THE EFFECT OF DUBBING, AMBIENT TEMPERATURE AND SOCIAL DOMINANCE ON MATING ACTIVITY AND FERTILITY IN THE DOMESTIC FOWL

By

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Bachelor of Science

Oklahoma A. & M. College

Stillwater, Oklahoma

1950

Submitted to the Faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
1951

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ACKNOWLEDGEMENT

It is with gratitude that I express my sincere appreciation to Professor R. B. Thompson for making this study possible.

It is a privilege to express my appreciation to Dr. George F. Godfrey for his assistance and direction of my course of study; and for his aid and criticism in the preparation of this thesis.

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INTRODUCTION

Low fertility has been a problem of economic importance to the poultry industry for many years. It is a conservative estimate that 10 to 15 per cent of all eggs set are infertile. This represents a large monetary loss to hatcherymen and breeders each year. There are two ways to solve this problem: (1) find a method to detect fertile eggs before setting, of which there is no practical method at present, or (2) increase the percent fertility of eggs set. The latter is possible but sometimes very hard to attain because of the many factors involved in fertility. Some measure of predictability of fertility would be helpful to attain the goal of higher fertility.

The effect of temperature on mating activity and fertility, and the effect of dubbing on mating activity and fertility have been controversial. The objectives of this problem are:

1. To study the effect of dubbing males on their mating activity.
2. To study the effect of temperature on mating activity.
3. To study the relationship of social dominance of males as it affects the frequency of matings and the proportion of eggs fertilized.
4. To study the duration of fertility of males as a measure of predicting fertility.

REVIEW OF THE LITERATURE

Fertilization

Fertilization is defined as the union of the sperm of the male with the egg or ovum of the female. Only the nucleus of one sperm unites with the nucleus of the ovum in the process of fertilization, although other sperms may penetrate the cell wall of the ovum. Patterson (1911) called these supernumary sperms and reported that they disappear in 4 to 5 hours after fertilization.

Male Reproductive Tract -- The male reproductive system of the chicken as described by Burrows and Quinn (1937) consists of two testes, with epididymides, vasa deferentia and the copulatory apparatus. Parker, McKenzie, and Kempster (1942) showed that the bulk of the testes is composed of seminiferous tubules and that in these tubules the sperm cells are formed by the process of spermatogenesis. As the sperms mature, they become detached from the Sertoli cells and pass through the tubules into the excurrent ducts of the epididymis. That the epididymis is small in comparison to other farm animals led Munro (1935) to believe that sperm do not completely "ripen" in the epididymis, but that the process is continued, and completed in the vas deferens. As the ducts continue posteromedian they become larger. Upon their entrance into the wall of the cloaca they measure as much as 3.5 millimeters in diameter (Parker et al., 1942). Munro (1935) stated that sperm spend the greater part of their time in the long coiled vas deferens subsequent to morphological maturity and before ejaculation. Burrows and Quinn (1939) concur with this concept.

The copulatory apparatus of the male fowl as described by Burrows and Quinn (1937), and Parker et al. (1942) consists of two papillae and the rudimentary copulatory organ. As the vas deferens enter the wall of the cloaca they terminate in two small conical-shaped papillae, each having a hole through which semen is emitted during copulation. The copulatory organ is somewhat irregular in outline and its dimensions vary from 3 to 5 mm. in length, 2 to 3 mm. in width, and 2 to 4 mm. in height.

Female Reproductive System -- The reproductive organs of the female chicken are unusual in that hens normally have only one functional ovary and oviduct. According to Warren (1949) the ovary is seen as a cluster of developing ova of varying sizes. The oviduct is a tube having many loops and it extends from its attachment at the base of the ovary to the cloaca. The approximately twenty-two inch oviduct is divided into five major parts: (1) the infundibulum or funnel, which picks up the ovum after release from the ovary; (2) the magnum, which comprises over fifty percent of the oviduct, and where most of the egg white is secreted; (3) the isthmus, where the shell membranes are formed; (4) the uterus or shell-gland, in which additions to the white are made and the shell is deposited; and (5) the vagina, which leads to the cloaca from which the egg is expelled.

Site of Fertilization -- The site of fertilization has been of interest to many workers. Patterson (1911) observed that hens' eggs were fertilized in the upper end of the oviduct immediately after ovulation. Crew (1926) stated that fertilization occurs shortly after ovulation by chance meeting of ovum and sperm. Nicolaides (1934) reported that fertilization may take place in a lower portion of the oviduct if no sperm awaits the ovum upon its release from the ovary. It may be that the sperm comes in contact with the ovum after ovulation, but the final act of fertilization does not occur until a later time when the egg is passing down the oviduct. He made no cytological study of time and location of fertilization or maturation. The studies of Olsen (1942) and Olsen and Neher (1949) provide direct evidence that the spermatozoa normally fertilize the ovum after ovulation and before it reaches the magnum. In turkeys Olsen and Fraps (1944) reported that the ovum is fertilized in the infundibulum within a few minutes following ovulation.

The speed in which sperm travel from the vagina to the funnel has been reported by many workers. Payne (1914) observed sperm in all parts of the oviduct thirty minutes after coitus. Warren and Kilpatrick (1929) also found sperm in all parts of the oviduct six hours after mating. The shape and size of the sperm they observed were normal, but large numbers had lost their flagellum. Walton and Whetham (1933) irrigated the peritoneal cavity and oviduct with spermicidal solution and found that fertility persisted as long after treatment as in the unoperated bird. However, the number of fertile eggs laid was reduced due to degeneration of the ova. This study confirmed the work of Ivanov (1924), quoted by Hutt (1949), who obtained fertile eggs up to three weeks after the entire body had been thoroughly douched with a spermicidal solution. Ivanov's (1924) conclusion was that spermatozoa penetrate the follicle and fertilize ripe and unripe ova before ovulation. Evidence by Walton and Whetham (1933) supported his hypothesis but they considered fertilization to be possible after irrigation, by spermatozoa which were buried in crypts of the oviduct and thus protected against the treatment. Van Drimmelen (1945, 1946) observed spermatozoa in the funnel up to 14 days after insemination. In other studies he observed that spermatozoa were located in "spermnests" in crypts of the mucous lining of the funnel region of the oviduct. Sometimes as many as 50 to 80 sperms were found in one "spermnest". This probably explains why fertility may persist after irrigation with a spermicidal solution.

The manner in which sperm travel has been reported by G. H. Parker (1930, 1932), quoted by Hutt (1949). In birds, spermatozoa are carried to the isthmus of the oviduct by muscular contraction in an antiperistaltic direction, and to the funnel by a current set up by cilia beating in the direction of the ovary. These pro-ovarian cilia were found in a band covering about one-quarter of the circumference of the oviduct. This work disproved the former belief that spermatozoa travelled up the oviduct by rheotaxis. The speed in which spermatozoa reach the funnel was investigated by Mimura (1939), quoted by Parker (1949), who found that spermatozoa inseminated into the vagina may reach the funnel in as short a time as twenty-six minutes.

In view of these data it seems most likely that fertilization occurs shortly after ovulation, and in the infundibulum.

Inheritance of Fertility -- It has long been recommended that to secure maximum fertility the breeder should make up his mating pens before the regular hatching season and test the eggs for fertility. Whether or not fertility is inherited is disputed. According to Pearl and Surface (1909), and Hays and Sanborn (1924, 1939), fertility is not inherited. However, Hays (1950) presented data which indicate that sex-linked genes may be operating to regulate fertility. Jull (1935) reported a significant correlation between the fertility of dams and their daughters. Blyth (1945) quoted by Parker (1949) concluded that fertility is an inherited characteristic. Hutt (1940) presented evidence that the White Wyandotte breed is characterized by lower fertility than others. He analyzed the records of official pedigree breeding stations for several years and found that the proportion of infertile eggs was higher in White Wyandottes than in other birds. Munro (1946), quoted by Parker (1949), believed that lower fertility in Wyandottes was more affected by environmental factors than by genetic factors. Gowe and Hutt (1949) reported lower fertility in a line of inbred Leghorns in comparison with proper controls. This infertility could not be attributed to environment. They also found that hens differ greatly in their ability to maintain the fertility of their eggs following a single mating. Using turkey hens, Harper and Parker (1950) presented evidence that differences in fertility between families, as measured by duration of fertility after one insemination, indicate that fertility is inherited.

In studies by Jones and Lamoreux (1942) it was observed that cockerels from a high-laying strain of White Leghorns produced more semen at 12, 24, and 30 weeks than males from a low-fecundity strain. Hutt (1949) considered this to indicate that, although egg production is a sex-limited character, the genes accelerating that process in females may have a corresponding effect in males. These genes, he hypothesized, might be considered as genes affecting gametogenesis in general. That age at sexual maturity as measured by semen production is inherited in White Leghorn cockerels and male turkeys was shown by Lorenz and Lerner (1946).

Studies by Jull (1930, 1933), Hays (1924, 1929), and Knox (1946) have shown that inbreeding decreases fertility. On the other hand, Waters and Lambert (1936) found no significant differences in fertility between progeny having different degrees of inbreeding and concluded that inbreeding had no effect on fertility because of intense selection for this character. Bernier (1947), quoted by Parker (1949), revealed that inbreeding, outcrossing, crossbreeding and inbreeding, to varying degrees, apparently do not affect fertility directly. Fertilization of the egg is apparently neither impaired nor enhanced by the presence of sperms from a related or unrelated male. Knox (1939) showed that crossbreeding had no effect on fertility. Goff and Tumlin (1950), using Barred Plymouth Rocks, reported that percentage fertility tended to decrease as the intensity of inbreeding increased.

Studies were made by Marsden and Olsen (1950) using Beltsville Small Whites, Broad Breasted Bronze, and their reciprocal crosses. The average fertility for a three-year period was: Beltsville Small Whites, 94.7; Broad Breasted Bronze, 88.6; Broad Breasted Bronze X Beltsville Small Whites, 83.1; and Beltsville Small Whites X Broad Breasted Bronze, 68.8 percent. Their only explanation for the lowered fertility of the Beltsville Small Whites X Broad Breasted Bronze was that it might be due to preferential mating due to differences in color, physical difficulties or differences in size and/or body conformation.

It is clear from evidence presented that fertility is inherited. Wilson (1948) estimated the heritibility of fertility to be .10 when unadjusted for inbreeding, but this value would probably be lower if the proper adjustments were made.

Miscellanea -- That males have an age of sexual maturity has been shown by Jones and Lamoreux (1942) and Lorenz and Lerner (1946). The development of sexual maturity has been studied by Hogue and Schnetzler (1937). Their results indicate that Barred Plymouth Rock males may reach sexual maturity at approximately 16 weeks of age. There were wide individual differences depending upon development of the males, but they concluded that a satisfactory level of fertility may be secured from pen matings after the males are twenty-six weeks of age.

Hays and Sanborn (1939) reported that males reached their maximum fertility as cockerels and thereafter showed a marked decline in fertility. Females reached their maximum fertility as yearlings and exhibited a less marked decline in fertility in succeeding years than did males. Jull (1935) reported that pullets having the highest fertility tended to have the highest fertility as yearlings.

Jull (1928) reported no relationship between fertility and hatchability. Knox (1927) made a correlation study and concluded that maturity had practically no relationship with fertility. Date of hatch did not influence fertility; nor did rate of egg production. However, he found that fertility is related to hatchability, the reverse of Jull's (1928) conclusion.

Shaffner and Andrews (1948) reported correlation coefficients as follows: percent fertility and semen volume, 0.128; fertility and sperm concentration, 0.040; fertility and initial sperm motility, 0.517; fertility and methylene blue reduction time, -0.546; and fertility and sperm survival time at 4°C., 0.409. The last three values are significant and indicate possible methods of predicting fertility.

The role of nutrition as it influences fertility has received little attention. Craft, McElroy, and Penquite (1926) reported that males on deficient diets were less active sexually and produced fewer sperm on the average than males on more complete rations. They presumed that this difference was due partly to the individuality of the males and partly to the diet. Parker and McSpadden (1943) obtained results which showed that inanition decreases the level of fertility in male fowls. Semen volume, number of sperm per collection, and fertilizing capacity of the males were adversely influenced by inanition. Ferrand and Bohren (1948) reported no individual or group differences in fertility between Barred Plymouth Rock, White Plymouth Rock and New Hampshire males when fed a low carotenol diet, and when the spermatozoa were not in competition with normal sperm.

Incomplete rations have an undesirable effect on the fertility of males. In view of the meager evidence, it would seem that specific ingredients may have an effect on fertility, while others may not.

Nicolaides (1934) reported no difference in fertility between stud mating and pen mating. On the other hand, Palafox (1948) reported that the fertility of pen mated White Leghorns was 80.3 compared to 60.1 percent for the same pullets when they were stud mated. Individual cockerels and pullets showed significant differences in fertility which makes selection for this trait possible.

A relatively small amount of work has been done on the ratio of males to females. Byerly and Godfrey (1937) reported that fertility fell in linear fashion as the number of females per male was increased. Their data indicated that the maximum number of fertile eggs could be obtained from a single male by mating him to about 120 females. Hays and Sanborn (1939) found that a range of 1 to 14 females per male had no influence on fertility. Results from experiments by Parker and Bernier (1950) over a two year period show that 6 to 7 males are required for each 100 hens for consistent high fertility.

Intensity of Egg Production

An analysis of the incubation records of more than 1200 hens was made by Lamoreux (1940) to determine the relationship between the rate of egg production and the proportion of eggs laid which are infertile. The hens which laid 13 to 22 eggs during a six-week period produced a larger proportion of infertile eggs than hens laying at a more rapid rate. Position of the egg within a given clutch has no effect on fertility which substantiates the work of Funk (1939). Hays and Sanborn (1939) found that the number of eggs laid by pullets to March 1 had no effect on their fertility.

Frequency and Time of Mating

The libido in the male has been observed by several investigators with conflicting results. Heuser (1916) reported that matings for each of the hours of the day run fairly constant for the first eight hours of the day. The last four hours, and especially the last two, run much higher. He reported that 62.2 percent of all matings occur from 2 P.M. to 6 P.M. and 42.7 percent of all matings occur from 4 P.M. to 6 P.M. The time of greatest activity is just after the late afternoon feeding. The highest number of matings by one male in one hour was 9, between 5 and 6 P.M. In White Leghorns copulations ranged from 0 to 32 in one day, and over a 14-day period, from 16 to 235. Penquite, Craft, and Thompson (1930) reported that males are more active the first two hours of the day. Using White Leghorn males, matings per day ranged from 6 to 28. The shortest interval between matings was one minute, and the longest was seven hours and eight minutes. However, the hens were removed as soon as they had been mated, which may have had some effect on the activity of the males. They reported that the males which were regularly active produced a higher percent of dead or weak sperm than those that were less active. Philips (1918) mated a Single Comb White Leghorn cockerel which had not mated for 15 days with 27 Leghorn hens that had not been mated for 15 days and found that during three hours of the afternoon the male mated 38 times. From these matings 40 percent of the eggs laid during the next 7 days were fertile.

Gracewski and Scott (1943) obtained highest fertility from males when mating was restricted to the afternoon. They concluded that fertility was higher because of the higher incidence of membranous eggs in the oviduct as compared to hens mated in the forenoon. On the other hand, Parker (1950) reported no increase in fertility by restricting matings to certain periods of the day compared to that of a control group. However, comparable results were obtained by restricting matings to the afternoon.

Parker, McKenzie and Kempster (1940) reported a marked variation between males in sexual activity and sperm production. General appearance and body type were not found to be good indices of sexual behavior. They found that males maintained in cages were less active than males maintained in breeding pens. The same workers reported males to be most active sexually late in the afternoon.

Parker et al. (1942) reported that sexual activity of males was somewhat lower during September than at other times of the year. They believed molt to be the attributing cause of the decreased sexual activity as no association between sexual activity and length of day was evident.

Morgan et al. (1950) fed first year turkey breeding toms iodocasein at the rate of 15 grams per 100 lbs. of ration, to determine its effect on semen volume and sperm concentration and activity. In two trials no differences were noted between the treated and untreated toms.

Dubbing and Its Effect Upon the Reproductive Performance of Males

The practice of removing the comb and wattles of males, commonly referred to as dubbing, is a common practice. The influence of dubbing males as it affects the gonads is controversial. Buckner, Insko and Martin (1932) reported that exclusion of direct sunlight causes abnormally large combs to develop. Males with these large combs had smaller testes than males receiving direct sunlight. The same investigators (1933) removed the combs of males and exluded direct sunlight and reported development of larger wattles and testes than males raised under similar conditions whose combs had not been removed. Zavadovskii (1935) weighed the testes of dubbed and undubbed males and found the heavier testes in dubbed males. He concluded that the comb and wattles exercise an inhibiting influence upon the gonads. The relation of the comb and wattles to the secondary sexual characteristics of rats was investigated by Zavadovskii and Slavina (1935). They found that the development of the genital organs of rats fed fresh comb tissue was retarded. Therefore, it appears that the comb inhibits the endocrine function of the testis. Hoskins and Koch (1939) reported that testes from dubbed males were significantly larger than those of normal controls, which indicates a reciprocal testis-comb relationship. Marlow and Payne (1940) found that the testes of dubbed birds were about twice the size of those of normal birds. However, no differences could be seen histologically in progression of spermatogenesis. They also reported that body weights of dubbed males were on the average about 15 percent heavier than normal birds. Lamoreux and Jones (1942) found no differences in body weight, testes weight, yield of semen, size of anterior pituitary gland, or the amount of gonadotrophic hormone in the pituitary gland when feed and water are freely accessible. They did find, however, that dubbed males were heavier and yielded more semen when held in cages, but these differences became insignificant when the males were placed in floor pens. Searcy and Andrews (1943) obtained similar results. They reported no differences in semen production, concentration, and in sperm viability between the control and dubbed Brown Leghorn and Barred Plymouth Rock males. The testes of the dubbed Brown Leghorns were heavier than those of the controls, but there were no differences in gonad weight between the treated and untreated Barred Plymouth Rocks. Piana (1949) removed the comb and wattles of five-months old White Leghorn males and observed a 70 percent increase in the weight of testicles two months after removal. A similar experiment carried out on adult White Leghorn males resulted in a 57 percent increase in the weight of the testicles. Bice (1942) reported that climatic conditions in Hawaii favor the development of large combs on White Leghorn males and females. These extra large combs reduce the vigor and mating ability of males. Dubbing the males increased the fertility. However, no quantitative data were reported to substantiate these conclusions.

The Effect of Seasonal Influence and Temperature on Mating Activity and Fertility

Seasonal influence on fertility is well known to poultrymen and has been demonstrated experimentally by Upp and Thompson (1927). Highest fertility was found between December 31 and April 7, and fertility decreased considerably during the summer and fall seasons.

Wheeler and Andrews (1943) reported a seasonal variation in the production of semen of Barred Plymouth Rock males. The largest volumes of semen were produced between November and March. Parker et al. (1942) found that increasing length of days stimulated sperm production.

The role of temperature on fertility is not too well understood. Payne and Ingram (1927) subjected White Leghorn males to temperatures as low as -6°F. and observed individual variation in the degree of freezing which affects the comb, wattles, and feet. The male which suffered least from freezing showed higher fertility the first two weeks than did the males more severely frozen. The frozen comb tissue dropped off in 4 to 5 weeks. The effects of this freezing reduced fertility below normal for only 11 days. One male's feet were so severely frozen that he was never able to mate again. Searcy and Andrews (1943) reported that Brown Leghorn males with frozen combs and wattles produced semen of inferior quality during the first 14 to 18 days after freezing the combs, which substantiates the evidence by Payne and Ingram (1927).

Hays and Sanborn (1939) in a study using 2101 Rhode Island Red females and 305 males, from 1922 to 1936, reported that outside temperature had a specific effect on fertility. Their data indicated that when the average temperature was below 32°F., average fertility ranged between 54 and 77 percent. When the temperature rose above 32°F., fertility ranged from 70 to 85 percent. With weekly hatches over an 11-week period, fertility rose consistently until the outside temperature was 37°F. Lamoreux (1942) in a similar study, using 71 males and 393 females, from 1935 to 1940 inclusive, found no relationship between outside mean temperature and the proportion of eggs laid that were infertile. He assumed that a reduction in fertility if it occurs as a result of low temperature, is actually the result of reduced activity and infrequent mating. He presented no quantitative data to uphold this assumption. Because of the long duration of fertility, he deemed it unlikely that a decline in fertility would occur during only two or three very cold days, even if no matings occurred during that time.

The Effect of Social Dominance of Males on Their Mating Activity

The social organization in flocks of chickens has received considerable attention during the past decade. Guhl (1941) in studying the frequency of mating with rank in social position, obtained conflicting results. When males whose social position was known, were placed singly in pens, it was found that the frequency of mating had no relation to the social position of the cocks, nor were the females treated in accordance with their own social status. But when the several males were placed in a small pen of hens, psychological castration took place. The male at the top of the peck order suppressed matings by his inferiors. Guhl (1945) further reported that the peck order is fairly stable among hens but likely to change among cocks.

Social dominance is related to the number of eggs fertilized by various males (Guhl and Warren, 1946). In each of the two flocks the top ranking male was most successful in the number of matings completed; he fertilized the most eggs and sired the most viable chicks. Guhl (1949, 1950) determined the influence of social dominance upon the receptivity of hens. Hens which composed the upper level of the social order tended to crouch less than those hens in the lower level of the social order.

Lamoreux (1940) assumed that during periods when the rate of ovulation is low, hens copulate less frequently and probably have a shorter duration of fertility following insemination. Heuser (1916) also reported that hens producing at a low rate copulate less frequently.

Investigations by Guhl and Eaton (1948) indicate that aggressiveness is not inherited.

<u>Preferential Mating and Selective Fertilization</u>

There are other factors which influence mating activity. Heuser (1916), Philips (1918, 1919), Upp (1928), and Milby and Thompson (1945) presented evidence that preferential mating is one such factor. Philips (1919) reported that the hen is the controlling factor of compatibility. The male is the one that must possess the active vigor in mating, as in most other species. At no time did he observe males forcing their attention upon the hens. Upp (1928) reported that the great variation in number of copulations with different females indicates that it was not mere chance that some hens mate more often than others. Preferential mating, resulting in hens laying few or no fertile eggs, is common in turkeys, in single male matings, and may even occur in matings where males are rotated (Milby and Thompson, 1945).

The idea that the hen is responsible for preferential mating is not held by Hays and Sanborn (1939). They observed that males were responsible for most infertile matings because a change in males resulted in 93 percent of the infertile matings becoming fertile.

The problem of selective fertilization is one of economic significance to breeders who wish to use two or more sets of males in the same pen. It is desirable to produce a minimum number of eggs of doubtful parentage. Experiments by Crew (1926) and Dunn (1927) indicated that in natural matings the spermatozoa of one male may be more effective in fertilization than those of another when both types are present. Curtis and Lambert (1929) reported a slight indication of selective fertilization.

Parker et al. (1942) inseminated New Hampshire females with equal volumes of semen from White Leghorn, Barred Plymouth Rock, and New Hampshire males. They obtained 42 and 40 chicks from the Barred Plymouth Rock and the New Hampshire, respectively; but only 7 from the White Leghorn. This is in agreement with the work of Bonnier and Trulsson (1939). They inseminated Rhode Island Red hens on alternate days with semen from Rhode Island Red and White Leghorn males, and obtained an excess of red chicks.

Ferrand Bohren (1948) reported that Barred Plymouth Rocks were superior to White Plymouth Rocks, and New Hampshires were superior to Barred Plymouth Rocks in sperm competitive ability. They concluded that the differences between breeds are real differences, and possibly strain differences.

When males are changed, the offspring of the replacing male very soon supplant those of the former and there is practically no over-lapping of the offspring of the two males (Warren and Kilpatrick, 1929). At Cornell University, Hutt (1949) uses three shifts of males and assumes that the replacing male supplants that of the original male within nine days. This is not true in turkeys. Kosin and Wakely (1950) obtained semen from Broad Breasted Bronze toms, and inseminated Beltsville Small White hens. These hens had only recently been mating with males of their own variety. The white poults continued to appear, in some cases, for eight weeks following removal of the white toms.

Onset and Duration of Fertility

Probably no other part of fertility has been investigated as thoroughly as that of onset and duration. The onset of fertility is of interest, as well as of economic importance, to hatcherymen and breeders. Crew (1926) reported that maximum fertility is reached by the first week after mating. Investigations by Curtis and Lambert (1929) showed that onset of fertile egg production ranged from 24 hours to 7 days, with 57.1 ± 2.6 hours as the average. Chlebaroff (1930) reported that the first egg fertilized by any one cock is laid on the second day, irrespective of whether the last mating took place in the morning or evening. Nicolaides (1934) obtained a fertile egg 19.5 hours after mating. Moore and Byerly (1942), using artificial insemination, obtained maximum fertility in 3 to 4 days. A study by Parker and Bernier (1950) revealed that the relative number of males used influenced the onset of fertility. The time for maximum fertility to be attained after introducing the males in the flocks, ranged from nine days with nine males per 100 females, to 16 days with 3.7 males per 100 females. Parker et al. (1942) reported no fertile eggs the first day following insemination of females. They reported 75 percent fertile eggs on the second day and on the third day 88 percent fertile eggs, which was their peak.

Duration of fertility has been studied for many years and by many investigators. It is of great economic importance that fertile eggs are produced several days after removal of the males. Spallanzani (1874), quoted by Jull (1940), reported that a hen can lay fertile eggs for 20 days after being mated. Crew (1926) secured a fertile egg 32 days after mating. Curtis and Lambert (1929) observed that the mean duration of fertility was 10.7 ± 0.4 days, with 21 days as the extreme duration. They obtained an average of 5.6 fertile eggs from a single mating, with 11 eggs as the extreme number. After segregation of the cock from the hens, Chlebaroff (1930) observed that after the last mating, the last fertile egg is most frequently laid at the end of the second week, more rarely in the course of the third week, and not later than the 19th day. His greatest number of fertile eggs after one mating was eight. The average duration of fertility reported by Nicolaides (1934) was 14.83 days with a maximum of 29 days. Of 68 single matings, 58 produced fertile eggs, 81.96 percent being fertile. Studies by Parker et al. (1942) indicate that after insemination with 0.1 cc. of undiluted semen, fertility declines gradually until the tenth day following insemination. No fertile eggs were produced on the twentieth to twenty-fourth days, but on the twenty-fifth day one fertile egg in 30 was observed. Kosin and Wakely (1950) concluded that the fertilizing capacity of turkey semen may persist for eight weeks in the oviduct of the hen.

MATERIALS AND METHODS

The females used in this study were Oklahoma A. & M. strain New Hampshires. They were housed June 24, 1950, in two 10' X 20' pens. These pens were separated by a wire partition, which allowed simultaneous unobstructed observation of both pens. They were fed a breeder mash ad libitum and scratch grain late in the afternoon.

The males consisted of two sets of full brothers from the same hatch and two sets of half-brothers from the same hatch. The two New Hampshire and the two Silver Oklabar males were full brothers, while the two Barred Plymouth Rock and the two Oklahoma Dominant White males were half-brothers. One brother of each pair was dubbed and placed in one pen, while the undubbed brother was placed in the second pen. These different varieties were used so as to identify their progeny when hatched. The dubbed Dominant White male died in December and his undubbed brother was removed from the other pen. Therefore, they are not considered in the results, except in Table 5.

To keep a record of the high and low temperature for each twenty-four hour period, a Taylor maximum and minimum registering thermometer was placed about four feet from the floor in the east pen, and the temperature was recorded daily.

Random observations were made to see if all males were mating. When the majority had been observed to mate, mating behavior was observed on four different days, 2 days in September, 1 day in October, and 1 day in November, to establish the time of day when sexual activity was at a peak. This was determined to be from 4 to 5 P.M. Thereafter, a total of 32 observations were made on different days from 4 to 5 P.M., during the period September 15 to March 17. The number of times each male and female mated was recorded. Each hen wore a numbered wing badge which could be recognized fairly easily. Matings were classified as follows: mating, when a mating was apparently complete; mating attempt, when the male grabbed the female with his beak and attempted to mate; interference, when one of the males prevented another from mating.

The hens were trapnested. When eggs were to be set, they were marked with the pen number, hen number and date laid. Eggs to be set were handled in the same manner as other hatching eggs on the farm and were never held longer than 14 days before setting. The eggs were all set in forced draft incubators, operated according to the directions of the manufacturer. The eggs were candled and transferred on the 18th day of incubation. The clear eggs were broken out, with the exception of the eggs from two hatches. The resulting chicks were pedigree hatched, and a record made of their parentage.

The duration of fertility study was begun the day after removal of the males. All eggs for 28 days were saved, incubated, and checked for fertility.

RESULTS

Frequency and Time of Mating

The results of the four days of observation to find the peak of daily sexual activity are shown in Figure 1. The total number of matings recorded was 223. The peak of mating activity fell between 4 and 5 P.M., when 26.9 percent of all matings occurred. This peak in libido was shown by all males sexually active at this particular time of the year, regardless of their activity during the earlier part of the day. The period of least sexual activity was between 7 and 8 A.M.

The mean number of matings per day ranged from 0.75 for the dubbed Barred Plymouth Rock male, to 25.25 for the undubbed New Hampshire male.

The greatest number of matings in one hour by any one male was eight. The undubbed New Hampshire and Silver Oklabar male each mated eight times between 4 and 5 P.M.; and the same New Hampshire mated eight times between 5 and 6 P.M.

Comparison of the Mating Activity of Dubbed and Undubbed Males from 4 to 5 P.M.

There is a marked variation in the mating activity of males. The number of matings ranged from 0 to 11 during the observation period. The average number of matings per observation ranged from 2.41 to 4.41. The number of matings and the mean number of matings for each male are presented in Table 1. An analysis of variance (Table 1a) indicates that there was no difference between the mating activity of dubbed and undubbed males. However, a highly significant difference was obtained between males. This cannot be interpreted to mean that the difference is due to breed differences, because of the confounding influence of social rank. The more aggressive males severely curtailed the mating activity of males at the lower level of the peck order.

Comparisons were made to see if there were any differences between the mating activity of full and half-brothers. These data were analyzed using the t test of "Student". The results are shown in Table 2. These data provide evidence that full and half-brothers, used in this study, tended to act alike insofar as mating activity was concerned. It is interesting to note, however, that the undubbed Barred Plymouth Rock and Silver Oklabar mated more than their dubbed brothers; the reverse was true with the New Hampshires.

The Effect of Temperature on Mating Activity and Fertility

The maximum and minimum temperatures were recorded daily. Temperature ranged from 12°F. to 88°F. on the days when observations were made. The minimum temperature for the 32 observation periods was arbitrarily divided into five classes as follows: below 20°F., 21 to 30°F., 31 to 40°F., 41 to 50°F., and 51°F. and up. The results and analysis of variance are presented in Table 3. These data, with one exception, provide evidence that temperatures from

12°F. to 88°F., have no effect on the mating activity of males. However, these data do indicate that optimum minimum temperature for mating activity may be between 31 and 40°F.

The one exception referred to above was the undubbed New Hampshire male. His comb and wattles were injured by freezing during the morning of February 1, 1951, when the minimum temperature in the pen reached a low of 12°F. The points on his comb appeared blue and his wattles were blue and swollen at 4 P.M. on February 1. He was very active sexually and mated seven times between 4 and 5 P.M. (Observation No. 20). During the next two observation periods, February 2 and 3, he was not observed to mate or attempt any matings. Nor was he observed to eat or drink. The wattles were greatly enlarged, and he held his head back to allow the wattles to rest on his neck. On February 4, he mated once and began eating grain from the floor. On February 5 he completed four matings, but because his wattles were still enlarged, never used his beak in holding the female. It is rather interesting to see how the percent of his chicks dropped from 63 percent of the total produced in the February 5 setting to 0 percent in the February 26 setting. (Figure 3). The total fertility for that pen dropped rather sharply for the hatch set February 26; much more than the same hatch for the dubbed lot. These data provide evidence that the drop in fertility was primarily due to the decline in mating activity of the New Hampshire male and his inability to fertilize his share of the eggs laid. It can be concluded that the New Hampshire's comb and wattles were frozen to the extent that it reduced his mating ability and lessened the chance of his sperm fertilizing an egg. This confirms the work of Payne and Ingram (1927). It would seem, therefore, that the number of days of reduced fertility depends upon the number of males injured and the severity of their injury by freezing.

The data were further analyzed to see if there was any relationship between total mating activity from 4 to 5 P.M. and the high and/or low temperature. The results are shown in Figure 2. A significant negative correlation coefficient of 0.416 was obtained between mating activity and minimum temperature; and a significant negative correlation coefficient of 0.414 was obtained between mating activity and maximum temperature. This indicates that as temperature goes up mating activity tends to decline.

In order to test the possibility that full and half-brothers might not respond alike to different environmental temperatures, a comparison between the mating activity of the full and half-brothers at different temperatures was made. The temperature range was once again divided into five minimum temperature classes. The number of observations at different temperature ranges, number of matings and the "t" value are presented in Tables 4, 4a, and 4b. The only significant difference was between the New Hampshire males at minimum temperatures over 51°F. This exception may be explained by the "one-in-twenty" of sampling probability. Another explanation could be the differential response of individual males to environmental temperature. These comparisons show that full and half-brothers tend to act alike at similar temperature ranges whether they are dubbed or undubbed.

Observations during the week long cold spell indicated that uninjured males are very active sexually, as measured by their mating activity and mating attempts. The receptivity of hens appeared to be lower during subfreezing temperatures than during warmer temperatures. The results of relating temperature to mating attempts are presented in Figure 4. In view of the difficulty in recording all mating attempts as such, the data were not statistically analyzed. However, the largest number of mating attempts was made by males at the lower levels of the peck order.

Effect of Social Dominance on Mating Activity and Proportion of Chicks Sired

The number and percent chicks sired by each male, the total number of chicks hatched, and the percent fertility are shown in Tables 5 and 5a for each hatch. The number and percent chicks sired by the dubbed Oklahoma Dominant White male are included in Table 5, until his death. His half-brother failed to sire any chicks and so is not included in Table 5a. It is remarkable how the number of chicks sired by the Barred Plymouth Rock and Silver Oklabar males increased after the death and removal of the Oklahoma Dominant White males from the pens.

The dubbed New Hampshire was the socially dominant male during the entire period. The large number of chicks he sired is evidence of the relationship between social dominance and number of chicks sired. These data substantiate the results of Guhl and Warren (1946). There was never any marked observable difference in social rank between the dubbed Silver Oklabar and the dubbed Barred Plymouth Rock. The number of observed matings, as well as the total number of chicks sired by these two males, was also quite comparable.

The social order in the undubbed pen was somewhat different. The New Hampshire male was the dominant male until his comb and wattles were frozen. For a few days he was still the dominant male. The Barred Plymouth Rock male supplanted him at the top of the social order during the second week of February. This is quite evident if one compares the percent of chicks sired by these two males as shown in Table 5a. Although the New Hampshire male was replaced as the dominant male, he sired the largest number of chicks over the entire period because he was dominant longer than the Barred Plymouth Rock male. The Silver Oklabar was dominant over the Barred Plymouth Rock male. However, the aggressiveness of the Barred Plymouth Rock permitted him to overcome this dominance by November. The Silver Oklabar, while at the bottom of the peck order, sired 32.18 percent of the total chicks. These data show that dominance among cocks may change. When this occurs, the number of chicks sired by the various males also changes in accordance with their new rank in the social order.

Simple correlation coefficients were calculated to find the relationship between the percent matings and the percent chicks produced by each hen and cock. The results are presented in Table 6. These data further substantiate the results of Guhl and Warren (1946). The dominant males are more successful in mating and sire the most chicks.

The interference of mating activity by other males in the same pen reduces the number of successfully completed matings. Interference as observed in this study is shown in Table 7. The dominance of the dubbed New Hampshire is evident from these data. The degree of dominance of the undubbed New Hampshire was less than that of the dubbed New Hampshire. After the freezing injury to the comb and wattles of the undubbed New Hampshire male, the undubbed Barred Plymouth Rock male interfered more often than previously with the mating activity of the other males. This accounts for his large number of interferences.

The Relation Between Mating Activity of the Hens and Their Egg Production from September 1 to March 31

A total of 919 matings were observed during the entire period, with an average of 10.4 per hen, and a range of 2 to 30. The 88 remaining hens laid an average of 97.4 eggs per hen from September 1 to March 31, with a range of 17 to 156. A simple correlation coefficient was calculated to determine the relationship between mating activity of the hens and egg production. A positive significant correlation coefficient of 0.2334 was obtained between mating activity and total egg production. This is in agreement with the work of Heuser (1916) and Lamoreux (1940), who reported that hens with a higher rate of production copulate more frequently than hens with a lower rate of production.

The Relation Between Egg Production from September 1 to March 31 and Fertility

The hens were arbitrarily divided into three groups, based upon their egg production: (1) 90 eggs and below (30 hens); (2) 91 to 120 eggs (34 hens); and (3) 121 eggs and up (21 hens). Simple correlation coefficients were calculated to find the relationship between egg production and fertility. The correlation coefficients for the three groups were: 0.0812, -0.452, and -.2549, respectively. The correlation coefficient for the 91 to 120 egg group was significant ($P > .05$). The total correlation coefficient was -0.1296. These results indicate that fertility is not intimately related to egg production. These data are not in agreement with Lamoreux (1940), who found that hens which laid 13 to 22 eggs during a six week period produced a larger proportion of infertile eggs than hens with a higher rate of production. However, Hays and Sanborn (1939) support the view that egg production of pullets to March 1 has little effect on their fertility.

The Relationship Between Mating Activity of the Hens and Their Fertility

To find the relationship between mating activity and fertility of hens, a simple correlation coefficient was calculated. In this study, the data from 87 hens were utilized. Their mating activity ranged from 2 to 30, with a mean of 10.4 matings per hen. The percent fertility ranged from 38.5 for a hen which mated seven times, to 100 percent for hens which mated 11, 5, 2, 2, 4, 24, 6, 10, and 17 times. The mean fertility for all hens was 88.6 percent. The correlation coefficient obtained was 0.0005. This indicates that there is no relationship between the number of times a hen mates and her fertility. The number of factors involved in the biological phenomenon of fertilization deems it unlikely that any single measure, such as mating activity of hens, would be related to fertility.

Duration of Fertility

The duration of fertility study was begun the day after removal of the males from the pens. The eggs were saved for twenty-eight days, incubated and checked for fertility. The results are shown in Tables 8 and 8a, and Figure 5. In Table 8 the number of eggs set, percent fertility, and the number and percent chicks sired by each dubbed male are presented. The same data are shown in Table 8a for the undubbed males. The data in Figure 5 are taken from Tables 8 and 8a to compare the percent of chicks by each male after his removal from the pen.

The peak in fertility after removal of the males from the pens was reached on the third and fifth days for the undubbed and dubbed lots, respectively. The average duration of fertility was 10.68 days, with a range of 4 to 17 days for the dubbed males. The average duration of fertility for the undubbed males was 10.83 days with a range of 2 to 16 days.

The socially dominant males in each pen produced the most chicks after their removal from the pen. Their duration of fertility was approximately one day longer than that of the other males. The proportion of chicks sired after their removal was comparable to the proportion sired before their removal. This indicates that selective fertilization or sperm competition were not involved in this study. However, insemination of composite samples of semen, of equal volume, from the three dubbed and undubbed males, would be necessary to substantiate this view.

Table 1

THE MATING ACTIVITY OF DUBBED AND
UNDUBBED MALES FROM 4 TO 5 P. M.

		N. H.		S. O.		B. P. R.	
Date	No. Observ-ations	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed
Sept. 15	1	3	8	2	2	1	1
Sept. 23	2	3	5	3	8	1	0
Oct. 7	3	3	5	0	1	0	0
Oct. 9	4	4	6	1	6	0	1
Oct. 11	5	0	3	0	3	0	1
Oct. 23	6	2	3	0	3	0	1
Oct. 25	7	2	2	0	3	0	1
Nov. 6	8	1	5	0	1	0	1
Nov. 8	9	4	2	0	3	0	0
Nov. 11	10	2	5	0	3	0	1
Nov. 20	11	6	4	0	3	0	2
Dec. 7	12	10	9	1	3	1	2
Jan. 13	13	8	11	1	1	1	0
Jan. 15	14	5	5	2	2	4	4
Jan. 27	15	10	4	3	6	4	5
Jan. 28	16	5	5	5	1	3	4
Jan. 29	17	3	3	2	5	3	1
Jan. 30	18	5	5	2	2	2	3
Jan. 31	19	3	4	2	1	2	2
Feb. 1	20	6	7	6	3	6	4
Feb. 2	21	7	0	5	2	6	5
Feb. 3	22	4	0	5	2	7	5
Feb. 4	23	7	1	4	4	6	8
Feb. 5	24	7	4	5	3	9	6
Feb. 12	25	6	1	5	6	4	8
Feb. 14	26	3	0	2	6	1	4
Feb. 15	27	3	1	3	3	4	4
Feb. 16	28	5	2	5	2	3	9
Mar. 14	29	7	2	2	2	4	7
Mar. 15	30	3	4	5	2	6	9
Mar. 16	31	2	3	4	2	3	5
Mar. 17	32	2	2	2	1	1	8
Total		141	121	77	95	82	112
Average		4.41	3.78	2.41	2.97	2.56	3.5

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 1a

ANALYSIS OF VARIANCE OF THE MATING ACTIVITY OF MALES

Source	Degrees of Freedom	Sum of Squares	Mean Square
Total	191	1158	- -
Observations	31	320	10.32
Between Males	5	94	18.80**
Error	155	744	4.80

F = 18.80/4.80 = 3.916**

** Significant P 7.01

Table 2

THE TOTAL NUMBER OF MATINGS FOR EACH SET OF BROTHERS

	N. H.		S. O.		B. P. R.	
	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed
No. Matings	141	121	77	95	82	112
Average	4.41	3.78	2.41	2.97	2.56	3.5
t value	1.00		1.191		1.397	

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 3

TOTAL NUMBER OF MATINGS AT DIFFERENT TEMPERATURES

	Below 20°F.	21-30°F.	31-40°F.	41-50°F.	51°F. & Up
Number Observations	5	5	7	9	6
Number Matings	107	97	172	189	74
Average	21.4	19.4	24.57	21.0	12.3

ANALYSIS OF VARIANCE OF MATING ACTIVITY
AT DIFFERENT TEMPERATURES

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Total	31	1891.0	- - -
Temperature	4	519.96	129.99
Error	27	1371.04	50.78

F = 129.99/50.78 = 2.56 Non-significant

Table 4

NUMBER OF MATINGS OBSERVED IN 32 DIFFERENT DAYS

NEW HAMPSHIRES

	20^{o}F.& Below		21-30^{o}F		31-40^{o}F.		41-50^{o}F.		51^{o}F. & Up	
No. Observations	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed
1	3	3	2	5	6	4	4	6	3	8
2	5	5	10	9	8	11	2	3	3	5
3	3	4	5	5	10	4	4	2	3	5
4	6	7	3	0	4	0	5	5	0	3
5	7	0	3	1	7	1	7	4	2	2
6					5	2	6	1	1	5
7					7	2	3	4		
8							2	3		
9							2	2		
Total	24	19	23	20	47	24	35	30	12	28
Average	4.8	3.8	4.6	4.0	6.71	3.43	3.89	3.33	2	4.67
$S_{\bar{x}}$	1.41		2.16		1.567		.81		.988	
t value	0.7092		0.278		2.093		.691		2.7024*	

* Significant $P > .05$

Table 4a

NUMBER OF MATINGS OBSERVED IN 32 DIFFERENT DAYS

SILVER OKLABAR

	20°F. & Below		21-30°F.		31-40°F.		41-50°F.		51°F. & Up	
No. Observations	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed
1	2	5	0	3	0	3	1	6	2	2
2	2	2	1	3	1	1	0	3	3	8
3	2	1	5	1	3	6	0	3	0	1
4	6	3	2	6	5	2	2	2	0	3
5	5	2	3	3	4	4	5	3	0	3
6					5	2	5	6	0	1
7					2	2	5	2		
8							4	2		
9							2	1		
Total	17	13	11	16	20	20	24	28	5	18
Average	3.4	2.6	2.2	3.2	3.33	3.33	2.67	3.11	0.83	3.00
$S_{\bar{x}}$	1.1		1.31		0.9725		0.92		1.195	
t value	0.7272		0.7633		0		0.4782		1.815	

Table 4b

NUMBER OF MATINGS OBSERVED IN 32 DIFFERENT DAYS

BARRED PLYMOUTH ROCK

	20°F.& Below		21-30°F.		31-40°F.		41-50°F.		51°F. & Up	
No. Observations	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed	Dubbed	Un-dubbed
1	3	1	0	1	0	2	0	1	1	1
2	2	3	1	2	1	0	0	1	1	0
3	2	2	3	4	4	5	0	0	0	0
4	6	4	1	4	7	5	4	4	0	1
5	6	5	4	4	6	8	9	6	0	1
6					3	9	4	8	0	1
7					4	7	6	9		
8							3	5		
9							1	8		
Total	19	15	9	15	25	36	27	42	2	4
Average	3.8	3.0	1.8	3.0	3.57	5.14	3.00	4.67	0.33	0.67
$S_{\bar{x}}$	1.056		0.97		1.55		1.54		0.408	
t value	0.7575		1.237		1.013		1.084		0.833	

Table 5

THE PERCENT FERTILITY AND THE NUMBER AND PERCENT CHICKS SIRED BY EACH DUBBED MALE

	N. H.		S. O.		B. P. R.		O. D. W.			
	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	Total Percent Fertility	Total No. Chicks
Sept. 25	58	66.7	8	9.2	4	4.6	17	19.5	87.85	87
Oct. 2	57	63.3	4	4.4	4	4.4	25	27.8	88.79	90
Oct. 11	84	77.8	2	1.85	0	0	24	22.2	93.44	110
Oct. 23	100	76.9	4	3.1	0	0	26	20.0	93.1	130
Oct. 30	52	85.2	2	3.3	0	0	7	11.5	98.6	61
Nov. 5	20	90.9	1	4.54	0	0	1	4.54	88.0	22
Nov. 20	35	83.3	2	4.76	0	0	5	11.9	85.71	42
Nov. 30	66	82.5	2	2.5	0	0	12	15.0	96.4	80
Jan. 22	70	62.5	26	23.21	16	14.29	--	--	96.83	112
Feb. 5	59	60.2	20	20.4	19	19.4	--	--	88.52	98
Feb. 12	77	66.4	14	12.1	25	21.6	--	--	90.9	116
Feb. 19	70	57.86	32	26.45	19	15.7	--	--	92.64	121
Feb. 26	77	63.1	26	21.3	19	15.6	--	--	82.7 *	122
Mar. 5	65	56.03	30	25.9	21	18.1	--	--	81.6 *	116
Mar. 12	87	69.05	31	24.06	8	6.35	--	--	82.46	126
Mar. 19	60	50.42	38	31.93	21	17.65	--	--	87.14	119
Total	1037	66.82	242	15.59	156	10.05	117	7.54	89.18	1552

* Clears not broken out

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock
O.D.W. = Oklahoma Dominant White

Table 5a

THE PERCENT FERTILITY AND THE NUMBER AND PERCENT CHICKS SIRED BY EACH UNDUBBED MALE

	N. H.		S. O.		B. P. R.			
Date Set	No.	Per-cent	No.	Per-cent	No.	Per-cent	Total Percent Fertility	Total No. Chicks
Sept. 25	40	45.9	34	39.1	13	14.9	92.23	87
Oct. 2	44	47.8	36	39.1	12	13.0	93.45	92
Oct. 11	64	49.6	42	32.6	23	17.8	90.9	129
Oct. 23	83	48.8	62	36.5	25	14.7	93.0	170
Oct. 30	67	54.9	39	31.9	16	13.1	91.4	122
Nov. 5	56	55.44	37	36.63	8	7.92	97.29	101
Nov. 20	100	52.1	82	42.7	10	5.21	97.37	192
Nov. 30	71	48.6	64	43.8	11	7.5	95.6	146
Jan. 2	73	54.48	33	24.63	28	20.9	90.97	134
Feb. 5	58	63.04	9	9.8	25	27.2	88.29	92
Feb. 12	43	33.07	35	26.9	52	40	84.8	130
Feb. 19	8	6.2	33	25.58	88	68.22	84.7	129
Feb. 26	0	0	46	38.6	73	61.3	66.7*	119
Mar. 5	3	2.8	46	43.0	58	54.2	73.3*	107
Mar. 12	33	25.4	24	18.46	73	56.15	88.41	130
Mar. 19	46	40.0	20	17.4	49	42.6	85.43	115
Total	789	39.55	642	32.18	564	28.27	88.16	1995

* Clears not broken out

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 6

CORRELATION COEFFICIENTS BETWEEN PERCENT MATINGS AND PERCENT CHICKS BY EACH HEN AND MALE

	N. H.	S. O.	B.P.R.	Number Hens
Dubbed Males	0.7416**	0.3719*	0.1933	44
Undubbed Males	0.5774**	0.3724*	0.4445**	42

* Significant (P > .05)
** Significant (P > .01)

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 7

THE NUMBER OF INCOMPLETED MATINGS DUE TO INTERFERENCE

Interfering Male	N. H.		S. O.		B. P. R.		Total	
	Dubbed	Undubbed	Dubbed	Undubbed	Dubbed	Undubbed	Dubbed	Undubbed
N. H.	--	--	15	11	22	8	37	19
S. O.	--	--	--	--	1	11	1	11
B. P. R.	1	4	2	19	--	--	3	23
Total	1	4	17	30	23	19	41	53

N. H. = New Hampshire
S. O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 8

DURATION OF FERTILITY IN THE PEN MATED WITH DUBBED MALES

No. Days	1	2	3	4	5	6	7	8	9
No. Eggs Set	22	18	20	25	24	23	22	24	20
No. Infertile	3	3	5	6	3	6	4	10	8
Percent Fertility	86.4	83.3	75.0	76.0	87.5	73.9	81.8	58.3	60.0
Total Chicks	19	15	15	17	20	17	18	14	12
No. N.H. Chicks	10	9	4	10	11	10	11	8	7
No. S.O. Chicks	4	3	6	3	4	5	4	3	1
No. B.P.R. Chicks	5	3	5	4	5	2	3	3	4
Percent N.H. Chicks	52.6	60.0	26.7	58.8	55.0	58.8	61.1	57.1	58.3
Percent S.O. Chicks	21.1	20.0	40.0	17.6	20.0	29.4	22.2	21.4	8.3
Percent B.P.R. Chicks	26.3	20.0	33.3	23.6	25.0	11.8	16.7	21.4	33.3

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 8 (Continued)

No. Days	10	11	12	13	14	15	16	17	Total
No. Eggs Set	19	22	21	18	24	19	20	22	363
No. Infertile	7	11	10	14	16	16	18	21	161
Percent Fertility	63.2	50.0	52.4	22.2	33.3	15.8	10.0	4.6	55.65
Total Chicks	12	11	10	4	8	3	2	1	198
No. N.H. Chicks	8	7	6	2	6	3	2	1	115
No. S.O. Chicks	0	2	3	1	1	0	0	0	40
No. B.P.R. Chicks	4	2	1	1	1	0	0	0	43
Percent N.H. Chicks	66.7	63.6	60.0	50.0	75.0	100.0	100.0	100.0	58.08
Percent S.O. Chicks	0	18.2	30.0	25.0	12.5	0	0	0	20.20
Percent B.P.R. Chicks	33.3	18.2	10.0	25.0	12.5	0	0	0	21.72

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 8a

DURATION OF FERTILITY IN THE PEN MATED WITH UNDUBBED MALES

No. Days	1	2	3	4	5	6	7	8	9
No. Eggs Set	14	22	22	24	21	22	18	23	23
No. Infertile	2	5	3	7	5	9	7	9	6
Percent Fertility	85.7	77.3	86.4	70.8	76.2	59.1	61.1	60.9	73.9
Total Chicks	12	16	19	17	15	13	10	14	16
No. N.H. Chicks	4	7	8	4	4	5	3	7	7
No. S.O. Chicks	3	2	2	3	1	2	1	1	3
No. B.P.R. Chicks	5	7	9	10	10	6	6	6	6
Percent N.H. Chicks	33.3	43.8	42.1	23.5	26.7	38.5	30.0	50.0	43.8
Percent S.O. Chicks	25.0	12.5	10.5	17.6	6.7	15.4	10.0	7.1	18.8
Percent B.P.R. Chicks	41.2	43.8	47.4	58.8	66.7	46.2	60.0	42.9	37.5

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

Table 8a (Continued)

No. Days	10	11	12	13	14	15	16	Total
No. Eggs Set	16	32	19	18	23	24	17	338
No. Infertile	8	20	12	13	20	22	15	163
Percent Fertility	50.0	37.5	36.8	27.8	13.0	8.3	11.8	51.78
Total Chicks	8	12	7	5	3	2	2	171
No. N.H. Chicks	3	3	2	1	0	0	0	58
No. S.O. Chicks	1	0	0	0	1	0	0	20
No. B.P.R. Chicks	4	9	5	4	2	2	2	93
Percent N.H. Chicks	37.5	25.0	28.6	20.0	0	0	0	33.92
Percent S.O. Chicks	12.5	0	0	0	33.3	0	0	11.7
Percent B.P.R. Chicks	50.0	75.0	71.4	80.0	66.7	100.0	100.0	54.39

N.H. = New Hampshire
S.O. = Silver Oklabar
B.P.R. = Barred Plymouth Rock

FIGURE 1

THE PERCENTAGE DISTRIBUTION OF MATINGS EACH HOUR OF THE DAY (FOUR DAYS)

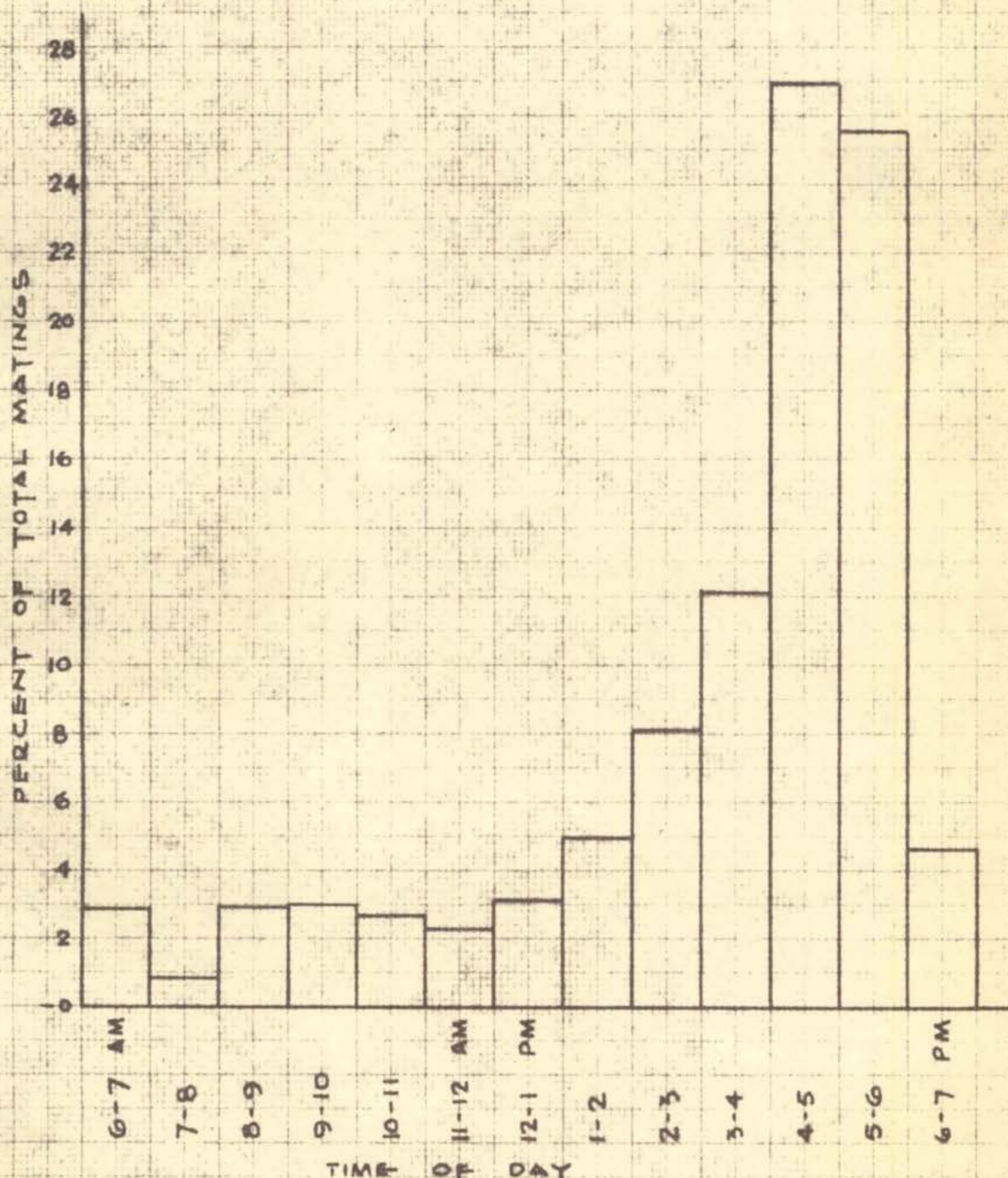


FIGURE 2

INFLUENCE OF ENVIRONMENTAL TEMPERATURE ON MATING ACTIVITY OF MALES.

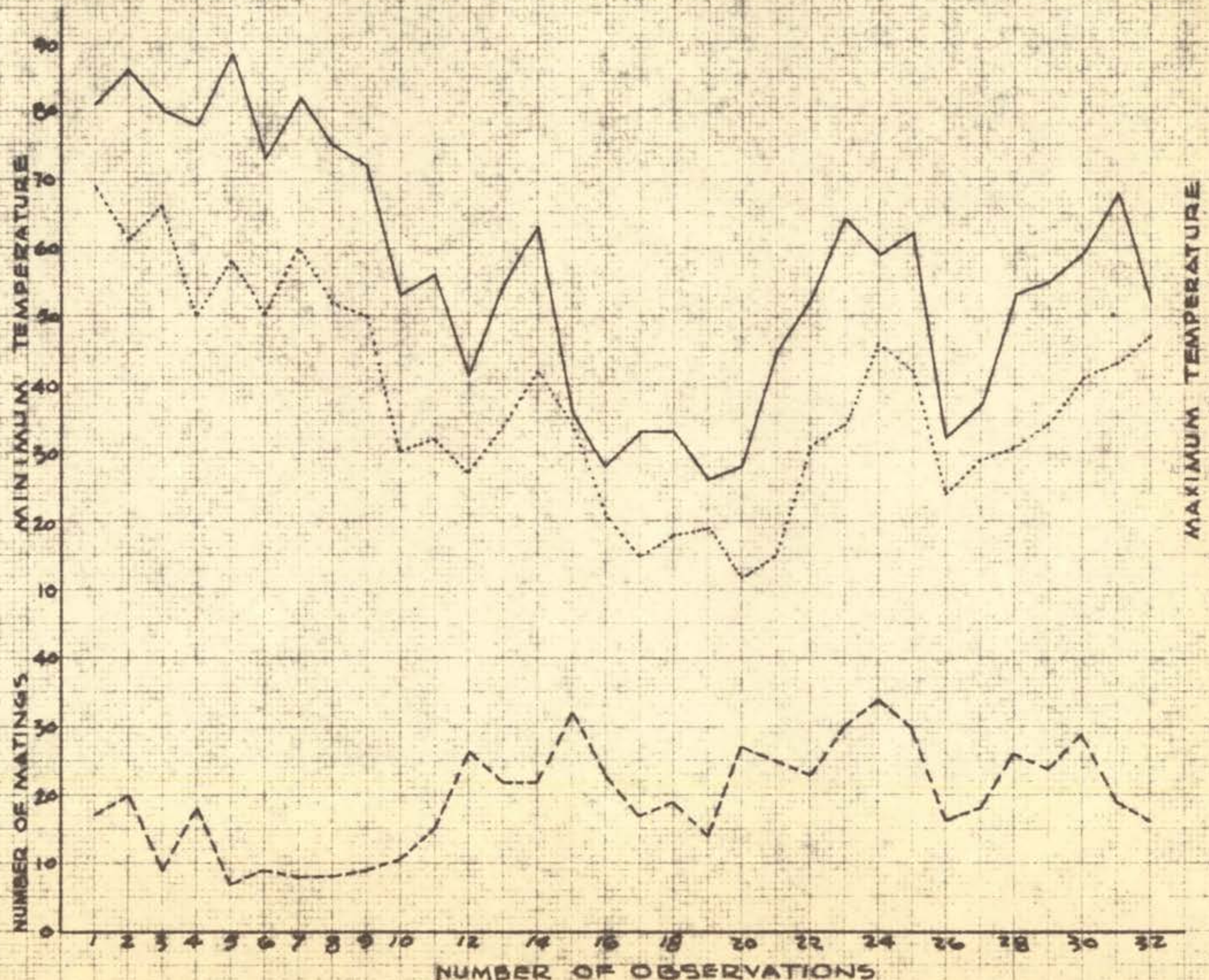


FIGURE 3
THE PERCENT FERTILITY IN EACH PEN & THE PERCENT CHICKS SIRED BY EACH MALE IN THE DUBBED & UNDUBBED GROUP

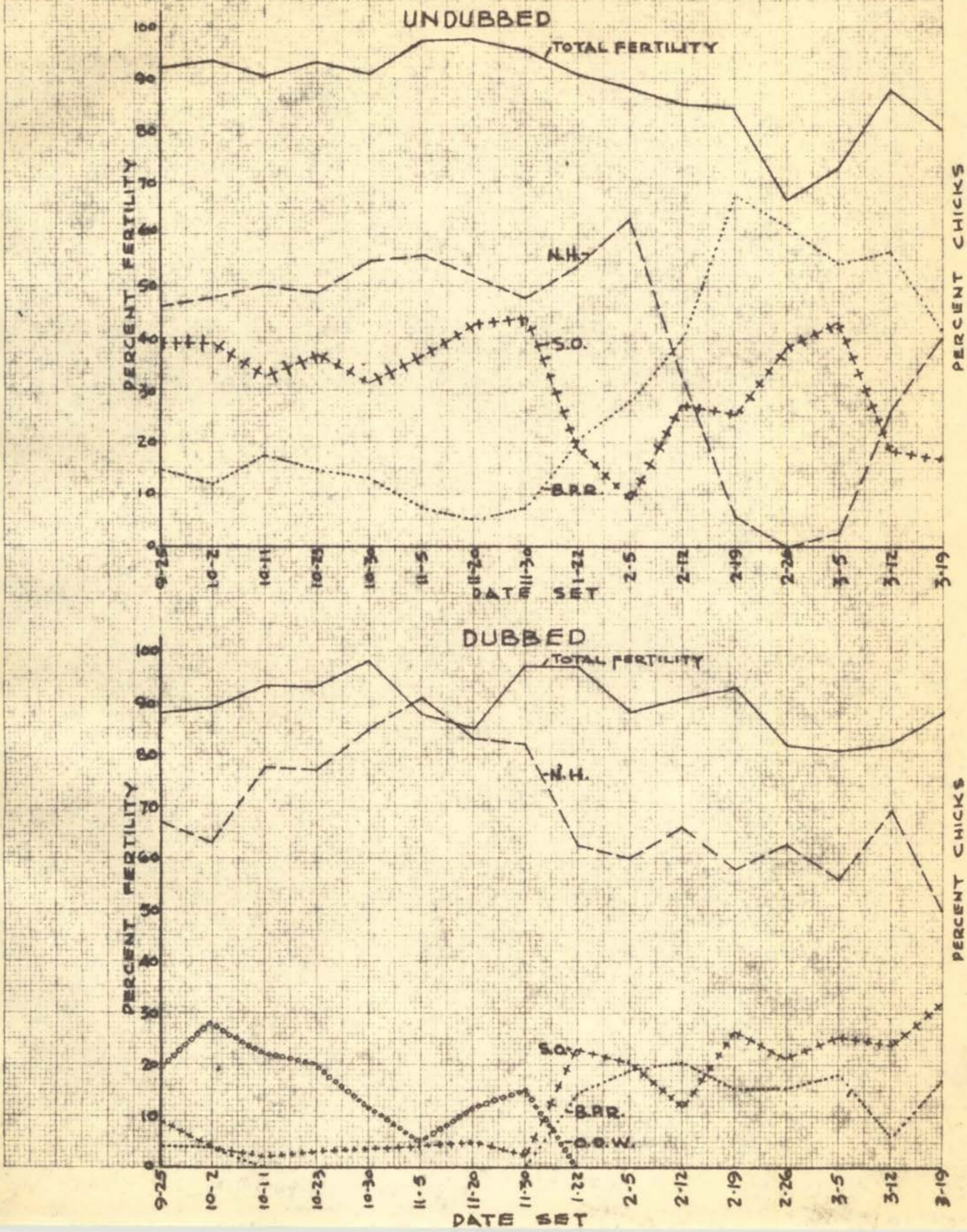


FIGURE 4
MINIMUM TEMPERATURE AND ITS EFFECT ON THE NUMBER OF MATING ATTEMPTS

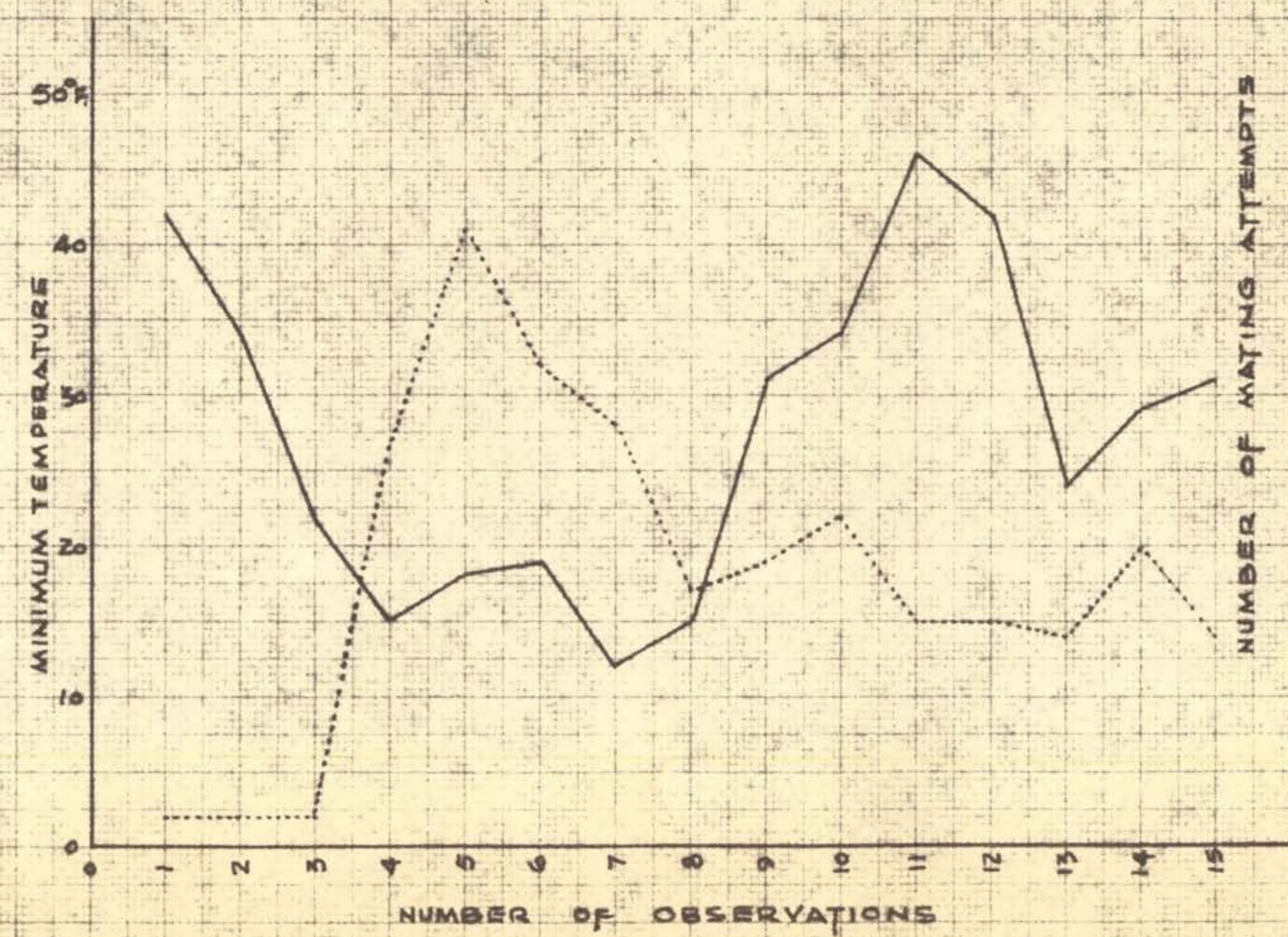
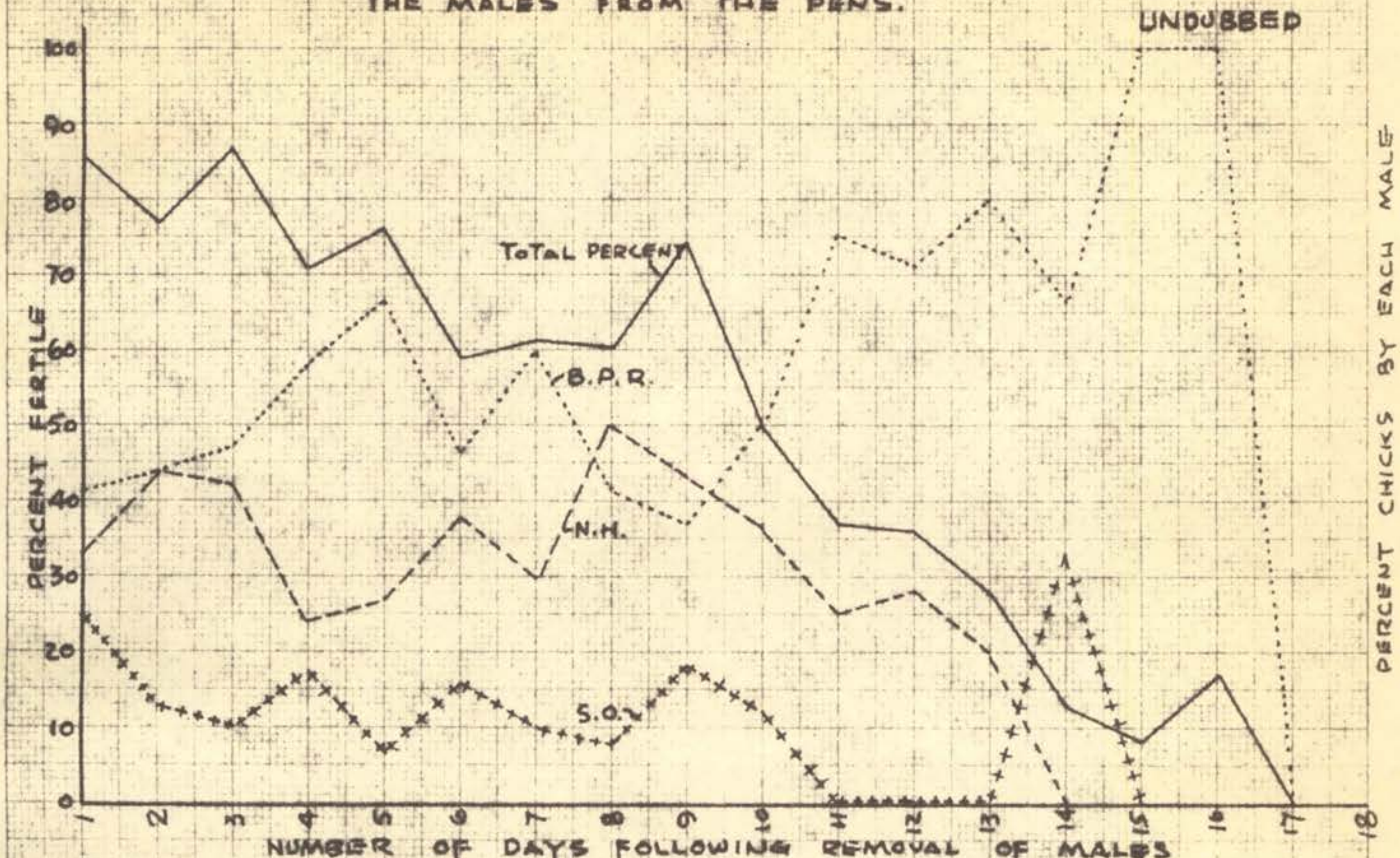
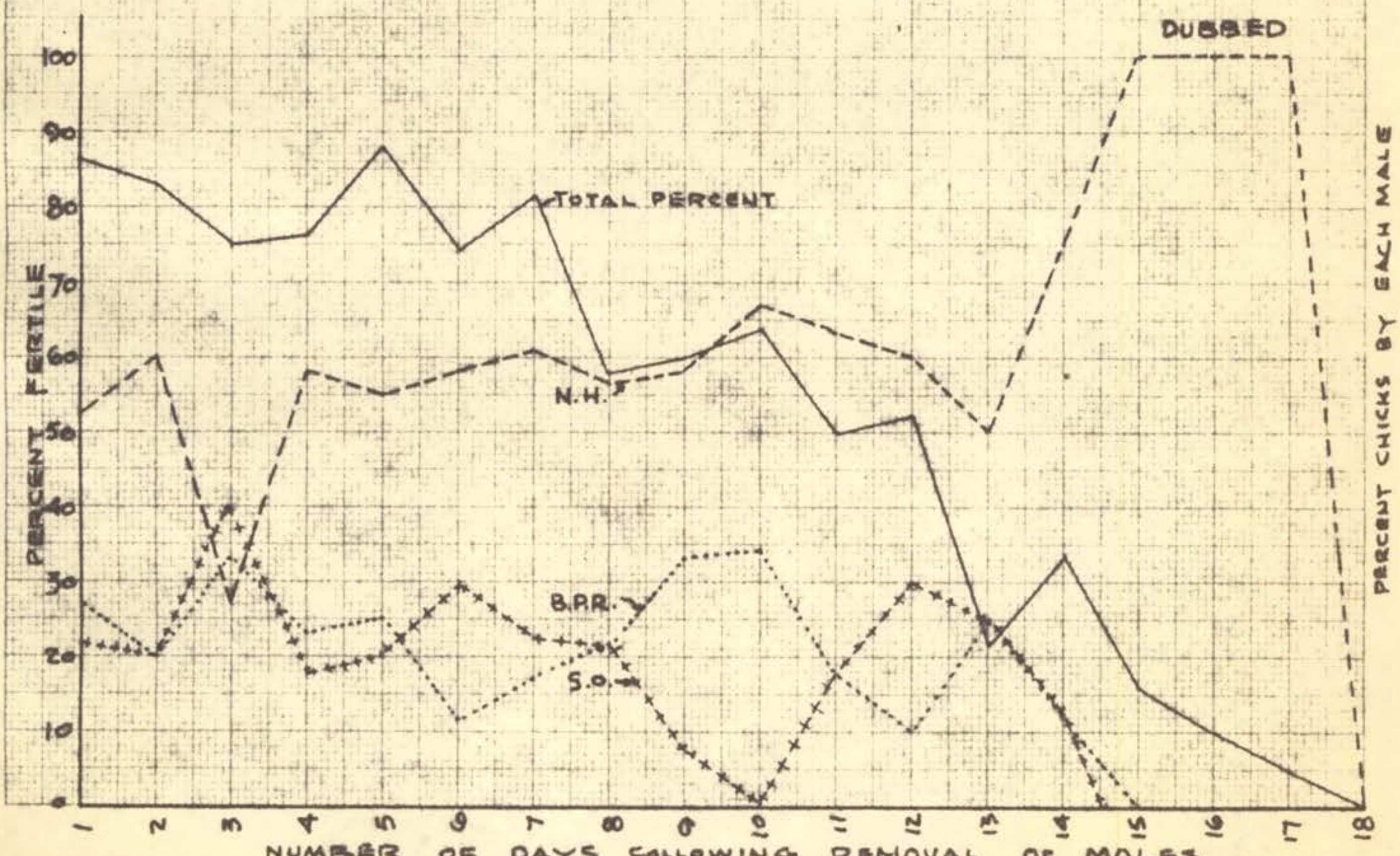


FIGURE 5

THE DURATION OF FERTILITY OF THE UNDUBBED AND THE DUBBED GROUP AND THE PERCENT CHICKS SIRED BY EACH MALE AFTER REMOVING THE MALES FROM THE PENS.





DISCUSSION

The results of observing mating activity for four days show that the greatest number of matings occur between 4 and 5 P.M. This substantiates the work of Heuser (1916), Philips (1918), and Parker et al. (1940). The specific reason or reasons why the peak of mating activity occurs late in the afternoon are not known. Moore and Byerly (1942) reported that highest fertility was obtained when hens were inseminated immediately after laying and when there was not a hard-shelled egg in the uterus. The fact that most hens have laid by 4 P.M. and do not have a hard-shelled egg in the uterus at that time of day, may have an influence on the time of mating.

The results of this study indicate that dubbing has little effect on mating activity of males or their fertility unless the temperature is low enough to freeze the comb and wattles of undubbed males, in which case the fertility of dubbed males is higher. The results in Table la provide evidence of a difference in mating activity of the different males. However, the social rank was such that the males did not have an equal chance to mate. The data provides evidence that the differences may have been characteristic of the breeds used. A possible explanation is that New Hampshires attain sexual maturity at a younger age than the other breeds used.

The similar behavior in mating activity of full and half-brothers may have been due to their comparable positions in social rank, as well as to their genetic relationship.

Temperature, with one exception, had little effect on the mating activity or fertility. The one exception was the undubbed New Hampshire male. His comb and wattles were injured by freezing. He lost his supremacy in mating and never fully recovered his former position. His fertilizing capacity was severely curtailed for approximately two weeks. There probably is a differential response to environmental temperatures by males. The other undubbed males were not injured at the same temperature as was the undubbed New Hampshire male. There was a sharp decline in fertility of the undubbed group as a result of the inactivity of the New Hampshire. The cold temperatures apparently had no effect on the mating activity or fertility of the other undubbed males, or the dubbed group.

The negative correlation coefficients (0.416; 0.414) between minimum and maximum temperature and mating activity indicate that matings may increase during low temperatures and decline when the temperature gets warmer. This might be one factor contributing to low fertility during the hot summer months.

The socially dominant males were most successful in mating and sired the most chicks. In view of the fact that dominance among males may change, it would seem wise for the poultryman to study the social rank of males regularly and replace those males at the lower end of the "peck order".

The dubbed New Hampshire male was more active in preventing matings by the other males than was the undubbed New Hampshire male. The reverse was true with the Barred Plymouth Rock males. This difference cannot be explained as a result of dubbing, but possibly was due to the variation in aggressiveness. It could be possible, however, that if a male was overly aggressive, and interfered with the other males to the detriment of his own mating activity, he could be a contributing factor to low fertility because of his "super" aggressiveness.

Egg production was related to the mating activity of hens. There was little relationship between egg production and fertility of hens, contrary to the view of Lamoreux (1940). However, Hays and Sanborn (1939) found no relationship between fertility and egg production to March 1. The conflicting results of these investigators might be due to the different periods of egg production used in their studies. This study was similar to the one by Hays and Sanborn (1939) and it compares favorably with their results. No logical explanation for these discrepancies is at hand.

The mating activity of the hens was not correlated with their fertility. At first thought this may be rather surprising, but if one considers all of the physiological factors involved in fertilization, it ceases to be perplexing.

There appears to be little relationship between mating activity and duration of fertility of hens. However, sperm from the socially dominant males persisted longer in the oviduct than sperm from the other males. This seems to be another example of the complex physiological processes involved in fertilization.

Hens varied from 2 to 17 days in their duration of fertility. After removal of the males, one hen laid 12 eggs in 16 days, 11 of which were fertile; the one infertile egg being laid on the fifteenth day. This hen was observed to mate 13 times. Another hen was observed to mate 21 times, and her duration of fertility was only 3 days. Chicks from both hens were sired by the same male. The egg production of the two hens was comparable. This indicates that the male was not at fault. What condition of the oviduct permits sperm to live for long periods in some hens and for only short periods in other hens? If there is such a factor present, is it genetic or environmental in nature? The answers to these questions would be of great value to breeders.

The frequency of mating by males may be so intense that it will result in a larger proportion of dead or weak sperm than those with less libido (Payne et al. 1930). The results of Parker et al. (1940) suggest that a male can successfully fertilize in a day, relatively few hens, and not 17 to 24. The hens which mate before the number of sperm ejaculated drops below one million should have a longer duration of fertility than hens which mate after the sperm concentration is less than one million per ejaculate. If a male distributed his matings randomly, he should, over a period of 3 to 5 days, fertilize a large proportion of the eggs from 20 to 30 hens. That there is a trend toward fewer males per 100 hens is evident from the investigation by Parker and Bernier (1950). They recommended 6 to 7 males as compared to the old recommendation of 8 to 9 males per 100 hens.

Further investigation is necessary to determine if the difference in the duration of fertility of hens is environmental or hereditary. Investigations are also needed to find if there are breed or strain differences in the male's ability to adequately fertilize the eggs from a large number of hens.

SUMMARY AND CONCLUSIONS

The effect of temperature, dubbing, and rank in the social order on the mating activity of males was investigated. From this study of 628 observed matings, 328 by the undubbed and 300 by the dubbed males, the following conclusions may be drawn:

1. The peak in sexual activity of the males was from 4 to 5 P.M. The period of least sexual activity was from 6 A.M. to 1 P.M.
2. Dubbing had little effect on the mating activity of males.
3. Dubbing had little effect on fertility of males.
4. There were no differences between the mating activity of the full and half-brothers used in this study.
5. Injury to the comb and wattles of one male by freezing reduced his mating activity for 5 days and subsequently no chicks were sired by him for approximately 10 days.
6. There was no evidence of reduced mating activity by males at low temperatures unless the comb and wattles were injured by freezing.
7. There was no difference in the mating activity of the full and half-brothers used in this experiment at different temperature ranges.
8. There was evidence that low temperatures increased mating activity.

9. The socially dominant males were most successful in mating and sired the most chicks.
10. The best layers mate more frequently than do the poor and mediocre layers.
11. The observed mating activity of hens was not related to their fertility.
12. The average duration of fertility after the males were removed from the pens was 10.68 days for the dubbed males and 10.83 for the undubbed group.
13. The dominant male of each group had the longest duration of fertility.
14. The proportion of chicks sired by males after their removal from the pens was approximately the same as before their removal.

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THESIS TITLE: The Effect of Dubbing, Ambient Temperature and Social Dominance on Mating Activity and Fertility in the Domestic Fowl

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THESIS ADVISER: George F. Godfrey

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