ON THE VARIABILITY OF THE AREAS OF SPERM HEADS AS RELATED TO THE FERTILITY OF BULLS.

By J.M.Isa, B.S.A.,
University of Manitoba

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''If the proposal be accepted, that successful reproduction must be based upon the mating of two sexually healthy individuals, it becomes essential to learn the most reliable standards by which sexual health may be measured...'' W.L.Williams.

INTRODUCTION:

It is common knowledge among stock breeders that all bulls are not equally effective at impregnating the females which they serve and at begetting healthy offspring. In this respect bulls vary from the virile sire which impregnates the majority of his females at one service to the animal whose repeated services result in nothing. A review of complete breeding histories conducted by Williams and Savage (23) on a number of sires in a highly specialized dairying State showed that 34% of them were definitely poor. It is suspected that the proportion of inferior animals in Western Canada is possibly higher. It is therefore considered of great economic importance that reliable means be available whereby these animals may be recognised as early as possible, preferably before they have opportunity to cause loss.

Three important indications have been used in estimating the fertility of bulls. These are:

1) The sire's past record as a breeder.

2) A thorough clinical examination.

3) A microscopic examination of the semen.

That the breeding history will indicate the past performances of a sire is beyond question, but it will do so only if the sexual health of the females is known. However it is in a minority of cases that actual details of matings are kept. The usual records are so vague and uncertain as to be valueless. Moreover breeding histories are but the records of past performances. They may give little indication of the condition of the animal at present, or of what he is likely to become.

A clinical examination of a bull may give an indication of his sexual health. However, until recognisable abscessation has taken place in his genitals the animal might be considered sound in spite of the fact that the products of inflammation have disturbed the process of spermatogenesis. When the condition reached the stage where it can be recognised, considerable damage may have been done to the breeding herd, thus limiting the usefulness of this method. It is naturally expected that sires with gross lesions in their genitals should exhibit some degree of impaired fertility. The reverse, however, is not always true; Williams and Savage (23) examined many bulls which, though anatomically sound, gave poor results when mated to cows that had reproduced normally with other sires. In nearly all such cases there were seminal alterations which could be detected with the microscope.

A microscopic study of semen may be undertaken on either the living sperm or on preparations of dead cells suitably stained. Many workers consider the observation of motility in fresh sperm a good indication of male fertility. More or less elaborate systems of enumerating per cent motility and numbers of sperm in semen have

been worked out. However many factors tend to make this method unreliable.

In the first place, the recovery of sperm allows the interference of external influences which may impede the movement of sperm from highly fertile sires. In the second place, the deformed sperm from poor bulls often exhibit normal motility. Some factors which may influence motility are the following:

1) Dilution of semen with water, a trace of disinfectant, or other extraneous fluid.
2) Presence of highly tenaceous mucus from the vagina or in the semen.
3) An admixture of vaginal blood.
4) Pus from inflammed male genitals.
5) Time between emission and examination.
6) Temperature at which the sample is kept and examined.

Although a seminal examination for motility may not be entirely without merit, it has been clearly established by Williams and Savage (23) and Savage, Williams and Fowler (17) that by a microscopic examination of stained sperm there is revealed accurate information of the greatest importance, far excelling all other sources of information combined. Its chief point of superiority is that, in a large measure, it makes possible the determination of the degree of fertility after a single copulation without awaiting the results of the service. This means that the state of the sexual health and fertility may be determined in advance, before the sire has had a chance to wreck a herd, in the case of the unproven bull, and it keeps a check on the active animal during the breeding season.

This method consists essentially of two parts:

1) A cytological examination.

2) A biometrical examination.

These will be described in some detail later. Meanwhile a digression on spermatozoa appears to be timely.

Spermatozoa were first observed by Ham, a student of Leeuwenhoek at Leyden in 1667. They were then described as "semen threads". The discovery was announced and confirmed by findings in the case of the dog and of the rabbit. The sperm were taken to be animals on account of their motility, but their significance remained questionable if not unknown. Spallanzani was the first to show that the filtered fluid was impotent, and that spermatozoa in the semen were essential to fertilization. Kolliker, in 1841 discovered that the sperm arise from the cells of the testis, and Barry in 1843 observed the conjugation of sperm and ovum in the rabbit. This led to a complete understanding of the function of spermatozoa.

The morphology of spermatozoa has been described in great detail by many workers. Retzius (14) is the most outstanding of these. He beautifully illustrated and described the sperm of many hundreds of species. A brief description of bovine spermatozoa would be in order at this point.

The sperm has three main parts: the head, the middlepiece and the tail. The length of the entire sperm is about 75 to 80 microns. The head is about 9.0 to 10.5 microns long. It is flattened, and when viewed in profile it appears slightly pyriform. Although the head consists largely of chromatin, the latter is not arranged as

threads or networks, but is distributed uniformly. However the head may be differentiated by staining reactions into a darkly staining posterior part, an anterior lighter part, and often a still lighter area between the two (Plate I). The anterior end has a sharp edge known as the acrosome. The whole is surrounded by a tough limiting membrane.

The middlepiece is united to the head by a constricted structure called the neck. The latter stains poorly or not at all. It contains the minute anterior and posterior centrosomes or neck granules. The middlepiece is the essential motile apparatus and is the thickest and strongest part; it joins the tail proper to the head. It consists of the central axial filament, a spiral filament around this and an outer mitochondrial covering. Anteriorly it is limited by the posterior neck granule, and posteriorly by a minute end disc.

The tail is all that portion beyond the middlepiece. It is composed of the axial filament, and covered for a considerable proportion of its length by a sheath. The end of the tail is uncovered.

Sperm vary in shape and size and show many aberrations; this is a common observation easily confirmed by wet mounts or stained smears. That these departures from the normal are real and not due to external influences has been adequately demonstrated by Moench and Holt (9).

According to the method of Savage, Williams and Fowler (17) the cytological examination of smears of semen consists of projecting

images of sperm on to a screen and counting the number of abnormal ones. This of course demands an intimate knowledge of sperm pathology, since all types of abnormalities do not bear equal weight. For example, a slight narrowing of an entire head is considered of much less significance than a sharply tapering one which only affects the base (Plate 2); the presence of 2---3% ''pseudo swellings'' of the middlepiece has but little value, though a single ''accessory'' stump warrants the suspension of an animal's use as a sire. Pyriform heads and nicked middlepieces are also regarded as serious defects. In the examination of semen from 57 excellent bulls, Savage, Williams and Fowler (17) found that the cytological picture was almost perfect. No highly efficient sire emitted more than 170 abnormal sperm per thousand, and none of these sperm were of the extreme types mentioned above. On the other hand some poor bulls had remarkably good cytological pictures.

The biometrical examination consists of measuring the head lengths of projected images of stained sperm as at 3000 diameters. Five hundred sperm on each slide are chosen at random, and their sizes grouped in classes to form a frequency distribution table. From this table certain statistics were derived and a curve drawn.

The measurements of head lengths of mammalian sperm had previously been undertaken by a number of workers. It happened however that these had been largely concerned with the question of <u>head length dimorphism</u>. It was postulated that if the sperm on a prepared slide were suitably magnified and measured, and that if the resulting figures were grouped to form a frequency distribution