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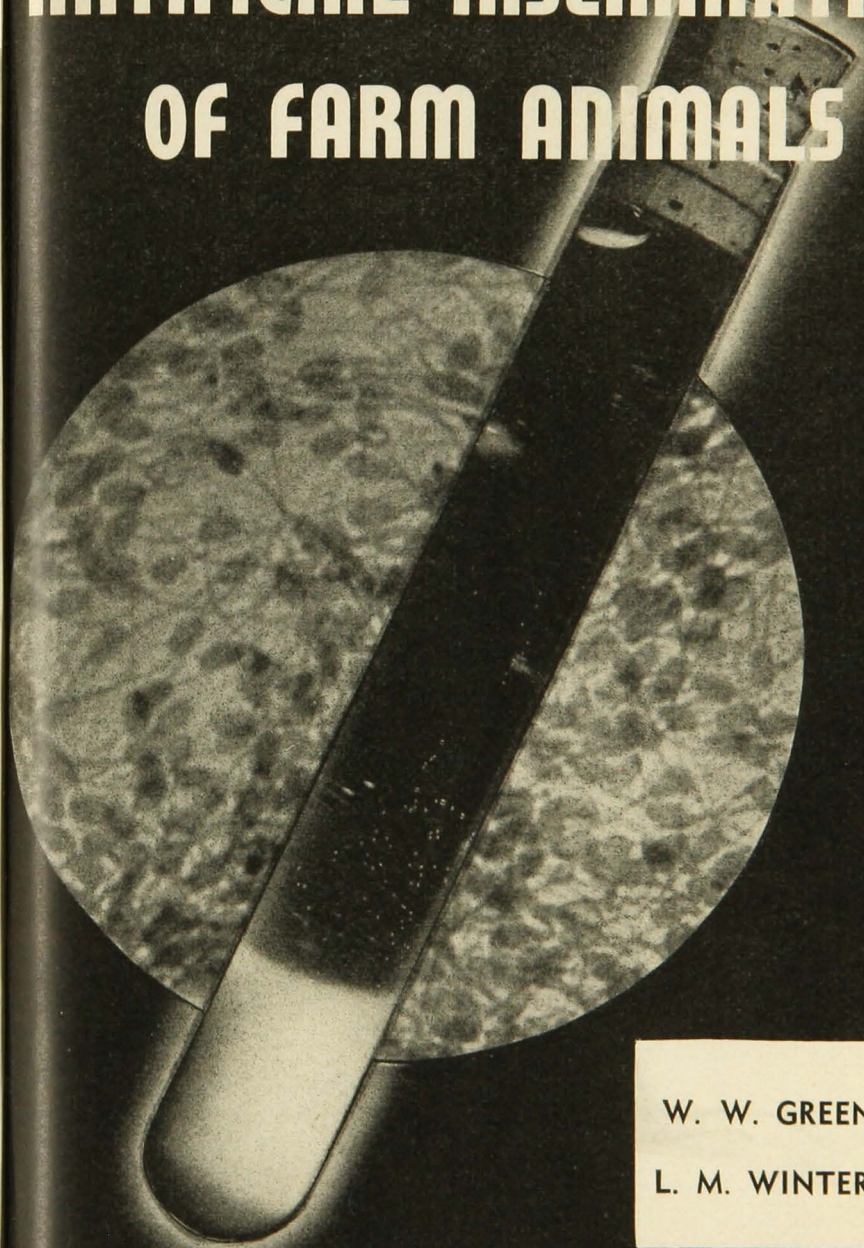
ARTIFICIAL INSEMINATION OF FARM ANIMALS



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Artificial Insemination of Farm Animals

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ARTIFICIAL INSEMINATION is the deposit of male reproductive cells (sperm cells) in the female reproductive tract by mechanical means rather than by the direct service of a male. It has been known for a long time that it is possible to breed animals artificially, but the early methods were not very satisfactory. Only during the last decade has the practice been expanded to any large extent in the United States. During that period, insemination technics have been developed and/or improved; research has been conducted on methods of collecting, storing, handling, and evaluating semen; and artificial breeding associations have been established.

Uses for Artificial Insemination

1. The usefulness of a given sire may be greatly extended. This may be turned to advantage in two ways: The young sire may be evaluated earlier in life than would be possible with natural mating, and more extensive use may be made of sires that prove to be valuable because they can be used on more females. Through artificial insemination, the service of a bull or ram may be extended 10, 20, or more times and that of a stallion or boar two, four, or more times. This is possible because a single ejaculate may be divided or diluted and then divided so that many females may be inseminated with one ejaculate. In addition, the number of wasted matings is greatly reduced. A male running with a group of females will mate each female a number of times during a single heat period. Service counts made on a vigorous ram ran as high as 22 within an eight-hour period. In that number of regulated services, the ram could have ejaculated enough semen to have artificially inseminated at least 200 ewes.

2. Valuable sires that cannot make a satisfactory service because of physical handicap, such as age, size, or a crippled condition, may, in many cases, be used successfully by means of artificial insemination. An example of such a male was a Shropshire ram which was owned by the University of Minnesota. Because of advanced age, the ram was unable to make a sufficiently vigorous service to deposit semen much beyond the vestibule. His sperm were fairly active but he failed to settle the majority of the females served. When his semen was collected and used artificially, a normal percentage of ewes was settled. Another case was that of a young Aberdeen Angus bull which was too short-legged to make a satisfactory service. In addition, his ejaculate was small and the number of vigorous sperm cells was rather low. He settled very few females by natural service, but the whole herd was settled through the aid of artificial insemination.

In crossbreeding it is sometimes desirable to use breeds quite dissimilar in size, and difficulty is frequently encountered in making such matings. Through the use of artificial insemination, this difficulty can be overcome.

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3. In monogamous species and cases of psychic incompatibility, artificial insemination may be used to good advantage.

4. Matings may be made between animals located at distant points at less expense or hazard than by transporting one of the animals. Semen may be shipped to any portion of the state serviced by reasonably good transportation facilities. Semen of Minnesota bulls has been shipped by airplane and has settled cows in Idaho and Ohio.

5. The dissemination of disease has been one of the chief handicaps of the community sire. Artificial insemination, properly used, can be instrumental in disease control.

6. Artificial insemination is making it possible for individual farmers to dispense with their own bulls. This to many dairy farmers is a great advantage because dairy bulls frequently are quite dangerous and always require some barn space and labor. Additional income is also secured by using barn space formerly occupied by the bull for housing productive females.

Limitations to the Use of Artificial Insemination

1. Many of the factors which previously limited the widespread use of artificial insemination have become of minor importance. The formation of artificial insemination organizations and the increased availability of instruments have about eliminated equipment costs and any additional labor on the part of the farmer as serious limitations.

2. Instances still exist where inseminators are not properly trained. This condition along with those cases where instruments are not properly cleaned, or where they are roughly or improperly used, will probably always tend to limit the full usefulness of artificial insemination.

3. The problem of disease transmission will always be present, but suitable precautions should continually minimize this source of limitation.

4. In the United States, species characteristics and management practices will probably limit the usefulness of artificial insemination in some cases for some time. This is especially true in the cases of range beef cattle, sheep, hogs, and fowl. Management practices will limit the practice in range beef cattle. The relatively low cost of sires and inconveniences in actual practice will be limiting factors in the other species.

Cost of Artificial Insemination

The cost of artificial insemination should be calculated in two ways: In actual cash outlay, artificial insemination can compete favorably with most cases of natural matings where mature bulls are used, as Dowell and Winters[1] found actual breeding costs by artificial insemination were averaging only about one half that of direct service by the bull. It has more difficulty in competing financially with the practice of using a young sire which is being raised and intended for later slaughter. That method of comparison really is insignificant, as artificial insemination has been developed primarily for the person who wishes to improve his stock.

Through the use of well-selected young sires and soundly proven bulls, farmers, on the average, may have their cows bred to bulls of higher quality than they probably could if they had to purchase their own bull. When this fact is considered, comparisons of actual costs in dollars largely lose their meanings, especially when the cost of artificial insemination in dollars is many times less than when natural mating is used.

[1] Dowell, A. A., and Winters, L. M. "Economic aspects of artificial insemination of commercial dairy cows." *Jour. Farm Econ.* August, 1942.

Proper Organizations and Technics Required

Artificial insemination is a method of breeding which has the possibility of being of great benefit to farmers and their livestock; however, a large financial loss to farmers may occur if artificial insemination organizations are improperly organized and/or managed.

The individual farmer is mainly interested in two things: improving his herd and getting his cows or other females settled. If, through improper organization of the artificial insemination unit or through the use of improper technics, the herd owners' females are not successfully settled within the limits of normal expectations, the resulting immediate financial loss may more than offset the long range benefits. It is imperative that each step in any artificial insemination program be done accurately and with the utmost care.

Male and Female Reproductive Tracts

FAMILIARITY with the genital organs of the animals, especially of the female, is necessary to successful use of artificial insemination. For that reason they are briefly described.

Female Organs

The important reproductive organs of the female (figure 1) are the ovaries, oviducts, uterus, vagina, and vulva. The ovaries, two in number, lie in the region below the loin. Two of their main functions are to secrete the female sex hormone, which is responsible for the production of estrus or "heat," and to produce the female reproductive cells (ova or eggs), figure 4.

When the eggs are shed from the ovaries, they are conducted to the uterus by means of the oviducts. The oviducts are long tubes which are very small in diameter; they are about 9 inches long in the cow. Fertilization of the egg by the sperm takes place in the oviduct.

The uterus consists of two horns, the body, and the neck or cervix. The horns are continuous with the oviducts but are much larger and have much thicker walls. The two horns join to form the body of the uterus which is relatively short in farm animals. During pregnancy the uterine horns contain the developing fetus and therefore vary in size depending upon the animal's stage of pregnancy. The uterus opens into the vagina by way of the neck of the uterus or cervix, which is a thick-walled, sometimes fibrous tube.

In the cow the cervix is from 3 to 4 inches long and about 2 inches in outside diameter. The cervical passage is rather tightly closed except during heat when it relaxes somewhat. In ewes and cows the passageway is small and neither straight nor smooth because of folds of tissue which project into it. Thus even during heat it is sometimes difficult to pass an instrument, even a small tube, through the cervix without injury to the tissue. In mares the cervix is somewhat smoother and more open so that a tube may usually be passed through with ease. At the time of parturition, the cervix relaxes a great deal to allow the passage of the fetus.

The vagina is strictly an organ of copulation, semen being deposited there by the bull and ram at the time of mating. It is partially restricted from the vulva or vestibule which belongs to both the reproductive and urinary tracts. The diameter of the vulva is similar to that of the vagina.

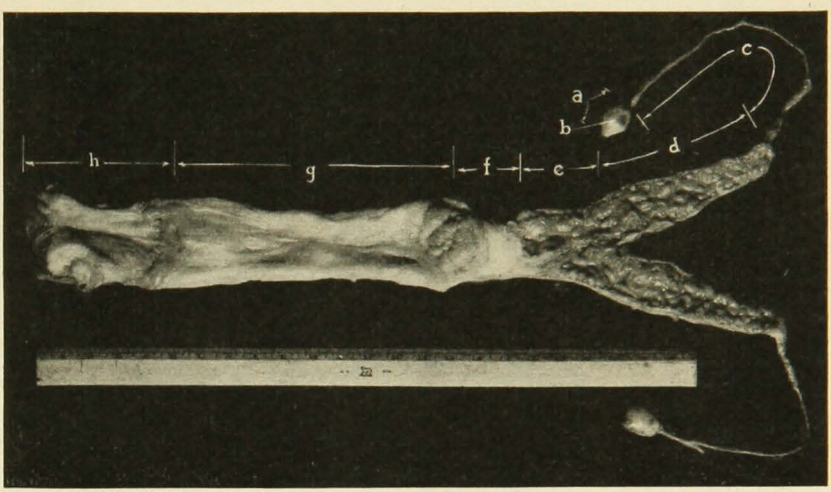


FIG. 1. Reproductive organs of the cow laid open

a, ovary; b, follicle about ready to burst; c, Fallopian tube, or oviduct; d, horn of uterus; e, body of uterus; f, cervix (opening to vagina); g, vagina; h, vulva or vestibule.

Male Organs

The male reproductive organs (figures 2 and 3) consist of the testes, epididymis, vas deferens, seminal vesicles, prostate gland, Cowper's glands, urethra, and the penis. The two testes are located in the scrotum and produce the male sex hormone and the male sex cells (sperm cells), figure 4. The sperm which are formed in the testis are conducted by a group of ducts into the epididymis which is a very long, coiled tube attached to the testis. In the epididymis, the sperm cells are stored and undergo a ripening process so they are ready for use when they leave that organ. The vas deferens or sperm duct is a curved tube leading from the epididymis to the urethra. The urethral end of each sperm duct is enlarged to form the ampulla which empties into the urethra.

The seminal vesicles, two in number, lie on either side of the ampullae. They secrete a fluid which is added to the total ejaculate. They empty into the urethra. Two other glands, the prostate and Cowper's glands, are located in this same (pelvic) region and also empty into the urethra.

All of the functions served by the secretions of the seminal vesicles, prostate, and Cowper's glands are not fully understood. However, during ejaculation some of the secretions usually pass first; then the bulk of the sperm cells are ejected, followed by the rest of the secretions. The secretions of the accessory glands are not necessary for successful results in artificial insemination. In fact, the secretions from some of the glands tend to shorten the life of stored sperm cells.

The male urethra is a long tube which extends from the urinary bladder throughout the length of the penis. Its function is to conduct urine and semen to the exterior of the body. The penis is the male organ of copulation; it is composed mainly of erectile tissue and encloses the extra pelvic portion of the urethra.

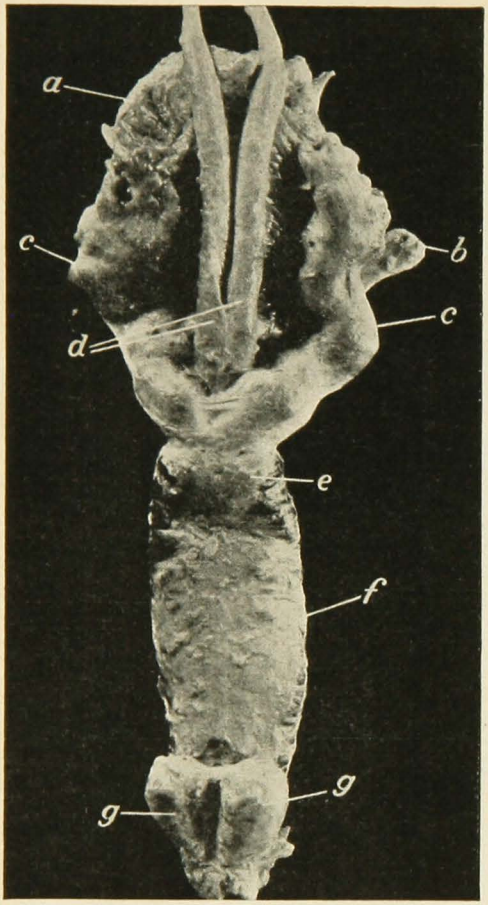


FIG. 2. Dorsal (top) view of the internal genital organs of a bull

a, bladder; b, ureter; c, seminal vesicles; d, ampullae; e, body of prostate; f, pelvic urethra; g, bulbo-urethral (Cowper's) glands. *(From Miller and Evans in Journal of Agricultural Research)*

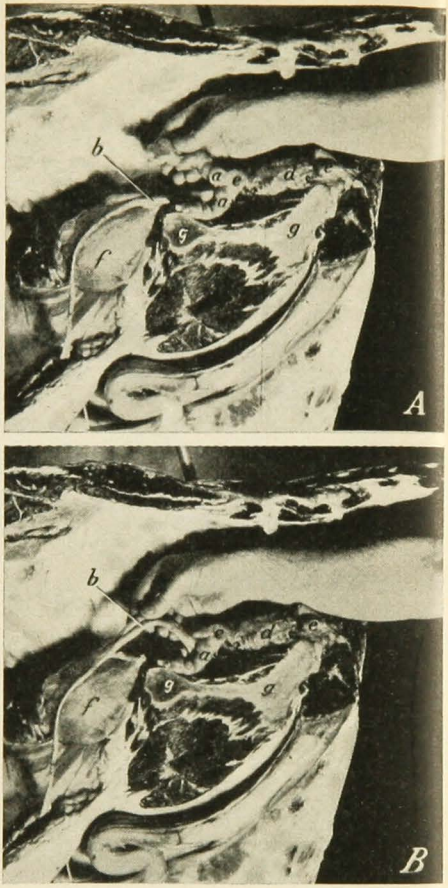


FIG. 3. Side view of bull's internal genital organs illustrating their positions

A, seminal vesicle lifted; B, ampullae lifted. a, seminal vesicles; b, ampullae; c, body of prostate; d, pelvic urethra; e, bulbo-urethral (Cowper's) glands; f, urinary bladder; g, pelvic bone.

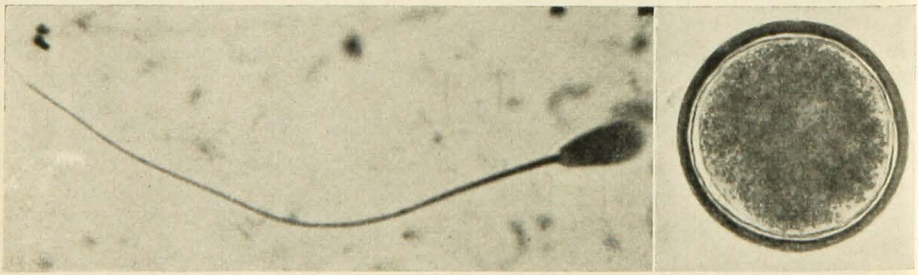


FIG. 4. Germ cells

Left, a bull sperm cell, × 1250; right, a cow ovum, or egg, × 180.

Technics for Handling Semen

SEMEN is an opaque, white to light cream-colored fluid normally ejaculated by the male at the time of mating. The average amount ejaculated at one time is one cc. (about 20 drops) for a ram, 4 cc. for a bull, 80 cc. for a stallion, and about 200 cc. for a boar. The semen consists of a fluid in which the male reproductive cells (sperm cells) are suspended. Figure 4 illustrates the shape of these cells which are microscopic in size. The normal number of cells per cubic centimeter of semen is reported to be one to five billion for the ram, 300 million to three billion for the bull, 30 to 200 million for the stallion, and 25 million to one billion for the boar.

Collection

The following practical methods of sperm collection have been developed:

1. Artificial vagina technic—This is the most satisfactory method for collection from the bull, stallion, or boar; it may also be used for the ram. Vaginae may be purchased or made by the operator. The one shown in figure 5, suitable for a bull or boar, is made of a 2¾-inch automobile radiator hose 18 inches long and a 30 x 3 inch automobile inner tube, used as a liner. Straight rubber tubing 4½ inches in flat diameter may be used in place of the inner tube, provided it, like one side of the inner tube, has a slightly roughened surface, as some bulls seem to work best if the surface the penis contacts is not absolutely smooth.

The collecting cone may be made of sheet dental rubber and cemented at the joints or cut from a piece of inner tubing and the joints vulcanized. If semen is collected in a cool place, it is advisable either to wrap the director cone with cloth, or, which is better, use a second rubber liner made of thin rubber. One end of this second liner is tapered into a funnel shape and a test tube fastened to the base of the cone. The second liner and test tube are both contained within the artificial vagina and the semen is kept warm until it may be taken to a warm room. A vagina so constructed would have to be over 18 inches long to accommodate the test tube.

The vagina is prepared by filling the double-walled space with water warm enough to bring the temperature of the inner wall to 98°-105° F. at the time of use. The amount of pressure on the inner wall may be adjusted by the quantity of water used or by the application of air pressure in addition to the water pressure. The inner wall is completely covered with vaseline, mineral oil, or gum tragacanth in order to lubricate the surface of the vagina and also to prevent the semen from contacting the rubber.

A male is allowed to mount a female, another male, or a dummy. The penis is directed into the artificial vagina by grasping the penis in the case of the horse or by grasping the sheath in the case of a bull, boar, or ram. The semen is removed from the vagina by means of the director cone as soon as possible after collection. For the boar, the rubber director cone may be directed into a bottle and the semen allowed to flow from the vagina during service. Usually the gelatinous material remains in the vagina and a very satisfactory sample is secured.

After use, the water is removed from the vagina, and the vagina is then cleaned by a thorough scrubbing with a paste made of sodium bicarbonate (baking soda) and water. It is then rinsed well, disinfected, and allowed to dry. It is desirable first to rinse the artificial vagina with hot water before using the soda in order to remove the

FIG. 5. Instruments used in insemination

a, speculum light; b, head lamp; c, fountain pen type flashlight; d, cow speculum; e, collecting pipette (sheep); f, pipette used for flushing ewes and also collecting ram semen; g, sheep speculum; h, test tube used for dilator in sheep, heifers, and small cows; i, funnels; j, bulb used on collecting and inseminating pipettes; k, vials and test tube used for semen storage; l, thermometer; m, 1 cc. pipette used for sheep insemination; n, Minnesota type cow inseminating pipette; o, modified Minnesota type cow inseminating pipette; p, 1 cc. pipette used with q, a 2 cc. hypodermic syringe, for inseminating cows; r, a metal tube (to be used with "q") for inseminating cows; s, artificial vagina (bull or boar); t, artificial vagina (horse).

bulk of the lubricant. Soap or other detergents not harmful to rubber may be used to wash the vagina, but extreme care must be taken to wash away all traces of the soap or detergent as it may be very toxic to sperm and injurious to rubber.

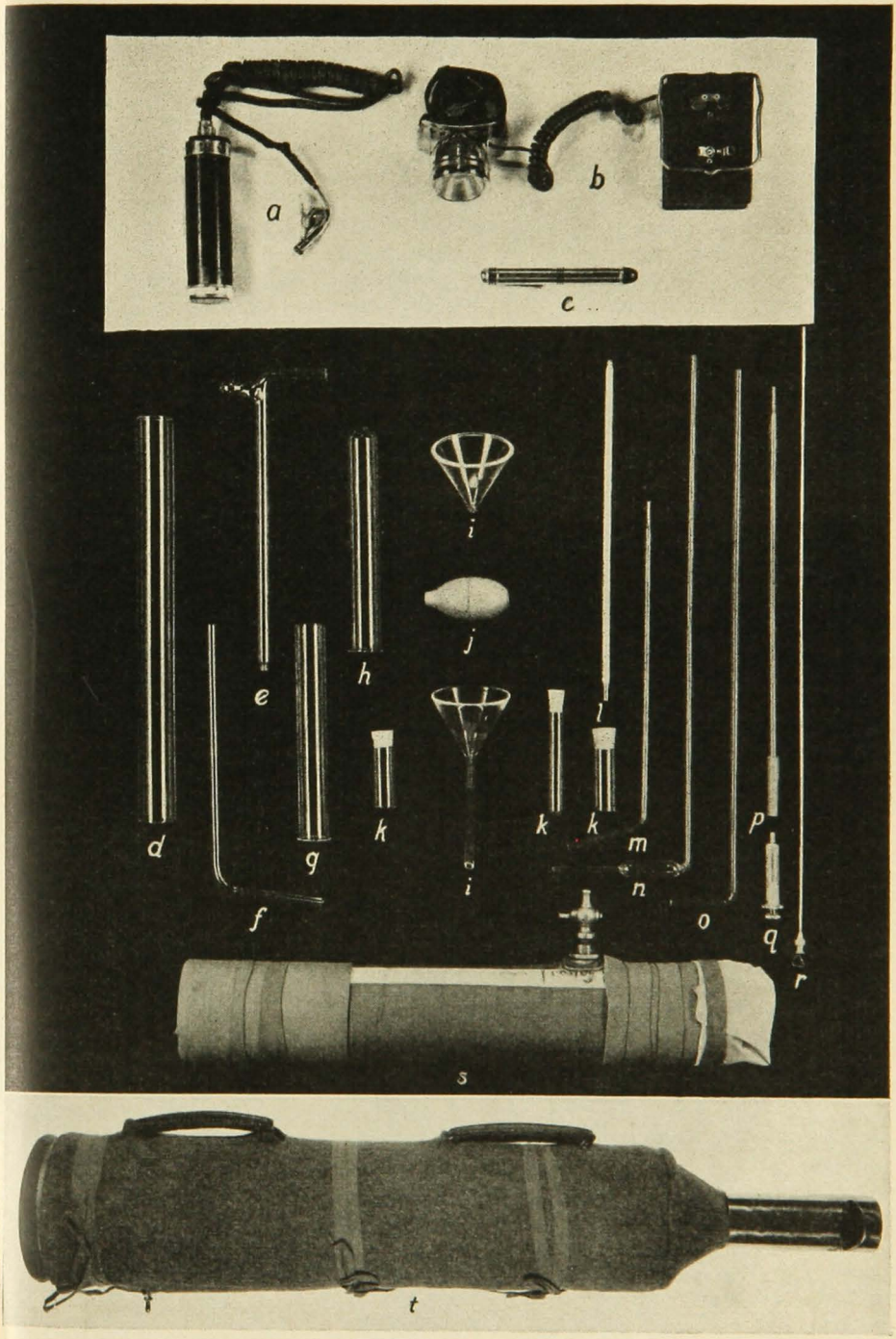
2. Rectal massage of ampullae—A trained operator can readily collect semen from bulls or stallions by rectal massage of the ampullae of the sperm duct (figure 2). This method was first described by Miller and Evans.[2] The massage method has the advantages of being rapid and requiring little special equipment. It is especially useful when a male cannot or will not use an artificial vagina or serve a female. If proper care is taken, a bull can be used by this method regularly over a long period of time without injury to the bull or his reproductive tract.

The disadvantages of the method are that it requires considerable experience and ability on the part of the operator, and that two persons are necessary for collection. Before attempting this method, one should learn the details first hand from someone who has used it successfully; otherwise, considerable damage to the rectal lining may result and other difficulties encountered. It is also advantageous to train the sire to this method as some difficulty may be encountered in securing samples from some untrained animals.

The outside of the sheath should be clipped carefully, stroked two or three times toward the opening to "strip" out any residual urine, washed with warm water, and thoroughly dried before collection to eliminate the possibility of getting extraneous material into the semen. Traces of urine are toxic to sperm. This cleansing procedure is desirable previous to collection by any method.

The assistant should hold a funnel, leading to a test tube, at the end of the sheath or penis. He should also have a series of test tubes available during the collection of the sample so that tubes may be substituted if one tube becomes dirty. The use of a long-sleeved rubber glove is desirable but not necessary to protect the operator. It is necessary, however, that his fingernails be clipped very short. The operator should lubricate his arm and the anus of the bull with vaseline, mineral oil, gum tragacanth, or mild soap. His hand and arm are then placed into the bull's rectum and all feces removed from that organ. After the rectum is cleaned it is rather easy to locate the ampullae. They may be found by placing the hand far enough forward in the rectum so that the fingers drop over the anterior border of the pelvic bone; then by pulling the arm backward with a gentle downward pressure by the hand, the fingers will come into a triangular space formed by the two ampullae (figures 2 and 3). At the apex of the triangle the two seminal vesicles join the urethra and a band of tissue may be found just back of this union (figure 2c, d, and e). The ampullae are massaged by a "stripping" action, the

[2] Miller, Fred W., and Evans, Everette I. "Technic for obtaining spermatozoa for physiological dairy studies and artificial insemination." *Jour. Agr. Res.* **48**:941-947. 1934.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second finger of the hand is run between the two ampullae and the index and third fingers are placed on the outer side of the respective ampullae. A slow, rhythmic motion is used while massaging, and, if done correctly, a sperm sample reasonably free from accessory secretions may be secured.

3. Collection of semen from vagina—Collection of semen from the vagina of a female mated in heat or force mated out of heat is the simplest and most satisfactory method for the sheep. It is not recommended for cattle and is not satisfactory for horses or swine.

The ewe to be used is placed in a breeding stall or held by hand. The vagina is washed free from mucus by repeated flushings using a pipette and the saline solution recommended for sheep semen dilution. The pipette used (figure 5) is made of ordinary 8 mm. diameter glass tubing. The arms of the pipette are 9 inches and 3½ inches long, the ends are fire polished, and the short end is equipped with a rubber bulb.

After all of the mucus and saline have been removed from the vagina, a ram is allowed to mate the ewe. The semen is then removed by the use of a glass pipette of the type shown in figure 5 or by use of a pipette identical to the one used for flushing the vagina. The air is expelled from the rubber bulb, the pipette inserted, and the pressure is released from the bulb as the pipette is drawn slowly along the floor of the vagina. If the end of the instrument is kept on the floor of the vagina, the suction will draw the semen into the pipette; however, the semen should not be allowed to enter the rubber bulb. It is well to apply a coating of lubricant (no soap) to the pipette prior to use to prevent irritation of the lining of the vagina.

The operator must be very sure that the male and female used in this method are free from disease. For some work, it is satisfactory to wash the vagina thoroughly between services of different rams. If the semen is to be used for breeding purposes and the pedigrees of the offspring are desired, each ram should be mated to a ewe which has not been used for semen collection within the past four days. An artificial vagina is most desirable when pedigrees of the offspring have to be exact.

4. Electrical stimulation method—This method, which may be used for sperm collection from rams and small animals, was first described by Gunn[3] and was also described by Winters.[4] Considerable labor, skill, and equipment are necessary to use this method. In addition, it is a more severe treatment than any other method of collection. For rams it is much simpler to collect from a female or to use an artificial vagina.

Other methods that may be used to collect semen include the use of a rubber sperm collector or breeding bag placed in the vagina of the female. This has not proved very satisfactory because of the difficulties in keeping the collector in the vagina and of directing the male's penis into instead of beside the collector. A breeding bag on the penis of the male may be used for the stallion or jack. Semen may be collected from the dog by masturbation by stroking the end of the penis through the wall of the sheath.

Care and Storage of Semen

It is absolutely necessary that the temperature of semen be carefully regulated. Sperm are injured at temperatures much above body heat. Outside the body, they live for relatively short periods of time at body or room temperatures. Sperm are injured by a rapid lowering in temperature, espe-

[3] Gunn, R. M. C. "Fertility in sheep." Commonwealth of Australia, Bul. 94. 1936.
[4] Winters, Laurence M. Animal Breeding. Ed. 3, 316 pp. John Wiley and Sons, Inc. New York. 1939.

cially if the range is below 70° F. In all cases the temperature of semen should be changed gradually. All glassware used to hold semen must be at the same temperature as the semen. When mixed with diluters, the two fluids should be the same temperature. Semen in test tubes may be cooled by placing the tubes in a wire rack or in a glass container partly filled with water and then putting the rack or glass container in a refrigerator the temperature of which is 38°-40° F. It should take about (not less than) one hour to cool the semen from ordinary room temperature (70° F.) to refrigerator temperature. If semen is to be reduced to a temperature of 33°-35° F., it should be so handled that about two additional hours are required to reduce the temperature of the semen from 38°-40° F. to the lower temperature. In ordinary use, sperm cells die if they are subjected to below freezing temperatures (32° F.)

Semen apparently may be warmed rapidly. Sperm are probably not injured to any great extent when the temperature is elevated even as rapidly as when semen is removed from storage and immediately placed into the cow.

Sperm cells are injured by media which are too acid or too alkaline, undue shaking, direct sunlight, and small amounts of urine, antiseptics, or soap. The cells are not injured by centrifuging at reasonable speeds and lengths of time. This is important because it is sometimes desirable to remove some of the secretions of the accessory sex glands, especially in the horse and boar, before the semen is diluted or stored. Semen and most diluters are ideal media for bacterial growth; however, the growth of certain types of bacteria may be held in check by proper storage.

Whole semen may be covered with pure mineral oil and stored in a stoppered tube in a refrigerator. Viability is usually prolonged, however, by the use of suitable diluters. It has been found in experiments at the University of Minnesota that sheep sperm are preserved longer if an equal quantity of the following solution is added to the semen: Na_2HPO_4, · 12 H_2O, 15.4 grams; KH_2PO_4, 3.2 grams, sterile water which has been distilled over glass, 1 liter; $CaSO_4$, saturate. The ingredients should be weighed accurately in order to get a *p*H of about 7.0.

The most widely used diluters for bull semen involve the use of the yolk of fresh eggs. The first diluter was developed by Lardy and Phillips.[5] This diluter may be used for species other than the bovine. Equal volumes of a sterile buffer (0.2 grams KH_2PO_4 and 2.0 grams of Na_2HPO_4 · 12 H_2O added to 100 cc. of sterile distilled water) and the yolk of fresh eggs are mixed thoroughly under sanitary conditions. The *p*H of the mixture should be close to 6.75; if it is lower, more of the buffer solution should be added. A second diluter using egg yolk has been suggested by Willett and Salisbury[6] as follows: A sodium citrate solution is made by dissolving 47.615 grams of crystalline 2 $Na_3C_6H_5O_7$ · 11 H_2O in 1 liter of water distilled over glass. Equal parts of this solution and the yolk of fresh eggs are mixed and used to dilute semen. The main advantages of the citrate buffer are that it is easier to observe the sperm cells after dilution and the sperm tend to live longer, although this latter point is not so important under routine use of dairy bull semen.

The rate of dilution of semen depends upon the number and quality of the sperm in the semen sample. Usual dilution rates are one part of semen to four to twelve parts of the

[5] Lardy, Henry A., and Phillips, Paul H. "Preservation of spermatozoa." *Amer. Soc. Anim. Prod. Proc.* 32:219-221. 1939.

[6] Willett, E. L., and Salisbury, G. W. "The effect of various diluters, cooling rate, temperature of storage, and some other factors, on the livability of spermatozoa in stored samples of bull semen." Memoir 249, Cornell Univ. Agr. Expt. Sta. 45 pp. 1942.

egg yolk-buffer solution. Higher dilution rates may be used if adequate tests indicate the sample warrants the higher rates. Dilution should be made as soon as possible after the semen sample is secured.

A convenient method for determining the *p*H of semen or diluters is to dip a good grade of filter paper into a solution of brom-thymol-blue indicator and allow the paper to dry. Apply a drop of the solution to be tested to the filter paper and note the color near the margin of the moist area. This color may be compared to the color of buffers of known *p*H to which the indicator has been added. Any druggist should be able to prepare the indicator and buffer solutions.

If semen is to be used within 30 minutes after its collection, it need not be cooled below 70° F. If the semen is not to be used immediately, it should be diluted with the proper buffer and stored at 33°-40° F. All of the precautions given above should be observed. Although calves and lambs have been born from semen stored six and seven days, respectively, storage over two to three days is not recommended for routine work.

Shipping

Semen that is to be shipped is put into a vial or test tube and the remaining space is filled with purified mineral oil. The tube is stoppered, plainly labeled, sealed with paraffin, and covered with a rubber finger cot. It is then cooled in the manner described previously. Thermos jars filled with water make satisfactory thermo-regulators during transportation. The thermos bottle, filled with water, is cooled to 35°-40° F. Ice placed in the water at the time the vial containing the semen is added helps to maintain a constant temperature for about 18 hours. Both the ice and the vial of semen are added just previous to sealing and shipment. In case the shipment is to be by mail, bus, or express, a padded cover should be fitted to the thermos jar. It should be labeled "Glass, Handle with Care."

Other types of shipping containers have been devised and are very satisfactory. They consist of a durable, insulated box or metal can in which is placed ice contained in rubber or metal containers. Test tubes containing the semen should be insulated so they cannot contact the ice containers and thereby subject the semen to rapid cooling.

Semen Evaluation

Various measures of seminal quality have been suggested: viscosity, color, and odor of the semen, number of sperm, number and type of abnormal sperm, per cent of motile sperm and types of motility exhibited by the sperm, sperm livability, and glycolysis and/or respiration of sperm. At the present time no one measure of sperm quality has proved adequate when used alone; however, by the use of a group of measures the quality of a sample may be evaluated rather satisfactorily. The easiest important measures for routine use in the field are: the quantity of semen, number of sperm, motility ratings, metabolic activity, and livability under storage conditions.

The number of sperm may be secured rapidly and satisfactorily for field use by means of opacity standards made of barium sulfate. The method developed at the University of Minnesota[7] is as follows: A series of seven opacity standards in which the barium sulfate content ranges from 0.05 to 0.20 per cent at intervals of 0.025 per cent is used. Five ml. of each were put in test tubes 11 mm. in diameter together with a crystal of thymol to prevent

[7] Comstock, R. E., Green, W. W., Winters, L. M., and Nordskog, A. W. "Studies of semen and semen production." Minn. Agr. Expt. Sta. Tech. Bul. 162. 55 pp. 1943.

bacterial growth. The tubes were stoppered and sealed with paraffin to prevent evaporation. One tenth of a milliliter of semen (this amount may be adjusted to suit a given semen sample) was mixed with 5 ml. of sheep semen diluter (see above) in the same type of tube used for the standards. The opacity of this suspension and the barium sulfate suspensions was then compared. (Shake the barium sulfate tubes vigorously for at least one minute immediately before use.) Comparisons were made in front of an electric light with a piece of window screen immediately back of the tubes. The ease with which the cross wires were seen through the suspensions facilitated comparison.

Extreme care must be exercised in the preparation of barium sulfate suspensions if results from different series of standards are to be comparable. The most satisfactory method of preparation is the precipitation of barium sulfate by mixing solutions of barium chloride and sodium sulfate. For most field work a series of five standards is sufficient; it should include 0.06, 0.09, 0.12, 0.15, and 0.18 per cent suspensions. Detailed directions for preparation of such a series are as follows:

1. Prepare (a) an aqueous solution containing 321.2 mg. (0.3212 g.) of barium chloride in 100 ml. and (b) an aqueous solution containing 219.0 mg. of sodium sulfate in 100 ml. (These solutions must be prepared in 100 ml. volumetric flasks using water distilled over glass.)

2. Into a series of five tubes in which standards are to be prepared, pipette 1.0, 1.5, 2.0, 2.5, and 3.0 ml., respectively, of the barium chloride solution.

3. Add 1.0, 1.5, 2.0, 2.5, and 3.0 ml., respectively, of sodium sulfate solution to the tubes containing the corresponding amounts of barium chloride solution. The sodium sulfate solution must be allowed to run in rapidly from a pipette calibrated "to deliver" since the rate of addition of this solution has a measurable effect on the opacity of the suspensions.

4. Allow the suspensions to stand 30 minutes. Then add sufficient distilled water to the first four to bring them to 6 ml. total volume. The fifth will already contain 6 ml.

The original solutions of barium chloride and sodium sulfate must be prepared at least four days before the suspensions are prepared and the suspensions should be made up three or four days before they are first used. New standards should be made every six months.

A shortcoming of the use of barium sulfate standards is that each laboratory or worker using it to estimate absolute values, in contrast to using it as a relative measure, will need to standardize a prediction curve, since comparisons with the standards will not be made in exactly the same way by any two workers. However, for the approximation of relative values the method is of considerable use in the field. Very little time is required and the equipment is inexpensive.

Anyone with a certain amount of experience can estimate density fairly accurately without standards for comparison, but the average level of their estimates will shift from time to time in the absence of a standard for reference. For example, there is marked seasonal variation in the average density of ram and bull semen. As a result, samples of equal density may appear relatively much more dense in one season than in another. The barium sulfate standards serve to anchor one's judgment to about the same range at all times.

The rate of sperm cell metabolism may be measured in various ways. The most practical field test developed to date has been the adaptation of the widely used methylene-blue reduction test to use with semen[8, 9]. The method is as follows[8]: A methylene-blue solu-

tion is made by dissolving 50 mg. of methylene-blue in 100 ml. of the same citrate buffer as is used for making the yolk diluent (4.76 g. crystalline sodium citrate, 2 $Na_3C_6H_5O_7 \cdot 11\ H_2O$, per 100 ml. of water distilled over glass). Two-tenths ml. of semen and 0.8 ml. of yolk-citrate diluent are placed in a test tube of approximately 10.0 mm. outside diameter and of 3.5 to 4.0 ml. capacity. One-tenth ml. of the methylene-blue solution is measured into the 1.0 ml. of diluted semen and the contents gently but thoroughly mixed. A half inch layer of pure mineral oil is layered on top of the semen and the tubes are then placed in a constant temperature water bath (116° F.) where reduction of the methylene-blue takes place.

The concentration of sperm in the semen and the motility of the sperm are of about equal importance in influencing the rate of reduction on the methylene-blue; therefore, to get an accurate appraisal of the semen, the time required for reduction should be weighed by the number of sperm as secured by the barium sulfate opacity method and by the motility rating of the sperm taken prior to the start of the test. The amount of ascorbic acid in the semen also affects the rapidity of reduction.

Equipment for field determinations of respiratory rate of sperm and technics for the microscopic study of semen have been developed at the University of Minnesota. Further information on these technics may be secured from that source.

[8] Sørensen, Ed. "The dehydrogenization power of sperm cells' as a measure for the fertility of sperm." *Skand. Vet. Tidskr.* **32:** 358-373. 1942.

[9] Beck, G. H., and Salisbury, G. W. "Rapid methods for estimating the quality of bull semen." *Jour. Dairy Sci.* **26:**483-494. 1943.

Insemination Technics

SUITABLE PIPETTES or syringes are used for insemination. In mares the semen can be injected through the cervix into the uterus. In cows and ewes it should be placed as far into the opening of the cervix as possible.

Inseminating pipettes used at the University of Minnesota are shown in figure 5. For cattle the portion inserted in the cow is a glass tube about 17 inches long, ¼-inch outside diameter with a 1/16-inch bore. This is fused at right angles to a tube 5 inches long which has a 3/16-inch bore. There is an advantage of having a pocket about 1½ inches long blown in the latter piece. The semen collects in this pocket when the pipette is loaded. The inseminating pipette for the sheep is merely a 12-inch long glass tube with a 3/16-inch outside diameter. It is bent about 3 inches from the outer end. The end of inseminating pipettes to be inserted into the cervix should be drawn slightly to a point and all rough edges removed by passing through a flame. A 1.0 cc. pipette graduated to the tip and with a bend about 3 inches from the blunt end (figure 5) is very satisfactory for the sheep. It is the correct size; it has a tapered end; and the amount of semen may be measured with ease.

Other types of inseminating pipettes and syringes have been used successfully by other workers. Two popular types for cattle are (1) a pipette patterned after the one described above with a larger inner diameter of the long portion of the tube (ordinary 6 mm. glass tubing) and the omission of the bulge in the short arm and (2) a hypodermic syringe with a glass or metal tube attached. Some breakage is encountered in using the glass type just mentioned and the metal tube is difficult to clean properly.

Rubber bulbs (figure 5) about 3 inches long and 1½ inches in diameter are needed. They are attached to inseminating and collecting pipettes.

Various specula are on the market. The one used at Minnesota for the cow is a simple glass tube 14 inches long and 1¼ inches in diameter. Sheep specula may be made by removing the bottom from a 1 x 8-inch test tube and fire polishing the edges. It is desirable to slightly constrict the one end of the speculum to facilitate insertion into the vagina. The advantages of glass specula are that they are inexpensive and easily cleaned. The specula as well as all other glassware should be made of pyrex glass.

In heifers, small cows, and ewes it is desirable to dilate the passage leading to the vagina before inserting the speculum. A 1 x 8-inch test tube is useful for this procedure. Before inserting either the speculum or test tube, it should be lubricated with mineral oil, vaseline, or gum tragacanth (no soap!).

A light is necessary in locating the cervix. A fountain pen type flashlight, a head lamp, or a speculum light (figure 5) are all satisfactory.

A special breeding stall is desirable for inseminating sheep. The one shown in figure 6 is easily constructed and simple to use. Special stalls are not necessary for cattle; however, at the time of insemination, cows should not be located near a wall or post against which they can swing in such a way as to injure the inseminator or his equipment.

Of the various insemination technics suggested, the use of the glass speculum and glass inseminating pipette (Minnesota type) is the most popular technic in Minnesota. The semen is first placed in the inseminating pipette.

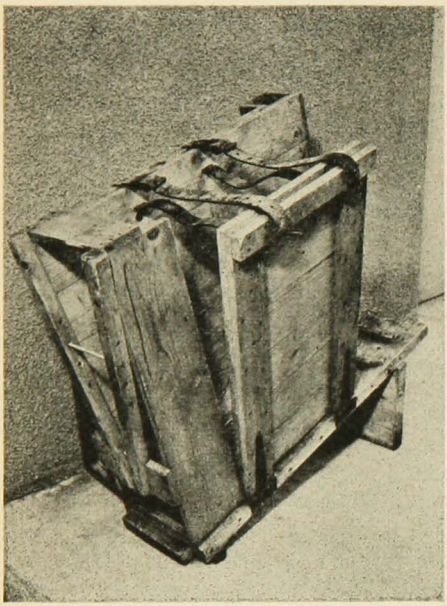

FIG. 6. Sheep inseminating crate

The speculum is lubricated, and with the aid of a good light, it is carefully watched as it is inserted through the vulva and into the vagina. After the cervix is located (figure 7), the inseminating pipette is passed through the speculum and inserted as far as possible into, or placed against the opening of, the cervix and the semen discharged gently. Just before the semen is discharged, the speculum should be withdrawn about 1 to 2 inches to prevent semen from flowing into the speculum (figure 8). After discharge of the semen, the pipette should be drawn back well into the speculum and the two removed as a unit.

A very popular method of insemination involves placing one hand into the rectum and guiding an insemination pipette by touch to, and frequently through, the cervix. From published results, the two methods (rectal and speculum) are about equally efficient in settling cows and the choice between the two methods depends largely upon the method popular in a particular locality. Semen may be placed in gelatin capsules and the capsules inserted into the uterus, cervix, or vagina in case of the mare or into the vagina or cervix in case of the ewe or cow. The use of a special instrument equipped with a plunger which pushes gelatin containing semen into the vagina or cervix is popular in some parts of Europe but has not become widely used in this country.

Time of insemination is an important factor. In general, about 12 to 24 hours before ovulation is the best time to inseminate or breed. Horses ovulate about two days before the end of heat (although this time is quite variable); therefore, it is most desirable to inseminate after the cervix relaxes or on the third day of the period and every day or every other day thereafter until the period is passed. For best results with the horse, the follicle should be examined by a well-qualified person and insemination take place when the follicle is about to rupture. Care should be taken in order to prevent too frequent examination of the

FIG. 7. Cow cervix as seen through speculum
a, speculum; b, cervix.

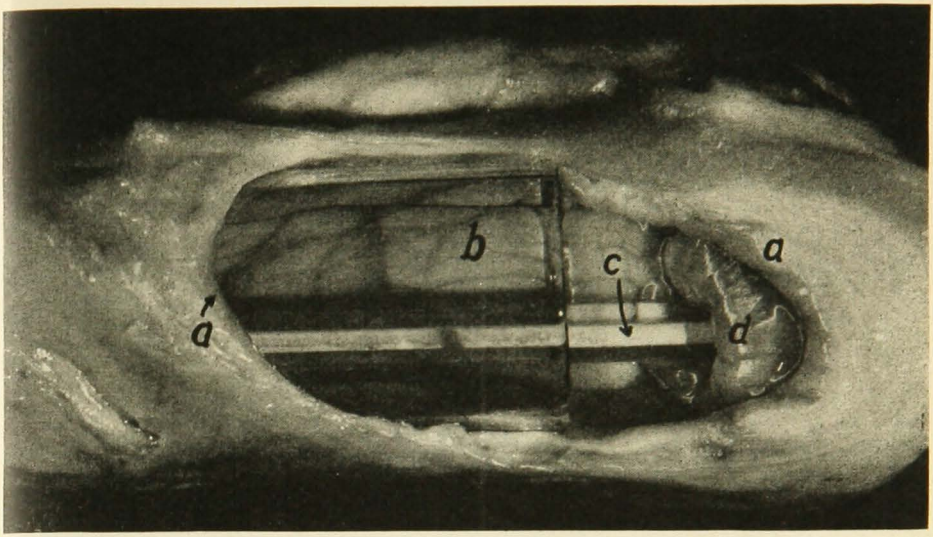

FIG. 8. Illustrating use of speculum in cow and position of instrument at the time of discharge of the semen

a, wall of vagina cut away; b, speculum; c, inseminating pipette containing semen placed in cervix; d, cervix.

ovaries. Green and Winters[10] have shown that ewes ovulate near the end of heat. Cows ovulate 12 to 24 hours after the end of heat and sows usually ovulate during the second day of their three-day period. Cows may be inseminated any time during heat; however, recent work at the University of Wisconsin indicates that the last half of the period might be best. Sheep should be inseminated during the last day of their heat period or every day if the length of the heat period is not known.

The number of sperm cells of good quality is important and dilution rates should be guided by sound laboratory tests. For sheep and cattle at least one cubic centimeter of diluted semen should be used in connection with the speculum method if the semen is properly placed in the cervix. A larger quantity is necessary if the semen is placed in the vagina. Mares that have never produced a colt require 10-15 cc.; those that have foaled one or more times require 20 cc. of semen. About 80-100 cc. should be used for the sow

[10] Green, W. W., and Winters, L. M. "Studies on the physiology of reproduction in the sheep. III. The time of ovulation and rate of sperm travel." *Anat. Rec.* 61:457-469. 1935.

Sanitary Precautions

EXACTING sanitary precautions must be taken or artificial insemination may prove more of a liability than an asset to the livestock industry. The male should be examined by a competent veterinarian at regular intervals and pronounced free from all disease. The operator must keep himself and his clothes clean at all times. He must never relax at any time in any sanitary precaution. The following suggestions are recommended:

1. Glass instruments should be used wherever possible.

2. Two instrument cases should be carried by the inseminator, one containing only clean equipment and one only dirty equipment.

3. Clean instruments must be used for each animal.

4. Glassware should be washed as follows:

(a) rinse with cold, then hot water containing soap or some other good detergent; then rinse with clear lukewarm water;

(b) place in cleaning solution for at least 10 hours (This will both clean and sterilize. The solution is made by saturating tap water with potassium bichromate and slowly adding an equal volume of concentrated commercial sulfuric acid. The solution should be discarded when it becomes greenish in color. Metal instruments will not withstand the action of this solution and for that reason the authors prefer glass);

(c) place instruments in running water for at least one hour;

(d) rinse instruments in a one per cent solution of sodium bicarbonate;

(e) rinse with distilled water;

(f) place in an oven to dry; and

(g) wrap instruments in paper or clean towels until used.

5. Rubber materials should be scrubbed with a paste of sodium bicarbonate and water as previously described and dried well between periods of use.

6. Rubber goods should be disinfected by dipping them in chlorine water, 70 per cent ethyl alcohol, or boiling water. This should be done immediately after washing, and the chlorine solution must be washed from the rubber before it is set aside to dry.

7. The inseminator should remove all dirt from his shoes and wash them with a good disinfectant before leaving each farm visited. The bottoms of the two kits and semen container should be treated in a similar manner. The inseminator's hands should then be washed thoroughly with soap and water and then disinfected.

8. Soap may be used to wash instruments. It is very toxic to sperm and does not disinfect in any manner comparable to the acid cleaning solution. If soap is used, all traces should be washed from the equipment and equipment then dipped into chlorine water, 70 per cent alcohol, or boiling water before rinsing and oven drying and wrapping.

Sire Management

SIRES USED for artificial insemination should be given the best care possible. The young bull needs to be fitted for a long, fertile life. The proven sire often has reached or passed his era of highest fertility and physical vigor, and his useful life needs to be extended as long as possible. In addition, a bull will probably be used more regularly when owned by an insemination association than when used for natural service. In contrast to the large amount of work completed on the feeding and management of producing females, very little attention has been given to proper sire care.

In all cases the sires must be handled as individuals rather than as groups because of the large variation in individual response to any set of managerial practices. Roughage should not be fed in quantities that will result in paunchiness. Proteins from a variety of sources are desirable in order to insure the correct quality of proteins. The grain ration may be regulated according to the condition of the animal. The amount of fat a sire can carry and still work well depends to a large extent on the individual himself. When overly fat, the sire may become lazy and sluggish and may also decline in fertility. This is especially true of older animals.

The sire should receive regular, individual attention. He should be well groomed each day. The amount of exercise given each sire should be regulated to fit each sire's individual need. A mechanical exerciser similar to the one shown in figure 9 has been found to be quite satisfactory. Periodic attention to his feet will help prevent overgrown hoof walls, which result in lameness and disability, corns, and other foot troubles. Examinations by qualified veterinarians will help prevent disease and be useful in detecting diseases such as tuberculosis, brucellosis, and trichomoniasis.

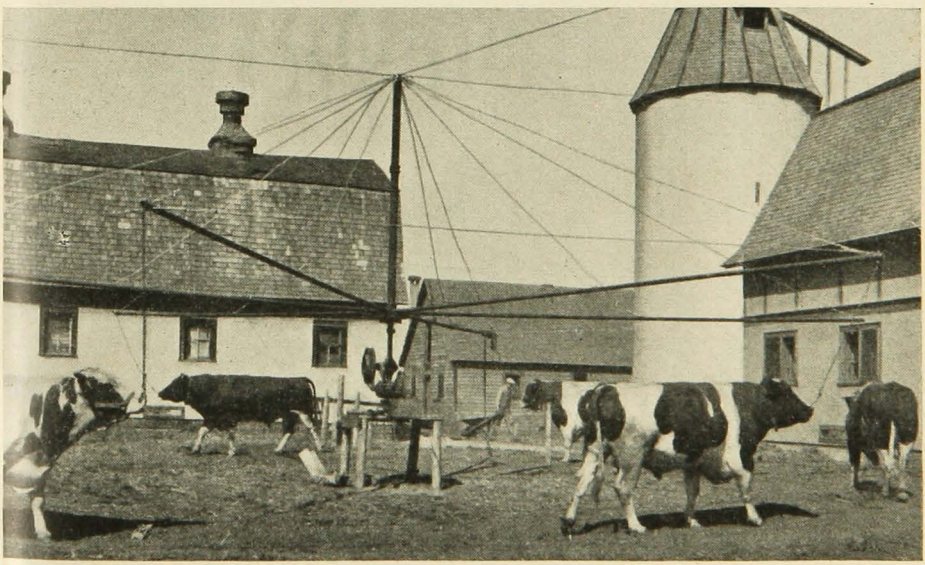

FIG. 9. Mechanical bull exerciser

Signs of Estrum in Cows

THE OWNER should record each heat period of a female and, if possible, approximately how long she remained in heat. This is of importance in helping the owner or inseminator to estimate the date of the next probable period, and it would also be of assistance to a veterinarian in diagnosing reproductive disorders. In addition it is very important that the owner be able to recognize a cow that is in heat and report the fact to the inseminator as soon as possible. If the inseminator knows of the cows to be inseminated during the day at the time he begins his circuit, much wasted effort will be avoided and a direct financial saving will be made by the association.

The signs of heat are usually more evident in heifers than in older cows; intensified by turning the cow loose with other cows; and more pronounced in summer than in winter and when the cow is warm rather than cold. She may "ride" other cows or stand still if "ridden." By turning the cattle into a pasture or barnyard both morning and afternoon for exercise, the cows in heat will usually be noted quickly. A cow tied in a stall often stands when others are lying down. She may twitch her tail frequently and often raise it. Her tailhead may be elevated while the hips and small of the back are lowered. The vulva may be slightly reddened and swollen. This sign may be intensified by massage of the vulva. Mucus may flow from the vulva and be seen on the tail or flanks. During the first part of the heat period the mucus is clear and rather watery in consistency. Later it becomes yellowish, containing cheesy lumps, and, finally, white and thickened.

If a bloody discharge is noted coming from the vulva after heat or even if heat was not noticed, the cow will probably be in heat about 16 to 18 days following the bleeding and should then be watched for signs of heat. If the discharge is noted on the cow's fertility chart and a second note made as to when the cow should return to heat, the owner, by watching for the signs of heat in the cow may observe an otherwise "missed" period. This is especially important in the winter. Through attention to details of this type an owner can obtain a higher herd fertility record and much saving.

Artificial Insemination of Fowl

THE METHODS developed for collecting semen from the cock are similar to those used for larger animals: (1) placing a dish between the cock and the hen; (2) using an artificial vagina; (3) mating a hen and securing the semen from the cloaca by means of a pipette or spoon; or (4) by stimulating ejaculatory responses by manual manipulation of the male. Of the methods presented, the last, or stimulation of ejaculatory responses, which was described by Burrows and Quinn[11, 12], is most widely used at the present time.

Ejaculatory Responses

The bird may be held in a specially constructed holder or it may be held in the lap of the operator. For a right-handed operator, the cock's legs are placed between the operator's knees (figure 10) and its head held under the left arm of the operator if the operator so desires. The thumb and last two fingers of the right hand are placed on the sides of the abdomen as shown in figures 10 and 11. Ejaculatory responses are induced by rapid massage of the abdomen between the gizzard and the pelvic bones. The thumb and fingers of the left hand are so placed (figure 11) that the semen may be "milked out" at the time of erection. The semen is caught in a small funnel which has either a solid glass stem or has the stem filled with paraffin. The upper portion of the funnel should also be coated with paraffin in order to insure the greatest recovery of the semen. The funnel is held by the right hand.

[11] Burrows, W. H., and Quinn, J. P. "A method of obtaining spermatozoa from the domestic fowl." *Poultry Sci.* **14**:251-254. 1935.
[12] Burrows, W. H., and Quinn, J. P. "The collection of spermatozoa from the domestic fowl and turkey." *Poultry Sci.* **16**:19-24. 1937.

FIG. 10. Method of holding cock and position of hands during semen collection from the cock

Contamination of the ejaculate may be prevented or lessened in the following ways: food and water may be withheld from the bird for 12 hours

FIG. 11. Position of hands and seminal discharge during collection from the cock

prior to securing the sample, or a small amount of absorbent cotton may be placed into the anterior portion of the cloaca or lower intestinal tract previous to collection. It is also desirable to clip the feathers from the area about the anal opening. As with the massage method of semen collection for the bull, it is advantageous to train a cock to this method of semen recovery.

Amount of Semen Secured

The amount of semen to be secured from the cock per day ranges up to 3 cc.; however, the average amount secured is usually about 0.2-2.0 cc. per day. The amount secured from pigeons and doves averages 0.01-0.02 cc. per collection and from turkeys, 0.3-0.4 cc. About 0.05-0.1 cc. of semen may be used for insemination purposes.

Previous to insemination the semen is placed in a pipette or medicine dropper. The hen's cloaca is everted and the opening of the reproductive tract into the cloaca is located. The pipette is then inserted about 1 to 2 inches into the reproductive tract (figure 12), and the cloaca is allowed to return to nearly normal position before the semen is deposited. Fowl semen may or may not be diluted with saline solutions and stored at 33°-35° F.; however, it is best to use the semen as soon as possible after recovery. For best fertility the hen should be inseminated twice a week although satisfactory results may be secured by weekly inseminations. Sanitary precautions similar to the ones noted in connection with the semen of larger animals should be observed at all times.

FIG. 12. Position of syringe placed into reproductive opening prior to insemination of the hen

Records

IT IS HIGHLY desirable to keep proper records for all phases of artificial insemination. Without correct records, it is impossible to know the true status of any portion of an insemination program. Samples of records mentioned in this bulletin are shown in the Appendix. These samples suggest subject headings and spacings. It is important to keep in mind that certain information is essential and that the forms should not be crowded. Forms should be made of such size as to be practical. There is a tendency to fit forms to standard page sizes. It is much better to select page size to suit the form rather than to fit the form to an arbitrary page size.

Sire Management Record

The sire management record is needed to keep an accurate account of the management of each individual sire. As ration, amount of exercise, etc., do not vary greatly from day to day, it is best to leave the date column blank and write in the dates that changes are made. The manager may draw horizontal lines across the page after each entry in order to use the form most efficiently.

Sire Fertility Record

It is essential to keep accurate records on the seminal characteristics and fertility of each sire. If properly kept, this form assists a manager to keep a check on his bulls and inseminators. It is quite valuable when studying cows or herds which are difficult to settle.

The records that should be kept are listed on the form shown in the Appendix. Sexual activity may be rated on an arbitrary scale such as 0-5, 5 indicating a high degree of vigor. The volume should be read to the nearest 0.1 cc. The per cent of motile sperm may be estimated. It is necessary to have the slide holding the sperm and the semen at a temperature between 70°-100° F. at the time of estimation of the type of motility, and the temperature selected should be the same each day to insure a consistent basis for estimates. Never try to evaluate sperm motility when the semen is cold. The type of motility may be rated on an arbitrary scale such as 0 (all dead) to 5 (vigorous forward motion) or by writing a descriptive word. The inseminator should check the per cent and type of sperm motility before he starts in the morning and again when he returns from his day's work. He should send that report with his Daily Report or communicate immediately if the sperm are poor.

The per cent nonreturn should be calculated at the end of 28 or 30 days or some other time interval. The four-week period is a satisfactory measure (but not absolutely accurate) of a sire's fertility. It also affords the quickest, reasonably accurate check. It is important to keep this record up-to-date.

The spacing on the form as it appears in the Appendix does not represent actual spacings. The practical form must be large enough to be used easily. Subdivisions of the horizontal spaces are desirable if two different ejaculates secured on one day are used separately or if one sample is used on two or more days.

Dairy Herd Records

Proper records for each female in the herd are very important. They may be grouped under management, production, and fertility. The management records may be similar to those

suggested for the bull, i.e., health, individual care, tuberculosis and brucellosis tests, special treatment, and feed. The feed record is especially important in order to assist in the proper evaluation of the female's economy of milk production.

For a dairy herd, a record of the milk and butterfat produced is essential not only to help establish the economy of production for the individual but also to assist in the evaluation of sires. This is especially important for artificial insemination associations proving young sires. The young bull's semen may be used to breed only a few cows in any one herd, but it should be spread throughout the association in order to obtain more satisfactory data on his ability as a sire. By dam-daughter comparisons the bull's ability to transmit milk and butterfat production can then be determined. Use of sires of unknown ability on only a few (two or three) cows per herd would guard against extensive loss on the part of any one owner in case the sire proved unsatisfactory, in contrast to the present system of using an unknown bull for one or two complete calf crops and consequently taking a chance of having all of the replacement stock of inferior quality.

Owner's Herd Record

In an insemination association the fertility record may be kept cooperatively by the owner and inseminator. The owner should note each heat period of the female regardless of whether she was bred or not and the length of time she was in heat. The owner may also record the date of calving.

The inseminator should record (1) the identity of each female (her name, number, and breed), (2) the date and time of insemination, (3) identity of the semen sample (both sire and date of collection), (4) time in the heat period (not absolutely necessary but desirable), (5) probable date of calving, (6) sex of the calf, and (7) proper identification of the young. These records may be kept on a simple record form and should be kept in a clean, convenient, and protected portion of the owner's barn.

Each of the purebred dairy associations has its own regulations governing procedure in recording data if the resulting calf is to be registered. The Purebred Dairy Cattle Association has certain regulations. For information concerning these regulations, it is best to contact the Dairy Extension Division of the University. Owners of purebred herds and inseminators should, therefore, keep informed as to the special requirements of the breed association with which they may wish to register calves bred by artificial insemination.

Inseminator's Record Forms

Field record form—This may be made as a combined receipt blank and note record. On the note portion the inseminator may record data such as numbers of calves or new cows, cows sold, cows with missed periods, or other pertinent information concerning the owner's herd. This form may be made of convenient pocket size and would be the only book the inseminator would have to carry into the field.

From the information on the field record form, the inseminator can fill in the daily report and the inseminator's herd record. These latter forms should be made in duplicate, one set to be kept by the inseminator and the other to be sent to the semen collector at the proper time.

Daily report—Exchange information between the inseminator and the semen collector should include a report of the females inseminated by each sample, indicating the sire, date of collection, and temperature of the water

in the thermos bottle at the time of arrival; the time the female was inseminated; and whether or not the female was settled by the insemination. If she was not settled, the dates of other heat periods and services should be reported.

The column headed "Repeat" should be used as follows: If, for example, the daily report should be for the day of November 1 of a specific year, a particular cow would appear on the sheet as inseminated that day. If she should return in heat on November 20, the number "19" should be written in the "Repeat" column on the same line as her name appears on the sheet filled out for November 1. If she returned in heat on November 25, a "24" should be inserted. If she returned in heat on December 28 of the same year, a figure "57" would be reported, etc.

The detachable sheet of this record should be sent to the Association Manager 28 days (or some other selected time) after the date on the top of the sheet; therefore, cows returning to estrus after that time would be entered in the "Repeat" column on the inseminator's copy and the information forwarded to the Association Manager if he should so desire. This information is of fourfold use: first, a check may be made on the progress and ability of the inseminators; second, the fertility of any bull can be carefully followed; third, farmers may be informed as to the fertility of their herds; fourth, the operator can eliminate the sample or bull used as a source of infertility on a particular farm if satisfactory results were obtained with that sample or bull on other farms. The inseminator's ability and the sire's fertility can be measured by the rate of conception. This conception rate may be expressed either in terms of percentage or as a ratio. The per cent of conceptions can be calculated as:

$$\frac{\text{number of cows settled}}{\text{number of inseminations}} \times 100$$

while the conception ratio can be determined as:

$$\frac{\text{number of inseminations}}{\text{number of cows settled}}$$

Conception rates may be evaluated at various times after insemination. Conception percentages calculated at the end of 28 days are usually 12 to 18 per cent higher than those calculated at the end of five months or by the actual calving rate. It is suggested that females be eliminated from calculations if they are sold or die before pregnancy has been diagnosed, if they are diseased, or if they have not conceived after three inseminations by high quality semen from two or more bulls. It is also questionable at times to include cows where the whole herd is not inseminated, as there is a tendency for farmers to enlist the aid of artificial insemination for their difficult cows. One should not expect a greater conception rate through the use of artificial insemination even though there are numerous instances where that condition has been found.

The methods used for determining the inclusion or exclusion of cows in the data used for the calculation of the conception rate vary greatly depending upon the judgment of different managers.

Herd record—The inseminator should keep a record of his own for each herd he services. This record is useful only if it is kept up-to-date. The suggested form shown in the Appendix indicates the essential information set in a usable form.

Organization of Artificial Insemination Units

IT IS very necessary to establish an insemination unit on a sound businesslike foundation. In Minnesota, there are a number of different types of organizations. Before a new unit starts, the men concerned should consult with the personnel of the University staff in order to avoid some of the mistakes that have occurred in the past. The work of any association may be divided into that concerned with the financial phases and the technical phases. If either phase of the work is improperly handled, it is immediately reflected in the other. It is, therefore, necessary to control carefully each detail of an organization at all times.

If the full benefit of artificial insemination is to be secured, adequate cow testing must be an integral part of a unit's activity. Another source of profit to the farmer which has not been exploited very much to date is the organized selling of surplus stock. Many of the heifers born from artificial insemination have genetic potentialities for good production. Organized sale of such stock should be beneficial.

SUMMARY

During the past few years, much progress has been made in the United States both in the development of technics of artificial insemination and in increased practice of artificial insemination, especially in dairy cattle. In the future, more attention should be given to proper record keeping, sanitary practices, sire management, and breeding programs. If properly used, artificial insemination may be the means for much livestock improvement in the future through the dissemination of superior germ plasm.

SIRE MANAGEMENT RECORD

Month_____ Year_____

Name of Sire_____ Registration No._____ Local Identification_____

Date	Amount of exercise	Groomed	Ration	Special treatments	Foot care	Veterinary examination	Tests and reaction	Remarks
			The amounts of various feeds fed may be noted by inclusive dates. Any changes should also be noted along with the date of change.	Treatments should be noted along with date of treatments.	Date and care should be noted regularly.	Any notes the veterinarian may wish to make at the date of visit.	Brucellosis Tuberculosis Trichomoniasis Etc. Date and result of test should be noted.	

SIRE FERTILITY RECORD

Month_____ Year_____

Name of Sire_____ Registration No._____ Local Identification_____

Collection			Sexual activity	Semen characteristics					Per cent motile sperm and type of motility at time of						Shipment			Results				Remarks
											Inseminator's report							Cows				
Date	Hour	Interval since last collection		Volume in cc.	Color	Presence of foreign cells	Number of sperm (Barium sulfate)	Methylene-blue reduction time	Collection	Shipping	Date	Morning	Night	Extended time	Date and time	To whom	Temperature of thermos water upon arrival at destination	Total number inseminated	Date	Number missed next heat period	Per cent nonreturn	

OWNER'S HERD RECORD

Year_____

Owner's Name_____ Address_____ Name of Association_____

Cow's name and number	Month†	Month	Month	Month
*	‡			

* The cow's name, barn number or ear tag number, breeding whether purebred or grade, and name of cow's sire may be inserted in this space.

† The form should include 12 columns, one for each month of the year. The year may be started at any month to suit the convenience of the owner. A space 1½ inches wide and ½ inch high should be allowed for each month per cow.

‡ The information to be filled in for each cow will be the date the cow was in heat, length of heat period, date inseminated, bull used, date semen collected, health reports, and calving data.

NOTE: This form should be printed on heavy manila paper, kept in a suitable folder, and placed in a dry, light location in the barn. The "Inseminator's Herd Record" may be substituted for this form.

INSEMINATOR'S HERD RECORD

Year_____ Owner_____ Address_____

Cow's name	Number	Sire	P.B. or Gr.*	Date bred	Bull used	Date bred	Bull used	Date bred	Bull used	Date bred	Bull used	Date due	Calving date	Calf ear tag No. and sex

* P.B. signifies a purebred cow. Gr. signifies a grade cow. If a purebred, the breed should also be indicated.

INSEMINATOR'S FIELD RECORD FORM

_____

(Name of Insemination Association)

_____

(Address of Insemination Association)

Date_____

Received of_____

(Owner's name)

Owner's address_____ the sum of_____

for the insemination of the cow given below:

Cow's name_____ Number_____ Breed_____ Age_____

Bull's identity_____ Date of sample_____

Hours since noted in heat_____ Time of day_____ Insemination number_____

(If payment is to be made by deductions from cream checks, an assignment order may be printed on the form at this place and a line added for the owner's signature.)

Inseminator's signature_____

Remarks*

* The inseminator may note any information pertaining to the herd such as identity of new calves, cows sold, cows with missed periods, etc. These notes would then be copied onto the correct record forms at the end of each day.

DAILY REPORT

Date_____ Inseminator_____ Association_____

Speedometer Readings: Start_____ Return_____

Total Miles_____ Semen Temperature:* Start_____ Return_____

Time: Start_____ Return_____ Sperm Motility Rating:† Start_____ Return_____

Receipt number	Name of farmer	Cow's name and/or number	Bull used	Age of semen	Length heat	No. of insemination	Paid or charged	Repeat
‡								

* Each container should be listed separately.

† Each bull should be listed separately.

‡ If this form is made to run the long dimension of an 8½ x 11-inch page, there should be room for about 25 cows per page.

NOTE: This form should be made up in pads to furnish two or three copies as needed by the type of organization.