The importance of boar sperm motility and morphology for fertility

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Sperm motility and morphology assessment is still fundamental in routine work at AI stations to discriminate ejaculates/boars which do not fulfill the minimum requirements, established by the different AI organisations.

Considering that large numbers of ejaculates must be collected and processed within limited time, the main problem at a modern AI centre is the short time available between the collection of an ejaculate and the decision whether to use it for extension or eliminate it depending upon its quality or quantity.

This situation makes it necessary to use spermatological methods which are simple and quick, but provide reliable information about the usefulness of the semen for preservation and AI. Thus, semen evaluation methods, which need too much time, or are material consuming procedures, are scarcely applied under routine conditions, where the time lapse for an ejaculate assessment is less than two minutes.

Substantial progress made

Considering these general limitations, the introduction of computer assisted microscopic semen analysis (CASA) facilitated a substantial progress in reliable motility and sperm cell concentration assessment, because a large number of cells is evaluated within a short time.

As only motile sperm are considered to be able to fertilise the oocyte, quantitative and qualitative motility parameters are used to predict the fertilising competence of a given semen sample.

Table 1. Minimum requirements for boar semen (ZDS, 2006).

Total morphological abnormalities	≤25%
Sperm with head abnormalities	≤5%
Sperm with acrosome abnormalities	≤10%
Sperm with plasma droplets	≤15%
Sperm with coiled tails	≤15%
Other morphological abnormalities	≤15%

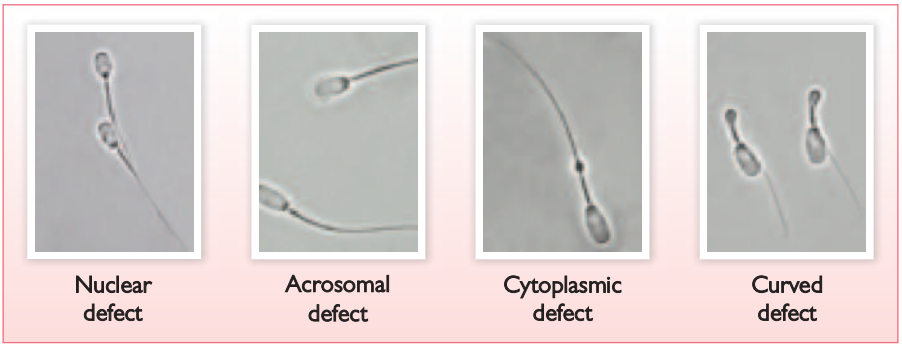

Fig. 1. Morphological defects detectable by microscopy with phase contrast and oil immersion (800-1000 x).

Despite the difficulty to establish significant correlations between motility parameters and fertility outcome under field conditions, where a surplus of sperm cells are used per semen dose and sows are inseminated repeated times within one heat interval to assure fertilisation, significant correlation between motility and fertility can be detected, when sperm numbers per dose and/or number of inseminations are reduced.

Sperm morphology is another important parameter used for selection of ejaculates/boars fulfilling the minimum requirements for use under AI conditions.

The incorporation of morphological parameters into the computer assisted analysis therefore seems to be a promising complementary tool in assessing semen fertility.

A full analysis of sperm morphology is only possible under phase contrast microscopy with 1000x magnification and oil immersion, which is quite time consuming and needs to be done by trained staff. Only few laboratories have such equipment and enough spare time.

As shown in Table 1, in the German AI industry minimum requirements for boar semen morphology have been established.

These should be fulfilled for ejaculates used in AI. However, these criteria are under discussion nowadays because they originate from boar andrologic evaluation criteria used in purchase contracts for breeding boars. With morphology analysis getting more automatic and possible to perform on each and every ejaculate, these criteria might undergo some adaptations in the future. When values of Table 1 are exceeded, low fertility of the semen dose can be the consequence.

Correlation with fertility

Based on a field experiment, a correlation between morphological alterations and fertility could be shown, depending on storage time of the semen used in AI.

The negative correlation between the percentage of distal cytoplasmic droplets and fertility counteract the assumption that distal droplets are less harmful than proximal droplets.

As cytoplasmic droplets are probably primary or secondary defects of testicular/epididymal origin in consequence of a membraneous defect which inhibits the physiologic migration of the droplet during the epididymal passage, they represent a serious morphological defect, especially when longer stored semen is used, probably in consequence of a reduced survival during aging of semen.

Based on these results, the above mentioned minimum requirements were established (Table 1), which tolerate a maximum of 25% of total morphological alterations. Within this maximum, 15% of cytoplasmic droplets are considered acceptable.

Sperm morphology contributes to variation in fertilisation, especially to variation in litter size, indicating that probably not all

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available oocytes could be fertilised. The effect of sperm morphology depends upon a series of other factors, like sperm motility, sperm number per dose, age of the semen, interval between insemination-ovulation, presence of other sperm quality deficiencies, variation of season and management of sows.

Sperm defects, which hinder sperm cells passing into the sperm reservoir of the oviduct, can partially be compensated for by an increase of the sperm number per dose. Sperm defects, which are not selected within the oviduct, are considered to be not compensable.

This definition applies not only for sperm cells with visible alterations but includes any functional or structural deficiency.

Experiments about in vitro binding of spermatozoa to oviductal epithelium showed a correlation to sperm morphology, indicating that the isthmus epithelium selects for morphological alterations, especially persistent cytoplasmic droplets and tail alterations.

Assuming that these alterations are compensable in the sense of the above mentioned theory, fertility of such semen quality might be increased by an increased sperm number in the inseminate. The literature gives different reports about the correlation between elevated morphological abnormalities and fertility and the interaction with other sperm parameters, especially motility.

As Alm et al. (2006) showed, the return rate of sows was significantly elevated when males with >30% of morphological abnormalities were included in the analysis.

The authors calculated the effect of an increase from 20 to 30% of abnormalities, resulting in a loss of 0.2% of non return rate, 0.5% of parturition and 0.08 live born piglets.

In an experiment by Gadea et al. (2004) the percentage of proximal cytoplasmic droplets was included as a significant component of a model of multivariant regression. Litter size was associated with the total of abnormalities, percentage of swollen tails and with proximal cytoplasmic droplets, showing a significant, however low value of correlation.

Age of semen	Farrowing rate (%) Day 2	Farrowing rate (%) Day 4	Litter size (No.) Day 2	Litter size (No.) Day 4
Morphologically abnormal sperm cells	** (-0.77)	*** (-0.9)	-	-
Proximal droplet	-	** (0.79)	-	*** (-0.87)
Distal droplet	*** (-0.87)	*** (-0.92)	** (-0.8)	-

Table 2. Correlation between abnormalities and fertility in 1,584 sows (Waberski et al, 1994).

An inverse relationship between the number of morphological abnormalities and fertility frequently affects litter size and not so much the farrowing percentage. In this sense, morphology explains a large part of variation in litter size under commercial conditions ($R^2 = 0.59$). Also, sperm head dimensions can have an impact on fertility, as computer assisted morphology analysis (ASMA) showed. Another possible impact on fertility is the intactness of the acrosomal membrane. However, the correlation coefficients between the percentage of sperm cells with intact acrosomal ridge (NAR) and fertility were not high.

As Gadea et al. (2004) postulated, the use of information from semen analysis for predicting the likelihood that a group of gilts/sows will conceive after AI provides only an estimate of probability – there can be no certainty. The probability is influenced by a series of factors, including semen quality.

The fact that many assays test only a single attribute make it uncertain that fertility will be predicted accurately, considering that many successive steps must occur for fertilisation to succeed. The use of multivariate analysis would help to discriminate potential fertility combining the functional information regarding different capacities of the sperm cell. A combination of selected semen tests, therefore, yields a higher accuracy than a single test in the prediction of fertilising capacity.

Conclusions

In conclusion, the above mentioned data about the fertilising relevance especially of morphological sperm alterations, reveal that:

- Sperm morphology is, besides motility, an important fertility relevant quality parameter.
- The degree of the fertility depressing effect depends upon many factors.
- Sperm morphology is not satisfactorily considered in AI.
- Sperm morphology detection needs improvement. Practicable concepts are needed.
- The overall goal is to deliver semen of maximal quality and maximise the chances of fertilisation. ■