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To the Graduate Council:

I am submitting herewith a thesis written by James J. Johnson, entitled "Effects of Light Intensity on Reproductive Performance of Mice." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

R. L. Murphy
Major Professor

We have read this thesis and
recommend its acceptance:

George M. Menzies
Karl M. Barth

Accepted for the Council:

Shirley R. Smith
Vice Chancellor for
Graduate Studies and Research

EFFECTS OF LIGHT INTENSITY ON REPRODUCTIVE
PERFORMANCE OF MICE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

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ABSTRACT

The effect of light intensity on reproduction in mice has not been investigated extensively. It was the purpose of this study to determine the effects of 10, 50, and 90 foot candles (ft.-c.) of light on the reproductive performance of C₃H/HeJ mice housed in either transparent or translucent cages. Filter covers on the cages minimized the influence of disease on the colony. Daylength was 14 hours for all treatments.

The incidence of sterile matings was significantly higher ($P < .01$) within the 90 ft.-c. group. Neither light intensity nor cage type significantly affected (1) the age of dam at first parity, (2) the number of mice born or weaned, or (3) the Q factor (number of mice produced per 100 breeding days).

Considering the results of the present study, the following conclusions are made subject to the conditions of this experiment:

1. Suddenly increasing light intensity by 50 to 100 per cent at puberty may cause sterility in some new matings.
2. Fertile mice maintained at illumination levels of 10, 50, or 90 ft.-c. will have similar levels of reproduction.
3. Mice reproduce equally well in transparent or translucent cages.

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CHAPTER I

INTRODUCTION

The improvement of reproductive performance is one of the aims of every constructive animal breeder. Producers of laboratory animals are acutely aware of the need to increase proliferation because infertility is one of their major problems. Inbred strains of mice such as the C₃H/HeJ line used in this trial are not usually prolific breeders and therefore are relatively expensive (\$1.00-\$1.50 per weanling mouse). If the reproductive capacity could be increased through manipulation of environmental factors, considerable economic advantage would be obtained. In addition, users of laboratory mice usually need a steady flow of these animals for their experiments. A lapse in reproduction can negate an expensive and time consuming study. If a method could be devised to regulate somewhat the irregular seasonal breeding pattern of mice, progress could then be made toward eliminating an important variable in animal research.

The University of Tennessee Memorial Research Center maintains colonies of mice in the experimental animal facility. Poor reproduction in a group of newly purchased C₃H/HeJ mice prompted action to discover the cause of this situation. Two environmental aspects considered were light intensity and photoperiod. A perusal of the literature revealed few documented recommendations regarding level of illumination or optimum length of day needed for reproductive efficiency in mice.

The purposes of this study were: (1) to determine the effect of three light intensities (10, 50, and 90 foot-candles) on reproduction in mice; (2) to ascertain the effects of modification of light intensity by transparent or translucent cages and (3) to find the optimum level of illumination using these two cage types.

CHAPTER II

REVIEW OF THE LITERATURE

Does photoperiod and light intensity influence reproduction in animals? What effects do different types of cages have on reproduction? These are the questions to be discussed in this chapter in view of currently available literature. A wealth of data has been compiled on the subject of photoperiodic influence on reproduction. Only a portion of the information will be discussed here, since photoperiod is not the phenomenon under investigation. Photoperiod, however, is a closely related topic and was a controlled factor in this trial.

Few references were found pertaining to the effects of intensity of illumination or quality of light on reproduction. Hence this is a fertile area for investigation.

Little attention has been given to the effects of transparent and translucent plastic cages on reproduction. It is of interest here because of the obvious importance of the degree of light penetrating into the cages.

A. Photoperiodism

Emme (1960) in his review of photoperiodism and reproduction used the term "critical length of day" (CLD) and defined it as "the duration of light at which a change in one direction stimulates sexual development and in the other direction suppresses sexual development."

He also stated that this definition held true for animals such as mice which exhibit a quantitative response to light. Where the response was qualitative ". . . the CLD is the photoperiod on one side of which sexual development is precluded." He observed that the homozygotic sex (female mammals, male birds) was more sensitive to photoperiod than the heterozygotic sex.

Baker and Ranson (1932) found that female field mice (Microtus agrestis) were very sensitive to variations in photoperiod. Mice under a 15 hour photoperiod produced 47 young in 14 pregnancies with ten additional abortive pregnancies, while, during the same period, a like number of mice under a 9 hour photoperiod produced only 8 young in three pregnancies with one abortion. The authors found the males to be fertile under both photoperiods.

An excellent series of investigations relating to light and its effects on sex hormones was conducted by Fiske (1941). She maintained colonies of rats in constant light, constant dark, and natural day length conditions. The female rats were examined daily by means of vaginal smears for changes in the estrous cycle. Rats kept in continuous light had prolonged periods of estrus. The investigator concluded that this was evidence of excessive secretion of follicle stimulating hormone (FSH). She arrived at this conclusion because FSH causes secretion of estrogen which had been shown to cause prolonged periods of estrus. She further reported that immature female rats kept in constant light from birth or from the 21st day of life reached sexual maturity, as evidenced by vaginal introitus, 6 days earlier

than females on a natural day-night cycle, and 16 days earlier than those kept in darkness.

In another phase of the same study, Fiske (1941) kept rats in constant darkness or constant light for 350 days and reported that the rats in constant light showed premature senility of the ovaries, evidently from prolonged stimulation. She also stated that testes of males kept in constant light for up to 250 days were larger than those of rats kept in darkness. She found that the increase in testes weight was due to enlarged seminiferous tubules in which the occurrence of active spermatogenesis was more prevalent than in testes of males in darkness. Comparison of seminal vesicle weights showed that the rats in continuous light also had heavier secondary sex organs than did those kept in darkness.

In an extensive investigation lasting 30 years, Benoit (1964) presented evidence about the relationship of light and gonadotropins in the duck. He stated that the testes of drakes increased 80-fold in volume within 3 weeks after the start of daily illumination when they had previously been kept in total darkness. The author posed the question whether light was indispensable for normal testicular growth. To answer this question, he placed male ducks of ages varying from 18 to 135 days in constant darkness for periods up to 8 years. The total lack of light did not keep them from reaching sexual maturity and exhibiting sexual cycles, although the onset of puberty was delayed and the sexual cycles of the treated drakes were short and

irregular. Fiske (1941) and Benoit (1964), therefore, agreed that light enhances but is not essential for sexual development. Succinctly, photoperiod appeared to increase reproductive performance by stimulating the production of gonadotropins and the growth of gonadal tissue.

Marshall (1937) reported observations on estrous cycles in sheep. When ewes were transported across the equator, from north to south, some quickly adjusted to the new light environment and changed estrous cycling accordingly; others maintained the seasonal variation of their origin for a year or more before changing; still others never adjusted and did not reproduce. Marshall further states that ewes exposed to continuous light or continuous 6 hour days continued to exhibit seasonal estrus much the same as when under natural light conditions. He concluded there is an inherent biological rhythm which can outweigh the effects of light.

Hammond (1954) proposed that inherent rhythm may be due to a previous light stimulus being stored in the animal. He noted that ferrets, which had been under different light treatments, all exhibited estrus at about the same time when subjected to the proper light stimulus; but they became anestrus at varying times according to the initial light treatment.

Thus it is apparent that daylength affects reproduction in mammals and birds and may cause an inherent rhythm to become established. These phenomena depend on the species of animal and its intrinsic ability to respond to the stimulus.

B. Light Intensity

References pertaining to the effect of light intensity on animals are somewhat conflicting. Benoit, Assenmacher and Walter (1953) reported that up to an optimum level testicle size in ducks increased proportionally to the increased light intensity to which the drakes were subjected. Total response above the optimum light level was not only disproportionate, but in absolute terms was less than at the optimum level of stimulation. Unfortunately, the authors did not specify energy levels in this experiment. In contrast Dobie et al. (1946), using chickens as experimental subjects, found that the stimulus of intensities ranging from 1 to 30 foot-candles (ft.-c.) (during 13 hour photoperiods) were similar.

The level of illumination was shown by Marshall (1940) to affect gonadal response in the ferret. When animals were positioned at different distances from a light for 8 hours per day, they came into estrus at increasing lengths of time roughly proportional to the distance from the light.

Bartholomew (1949) kept sparrows under different intensities of artificial light for 16 hours per day. No appreciable stimulation was obtained at .04 ft.-c. (about twice the intensity of full moonlight). Starting at .7 ft.-c., the response increased with intensity, but he found little difference from 50 to 250 ft.-c. These data are difficult to compare with data of other workers since the intensities used were not always clearly defined and the experimental procedures varied so widely.

Some investigators deny the importance of level of illumination in laboratory animal reproduction and management. Cobb (1963) stated that 30 ft.-c. was adequate for routine handling and inspection of laboratory animals. He further commented ". . . several researchers have noted that 'Light is light,' and that the actual illumination level is relatively unimportant." Kosin (1968) reported that light intensity above 1 ft.-c. was not a factor except when the duration of light was strictly limited as in brief flashes of light. Porter et al. (1963), however, found IAC non-inbred mice placed under "strong light" (2.5 feet from an 80 watt fluorescent tube) with no overhead shading produced more offspring (11 per litter) than those in diffused light (8.4) but weaned fewer mice (6.8 and 8.3 respectively) because of higher death losses which the authors attributed to poor mothering ability and abnormal behavior of the mice under "strong light." A similar experiment with CBA inbred mice revealed only a slight decrease in the reproductive ability of mice under strong light and no abnormal behavior.

In summary, photoperiods of unspecified intensities have been shown by Fiske (1941) and Benoit (1964) to stimulate reproductive organs, and by Baker and Ranson (1932) to stimulate reproductive capacity. Light intensity affects reproductive physiology according to the work of Benoit (1964), Marshall (1940) and Bartholomew (1949). Porter (1967) found that light intensity also affects reproductive ability. It seems, therefore, that the preponderance of evidence is

in favor of a light intensity effect on reproduction in laboratory animals.

C. Effect of Type of Cage

There are many kinds of enclosures for laboratory animals in general and mice in particular. A complete discussion of caging is not attempted. The comparison of main interest is the relative effect of opaque, translucent and transparent cages on reproduction.

Porter (1967) compared transparent versus opaque cages in an unspecified light level and a 12 hour photoperiod. He found no difference between the effects of the two kinds of cages regarding age at sexual maturity or length of estrous cycle. The number of young weaned per breeding pair over two generations was reduced in transparent cages. He reported that 13.1 viable young were produced per 100 days by the transparent caged pairs whereas 23.0 young were produced by those in opaque cages in a like period. The author also noted that the mice in the transparent cages built their nests under the food hoppers, seemingly to avoid the light. When the position of the food hoppers was changed, the mice changed the position of their nests during the succeeding period of darkness. He concluded that the mice seemed to prefer the overhead cover of the food hopper for protection as much as for shade.

Lipscombe et al. (1966), in an uncontrolled experiment, housed breeding mice in metal cages which excluded practically all light.

They reported a low percentage of fertile post partum matings which they attributed to insufficient light entering the cage microenvironment.

Porter (1967) states that transparent caging and "powerful" lighting are not "complementary" to each other. He does not define how powerful the lighting must be to be detrimental to animals in transparent cages.

Thus there is a need for further research in the field of effect of the microenvironment on laboratory animals. The results of a series of experiments with clearly specified light intensities and cage characteristics would be of great interest to those establishing or trying to improve colonies of laboratory animals species.

CHAPTER III

EXPERIMENTAL PROCEDURE

The experimental animals consisted of C₃H/HeJ mice whose random-bred parents were descendants of a highly inbred stock purchased from Jackson Laboratory, Bar Harbor, Maine. This strain of mice has been reported by Fuller and Wimer (1966) to have a retinal deficiency. According to Karli (1952, 1954) this deficiency does not render the animals completely blind, but their threshold of light recognition is higher than normal mice. One hundred eight pairs of these mice were allotted, 18 pairs to each of six treatments in a 3 x 2 factorial experiment involving three levels of light and two types of cages. Illumination levels within the breeding room were 90 ± 2 ft.-c. (high level), 50 ± 2 ft.-c. (medium level), and 10 ± 2 ft.-c. (low level). Room and cage light intensity was measured with a Weston light meter. Room light intensity was measured at a point 48 inches from the floor and 6 inches horizontally from the cages in which the mice were housed. The light was produced by a mixture of incandescent and fluorescent sources. Cages were placed on two shelves 6 inches above or 6 inches below the point of measurement and were interchanged vertically three times per week (Monday, Wednesday, and Saturday) to prevent stratification. A photoperiod of 14 hours was maintained for all treatments throughout the experiment. Humidity was uncontrolled but was the same for all treatments. Temperature was maintained at $26 \pm .5^{\circ}\text{C}$. Mice

were transferred into clean cages once or twice each week as needed. Cages were either transparent Tyril plastic¹ or translucent polypropylene plastic and were bedded with processed corn cob bedding.² Cage covers were of the wire bar type. The cages were provided with a paper filter cap. The filter cap drastically reduced light intensity inside all cages, practically eliminated the line-of-sight of the light source for the mice in the translucent cages and caused a shaded area in the rear half of the transparent cages. The data in Table I illustrate the variation of light intensity within the cages. Light meter readings were taken in the lightest and darkest area of each cage.

The transparent and translucent cages within each treatment group were placed alternately on the shelves to ensure against confounding of other factors (e.g., disease, temperature, humidity, and noise) with treatment effects.

The mice were watered using pint glass bottles equipped with stainless steel sipper tubes. Drinking water was hyperchlorinated with 14 to 20 parts per million of chlorine and was changed at each cage change. A standard mouse feed³ was fed ad libitum.

¹Transparent cages, translucent cages, cage covers, and filter caps were manufactured by Carworth Lab Cages, catalog numbers 18320, 18520, 10220, and 20020, respectively.

²Manufactured by Paxton Processing Company.

³Laboratory chow manufactured by Ralston-Purina Company.

TABLE I
LIGHT INTENSITIES INSIDE CAGES

<u>Light level and cage type</u>	<u>Light intensity</u>
High transparent	5-25 ft.-c.
High translucent	2-5 ft.-c.
Medium transparent	2-5 ft.-c.
Medium translucent	2-5 ft.-c.
Low transparent	1-3 ft.-c.
Low translucent	1-3 ft.-c.

Full sibling matings were used in this experiment. Since these mice can be considered to be a homogenous population, litter-mate pairs were assigned to treatments non-randomly. The mice varied from 18 to 42 days of age at pairing (meaning, hereafter, to place a male and a female together) and had been reared in translucent cages at 70 ± 15 ft.-c. of light. Table II shows the age (mean and standard deviation) when paired. Age at pairing, within the limits stated here, has been shown by Porter and Bleby (1966) to have little effect on reproduction and mothering ability of mice.

Records for each pair (i.e., numbers of births and deaths, and the dates of each) were posted on Monday, Tuesday, Wednesday, Friday and Saturday. Mice were weaned on Monday, Wednesday, or Thursday at 20 to 23 days of age. The experimental period extended from time of pairing to 175 days of age of each pair. Criteria included in statistical analyses were: (1) the ratio of sterile to fertile pairs; (2) number of mice produced per female; (3) age of dam at first parturition; (4) number of young produced per 100 breeding days (Q factor) and (5) the theoretical number of mice produced commercially.

Culling was simulated because of experimental considerations; however, the data were analyzed as if it had been accomplished. Criteria for culling were based on a maintenance cost of \$3.00 per pair per month and a sale price of \$1.25 per weanling mouse. A pair was "culled" if it (1) did not produce the first litter by 75 days of age; (2) had more than a 50 day interval between litters; or (3) had

TABLE II
AGES OF BREEDER MICE WHEN PAIRED

Treatment	Mean days	Standard deviation
High transparent	34.9	3.1
High translucent	35.2	3.3
Medium transparent	26.8	7.9
Medium translucent	26.9	8.2
Low transparent	35.1	3.1
Low translucent	35.3	2.8

a mean litter size of less than three weanlings.

Statistical analyses included Bartlett's test for homogeneity of variances, the chi-square test for independence, analysis of variance (Steel and Torrie, 1960), the outlier test (Dixon, 1953) and the Winsorization procedure by Dixon and Tukey (1968).

CHAPTER IV

RESULTS AND DISCUSSION

A. Sterile Pairs

The distribution of sterile breeders is shown in Table III. Both high light level treatment groups had a disproportionate share of sterile pairs. Chi-square analysis on individual treatments showed that the unequal distribution of sterile animals in the high light transparent cages or the high light translucent cages was non-significant (calculated value was between $P < .1$ and $P < .05$). Analysis of the effects of light intensity on the distribution of sterile pairs (Table IV), however, showed a highly significant ($P < .01$) deviation from a random distribution indicating that the predominance of sterile matings in the high illumination group is an effect of that treatment.

Since all of the mice used in this study were reared nearly to puberty in a light environment similar to that of the medium translucent group, endocrinological shock may have occurred when the mice were placed in the high level of light. Stress from the change in light may have blocked initiation of estrous cycling in the females. While there is no direct reference to this problem in the literature, Marshall (1937) found that when ewes were subjected to abrupt reversal of season some failed to cycle and did not reproduce. Emme (1960) theorized that conditions of long daylight inhibit

TABLE III
DISTRIBUTION OF STERILE AND FERTILE PAIRS

Treatment	Number sterile	Number fertile
High transparent	3	15
High translucent	3	14
Medium transparent	0	18
Medium translucent	1	17
Low transparent	0	18
Low translucent	0	18

TABLE IV
CHI-SQUARE TEST FOR INDEPENDENCE

Treatment	Sterile	Fertile	Total	$\hat{P}_i$	$\hat{P}_{is}$
	(S)	(F)			
High light	6	29	35	.171	1.026
Medium light	1	35	36	.028	.028
Low light	<u>0</u>	<u>36</u>	<u>36</u>	.0	<u>0</u>
Totals	7	100	107		1.054
	$\hat{P}_i \quad 7/107 = .065$				.455
χ^2	$\frac{1.054 - .455}{.065 (1 - .065)} = .982$			2df**	

**P < 0.01.

sexual cycles in short-day animals because of an upset in endocrine processes. Possibly a similar type of upset may have occurred to some extent in the high light environment.

B. Performance of Breeding Pairs

1. Births

It would seem that if some pairs were rendered sterile by high light intensity, others in the same treatment should have been inhibited somewhat in reproductive performance. From Table V it is apparent that this is true of the high transparent cage group but not true in the high translucent treatment, since the number of mice born per mating in the latter is as high as any treatment. Since mice in transparent cages received more light than those in translucent cages (Table I, page 13) one would expect the high transparent cage mice to be depressed reproductively.

2. Weanlings

The mean number of mice weaned per pair during the experimental period is shown in Table VI. The experimental period began when the mice were paired and was terminated when each breeding pair reached 175 days of age. The right hand column of data shows means of fertile pairs only, whereas the other column reflects the inclusion of sterile pairs in the computation of the means. While some fairly large differences exist, they do not exhibit a trend or relationship between reproduction and light intensity (whether measured inside or outside of the cages).

TABLE V
AVERAGE NUMBER OF YOUNG BORN PER FERTILE PAIR

Treatment	Mean $\pm$ Standard Error
High translucent	22.58 $\pm$ 1.89
Medium transparent	22.56 $\pm$ 1.18
Low transparent	20.25 $\pm$ 2.46
Low translucent	18.90 $\pm$ 1.93
High transparent	18.06 $\pm$ 2.01
Medium translucent	17.31 $\pm$ 1.59

TABLE VI
TOTAL PRODUCTION TO 175 DAYS OF AGE OF PARENTS

Treatment	Weanlings per pair	Weanlings per fertile pair
High transparent	14.50 $\pm$ 2.11 ^a	16.73 $\pm$ 1.82 ^a
Medium transparent	20.31 $\pm$ 1.76	20.31 $\pm$ 1.76
Low transparent	19.13 $\pm$ 2.35	19.13 $\pm$ 2.35
High translucent	17.40 $\pm$ 3.94	21.75 $\pm$ 1.83
Medium translucent	15.00 $\pm$ 1.75	15.94 $\pm$ 1.59
Low translucent	17.61 $\pm$ 1.99	17.61 $\pm$ 1.99

^aMean $\pm$ standard error.

Since the experiment was designed with ample replication according to the method of Stein (Steel and Torri, 1960), the possibility existed that the experimental procedure had caused an artificial increase in variability. Accordingly, the data were tested for outliers, according to Dixon (1953), without success. Apparently, there was an insufficient range or number of isolated outliers to enable the process to reject any values. The data were also "Winsorized" by the technique of Dixon and Tukey (1968) to further test for the presence of an underlying, highly variable population. This process, too, yielded no decrease in variance. The conclusion must be accepted, therefore, that light did not significantly affect the production of weanling mice. These results agree with the report of Porter et al. (1963) who showed that "strong light" did not affect mothering ability and reproduction of CBA inbred mice. These authors hypothesized that the CBA mice were not light sensitive because of their dark-pigmented eyes. In the same series of experiments they found that a pink-eyed strain of mice exhibited unusual behavior and poor mothering ability when subjected to "strong light." The dark-eyed, inbred mice used in the present study may, like the CBA strain, possess some insensitivity to light. Since Benoit (1964) has shown that gonadal stimulation readily occurs after removal of the eye, the retinal deficiency inherent to the C3H/HeJ strain (Fuller and Wimer, 1966) should not affect the endocrine response of these mice to light radiation. This ocular deficiency is a factor to consider, however, in determining the significance of this report.

While interspecies comparisons are not always valid, the paucity of evidence on the effect of light intensity upon reproduction necessitates that an attempt be made to elicit information from related investigations. The work of Dobie et al. (1946) is somewhat relevant. They found that a number of intensities ranging from 1 to 31.3 ft.-c. of incandescent light were similar stimuli for egg production in domestic hens. The data suggest that increasing light intensity does not stimulate ovulation. The same lack of effect was found in the present study as evidenced by the number of births per fertile pair (Table V, page 21).

3. Age at First Parturition

The results of the present report do not agree with Marshall (1940) who reported that ferrets came into estrus more quickly when light intensity was increased. A comparison of the high and low light levels illustrates the lack of significant influence of light intensity on age at first parturition (Table VII). Since these mice were the same age when paired, age at first litter is an indication of onset of estrus, because those which came into estrus more quickly would likely copulate and conceive earlier than those whose estrus was delayed. Although the high light translucent group littered slightly earlier than the high-transparent group or the low-light mice, no significant differences exist. The fact that the translucent mice reached first parity earlier than the mice in transparent cages, also contradicts the idea that there is a proportionate effect of intensity

TABLE VII
AGE AT FIRST PARTURITION

Treatment	Age in days ^a
90 ft.-c.	
Transparent cage	72.3 $\pm$ 3.3
Translucent cage	66.1 $\pm$ 1.0
10 ft.-c.	
Transparent cage	74.6 $\pm$ 4.2
Translucent cage	72.2 $\pm$ 3.1

^aMean $\pm$ standard error.

on earliness of littering. Either there is a species difference in light responsiveness between ferrets and mice, or the experimental design of this study was such that a good measure of onset of estrus was not obtained.

4. Cage Effects

The type of cage--whether transparent or translucent--did not significantly affect the number of mice born or weaned per female, or the age of dam at first litter (Tables V, VI, and VII, pages 21, 22, and 25 respectively). The data do not agree with statements made by Porter (1967) that transparent cages have an adverse effect on reproduction especially in the presence of "powerful lighting." He reported observing that mice in transparent cages preferred to place their nests under the protection of the feed hopper and would move the nest if the hopper was moved. In the experiment reported here, the paper filter cap provided a uniform overhead protection. In the transparent cages, the mice had a choice of placing their nests in the rear of the cage, which was shaded by the filter cap, or in the front of the cage, which was in line-of-sight with the light source. The mice seemed to prefer sleeping in the lighted front of the cage and reared their litter in that area as often as in the shaded rear of the cage. Although mice are by nature covert animals, these observations suggest that no psychological disadvantage is inherent to transparent plastic cages equipped with filter covers. The main advantage

of transparent cages was the ease with which the occupants were observed without disturbing or handling them.

C. Commercial Implications

In order for the results of this study to be more meaningful for commercial breeders and others interested in producing mice efficiently, the data were subjected to analysis using commercial standards of husbandry. Treatment of the data entailed listing the number of days each pair of breeders remained in the breeding colony, and recording the number of offspring that each pair weaned during the time spent in the colony. The first factor was the period from 21 days prior to first litter to time of theoretical culling, death, or termination of the experiment at 175 days of age (computed individually). "Culling" depended on three criteria. A breeding pair was "culled" if it (1) did not produce the first litter by 75 days of age, (2) had more than a 50 day interval between litters, or (3) had a mean litter size of less than 3 weanlings. Culling standards were based on a maintenance cost of \$3.00 per pair per month, and a sale price of \$1.25 per weanling mouse.

The number of mice weaned per pair if the colony had been managed on a commercial basis is shown in Table VIII. Medium and low transparent groups have the highest values, while the high-transparent and medium-translucent treatments had the lowest number of weanlings per pair. The analysis of variance of the preceding data (Table IX) shows that the observed differences are not significant.

TABLE VIII
WEANLINGS PER PAIR MANAGED COMMERCIALY

Treatment	Mean $\pm$ standard error
Medium transparent	18.56 $\pm$ 2.27
Low transparent	18.44 $\pm$ 2.65
Low translucent	15.83 $\pm$ 1.76
High translucent	14.83 $\pm$ 2.07
Medium translucent	13.50 $\pm$ 2.28
High transparent	13.33 $\pm$ 2.42

TABLE IX
ANALYSIS OF VARIANCE OF THE NUMBER OF WEANLINGS
PER PAIR MANAGED COMMERCIALY

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Treatments	(5)	(484.6)	96.9	
Light level	2	172.2	86.1	1 ns
Cage type	1	114.0	114.0	1.24 ns
Light level x cage type	2	198.4	99.2	1.08 ns
Error	102	9375.6	91.9	
Totals	107	9860.2		

The average number of mice weaned per pair, divided by the average number of days that a pair spent in the breeding colony, when multiplied by 100 is called the Q factor. In other words, the Q factor is the number of mice weaned per 100 breeding days. There was a difference of 3.8 mice per 100 breeding days, between the high and low values of the low transparent and medium translucent treatments respectively. This difference represents a 27 per cent increase in productivity of the mice housed in transparent cages at the 10 ft.-c. light level over those housed in translucent cages at the 50 ft.-c. illumination. Since the latter group of mice were mated in the same environment in which they were born and reared, they may be considered a unique group regarding effect of change of light environment. The present data would then suggest that an increase in reproductive performance of fertile mice may result from (1) an increase in light intensity from 50 to 90 ft.-c. when the mice are housed in translucent cages, (2) a decrease in light level from 50 to 10 ft.-c. whether the mice are in translucent cages or changed from translucent to transparent cages or (3) merely changing the mice from translucent to transparent cages at the 50 ft.-c. light level. Since the increase in productivity is not significantly different, it points to the need for more research in this area. A duplicate experiment using larger numbers of breeders would answer the questions raised here concerning light intensity and caging effects on reproduction.

CHAPTER V

SUMMARY AND CONCLUSIONS

The effects of three levels of illumination and two types of cages on reproduction in C₃H/HeJ mice were studied by comparing (1) the proportion of sterile matings, (2) the number of mice born and weaned per pair, and (3) the age of dam at first parity.

The number of sterile matings was significantly greater ($P < .01$) at 90 ft.-c. than at 50 or 10 ft.-c. of illumination. Sterile matings were not observed in the 10 ft.-c. light treatment or in transparent-caged mice under 50 ft.-c. of illumination. Among fertile pairs, neither light level nor cage type significantly altered the number of mice born or weaned. Light intensity and cage material likewise failed to significantly affect the age of dam at first parturition. Evaluation of the data, as if the colony had been managed commercially, suggests that light intensities within the range of 10 to 90 ft.-c. for 14 hours per day are similar stimuli for reproduction. Superiority of one type of cage over the other was not apparent.

Remembering that the C₃H/HeJ mice were housed in filtered plastic cages and subjected to a 14 hour photoperiod, the data suggest that:

1. Abruptly increasing light intensity by 50 to 100 per cent at puberty may cause sterility in some matings.

2. Fertile mice maintained at illumination levels of 10, 50 or 90 ft.-c. will have similar levels of reproduction.

3. Mice reproduce equally well in transparent or translucent cages.

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VITA

James Joseph Johnson was born in Cincinnati, Ohio on 15 May, 1935. He was educated in the parochial, elementary, and secondary schools of that area. In 1953 he was graduated from Knoxville Catholic High School, having moved to that city in 1951. He attended The University of Tennessee from 1953 to 1957 and received a Bachelor of Science degree in Animal Husbandry. While awaiting active duty as an officer in the United States Army he served as swine herdsman for The University of Tennessee. After serving two years military service, he reverted to Reserve status in which he has been active to the present time. From 1960 to 1964 he was engaged in cattle and farm management. In February of 1964 he became employed by The University of Tennessee at the Oak Ridge Experiment Station from which he transferred to his present duty as supervisor of the experimental animal facility at The University of Tennessee Memorial Research Center. In January 1965, he entered the graduate school of The University of Tennessee on a part-time basis. In December 1968, he received his Master of Science degree. He is a member of the American Association for Laboratory Animal Science.

He is married to the former Linda Ann Sitzman of Knoxville, Tennessee, and has one son and three daughters.