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Semen characteristics and egg production of male and female commercial broiler breeders maintained in cages or on litter floors were evaluated over a 24-week period. Semen was collected from males caged singly or in pairs on a schedule of 3, 5, and 10 times (3X, 5X, and 10X) weekly from 36 through 59 weeks of age. Semen volume and concentration were determined once weekly for each male. Fertility and hatchability data of semen from males of the various treatment groups were obtained at 4 week intervals. Body weights and leg and foot problems were recorded at 28 day intervals and mortalities noted. No significant differences in semen volume, sperm concentration, percent fertility and percent hatchability were found between males ejaculated 3X and 5X weekly, or between males caged individually or as pairs. Total sperm per ejaculate was highest in birds ejaculated 5X weekly. Males ejaculated 10X weekly showed excessive cumulative mortality. The data suggest that although frequent semen collection (10X weekly) is feasible for up to 15 consecutive weeks,

intensive use of males may not be practical for a longer period of time.

Broiler breeders, 36 through 59 weeks of age, were maintained on litter floors in groups based on male:female ratios of 1:25, 2:25, and 3:25 in individual pens. Fertility and hatchability data were obtained at 4 week intervals from hatching eggs produced by natural mating. Percent egg production, mortality and female body weights at 28 day intervals were recorded. Percent fertility and hatchability were not significantly different among male:female ratios of 1:25, 2:25, and 3:25.

Reproductive Performance of Broiler Breeders Maintained in Cages or on Floors through 59 Weeks of Age

by

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Reproductive Performance of Broiler Breeders Maintained in Cages or on Floors through 59 Weeks of Age

I. INTRODUCTION

Traditionally, broiler breeders have been maintained on the floor to produce fertile hatching eggs by natural mating. One of the major problems associated with this mating system is a decline in fertility at 40 weeks of age or older (Van Krey and Siegel, 1976; McDaniel, 1978). This reduced fertility may be caused by mating difficulties of over-weight males resulting in a decreased frequency of successful matings (Parker, 1961; Wilson et al., 1979).

Reproductive inefficiency is one of the most costly and production limiting problems facing the poultry industry. Interest is increasing considerably among producers for housing broiler breeders in cages and using artificial insemination (A.I.) to produce fertile hatching eggs. Short term studies (8-14 weeks of production) have shown that maintaining breeders in a conventional manner (McDaniel, 1974; McCartney, 1976; McCartney and Brown, 1976; Van Krey and Siegel, 1976).

Information is limited on the reporductive performance of male broiler breeders maintained in cages and used for artificial insemination. McDaniel and Sexton (1977) studied the relationships of semen collection frequency to semen volume, sperm concentration, and fertility in caged broiler breeders during the first 13 weeks of production (26 weeks to 38 weeks of age). They found the frequency of semen collection to have a definite effect on semen volume and

sperm concentration, but fertility was not affected. The optimum number of inseminations obtained per male resulted from a collection frequency of twice daily, seven days per week.

Intensive and efficient use of broiler breeder males for semen production may be possible during the early weeks of production. However, there is neither information for male performance throughout an extended period of time nor during the latter weeks of the production cycle when major fertility problems occur. The purpose of this study was to evaluate the reproductive potential of broiler breeder males maintained in cages and subjected to various semen collection frequencies during the latter portion of a normal production cycle. In addition, comparisons for egg production, fertility and hatchability were made between broiler breeders maintained in cages and breeders kept on the floor.

II. MATERIALS AND METHODS

Broiler breeder males and females (Hubbard) were raised separately on litter floors according to Hubbard commercial recommendations. Special attention was given to suggested feed restriction programs to ensure proper body weights during the growing period. All birds were moved to production quarters at 20 weeks of age.

Experiment 1. One hundred twenty-eight females were randomly placed in individual laying cages (30.45 cm X 45.72 cm X 45.72 cm) inside a positive pressure ventilated house. The females were fed for maximum egg production and received 160 g of feed/bird/day (15.06% protein with 2898 Kcal per kg ME) during peak egg production. Water was provided 15 minutes about every 2 hours from 0415 hrs to 1745 hrs in continuous U-trough plastic waterers. During the laying period the females were given 14 hours of light from 0400 hrs to 1800 hrs and 10 hours darkness. Daily egg production, monthly body weights, and mortality were recorded from sexual maturity to 60 weeks of age.

Thirty-six males were randomly and evenly assigned to six treatment groups and placed in similar cages within the same house. Each male received 115 g of feed/day (13.11% protein with 3148 Kcal per kg ME) after 24 weeks of age. The males were maintained on the same watering and lighting schedule used for the females. Treatment groups were determined by the number of males per cage and frequency of semen collection, and are presented in Table 1. Both single and double bird cages allowed 1394 cm^2/ bird. Double cages were made by removal of a partition between 2 single cages.

Table 1. Treatment groups of males in Experiment 1, based on the number of birds per cage and the frequency of semen collection

Treatment group	Number birds per cage	Frequency of semen collection	Time of collection
1	1	3X weekly, MWF	1400 hrs
2	1	5X weekly, MUWHF	1400 hrs
3	1	10X weekly, MUWHF (2X daily)	1100 hrs 1400 hrs
4	2	3X weekly, MWF	1400 hrs
5	2	5X weekly, MUWHF	1400 hrs
6	2	10X weekly, MUWHF (2X daily)	1100 hrs 1400 hrs

Collection of semen began when the males reached 36 weeks of age and continued to 60 weeks of age (24 week period). Individual semen volume and concentration were measured every Friday. Volume was measured by collecting semen directly into a conical graduated centrifuge tube. Sperm concentration was estimated by optical density using a Spectronic 20 at 600 mu according to the procedure of Kosin and Wheeler (1956).

Semen quality was measured by determining fertility and hatchability from the various treatment groups by artificially inseminating the breeder females at 4 week intervals. Hens were inseminated with .05 ml of undiluted semen from individual males. Eggs were collected daily for one week following insemination and identified by hen number and date of lay. Eggs were stored at 16^{o}C for up to 12 days before incubation. All eggs were candled at 10 days of incubation and at transfer to hatching baskets (17 days). All infertile eggs, dead embryos, and pips were individually broken out and macroscopically inspected.

Monthly body weights beginning at 39 weeks of age, leg and foot problems, and mortality were recorded for the males. The development of leg problems was monitored and feet were rated at 4 week intervals using the following scoring system: 0=normal; 1= inflammation, no broken skin; 2=small patches of lesions; 3=large amount of inflammation, severe lesions; 4=very severe deep open lesions; 5=lame. Semen volume and concentration, fertility, and hatchability data were analyzed among treatment groups 1, 2, 4, and 5 by a split plot design analysis of variance as outlined by Steel and Torrie (1960). Treatment groups 3 and 6 were not included in the analysis due to excessive

cumulative mortality (13.9%) by 51 weeks of age, which resulted in insufficient numbers of males per group. A potential relationship between foot problems and body weight was examined using Product-moment correlation analysis (Rowe and Barnes, 1976).

Experiment 2. One hundred and fifty females were randomly and evenly divided among 6 litter floor pens in a windowed naturally ventilated house. Each pen measured 3.35 m X 5.18 m with a 2.13 m X 1.22 m roost and contained 12 nesting boxes. Feeding and lighting schedules were similar to those described for females in Experiment 1, with lights commencing at 0430 hrs. Water was provided 15 minutes about every 2 hours from 0445 hrs to 1815 hrs.

Twelve males were randomly assigned to six groups, consisting of three treatment groups based on male:female ratios in individual pens (Table 2). Each treatment was replicated twice. Daily egg production, mortality, and monthly female body weights beginning at 39 weeks of age were recorded through 59 weeks of age.

From 36 weeks through 59 weeks of age, fertility and hatchability data of the various treatment groups were obtained. Hatching eggs were produced by natural mating. Eggs were collected during the same seven days every 4 weeks as in Experiment 1. Each egg was identified by pen number and date of lay. Eggs were stored, incubated, and examined with eggs from Experiment 1. After each egg collection period, males were randomly reassigned to floor pens, maintaining the same male:female ratio in each pen. Fertility and hatchability data were treated by a split plot design analysis of variance of the 3 treatment groups as outlined by Steel and Torrie (1960). Female

Table 2. Treatment groups of Experiment 2, based on the male:female ratio in individual pens

Treatment group	Number of males	Number of females	Equivalent male:female ratio
1	1	25	4 : 100
2	2	25	8 : 100
3	3	25	12 : 100

body weights of caged and floor birds were compared using a t-test for equality of means and an F-test for equality of variances (Rowe and Barnes, 1976).

III. RESULTS AND DISCUSSION

In Experiment 1, no significant differences in semen volume or concentration were found among treatments 1, 2, 4, and 5 through 59 weeks of age, or 420 days (Table 3). Total sperm per ejaculate was highest in birds ejaculated 5X weekly, whether caged singly or in pairs. The percent fertility and hatchability were not significantly different between the four treatments. Treatment groups 3 and 6 showed excessive mortality by 59 weeks of age, but semen volume and concentration as well as percent fertility and hatchability of birds ejaculated 10X weekly were similar to birds ejaculated 3X and 5X weekly up to 51 weeks of age. The data suggest that although frequent semen collection (10X weekly) is feasible for up to 15 weeks, as supported by McDaniel and Sexton (1977), intensive use of males in this way may not be practical for a complete production period. Broiler breeder males did not endure frequent handling and semen collection under our housing conditions. Monthly variations in semen characteristics for all treatments are presented in Figure 1. There were no significant differences in semen characteristics, fertility, hatchability or mortality between males caged individually or as pairs. Similar results were found by Craig and Polley (1977). However, Crawford and Proudfoot (1967) found that crowding of males in cages significantly reduced semen volume.

The development of leg weakness is a problem with male broiler breeders on litter floors and may be caused by excessive body weight by 40 weeks of age (McDaniel, 1978). Leg weakness was observed for male breeders in cages in Experiment 1, but females were not affected.

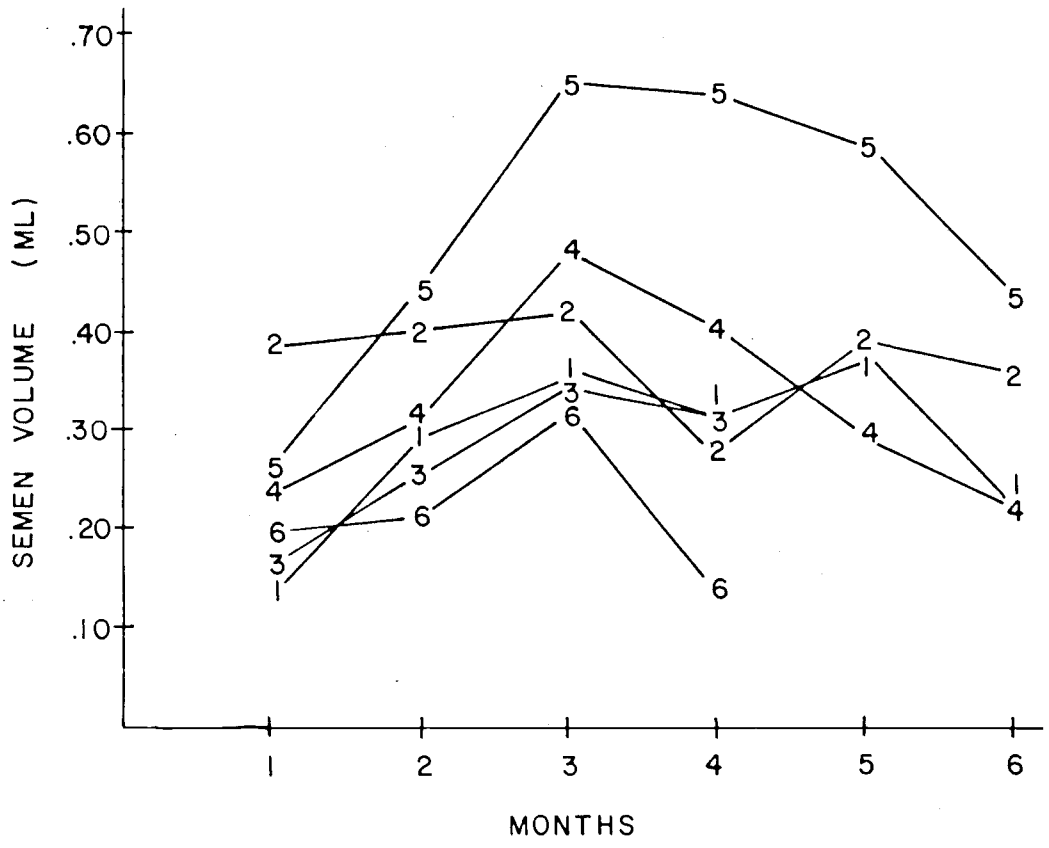
Table 3. Mean volume, concentration, and fertility of semen, including hatchability of fertilized eggs from broiler breeder males on various semen collection schedules during 36-59 weeks of age

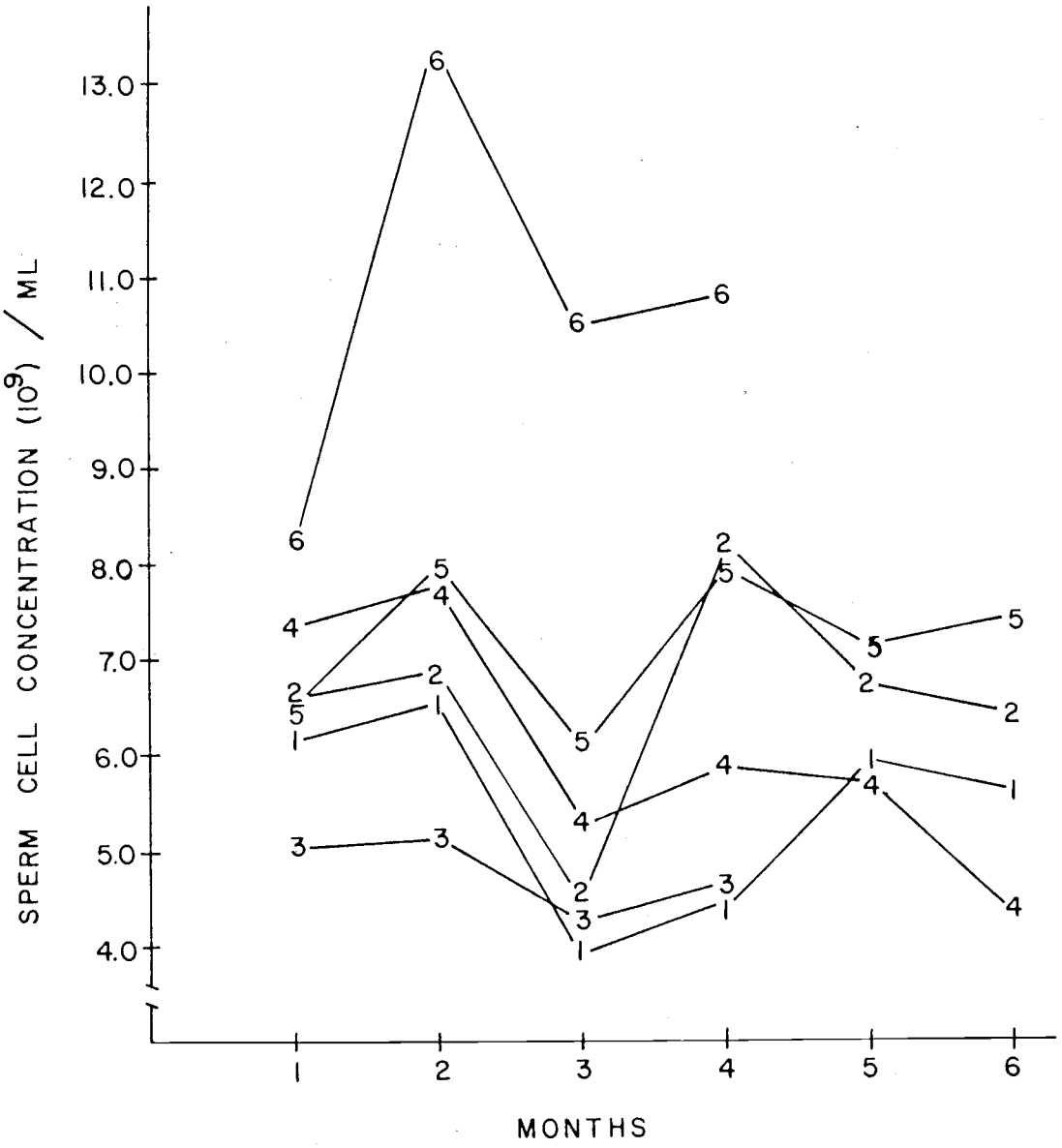
Treatment group[b]	Semen characteristics, per ejaculate: Volume (ml)	Concentration (10^9 sperm/ml)	Total sperm (10^9)	Fertility (%)	Hatchability (%)
1	.28[a]	5.21[a]	1.48	80.26[a]	85.88[a]
2	.37[a]	6.38[a]	2.38	91.76[a]	87.07[a]
4	.32[a]	5.92[a]	1.94	89.17[a]	79.16[a]
5	.51[a]	7.16[a]	3.65	89.73[a]	81.37[a]

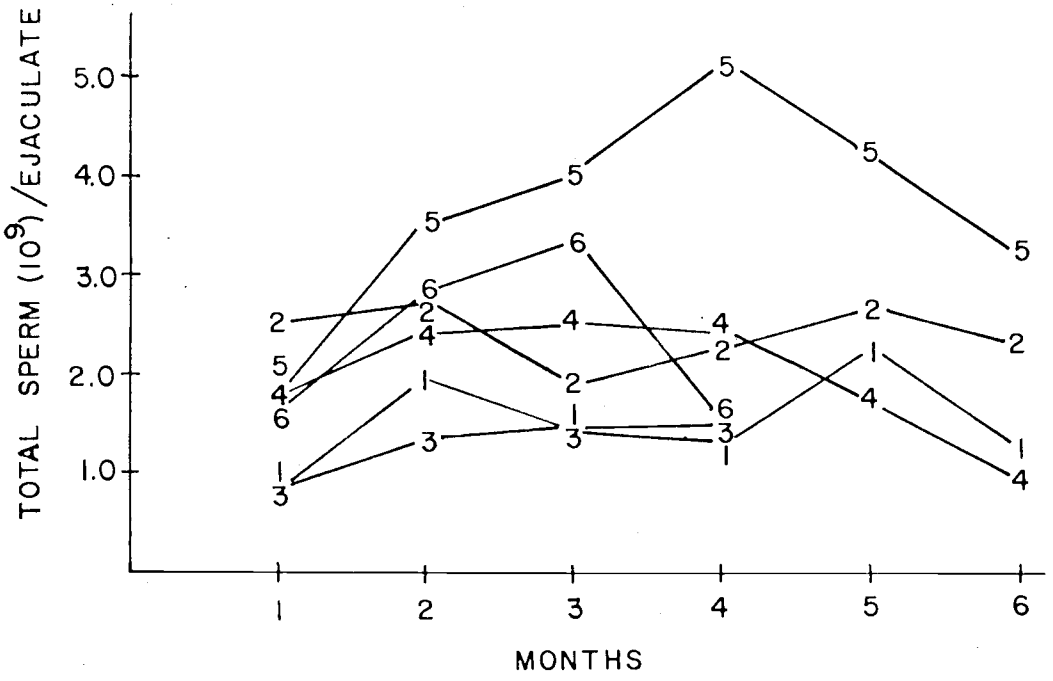
[a]Means and percentages within a column with the same superscript are not significantly different ($P<.05$).

[b]Treatments 1 and 2 refer to collection of semen 3X and 5X weekly, respectively, with 1 male per cage, and treatments 4 and 5 refer to collection of semen 3X and 5X weekly, respectively, with 2 males per cage.

Figure 1. Monthly variation of semen characteristics of broiler breeder males subjected to various semen collection schedules during 36-59 weeks of age. Treatment groups 1, 2, and 3 refer to collection of semen 3X, 5X, and 10X weekly, respectively, with 1 male per cage. Treatment 4, 5, and 6 refer to collection of semen 3X, 5X, and 10X weekly, respectively, with 2 males per cage. Each month refers to pooled data over a 4 week period. Months 1, 2, 3, 4, 5, and 6 represent age in weeks of 36-39, 40-43, 44-47, 48-51, 52-55, and 56-59, respectively.


SEMEN VOLUME (ML)
.70
.60
.50
.40
.30
.20
.10
1
2
3
4
5
6
MONTHS


SPERM CELL CONCENTRATION (10^9) / ML
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
1
2
3
4
5
6
MONTHS


TOTAL SPERM (10^9)/EJACULATE
5.0
4.0
3.0
2.0
1.0
1
2
3
4
5
6
MONTHS

The mean foot score for all males was 2.5. A nonsignificant positive relationship (r=+.15) existed between body weight and average foot score up to 51 weeks of age, and a nonsignificant negative relationship (r=-.15) was found for these birds between 51 and 59 weeks of age. These small correlations suggest that the development of leg problems of broiler breeders in cages under our conditions was not as closely associated with excessive body weight as is reported for breeders on litter floors. The change from a positive to a negative correlation was probably caused by males developing severe leg problems with related secondary disorders, which led to a subsequent weight loss. Staphylococcus aureus (Staph arthritis) was isolated from swollen hock joints at necropsy of birds which died. The appearance or severity of leg weakness was not significantly different among the 6 treatment groups of Experiment 1.

Data from broiler breeders maintained on litter floors in Experiment 2 are presented in Table 4. Percent fertility and hatchability of fertile eggs were not significantly different among the male:female ratios of 1:25, 2:25, and 3:25. These results are in agreement with those of Parker (1958), who found that fertility was not increased by using more than 4 to 5 meat-type males per 100 females.

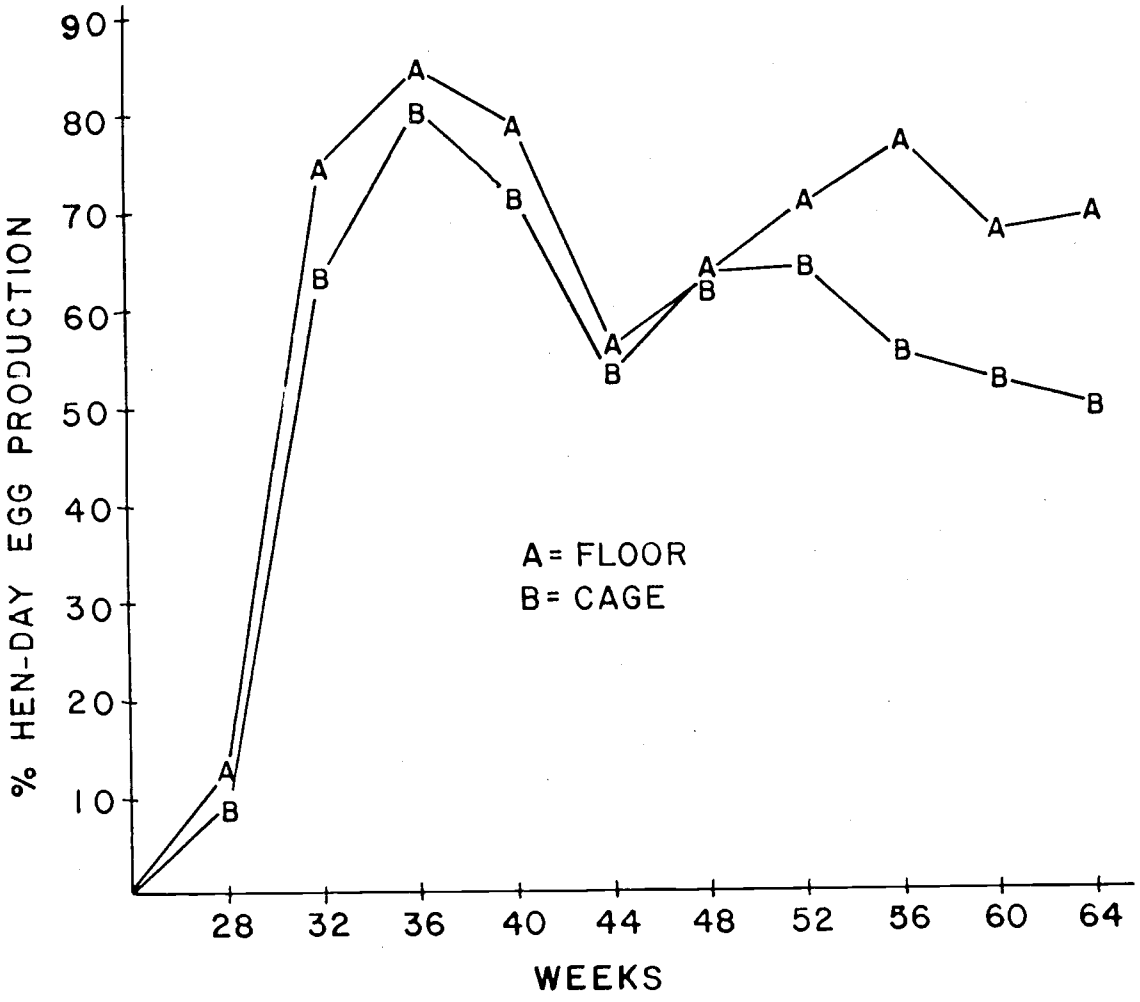
The percent hen-day egg production of females in both Experiments 1 and 2 is shown in Figure 2. Hens maintained in floor pens produced more eggs per day than hens kept in cages throughout the production cycle. The drastic drop in egg production at 40 weeks of age was due to extremely cold weather ($0^{o}C$ was the average temperature at 0800

Table 4. Mean fertility and hatchability of eggs from broiler breeders maintained in floor pens with various male: female ratios during 36-59 weeks of age

Treatment group	Sex ratio (male:female)	Fertility (%)	Hatchability (% of fertile eggs)
1	1 : 25	85.36[a]	75.40[a]
2	2 : 25	80.06[a]	81.98[a]
3	3 : 25	85.02[a]	76.42[a]

[a]Percentages within a column with the same superscript are not significantly different ($P<.05$).

Figure 2. Percent hen-day egg production of broiler breeder females maintained in cages and on litter floors.


% HEN-DAY EGG PRODUCTION
90
80
70
60
50
40
30
20
10
28
32
36
40
44
48
52
56
60
64
WEEKS
A= FLOOR
B= CAGE

hrs from 40 to 43 weeks of age) and excessive feed restriction. Additional feed supplementation returned egg production to acceptable levels by 52 weeks of age. The mean body weight of females at 60 weeks of age was 4.45 kg and 3.74 kg, in cages and on the floor, respectively. The body weight of caged females was significantly higher ($P<.05$) than for females on the floor. The variation in body weight within females in cages (.52 kg) was also significantly greater ($P<.05$) than variation in body weight within females on the floor (.40 kg). The coefficients of variation, however, are the same, therefore the differences in variance are due to a scale effect.

McDaniel (1974) showed that broiler breeder hens generally produce more eggs when kept in cages. The results found in this study were not in agreement. Reduced egg production by breeder hens in individual cages under our conditions of housing may be partly due to the limited ability of potentially high producing hens to meet their metabolic needs because of access to feed, which is restricted to what is placed in front of a particular bird's cage. Conversely, poor egg producing hens in cages may have access to more feed than they need resulting in obesity. If breeder females are to be kept in cages, appropriate feeding recommendations and methods of providing feed will need to be developed.

Data for fertility and hatchability of fertile eggs from broiler breeders kept in cages and artificially inseminated and breeders maintained on floors and naturally mated are shown in Table 5. Data for fertility and hatchability were pooled for treatment groups within each experiment. Caged birds generally exhibited as good or better

Table 5. Percent fertility and hatchability of fertile eggs of broiler breeders kept in cages and on floors during 36-59 weeks of age

Weeks of age	Fertility (%)		Hatchability (%)	
	Cage	Floor	Cage	Floor
36 - 39	93.42[1]	85.33	86.10[1]	79.73
40 - 43	82.57[1]	81.67	*	*
44 - 47	81.07[1]	83.67	77.27[1]	84.47
48 - 51	88.26[1]	78.29	85.71[1]	80.75
52 - 55	86.94[2]	81.17	79.49[2]	64.37
56 - 59	92.50[2]	92.34	86.87[2]	80.35
Total	87.42	83.75	83.09	77.93

[1]Percentage includes treatment groups 1 - 6.

[2]Percentage includes treatment groups 1, 2, 4, and 5.

*Incubator malfunction.

fertility and hatchability through 59 weeks of age. Previous work by Parker and McCluskey (1959) has shown that caged housing of male chickens, as compared to floor housing, does not adversely affect reproductive performance. They found no difference in semen volume of Delawares kept in cages or on the floor. Satisfactory fertility was obtained using artificial insemination. Using males from several lines, Siegel and Beane (1963) found semen volume to be significantly greater from males maintained in cages than on the floor. Mortality of caged birds was greater than floor birds (Table 6).

Causes of embryonic mortality and age of death were similar for eggs fertilized by artificial insemination and by natural matings. The majority of deaths (55.3%) occurred at hatching, with 50.5% of all embryonic deaths due to malpositions.

Improvement in cage design to facilitate easier access and handling of birds may reduce leg problems and mortality and improve semen and egg production. Severe foot lesions provide an excellent portal of entry for micro-organisms, and will continue to be a problem in the spread of disease unless cage floors are designed to minimize damage to the feet. The collection of uncontaminated and maximum volumes of semen may be made easier if males can be readily removed from cages without undue upset or stress to the birds just prior to ejaculation. Advancements in incubation procedures to reduce the occurrence of malpositions may be an important way to improve the hatchability of broiler chicks. While males used in this study were selected as potentially good breeder candidates using visual criteria such as body conformation and vigor before being randomly assigned

Table 6. Mortality of male and female broiler breeders housed in cages and on the floor during 36-59 weeks of age

Weeks of age	Mortality (%)[a]			
	Males		Females	
	Cage	Floor	Cage	Floor
36 - 39	2.8	0	1.6	0.7
40 - 43	5.5	0	0	0
44 - 47	0	0	1.5	0
48 - 51	8.4	0	0	0
52 - 55	0	8.3	0	0
56 - 59	8.3	0	0	0
Total	25.0	8.3	3.9	0.7

[a]Values obtained by pooling birds regardless of treatment.

to treatment groups, better semen production and fertility of males may be possible if birds are evaluated and selected for semen quality and fertilizing capacity prior to the breeding season.

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V. REFERENCES

Craig, J. V., and C. R. Polley, 1977. Crowding cockerels in cages: effects on weight gain, mortality, and subsequent fertility. Poultry Sci. 56:117-120.

Crawford, R. D., and F. G. Proudfoot, 1967. The effects of cage housing and aggressiveness of chicken males on semen qualities. Poultry Sci. 46:672-675.

Hughes, B. L., and K. A. Holleman, 1976. Efficiency of producing White Leghorn hatching eggs via artificial insemination and natural mating. Poultry Sci. 55:2383-2388.

Kosin, I. L., and A. Wheeler, 1956. Methods for estimating spermatozoa numbers in turkey semen. Northwest Sci. 30:41-47.

McCartney, M. G., 1976. The effects of semen dosage and insemination frequency on the fertility of broiler breeder hens. Poultry Sci. 55:669-671.

McCartney, M. G., and H. B. Brown, 1976. Effects of method of mating on fertility in broiler breeder hens. Poultry Sci. 55:1152-1153.

McDaniel, G. R., 1974. The production of broiler hatching eggs in cages. Poultry Sci. 53:1954.

McDaniel, G. R., 1978. Low fertility in broiler hatching eggs. Poultry Digest 37:446.

McDaniel, G. R., and T. J. Sexton, 1977. Frequency of semen collection in relation to semen volume, sperm concentration, and fertility in the chicken. Poultry Sci. 56:1989-1993.

Parker, J. E., 1958. Relation of male to female ratios on fertility in crossmated flocks of chickens. Poultry Sci. 37:644-648.

Parker, J. E., 1961. Observations on the low fertility problem in Cornish cockerels. Poultry Sci. 40:1214-1219.

Parker, J. E., and W. H. McCluskey, 1959. Volume and fertilizing capacity of semen collected from cockerels maintained in cages and on litter floors. Poultry Sci. 38:858-860.

Rowe, K. and J. Barnes, 1976. Statistical interactive programming system (SIPS). Statistical Computing Report No. 3, Department of Statistics, Oregon State University, Corvallis, Oregon.

Siegel, P. B., and W. L. Beane, 1963. Semen characteristics of chickens maintained in all-male flocks and in individual cages. Poultry Sci. 42:1028-1030.

Steel, R. C. D., and J. H. Torrie, 1960. Principles and procedures of statistics. McGraw-Hill Book Co. Inc., New York, NY.

Van Krey, H. P., and P. B. Siegel, 1976. A revised artificial insemination schedule for broiler breeder hens. Poultry Sci. 55:725-728.

Wilson, H. R., N. P. Piesco, E. R. Miller, and W. G. Nesbeth, 1979. Prediction of the fertility potential of broiler breeder males. World Poultry Sci. J. 35:95-118.

APPENDICES

Table 7. Composition of station layer ration (1469)[a]

Ingredient	Percent
Corn, yellow	72.65
Soybean meal (44%)	12.62
Meat meal with bone	5.00
Alfalfa meal (17%)	2.50
Defluorinated phosphate	1.00
Limestone flour	3.08
Oystershell flour	2.50
Salt, iodized	.40
Vitamin mix 1-75[b]	.20
Mineral mix DD-65[c]	.05
Total	100.00
Calculated Analysis	
Protein (%)	15.06
Energy (kcal/kg ME)	2898.46

[a]Fed to broiler breeder females in cages and both male and females on litter floors.

[b]Vitamin mix provides per kg ration: vitamin A, 3300 IU; vitamin D_3, 1100 ICU; riboflavin, 3.3 mg; d-pantothenic acid, 5.5 mg; niacin, 22.0 mg; choline, 190.0 mg; vitamin B_{12}, 5.5 mcg; vitamin E, 1.1 IU; vitamin K, 0.55 mg; folic acid, 0.22 mg; ethoxyquin, 0.06 g.

[c]Mineral mix provides per kg ration: Mn, 50 mg; Fe, 2 mg; Cu, 0.2 mg; Zn, 27.5 mg; Co, 0.2 mg.

Table 8. Composition of station developer II ration (1472)[a]

Ingredient	Percent
Corn, yellow	84.20
Soybean meal (44%)	6.00
Meat meal with bone	5.00
Alfalfa meal (17%)	2.50
Defluorinated phosphate	1.25
Limestone flour	.50
Salt, iodized	.40
Vitamin mix 1-75[b]	.12
Mineral mix DD-65[c]	.03
Total	100.00
Calculated Analysis	
Protein (%)	13.11
Energy (kcal/kg ME)	3147.73

[a]Fed to broiler breeder males in cages.

[b]Vitamin mix provides per kg ration: vitamin A, 3300 IU; vitamin D_3, 1100 ICU; riboflavin, 3.3 mg; d-pantothenic acid, 5.5 mg; niacin, 22.0 mg; choline, 190.0 mg; vitamin B_{12}, 5.5 mcg; vitamin E, 1.1 IU; vitamin K, 0.55 mg; folic acid, 0.22 mg;ethoxyquin, 0.06 g.

[c]Mineral mix provides per kg ration: Mn, 50 mg; Fe, 2 mg; Cu, 0.2 mg; Zn, 27.5 mg; Co, 0.2 mg.