between boar breeds and cross-breds so that the highest VOL (303 ml) and lowest CON (181x10^6 per ml) were determined in Hampshire boars. The lowest VOL was determined in Pietrain boar (177 ml), while the highest CON in Duroc (218x10^6 per ml). The VOL of ejaculate in Duroc was lower than average in all examined breeds and cross-breds (191 vs. 262 ml). In the research by these authors an average progressive motility of spermatozoa was 78%, the lowest being in Duroc boar (75%), and the highest in Pietrain (83%).

Values of VOL determined in the research of *Savić (2014)* for Landrace and Large White fertile breeds were 236.30 ml and 239.57 ml, while in extremely meaty breed Duroc, value of VOL was 218.09 ml. In the same research the motility of spermatozoa (in native state and after dilution; subjective evaluation) was examined and the Duroc boars were superior in relation to fertile breeds. Differences existed also in the number of doses produced per ejaculate (NPD) because the smallest number of doses for artificial insemination (9.56 doses) was obtained from the ejaculates produced by Duroc. Superiority of swine fertile breeds in relation to Duroc regarding VOL was determined also in other studies (*Wolf, 2009; Savić et al., 2013a).*

In the research of *Knecht et al. (2014)* the highest volume of ejaculate was determined in Polish Great White breed (258.6 ml), but also the smallest number of insemination doses (22.44) due to the lowest concentration (345.1x10^6/ml) and total number of live spermatozoa (68.8x10^9) in ejaculate. The results of this research indicate, a negative relationship between the ejaculate volume and sperm concentration.

Many studies indicate differences in ejaculate traits between the breeds, but in some studies the effect of boar genotype on the ejaculate characteristics was not determined. Thus in the research of *Šernienė et al. (2002)* the effect of breed on the sperm traits (motility, total number of pathological spermatozoa, percent of vital spermatozoa, percent of spermatozoa with anomalies of the tail and head) was not determined .

Differences in sperm traits phenotypic values can be a consequence of the purpose meant for the breeds in a breeding programme. Actually, inferiority of exceptionally meaty Duroc breed in the volume of ejaculate and number of doses produced per ejaculate in relation to fertile breeds might be a consequence of selection directed towards high meat production. Some studies indicate possible disorder of the functions of accessory sexual glands when genotypes with exceptionally small volume of ejaculate are in question. Taking into account a complexity of reproductive mechanism this can most likely be the question of a number of genetic and hormonal effects.

Effect of ejaculation frequency

The intensity of exploitation or a frequency of sperm collection affects boar quantitative and qualitative parameters *(Wolf and Smital, 2009a; 2009b)*. According to the reports of a number of researchers an optimal pause between two jumps for boars in exploitation is 3-5 days, however for young boars the pause between two jumps should be larger (minimum 7 days). Number of spermatozoa in ejaculate is gradually decreasing when boar is used more than once weekly in spite of slight increase of the production of sperm with ejaculation frequency *(Rothschild and Ruvinsky, 2011*). The research conducted by *Savić et al. (2015)* showed a significant effect of interval between two jumps on a volume of ejaculate, total number of spermatozoa and total number of doses per ejaculate. An acceptable level of volume of ejaculate occurred after a 3-day sexual pause, spermatozoa reserves replenished after 5-7 days, while full recovery took about 10-11 days (*Smital,2009)*.

Interval between two successful collections of ejaculates has a great effect on semen concentration *(Wolf and Smital, 2009a).* Prolonging this interval from 2 to 6, that is, 10 days, semen concentration increases for approximately $100x10^3$, i.e., $150x10^3$ spermatozoa per mm^3. As regards the volume of ejaculate, the effect of interval between the two semen collections is considerably weaker and slight increase when interval was prolonged from 2 to 7 days was perceived. Intervals longer than 12 days result botn in a decrease of the percent of motile spermatozoa and certain increase of the percent of abnormal spermatozoa in ejaculate.

By prolonging the interval between sperm collections the motility shows a tendency to decrease while a percent of abnormal spermatozoa shows a tendency to grow but the changes are relatively small *(Wolf and Smital, 2009b).*The results obtained in the studies of the same authors show that phenotypic values of the traits of total count and count of functional spermatozoa may increase when the interval between two semen collections is being prolonged to 10 days and when longer intervals are in question the values of these traits are slightly reduced.

Interval between two collections (≤7 days) showed better effect on sperm production implying that collecting the boar sperm be performed at least once a week *(Savić et al., 2016)*. The intervals between two collections lasting 7 days or less resulted in higher volume of ejaculate (by 42.64 ml), higher count of spermatozoa in ejaculate (by $7.68x10^9$) and higher number of doses per collection (by 2.64) compared to the intervals lasting longer than 7 days. When the intervals exceed 7 days, a productivity of boar per collection decreases at an annual level as well what can be negatively reflected on boar performance increasing the cost of production (less number of doses per collection, less number of collections at an annual level and necessity to raise greater number of boars).

In practical pig production some boars are more often exploited for ejaculate collection because of the ease of manipulation or shorter preparation time for a jump but at the same time we ignore the intensity of exploitation and make shorter pauses between jumps. In this way the animals are not only extremely exhausted but also obtain a weaker fertilising capacity ejaculates. For this reason it is necessary to take care of frequency of boar semen collection in order to obtain the sperm of optimal fertilising capacity.

Libido

Libido is important feature in boars but there is no standardised procedure for the assessment of sexual behaviour of boars used in artificial insemination. Also, the knowlegde of the effect of libido on boar fertility are limited.

Swine reproductive ability depends on the environment they live in. Pigs are social animals therefore for their normal sexual development a contact with other individuals of the same species in the group is necessary. Social environment can affect the age of puberty maturing, manifestation of sexual instinct, behaviour during mating, manifestation of oestrus and alike.

By reviewing the literature there could not be found any standardized procedure for the evaluation of sexual behaviour of boars used for artificial insemination and insight into the effect that sexual behaviour can have on boar reproductive performances is much more inferior than insight into a physiological mechanism of sperm production *(Levis and Reicks, 2005)*. Libido manifestation is under the effect not only of genetic and hormonal factors, but also of paragenetic effects (social environment, season, housing, boar training), so that changes in libido can indirectly indicate possible technological neglects (bad microclimate, fattening condition, stress exposure, badly skilled workers who manipulate the animals).

Social environment has a significant effect on boar sexual ability taking into account that modern testing of male breeding material means housing of a boar in individual or group boxes for purpose of controlling its productive parameters. According to different studies *(Petrović et al., 1994; Levis et al., 1997; Knox, 2003)*, boars raised separately either from female of male animals, mature later sexually, show weaker sexual drive and lower volume of ejaculate. Such animals can even be asocial, showing aggressivness towards individuals of the same breed. For the purpose of improving reproductive ability and socialisation it seems to be necessary to provide the presence of female animals in test stations for testing the male breeding material. By this approach it is possible to expect that boars raised in that way will have better libido, higher volume of ejaculate, and indirectly, higher conception rate and larger size of litter during their reproductive life. *Petrović et al. (1994)* in a review paper reports an unfavourable effect of isolation of boar on his sexual behaviour, occurence of later puberty and decrease of ejaculate volume. Keeping the sexually matured boars in the group had a favourable effect on their libido and boars who were in contact with female breeding animals had better sperm parameters. Raising the boars individually (for purpose of measuring liveweight gain, conversion, daily consumption) can have a negative effect on age at puberty, sexual behaviour and firmness of legs and toes *(Levis et al., 1997).* Besides this, it is also necessary to take into account the behaviour of people towards animals, where different veterinary or zootechnical interventions must be performed in such a way so as not to endanger the welfare of animals and by gaining confidence, particulary towards people who are in direct contact with the boars.

According to different studies, the libido evaluation is performed on the basis of duration of preparation time for a jump, duration of erection, period from the entrance into the room with a dummy sow to the beginning of ejaculation, duration of ejaculation or total time elapsed from the entrance into the room for sperm collection to the end of ejaculation *(Okere et al., 2005; Szostak and Sarzyńska, 2011; Oberlender et al., 2012).* The libido evaluation only on the basis of duration of ejaculation is not sufficient so it is also essential to take into account a pre-jump period. When the evaluation of libido is performed on the basis of total duration of period from the entrance into the room with dummy sow to the end of ejaculation (total manipulative time) the period of preparation of boar is not being separated from the duration of ejaculation. Manifestation of sexual instinct in boar is more complex and requires different defining of libido, and taking into account its importance it is quite certain that in the future it will be a subject of numerous studies.

It was assumed that longer duration of ejaculation and shorter preparatory time are indicators of a good libido (*Savić and Petrović, 2015a)*. Preparing to collect is a non-productive period (NP) within the total manipulative time, which is calculated from when a boar enters the room with the dummy sow until the end of ejaculation. The productive period (PP) is defined as the time during which the boar ejaculates. Libido may be defined as the ratio of productive to non-productive period, based on this formula: I = PP/NP and obtained numerical value representing the libido index (I). When it came to libido, L boars had better sex drive. That is, the PP to NP ratio was higher ($p<0.05$) by 0.10 and 0.12 index points, compared with Large White and Duroc boars, respectively. The main reason for pronounced libido in Landrace boars is the result of the shorter duration of preparing for the collection. Duroc boars were inferior to the fertile breeds (Large White and Ladrcae) with the the weakest libido (1.73).

Phenotype relationship of the traits of sexual activity indicates the possibility of simultaneous improvement of these traits (*Savić and Petrović, 2015b*). A weak relationship (r<0.2000) exists between libido and intensity of ejaculation, but values of coefficients are positive what makes possible simultaneous improvement of both traits. By comparing relationship of libido with VOL and intensity of ejaculation (the flow of ejaculate per time) among the breeds, the values of correlation coefficients are the least within Large White breed.

The one study with libido effect on boar fertility, found that the boars expressing the highest level of sexual behavior were characterized by the greatest number of ejaculate, the best quality of ejaculate (the higher percentage of spermatozoa with progressive motility, the small percentage of defect spermatozoa) and the high number of insemination doses from one ejaculate *(Szostak et al., 2015)*.

In the research of *Szostak and Sarzyńska (2011),* the value of preparation time before the jump was higher in L boars (4.19 min) compared to LW boars (3.10 min). Total time (preparation time+ejaculation) was shorter in LW boar (10.36 min) compared to L boar (12.62 min) and the best libido was determined in hybrid (6.47 min) and Duroc (7.05 min) boars. More distinct sexual drive is probably a consequence of a higher level of testosterone in blood, and the research by *Williams (2009)* indicates close relationship of the level of testosterone and sexual behaviour and libido. This can be confirmed by castrated male animals with a low level of hormones that do not show sexual interest.

Differences in libido among studies, when the same breeds are in question, seems to be the consequence of differences in genetic structure of studied populations, technology of keeping, but also of the way of defining and evalution of boar libido. Taking into account that boars are primarily selected on the traits which have an economic importance (liveweight gain, meatiness, fertility) it is also necessary to take presence of libido into consideration as one of more important criteria at choosing male breeding animals.

Reproductive efficiency of boars

Regardless the mode of mating (natural or artificial) a mating can be either successful or unsuccessful. A successful mating is the one in which a physiological duration of pregnancy in a breeding female results in farrowing. Unsuccessful serving can result in a repeated occurrence of oestrus or pregnancy may end in a miscarriage. When we talk about a reproductive efficiency of herd we primarily think both of a realised return rate and farrowing rate. Taking into account a wide application of artificial insemination and number of breeding females that are inseminated by the sperm of one boar during a determined period an importance to understand parameter values of these traits is for that reason even greater and represents an unavoidable segment in the control of boar productivity. Control of productivity and ranking of boars based on the farrowing rate should be continuously carried out *(Savić et al., 2015).*

Oestrus can be both regular and irregular. If we presumed that an average duration of oestrous cycle is from 18 to 24 days, a regular oestrus would be in the period from 18 to 24 or 36 to 48 days post service. A repeated occurrence of oestrus in breeding females in the period ≤17, 25-35 and ≥49 days is an irregular oestrus.

In the research of *Didion et al. (2009)* involving 18 boars analysed, the percent of farrowing varied in the interval from 38.9-82.7%. *Holm et al. (2005)* confirmed that the value of oestrus in gilts was 14% and in the first farrowing sows 18%.

There are different studies on the traits of boar sperm and fertility in *in field* conditions. *Flowers (2003)* in his review paper presented the results of a several studies which indicate the differences in farrowing rate (from 65.8 to 92.5%) depending on the way of insemination, spermatozoa contained in dose, volume of doses and number of doses per sow.The results of *Tsakmakidis et al. (2010)* showed that the farrowing rate, in relation to differences in boar sperm, varied from 59.3 to 88.9%. For this reason, recommendation of some researchers *(Sutkevičiené and Žilinskas, 2004)* implies that maintaining the conception rate at a constant level means that ejaculates with lower motility of spermatozoa should be used so as to have larger number of spermatozoa in insemination doses. The success of insemination can depend upon a quality of ejaculate what is confirmed also by the research of *McPherson et al. (2014)* about the relationship of acrosomal defects of spermatozoa with a repeated occurrence of oestrus and their research implicate that the estimation of morphological characteristics of spermatozoa (particularly acrosomal region) can be used for predicting a repeated occurrence of oestrus. The research of *Park (2013)* in which a stimulative linear regression effect of overall motility of spermatozoa on the farrowing rate was established reports in favour of relationship between the ejaculate traits and success of insemination. The research of *Savić (2014)* implicates that fertilising capacity of sperm *in field* conditions depends primarily on spermatozoa motility.

In the research of *Savić (2014)* the average value of return rate in breeding females mated with boars of L, LW and D breeds was 11.70% and varied from 4.82% to 28.04%. The farrowing rate was on average 81.40% with variations from 63.55% to 90.00%. An average index of mating (100/81.40) indicates that 1.23 matings are necessary for one farrowing. The largest number of breeding females in which oestrus reappeared was mated with the boars of LW breed (12.79%). The lowest value of return rate was confirmed in the boars of Duroc breed (10.79%). Difference in return rate in breeding females between the boars of LW and D breeds with which they mated was 2%. Breeding females that mated with LW boars also had lowest farrowing rate of 79.66% with highest varying interval of 22.60%, while breeding females mated with D boars, and compared to them, had farrowing rate higher for about 3%.The average value of return rate in breeding females mated with L breed boars was 11.55% and varied in the interval of 4.82 to 25.60%. Difference among the boars with the lowest and highest farrowing rate was 21.20%.

Bringing the sows into a contact with boars has a favourable effect on parameters of reproductive efficiency. In the research of *Umesiobi (2010)* different ways of exposing sows to the boars were applied (no contact, contact over the fence and physical contact) where the farrowing rates were 50.4, 62.9 and 88.3%, respectively, while depending on the frequency of ejaculation (interval between two jumps, 24 h and 92 h), the conception rates were 76.8% and 93.5% and farrowing rates were 56.8% and 85.5%. Contrary to previously mentioned, different frequency of exposing the sows after weaning (once, twice and three times daily) to the presence of boars showed no differences in the farrowing rate *(Knox et al., 2002;* 75%; 87% and 83%*)*.

Boar direct effect explains 5.3% of total variability of farrowing rate *(Broekhuijse et al., 2012b)*. The highest share in boar direct effect involve an individual (29%) and breed (22%), age of boar participates with 0.3%, progressive motility of sperm with 9%, and about 40% variability of the farrowing rate cannot be explained, according to the results of these authors. The research of *Broekhuijse et al. (2012a)* showed that only 5.9% of total variations of farrowing rate was caused by boar, while a variability of the sperm traits was by 21% explained by the effect of a boar genetic line, 11% by laboratory technique and 7% by the centre for artificial insemination. *Park (2013)* reported that variability of the farrowing rate was by 3.33% explained by the effect of boar, 1.22% by the effect of breeding female and 0.57% and 0.17% by the effect of year and season (month) of mating. If these rates were applied on a large population of animals a boar significant effect on reproductive parameters would be clearly seen.

The ranking of boars according to the value of return and farrowing rate during the reproductive exploitation is important part in the reproductive managment.

Conclusions

A large number of descendants per boar at an annual level clearly shows the need to control boar productivity. It is necessary to develop testing methodology by which their reproductive potential could be estimated in the most objective way possible and as earlier as possible. Reproductive parameters vary among the breeds and intensity of utilisation. Differences in return and farrowing rates between the boars can be larger than 20% what indicates the importance of the research on fertility in boars. Early identification of hypoprolific boars (or close to the average) is needed. That is why the improving of reproductive traits means improving the traits of ejaculate, libido, reproductive efficiency and litter size traits. Therefore it is important to observe genetic structure of pig populations, to implement continuous control of productivity, to respect the mating plans and to exploit the boars in an optimal way.

Plodnost nerasta - šta je važno znati

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Rezime

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Ključne reči: nerast, veštačko osemenjavanje, osobine sperme, libido, reproduktivna efikasnost

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