THE EFFECT OF VARIOUS TYPES AND INTENSITIES OF ELECTRIC LIGHTS ON THE EGG PRODUCTION OF PULLETS
and
THE EFFECT OF LIGHT RATIONING ON THE EGG PRODUCTION OF PULLETS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY

Charles Evans Ostrander

1960

THE EFFECT OF VARIOUS TYPES AND INTENSITIES OF ELECTRIC LIGHTS ON THE EGG PRODUCTION OF PULLETS

and

THE EFFECT OF LIGHT RATIONING ON THE EGG PRODUCTION OF PULLETS

By

Charles Evans Ostrander

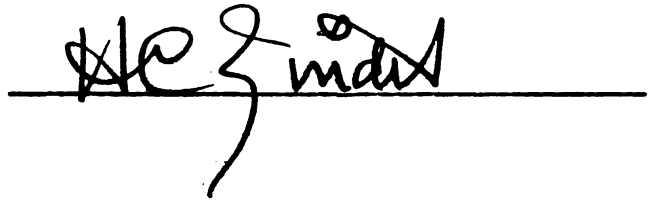
AN ABSTRACT

Submitted to the College of Agriculture
Michigan State University of Agriculture
and Applied Science in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

DEPARTMENT OF POULTRY SCIENCE

1960

Approved 

ABSTRACT

Poultry lighting has been used to stimulate egg production since late in the nineteenth century. Dr. E. C. Waldorf of Buffalo, New York, did some of the first recorded research on stimulation of egg production by use of artificial light.

For many years the standard recommendation has been to provide a 13 - 14 hour day, using a 40 watt bulb in a 16 inch reflector, suspended six to seven feet above the floor, for each 200 square feet of floor area.

During the past few years some claims have been made that egg production could be increased by increasing the light intensity visible to the human eye or by using various newer types of luminaries. It has been thought by many poultrymen and others in the poultry field, that egg production was increased when lights were turned on during dark days.

A more recent recommendation to increase egg production has been to restrict the light during the growing period and then increase the length of day by gradually increasing the lighting period throughout the laying period. When careful observation appeared not to substantiate some of these claims, it was decided to test them under carefully controlled conditions. These tests were conducted

over a period of three years - 1957-58, 1958-59 and 1959-60. Four different types of luminaries were tested, including the R-30, a 75 watt conical type reflectorized incandescent bulb; the "Birdseye 60," a 60 watt incandescent bulb reflectorized in the upper half; a 40 watt fluorescent light and the conventional 40 watt bulb in a 16 inch reflector. Each test was replicated and it was found that production differences were not significant when tested by the "t" test or the coefficient of variance. No one type appeared to produce more eggs than the other when a 13½ hour light period was supplied.

The effect of various intensities of light on egg production was also tested. Four variations, including the regular 60 watt incandescent bulbs, 40 watt fluorescent lights, 100 watt incandescent bulbs and 15 watt red bulbs[1], were tested. Again, no significant effect on egg production was shown by any of the treatments.

From this work, it appears that a 40 or 60 watt incandescent bulb for each 200 square feet of floor area is sufficient for maximum egg production. The 15 watt red bulbs give sufficient red rays for maximum stimulation if suspended 18 inches over the heads of the birds on the roosts.

Turning lights on during dark days was tested by mounting photo-electric cells in the pens to turn on the lights whenever the intensity dropped below a certain point.

---

[1] Suspended 18 inches over the birds' heads on the roosts.

While this technique gave a slight increase in egg production, it was not significant when checked by the previously mentioned tests. The increase did not appear to justify the purchase of the photo-electric cell or the cost of the extra electricity used. The photo-electric cell increased egg production 1.3 eggs per bird above the controls over a six months period. At three cents per egg this gives an increase of 3.9 cents per bird. The extra cost for electricity, at 2¢ per kilowatt, used during dark days was 3.7 cents per bird leaving a balance in favor of the photo-electric cell of .2 cent per bird per year not figuring the cost of the photo-electric cell or installation.

When checking the use of rationed light, starting at six hours per day and increasing 15 minutes per week, it was found that the controls produced 13 more eggs per bird than the light rationed birds. The controls were given a 14 hour day throughout the laying year. When checked by the "t" test and the coefficient of variance, there was found to be no significant difference.

Observations from the tests were that:

1. There was no difference in production from any of the various types of luminaries used.
2. a) There was no benefit from using intensities higher than those produced by a 40 watt bulb in a 16 inch reflector.
   b) Egg production was just as satisfactory

when 15 watt red bulbs were placed 18 inches over the birds' heads as from any other treatment used.

3. Rationing light during the growing period and laying period had no beneficial effect on egg production.

From these observations it was concluded that the standard recommendation, using a 40 watt bulb in a 16 inch reflector, or its equivalent, for each 200 square feet of floor space is as satisfactory as any other type or system of lighting tested.

THE EFFECT OF VARIOUS TYPES AND INTENSITIES OF ELECTRIC LIGHTS ON THE EGG PRODUCTION OF PULLETS

and

THE EFFECT OF LIGHT RATIONING ON THE EGG PRODUCTION OF PULLETS

by

CHARLES EVANS OSTRANDER

A THESIS

Submitted to the College of Agriculture
Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

DEPARTMENT OF POULTRY SCIENCE

YEAR 1960

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Professor C. N. Turner of the Agricultural Engineering Department at Cornell University who has worked very closely with him on this research project and to Dr. J. H. Bruckner, Head of the Poultry Department at Cornell University, for providing the facilities for the tests and his guidance, advice and encouragement during the time the work was carried on.

He is also indebted to Dr. H. C. Zindel, Head; Dr. R. K. Ringer; and Dr. T. H. Coleman of the Poultry Science Department, Michigan State University, for their continued advice and guidance during the preparation of this thesis.

Grateful acknowledgement is due Dr. W. D. Baten, Agricultural Statistician, for his help in analyzing the results statistically, Mrs. Carol Hall for her clerical help, J. B. Ward for the photographic work and E. H. Farmer for his assistance in arrangements.

Above all, the author is indebted to his wife Gracia for her constant interest and encouragement and for her assistance in the preparation of this thesis. Finally, the author is grateful to his two daughters Linda and Marcia for their understanding and patience during the preparation of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

INTRODUCTION

The first recorded investigation of providing artificial light for poultry flocks in the United States was conducted late in the nineteenth century. From this work by Dr. E. C. Waldorf (1889) it was concluded that artificial light increased egg production and the increase came about because of the increased feeding period. Early in the twentieth century, artificial lights in poultry houses became widely used to increase egg production but even then, no one suspected that the benefit came from stimulation of the pituitary gland.

There have been many claims for various lighting systems, types of lights and intensities of lights during the past several years. Most of these claims were unfounded because they had not been checked and tested scientifically. Nevertheless, many of the schemes were adopted by poultrymen who have used them throughout the years. For many years, poultrymen have been using all-night lights with little or no knowledge of benefit or harm or proof of more egg production. Poultrymen have used high intensity lights but have had no proof of the benefit from this action. Likewise, they have been using fluorescent bulbs, even with their high initial costs, with no assurance of increased egg production. It has been a common practice to turn on

the lights in poultry pens during dark days and some poultrymen are now using photo-electric cells to do this for them. No one had apparently checked to see if this technique was of any value or if it actually increased egg production as it was claimed. Recently, various lighting systems which were supposed to increase egg production measurably have been promoted in the popular press and by other means. Some poultrymen remodeled their poultry houses to adopt these new systems without ascertaining if the claims were founded.

When poultry was a backyard or sideline enterprise, it made little difference what system of lighting was used, as far as cost was concerned. Now that poultry is a major enterprise, where flocks may consist of thousands of birds, lighting is becoming a major cost. It is not uncommon today to find electric bills varying from $100 per month to several hundred dollars per month on poultry farms. With figures of this magnitude, it is important that the money spent bring maximum returns. If high intensities will increase egg production, the extra cost can then be justified; but if no benefit is obtained, this practice should be discouraged. This is also true of various types of lights and lighting systems.

Due to some of the unfounded claims for various lighting schemes, it was decided to test some of the lighting practices scientifically in order to obtain the facts. Several tests were designed to check various types of

lights for poultry houses and various intensities of light to find the effect on egg production. Plans were also made to check the profitability of turning on lights during dark days. Further tests were designed to check systems of lighting, particularly the rationing of light, to see if they had an effect on egg production. These tests were conducted over a three year period and consisted of large enough flocks to be of practical significance. Each test was replicated to increase its validity and value. The tests were set up to measure egg production, feed per dozen eggs, mortality and in some instances egg size and cost of operation.

REVIEW OF LITERATURE

There were a few people who foresaw the benefit from artificial light to increase egg production in poultry even back in the eighteen hundreds. The first recorded work in the United States was done by Dr. E. C. Waldorf in 1889 at Buffalo, New York, as reported by The Reliable Poultry Journal Publishing Company (1920). Dr. Waldorf was a practicing physician and a student of natural sciences. He found that if lights were turned on at unexpected moments, the chickens were disturbed. He devised an automatic time-trip and patented it as the "Waldorf Chronometric Adjuster". The light that Dr. Waldorf used was produced from gas. He used four 100 candle power Argand brass burners. These were suspended from the ceiling one foot from the outside edge of the building and five feet from the floor. Each burner was equipped with a reflector that reflected the light down and to the back of the house. The lights were turned on at 3:30 A.M. and off at 7:30 A.M. and then turned on again at 5:00 P.M. and off at 8:00 P.M. allowing a 16½ hour day. Dr. Waldorf and other early workers with artificial light thought the benefit therefrom to be the result of increased exercise and increased intake of feed and water.

J. P. Jordan (1920) made the following statement.

"What if you had to go to bed at half past three or four o'clock on a winter afternoon, your food all digested by ten or eleven o'clock, and then you had to huddle yourself up as best you could until 7:30 or 8:00 before you could see to eat again? You, too, would become discouraged with life, contract all diseases born of weakness and fail to produce your share of the interests of life which you otherwise produce if you were given the opportunity."

Professor James E. Rice (1920) stated that we could overlight laying hens and cause them to lay so heavily they would break down. He indicated that 12-14 hours of light is best and safe. "If light is provided so hens have more than a 14 hour day, it is dangerous to their well-being." Professor Rice published elaborate colored graphs in 1918 showing the time of lighting laying hens and the production from various lighting periods.

Results from one of the first practical tests in the field were published by the Reliable Poultry Journal Publishing Company in 1920 on a flock of 420 Single Comb White Leghorns at the Hillcrest Farm, Orchard Park, New York. They showed that lighted birds laid at the rate of 51.2 percent and the unlighted birds laid at the rate of 17.7 percent from January 10 through February 10.

J. E. Daugherty (1927) stated that lights should not be used for breeders. He further claimed that it would be of little value to bring the birds off the roosts on cold mornings without food and water. Daugherty indicated that

a 100 watt bulb in a commercial reflector gave better results with more intensity than using two 50 watt bulbs in homemade reflectors.

Professor R. T. Parkhurst, of England (1930), reported that May hatched pullets laid 3% more eggs when lighted than when not lighted. He indicated the most important factor was that the largest production came when eggs were highest in price, thereby increasing total income. Professor Parkhurst is credited with saying that lighting was "not primarily a method of increasing egg production but changing the season of production to a time when eggs are highest in price."

Elizabeth Whetham (1933) reported that the change in ration of light was probably more important than the absolute amount. She indicated that the effect of all-night lights or long periods of light wears off. Back in 1933, Whetham suggested the possibility of stepping up the length of light periods but never reported doing it. Whetham suggested that low producers (inherently) received more effect from light than high producers. Whetham also suggested that we may find other spectral rays more effective than those from electric lights.

Experimental work in 1941 by Roberts and Carver concluded that 13 hours of light satisfies optimum requirements for egg production.

Egg production is stimulated by the stimulation of the pituitary gland. Sturkie (1954) reporting work by Benoit

(1937 and 1950) stated that irradiation of the head and eyes stimulates the pituitary, but when the head and eyes are covered and other parts of the body irradiated, the hypophysis is not stimulated. When the eyes are enucleated and light is introduced only through the orbit by way of a quartz rod, the pituitary is stimulated. The hypophysis can also be stimulated by irradiating the head even when the optic nerves are cut and also by stimulating directly the hypothalamus and hypophysis with light.

Ultraviolet and other rays:

Hughes et al. (1925) exposed hens, on vitamin D deficient diets, to ultraviolet rays and received four times as many eggs in five months from these hens as from the groups of hens not exposed to ultraviolet rays. On the other hand, Mussehl and Yung (1942) exposed hens to ultraviolet rays and obtained the same number of eggs as when conventional fish oils were used in the ration.

G. E. Kable and F. E. Fox (1928) of the Oregon State Experiment Station reported that using carbon arc lights, supplemented with a 50 watt incandescent lamp, increased egg production and decreased mortality. The control pen had two 50 watt incandescent lamps. Mortality under the arc lamps was 10.4% and mortality under the control lamps was 26.6% during a five month period. They also reported better shell strength under the arc lights. The cost of electricity for the arc operation was $11.25 and $14.40 for the arc carbons, for a total of $26.65 over a six month

period compared to $2.75 for the two 50 watt Mazda lamps. They did not report the production obtained.

Barrott, Schoenleber, and Campbell reported in 1951 that light is generally thought of as being radiation which is visible to the human eye (light waves of 4000 - 8000 Angstrom units).[1] Below 4000 Angstrom units are the ultraviolet waves which are not visible. These waves kill bacteria, produce sun burn and fluoresce certain material.

1.	Bactericidal	2000 - 2800 Angstrom units
2.	Erythemal or Suntan	2800 - 3200 Angstrom units
3.	Black light	3200 - 3800 Angstrom units

Vitamin D is activated by the erythemal band 2 which peaks at 2967 Angstrom units.

In a five year test, Barrott et al. (1951) exposed hens to ultraviolet rays and obtained 10% to 19% more eggs than from the controls (not exposed). The controls received no daylight or ultraviolet rays but did receive artificial light consisting of 12 foot candles[2] under 40 watt white

---

[1]Angstrom unit is a measure of light waves. One Angstrom unit is one ten thousandth of a micron.

[2]A foot candle, as described by T. E. Hienton, D. E. Wiant and O. A. Brown, in Electricity and Agricultural Engineering, is "the unit of illumination equal to illumination of a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illumination produced at a surface all points of which are at a distance of one foot from a uniform point source of one candle." The new candle is defined as, "one sixteenth of the intensity of one square centimeter of a black body radiator at the temperature of the solidification of platinum (2046° Calvin)."

fluorescent lights for a 14 hour day (They did not report if this fluorescent light gave any red rays). A 15 watt filament light burned continuously in the pens with the exposed birds. All birds had adequate vitamin D in the ration. Additional vitamin D in ration gave no increase in egg production. Exposure to rays longer than ultraviolet but shorter than visible rays gave no increase in egg production. They concluded that ultraviolet rays peaking at 2537 Angstrom units gave stimulatory effects on egg production.

Intensity of light:

Bissonnette (1931), working with starlings, showed that rate of acceleration of spermatogenic activity increased with intensity of light to a certain point. He showed that 10 watts gave the least activity with an increase up to 40 watts. He received no increase above 40 watts. On the other hand, Whetham (1933) indicated that light ration was more important than intensity. Nichols, Callenbach and Murphy (1944) showed no difference in production with intensity from 0.5 to 38 foot candles. They found some evidence of a very intense light causing more trouble from pick-outs. These men also reported no relation between light and egg weight and no relation between light and mortality.

Barrott and Pringle (1951) tested the effect of light intensity on growing chicks. They tested intensities from .1 foot candle to 24 foot candles and concluded that any-

thing above one foot candle was not necessary for good growth. They reported less growth when 12 - 24 foot candles were used. In their tests they also used white, red, blue and green light and found no differences in growth rate attributable to color of lights.

Rider (1938) suggested that rearing chickens in darkness did not delay sexual maturity.

Tomhave (1954) reported that maturity and production are separate processes and that intensity of light during the growing period had little effect on later production.

Dobie et al. (1946) tested intensities from 1.0 foot candle to 31.3 foot candles at the feeders and found no increase in production from the use of intensities above 1.0 foot candle. They also found no difference in production between birds receiving light from ultraviolet, ruby red, and red fluorescent lights. These workers found no increase in production when more than 13 hours of light was provided but they did conclude that at least 13 hours of light was required for optimum egg production.

Bissonnette (1933) found that low intensity red light gave just as much stimulation for egg production as high intensity white light. He did not report stimulation from low intensity green or violet light, however. Sunlamps were less effective than incandescent lamps.

Skaller et al. found that the threshold of light intensity to maintain production is below one foot candle over the feeders.

Platt (1953) showed that 15 watt red lights 18 inches over the heads of the birds gave egg production equal to that secured from the use of 40 watt bulbs over the work area and much better than that secured when no lights were used. The lights were 4 feet o.c.[3] over the center of the perches. There was no more than 36 inches from any light to the perch. These pens were lighted from 8 P.M. to midnight, from 8 P.M. to 4 A.M. and from 6 P.M. to 6 A.M. A fourth group was lighted with 60 watt incandescent lights with one bulb for each 200 square feet, from 3 A.M. to sunrise. The birds in the control pen received no supplementary light.

The results obtained by Platt were as follows:

	No Art. light	RED LIGHT 4-8 P.M.	RED LIGHT 8 P.M.-4 A.M.	RED LIGHT 6 P.M.-6 A.M.	WHITE LIGHT 3 A.M.-daylight
		Percent Production			
September	56.9	64.3	61.9	63.3	62.7
		Artificial light started on 10/5			
October	61.7	68.3	69.8	74.8	70.5
November	53.2	66.6	72.4	68.8	64.0
December	50.2	63.3	73.3	70.7	57.6
January	39.2	54.5	67.5	57.8	59.5
February	34.3	53.7	64.8	58.3	59.4
AVERAGE	49.2	61.8	68.3	65.4	62.3

Platt concluded that if red light is used, it must be dim for if it is too intense, the birds leave the roost. Then

[3] On Center (from the center of one to the center of the next one).

they are too far from the light source to absorb red rays and no stimulation of the pituitary gland takes place. He also concluded that eight hours of stimulation gave best results. With less than this amount, production decreased and above this there was no benefit. Four hours of red light gave results equivalent to those obtained with a 14 hour day using incandescent light.

Jensen and Matson (1957) reported that continuous light on chicks produced chicks with eyeballs 38% larger than those of chicks receiving only 12 hours of light.

Lighting chicks and its effect on egg production:

Mueller et al. (1951) showed growth to 8 weeks of age was most rapid in chicks exposed to atmospheric conditions outside the hover. Chicks given constant levels of light (12 hours daily) made up the difference in weight by 12 weeks of age. This agreed with results by Clegg and Sanford (1951) who used lights that were on for 6 hours and off for 6 hours, on 12 hours and off 12 hours, and on 2 hours and off 2 hours. The test where 2 hours on and 2 hours off was used gave by far the best growth, with 6 hours on and 6 hours off being next best. They concluded the increased growth was from extra feeding periods and not from light stimulation.

Barrott and Pringle (1951) observed that 12 hours of light and 12 hours of dark gave 71% of the growth obtained from 1 hour of light and 3 hours of dark. Three hours of light and 3 hours of dark gave 87% of the growth obtained

from 1 hour of light and 3 hours of dark. They concluded that the number of feeding periods was important but not the only factor affecting efficiency. Jordan (1920) found that if feeding periods were too close, chicks did not feed fully each period. He concluded that feed periods should be timed so that the crop is emptied between each successive period and the feed period needs to be only long enough for the bird to fill the crop again. The dark period should not be so long that the chick becomes excessively hungry between feedings.

Tomhave (1954) reported that production from birds that had been lighted as chicks did not differ from that of those that had not been lighted. The lighted birds matured more slowly and laid less small eggs. The non-lighted birds produced more eggs below 22 ounces per dozen but did eventually lay eggs of the same size as those produced by the lighted birds.

Hutt, Lamoreaux and Goodwin (1955) showed that keeping chicks on constant artificial light produced some false layers. They indicated that breaking the light period, by providing only daylight, for one month before maturity prevented the false layer condition.

Carson, Junnila and Bacon (1958) used a series of red, green, gold and blue fluorescent lights, no lights and 24 hours of 60 watt incandescent plus daylight, on growing chicks to check the effect on egg production. They found no significant difference in mortality due to light type

or light period. All night lights, regardless of color, stimulated the birds so treated to such an extent that they reached sexual maturity before those receiving only daylight. There was no difference between the effects from colored lights and incandescent lights as far as egg production was concerned. Twenty watt colored lights were used in all cases except where 40 watt red bulbs were used. The lights were located at the ceiling over the work area. The chicks were started on September 9th. At 10½ weeks of age, they were lighted by 60 watt incandescent bulbs until the start of the 15th week. These lights were on 24 hours per day. At the 15th week, they were then put on the various treatments and left until March 6th. They were then returned to continuous lighting with 60 watt incandescent bulbs. These workers reported no significant difference in production after production figures were adjusted for delay in maturity. The conclusion was that there was no adverse or stimulating effect from any of the treatments.

Length of light period and effect on egg production:

A. H. Sykes (1956) reported that sexual maturity was not affected by absolute length of day but that egg production was affected by absolute length of day and by changes in length of day. He indicated that the effects from decreasing day length were more serious the later the change occurred in the laying year. Sykes housed birds at 12 weeks of age in pens receiving 6 hours of light per day. From time to time he transferred some of these birds to

pens that were receiving only natural light. He also took birds from the pens receiving only natural light and put them in the pens with six hours of light. The birds in natural light produced much better than the birds with six hours of light. The birds which were moved to the longer hours of light (natural) increased in production within two weeks and production was maintained. The birds moved from natural light to the six hour pens dropped in production by the end of the second week. There were also differences in birds as to how they were affected. The birds changed early in the laying period were not affected as much as those moved later in the laying period. The last group moved to six hours of light on August 14 went into a molt.

Platt (1955) showed that pullets restricted to 8 hours of light matured more slowly than pullets in natural light. The birds on restricted light were given a 14 hour day at 7 months of age. They increased in production rapidly when lighted, and produced much heavier than the natural lighted birds which were lighted from 2 A.M. to daybreak at 35 weeks of age. The 8 hour treated pullets reached 89.4% production after lighting and the controls never went above 72.4%. Egg weight was equal at 40 weeks of age.

Hutchinson and Taylor (1957) concluded that a change in light is more vital to egg production than a change in season or a change in temperature. They reared one group of birds on 12 hours of light and one group on 23½ hours of light both at a uniform temperature of 64-65°F. Part of

group two had light reduced gradually to 12 hours starting two months after maturity. This was carried out over 8 weeks of gradual reduction, until 12 hours of light was reached. It was reported that these birds molted as a result of the light reduction. Temperatures were changed to assimilate the autumn season. The egg production was affected adversely in the pens receiving 24 hours of light, when the temperature was lowered.

Byerly (1957) found that changes in temperature affected production as much or more than changes in light. He found that pullets maturing at different times are affected differently by lighting. Byerly suggested there are drastic differences in individuals in their response to minimal length of day and to an increase in length of day.

Bastian and Zarrow (1955) showed that light and enforced wakefulness delayed the ovulation of the first follicle of a clutch.

Ragab and Assem (1953) found that increases in temperature offset stimulation by increase in light to a point that production decreased. They concluded that control of heat is as important as, or more so than, control of light.

Hall (1946) showed that by restricting red rays, production was inhibited. He checked restricted feeding vs. restricted feeding and lighting vs. a control. To restrict all red rays, he used a Corning H. R. Lantern Blue B glass filter with a 60 watt bulb. The light-restricted birds molted quickly and all at once while the other birds molted

over a long period of time.

Flash lighting:

Nightall (1955) reported that Blount compared 1500 watts of light for 20 seconds, at four hourly intervals, between 3 and 6 A.M. with a treatment of 75 watts for 4 hours. The flash system was uneconomical because of installation costs, even though slightly higher production was obtained.

A test at the University of Nottingham School of Agriculture conducted by Nightall (1953-54) checked the production of birds receiving 40, 60 and 100 watts of light for 20 seconds at 2 A.M., 3:25 A.M. and 4:50 A.M. against the production of a control pen of birds which was unlighted. Nightall concluded that 100 watts was impractical as 60 watts produced the maximum production. Production was recorded as follows:

Control	71.1%	60 watt	78.5%
40 watt	68.9%	100 watt	77.8%

Sicer (1956) reported that 1000 watts over the roosts for 30 seconds during the night gave equal results to 60 watts from 4 A.M. to daylight even though the birds didn't leave the roosts. He stated that heavy wiring and fusing was necessary when using high wattage.

Other lighting tests:

Wilson and Abplanalp (1954) indicated that the minimum amount of light necessary to sustain egg production has not

been established. They reported that reducing the hours of light to less than 14 hours reduced production regardless of the method used. In four out of five cases, intermittent light gave better production than continuous light. Hens with a high rate of production were less affected by light changes than were low producers. Production under short photo-periods was not proportionate to the amount of light given. Hens were more susceptible to light changes than pullets.

Warren and Scott (1936) found they could change the laying period so that it came at night rather than during the day by darkening the pens during the day and lighting them at night.

H. M. Simons, Jr. (1955) reported that a two platoon system could be used for layers. To accomplish this there is one work area with two roosting areas which are smaller. With this system, one group rests while the other is working and laying. He reported an average of 70% production in each group. To get 13 or 14 hours of light the group roosting must be lighted 1 to 2 hours.

Current work with lighting systems:

Considerable work has been done in the past few years and is being currently carried on with different lighting systems.

Professor King (1958) at Alabama has reported on results with "Stimulighting". His results indicated very significant increases in production of birds subjected to

this system. Skoglund at New Hampshire is also carrying on similar work, but his results have been less spectacular than King's.

Ralston Purina Company and Kimber Farms have also been working with restricted lighting during the growing period. They both showed best production results when chicks were restricted to 6 or 8 hours of light during the growing period and placed on 14 hours of light at maturity. Heisdorf and Nelson have been using a step-down, step-up lighting system. In this program, they start the chicks on long lighting periods and gradually reduce this period to maturity. The light is then increased throughout the laying period. They reported increased production from this system of lighting.

OBJECTIVES

The objective of this research was to find the beneficial application of artificial lighting for commercial poultry farms. To do this, research was set up in five different categories to check various phases of lighting.

TEST I was set up to test the hypothesis that equal egg production will be obtained from birds on commercial poultry farms by using various types of luminaries.

TEST II was conducted to test the hypothesis that maximum egg production can be obtained without using high light intensities in the laying pens.

The purpose of TEST III and IV was to test the hypothesis that it is not necessary to turn lights on, in the laying pens, during dark days if recommended window areas are provided.

TEST V was inaugurated to test the hypothesis that egg production will be increased by providing a short day growing period and gradually increasing the light during the laying period.

GENERAL PROCEDURE

Each test will be reported in its entirety including procedure, results, and discussion before reporting the next test. This is done due to the different nature of each test.

All of the tests were conducted at Cornell University on their research farms or on farms leased for research purposes.

Single Comb White Leghorns were used in each test. The tests were conducted during the years of 1957-58, 1958-59 and 1959-60.

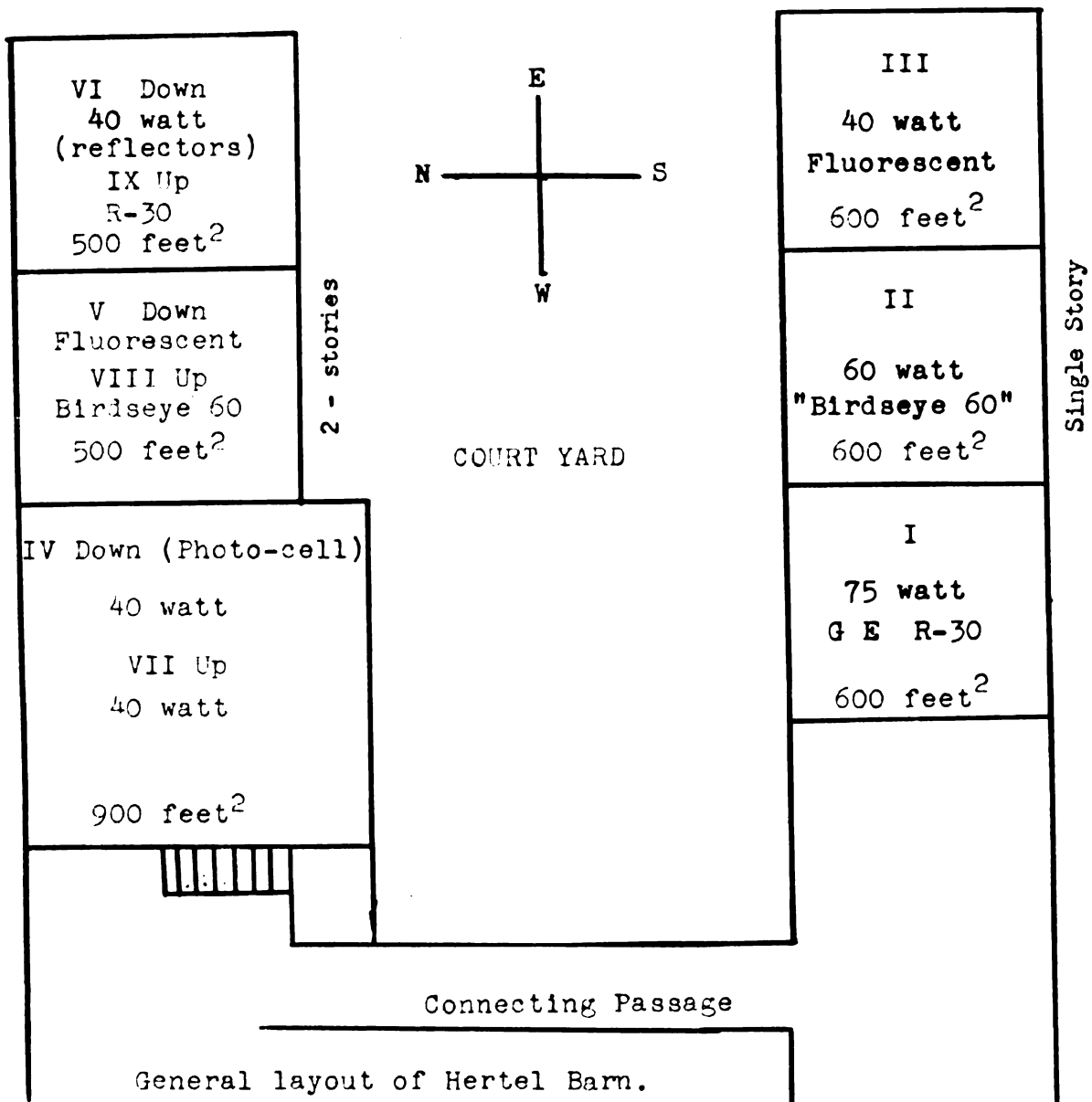
EXPERIMENTAL

TEST I

EFFECT OF VARIOUS LUMINARIE ON EGG PRODUCTION

Procedure:

Test I was carried on during the year 1957-58. This test was conducted in a barn on one of the leased farms (Figure I). Due to the layout of the pens, it was impossible to have each treatment placed in identical pens. One replicate of each treatment was placed in each section with replicates of each other treatment (Table I)(Figure I). Pens I, II, III, V, VI, VIII and IX were used in this test. All treatments were replicated except treatment VI(The 40 watt bulb in a 16 inch reflector). All pens were divided



General layout of Hertel Barn.
Only that part of the barn used for this test is shown. This is not to scale but shows the general layout of pens used and pen area and type of luminary used in each pen.

Pen Layout and Light Treatments Used in Test I

FIGURE I

TABLE I

Area of Pens, Number of Birds, Equipment Used

and Light Treatment for Test I

Pen No.	Area in sq. ft.	No. of birds	Feeder space Lineal feet	Water Fountains	Nests	No. of lights	Type of Lights
I*	600	210	90	3	40	3	G.E. R 30 75 Watt
II#	600	210	90	3	40	3	Sylvania, "Birds-eye 60" 60 Watt
III +	600	210	90	3	40	3	Fluorescent 40 Watt
IV	900	300	135	4	Community Nesting Rooms	5	Incandescent 40 Watt Photo-cell
V +	500	175	80	2	30	2	Fluorescent 40 Watt
VI	500	175	80	2	30	2	40 Watt with 16" reflectors
VII	900	300	135	4	Community Nesting	5	Incandescent 40 Watt
VIII#	500	175	80	2	30	2	Sylvania Birds-eye 60 60 Watt
IX*	500	175	80	2	30	2	G.E. R 30 75 Watt

* Replication - Pen I and IX # Replication - Pen II and VIII + Replication - Pen III and V

by solid partitions but they were not all of equal size; therefore, the birds of one replicate were put in pens of one size and the other replicate in pens of another size. As this building was not insulated it was felt that each pen should be filled to capacity at three square feet per bird. This, of course, made unequal numbers of birds in the replicates of each setup. All reports are on a per hen or a percentage basis so the slight variation in numbers of birds per pen should not affect the results of the test.

On October fourteenth, 1330 Single Comb White Leghorn pullets made up of 1120 surplus Random Sample birds 22 weeks of age plus 210 Cornell strain birds of equal age were randomly selected. The birds were divided as shown in Table I.

All of the birds were fed a commercial all mash laying ration (16 percent protein.) They were hand fed every morning, and a record kept of the amount of mash fed to each pen. The mash troughs were wooden V type, on legs, about 15 inches from the floor. The caretakers were instructed not to fill the troughs over one half full in order to prevent wastage. The birds were watered with automatic water fountains located across the house in the front half of the pen. These were protected from freezing by heating cables. Each pen had at least two fountains (Table I). Litter used in the pens consisted of chopped straw which matted badly due to the poor ventilation in the pens. The pens had to be partially cleaned several times during the winter because of dampness and packing. During the coldest

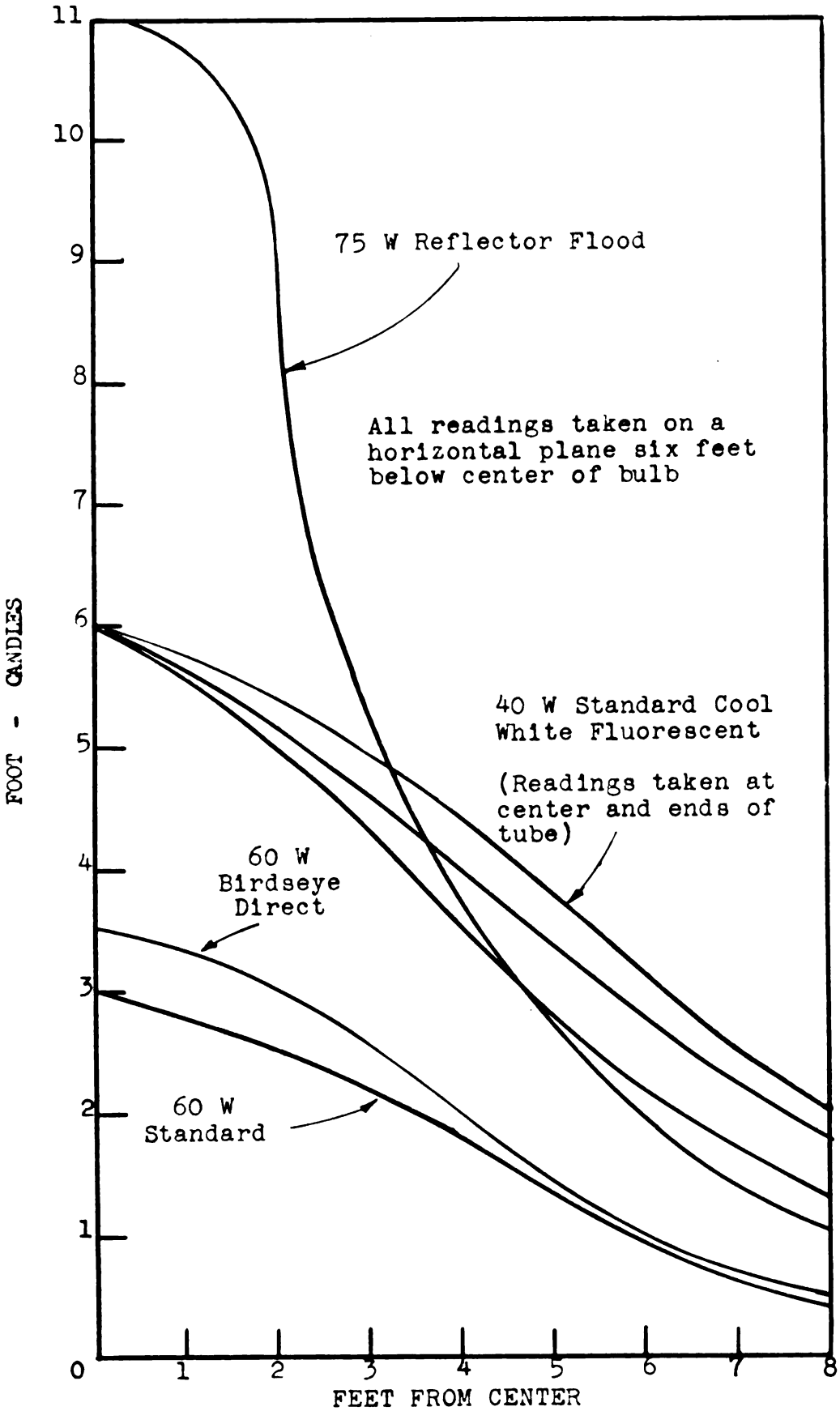
part of the winter, the birds were fed five pounds of all mash pellets per 100 birds every afternoon at 3:30 P.M. Oyster shells were available, at all times, in each pen. Ventilation consisted of the flue system using the windows for inlets which proved to be unsatisfactory.

The lighting schedule was set to give the birds a 13½ hour day. To keep this uniform, the time clocks were set to turn the lights on at 5:30 A.M. and off at 8:00 A.M. They were turned on again at 4 P.M. and off at 7 P.M. The caretakers were instructed to clean all bulbs each week to prevent dust from decreasing the intensity of light from any one fixture. Burned out bulbs were replaced immediately.

The intensity of light was measured in each pen using a General Electric light meter of the type used to measure intensities of city street lights. The intensity was measured directly under the lights and at various points in the pens including the corners and roosts. The intensities ranged from less than 0.4 foot candle to 11 foot candles. The highest reading was directly under the light (Figure II). The R-30[1] (Figure III) had a very high intensity "hot spot" directly under the lamp and dropped off very sharply, a short distance from the lamp where it closely approached the intensity of a standard 60 watt bulb without a reflector. The fluorescent lamp also produced considerably more intensity directly under the lamp, than

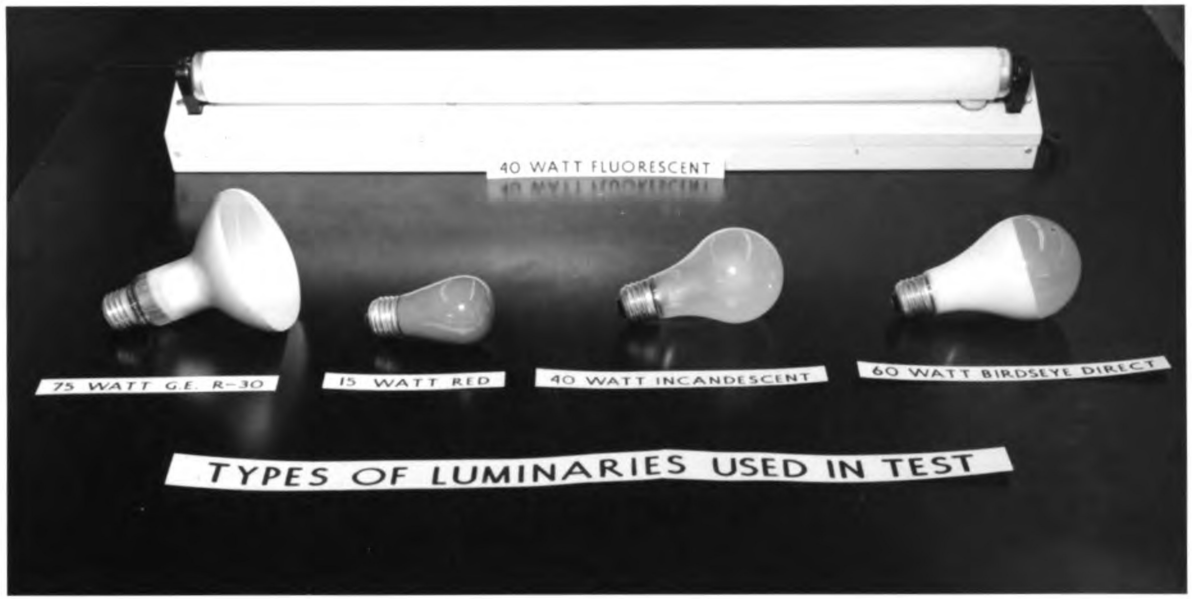
---

[1] G.E. R-30 is a conical type reflectorized lamp.



Light Intensities From Luminaries Used in Test I

FIGURE II



Various Types of Luminaries Used in Test I

FIGURE III

out in the perimeter of the pen. The "Birdseye 60"[2] (Figure III) and the standard 60 watt bulb gave the most uniform distribution of any of the types of lights (Figure II).

Daily egg production and feed consumption records were kept for the birds in each pen. Monthly egg production was calculated for number of eggs per bird and percentage production. Total feed consumption and feed required per dozen eggs produced was computed and recorded monthly.

All birds used in the test were vaccinated for Infectious Bronchitis, Newcastle disease and Fowl Fox as recommended by the Cornell Poultry Pathology Department.

This test was conducted for a period of thirty seven weeks, from October 15, 1957, through June 1958.

Results:

This test showed very little difference in egg production between any of the treatments (Table II and III, Figure IV). The birds in pens receiving light from the "Birdseye 60" lamps had the highest egg production (66.4 percent). The lowest egg production (60.6 percent) was from the birds in the pens with the R-30 lamps. Birds receiving light from the other luminaries, including the control, fell in between the "Birdseye 60" and the R-30 groups. The birds in the pens with the 40 watt fluorescent lights

[2]Sylvania "Birdseye 60" is a pear shaped bulb reflectorized in the upper half of the bulb.

TABLE II

TEST I

Effect of Various Luminaries on Percentage Egg Production by Month

Total light day(daylight+artificial light) equals 13.5 hours

	Type of Luminary			
Month	GE R-30	Birdseye 60	40 W. Fluor.	40 W.(Incand.)
October	65.0	71.3	67.7	69.0
November	68.9	73.7	77.7	74.9
December	64.5	67.3	72.2	69.5
January	61.0	66.3	63.1	62.7
February	48.7	59.7	53.9	56.8
March	53.8	61.7	53.5	47.5
April	60.9	67.0	61.9	60.2
May	63.2	67.1	65.3	62.0
June	60.5	63.7	60.9	65.1
Ave.	60.6	66.4	64.0	63.1

TABLE III

Effect of Various Luminaries on
Number of Eggs Per Bird

Total light day(daylight+artificial light)
equals 13.5 hours

	Type of Luminary			
Month	GE R-30	Birdseye 60	40 W. Fluor.	40 W.(Incand.)
October	11.1	11.8	11.5	11.7
November	20.7	22.1	23.3	22.5
December	19.9	20.8	22.3	21.5
January	18.9	20.5	19.5	19.4
February	13.6	16.7	15.1	15.9
March	16.7	19.1	16.6	14.7
April	18.9	20.8	19.2	18.7
May	19.6	20.8	20.2	19.2
June	18.1	19.1	18.2	19.5
TOTAL	157.4	169.7	165.9	163.1

TEST I

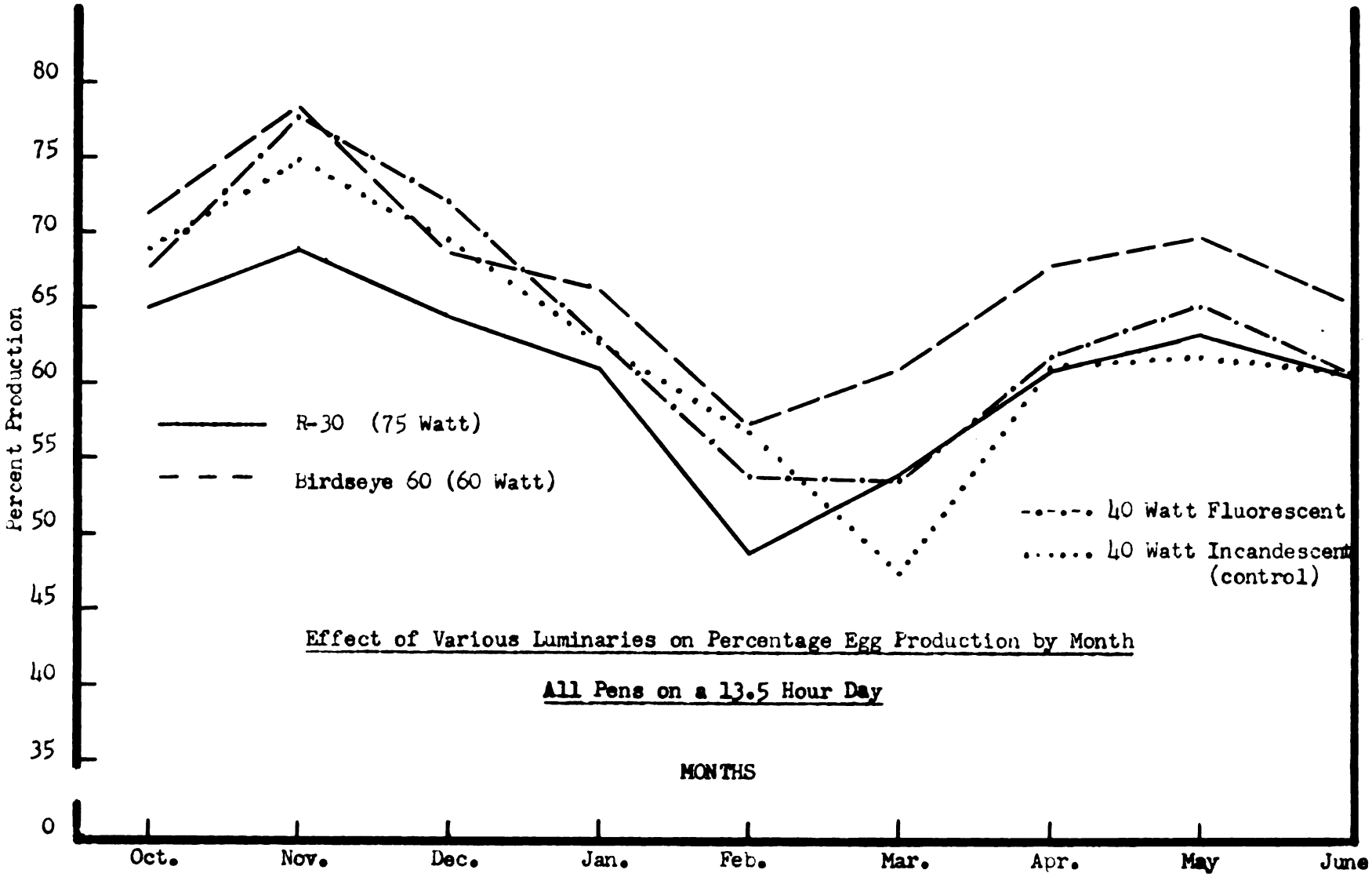


FIGURE IV

TEST I

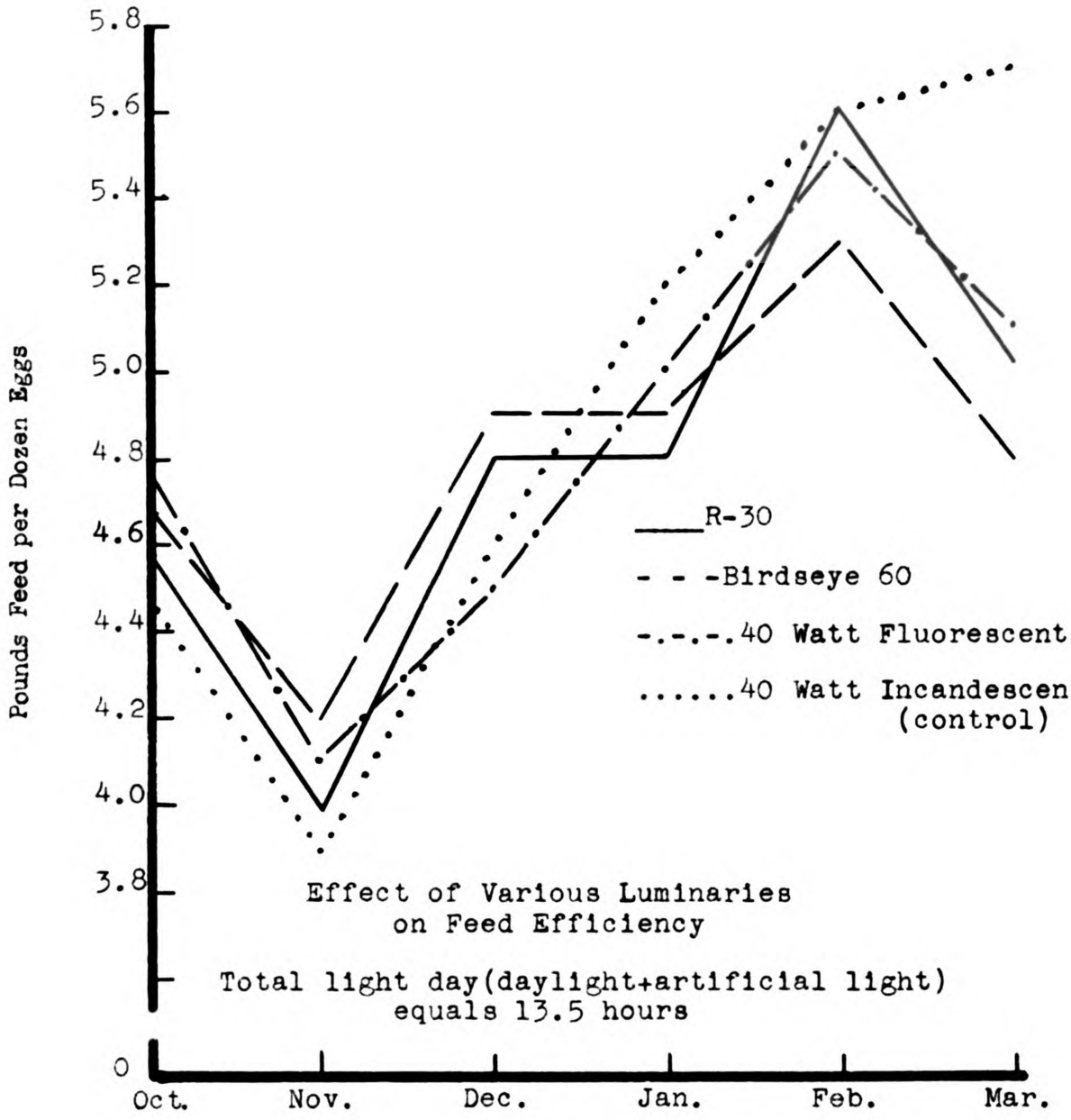


FIGURE V

averaged 64 percent egg production and the controls (40 watt incandescent) averaged 63.1 percent egg production. Feed efficiency varied little between treatments (Figure V).

Although there was no great difference in egg production from any of the treatments, birds in the pens with the R-30 luminaries were consistently below the others. Figure IV shows that egg production from birds on all four treatments was extremely close throughout the test.

The results were analyzed statistically with the help of Dr. W. D. Baten, Agricultural Statistician, using the "t" test and coefficient of variance test. The results were not statistically significant.

Discussion:

Many claims have been made by service people and poultrymen that various types of lights in the poultry house increase egg production. This test, using "G.E. R-30", "Birdseye 60", 40 watt fluorescent bulbs and standard 40 watt incandescent bulbs, failed to show any significant difference in egg production from any of the treatments. The pens containing the R-30 bulbs, which was the highest wattage of any type used, had the lowest egg production. In one field test, where this bulb was used, egg production was lower than in the controlled test reported. When the R-30 was used in the field test, the light fixtures were a considerable distance from the roosts. Several times birds were observed on the roosts long after the lights were turned on. It was postulated that the "spot" effect of the

light failed to light the roost area sufficiently, thereby not stimulating the birds remaining on the roost.

The fluorescent lights have the disadvantage of high installation cost but normally the bulbs have a long life. Contrary to many claims, operation cost for fluorescent lights is no lower than for other types of lights on a watt for watt basis. It is very important, if fluorescent lights are used, to use a type that produces red rays equal to incandescent lights. The pink bulb produces the largest number of red rays and these red rays are the ones shown to stimulate the pituitary gland in chickens thus inducing egg production. While the light from fluorescent bulbs is more intense, there are no more red rays produced, watt for watt, than from incandescent bulbs. In fact, there are fewer red rays from some types of fluorescent lights than from incandescent lamps.

The "Birdseye 60" bulb has an advantage in that no reflector is required while another advantage is that dust settling on the bulb does not seem to impair its effectiveness because the upper half of the bulb is reflectorized. The "Birdseye 60" also has a low temperature filament thereby giving it longer life than an ordinary bulb. It is rated for 2000 hours compared to 750 hours for an ordinary bulb. Even though the test showed no outstanding advantage in favor of it, the "Birdseye 60" did give a slight advantage in egg production. Due to this reason, and its other advantages, the "Birdseye 60" appeared very favorable in the test.

The 40 watt bulb plus a 16 inch reflector produced results equal to those secured with any other type of light. The problem encountered, in the field, is that most poultrymen will not keep reflectors on the bulbs. This procedure cuts efficiency and requires a higher wattage bulb to get equal results, thus increasing operating cost. When bulbs become dirty, the efficiency drops rapidly.

From this test, it appears that any type of luminary will produce satisfactory egg production if maintained in good condition. The main prerequisite is to use the type of luminary that is economical to install and to operate and one that requires low maintenance costs.

TEST II

EFFECT OF VARIOUS INTENSITIES OF LIGHT ON EGG PRODUCTION

Procedure:

In this test, emphasis was placed on light intensity and its effect on egg production. The test was started October 1, 1959, using 1300 mature Single Comb White Leghorn pullets of the Cornell Strain. They were randomly selected and housed in pens I, II, III, V, VI, VII, IX and X at the Old Cornell Poultry Research Farm placing 130 pullets in each pen measuring 20' by 20 feet. The pens were separated by solid partitions and had glass fronts facing south and were partially insulated.

The birds were fed a commercial all mash laying ration(16 percent protein), free choice, and were allowed 45 feet of feeder space per 100 birds. During the cold part of the winter the birds were fed six pounds of all mash pellets in the litter in an effort to activate them and to help stir the litter. These pellets were fed at 3:30 P.M. each day. Each pen was equipped with one trough-type water fountain four feet in length which had an emersion type water heater. The water pipes were protected from freezing by heating cables. Every pen also contained a hopper of oyster shells. Twenty-five open front nests

were located in each pen. The ventilation consisted of the natural system using windows for inlets and flues for exhausts.

The lighting systems tested included 60 watt incandescent without reflectors, 40 watt fluorescent, 100 watt incandescent without reflectors and 15 watt incandescent red bulbs placed over the roosts. Each lighting setup was replicated (Figure VI). The lights were controlled by time clocks to provide a 14 hour day. The clocks were set to turn the lights on at 5 A.M. and off at 8 A.M., then on again at 4 P.M. and off at 7 P.M. Each pen had two light fixtures 10 feet o.c. placed equal distance between the front of the house and the perches, located at the back, except for the pens on the red light treatment. In this treatment, four 15 watt red bulbs were placed above the heads of the birds, as they sat on the roosts 5 feet o.c. (Figure VI).

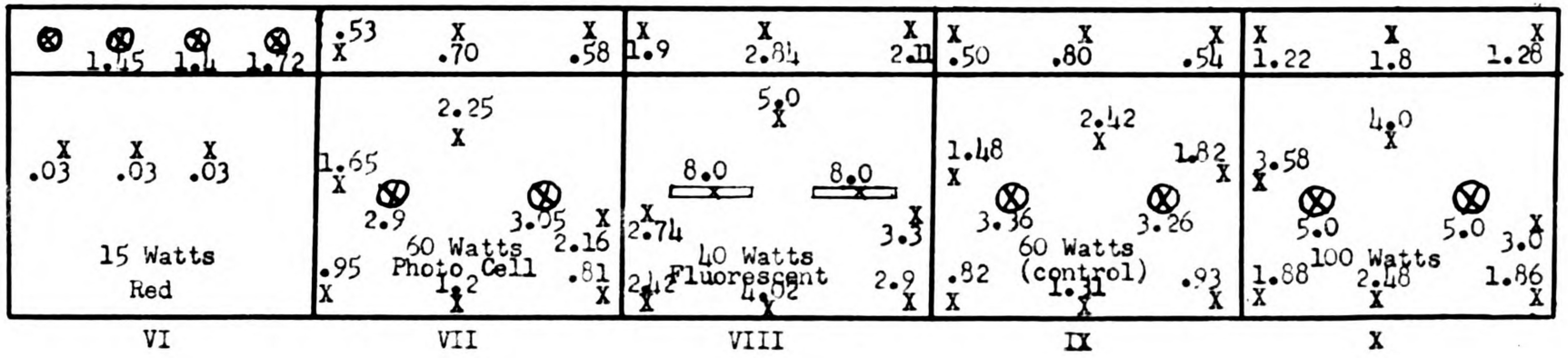
Egg production and feed consumption records were recorded. Egg production records were computed weekly on a percentage basis and number of eggs per bird basis, while feed per dozen eggs was computed for each four week period. Mortality records were kept and recorded.

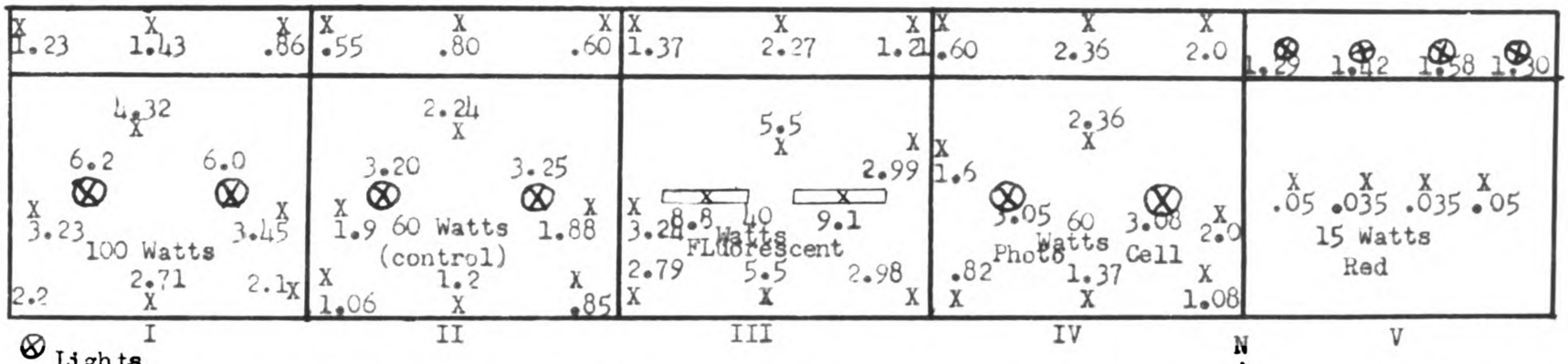
The birds were all vaccinated for Newcastle disease, Infectious Bronchitis and Fowl Pox in accordance with the recommendations of the Cornell Poultry Pathology Department.

Results:

While it is alleged by many people, that high light

TEST II





⊗ Lights

Experimental Design of Pens for Test II Showing Light Intensities Used

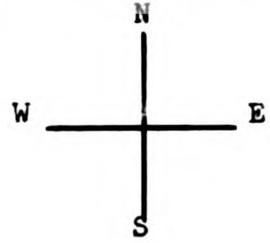


FIGURE VI

intensities will increase egg production, this claim was not proven in this test (Table IV, Figure VII). In fact, the two treatments with the highest light intensity, the fluorescent and the 100 watt, had the lowest egg production. This reduction in number of eggs cannot be explained, as there is no evidence to prove that bright light inhibits egg production. Egg production was consistently higher from the birds receiving light from the 15 watt red bulbs and the 60 watt bulbs than from those birds receiving the high intensity treatments.

From this test, it would appear that high light intensities are not needed for maximum egg production.

Feed efficiency varied between 4.1 pounds per dozen eggs in the red light pens to 4.5 pounds per dozen eggs in the 60 watt pens (Table V, Figure VIII).

Mortality ranged from 2.25 percent in the 100 watt pens to 8.05 percent in the 60 watt control pens. This mortality was not excessive, in fact, it is below average.

The results of this test showed no significant differences when analyzed statistically.

It was concluded that all types of lights used gave equal results, that there is no benefit from using intensities of light higher than that obtained from a 60 watt incandescent bulb and that the 15 watt red bulbs over the roosts gave as good results as any other treatment.

Discussion:

For many years, there has been disagreement in the

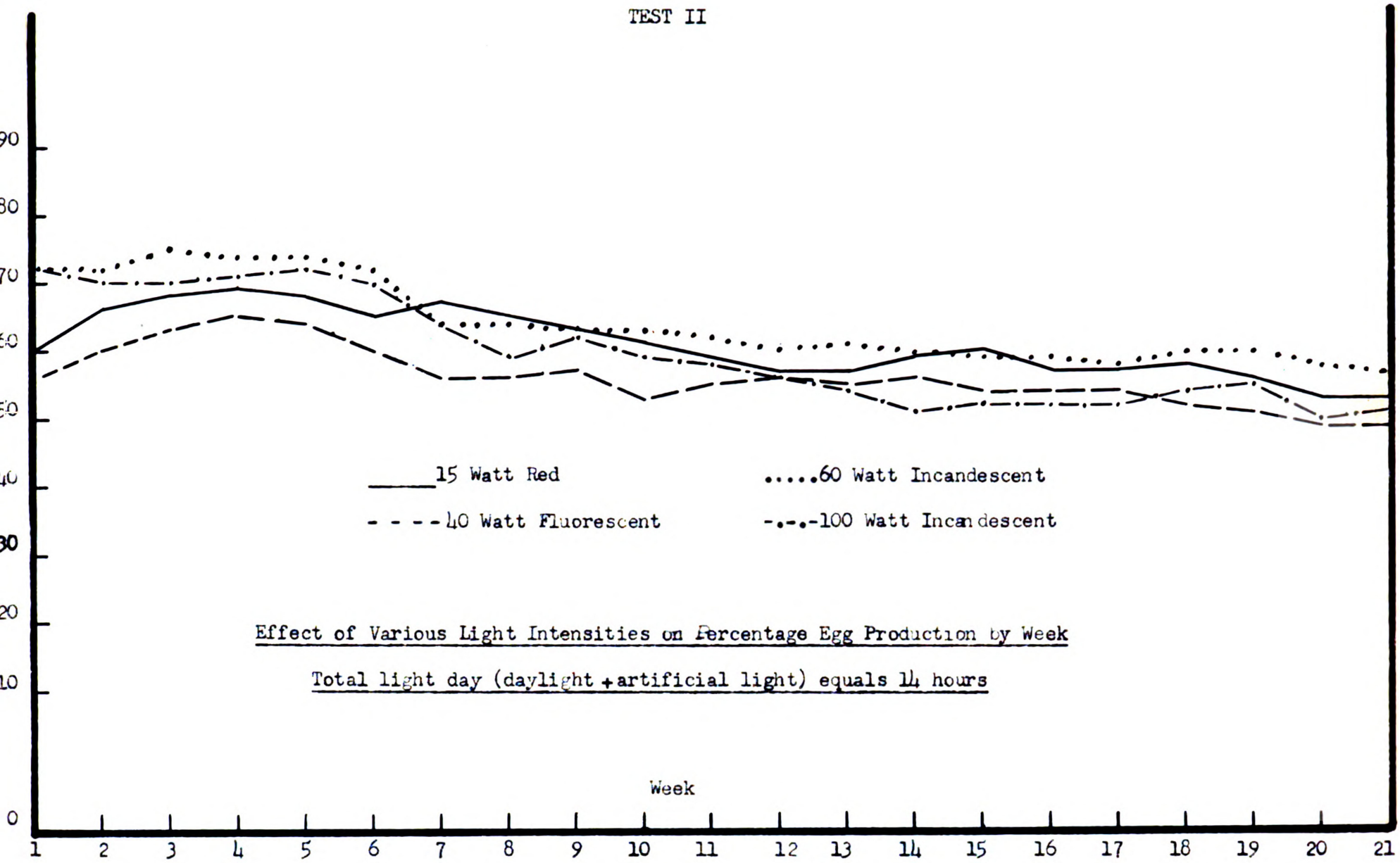
TABLE IV

TEST II

Intensity of Light and its Effect on Eggs Per Bird by 4-Week Periods

Periods	Total light day (daylight + artificial light) equals 14 hours								
	15 Watt Red		40 Watt Fluor.			60 Watt(Incand.)		100 Watt(Incand.)	
	V	VI	III	VIII	Pen Numbers	II	IX	I	X
0 - 4	18.5	17.9	16.6	17.4		18.7	22.1	19.1	20.5
4 - 8	17.4	19.5	15.7	17.1		18.7	19.4	18.2	18.5
8 - 12	16.4	17.1	14.2	16.4		16.9	17.3	16.2	16.5
12-16	16.2	16.2	14.0	16.4		16.1	16.5	14.5	14.8
16-20	14.9	16.2	13.0	15.5		15.4	17.2	14.5	14.9
21st. week	3.4	4.0	2.9	3.9		3.6	4.2	3.5	3.5
TOTAL	86.8	90.9	76.4	85.7		89.4	96.7	86.0	88.7
Ave. of Reps.	88.8		81.0			93.0		87.3	
Mortality	2.65		3.05			8.05		2.25	

TEST II



Effect of Various Light Intensities on Percentage Egg Production by Week

Total light day (daylight + artificial light) equals 14 hours

FIGURE VII

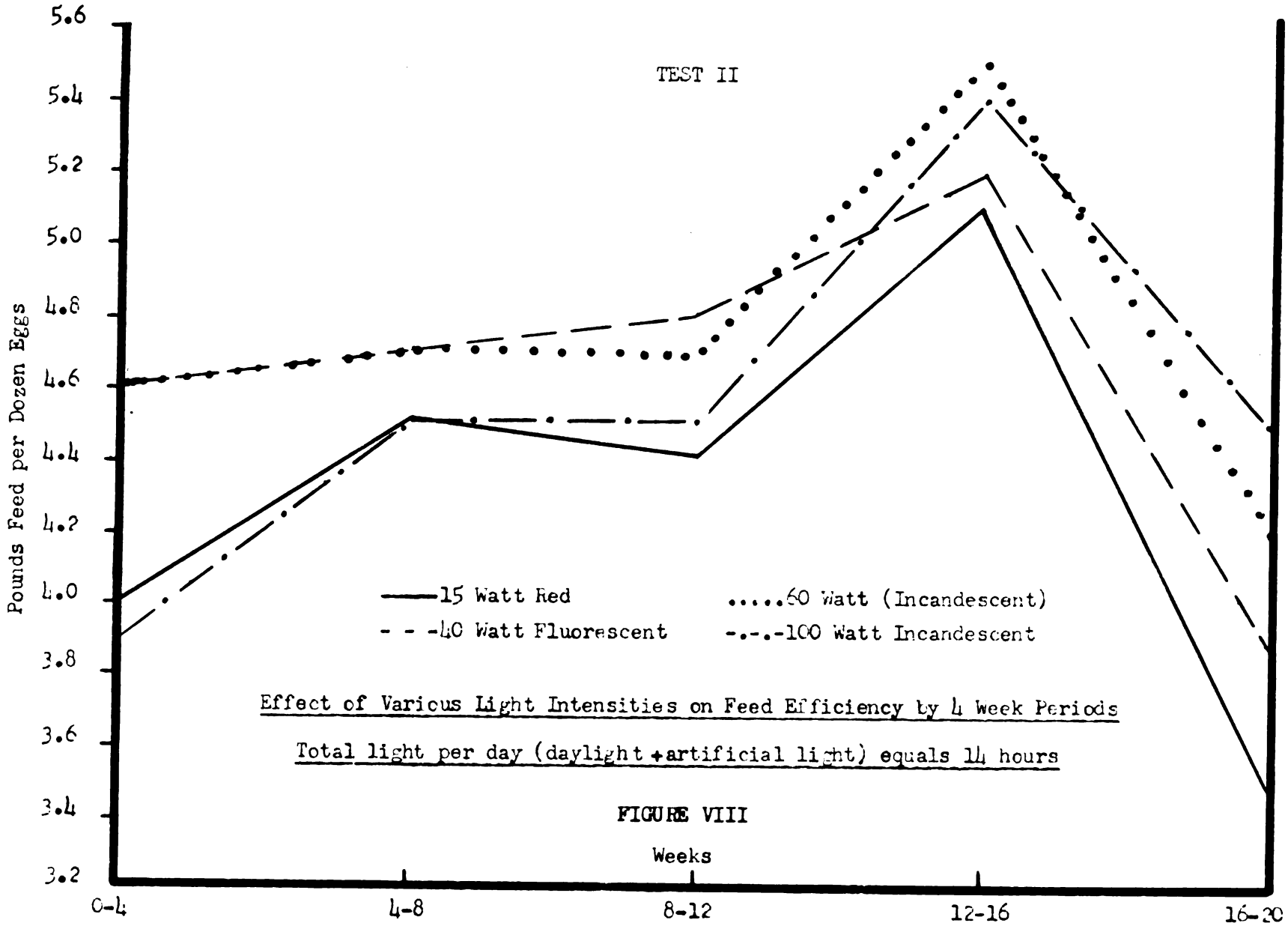
TABLE V

TEST II

Intensity of Light and its Effect on Feed Efficiency by 4 Week Periods

Pounds Feed per Dozen Eggs

Treatment	Total light per day (daylight + artificial light) equals 14 hours							
Period	15 Watt Red		40 Watt Fluor.		60 Watt (Incand.)		100 Watt Incand.	
	Pen numbers							
	V	VI	III	VIII	II	IX	I	X
0 - 4	4.0	3.6	4.5	4.2	4.5	4.2	3.8	3.6
4 - 8	4.3	4.3	4.7	4.3	4.6	4.3	4.1	4.5
8 - 12	4.5	3.8	5.2	3.9	4.5	4.4	4.6	4.0
12-16	4.6	5.2	5.4	4.5	5.4	5.2	5.2	5.1
16-20	3.1	3.5	3.7	3.6	3.9	4.0	3.9	4.4
Ave.	4.1	4.1	4.7	4.1	4.6	4.5	4.3	4.3
Ave. of Reps.	4.1		4.4		4.5		4.3	



Effect of Various Light Intensities on Feed Efficiency by 4 Week Periods

Total light per day (daylight + artificial light) equals 14 hours

FIGURE VIII

Poultry industry pertaining to the effectiveness of various light intensities on egg production. However, no scientific work reveals an advantage for light intensities above one foot candle at the feeder level. Several references are cited in the review of literature but none showed any advantage for high light intensity. This test confirmed results of other investigations, in which no egg production increases resulted when high intensities were used. For some reason, the high intensity pens in this test produced slightly fewer eggs than the low intensity pens. There is no explanation for this as no work has been reported showing lower egg production from high intensities. The 15 watt red lights over the roosts were as satisfactory as the control treatment and more satisfactory than either the fluorescent or 100 watt treatment. If these 15 watt red lights are used, the bulbs must be no farther than 15 to 20 inches from the heads of the birds or the red rays may never reach the bird. The results of this test would indicate that there is no scientific justification for having high light intensity in the poultry house.

TEST III

EFFECT OF TURNING LIGHTS ON DURING DARK DAYS ON EGG PRODUCTION

Procedure:

Many poultrymen believe that they must turn the electric lights on inside of their poultry houses during dark days to obtain maximum production. It was decided to check on the practicability of this practice.

Test III was a preliminary test. At the particular time that it was to be run, facilities were not available to replicate the test. Nevertheless, the test was carried on to see if there would be a noticable difference in production between birds in a pen where a photo-electric cell was used compared to those in a control pen. Pens IV and VII (Figure I) were used for Test III because they were comparable in size and layout.

Three hundred Single Comb White Leghorn pullets, of the same heredity as used in Test I, were housed in each pen on October 14, 1957. The photo-electric cell was placed behind one of the front windows in the feed room and was adjusted to turn on the lights when the light intensity reached a point where the caretaker ordinarily turned on the lights. This was adjusted by painting the glass red in front of the cell and then scraping it until the lights turned on at the intensity desired. This method proved

to be satisfactory.

These birds were fed and cared for in the same manner as the birds in Test I. The lights in pens IV and VII consisted of five 40 watt incandescent bulbs without reflectors. These lights were on time clocks set in a similar manner as those in Test I, except that the photo-electric cell by-passed the clock during the day and turned on the lights when the cell was activated and called for light.

Results:

Even though many poultry authorities claim production will be increased by turning on the lights in the pens during dark days, results of this test did not bear out this contention.

The test did show slightly increased egg production from the birds in the pen containing the photo-electric cell (Table VI, Figure IX). However, this slight increase was not statistically significant. Although no records were obtained on increased use of electricity, it was postulated that the use of the photo-electric cell was uneconomical.

Feed efficiency of birds appeared to be consistently better in the photo-electric cell pen but again the difference was not significant (Table VI).

At no time, was there a great difference in egg production between treatment and control birds but feed efficiency varied considerably during January and February. The control pen was colder than the photo-electric cell pen

TABLE VI

TEST III

The Effect of Using a Photo-Electric Cell on Egg Production and Feed Efficiency

Month	PHOTO-CELL		NO PHOTO-CELL	
	Percent Prod.	Pounds Feed/Doz. Eggs	Percent Prod.	Pounds Feed/Doz. Eggs
October	45.0	6.4	46.0	6.5
November	67.7	4.1	68.9	4.1
December	65.3	4.4	61.7	5.1
January	61.9	4.5	50.6	5.6
February	47.4	4.8	42.0	6.4
March	51.3	4.5*	48.5	5.8
April	60.0		64.4	
May	61.0		64.0	
June	59.0		64.5	
Average	57.6		56.7	

*Feed records discontinued after this date.

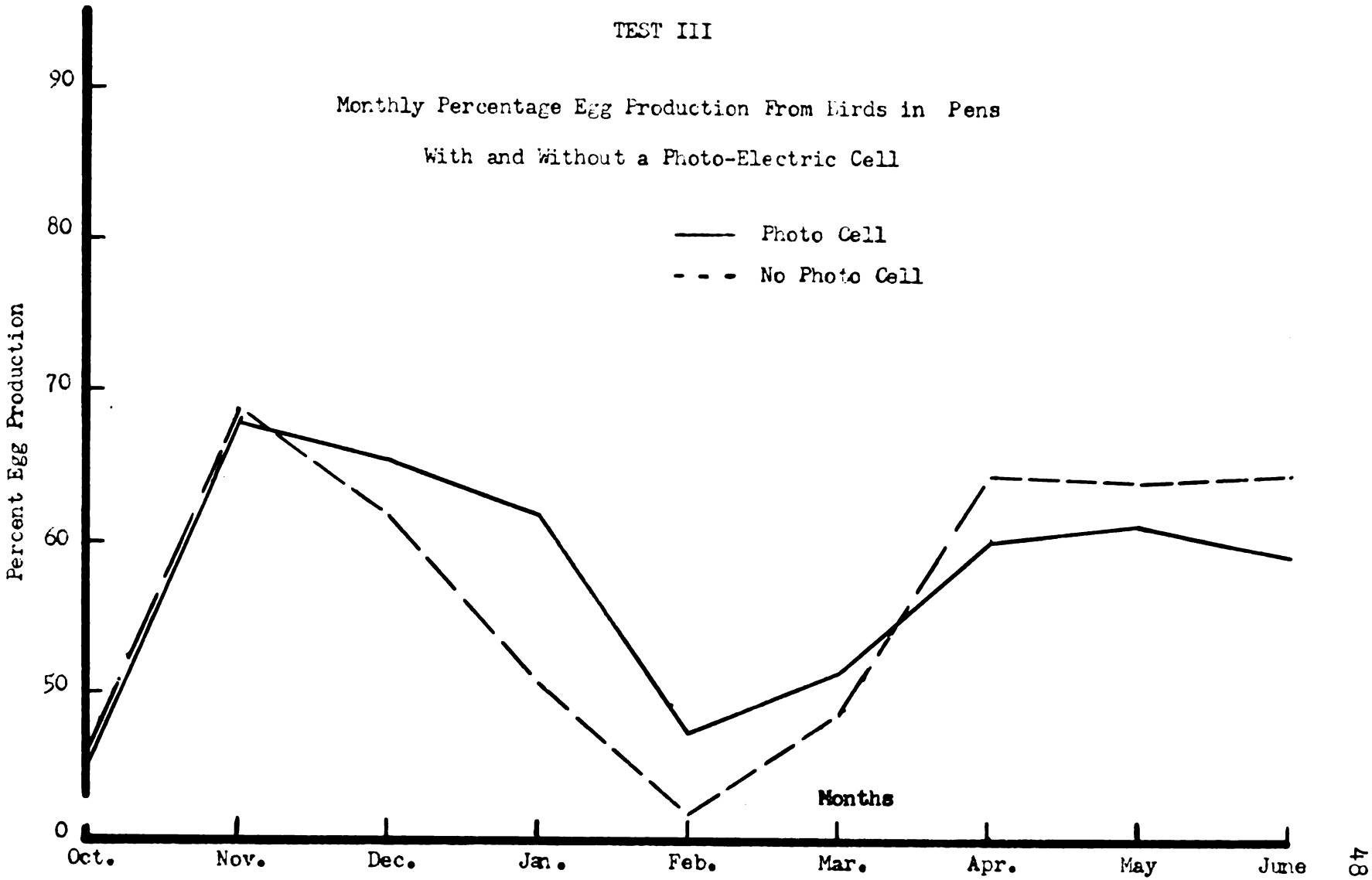

TEST III
Monthly Percentage Egg Production From Birds in Pens
With and Without a Photo-Electric Cell
Photo Cell
No Photo Cell
Percent Egg Production
90
80
70
60
50
0
Months
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June

FIGURE IX

which may have accounted for the poorer feed conversion.

Discussion:

Little significance is attached to this test. It was more of a trial than a test, due to the fact that the treatments were not replicated. However, the trial did give some indication of what might be expected. Practically no difference in egg production was shown between birds in the control pen and birds in the pen with the photo-electric cell. No record was kept of extra current used when the cell turned on the lights during the day.

TEST IV

EFFECT OF TURNING LIGHTS ON DURING DARK DAYS ON EGG PRODUCTION

Procedure:

Since no replicate had been possible in Test III, it was decided to repeat the test using replicate pens.

On October 1, 1959, two hundred and sixty Single Comb White Leghorn pullets of the Cornell Strain were divided randomly into two pens of 130 birds each. The set-up was similar to that given for Test II except for the lighting treatment. The birds were placed in pen IV and VI at the Old Cornell Poultry Research Farm (Figure VI). They were both given 14 hours of light, controlled by time clocks. The clocks were set to turn on at 5 A.M. and off at 8 A.M. and then on again at 4 P.M. and off at 7 P.M. In addition to this, these pens were equipped with a photo-electric cell to turn the lights on during dark days. Both pens were controlled by one cell which was adjustable for intensity. This cell was placed in the center of pen IV. It was adjusted to turn the lights on when the intensity in the pen reached a point where the caretaker would ordinarily turn on the lights had he adjusted the lighting himself. When intensity dropped below this point, the lights turned on and when it went above this point, the lights turned off. Management and pen arrangement were similar to that

as described in Test II. The control pens were pen II and pen IX (60 watt incandescent). Egg production was recorded daily and computed weekly for number of eggs per bird and the percentage egg production. Feed consumption was recorded and feed per dozen eggs was computed for each four week period.

Results:

As in Test III, egg production of the birds in the pens provided with photo-electric cells was approximately the same as that of birds in the control pens (Table VII and VIII, Figure X). The results were analyzed statistically and were found to be not significant.

In this test, a watt hour meter was attached to the photo-electric cell pens to measure the electric power used. The photo-electric cell pens used 335 kilowatts of electricity while the control pens (60 watt used 92 kilowatts). On the average, birds in the photo-electric cell pens produced 1.3 more eggs per bird than birds in the control pens. Calculated at three cents per egg, this production gives an increased income of three and nine tenths cents per bird. The extra electricity used calculated at two cents per kilowatt, increased the electricity cost by three and seven tenths cents per bird leaving a net increase of two tenths cent per bird in the photo-electric cell equipped pens as compared to the control pens. This figure was calculated without including the cost of the control unit or the installation.

TABLE VII

TEST IV

The Effect of Using a Photo-Electric Cell on Percentage Egg Production by Week

	Photo Cell		No Photo Cell	
Week	Pen IV	Pen VI	Pen II	Pen IX
1	73	71	67	77
2	72	73	65	79
3	76	72	70	80
4	75	78	67	81
5	74	74	70	77
6	70	69	68	75
7	67	69	66	62
8	67	66	64	63
9	64	63	62	64
10	62	64	62	63
11	66	66	62	62
12	61	64	59	60
13	62	62	59	62
14	63	65	59	60
15	63	61	58	59
16	58	62	57	60
17	59	59	55	61
18	57	59	58	61
19	52	57	56	64
20	48	54	54	62
21	46	56	53	61
Ave.	63.6	65.0	61.0	66.0
Ave. of Reps.	64.3		63.5	

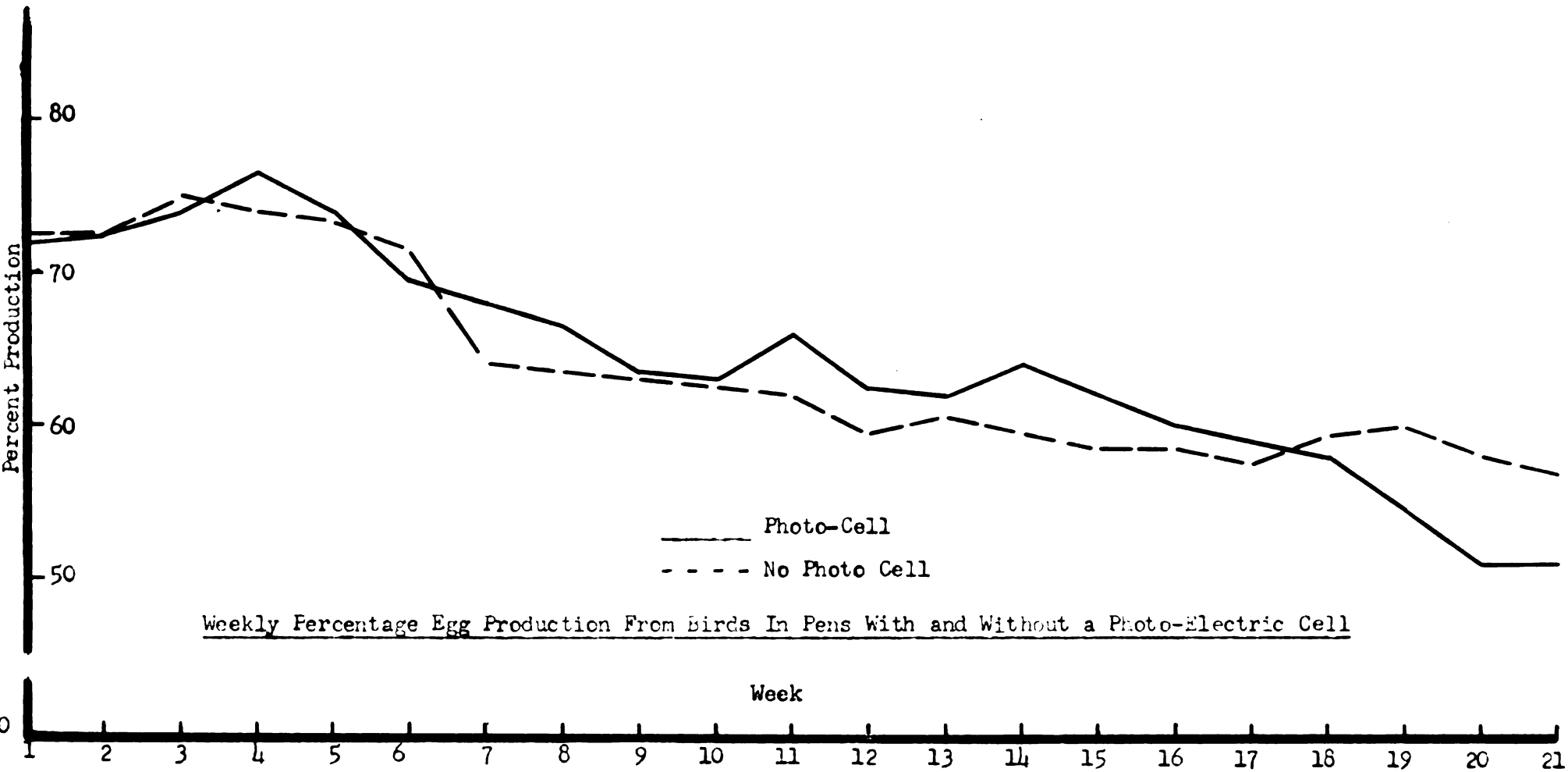
TABLE VIII

TEST IV

The Effect of Using a Photo-Electric Cell on Eggs Per Bird by 4-Week Periods

	Photo-Cell		No Photo-Cell	
	Pen Numbers			
Period	IV	VI	II	IX
0-4	20.6	20.5	18.7	22.1
4-8	19.3	19.3	18.7	19.4
8-12	17.6	17.9	16.9	17.3
12-16	17.2	17.5	16.1	16.5
16-20	15.1	16.1	15.4	17.2
21st. Week	3.2	3.8	3.6	4.3
TOTAL	93.0	95.1	89.4	97.3
Ave. of Reps.	94.0		93.3	

TEST IV



Weekly Percentage Egg Production From Birds In Pens With and Without a Photo-Electric Cell

FIGURE X

It was concluded from this test, that the use of a photo-electric cell was not economically sound nor would it be economical to use lights in the pens on dark days.

Discussion:

This test did not substantiate claims that increased egg production was a result of providing lights in the laying pens on dark days. There were enough dark days when the photo-electric cell turned on the lights to use 335 kilowatt hours of electricity compared to 92 kilowatt hours used in the control pen. The benefit appears to be more of a psychological effect on the poultryman than a benefit to the hens. Egg production of the birds in pens equipped with a photo-electric cell was increased only slightly as compared to that of birds in the control pens. The additional egg production was not enough to pay for the extra electricity used, the cost of the photo-electric cell and the installation of the cell. On the basis of the results from Test III and IV the installation of photo-electric cells in poultry houses cannot be recommended.

TEST V

THE EFFECT OF LIGHT RATIONING DURING THE GROWING PERIOD AND LAYING PERIOD ON EGG PRODUCTION

Procedure:

This test was conducted to determine the importance of the amount of light during the growing period and during the laying period on laying performance.

Five hundred and ten pullet chicks were started on March 27, 1958. Three hundred and twelve of these were surplus Leghorn type chicks from the Western New York Random Sample test and the remaining 198 were purchased from a commercial hatchery. The chicks were randomly divided so that each treatment had the same number of each strain of surplus random sample birds and that, likewise, each test had equal numbers of commercial birds (Table IX). These 510 chicks were brooded in a conventional permanent brooder house under normal conditions until ten weeks of age. No lights were used during this period except for attraction lights under the hovers and the natural daylight from the windows.

During the brooding period (1-8 weeks) the chicks were fed a commercial all mash chick starter and from 8-21 weeks the pullets were fed a commercial all mash growing

TABLE IX

Distribution of Chicks at 10 Weeks of Age Used in Light Rationing Test and Degree of Rationing from 10-21 Weeks of Age.

Strain * Number	6 Hours Light Per Day	Natural Light	Natural Light
1	33	33	33
2	33	33	33
3	5	5	5
4	11	12	13
5	6	5	5
6	8	9	8
7	7	8	8
8	6	5	5
9	5	4	4
10	7	7	8
11	8	10	8
12	4	4	4
13	37	35	36
	170	170	170

*Strains 1 and 2 were commercial strains: strains 3-13 were Random Sample extras.

ration. Fresh feed was added daily.

The birds were all vaccinated for Newcastle Disease and Infectious Bronchitis according to recommendations of the Cornell Poultry Pathology Department.

On June 6, 1958, at ten weeks of age the treatments were started. The pullets were weighed before being placed in their respective experimental quarters (Table X). At this time, 170 pullets were placed in two windowless pens and given six hours of light per day, from 6 A.M. to 12 noon. The other 340 pullets remained in naturally lighted pens until maturity (21 weeks of age). The windowless pens were ventilated by exhaust fans and air inlets, which were both covered and baffled, to prevent light entrance. All chores were done between 6 A.M. and 12 noon so the doors would not be opened during the dark period. No one was allowed in these pens during the dark period from 12 noon to 6 A.M. The pen arrangement and light intensities are shown (Figure XI).

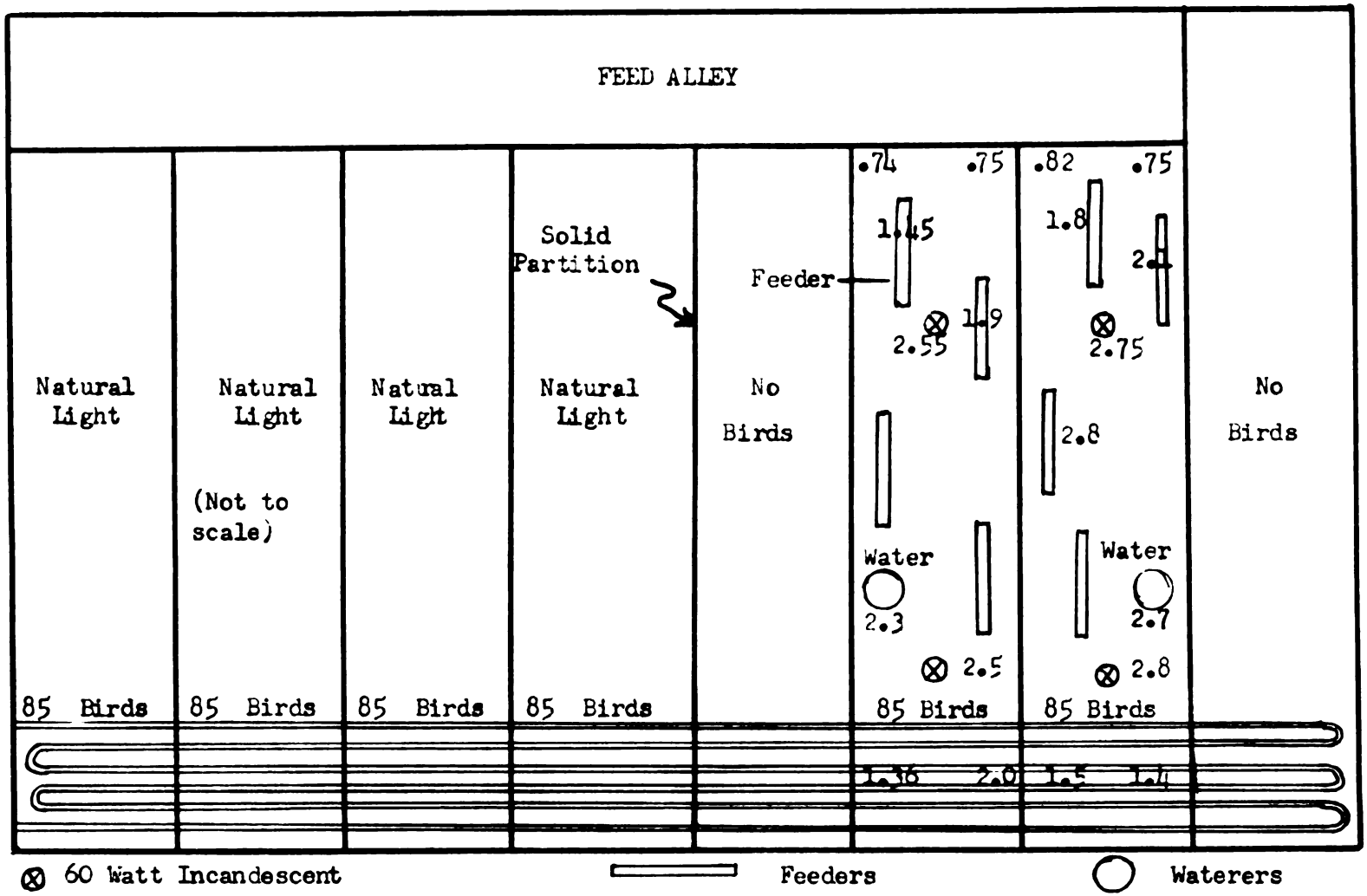
On August 22, 1958, the birds (85 per pen minus mortality losses) were placed in six windowless pens on another farm (Figure XII). At this time two more pens (170 pullets) were cut back to 6 hours of light per day (6 A.M. to 12 noon). The other two pens (170 pullets) were now given 14 hours of light per day. There were now four pens (340 pullets) on 6 hours of light and two pens (170 pullets) on a 14 hour day. This provided for a replicate of each treatment. Each pen was provided with two 40 watt

TABLE X

TEST V

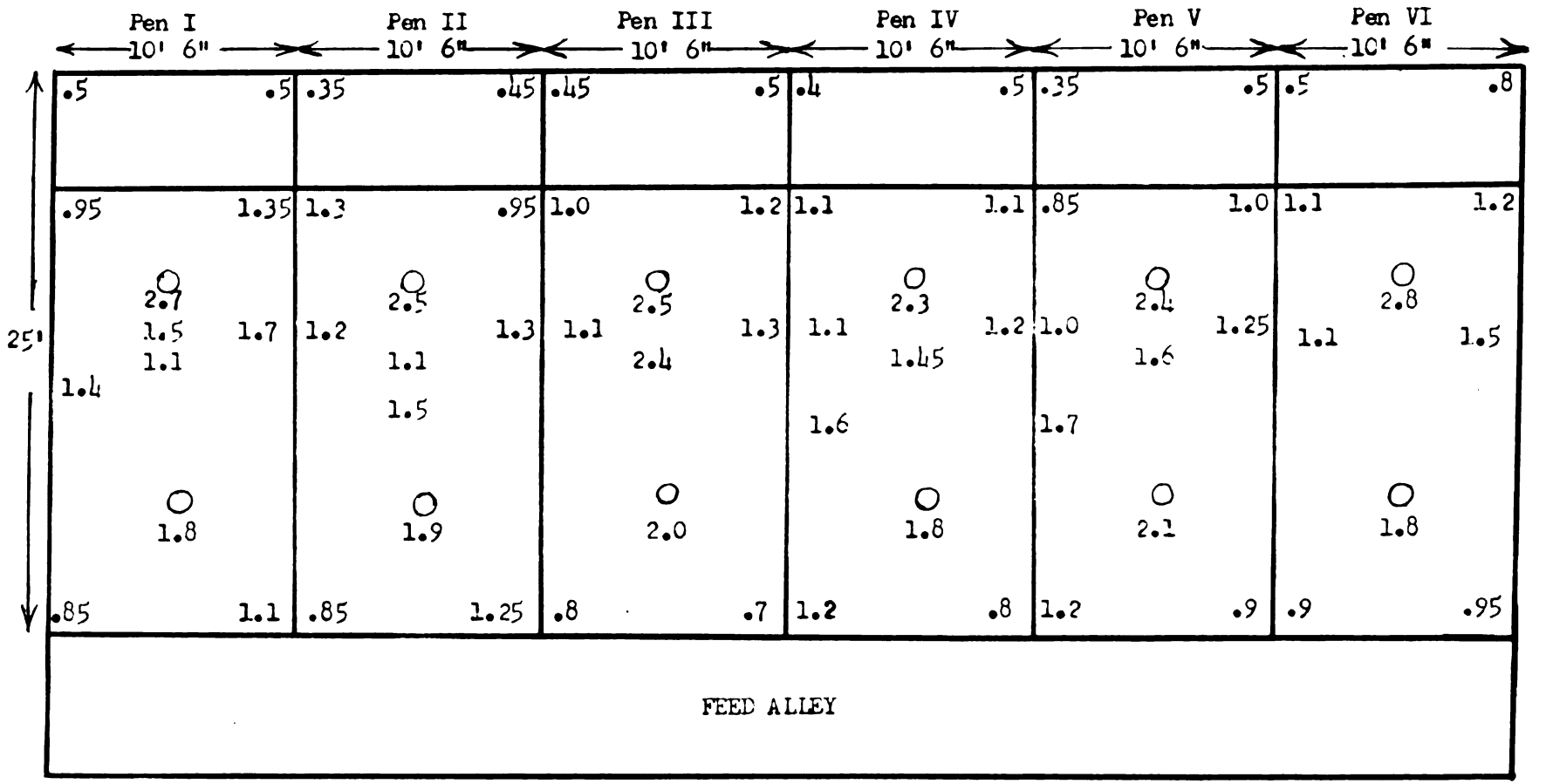
Effect of Light Rationing From 10-21 Weeks of Age on 21 Week Body Weights and on Total Feed Consumption During This Period.

Treatment	Initial Body Weight at 10 Weeks (lbs.)	21 Weeks Body Weight(lbs.)	Total Pounds Feed Consumption From 10-21 Weeks of Age
6 hours of light	1.82	3.23	13.75
Natural Light	1.84	3.38	13.91
Natural Light	1.84	3.40	14.17



Experimental Design of Pens Used for Rearing Birds from 10-21 Weeks of Age for Test V Showing Light Intensity at Various Locations Within the Two Windowless Artificially Lighted Pens

FIGURE XI



Experimental Design of Pens Used During the Laying Period for Test V Showing Light Intensity at Various Locations Within the Windowless, Artificially Lighted Pens

FIGURE XII

bulbs. Light intensity readings were made in various areas in each pen (Figure XII). The birds in pens I, II, IV and V were given six hours of light per day and pens III and VI were given 14 hours of light per day. Pens I and IV were replicates, pens II and V were replicates and pens III and VI were replicates.

Starting August 22, 1958, pens I, II, IV and V were lighted from 6 A.M. until 12 noon. One week later and every week thereafter throughout the test, the lighting period was increased by an additional 15 minutes over the preceding week. The addition was always made at the end of the lighting period with the 6 A.M. starting time kept constant. Pens III and VI remained on 14 hours of light throughout the laying year (12 months).

Each pen was provided with four round hanging feeders with an 18 inch base and two "Johnson Cup" type water fountains which were equipped to prevent freeze-ups. Each pen had 15 nests of the regular open front type. Oyster shell was provided in a wall feeder and the birds were fed a commercial all mash laying ration (16 percent). Eggs were gathered four times daily. Each time that the eggs were gathered, the hanging feeders were shaken so the feed would come down properly. Each afternoon, during cold weather, four pounds of layer mash pellets were fed in the litter to activate the birds to stir the litter. The litter remained in good condition all winter. These pens were insulated in the ceiling but this insulation did not prevent low tem-

peratures in these pens several times.

The egg production and feed consumption were calculated monthly. Eggs were weighed November 11, December 16 and December 30 to see if the various lighting programs had any effect on egg size. Mortality figures were also recorded and computed.

Results:

Test V was conducted to determine the effect on age at sexual maturity, egg production, egg size and feed efficiency of rationing light in different amounts during the growing and laying period.

Birds in one of the control pens produced the first egg. However, eggs were produced from birds in two of the other pens before the birds in the second control pen started to lay (Table XI). The birds in Pen IV took the longest to start producing eggs while the birds in its replicate (pen I) were one of the first groups tested to start producing eggs. The birds in the control pens with 14 hours of light increased in production much more rapidly than the birds in either of the other treatments (Table XII, Table XIII, Figure XIII).

There was little difference in average body weights of birds between treatments. Weights ranged from 3.0 pounds per bird in treatment five to 3.43 pounds per bird in treatments three and four. Birds receiving treatment two and treatment five, were the lightest. These were the birds that were reared with six hours of light from 10 weeks until

TABLE XI

Replications: I and IV
II " V
III " VI

Summarized Results of Rationed Light Test. Test V

Pen Numbers	I	II	III	IV	V	VI
Ave. Weight - 6/6/58	1.84#	1.86#	1.84#	1.84#	1.86#	1.84#
Light during growing period 10 wks.-21 wks.	Daylight	6 hrs.	Daylight	Daylight	6 hrs.	Daylight
Feed per bird(10-21 wks.)	13.66#	13.73#	14.25#	14.17#	13.77#	14.09#
Ave. weight at 21 wks. of age (housing)	3.33#	3.27#	3.43#	3.43#	3.20#	3.37#
Light after 21 wks. of age	6 hrs. +15 min. each wk.	6 hrs. +15 min. each wk.	14 hrs.	6 hrs. +15 min. each wk.	6 hrs. +15 min. each wk.	14 hrs.
Date of first egg	8/12	8/31	8/7	9/2	8/17	8/19
Lb. feed per bird 21-73 wks.	95.6	99.4	110	101	94.7	106.4
Lb. feed per doz. eggs	4.6	4.8	4.8	4.8	4.7	5.0
Ave. egg weight(11/11/58)	56.3	56.7	53.9	57.9	57.7	56.1
in grams (12/16/58)	59.8	57.5	57.7	59.1	59.7	58.5
(12/30/58)	59.6	57.7	58.4	58.8	63.3	58.6
Laying House Mortality	17%	21%	13%	12%	12%	10%
Eggs per bird (hen day)	246.2	249.9	264.5	249.4	241.3	252.1
Percent Production	67.4	68.3	71.8	67.7	66.5	69.4

21 weeks of age.

Eggs were weighed on November 11, December 12 and December 30 and showed little difference in egg size between treatments (Table XI).

The control group took an early lead in egg production and the other pens never caught up. All of these groups produced well, averaging from 241.3 eggs per bird to 264.5 eggs per bird (Table XI).

It was concluded, from the results of this test, that restricting light during the growing period and gradually increasing it throughout the laying period did not increase egg production but, rather, inhibited production somewhat. The control birds, reared in daylight and provided a 14 hour day during the laying year, produced the most eggs. However, the differences proved to be statistically not significant.

Discussion:

The light rationing test conducted did not substantiate the claims, made in the popular press, showing considerably higher egg production by rationing light. Birds in all of the pens produced very satisfactorily. The lowest pen produced an average of 241 eggs per bird and the highest pen produced at an average of 264 eggs per bird. The only advantage, in favor of the control birds, was that they jumped into an early lead, This situation occurred in September, October and November when eggs were highest in price, thereby giving these birds a larger advantage than

TABLE XII

Effect of Rationed Light on Percentage Egg Production by Month

Month	PERCENT EGG PRODUCTION					
	Pen I*	Pen II#	Pen III+	Pen IV*	Pen V#	Pen VI+
September	21	11	50	10	25	52
October	54	61	79	60	57	85
November	67	75	84	79	72	84
December	65	73	82	79	65	73
January	75	76	81	79	69	71
February	83	83	78	80	79	69
March	84	83	74	79	81	68
April	82	79	75	79	77	71
May	73	76	71	74	73	70
June	73	74	69	72	71	68
July	67	68	63	68	68	64
August	63	62	56	64	61	58
Ave. Percent Production	67.3	68.4	71.8	68.6	66.5	69.4
Ave. of Rep.	68	67.5	70.6			

*Pens I and IV were reared in daylight and cut to 6 hours of light at 21 weeks of age. Starting the 22nd. week their light period was increased 15 minutes each week throughout the laying year.

#Pen II and V were provided 6 hours of light per day from 10 through 21 weeks of age. Starting the 22nd. week their light was increased 15 minutes each week throughout the laying year.

+Pen III and VI were reared in daylight and were provided a 14 hour day from the 22nd. week throughout the laying year.

All pens were windowless and birds received only artificial light.

TABLE XIII

Effect of Rationed Light on Eggs Produced Per Bird by Month

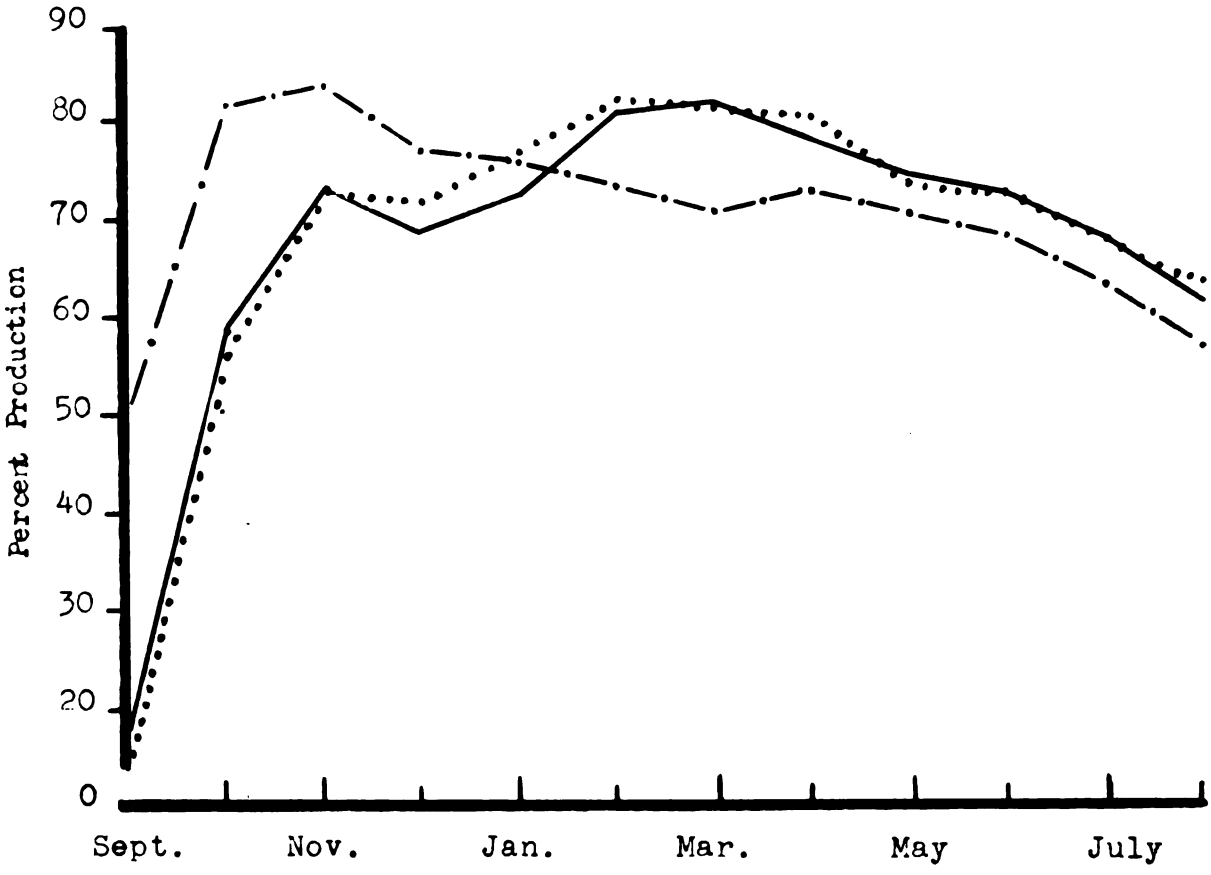
Month	Pen I	Pen II	Pen III	Pen IV	Pen V	Pen VI
September	6.2	3.4	15.2	2.9	7.4	15.2
October	16.8	18.8	24.8	18.3	17.4	26.2
November	20.6	22.7	26.3	23.7	21.5	25.3
December	20.2	22.9	26.2	24.6	20.1	22.4
January	23.3	23.6	25.1	24.5	21.5	22.1
February	23.7	23.0	21.7	22.5	22.0	19.0
March	25.9	25.6	22.9	24.4	25.1	21.0
April	24.4	23.7	22.4	23.3	22.7	21.0
May	22.7	23.7	22.1	22.8	22.5	21.7
June	21.7	22.3	20.6	21.5	21.3	20.4
July	21.1	21.1	19.4	21.0	21.0	19.8
August	19.6	19.1	17.5	19.9	18.8	18.0
TOTAL	246.2	249.9	264.5	249.4	241.3	252.1
Ave. of Reps.	247.8	245.6	258.3			

*Pen I and IV were reared in daylight and cut to 6 hours of light at 21 weeks of age. Starting the 22nd. week their light period was increased 15 minutes each week throughout the laying year.

#Pen II and V were provided 6 hours of light per day from 10 through 21 weeks of age. Starting the 22nd. week their light was increased 15 minutes each week throughout the laying year.

+Pen III and VI were reared in daylight and were provided a 14 hour day from the 22nd. week throughout the laying year.

All pens were windowless and birds received only artificial light.



Code	Lighting 10-21 weeks	Lighting During Laying Period
. . . .	6 hours per day	6 hours + 15 minutes weekly
———	Natural	6 hours + 15 minutes weekly
.-.-.-.	Natural	14 hours per day

Effect of Rationed Light on Percentage Egg Production by Month

FIGURE XIII

indicated by egg production alone. By the time that the birds in the other pens caught up in production, egg prices had dropped. No advantage could be attributed to the light rationing nor did the birds mature faster or lay larger eggs in the light rationed pens. Little difference in mortality occurred between any of the treatments.

Results from this test would indicate that a 14 hour day is sufficient for maximum egg production. To keep the day constant, it is probably best to provide part of the light at each end of the day.

SUMMARY

Test I:

1. Egg production appeared to be equal where birds were exposed to any of the types of luminaries tested.

2. It was concluded that the most practical luminary to use of those tested is the one that is the most economical to install and to operate and one that requires the least maintenance.

3. The cost of installing fluorescent lights does not justify their use.

4. The cost of the bulb and the extra electricity used, does not justify the use of the 75 watt R-30.

5. The results and costs were approximately equal for the 40 watt bulb in a 16 inch reflector, the "Birdseye 60" and the 15 watt red bulbs; therefore, any one of these systems of lighting should be equally satisfactory.

Test II:

1. There appeared to be no difference in egg production attributable to any of the treatments

tested.

2. There was no benefit shown from using lights that produced higher intensities than obtained from a 40 watt bulb in a 16 inch relfector for each 200 square feet of floor space when placed over the work area.

3. Fifteen watt red bulbs placed 18 inches above the birds' heads on the roosts gave egg production equal to any treatment used.

Tests III and IV:

1. There was no benefit shown from using a photo-electric cell to turn on the lights during dark days in these tests.

2. The birds in the control pens laid as well as those in the pens controlled by a photo-electric cell.

3. The cost of the photo-electric cell, its installation and the cost of the extra electricity used could not be justified by additional egg production.

Test V:

1. No benefit was shown from rationing light during the growing or laying period in this test.

2. Egg production was slightly higher from birds on

the control treatment in which the birds were grown in daylight and provided a 14 hour day after maturity. This difference was not significant.

3. Light rationing did not increase egg size.

4. Age at date of first egg was not affected by light rationing.

5. Age at time of fifty percent egg production was retarded by restricting light in this test.

6. Mortality was approximately the same regardless of treatment.

BIBLIOGRAPHY

Barrott, H. G., and E. M. Pringle, 1951. Effect of Light on Early Growth. Journal of Nutrition. 45:265-74.

Barrott, H. G., L. G. Schoenleber and L. E. Campbell, 1951. Effect of Ultraviolet on Egg Production. Poultry Science. 30:409-416.

Bastian, J. W. and M. X. Zarrow, 1955. A New Hypothesis for the Asynchronous Ovulatory Cycle of the Domestic Hen. Poultry Science. 34:776-87.

Bissonnette, T. H., 1931. Effect of Light of Different Intensities on Testis Activity. Physiology Zoology. 4:542-74.

Bissonnette, T. H., 1933. Does Increased Light Absorption Cause Increased Egg Production in the Fowl. Poultry Science. 12:391-99.

Byerly, T. C., 1957. Light and Egg Production. Poultry Science 36:465-68.

Carson, J. R., W. A. Junnila and B. F. Bacon, 1958. Sexual Maturity and Productivity in the Chicken as Affected by the Quality of Illumination During the Growing Period. Poultry Science. 37:102-12.

Clegg, R. E. and P. E. Sanford, 1951. The Influence of Intermittent Periods of Light and Dark on the Rate of Growth of Chicks. Poultry Science. 30:760.62.

Daugherty, J. E., 1927. The Use of Artificial Lighting to Increase Winter Egg Production. Agricultural Engineering. 8:343-44.

Dobie, J. B., J. S. Carver and J. Roberts, 1946. Poultry Lighting for Egg Production. Washington Agricultural Experiment Station Bulletin 471.

Hall, G. O., 1946. Artificial Control of Egg Production. Poultry Science. 25:3-12.

Hughes, J. S., L. F. Payne and W. L. Latshaw, 1925. The Influence of Ultraviolet Light on Leg Weakness in Growing Chicks and on Egg Production. Poultry Science. 4:151-56.

Hutchinson, J. D. and W. W. Taylor, 1957. Seasonal Variation in the Egg Production of Fowls: Effect of Temperature and Change of Day Length. Journal of Agricultural Science. 49:419-34

Hutt, F. W., W. Lamoreaux and K. Goodwin, 1955. Don't Light Growing Pullets. Kimberchik News. April, 1955.

Jensen, L., and W. Matson, 1957. Continuous Light Causes Bigger Eyeballs. Science News Letters. 72:6.

Jordan, J. P., 1920. Use of Artificial Light to Increase Winter Egg Production. Reliable Poultry Journal Publishing Co., Quincy, Illinois. Pg. 9.

Kable, G. E., and F. E. Fox, 1928. Carbon Arc Lamps for Lighting and Irradiating Laying Pullets. Agricultural Engineering. 9:191.

King, D. F., 1958. Farm Journal. 82:36-7, and Personal Communications.

Moore, O. K., and N. R. Mehohof, 1946. Periodic Increase in Lighting versus Continuous Lighting for Layers. Florida Agricultural Experiment Station Bulletin 420.

Mueller, C. D., T. B. Avery, H. D. Smith, and R. E. Clegg, 1951. The Effect of Controlled Light and Temperature for Laying Hens. Poultry Science. 30:679-86.

Mussehl, F. E., and F. D. Yung, 1942. Sunlight Lamps for Laying Hens. Agricultural Experiment Station University of Nebraska, College of Agriculture Bulletin 344.

Nichols, J. E., E. W. Callenbach and R. R. Murphy, 1944. Light Intensity as a Factor in the Artificial Illumination of Pullets. Pennsylvania Agricultural Experiment Station Bulletin 462.

Nightall, E. W., 1955. Egg Production and Flash Lighting.

Journal of the Ministry of Agriculture. 62:421-24.

Parkhurst, R. I., 1930. Artificial Illumination to Increase Winter Egg Production. Journal of Ministry of Agriculture. 36:960-61.

Platt, C. S., 1953. Maintaining Winter Egg Production by the Use of Dim Red Lights. Poultry Science. 32:143-45.

Platt, C. S., 1955. A Study of the Effect of Restricted Lighting on January Hatched Pullets. Poultry Science. 34:1045-47.

Ragab, M. T., and M. A. Assem, 1953. The Effect of Atmospheric Temperature and Daylight on Egg Weight and Yield in Fayonmi and Baladix Fowl. Poultry Science. 32:1021-27.

Reliable Poultry Journal Publishing Company, Quincy, Illinois, 1920.

Rice, J. E., 1920. The Use of Artificial Light to Increase Winter Egg Production. Reliable Poultry Journal Publishing Co., Quincy, Illinois.

Rider, P. L., 1938. The Influence of Light on Growth and Reproduction of the Domestic Fowl. (Unpublished) Master's Thesis, Ohio State University.

Roberts, J., and J. S. Carver, 1941. Electric Light for Egg

Production. Agricultural Engineering. 22:357-60.

Sicer, J. W., 1956. Lights for Layers. Hoards Dairyman. 101:1150.

Simons, H. M., Jr., 1955. Two Platoon System. Farm Journal. 79:32.

Skaller, F., T. E. Allen and B. L. Sheldon, 1954. The Effect of Intensity of Daylight on Egg Production of Fowls in Cages. Australian Journal of Agricultural Research. 5:578-83.

Skoglund, W. C., 1959. Unpublished Personal Communications.

Sturkie, P.D., 1954. Avian Physiology. Comstock Publishing Associates, Ithaca, New York. P. 319.

Sykes, A. H., 1956. Short Day Length and Egg Production in the Fowl. Journal of Agricultural Science. 47:429-34.

Tomhave, A. E., 1954. Influence of Artificial Lights During Rearing on the Egg Production of October Hatched New Hampshires. Poultry Science. 33:725-29.

Warren, D. C., and H. M. Scott, 1936. Influence of Light on Ovulation in the Fowl. Journal of Experimental Zoology. 74:137-56.

Whetham, E. O., 1933. Factors Modifying Egg Production with Special Reference to Seasonal Changes. Journal of Agricultural Science. 23:383-418.

Wilson, W. O., and H. Abplanalp, 1954. Intermittent Light Stimuli in Egg Production Poultry Science. 35:532-38.

1 + 24 app