

FOURTH CHAPTER.

A.— SUMMARY.

Literature.

1. Previous work, that has led up to the present knowledge of artificial insemination of birds, is reviewed.

Intraperitoneal Insemination.

2. The technique of intraperitoneal insemination in pigeons and fowls is described. Data collected on—

- (a) 62 intraperitoneal inseminations with 21 control matings of pigeons; and
- (b) the first 117 intraperitoneal inseminations with 33 control inseminations or matings of fowls, which included 3421 "Hen-days" of observation before and after the operation, as well as 978 "Hen-days" of observation before and after the control inseminations or matings, showed the following results:—
 - (1) The egg-production of the female birds was not seriously affected, but in the case of fowls it was temporarily inhibited after the operations, similar to the results of the artificial insemination by other methods (controls). A characteristic notch in the curve of recovery is reported and an explanation suggested.
 - (2) The health of females was not affected by the operations, although under unfavourable conditions a few deaths from peritonitis occurred.
 - (3) In fowls and pigeons the onset of fertility was usually immediate, i.e. the first ovum to be liberated after the operation was as a rule fertile if fertility was produced at all.
 - (4) The length of the period of fertility in the fowl was similar to that reported by other workers after separation of the cocks from the hens, but the average length of the period in the 45 consecutive cases of fertility tested for duration (10.78 days) was slightly less than in the thirteen control cases fertilized after coitus or artificial insemination *per vaginam* (13.85 days). The maximum duration (25 days) however, exceeded by three days the maximum recorded locally in controls, although the maximum reported in the literature, 32-34 days, (Crew, 1926; Nalbandov and Card, 1943; Barfurth, 1896) was not attained.
 - (5) The number of eggs fertilized from one injection in the fowl (4.78), showed an average figure below that of the control cases (6.69), in which other methods of insemination had been employed but the maximum on record (fourteen eggs; Nicolaidis, 1934) was exceeded in three out of the 46 cases tested: Sixteen fertile eggs were obtained once and fifteen twice. In the thirteen control cases the number of eleven fertile eggs was the maximum.

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- (6) The percentage of fertility of fowl eggs laid during the period between 24 hours after injection of semen and the laying of the last fertile egg in the 46 cases tested, was slightly higher (82.7 per cent.) than in the fertile control cases (82.0 per cent.).
- (7) The decline in percentage of eggs fertile after the middle of the fertile period in fowls was only barely detectable in the cases of intraperitoneal insemination, whereas in the control cases, it amounted to a 50 per cent. drop (Table 26). Fertility during the second half of the fertile period was considerably higher after intraperitoneal insemination than after other methods tested. (64 per cent. against 44 per cent.). The fertile periods of different lengths showed no difference in fertility following intraperitoneal insemination (Table 25).
- (8) The percentage of inseminations proved fertile in fowls was measurably higher after intraperitoneal inseminations than after insemination *per vaginam*.
- (9) The hatchability of fowl eggs after intraperitoneal insemination did not as a rule differ from that found after other methods of obtaining fertility, except that in several individual cases chicks were hatched from eggs laid a few days later after the day of introduction of the fertilizing semen into the hen, viz.: Twenty-fourth day twice, twenty-first day once and the twentieth day thrice, than had been recorded in the literature (nineteenth day: Nalbandov and Card, 1943).
- (10) The number of chicks hatched from one intraperitoneal insemination reached a maximum of thirteen, with an average of 3.3 in the 36 consecutive cases in which hatchings were recorded. In the 12 control cases the maximum was seven and the average 1.7 chicks.
- (11) In fowls the seasonal influences on the results were strikingly absent, under the given conditions; but the results on hens kept indoors, showed a decreased fertility, which was slightly compensated for by a better hatchability of the fertile eggs collected indoors.
- (12) Effects of breed, age (or conformation), on previous production and on previous insemination in fowls show that
 - (a) fertility was better in birds of the "heavy" than in birds of the "light" breeds, but this lower fertility in the "light" hens was compensated for to some extent by a larger number of chicks obtained per dozen fertile eggs incubated;
 - (b) second-year hens performed better than pullets in respect of the number of inseminations followed by fertility and hatchings and in percentage fertility, but pullets showed better hatchability and duration of fertility;
 - (c) birds with a production of over 60 per cent. in the ten days prior to intraperitoneal insemination showed all round superior results over birds with a production below 60 per cent.; but the lower fertility of birds with a less than 60 per cent. previous production was again partly compensated for by higher hatchability. The egg-production of the higher producers was more seriously affected.

- (13) The influence of the instruments used for the intraperitoneal operation was variable in respect of egg-production and incubation results, viz.: as far as the shape of the penetrating instruments was concerned, those with less adverse influence on production: "blunt" and "fine" needles, were followed by incubation results inferior to the results from the use of "sharp" and "coarse" instruments.

The contact between semen and metal parts was shown to be a factor grossly implicated in the selection of instruments for the intraperitoneal insemination technique. The elimination of metal from the syringes used, was highly favourable to the incubation results, but the wax-coating of the metal needles showed no marked benefit.

The contrast between the positive correlation between fertility and hatchability percentages in connection with factors concerning the semen and the negative correlation between the fertility and hatchability encountered in connection with factors concerning solely the hen is submitted for further investigation.

The conclusion is reached that all-glass (non-metal) instruments with passages of a relatively wide lumen (e.g. 1 mm.), and with blunt penetrating ends, were most suitable for the technique of intraperitoneal insemination. Two special instruments evolved viz.: (a) an all-glass syringe with long glass nozzle (rather fragile) and (b) a modified "Holborn" sheep inseminator made to fit an all-glass insulin syringe, are described.

- (14) The best site for performing the operation in the fowl was a point on the abdominal wall, at the anterior border of the left pubic bone at the ventral border of the superficial muscles that pass over its posterior process. In pigeons the obturator fossa was the site of choice in view of the greater extent of the lateral air-sac.
- (15) The optimum depth of penetration from the best site was 6.0 cm. for smaller hens (e.g., White Leghorn pullets) and 8.0 cm. for larger birds.
- (16) The optimum direction of penetration was in a plane parallel to the backbone in an antero-medial direction at a ratio of 2:1, i.e.: 6.0 cm. forward for every 3.0 cm. in a medial direction.

Semen Collection and Examination.

3. Observations were made on 1,163 collections of pigeon semen of which 805 were made by means of a new technique whereby excitable birds could be more satisfactorily controlled. The method was a modification of that described by Burrows and Quinn (1935) as adapted to pigeons by Owen (1941).

The methods of semen collection from male fowls by fixing a receptacle to a male cloaca during coitus (Parker 1939) and by manual ejaculation (Burrows and Quinn 1935, 1937) were carried out, and a new modification of the latter evolved, by which 292 consecutive collections were executed of which 98.6 per cent. were successful. An average of 0.45 c.c. semen per collection was obtained by this method including the primary failures, and no assistance was required for the holding of the birds or the semen receptacles. A wire leg-holder for the control of birds without assistance was evolved.

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(a) The semen of pigeons had a density of approximately 2 million sperms per c.mm. when collected with a pipette direct from the vent. The volume obtained averaged 0.005 c.c. A relatively small number of racing homer pigeons proved to be good semen producers. There was a very large variation between individual birds and separate collections. One bird produced markedly pathological spermatozoa for a time.

(b) The semen of fowls was measured, examined and tested during all seasons in the *first*, *third* and *fourth* series of inseminations, using a variety of males which supplied semen with—

- (1) an average volume of 0.45 c.c. per collection;
- (2) a viscosity which varied in different males and in the same male at different collections, from a watery semen to a thick oily semen, estimated to run 0.25 times as fast as water through a glass tube of 0.2 mm. bore at room temperature;
- (3) the colour of pure semen was as a rule ivory white;
- (4) the percentage of samples soiled varied in different males to average about one quarter, when untrained males were included;
- (5) motility in fresh samples at room temperature was almost 100 per cent. progressive in all samples tested.
- (6) The estimated density of the samples varied between one million and 5.5 million sperms per c.mm. but in the small number of samples checked by haemocytometer counts, the density was found to be usually higher than the rough estimate from semen smears, 7.9 million per c.mm. being the maximum counted. Two samples counted by the technique of milk-“Breed”-clump-counts, showed a figure of 8.5 millions.
- (7) the pH measurements on semen by the “B.D.H. Capillator” gave readings of 7.1 to 7.4. Accurate determinations with “Beckman’s pH meter” gave readings of 7.0 to 7.4;
- (8) morphological abnormalities were very rarely observed and only occurred in large numbers in the semen samples from a very young cockerel and a relatively infertile but not sterile cock. The most striking abnormality noticed was the curled up head which was often also seen in semen samples aged *in vitro*.
- (9) the fertilizing qualities of semen samples were tested in a total of 220 intraperitoneal inseminations and 71 control matings and inseminations on 81 hens used in the *first*, *third* and *fourth* series of inseminations with the following results:—
 - (i) The fertility of semen samples inseminated by the intraperitoneal method was higher for most males, than from samples introduced into the vagina, and the duration and percentage hatchability in the largest group (cock No. 6 Table 48), was also higher for intraperitoneal insemination.
 - (ii) Larger doses of semen were followed by better fertility and a fertile period of longer duration. (Table 49.)

- (iii) The samples of semen subjected to storage and dilution gave a markedly lower fertility than fresh samples (Tables 51 and 52) although storage up to 2 hours under liquid paraffin had little effect.
- (iv) The results of insemination with mixed samples of semen were often inferior to those with pure separate semen and provided some evidence that a mixed semen sample tends to be reduced to the quality of the poorest of its components, rather than that the poor quality of a given sample of semen can be offset by admixture with semen of better quality. Except in two isolated instances in the third series of inseminations all the chicks hatched from each insemination with a mixed sample of semen, were the progeny of only one of the males which contributed semen to the sample.
- (v) Simultaneous insemination with different samples of semen, with different instruments by the intraperitoneal method had results in agreement with the findings mentioned earlier:—
 - (i) Deposition of the semen in the region of the ovary was more successful in producing fertility, than deposition in the posterior peritoneal cavity near the point of entry, irrespective of which was the larger dose.
 - (ii) The coarse needle was more favourable to successful insemination than the fine needle (Table 56).
 - (iii) Pure semen produced fertility although injected through a fine needle, whereas mixed semen injected through a coarse needle into the same bird at the same time, failed (Table 57) to be successful.
- (vi) Insemination with different samples of semen by the various methods showed that—
 - (i) the fertilizing quality of semen was more important than the route of introduction in determining which of two kinds of sperm would gain the advantage in the competition for fertilization of ova when present in the hen at the same time (table 58);
 - (ii) the same was true in respect of the doses of semen used, unless smaller doses than 0.1 c.c. were given;
 - (iii) the superior fertilizing quality of a given semen sample, was lost on admixture with a sample of indifferent quality.

Storage of Spermatozoa in the Hen.

4. Storage of fowl spermatozoa *in vivo* in the body of the fertile hen was studied by examinations made on thirty-three hens during the *first*, *third* and *fourth* series of inseminations. A new technique was evolved whereby sperm-cells could be picked up from serous and mucous surfaces by means of capillary action of small, very fine, glass tubes.

(1) The lumen of the infundibulum was the only locality where spermatozoa were demonstrated in a morphologically normal and progressively motile state, during the period 3 to 14 days (72 to 336 hours) following insemination by various methods.

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(2) The discovery of sperm concentrations contained in the mucosa of the chalaziferous region in the infundibulum in one hen eight days after intraperitoneal insemination has been confirmed by demonstration of similar structures containing sperm in two hens four and six days after natural copulation and separation from the male.

(3) The term "Spermnests" has been proposed for this structure and the significance of this finding is discussed.

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C.—BIBLIOGRAPHY.

- ADAMSTONE, F. B., AND CARD, L. E. (1934, a). A study of the spermatozoon of the fowl with particular reference to osmiophilic bodies in the sperm head. *Jnl. Morph.*, Vol. 56, pp. 325-337.
- ADAMSTONE, F. B., AND CARD, L. E. (1934, b). The effects of vitamin A deficiency on the testis of the male fowl (*Gallus domesticus*). *Jnl. Morph.*, Vol. 56, pp. 339-352.
- ALLEN, E. (1923). Ovogenesis during sexual maturity. *Am. Jnl. Anat.*, Vol. 31, p. 439.
- ALLEN, E., AND WHITSETT, J. M. (1924). The follicular hormone of the hen's ovary. *Proc. S. Exp. Biol. and Med.*, Vol. 21, p. 500.

- AMANTEA, G. (1922). Ricerche sulla secrezione spermatica XIV. La raccolta dello sperma e illiminazione degli spermatozoi nce Gallo. *Rend. d. R. dei. Linnei.* Vol. 31, p. 207. (cit. Burrows & Quinn, 1937).
- AMANTEA, G. (1925). Collection of sperm and elimination of spermatozoa in the pigeon. *Physiol. abstr.*, Vol. 10, p. 423.
- ANDERSON, W. S. (1922). The vitality of spermatozoa in some domestic animals. *Kentucky Agric. Ex. Sta. Bull.* No. 239.
- ANDERSON, J. (1941, b). The clinical significance of the hydrogen-ion concentration of the semen of the bull. *Vet. Rec.*, Vol. 54, pp. 317-318.
- ANDERSON, J. (1941, c). Further investigations on artificial insemination of cattle. *Jnl. Agr. Sci.*, Vol. 31, No. 3, p. 348.
- ANDERSON, J. (1945). The semen of animals and its use for artificial insemination. *Imp. Bur. of An. Breed. and Gen. Tech. Commun.*, p. 151.
- ASMUNDSEN, V. S. (1931). The formation of the hen's egg. *Sci. Agr.*, Vol. 11, pp. 662-680.
- ASMUNDSEN, V. S., AND BURMESTER, B. R. (1936). The secretory activity of the parts of the hen's oviduct. *Jnl. Exp. Zool.*, Vol. 72, pp. 225-246.
- ATWOOD, H. (1929). A study of the time factor in egg production. *Wva. Exp. Sta. Bull.* 223, p. 11.
- BARFURTH, D., 1896.—Versuche über die parthenogenetische Forschung des Hühnereies. *Arch. f. Entw. Mech.*, Vol. 2, pp. 303-351.
- BARTELMEZ, G. W., AND RIDDLE, O. (1924). On parthenogenetic cleavage and on the role of water absorption by the ovum in the formation of the subgerminal cavity in the pigeon's egg. *Am. Jnl. Anat.*, Vol. 33, pp. 57-66.
- BEDERKE, G. (1933). Untersuchungen über den Einfluss verschiedener Konservierungsmethoden auf die Vitalität von Hundenspermien. *Arch. Tierernähr. Tierz.*, Vol. 9, pp. 585-622. (Abstract in A.B.A., 1933, Vol. 1, p. 276).
- BESHELONOV, A. V. (1938). The optimal time of insemination in cows during oestrus. *Probl. Zivot.*, Vol. 2, pp. 73-88 (A.B.A., Vol. 6, p. 291).
- BELONOSCHKIN, B. (1929, a). Die Geschlechtswege von *Oktopus vulgaris* und ihre Bedeutung für die Bewegung der Spermatozoen. *Zeitschr. f. Zellforsch. Mikr. Anat.*, Vol. 9, pp. 643-662.
- BENZINGER, TH., AND KREBF, H. H. (1933). Über die Harnsäure synthese im Vogelorganismus. *Klinischer Wochenschr.*, Vol. 12, pp. 1206-1208. (Cit. Bonnier and Trullson, 1939.)
- BERNSTEIN, A. (1933). Problems of artificial insemination. *Probl. Zivotn.*, Vol. 1, pp. 77-82. (A.B.A., 1933, Vol. 1, p. 82).
- BISSONETTE, T. H., AND WALUND, A. P. R. (1932). Duration of testis activity of *Sturnus vulgaris* in relation to type of illumination. *Jnl. Exp. Biol.*, Vol. 9, p. 339.
- BLACK, D. J., AND SCORGIE, N. J. (1942). The collection of semen and artificial insemination in the fowl. *Vet. Jnl.*, Vol. 98, pp. 108-114.
- BLANDAU, R. J., AND JORDAN, E. S. (1941). The effect of delayed fertilisation on the development of the rat ovum. *Am. Jnl. Anat.*, Vol. 68, pp. 275-287.
- BLANDAU, R. J., AND YOUNG, W. C. (1939). The effect of delayed fertilisation on the development of the guinea pig ovum. *Am. Jnl. Anat.*, Vol. 64, pp. 275-287.
- BLOUNT, M. (1907). The early development of the pigeon's egg with special reference to polyspermy and the origin of the periblast nuclei. *Jnl. Morph.*, Vol. 20, part 1, pp. 1-64.
- BLOUNT, M. (1907). The early development of the pigeon's egg. *Biol. Bull.*, Vol. 13, p. 231.
- BONADONNA, T. (1939). Artificial insemination of birds. *Seventh W. Poultry Congr. and Exp. Proc.*, pp. 79-82.
- BONNIER, G., AND TRULLSON, S. (1939, a). Artificial insemination results in fowls. *Seventh W. Poultry Congr., Washington*, pp. 76-79.

ARTIFICIAL INSEMINATION OF BIRDS.

- BONNIER, G., AND TRULLSON, S. (1939, b). Selective fertilisation in Poultry. *Hereditas*, Vol. 25, pp. 66-76.
- BRADLEY, O. C. (1915). The structure of the fowl. *A. & C. Black, London*.
- BRADLEY, O. C. (1928). Notes on the histology of the oviduct of the domestic hen. *Jnl. Anat.*, Vol. 62, p. 339.
- BUCKNER, G. O., AND MARTIN, J. H. (1929). The hydrogen-ion concentration of the reproductive organs of the White Leghorn chicken. *Am. Jnl. Physiol.*, Vol. 89, No. 1, p. 164.
- BURBANK, R. C. (1935). The quantitative standardization of sperm suspensions by means of opacity. *Quart. Jnl. Exp. Physiol.*, Vol. 25, pp. 393-397.
- BURMESTER, B. R., AND CARD, L. E. (1939). The effect of resecting the so-called "chalaziferous" region of the hen's oviduct in the formation of subsequent eggs. *Poult. Sci.*, Vol. 18, p. 138.
- BURMESTER, W. H., AND CARD, L. E. (1941). Experiments on the physiology of egg-white secretion. *Poult. Sci.*, Vol. 20, pp. 224-226.
- BURROWS, W. H., AND BYERLY, T. C. (1942). Premature expulsion eggs by hens following injection of whole posterior pituitary preparations. *Poult. Sci.*, Vol. 21, p. 416.
- BURROWS, W. H., AND MARSDEN, S. J. (1938). Artificial insemination of turkeys. *Poult. Sci.*, Vol. 17, p. 408.
- BURROWS, W. H., AND QUINN, J. P. (1935). A method of obtaining spermatozoa from the domestic fowl. *Poult. Sci.*, Vol. 14, pp. 251 and 253-254.
- BURROWS, W. H., AND QUINN, J. P. (1937). The collection of spermatozoa from the domestic fowl and turkey. *Poult. Sci.*, Vol. 16, p. 19.
- BURROWS, W. H., AND QUINN, J. P. (1938). Effective dosages of undiluted semen in artificial insemination of chicks. *Poult. Sci.*, Vol. 17, pp. 131-135.
- BURROWS, W. H., AND QUINN, J. P. (1939). Artificial insemination of chickens and turkeys. *U.S. Dept. Agr., Circ.* 525, 13 pp. illus.
- BURROWS, W. H., AND QUINN, J. P. (1939, b). Artificial insemination of chickens and turkeys. *Proc. Seventh W. Poult. Congr.*, 1939.
- BURROWS, W. H., AND TITUS, H. W. (1939). Some observations on the semen production of the male fowl. *Poult. Sci.*, Vol. 18, pp. 8-10.
- BYERLY, T. C. (1939). Present status of poultry physiology. *Proc. Seventh W. Poult. Congr.*
- BYERLY, T. C., AND MOORE, O. K. (1941). Clutch length in relation to period of illumination in the domestic fowl. *Poult. Sci.*, Vol. 20, No. 5, pp. 387-390.
- CHAPPELLIER, M. A. (1914). Pendant combien de jours les spermatozoides gardentils leur pouvoir fecondateur, dans le oviducte de la poule ou de la cane. *Asso. Fran. pour l'Avan. d. Sci. Comp. Rend.*, Vol. 43, pp. 519-526.
- CHLEBAROFF, G. S. (1930). The fertilisation of hen's eggs. *Fourth W. Poult. Congr., London*, Vol. 2, p. 6.
- COMSTOCK, R. E., GREEN, W. W., WINTERS, L. M., AND NORDSKOG, A. W. (1943). Studies on semen and semen production. *Univ. Minnesota Tech. Bull.* 162, p. 55.
- CONRAD, R. M., AND PHILLIPS, R. E. (1938). The formation of the Chalazae and the inner thin white of the hen's egg. *Poult. Sci.*, Vol. 17, pp. 143-146.
- CREW, F. A. E. (1926). On fertility in the domestic fowl. *Proc. R. Soc. Edin.*, Vol. 46, pp. 230-238.
- CREW, F. A. E. (1926). The scrotum; a temperature regulating mechanism. *Verhandl. I. Intern. Kongr. Sexual Forschung.* Okt. 1926. Verlag Markus und Weber, Berlin und Köln, 1927.
- CURTIS, M. R. (1914). Studies on the physiology of reproduction in the domestic fowl VI. Double and triple yolked eggs. *Biol. Bull.*, Vol. 26, No. 2, pp. 55-83.

- CURTIS, M. R. (1916). Studies on the physiology of reproduction in the domestic fowl XVI. *Biol. Bull.*, Vol. 31, p. 181.
- CURTIS, V. (1928). A study of the duration of fertility in poultry. *Iowa Ac. Sci. Proc.*, Vol. 35, pp. 345-346.
- CURTIS, V., AND LAMBERT, W. V. (1929). A study of fertility in poultry. *Poult. Sci.*, Vol. 8, p. 142.
- CUSHNY, A. R. (1902). On the glands of the oviduct in the fowl. *Am. Jnl. Physiol.*, Vol. 6, p. 18 (Cit. Richardson, 1935).
- DULZETTO, F. (1937). On the structure of the female reproductive system in *Gambusia holbrooki*. *Arch. Zool. (Ital) (Napoli)*, Vol. 24, pp. 275-310 (A.B.A., Vol. 6, p. 141).
- DUNN, L. C. (1927). Selective fertilisation in fowls. *Poult. Sci.*, Vol. 6, pp. 201-214.
- ELLENBERGER, W., AND BAUM, H. X. (1939). Handbuch der Vergleichenden Anatomie der Haustiere. *Berlin: Julius Sprenger* (1932).
- EVANS, H. M., AND COLE, H. H. (1931). *Memoirs Univ. of California*. Vol. 9, p. 2 (cit. Phys. of Domestic animals; 1935. H. H. Dukes 3rd ed. Comstock, Ithaca, N.Y.).
- FEKETE, E., AND DURAN-REYNOLDS, F. (1943). Hyaluronidase in the fertilisation of mammalian ova. *Proc. S. Exp. Biol., N.Y.*, Vol. 52, pp. 119-121.
- FISH, P. A. (1924). An undescribed constituent of semen. *Proc. Sci. Exp. Biol. and Med.*, Vol. 21, p. 566.
- FOLK, G. E. (1940). The longevity of sperm in the female bat. *Anat. Rec.*, Vol. 76, pp. 103-107.
- FUNK, E. M. (1934). Factors influencing hatchability in the domestic fowl. *Mo. Agr. Exp. Sta. Bull.* 341.
- FUNK, E. M. (1939). The relation of clutch and position of the egg in the clutch, to hatching results. *Poult. Sci.*, Vol. 18, pp. 350-353.
- GERHARDT, U. (1905). Studien über den Geschlechtsapparat der weiblichen Säugetiere. I. Die Überleitung der Eier in die Tuben. *Jena. Zeitschr. Naturwiss.*, Vol. 39, pp. 649-712 (cit. Parker, 1931).
- GILBERT, A. G. (1906). *Rept. Poult. Manager Can. Exp. Farm Rept.*, 1906 (cit. Nalbandov and Card, 1943).
- GILES, A. E. (1919). Sterility in Women. *Hodder and Stoughton, London*.
- GRACEWSKI, J. J., AND SCOTT, H. M. (1943). The influence of the time of mating on fertility. *Poult. Sci.*, Vol. 22, pp. 264-265.
- GRECKA, M. K. (1935). Artificial insemination of farm animals. *First. Rep. Comm. on Art. Insem. Moscowa.* (cited Hammond, 1940).
- GRIFFINI, G. (1938). La fecondazione strumentale nei volatili. *Fec. Artif. d. Anim. Domest. Milan.* (cit. Bonadonna, 1939).
- GREENBERG, B. E., BERMAN, S., GARGILL, S. L., AND GRIFFINI, R. C. (1943). A new method for staining spermatozoa. *Jnl. clin. Endocrin.*, Vol. 3, pp. 179-182.
- GREEN, W. W., AND WINTERS, L. M. (1935). Studies on the physiology of reproduction in sheep. III. The time of ovulation and rate of sperm travel. *Anat. Rec.*, Vol. 61, pp. 457-469.
- GREEN, W. W., WINTERS, L. M., AND COMSTOCK, R. E. (1942). Artificial insemination of farm animals. *Univ. Minnesota Agr. Exp. Sta. Bull.* 336 (revised).
- GRODZINSKI, Z., AND MARCHLEWSKI, J. (1935). Studies on motility of sperm of the domestic cock outside the organism. *Bull. int. Acad. Cracovie. Cl. Sci. Mat. Nat. B.* 11,, pp. 347-361 and 1939 -idem: pp. 55-68. (A.B.A., Vol. 4, p. 461).
- GUNN, R. M. C. (1936). Fertility in sheep. Artificial reproduction of seminal ejaculation and the characters of the spermatozoa contained therein. *Bull. Com. Sci. indust. Res. Aust. No.* 94, 116 pp., 8 figs. (B).

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- GUYER, M. (1909). The spermatogenesis of the domestic chicken (*Gallus gallus domesticus*). *Anat. Anz. Bd.*, Vol. 34, pp. 573-580.
- HAMMOND, J. (1934). The fertilisation of rabbit ova in relation to time. A method of controlling the litter size, the duration of pregnancy and the weight of the young at birth. *Jnl. Exp. Biol.*, Vol. 11, pp. 140-161.
- HAMMOND, J. (1940). Farm animals: Their breeding, growth and inheritance. *London*.
- HAMMOND, J., AND ASDELL, S. A. (1926). The vitality of the spermatozoa in the male and female reproductive tracts. *Br. Jnl. Exp. Biol.*, Vol. 7, No. 2, pp. 155-185.
- HAMMOND, J., AND WALTON, A. (1934). Notes on ovulation in the ferret. *Jnl. Exp. Biol.*, Vol. 11, pp. 307-319.
- HARPER, E. H. (1904). The fertilisation and early development of the pigeon's egg. *Am. Jnl. Anat.*, Vol. 3, pp. 349-386.
- HARTMAN, C. G., AND BALL, J. (1930). On the almost instantaneous transport of spermatozoa through the cervix and uterus of the rat. *Proc. Soc. Exp. Biol. and Med.*, Vol. 28, p. 312.
- HARTMAN, C. G. (1935). On the survival of spermatozoa in the female genital tract of the bat. *Quart. Rev. Biol.*, Vol. 8, pp. 185-193.
- HAUSMAN, D. (1879). Über das Verhalten der Samenfäden in den Geschlechtorganen des Weibes. *Berlin* (cit. Quinlan, *e.a.*, 1932).
- HENSEN, O. (1876). Beobachtungen über die Befruchtung und Entwicklung des Kaninchens und Meerschweinchens. *Zeitschr. Anat. Entwickl.* Vol. 1, pp. 213-253 (cit. Parker, 1931).
- HEUSER, G. F. (1916). A study of the mating behaviour of the domestic fowl. *Thesis, Cornell Univ.* (cit. Lamoreux, 1940, etc.).
- HEYWANG, B. W. (1945). Gathering and storing hatching eggs during hot weather. *Poult. Sci.*, Vol. 24, pp. 434-437.
- HOTCHKISS, R. S. (1936). Methods in sperm analysis and evaluation of therapeutic procedures. *J.A.M.A.*, Vol. 107, pp. 1849-1851.
- HÜHNER, M. (1913). Sterility in male and female. *New York* (cit. Quinlan, *e.a.*, 1932).
- HUTCHENREITER, K. (1915). Vagina und Uterus der Pferdestute im ihren Reaktionen auf der Koitus. *Wien. Tier. Mon.*, Vol. 2.
- HUTT, F. B. (1929). On the relation of fertility in fowls to the amount of testicular material and density of sperm suspensions. *R. Soc. Edin. Proc.*, Vol. 49, pp. 102-117.
- HUTT, F. B. (1940). A relation between breed characteristics and poor reproduction in White Wyandotte fowls. *Am. Nat.*, Vol. 74, pp. 148-156.
- HUTT, F. B., AND GREENWOOD, A. W. (1929). Studies in embryonic mortality in the fowl. I, II and III. *Proc. R. Soc. Edin.*, Vol. 49, p. 118.
- ISHIKAWA, H. (1930). The life duration of cock spermatozoa outside the body. *Fourth W. Poult. Congr.* 90, *London* (cit. Adamstone and Card, 1934).
- IVANOV, E. E. (1913). Experience sur la fecondation artificielle des oiseaux. *Compt. Rend s.d. Biol.*, Vol. 91, p. 54.
- IVANOV, E. E. (1924). Recherches experimenteles a par due processus de la fecondation chez les poules. *Compt. Rend. Soc. de Biol.*, Vol. 91, p. 54.
- JACKSON, C. (1944). The cytology of the contagious (venereal) tumour of the dog. *O.P. Jnl. Vet. Sci. and A.I.*, Vol. 20, Part I, pp. 97-118.
- JONES, D. G., AND LAMOREUX, W. F. (1942). Semen production of White Leghorn males from strains selected for high and low fecundity. *Poult. Sci.*, Vol. 21, pp. 73-184.
- JULL, M. A. (1930). *Poultry husbandry, 2nd Ed.*, *New York*.
- JULL, M. A. (1935). Studies in fertility in the domestic fowl. *Poult. Sci.*, Vol. 14, pp. 37-41.

- JULL, M. A., AND QUINN, J. P. (1931). The inheritance of body-weight in the domestic fowl. *Jnl. Hered.*, Vol. 22, p. 283.
- KAUP, B. F. (1919). Fertility experiments. *Am. Ass. Industr. and Invest. Poult. Husb. Jnl.*, Vol. 5, pp. 53-54.
- KELLY, R. B., GRANGER, W., AND GUNN, R. M. C. (1942). Artificial insemination of Australian merino sheep with a foreword by G.B.S. Falkiner; *Australian Medical Publishing Co., Ltd., Sydney.*
- KILLIAN, J. A. (1933). Metabolism of spermatozoa in semen. *Am. Jnl. Surg.*, Vol. 19, pp. 76-79 and 103.
- KIWISH, F. A. (1851). Die Geburtskunde, mit Eindschluss von den übrigen Fortpflanzungsvorgängen im weiblichen Organismus. (incomplete, cit. Parker, 1931).
- KOMAROV, N. J., AND GLADCINOVA, E. F. (1937). Hianenie spermy lyka (storing bull sperm). *Probl. Zivotn.*, Vol. 8, pp. 62-68 (*A.B.A.*, Vol. 6, p. 106).
- KUDRJASCHOV, B. A. (1930). Das Vitamine E und die Produktion des testikular Hormone. *Endokrinologie*, Vol. 34, p. 573.
- KUSNETZOWA, N. V., MILOVANOV, O., NEUMANN, V., NAGAEW, AND SKATKIN, P. (1932). The artificial insemination of cattle and sheep. *Inst. of An. Husb., Moscow.*
- KUZJMINA, M. D. (1933). Artificial insemination in the duck. (Trans). *Trudy Inst. Gibrid, Askania Nova.*, Vol. 1, pp. 197-205 (*A.B.A.*, Vol. 2, p. 148).
- LAGERLÖF, N. (1936). Sterility in bulls. *Vety. Rec.*, Vol. 48, pp. 1159-1173.
- LAMBERT, W. V., AND MCKENZIE, F. F. (1940). Artificial insemination in Livestock Breeding. *U.S. Dept. of Agr. Circ. No. 567*, pp. 1-68.
- LAMOREUX, V. F. (1940, a). The influence of intensity of egg production upon infertility in the domestic fowl. *Jnl. Agric. Res.*, Vol. 61, pp. 1919-29.
- LAMOREUX, V. F. (1940, b). Spermatozoal antibodies and infertility in the fowl. *Jnl. Exp. Zool.*, Vol. 85, pp. 419-430.
- LANDAUER, W. (1937). The hatchability of chicken eggs as influenced by environment and heredity. *Storrs. Agr. Exp. St. Bull.* 216.
- LANDAUER, W. (1941). The hatchability of chicken eggs as influenced by environment and heredity. *Conn. Agr. Exp. Sta. Bull.* 236, p. 142 (cit. Phillips, 1941).
- LANZ, T., VON (1929). Die reele Acidität in den einzelnen Abschnitten des männlichen Genital Apparates der Ratte und ihre hormonale Bedingtheit. *Pflüg. Arch. ges. Physiol.*, Vol. 222, pp. 181-214.
- LARDY, H. A., AND PHILLIPS, P. H. (1939). Preservation of spermatozoa. *Am. Soc. Anim. Prod. Proc.*, Vol. 32, pp. 219-221.
- LASLEY, J. F., AND MAYER, D. T. (1944). A variable physiological factor necessary for the survival of bull spermatozoa. *Jnl. Am. Sci.*, Vol. 3, pp. 129-135.
- LAU, H. (1894). Die parthenogenetische Forschung des Hühnereiers. *Inaug. Dissert. Jurjew. Dorpat*, p. 50.
- LAURIE, D. F. (1919). Fertilisation of hens' eggs. A record of experimental work in deciding the duration of the influence of the male bird. *S. Austr. Dept. Agr. Jnl.*, Vol. 22, pp. 459-464.
- LETARD, E., AND TINET, F. (1937). L'insemination artificielle chez les oisiseaux et les proceds electriques d'obtent ion du sperme. *Rev. d. Zootechnie.*, Vol. 12 (cit. Hammond, 1940).
- LEWIS, L. L. (1931). The vitality of reproductive cells. *Okla. Agr. Exp. Sta. Bull.* 96 (cit. Quinlan, 1932, and Hammond, 1940).
- LEUKAERT, R. (1853). *R. Wagner, Handwörterbuch d. Physiologie*, Vol. 4, p. 707.
- LOEB, J., AND BANCROFT, M. (1912). Can the spermatozoon develop outside the egg? *Jnl. Exp. Zool.*, Vol. 12, p. 381.

ARTIFICIAL INSEMINATION OF BIRDS.

- LUKIN, A. A., AND EREMEV, I. V. (1938). Artificial insemination of sheep by encapsulated sperm. (*A.B.A.* Vol. 8, p. 51).
- MCLEAN, D., AND ROWLANDS, I. W. (1942). The role of hyaluronidase in fertilisation. *Nature*. London, Vol. 150, pp. 627-628.
- MCKENZIE, F. F., AND BERLINER, V. (1937). The reproductive capacity of rams. *Mo. Agr. Exp. Sta. Res. Bull.* No. 265, p. 143.
- MCKENZIE, F. F., MILLER, J. C., AND BAUGUESS, L. C. (1938). The reproductive organs and semen of the boar. *Miss. Agr. Exp. Sta. Res. Bull.* 279.
- MCNALLY, E. A. (1942). The origin and structure of the vitelline membrane of the domestic fowl's egg. *Poult. Sci.*, Vol. 22, p. 40.
- MCNALLY, E. A., AND BYERLY, T. C. (1936). Variation in the development of embryo's of hen's eggs. *Poult. Sci.*, Vol. 15, No. 4, pp. 280-283.
- MALMSTRÖM, M. V. (1943). Factors influencing fertility in the domestic fowl. Master's thesis. *Connecticut Univ.*
- MARCOLIN, S., BARTLETT, J. W., AND LEPARD, C. L. (1943). The relation of longevity to fertility of bull semen. *Jnl. Dairy Sci.*, Vol. 26, pp. 983-985 (*Vet. Bul.*, Vol. 14, part 5, p. 1086).
- MARLOW, H. W., AND RICHERT, D. (1940). Estrogens of the fowl. *Endocrinology*, Vol. 26, pp. 531-534.
- MARTIN, J. A., AND ANDERSON, W. S. (1918). The result of single one-day matings. *Am. Ass. Instr. and Invest. P. Husb. Jnl.*, Vol. 5, pp. 22-23.
- MATHEWS, L. H. (1937). The formation of the penis in British Rhinolophid and Vespertilionid bats. *Trans. Zool. Soc., Lond.*, Vol. 23, pp. 213-223.
- MILLER, F. W., AND EVANS, E. J. (1934). Technic for obtaining spermatozoa for physiological dairy studies and artificial insemination. *Jnl. Agr. Res.*, Vol. 48, pp. 941-947.
- MILOVANOV, V. K. (1938). Artificial insemination of agricultural livestock. 4th Ed., Moscow, p. 161.
- MILOVANOV, V. K. (1940). Artificial insemination in animal husbandry. *Govt. Press, Moscow*, 1940, p. 368.
- MILOVANOV, V. K. (1941). New problems in artificial insemination of farm animals. *Sovetsch. Zootch.*, Vol. 2, pp. 51-60. (*A.B.A.* Vol. II, p. 47).
- MIMURA, H. (1939). On the mechanism of travel of spermatozoa through the oviduct in the domestic fowl, with special reference to artificial insemination. *Okajima's Fol. Anat. Japan*, Vol. 17, part 5, pp. 459-476.
- MIRSKAYA, L., AND CREW, F. A. E. (1932). The effect of destruction of the spermatogenic tissue by X-rays upon certain secondary gonadic characteristics in the cock. *Quart. Jnl. of Exp. Physiol.*, Vol. 21, pp. 135-138.
- MOORE, C. R. (1939). Biology of the testis. Chapt. 7: Sex and internal secretions. *E. Allen, 2nd Ed. W. and W. Baltimore*.
- MOORE, C. R. (1941). Glandular physiology and therapy. The physiology of the testis. *J.A.M.A.*, Vol. 116, No. 15, pp. 253-255.
- MOORE, P. A. (1916). *Rept., Exp. Farm, Agassiz, B.C. Can. Dept. Agr. Poult. Divis. Rept.*, 1915-16, p. 1376.
- MUNRO, S. S. (1935). Motility and fertilising capacity of the fowl sperm in the excretory ducts. *Proc. Soc. Exp. Biol. and Med.*, Vol. 33, pp. 255-257.
- MUNRO, S. S. (1938, a). Functional changes in fowl sperm during passage through the excretory ducts of the male. *Jnl. Exp. Zool.*, Vol. 79, pp. 71-92.
- MUNRO, S. S. (1938, b). The effect of dilution and density on the fertilising capacity of fowl sperm suspensions. *Canad. Jnl. Res. D.*, Vol. 16, p. 281.

- MUNRO, S. S. (1938, c). Fowl sperm immobilisation by a temperature media interaction and its biological significance. *Quart. Jnl. Exp. Physiol.*, Vol. 27, pp. 281-291.
- MUNRO, S. S., AND KOSIN, J. L. (1943). Dramatic response of the chick oviduct to Estrogen. *Poult. Sci.*, Vol. 22, p. 330.
- NAGORNY, E. (1937). Vaginal method of artificial insemination of sheep. *Probl. Zivot.*, Vol. 8, pp. 53-61.
- NAKANO, O. (1928). Über die Verteilung des Glykogens beiden zyklischen Veränderungen in den Geschlechtsorganen der Fledermaus und über die Nahrungsaufnahme der Spermien un den weiblichen Geschlechtswegen. *Folio Anat. Japon.*, Vol. 6, pp. 777-828.
- NALBANDOV, A., AND CARD, L. E. (1943). Effect of stale sperm on fertility of chick eggs. *Poult. Sci.*, Vol. 22, pp. 216-226.
- NEUMANN, O. F. (1935). Artificial insemination in the physiological laboratory institute of animal husbandry. *15th Inter. Physiol. Congr. Leningrad*, p. 153.
- NICOLAIDES, C. (1934). Fertility studies in poultry. *Poult. Sci.*, Vol. 13, pp. 178-183.
- NIKITINA, M. V. (1932). Artificial insemination in the fowl. *Probl. Zivotn.*, Vol. 9, Mo. 10, pp. 97-100. (*A.B.A.* Vol. 1, p. 116).
- OLSEN, M. W., AND BYERLY, T. C. (1932). Orientation of the hen's egg in the uterus and during laying. *Poult. Sci.*, Vol. 11, pp. 266-271.
- OWEN, R. D. (1941). Artificial insemination of pigeons and doves. *Poult. Sci.*, Vol. 20, pp. 428-431.
- PAPANICOLAOU, G. K. (1924). Ovogenesis during sexual maturity as elucidated by experimental methods. *Proc. Soc. Exp. Biol. and Med.*, Vol. 21, p. 393.
- PARKER, G. H. (1931). The passage of sperms and eggs through the oviduct in terrestrial vertebrates. *Phil. Trans. H. Sec. Biol.*, Vol. 219, pp. 381-419.
- PARKER, J. E. (1939). An avian semen collector. *Poult. Sci.*, Vol. 18, pp. 455-456.
- PARKER, J. E. (1945). Relation of time of day of artificial insemination to fertility and hatchability of hens' eggs. *Poult. Sci.*, Vol. 24, pp. 314-317.
- PARKER, J. E., MCKENZIE, M., AND KEMPSTER, H. L. (1940). *Poult. Sci.*, Vol. 19, pp. 191-197.
- PARKER, J. E., MCKENZIE, F. F., AND KEMPSTER, H. L. (1942, a). Development of testis and combs of White Leghorn and New Hampshire fowls. *Poult. Sci.*, Vol. 21, pp. 35-44.
- PARKER, J. E., MCKENZIE, F. F., AND KEMPSTER, H. L. (1942, b). Fertility in the male domestic fowl. *Res. Bull. Mo. Agr. Exp. Sta. No. 347*, p. 50.
- PARKER, J. E., AND McSPADDEN, B. J. (1943, a). Seasonal variation in semen production in the domestic fowl. *Poult. Sci.*, Vol. 22, pp. 142-147.
- PARKER, J. E., AND McSPADDEN, B. J. (1943, b). Influence on feed restriction on fertility in the male domestic fowl. *Poult. Sci.*, Vol. 22, p. 170.
- PATTERSON, J. T. (1910). Studies on the early development of the hen's egg. *Jnl. Morph.*, Vol. 21, p. 101.
- PAYNE, L. F. (1914). Preliminary report on vitality and activity of spermcells and artificial insemination of the chicken. *Okla. Agr. Exp. Sta. Circ. No. 30*, pp. 1-8.
- PEARL, R. (1912). The mode of inheritance of fecundity in the domestic fowl. *Jnl. Exp. Zool.*, Vol. 13, No. 2, pp. 153-268.
- PEARL, R., AND BORING, A. M. (1918). Sex studies X: The corpus luteum in the ovary of the domestic fowl. *Am. Jnl. Anat.*, No. 23, pp. 1-36.
- PEARL, R., AND CURTIS, M. R. (1912). Data regarding the physiology of the oviduct. *Jnl. Exp. Zool.*, Vol. 12, p. 99.
- PENQUITE, R., CRAFT, W. A., AND THOMPSON, R. B. (1930). Variation in activity and production of sperm by White Leghorn males. *Poult. Sci.*, Vol. 9, pp. 247-256.

ARTIFICIAL INSEMINATION OF BIRDS.

- PHILLIPS, A. G. (1918). Brief study of the mating of fowls with a test for the value of a single mating. *Jnl. Am. Ass. Instr. and Invest. in P. Husb.*, Vol. 4, p. 30.
- PHILLIPS, R. E. (1945). Hatchability as influenced by environmental and different storage temperatures. *Poult. Sci.*, Vol. 24, pp. 25-28.
- PHILLIPS, R. W. (1935). The physiology of spermatozoa. *Proc. Am. Ass. A. Prod.*, Vol. 28, pp. 222-235.
- PHILLIPS, R. W., AND MCKENZIE, F. F. (1934). The thermoregulatory function and mechanism of the scrotum. *Mo. Agr. Exp. Sta. Res.*, Bul. No. 217.
- PHILLIPS, R. W., SCHOTT, R. C., AND GILDOW, E. M. (1938). Longer range paternity in sheep. *Jnl. Hered.*, Vol. 29, p. 471.
- PHILLIPS, R. F., AND WARREN, D. C. (1937). Observations concerning the mechanics of ovulation in the fowl. *Jnl. Exp. Zool.*, Vol. 76, pp. 117-136.
- PINCUS, G. (1930). Observations on the living eggs of the rabbit. *Proc. R. Soc. B.*, Vol. 107, pp. 132-167.
- PINCUS, G. (1936). The eggs of mammals. *MacMillan Co.*, N.Y.
- POLLAK, C. J., AND JOEL, C. A. (1939). Sperm examination according to the present state of research. *J.A.M.A.*, Vol. 113, p. 5.
- POPPA, G. T., AND MARZA, V. (1930). La Phagocytose des spermatozoides vivants par les elements cellulaires du tractus genital femelle de la même espece. *Compt. R. de la Soc. de Biol.*, Vol. 101, pp. 1185-1186.
- PULLINGER, E. J. (1945). Personal communication.
- QUINLAN, J. B., AND MARE, G. S. (1931). The physiological changes in the ovary of the merino sheep in South Africa and their practical application in breeding. *17th Rept. D.V.S. and An. Ind.*, pp. 663-707.
- QUINLAN, J. B. (1932). The vitality of the spermatozoa and the liberated ovum in the domesticated animals, with special reference to the relation of the time of copulation during oestrus, to conception. *Jnl. S.A.V.M.*, Vol. 3, No. 1, pp. 1-7.
- QUINLAN, J. B., MARE, G. S., AND ROUX, L. L. (1932). The vitality of the spermatozoa in the genital tract of the merino ewe, with special reference to its practical application in breeding. *18th Rept. D.V.S. and An. Ind.*, pp. 831-871.
- QUINLAN, J. B., MARE, G. S., AND ROUX, L. L. (1932). A study of the duration of motility of spermatozoa in the different divisions of the reproductive tract of the merino ewe. *Jnl. S.A.V.M.A.*, Vol. 3, No. 2, pp. 149-162.
- QUINLAN, J. B., MARE, G. S., AND CLAASENS, C. C. (1936). Preliminary report on the, artificial insemination of merino sheep in South Africa. *Jnl. S.A.V.M.A.*, Vol. 7, No. 3, pp. 86-105.
- QUINLAN, J. B., MYBURGH, S. J., AND DE VOS, D. (1941). The hydrogen-ion concentration of the vaginal secretion of merino sheep during oestrus, dioestrus and pregnancy with some remarks on the influence on sex determination, and the influence of the vaginal temperature at the time of mating on conception. *O.P. Jnl. Vet. Sci. and An. Ind.*, Vol. 17, pp. 105-114.
- QUINLAN, J. B., STARKE, N. C., AND STEYN, H. P. (1943). Some aspects of sex-physiology and their relation to fertility of animals—a review. *Jnl. S.A.V.M.A.*, Vol. 14, No. 1, pp. 1-9.
- QUINLAN, J. B. (1944). Personal communication.
- QUINN, J. P., AND BURROWS, W. H. (1936). Artificial insemination of fowls. *Jnl. Hered.*, Vol. 27, pp. 31-37.
- QUINN, J. P., BURROWS, W. H., AND McNALLY, E. H. (1945, a). Rhode Island Red pullet with two oviducts. *Poult. Sci.*, Vol. 18, pp. 381-384.
- RALF, A. F. (1916). Artificial insemination and determination of viability in the male bird by the microscope. *Jnl. Am. Ass. Instr. and Invest. Poult. Husb.*, Vol. 2, p. 44.

- RAIMO, H. F. (1943). Estudos sobre a fisiologia da reprodução em aves. *Bol. Indust. Animal. S. Paulo*, Vol. 6, pp. 69-83, 117-128 and 16-26.
- RAZUMOV, P. G. (1938). Artificial insemination of sheep by gelatinized sperm. *Probl. Zivotn.*, Vol. 10, pp. 122-123.
- REDENZ, E. (1928). Nebenhodien und Spermienbewegung. *Wurzb. Abt. a.d. Gesamtgeb. d. Med. N. Folge.*, Vol. 4, pp. 107-150.
- REDENZ, E. (1929). Das Verhalten der Säugetierspermatozoen zwischen Begattung und Befruchtung. *Zeitschr. f. Zellforsch. u. Mikr. Anat.*, Vol. 9, pp. 734-749.
- RICHARDSON, K. C. (1935). The secretory phenomena in the oviduct of the fowl, including the process of shell formation examined by the micro-incineration technique. *Trans. R. Soc. Lond. Ser. B.*, Vol. 225, pp. 149-195.
- RIDDLE, O., AND BEHRE, E. H. (1921). Studies on the physiology of reproduction in birds IX. On the relation of stale sperm to fertility and sex in ringdoves, *Am. Jnl. Physiol.*, Vol. 57, No. 2, pp. 228-249.
- RILEY, G. M. (1940). Diurnal variations in spermatogenic activity in the domestic fowl. *Paper presented 32nd Ann. Meeting Poult. Sci. Assoc.*, June, 26-29, 1940. (*Poult. Sci.*, Vol. 19, p. 360).
- ROEMMELE, O. (1927). Biologische und physiologische Untersuchungen am Sperm und am Schiedensekret des Rindes im Hinblick auf die Künstliche Besamung. *Zool. Jahrbücher Abt. f. allg. Zool.*, Vol. 44, No. 1, pp. 85-148 (cit. Milovanov, 1940).
- ROMANOFF, A. L. (1931). Why some eggs do not hatch. *Cornell Univ. Extens. Bul.* 205.
- ROTHCHILD, J., AND FRAPS, R. M. (1944). On the function of the ruptured ovarian follicle of the domestic fowl. *Proc. Sci. Exp. Biol.* (New York), Vol. 56, pp. 79-82.
- SALISBURY, G. W., ELLIOT, I., AND VAN DEMARK, N. L. (1945). Further studies of the effect of dilution rate on the fertility of bull semen used for artificial insemination. *Jnl. Dairy Sci.*, Vol. 28, pp. 233-247.
- SALISBURY, G. W., FULLER H. K., AND WILLET, E. L. (1941). A yolk-citrate dilutor for bull semen. *Jnl. Dairy Sci.*, Vol. 24, p. 905.
- SAMPSON, F. R., AND WARREN, D. C. (1939). Density of suspension and morphology of sperm in relation to fertility in the fowl. *Poult. Sci.*, Vol. 18, pp. 301-307.
- SABOTTA, J. (1895). Die Befruchtung und Zuchtung des Eies der Maus. *Arch. Mikr. Anat.*, Vol. 45, p. 15.
- SCHOOLEY, J. P., AND RIDDLE, O. (1938). The morphological basis of pituitary function in pigeons. *Am. Jnl. Anat.*, Vol. 62, part 3, p. 313.
- SCHOTT, R. C., AND PHILLIPS, R. W. (1941). *Anat. Rec.*, Vol. 79, p. 531.
- SCOTT, E. M. (1933). The effect of age and holding temperature on hatching of turkey and chicken eggs. *Poult. Sci.*, Vol. 12, pp. 49-54.
- SCOTT, E. M., AND BURMESTER, B. R. (1939). Effect of resection of the albumen tube on secretion of egg white. *7th W.P. Cong. Proc.*, pp. 102-106.
- SCOTT, H. M., AND WAI-LAN HUANG (1941). Histological observations on the formation of the chalaza in the hen's egg. *Poult. Sci.*, Vol. 20, pp. 402-405.
- SEARCY, G. L., AND ANDREWS, F. N. (1943). The effect of wattle and comb removal upon the testicular activity in the domestic fowl. *Poult. Sci.*, Vol. 22, p. 235.
- SEREBROWSKEY, A. S., AND SOKOLOVSKY, I. L. (1935). Electrical ejaculation in fowls. *Probl. Zivotn.*, Vol. 5, p. 57.
- SERGIN, N. P. (1939). Respiration of sperms of farm animals. *Dokl. Akad. sel'skokož. Nauk.*, Vol. 2, No. 3, p. 60 (*A.B.A.* 1939, Vol. 7, p. 181).
- SHAFFNER, C. S., AND ANDREWS, F. N. (1943). The determination of the concentration of spermatozoa in fowl and bull semen. *Anat. Rec.*, Vol. 86, pp. 99-127.

ARTIFICIAL INSEMINATION OF BIRDS.

- SHAFFNER, C. S., HENDERSON, E. W., AND CARD, C. G. (1941). Vitality of spermatozoa of the chicken under various environmental conditions. *Poult. Sci.*, Vol. 20, pp. 259-265.
- SIMEONE, F. A., AND YOUNG, W. C. (1931). A study of the function of the epididymis. *Jnl. Exp. Biol.*, Vol. 8, pp. 163-175.
- SMERNOV, I. V. (1938). Artificial insemination of cows with sperms in gelatin capsules. *Probl. Zivotn.*, Vol. 2, pp. 186-189.
- SÖDERWALL, A. L., AND YOUNG, W. C. (1940). The effect of ageing in the female genital tract on the fertilising capacity of the guineapig spermatozoa. *Anat. Rec.*, Vol. 78, pp. 19-20.
- SPRENSSEN, E. (1941). Über Verfahren zur Untersuchung von Sperma und vom Flüssigkeiten für die Verdünnung des Semens. *Maandschr. Dyrtaeg.*, Vol. 53, pp. 84-96. Abstr. *Tierartzl. Rdsch.* 1942, Vol. 118, pp. 289-290.
- SPALLANZANI, LAZZARRO (1780). Experiences pour servir à l'histoire de la generation des animaux et des plantes. *Genève*.
- SPALLANZANI, L. (1785). Experiences pour servir à l'histoire de la generation des animaux et des plantes. *Genève*.
- STARKE, N. C. (1943). Examination of the sire for fertility. *Jnl. S.A.V.M.A.*, Vol. 14, part 4, pp. 142-147.
- STARKE, N. C. (1945). Personal communication.
- SURFACE, F. M. (1912). The histology of the oviduct of the domestic hen. *Me. Agr. Exp. Sta. An. Rept.*, pp. 395-430.
- TERRILL, C. E., AND GILDOW, E. M. (1938). Another experiment on long range paternity in sheep. *Jnl. Hered.*, Vol. 29, p. 77.
- TIMJAKOV, G. G. (1933). A new method of sperm collection in Gallinaceae. *Probl. Zivotn.*, Vol. 6, pp. 90-92.
- TOOTHILL, M. C., AND YOUNG, W. C. (1931). Time consumed by spermatozoa in passing through the ductus epididymis of the guineapig as determined by means of india-ink injections. *Anat. Rec.*, Vol. 50, pp. 95-107, July, 1925.
- UPP, C. W. (1928). Preferential mating of fowls. *Poult. Sci.*, Vol. 7, pp. 225-232.
- VAN DER MERWE, J. A. (1942). Artificial incubation of eggs. *Farm. in S. Afr.*, 1942, Aug., p. 8 (reprint).
- VAN DRIMMELEN, G. C. (1945, a). Intraperitoneal insemination of birds. *Jnl. S.A.V.M.A.*, Vol. 16, No. 1, pp. 1-6.
- VAN DRIMMELEN, G. C. (1945, b). The location of spermatozoa in the hen by means of capillary attraction. *Jnl. S.A.V.M.A.*, Vol. 16, No. 4, pp. 97-101.
- VAN DRIMMELEN, G. C. (1946, a). "Spermneests" in the oviduct of the domestic hen. *Jnl. S.A.V.M.A.*, Vol. 17, No. 1, pp. 42-52.
- VAN MANEN, E. (1932). Poultry management. *Jnl. S.A.V.M.A.*, Vol. 3, No. 3, pp. 106-114.
- VAN OORDT, G. I. (1920). *Tijdschr. d. Ned. Dierk. Ver.*, Vol. 3, No. 1, p. 1.
- VERMEULEN, H. A. (1929). Anatomie u. Physiologie der Geflügel. *Handb. d. gefl. krankh. und d. Gefl. zucht; Heelsbergen, Ferd. Enke. Stuttgart*, pp. 1-50.
- WAITE, R. H. (1911). The persistence of fertility in the hen after removal of the male. *Ma. Agr. Exp. Sta. Bull.* 157, p. 93.
- WALTON, A. (1927). The relation between density of sperm suspension and fertility as determined by artificial insemination of the rabbit. *Proc. R. Soc. B.*, Vol. 101, p. 303.
- WALTON, A. (1930). Effect of temperature on survival *in vitro* of rabbit sperms obtained from the Vas deferens. *Br. Jnl. Exp. Biol.*, Vol. 7, p. 201.
- WALTON, A. (1933). The technique of artificial insemination with an introductory chapter by Arthur Walton. *Imp. B. of An. Gen.* (Oliver Boyd), Edinburgh.

- WALTON, A. (1936). Artificial insemination of sheep, cattle and horses. *Holborn Instr. Co., London*.
- WALTON, A. (1938, a). Preservation of fertilising capacity of horse semen. *Proc. Am. Soc. An. Prod.*, Vol. 31, p. 238.
- WALTON, A. (1938, b). Artificial insemination of cattle, horses and sheep. *Holborn Surgical Instr. Co., London*, 2nd Ed.
- WALTON, A., AND EDWARDS, J. (1938). Criteria of male fertility I, the exhaustion test. *Proc. Am. Soc. An. Prod.*, Vol. 31.
- WALTON, A., HAMMOND, J., AND ASDELL, A. S. (1928). On the vitality of spermatozoa in the male and female genital tracts and outside the body. *Zeitschr. Zuchtung*, Vol. 14, No. 2.
- WALTON, A., AND PRAWOCHENSKI, R. (1936). An experiment in eutelegensis. *Jnl. Hered.*, Vol. 27, pp. 341-344.
- WALTON, A., AND WETHAM, E. O. (1933). The survival of spermatozoa in the domesticated fowl. *Jnl. Exp. Biol.*, Vol. 10, pp. 204-211.
- WARREN, D. C. (1934). The influence of some factors on the hatchability of the hen's egg. *Kam. Agr. Exp. Sta. Tech. Bul.* 37.
- WARREN, D. C. (1939). Effect of temperature on the size of eggs at different latitudes. *Jnl. Agr. Res.*, Vol. 59, pp. 441-452.
- WARREN, D. C., AND GISH, C. L. (1943). The value of artificial insemination in Poultry Breeding work. *Poult. Sci.*, Vol. 22, pp. 108-117.
- WARREN, D. C., AND KILPATRICK, L. (1929). Fertilisation in the domestic fowl. *Poult. Sci.*, Vol. 8, pp. 237-256.
- WARREN, D. C., AND SCOTT, H. M. (1934). Ovulation in the domestic hen. *Sci. (N.S.)*, Vol. 80, pp. 461-462.
- WARREN, D. C., AND SCOTT, H. M. (1935, a). The time factor in egg formation. *Poult. Sci.*, Vol. 14, pp. 195-207.
- WARREN, D. C., AND SCOTT, H. M. (1935, b). Factors influencing egg-formation in the domestic hen. *Jnl. Agr. Sci.*, Vol. 51, pp. 565-572.
- WARREN, D. C., AND SCOTT, H. M. (1936). Influence of light on ovulation in the fowl. *Jnl. Exp. Zool.*, Vol. 74, pp. 137-156.
- WEBER, A. (1936). Zur Physiologie des Bullenspermas. *V. Med. Desert., Leipzig*, 52 pp.
- WESTER, J. (1921). Eierstock und Ei Befruchtung und Unfruchtbarkeit by den Haustieren. *Berlin* (cit. Quinlan, e.a., 1932).
- WESTMANN, A. (1929). Experimentale Studien über die funktionelle Bedeutung der Theca interna-Zellen. *Acta. Obstet. Gyn. Scan.*, Vol. 8, p. 307 (cit. Parker, 1931).
- WETHAM, E. S. (1933). Factors modifying egg-production with special reference to seasonal changes. *Jnl. Agr. Sci.*, Vol. 23, p. 383.
- WHEELER, N. C., AND ANDREWS, F. N. (1943). The influence of season on semen production in the domestic fowl. *Poult. Sci.*, Vol. 22, pp. 361-367.
- WHITE, M. J. D. (1932). The chromosomes of the domestic fowl. *Jnl. Gen.*, Vol. 26, pp. 345-350.
- WILKINS, R. H. (1915). Some factors influencing the fertility and hatching power of fowl's eggs. *Thesis Cornell Univ.* (cit. Lamoreux, 1940).
- WILLET, E. L., AND SALISBURY, G. W. (1942). The effect of various dilutors, cooling rate, temperature of storage and some other factors on the livability of spermatozoa in stored samples of bull semen. *Mem. Cornell. Agr. Exp. St. No.* 249, p. 45.
- WILLIAMS, W. L. (1939). The diseases of the genital organs of domestic animals. 2nd ed. *W. L. Williams, New York*.

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- WINBERG, H. (1939). Beitrag zur Kenntnis des Stoffwechsels der Vogelspermien. *Arch. Zool.*, Vol. 32, A No. 7, 11 pp.
- WINBERG, H. (1941). Über das physiologische Verhalten der Vogelspermien bei variierender temperatur. *Arch. Zool.*, Vol. 33A, part 7, 12 pp.
- WINTERS, L. M. (1939). *Animal Breeding* Ed. 3, *J. Wiley and S. Inc., New York*, 316 pp.
- YOCHER, D. E. (1929). Spermatozoon life in the female reproductive tract of the guinea-pig and rat. *Biol. Bull.*, Vol. 56, pp. 274-297.
- YOCHER, D. E. (1930). A study of the motility and resistance of rat spermatozoa at different levels in the reproductive tract. *Anat. Rec.*, No. 45.
- YOUNG, W. C. (1929, a). *Morph. and Physiol.*, Vol. 47, pp. 479-495. (cit. Young, 1931).
- YOUNG, W. C. (1929, b). Study of function of epididymis: Importance of ageing process in sperm for length of period during which fertilising capacity is retained by sperm isolated in epididymis of guinea-pig. *Morph. and Physiol.*, Vol. 48, pp. 475-491. (Cit. Young, 1931). (December 5th, p. 29).
- YOUNG, W. C. (1931). A study of the function of the epididymis. III. *Jnl. Exp. Biol.*, Vol. 8, p. 151.
- ZAGAMI, V. (1937). Ricerche sperimentali sul liquido seminale II. Sul valore del pH del liquido seminale di gallo. *Att. d. R. Noz. dei. Linnei. Ser. 6*, Vol. 26, pp. 123-128.