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Artificial Insemination
Of Swine

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(Editor's Note: Due to the comprehensive nature of Dr. Herrick's paper on this subject, it has been necessary to divide the article and publish it in two issues.)

The past ten years have seen remarkable interest in the application of artificial techniques to the breeding of dairy cattle in this country. The most extensive and refined research as well as the most practical appeal to the farmer-breeder is centered on this class of livestock. By contrast, the artificial insemination of swine is still in the experimental stage. The question that arises at the present time is the difference in popularity between these two classes of livestock with regard to artificial insemination.

A review of the literature reveals several facts of general interest. By far the greatest contribution to our knowledge of the semen and reproductive organs of the boar has been made by Fred F. McKenzie and his associates at the Missouri Agricultural Experiment Station. Russian investigators, particularly Milo- vanov, Rodin, Payseva and Hudjahov, have studied diluents for boar semen and developed apparatus to facilitate semen collection and sow insemination. A Philippine investigator, Rodolfo, had made interesting observations on the natural breeding habits of the boar. The most comprehensive summary of the pertinent recent data has been compiled by James Anderson in a Scotland publication. Most of the published material deals with research conducted between 1935-1940. It may be assumed that very little work has been reported on this subject in the past eight years.

I. SWINE SEMEN STUDIES

A knowledge of the characteristics and composition of swine semen, as well as the morphology and viability of boar spermatozoa, is basic to the development of good insemination technique. The following description is taken from McKenzie et al., 1938 and observations of the author.

The semen of normal boars is greyish to milky white in color, depending on the concentration of spermatozoa; the higher the sperm concentration the higher the semen count. Fresh semen has no odor unless contaminated with urine or the contents of the preputial diverticulum. This diverticulum contains decomposing urine and cellular debris, which has a disagreeable odor and is responsible for the disagreeable odor to the boar. About 60-75 percent of the whole semen is liquid and slightly viscous, with a specific gravity of 1.01 to 1.02.

In addition to the liquid portion, normal whole semen contains lumps of gelatin-like material resembling tapioca. In freshly ejaculated semen this material appears as chains of platelets, 3-5 mm. in diameter, with their flat surfaces attached, but the gelatinous bodies absorb liquid on standing, become greatly enlarged and settle down to the bottom in a solid mass of jelly-like material. After cooling for 24 hours or more, they may take up the bulk of the liquid portion of the semen and comprise 50-75 percent of the total weight.
This mass has an opaque grey color. Spermatozoa are present in the gelatinous material, apparently being trapped and held by it after ejaculation.

Some gelatinous material is found throughout the period of ejaculation, but it varies in appearance and quantity with the stage of ejaculation. In the first few minutes it is somewhat discolored, perhaps by urine, and lacks the characteristic tapioca lumps; instead it is a more uniform mass with the consistency of a thick lubricant. The largest amount of the typical tapioca material appears with or immediately following the high sperm-containing fractions. Near the end of the sperm-containing fractions the ejaculate is frequently all gelatinous material. In the interval between high sperm peaks or, if only one occurs, following it, a clear thin fluid appears, containing very few, if any, spermatozoa and having a specific gravity of 1.01 or less.

Boar semen differs from bull semen in two noteworthy respects. The characteristic gelatin material is peculiar to boar semen; also, the total volume of boar semen is many times greater than that of the bull. Reference to the “sperm peaks” and sperm-containing fractions in boar semen are made in recognition of the fact that spermatozoa are not ejaculated uniformly by the boar throughout the period of copulation. They appear, rather, in waves of great concentration at certain intervals when the rate of semen discharge is greatest. An ejaculation can be divided into three or five phases, depending on whether one or two sperm waves occur in it. The first or pre-sperm phase, which lasts 1-5 minutes, consists of slightly urine colored, semi-solid material, contains no sperm, and comprises 5-20 percent of the ejaculate. The second or sperm-containing phase, which lasts 2-5 minutes, consists of a milky white liquid and some gelatin or tapioca-like material, contains most of the sperm, and comprises 30-50 percent of the ejaculate. The third or post-sperm phase lasts 3-8 minutes, consists of a thin, watery liquid with more or less gelatinous material, contains few sperm, and comprises 40-60 percent of the total volume. When there are two waves of ejaculation the second and third phases are repeated, but the sperm concentration and volume are much lower than in the first wave. The second wave tends to disappear with more frequent ejaculations.

The duration of ejaculation varies greatly in different boars, from 5-20 minutes, and there is no apparent relation between duration and frequency of ejaculation. The rate of ejaculation usually increases up to the third minute, reaches a peak in the third, fourth, and fifth minutes, and decreases thereafter for 2 or 3 minutes, to be followed by a second rise near the end of the ejaculation. There is thus a high initial peak, or wave, and a second lower peak, and coincident with the peaks in the rate of ejaculation are the peaks of sperm concentration.

**Volume and Sperm Concentration of Boar Semen**

Rodin (1934) collected boar ejaculates in glass vials, changed every 15 seconds, and distinguished three phases of semen ejaculation. The first phase consisted of about 20 cc. of urine-contaminated liquid which contained very few sperm. The second phase consisted of over 100 cc. of semen containing some 34 billion sperm. The highest sperm concentration occurred in the first fraction of this phase and these sperm retained their motility much longer than those in low concentration fractions. The third phase contained about 164 cc. of ejaculate and included 2.2 billion sperm. Total semen per ejaculate was 284 cc.

Wishart (1944) reports a range of 125-500 cc. of semen per ejaculate with an average of 200 cc., Milovanov (1936) gives the volume as from 150-400 cc. There is no direct relation between live weight of the boar and semen volume. The seminal vesicles, Cowper’s glands, prostate and urethral glands, and the epididymal fluid contribute respectively 15-20 percent, 10-15 percent, 55-70 percent, and 2-5 percent of the semen volume. The liquid-gelatinous ration is fairly constant, averaging about 70 percent liquid for the entire ejaculate.
The author reports collecting 480 cc. of semen from a mature boar taking approximately 20 minutes to collect the sample. The average amount of ejaculate from a boar weighing 250 to 300 pounds is from 150 to 200 cc.

The number of spermatozoa per cmm. ranges from 25 thousand to 1 million, the most common concentration being 100 thousand. Milovanov (1936) found an average sperm concentration of 305 thousand per cmm. in eight collections from three boars.

There is no correlation between volume and number of spermatozoa per ejaculate, as both are subject to wide variation. According to Rodolfo (1934) the average number of spermatozoa per ejaculate for a number of boars was 7.83 x 10^10. However, the range reported by McKenzie et al (1938) was from 27 to more than 30 x 10^10 spermatozoa per ejaculate and Milovanov's data averaged 8.5 x 10^10.

### Sperm Morphology and Its Relation to Boar Fertility

Rodolfo (1935) described three types of boar spermatozoa. Type I has no protoplasmic drop; in Type II the drop is located on the neck, and in Type III towards the middle of the tail. He believes that these types represent stages in development. All sperm in the proximal end of the epididymis belong to Type II and are non-motile; subsequently they are transformed to Type III and finally to Type I, which is predominant in the semen.

Phillips (1935) found that the number of abnormal forms in the spermatozoa of boar semen correlated with the degree of fertility of the boar. Semen containing spermatozoa with from 62-104 abnormalities per 1,000 sired litters consistently large in number and of strong vitality. Boars producing semen containing abnormal spermatozoa in the ratio of 146-501 per 1,000 sired small litters containing mummies or weak pigs. The abnormalities that seem most indicative of affected fertility were appreciable numbers of small heads, tapering heads, and enlarged middle pieces. Observations in practice indicate that the boar is subject to rather sudden changes in fertility, and further study is necessary before definite limits to the numbers and types of abnormal forms in normal semen can be established.

The frequency of semen collection or natural service is also correlated with fertility. McKenzie et al (1938) found frequency of ejaculation to be an important factor affecting volume of semen, sperm numbers, sperm morphology and duration of sperm motility. His recommendations on the breeding interval of boars are based on these findings.

### Accessory Sex Gland Secretion

It has been noted that the boar ejaculates a larger volume of semen than any other farm animal. Most of this material consists of secretions from the accessory sex glands, particularly the bulbourethral gland. The range in percent composition of semen contributed by these glands as reported by McKenzie has been presented.

An interesting experiment was carried out by this investigator (1936), in which certain of the accessory organs were removed surgically from some of the boars and semen collections made 6-8 months thereafter. Some boars were deprived of seminal vesicles, others of seminal vesicles and Cowper's glands, and one individual bilaterally vasectomized, two-thirds of his prostate removed, and all of his seminal vesicles removed. None of these operations seemed to affect libido nor materially reduce fertility except in the case of the vasectomized boar. This animal produced no sperm but evidenced normal libido. Voluminous quantities of semen were obtained from boars without either seminal vesicles or Cowper's glands, apparently more than could be accounted for under the circumstances.

A synopsis of observations on accessory gland secretions in normal boars as reported by McKenzie et al (1936) is presented in Table I.

The pH range of semen may be compared with that of later investigators. Wishart (1944) gives it as 6.8-7 x 2 and Anderson (1945) as 7.3-7.9. This latter source states that in fractionated collect-
ions of semen the pre-sperm fractions usually have the highest pH (8.4-9.0), probably due to contamination with urine. High sperm-containing fractions have a pH intermediate between the other two.

**Practical Implications of Semen Studies and Observations of Boar Matings**

The initial part of the ejaculate probably serves the double purpose of cleansing the urethra of urine and debris, and acting as a lubricant to facilitate the entrance of the penis into the female tract. In normal coitus, this material is usually discharged before the penis enters the vulva. The chief function of the great volume of fluid ejaculated with and immediately following the sperm fraction is apparently to wash the sperm cells into the uterus. The cervix of the sow does not evaginate; the length of the vaginal and cervical tract combined is no greater than the depth to which the penis enters; ejaculation proper does not begin until the penis is inserted to its greatest depth; hence there seems to be little doubt that the boar normally deposits his semen directly into the cervix.

The presence of materials from the seminal vesicles and Cowper's glands in the post-sperm fraction and the capacity of such substances for forming a rubbery, gelatinous mass, indicate that they may serve to seal the cervix, thus preventing an outflow of semen. This vaginal plug, however, is not essential to complete fertilization of all eggs.

Another function of the large volume of seminal fluid is to give bulk to the ejaculate, rendering the peristaltic contractions of the urethra more effective in forcing the sperm to the exterior.

According to Rodolfo (1934), sexual attraction appears to play a very little part in the mating behavior of the boar. He is readily stimulated to attempt mating by the presence of a dummy sow. The only other stimuli necessary are warmth and a gentle pulsating pressure. He states that the following adaptions ensure that fertilization will take place: the ejaculation of the semen directly into the cervix by means of the left-hand corkscrew-shape gland, the large volume of semen, and the presence of the vaginal plug which prevents an outward flow of the semen.

Further data on sensory stimulation of the boar's penis is reported by Rodin, I. I. (1940). Tests were conducted with ten boars, using an artificial vagina composed of five short sections in which temperature and pressure could be varied independently. Ejaculation occurred only when both the head of the penis and the portion 30-35 cm. distant from the head were subjected to the usual temperature (40-42°C.) and pressure stimuli; stimuli along the whole length of the penis were not necessary. The semen obtained in this way did not differ in quantity or quality from that obtained without any artificial vagina by interrupting natural service after 1½ to 2 minutes, applying pressure manually to the two sensitive areas, and allowing ejaculation to be completed directly into a glass jar.

McKenzie (1938) states that the large volume of semen, the extremely large number of sperm per ejaculate, the rela-
tively long time required for ejaculation, and the chemical composition of his semen gives some indication of the heavy drain on the protein, mineral and energy supply of the boar during excessive sexual activity. Observations on the effects of frequent ejaculation indicate that yearling boars should not be used more often than once in 24 hours, and that best results might be expected at 48-hour intervals if the breeding season is to extend over a period of two weeks or more. According to Rodolfo (1934), a boar should not be mated at all before 14 months of age and not used intensively before 2 years old. Hog producers in the cornbelt will heartily disagree with this statement; the average boar in this country is put into service when he is eight months of age. One mating per day is sufficient and there should be an interval of rest following two days of service.

As noted previously, evidence is at hand indicating that the fertility of a boar may be determined roughly by a microscopic examination of his semen. More work along this line is needed before it can be used routinely as a diagnostic measure. Milovanov (1936) concludes that normal fertile boars may have up to 30 percent abnormal forms of spermatozoa, and this agrees with the findings of Phillips (1935) who found 20-25 percent abnormality in the spermatozoa of boars which sired unsatisfactory litters.

II. SWINE SEMEN STORAGE

Lasley and Bogart (1944) studied some factors affecting the resistance of ejaculated and epididymal spermatozoa of the boar to different environmental conditions. Semen was collected from 20 boars with an artificial vagina and immediately afterwards each boar was castrated and the sperm washed out of the epididymis with phosphate buffer. After 16 days storage out of contact with air, 51.2 percent of the epididymal sperm but only 9.6 percent in the ejaculate were alive according to the opal-blue rosin staining test. The epididymal sperm exhibited a protoplasmic drop in the mid-piece (corroborating Rodolfo's observations) which was rare in the ejaculated sperm; also, the motility of the epididymal sperm was less than that of the ejaculated sperm. Upon subjecting the spermatozoa to cold shock (0°C for 10 minutes), 65 percent of the epididymal sperm were still alive but only 12.5 percent of those in the ejaculate were living.

This evidence indicates that the resistance of spermatozoa to cold shock varies with the place in the reproductive tract from which they are obtained. Spermatozoa from the head of the epididymis are very resistant and survive during storage for long periods, but their resistance and survival capacity decreases as the distance of their location from the testis increases, until spermatozoa in the ejaculate have practically no resistance or storage capacity. It is suggested that reduction in these respects are morphological rather than environmental.

Effect of Diluents and Buffers on Boar Semen Storage

Milovanov (1936) investigated the effect of protective colloids on sperm and reported them in the following ascending order of protective effect: (1) gum, (2) gelatin, (3) egg albumin, (4) alkaline egg albumin, (5) alkaline albumin from meat or blood serum and (6) mucin from boar semen. Mucin was the most effective and it is considered that one of the functions of mucin in the oestrus secretions of the female consists in preventing agglutination of sperm. The high acid-combining power of mucin may be partly responsible for increased survival in the female genitalia.

Semen has been successfully stored by removing the gelatinous lumps (either by straining the semen through cheesecloth or with a glass rod in a porcelain dish) and then adding an equal volume of Milovanov's diluent. This modified tartrate diluent was evolved in 1939 and designated TGH-6:

- Anhydrous glucose 6.85 gms.
- Potassium sodium tartrate .15 gms.
- Tartaric acid .008 gms.
- Double-distilled water 100 cc.

According to Anderson (1945), both sulphate and tartrate diluents are equally good for boar semen. The following formulae are recommended:
Quantities are given in grams/liter of double-distilled water:

<table>
<thead>
<tr>
<th></th>
<th>Sulphate or SGP-2</th>
<th>Tartrate or TGP-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhydrous glucose</td>
<td>46.1</td>
<td>46.1</td>
</tr>
<tr>
<td>Salt-free peptone</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Anhydrous sodium sulphate</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Sodium potassium tartrate</td>
<td>5.6</td>
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Lasley and Bogart (1944) found that the degree of dilution using several different dilutors had no influence on the resistance of epididymal spermatozoa to cold shock. Fluids from the epididymis obtained by centrifuging boar epididymal suspension did not influence the resistance to cold shock or the storage potentialities of ejaculated spermatozoa. However, dilution of suspensions of epididymal and ejaculated boar spermatozoa with egg-yolk phosphate buffer did increase their resistance to cold shock and storage survival.

Rimodli (1940) found that whole semen stored at 0°C. lost its activity after 19 hours. Centrifuged sperm, either concentrated or diluted with glucose-sulphate or glucose-phosphate could be stored from 126 to 128 hours. Apparently, the buffer or diluent is not as important to successful storage as the centrifuging process, which results in a highly concentrated sperm fraction.

**Effect of Fractionating Boar Semen for Storage**

The first successful attempt to store swine semen in this country was reported by McKenzie and associates in 1942. Using the principle of fractionation, they cooled the highly concentrated sperm fraction gradually and stored it at 10°-12°C. This fraction impregnated sows 12, 13 and 24 hours after collection. Results were satisfactory when 23 cc. of the concentrated fraction was diluted up to 50 and 100 cc. for insemination. When two or more inseminations per heat period were made from such semen, 13 of 28 gilts conceived. The extra inseminations doubled the percentage of pregnancies.

**Streptomycin**

Those who handle or administer streptomycin should wear rubber gloves. This and other certain precautions against getting sensitized to the drug are suggested by personnel of the Veteran’s Administration Tuberculosis Hospital at Oteen, North Carolina.

They also suggest that all sterilizers used for needles and syringes be allowed to cool before opening them, as a protection from streptomycin particles which might be carried in steam emanating from sterilizers.

**Newcastle Vaccination**

Recent tests with thousands of birds under farm flock conditions have proved the practical value of a new vaccine developed by veterinary scientists for protecting chickens against Newcastle disease. Drs. F. R. Beaudette, J. A. Bivins and Barbara R. Miller of the New Jersey Agricultural Experiment Station at New Brunswick, N. J., conducted the tests.

In field tests, they reported, birds were inoculated with a minute amount of virus vaccine. The vaccine had been developed after long and thorough screening of strains of virus from 105 outbreaks of Newcastle disease.

In most vaccinated birds, Dr. Beaudette and his associates said, the only reaction was a slight reduction in feed intake for a few days. In a few cases, there were mild respiratory symptoms. But the loss from deaths and paralysis incident to the vaccination was only about one per cent.

A cow that produces 8,000 pounds of milk a year secretes twice as much dry matter in that milk as is contained in her entire body. By contrast, it requires some three years for a steer to build a body weighing 1,200 pounds, and the yield of edible dry matter would be approximately 300 pounds.

Winter, 1950