EFFECTS OF NUMBER AND LOCATION OF NIPPLE WATERERS ON THE PERFORMANCE OF CAGED WHITE LEGHORN LAYERS

by

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B.S., University of Florida Gainesville, 1984

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER'S OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1989

Approved by:

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ACKNOWLEDGEMENT

I would like to dedicate this paper to my parents William and Dylcia Gernat and to my darling wife, Carolina, for their consistent moral support and love through all the good and the not-so-good years.

I am extremely grateful and forever indebted for the couple who made all of this possible, Dr. Don Good and wife, Jane, two of the most wonderful persons I have ever known.

I would like to express my sincerest gratitude to Dr. Albert Adams, my major professor, for the guidance, patience and trust he has bestowed upon me, also for the enhancement of my capabilities, responsibilities and knowledge in and out of the field of poultry science.

A special thanks to all of the people at Zamorano, especially Dr. Simon Malo, Mariano Jimemenez, Javier Oleachea, and Randolfo Cruz, who in one way or another, have helped me to achieve my goals.

I would like to express my appreciation to the graduate committee members, Dr. James Craig, and Dr. Len Harbers for their advice and assistance, and to Dr. K Kemp for his assistance in the statistical analysis. I would also like to give a sincere thanks to Ken, Myron and the KSU Poultry Research Center staff for their assistance in data collection and management of the birds. Thanks to Danita, Vanessa, Liz and Eva who helped get this project on paper. A very special thanks to Norman Ramos who has been a great help and friend.

Introduction

Water is a nutrient which plays a vital role in all aspects of body metabolism. Maintenance of adequate water consumption is, therefore, a priority function of the body's homeostatic mechanism.

The quantity of water available to the caged laying hen is controlled by the ability of the hen to obtain water from the drinking device. Hostetler (1987) showed that egg production of birds can be affected by the type of commercial drinking devices, the watering regimens that the hens are raised on as pullets and on the type of watering system available to them in layer cages. Selecting a water system can be difficult because of the number of systems available, the lack of published research data on various systems, conflicting performances under practical conditions, and the number of variables that can affect the amount of water needed by the birds.

Cone-shaped, trigger and fount-cups, and nipple waterers are replacing conventional trough waterers in new and remodeled poultry houses. These watering devices can be classified into three basic systems: passive, semi-active, and active (Hostetler 1987). Nipple waterers are considered an active system because they require the active participation of the bird for each drop of water it consumes. Nipple waterers have been used for approximately 10-15 years in cage layer systems and to some extent in brooding-rearing cages for egg-type pullets.

Although nipples have been used in some instances for broiler production, usage has not been widespread because broilers have not performed as well on nipples as on other types of waterers (Andrews 1976). But there is an increasing interest in the use of newer types of nipples by the commercial broiler industry.

Research conducted by Cunningham (1987) relating nipple waterers to the performance of laying hens suggested that the change from cup waterers to the nipple system required a period of adaptation by the pullets that resulted in some loss of early egg production. This loss of production, however, was only transitory and the pullets compensated for this loss later in the production period. The results suggest the importance of management during the period immediately after housing in cages to insure that pullets adjust to a different watering system as quickly as possible in commercial cage units.

There are a number of factors that affect the location of the waterers. Some watering system manufacturers suggest locating the waterers away from the feed trough so the birds can rotate at the feed trough and thus provide eating space and drinking space for each and every bird in the cage. Other manufacturers recommend locating the waterers near the front and center of the cage. Waterers should be located for ease of access for the birds as well as for the caretaker in the event a repair is needed. Also the waterers should be located where there is sufficient light because light reflecting on the water surface attracts the birds to the waterers.

There is a lack of uniform recommendations on number of waterers per cage. Some manufacturers recommend placing two or even more waterers per cage. The United Egg Producers (1982) recommended that adequate fresh water should be easily accessible to the birds and care shall be taken at each change of a system to insure that the birds find the water points. To facilitate this, a minimum of 2.5 cm. (1 inch) of water trough per bird and maximum of 20 birds per cup or nipple shall be provided. Anonymous (1987) reported that the European Economic Community has recommended that cages should provide two nipples or cups per cage or a continuous drinker.

The objective of this study was to investigate the effects of cage shape, and the number and position of nipple waterers on the productivity and water consumption of White Leghorn layers housed in deep and shallow cages.

Literature Review

Cage Shape. The concept of the reverse cage, the long dimension adjacent to the feed trough. was developed by Bell (1972). He showed that birds housed in 45.7 x 30.5 cm reverse cages had significantly ($P<.05$) less mortality than those in 30.5 x 45.7 cm conventional cages, 7.1 vs. 19.7% , respectively. Birds in reverse cages laid significantly more eggs with fewer cracks and had better feed conversion than those in conventional cages. No difference was seen in overall feed consumption.

Martin et al, (1976) analyzed the effect of cage shape and crowding on layers using cages ranging from 25.5 x 30.5 cm deep to 61 x 51 cm wide at densities of 17.2 to 32.3 birds per m^2. Bird performance was observed at densities exceeding 22 birds per m^2. In the range of 22 to 32 birds per m^2 mortality increased 1.2%, hen-day production decreased .75%, feed requirements increased 14.8 g per dozen eggs, and eggs per pullet decreased 4.7 for each additional bird per m^2. The same bird densities were used in cages 30.5 to 35.5 cm from front to back. These birds produced from 9 to 20 more eggs and earned $0.16 to $0.83 more return over feed and chick cost than flockmates in cages 46 to 51 cm from front to back. The production and net return margin were attributable to the increase in depth of the cage as bird density increased.

Performance of Red x Rock sex-linked females in reverse and conventional laying cages of varying heights was studied by Muir (1976). He housed 100 Red x Rock females at three birds per cage in reverse cages measuring 45.7 x 30.5 cm and 300 females were housed in conventional 30.5 x 45.7 cm cages. One half of the cages measured 35.6 cm and the other half 30.5 cm in height . There were no significant treatment differences for hen-day egg production, feed efficiency or livability in trial one. Feed consumption for birds housed in reverse cages measuring 35.6 cm in height was significantly greater than for the other treatment groups. Trial 2 revealed significantly higher egg production and improved feed efficiency for the layers housed in reverse cages with a height of 30.5 cm.

The interaction of cage size, cage level, social density, fearfulness and production of Single Comb White Leghorn was seen by Sefton (1976). Hens housed in the top tier of cages laid at a lower rate and were more fearful than those housed in the bottom tier. Three birds were housed in cage size of 30 x 46 cm and two birds were housed in cage sizes of 25 x 46 cm and 20 x 46 cm cage, giving an area per bird of 460 cm^2 in cage size of 30 x 46 cm and 20 x 46 cm and 575 cm^2 for birds in cage size 25 x 46 cm. Increasing the number of birds per cage while holding area per bird constant tended to influence both egg production and fearfulness more than did holding number of birds constant and changing the area per bird. Livability was not significantly influenced by mating, cage tier or cage size. Within matings, fearfulness and egg production as well as fearfulness and livability tended to be negatively related. There was no relationship between these factors over matings within either cage size or cage tier, indicating a genetic component to the relationship between fearfulness and either egg production or livability.

Layer performance in reverse versus conventional cages was observed by Swanson and Bell (1977). They showed higher egg production , feed efficiency and egg income over feed costs by birds housed three per 45.7 x 30.5 cm shallow cages than those in 30.5 x 45.7 cm deep cages. At a higher bird density, these same performance factors were lower for both cage shapes. There was little or no effect of either cage shape or bird density on egg size, shell quality and Haugh unit values.

Hill and Hunt (1978) provided space allowance of 310, 387, and 464 cm^2 per bird in groups of 3, 6, and 12 birds. They concluded that a space allowance of 310 cm^2 adversely affected egg production. A negative linear response was obtained between groups size and egg production. As floor space diminished from 464 to 310 cm^2 body weights decreased (2.06 vs 1.84 kg), resulting in poorer feed conversion (2.75 vs 2.85 kg feed/kg eggs). As group size increased from 3 birds to 12, mortality increased significantly (10.7 vs 26.2%).

Hen-day production and feed conversion of commercial layers was significantly higher in 40 x 25 x 45 cm and 30 x 25 x 45 cm reverse cages compared to hens in normal conventional cages with the exact reverse dimensions (Baiao and Campos, 1979). Hens in both types of reverse cages showed better livability than those in the deep cages.

Robinson (1979) used wire cages of variable widths and depths with a floor slope of 1:12 to study the effects of cage depth, feeding space, floor area, colony size and methods of controlling cannibalism on White Leghorn x Australorp crossbred laying hens. Results showed that feeding space had more of an effect on laying performance and feed intake than did colony size or floor space. Increasing cage depth did not increase the proportion of cracked eggs. Mortality was higher among birds fitted with plastic spectacles than among debeaked birds.

The economic implication of different combinations of cage shape and colony size were analyzed by Bell et al (1979). Cages were from 30.5 to 45.7 cm deep and from 30.5 to 61 cm wide. Feeder space and floor space per bird were positively correlated with egg income over feed cost. Birds in shallow cages yielded a significantly higher monetary return at the same floor space allowed per bird than those in deep cages.

Cage orientation effects on cage performance was observed by Hill and Hunt (1980). They used deep cages (45.6 cm deep x 30.5 cm wide) and shallow cages (30.4 x 45.6 cm) with feed trough space limited to 30.4 cm. in the latter cages. Three and four layers were in each cage. The deep caged birds had significantly lower mortality, lower hen-day feed consumption, and higher egg cracking percentages than reverse caged hens. The restriction of feeding space in reverse cages significantly reduced mortality, hen-day feed consumption, and body weight. Cracked eggs were significantly higher in deep cages. There was no interaction between the cage design and population-density combination. They concluded that layers in deep cages had eggs with more cracks but performed equally well compared to those in reverse cages providing that the feeding space was restricted. Mortality, feed consumption, and body weight were significantly higher without this feed space restriction in the shallow cages.

Martin et al. (1980) housed five strains of layers in a light and air controlled house equipped with 30.5 x 40.6 cm deep and 40.6 x 30.5 cm shallow cages with three or four birds per cage. Birds in shallow cages showed significantly higher feed consumption, more feed per dozen eggs, lower percentage of B grade eggs during the last 14 wk, higher final body weight, and lower Haugh units than birds in deep cages. Nonsignificant effects of shallow cages included 0.8 fewer eggs per bird housed, 1% higher mortality, and lower income over feed and chick costs than observed in deep cages. Significant effects of reducing cage space from 64 to 48 sq.in. (24 to 32 birds/m^2) in the light and air controlled house included 11.5 fewer eggs per bird, lower feed consumption, lower egg grade and lower income over feed and chick costs.

Two commercial cages, one a deep design measuring 38.1 x 50.8 cm and the other a shallow measuring 60.9 x 35.5 cm were tested by Cunningham and Ostrander (1981). The deep design cages contained populations of 4,5, and 6 birds per cage while shallow cages were stocked with populations of 5,6, and 7 birds per cage. The pullets in deep cages had significantly lower egg production than birds in shallow cages. The birds in shallow cages consumed significantly more feed and had heavier body weights due to more feeder space. Eggs from birds in shallow cages were significantly ($P<.05$) heavier and had greater egg mass as a result of greater feed intake. Increasing bird population reduced egg production, body weight, feed usage, egg mass and undergrade in both cage shapes. There were no significant difference between cage designs for mortality, feed conversion, percentage undergrade and net egg income per bird

The effects of social rank, cage shape and aggressive activity on selected behavioral and performance traits of White Leghorn Layers was observed by Cunningham (1981). Layers were housed four per deep and shallow designed cages in a semi-commercial environment. Birds in shallow cages fed more frequently, consumed significantly more feed and had significantly larger egg size than the deep caged hens. No differences were observed between cage types for fearfulness, egg production or body weight gains.

The effect of full vs. controlled feeding on birds placed in deep and shallow cages was studied by Cunningham (1982a). The full-fed birds in shallow cages used significantly more feed, had larger body weight and weight gains, produced more eggs, and had greater egg income than the full-fed birds in deep cages or the control-fed which were birds in shallow cages with the feed controlled to the same level as the full-fed birds in deep cages. No significant differences were observed between the full-fed deep caged birds and the control fed shallow cage birds for any of the traits measured.

The effect of cage design and feeding level on the performance of four commercial strains of egg laying chickens was reported by Carey et al. (1986). Hens in standard cages (30.5 x 45.7 cm) laid 9% more eggs, ate 9/g/day more feed, and had 3% better feed conversion from 40 to 68 wk than hens housed in reverse (45.7 x 30.5 cm.) cages. Hens in the standard cages also showed slight advantages for livability and total egg mass.

Hens in shallow cages (60.9 x 31.8 or 60.9 x 35.5 cm) had higher hen-day egg production, better weight gain, larger egg weights and egg mass, increased number of eggs grading large and extra large than those in 38.1 x 50.1 cm deep cages (Cunningham, 1982b). Birds in shallow cages had poorer feed conversion and reduced net income. There were no significant difference ($P>.05$) between hens in the two sizes of shallow cages for the traits measured except for egg loss.

Ouart and Adams (1982a) studied the effects of cage design and bird density with three or four birds per cage with a floor area of 516 and 387 cm^2 on two strains of SCWL. In the first experiment they compared the effects of cage shape, feeder space and bird density on performance, nervousness, and feather condition. Strain one hens housed three per cage had significantly higher rates of lay and fewer body checks and cracks than those housed four per cage. A second experiment compared the effects of cage shape, feeder space, cage barrier and bird density on feeding behavior and bird movement. Three birds per cage laid at a significantly ($P<.05$) higher rate 5.4% and produced 2.8% fewer undergrade eggs than hens housed four per cage.

As part of the previous study, Ouart and Adams (1982b) compared the effects of cage shape, feeder space, cage barrier, bird density, level of feeding and period on feeding behavior and bird movement. A significant ($P<.05$) feeder space x period interaction showed that increased feeder space was important in reducing feeder competition during peak feeding times. Hens housed two birds per cage ate 10.5 g per hen per day more feed than those housed three per cage. Hens with 45.7 cm of feeder space per cage, housed three per cage and receiving 90% of full feed had more simultaneous feeding activity than hens with 25.4 cm of feeder space, housed two per cage and on full feed.

Two strains of White Leghorn pullets were tested for production performance and fearfulness by Cunningham and Ostrander (1982). Population sizes of 4 and 5 birds/cage were used in 38.1 x 50.8 cm deep and 60.9 x 31.8 cm shallow cages. Birds in shallow cages had higher egg production rates, higher body weight gains, used more total feed, and produced greater egg mass and had larger plus size eggs than birds in deep cages. Average net incomes favored the shallow caged hens at the higher bird density.

The effects of declawing and cage shape on productivity, feathering and fearfulness of egg type chickens was studied by VanSkike and Adams (1983). They found that hens housed in 45.7 x 25.4 cm shallow cages tended to be better feathered than those housed in 25.4 x 45.7 cm deep cages. Neither declawing nor cage shape had a significant effect on the time required for birds to return to feeding after exposure to a noise stimulus, which was used as a indicator of fearfulness.

Effects of cage density and dietary energy concentration on performance of growing Leghorn pullets subjected to early induced maturity was studied by Leeson and Summers (1984). A commercial strain of Leghorn pullets were caged-reared at densities of 293 or 586 cm^2/bird. Diet treatments consisted of a control step down protein program, a reverse protein program, and two treatments involving 18% crude protein throughout rearing with modification of texture and energy cocentration according to bird age. Irrespective of diet treatment, the more liberal density of 586 cm^2/bird resulted in a 5 to 8% increase in feed intake ($P<.01$). However, this increased intake was not associated with increased body weight. Birds reared at 293 cm^2 subsequently produced larger eggs ($P<.01$) than did birds reared at 586 cm^2, although the latter birds produced more eggs while consuming more feed ($P<.01$). It was concluded that reduced stocking density during rearing cannot be used as a means of stimulating growth of early maturing Leghorn pullets.

Effects of crowding and cage shape on productivity and profitability of caged layers were studied by Adams and Craig (1985). Three density categories were selected for analysis based on cage floor area per hen: 1) low, ranging from 432 to 561 cm^2, averaging 516 cm^2; 2) medium, ranging from 355 to 426 cm^2, averaging 387 cm^2; and 3) high, ranging from 271 to 348 cm^2, averaging 310 cm^2. Comparisons were made of exactly reversed and not exactly reversed, deep vs. shallow cages. Reducing floor space per hen from an average of 387 cm^2 (medium) to 310 cm^2 (high) reduced eggs per hen housed by 16.6 ($P<.001$), increased mortality 4.8% ($P<.001$), decreased feed consumption 1.9 g/hd ($P<.05$), and increased feed consumption per dozen eggs by 68 g ($P<.001$). Comparisons of 516 (low) vs. 387 cm^2 (medium) showed the increase in crowding reduced egg production by 7.8 eggs per hen housed ($P<.01$), increased mortality by 2.8% ($P<.05$) and decreased feed consumption/hd by 4.3 g ($P<.05$). Egg production was significantly ($P<.05$) affected by cage shape. Hens in shallow cages produced 5.8 more eggs per hen housed than those in deep cages.

Effect of type of cage partition, cage shape, and bird density on productivity and well being of layers was studied by Ramos et al. (1986). Pullets were housed 3 or 4/cage in a row of double deck 30.5 x 45.7 cm cages and in an adjacent row of double deck 45.7 x 30.5 cm shallow cages. Floor area per bird was 464 and 348 cm^2 in 3 and 4 bird cages, respectively. In Experiment 1, the deep caged hens had significantly lower mortality (8%) than the shallow caged hens. Hens housed at 464 cm^2 of floor area/hen had significantly higher hen housed egg production (4.9%), lower weight gain (8%) and higher average feather scores (.8 unit) than those housed at 348 cm^2. In Experiment 2, birds in deep cages had significantly lower mortality (8.6%) and higher feed consumption (15.2g/hd) than those in shallow cages. Hen housed rate of lay, mortality, weight gain, feed conversion and feather scores were significantly affected by bird density: 64.6%, 15%, 24.6%, .384 g egg/g feed, and 4.7 units, respectively, for hens with 464 cm^2 floor area vs. 70.8%, 8.3%, 25.2%, .362 g egg/g feed, and 5.8 units for hens with 348 cm^2.

Watering System

Rearing Phase. Effects of watering systems for floor reared pullets on subsequent caged layer performance were studied by Roush et al. (1984). Two trials were conducted. They reported that pullets raised on trigger cups showed significantly ($P<.05$) better feed conversion and lower mortality compared to those on dome waterers. Also a significant difference was shown between 4 and 5 hens per cage for hen-day egg production and feed per dozen eggs in favor of 4 birds per cage. The second trial showed that raising pullets on trigger cups, dome waterers or a dome waterer to trigger cup change during the rearing phase had no significant effect on performance of caged layers.

The effect of watering devices on performance during pullet rearing and cage laying phases of SCWL hens has been reported by Roush and Boggen (1987). In the pullet phase, birds were placed in one of three watering regimens: start-grow, trigger-cups, bell drinkers or a combination of the two types. During the laying phase birds were placed four to a cage in cages equipped with mature bird trigger-cups, fount cups, vertically activated nipple drinkers or cone shaped cups. Type of cage waterer showed a significant influence on average hen-day egg production and feed conversion. There was no significant difference between hens on cone shaped cups and trigger cups or between cone shaped cups and fount cups for hen-day production. There was significantly lower hen-day production and feed conversion with birds on vertically activated nipple drinkers compared to the other waterers. No significant differences were found in body weights, egg weights or Haugh units among the hens on the different watering systems. Specific gravity was poorer for eggs produced by hens drinking from fount cups as compared to cone shaped cups or vertically activated nipple drinkers.

Laying Phase. Richardson (1969) found there is a tendency for birds to prefer trough waterers over nipple waterers when given a choice. The total amount of drinking activity over 24 h was greater when using nipple than when using trough waterers. Birds drank in fairly discrete bouts, these bouts contained more drinking responses in the case of nipples (up to 100) than troughs (rarely more than 30). However, the temporal distribution of bouts did not appear to differ.

The effects of nipple and trough watering systems on broiler performance was studied by McMasters et al. (1971). Dayold chicks had no difficulty locating nipple drinkers. It was observed that the nipple waterers needed to be at a height that the chicks could easily reach by an upward pecking motion. No significant differences in mortality or feed/gain ratio were noted between the nipple and trough systems. Body weight was significantly lower ($P<.05$) for birds on nipples at a 13:1 bird to nipple ratio. Nipple to bird ratios of 2.5:1 and 8:1 resulted in a nonsignificant increase in body weight compared to birds on trough waterers. The total water consumption of broilers from 0 to 8 wk of age on the nipple and trough waterers was equal (131 cc per bird per day). However, a higher rate of water consumption for the birds on nipples appeared from 5 to 8 wk of age.

Dun and Emmans (1971) compared nipple and trough waterers for layers housed two per 15 x 18 in deep cage. Nipple drinkers were located on the outside of each alternate cage division and open troughs were supplied water by drip fed taps. Results showed that hen day production was slightly but significantly less for birds on a 4:1 bird to nipple ratio than for birds using troughs. Egg size and grades were slightly better for hens on the trough waterers. There was a difference of about 10 eggs per bird in favor of the troughs when compared with a stocking density of 4 birds/nipple. There was no real difference in feed consumption. Water consumed on the nipple drinkers at 4 birds per nipple was 39%, 35% and 30 percent lower than on the trough waterers in three years.

The effects of various water systems on the performance of chicks was studied by Al-Zujajy (1974). He cited Eley and Hoffman (1949) who stated that feed wastage may be markedly influenced by the form of feed and the type of waterer. He also cited Weiss (1966) who stated that the wastage of mash was reduced by the use of dew-drop waterers to approximately a tenth of what chicks using trough and pan waterers would waste.

Al-Zujajy (1974) used 500 dayold Nichol broiler chicks to compare, continuous flowing water supplied by a V shaped stainless steel trough, automatic trough waterers and conventional pan-waterers. A significant difference ($P<.01$) in body weight of 48g at the final age was obtained between chicks using ordinary pan waterers and those using continuous flow waterers. Chicks kept on pan waterers were significantly heavier (39g) than those kept on trough waterers. Feed efficiency of chicks kept on ordinary waterers were 2 and 4% better than the chicks using automatic and continuous flowing water systems, respectively.

Andrews and Harris (1971) compared watering systems for broilers using spacings of 15, 20 and 30 broilers per nipple and the use of a commercial automatic, round, hanging plastic fountain. At the end of 18 wk, the broilers grown on the hanging fountains were significantly heavier than those grown on nipples. There was no significant difference in body weight among the broilers grown on nipples at the densities used in the experiment. Neither were there differences in feed efficiency between broilers raised on the different watering systems.

The performance of broilers grown on different waterers was investigated by Andrews (1976). In the first experiment, one Plasson drinker was placed in each of seven pens and eight red plastic-jacketed nipples with stainless steel inserts were placed in each of seven other pens. No differences in feed conversion were found for birds on the two types of waterers at the end of 8 wk, but the broilers on the Plasson drinkers were significantly heavier ($P<.01$) than the broilers on nipple waterers. In a second experiment, a broiler cage system of 12 birds in a 24 x 30 in cage and two types of nipples was used. The 8 wk body weights of birds on the two types of nipples did not differ significantly. No significant difference was found in feed conversion.

The hourly patterns of food and water intake in 10 Brown Leghorn laying hens were observed by Savory (1978). Only half of the birds showed a significantly ($P<.05$) positive correlation between daily food and water intake. Restricting the daily water supply for each bird to 90 % of its ad libitum intake, for a period of 6 wk, caused a reduction in daily food intake. This suggests that water restriction may be a good way of controlling the food consumption of groups of birds but not individuals. Egg production did not differ significantly between the ab libitum and water restriction periods, but did decline in the second half of the restriction period at a time when birds were gaining weight. He indicated body weight cannot be controlled with water restriction without it first affecting egg production.

Patterns of water intake in caged birds was observed by Hill and Powell (1977). A brown and a white egg shell color strain of laying hens were maintained in experimental cages at 18s C or 24s C and were fed on 6, 8 h or ad libitum regimens. Water was monitored automatically to each of the cages over the major part of the laying cycle. The daily pattern of water intake of the birds on the 6 and 8 h feeding regimens suggested that feeding and drinking are closely correlated in time. The birds on the ad libitum feeding regimen spread their water intake throughout the day, but drank most of the water in the latter part of the photoperiod.

North (1978) reported birds of all ages in cages drink more water than those on a litter floor. The hourly intake of water varied, birds drank 25% of their daily water consumption during the 2 h immediately following the time of lights off or sun down regardless of the house temperature. Consumption during the rest of the day showed a uniform hourly intake.

Two watering systems for broilers were compared by Tugwell and Goan (1980). Watering troughs at the rate of one, 8 foot trough per 3000 broilers and nipple-type waterers at the rate of 15, 20 and 24 birds per nipple were randomly placed in 12 floor pens of a 9.69 x 19.39 m^2 house. Results showed that significantly lower weight gains occurred where broilers raised at 24 bird per nipple waterer were compared with 15 or 20 birds per nipple or trough waterers, indicating greater competition for available drinking space. This trial was conducted during the months of July and August when temperatures were at mid 20s C during the afternoon and reached into the mid 30s C on a few days. A second trial was conducted where nipple drinkers were placed in pens at the rate of 11, 15 or 20 birds per nipple and compared with birds on trough waterers. Pens remained the same size. This trial was conducted during the months of September and October.

Weight gains for broilers using the trough watering system were significantly greater than birds on the nipple system. There was no significant difference in feed conversion and percent mortality as a result of the different treatments.

The daily water consumption of broiler chickens was observed by Pesti (1985). Water:feed consumption ratios averaged 1.77 g/g. Water consumption was a linear function of broiler age ($R^2 > .99$). Housing type had no effect on water consumption. Increasing dietary sodium increased water consumption. It was suggested that 5.28 ml/bird/day of age is a good method of predicting the water consumption of broiler chickens.

Roush and Boggan (1984) studied the effect of cage watering devices on the performance of SCWL laying hens. Nine hundred and sixty pullets were reared in floor pens for an 18 wk period. Three water regimens were used in the pullet phase: trigger cups, dome waterers, or a combination consisting of 9 wk on dome waterers and 9 wk on trigger cups. During the laying phase, cages were equipped with trigger cups (TC), fount cups (FC), nipple waterers (NW), or cone-shaped waterers (CW). Type of cage waterers during the laying period had a significant influence on average hen-housed and hen-day egg production, and feed conversion. There was no difference between birds on CW and TC followed by birds on FC and then by NW (67.6%) for hen housed production. There was a significant difference for feed conversion (kg/dozen eggs) between hens raised on NW and birds on the other waterer types . Hen mortality for each waterer treatment was NW (10.4%), FC (9.7%), TC (8.75%) and CW (3.75%). There were no significant effects noted for egg weight or body weights.

Carr (1984) compared three drinker systems for broilers. They were Ziggity E-Z sip drinker (closed multidirectional needle nipple type), 2.42 m trough and the Lohom red drinker (round). Data showed birds weights and feed conversions were non-significantly less in the closed system. Skin color of the processed birds showed no differences between watering systems. A significant difference ($P<.05$) for incidence of breast blisters was observed in favor of the closed system. There was a significant difference in mortality ($P<.05$) when comparing the closed to the two open systems, birds on the closed system having the highest mortality.

A 2 x 4 x 3 factorial experiment was conducted by Roush and Mylet (1985) on the effects of water softening, drinking devices and dietary salt level on the performance of caged SCWL laying hens. At 19 wk of age, the pullets were randomly placed in cages (30.5 x 50.8 cm). Although there was an effect of watering devices on laying hen production, there was no indication of an interaction between drinking of softened water and the watering devices on laying hen performance. Hen-day production and feed per dozen eggs were significantly affected by the type of watering device. Responses were lowest for hen-day production and most unfavorable for feed conversion for hens drinking from vertically activated nipple drinkers. There were no significant difference in the hen-day production or feed conversion response, associated with the other type of drinking devices. There were no significant differences in body weights for any of the treatments or interactions.

Anonymous (1987) reported that the European Economic Community has set standards and determined that hens should be provided two nipples or cups/cage or a continuous drinker, a height of 40 cm over 65% of the cage area and a floor slope not to exceed 14% or 8 degrees. This directive applies to all cages installed from January 1988 and all cages by 1995.

Cunningham (1987) compared the effects of cup and nipple drinkers at different cage densities on the production of White Leghorn layers. He compared trigger cups located at the front of the cage with nipple drinkers located across the top of the cage system. The drinkers were situated at each cage partition. The birds were housed at 20 wk of age and reared on fountain cups. They were housed in 60.96 x 35.56 cm cages with five, six and seven birds per cage. Significant interaction effects between density treatments and drinker type were not present. There were no significant differences in livability, body weight, or egg weights for the drinker comparison. There did exist a greater amount of feed wastage with the nipple system (.4 kg/bird) during the 40 wk study.

Materials and Methods

Experiment 1. A commercial strain of dayold Single Comb White Leghorn chicks were purchased from a local hatchery on January 25, 1987. The chicks were wingbanded and vaccinated for Marek's disease at 1-d of age; Newcastle disease at 10-d, 5 and 16 wk of age; infectious bronchitis disease at 10-d, and 5, 8 and 16 wk of age; and fowl pox and avian encephalomyelitis at 12 wk of age. The chicks were assigned randomly to 16, 3.04 x 3.67 m brooding-rearing pens in a curtain-sided, brooding-rearing house with no more than 120 chicks per pen.

Eight pens were each equipped with a plastic dome waterer (DW) and each of the remaining eight pens were equipped with three starter-trigger cups (STCW) which required activation to obtain water, but did not require that the system be activated for each drink of water. Plastic gallon jugs were utilized the first few days after placing the chicks in the pens. This was to acquaint and facilitate the chicks to water. Water was supplied ad libitum.

The pullets were fed the KSU starter and grower diets (Appendix A1-3) which were calculated to contain 20.9% crude protein (CP) and 2823 kcal metabolizable energy (ME)/kg from 0 through 6 wk; 17.9% CP and 2864 kcal ME/kg from 7 through 12 wk; and 15.9% CP and 3001 kcal ME/kg from 13 wk to housing in layer cages. All diets were fed ad libitum.

Chicks were beak trimmed at 1 wk of age and retrimmed at 18 wk of age. Pullets were reared in photoperiods decreasing from 21 h the first wk to 14 h (natural daylight) at housing. Body weights were determined by weighing individually 25 birds per pen at day old and at 28 day intervals thereafter.

The pullets were transferred to a curtain-sided, naturally-ventilated cage house at 18 wk of age. The hens in four replicates per treatment were weighed individually. The KSU 18.5% protein and 2671 kcal ME/kg laying ration (Appendix A-4) and water were supplied ad libitum. The photoperiod was increased 15 min per wk until reaching 16 h of total light per day.

Four treatments were assigned to the top deck of a row of 30.5 x 45.7 cm double-deck deep cages and the top deck of a row of double-deck 45.7 x 30.5 cm shallow cages: 1) one nipple waterer (NW) located 7.62 cm from the front and 15.25 cm from each side of the deep cage and 7.62 cm from the front and 22.85 cm from each side of the shallow cage, 2) one NW located 7.62 cm from the back and 15.25 cm from each side of the deep cage and and one located 7.62 cm from the front and 22.85 cm from each side of the shallow cage, 3) two NW in front of the cage, and 4) two NW in back of the cage. Each of these nipples were located 7.62 cm from the front or back and 5.08 cm from the side of the cage. Each treatment was assigned to a block of four contiguous cages. Two of the four cages contained pullets which were reared on DW and two contained pullets reared on starter-trigger cups (STCW). There were six blocks per treatment of four deep cages (6 x 4 x 4 = 96 pullets) and four blocks per treatment of four shallow cages (4 x 4 x 4 = 64 pullets). End cages were not used to eliminate end cage effect. All treatments were assigned randomly.

Data were collected on water consumption, feed consumption, egg weight, egg production, and mortality. Water consumption was measured daily for 12 consecutive wk post-housing then 1 wk per 28-d period thereafter. Water consumption was recorded by attaching a 5 L plasma bag to individual nipples in two randomly assigned cages per treatment. The bags were filled with tap water and weighed the first day of the assigned week and weighed again at the end of the assigned week. Water was added to the bags as needed. The difference in weights was the amount of water consumed through that nipple for that time period.

Feed consumption was measured and the daily high and low temperatures within the house was taken during the same time period as water consumption. The feed troughs were emptied and feed that was previously weighed was placed in the trough. The birds were fed on a daily basis for that week. The feed left over at the end of the week was collected and weighed back and the difference recorded.

Egg production was based on the eggs produced during 3 consecutive d per wk. Egg weight measurements consisted of collecting eggs for 3 consecutive d each 28 d interval. The eggs from each cage were counted and bulk weighed.

Mortality was recorded daily. Mortalities were replaced by birds from cages in the bottom rows that had been on the same rearing watering system.

Cage shape, number of NW, location of NW were the main effects in a factorial analysis of variance (Ott 1984) for age at sexual maturity, egg production, mortality, feed consumption, feed conversion, average egg weight, and body weight gain. For water consumption data cage shape, number of NW, location of NW, rearing waterer, position of NW and period were main effects. Period was treated as a repeated measure and was analyzed as the subplot effect in a split-plot design. Linear contrasts were used to measure the effects of location and number of NW.

Experiment 2. Except for water consumption measurements, the strain of birds, vaccination program, experimental design and statistical analysis were similar to Exp. 1. Water consumption data were measured daily for the first wk, weekly for 8 consecutive wk post housing then for 1 wk every 28-d thereafter.

Results and Discussion

Analysis of variance data for egg production, mortality, sexual maturity, egg weight, feed consumption, feed conversion and water consumption are shown in Appendix A-5 through A-23.

Effects Of Rearing Watering System. Table 1 shows there was no significant carry over effect of type of rearing watering system on water consumption from 18-70 wk of age in Exp. 1. These results indicate the pullets did not have difficulty in adjusting to the NW in the layer cages. However, in Exp. 2, hens raised on TCW consumed significantly ($P<.05$) more water than those raised on DW (211.4 vs. 196.6 g/hd).

Table 1. Means for water consumption and egg production of hens reared on trigger cup and dome waterers, Exp. 1 and 2[1]

Type of rearing waterer	Water consumption Exp. 1	Water consumption Exp. 2	Egg production - hen housed Exp. 1	Egg production - hen housed Exp. 2
	------ g/hd ------		------- % ------	
Trigger cup (TCW)	184.1	211.4[2]	72.2	68.7
Dome (DW)	177.5	196.6	75.6	74.9

[1]Exp. 1, 18-70 wk of age; Exp. 2, 18-62 wk of age.
[2]$P<.05$.

No significant effects were observed for the rearing watering system on egg production in Exp. 1 and 2 (Table 1). These results agree with findings by Roush and Boggan (1987) who reported that there were no significant carry over effect on birds reared on TCW and DW when transferred to cages equipped with either trigger cups, fount cups, vertically activated nipple drinkers, or cone shaped cups. They reported no significant difference in egg production between hens reared on cone shaped cups and trigger cups or between cone shaped cups and fount cups. Using the same birds from the rearing phase into the laying phase, they reported significantly lower hen-day production for birds on vertically activated nipple drinkers compared to those on cone shaped cups, trigger cups, or fount cups.

Effects Of Cage Shape, Number Of Nipples Per Cage And Location Of Nipples In The Cage. Neither cage shape, nipple location, nor number of nipples per cage had significant effects on age at sexual maturity of the birds in Exp. 1 and 2 (Table 2).

Table 2. Effect of cage shape, location of nipples and number of nipples per cage on age at sexual maturity, egg production, and mortality, Exp. 1 and 2[1]

Variable	Age at sexual maturity Exp. 1	Age at sexual maturity Exp. 2	Egg production hen-housed Exp. 1	Egg production hen-housed Exp. 2	Mortality Exp. 1	Mortality Exp. 2
	- - - - Days - - - -		- - - - - % - - - - -		- - - - - % - - - - -	
Cage shape:						
Deep (30.5 x 45.7 cm)	154.3	156.2	72.6	78.0	13.4	12.6
Shallow (45.7 x 30.5 cm)	154.4	155.8	73.3	80.1	14.0	10.1
Location of nipples:						
Front	154.2	156.4	73.0	78.2[2]	11.0[2]	11.9
Back	154.2	155.6	72.9	79.9	16.4	10.8
Number of nipples:						
1	154.1	156.1	73.5	78.9	15.0	11.7
2	154.6	156.0	72.4	79.2	12.4	11.1

[1]Exp. 1, 18-70 wk of age; Exp. 2, 18-62 wk of age.
[2]$P < .05$.

There were no significant difference in percentages of hen-housed egg production between birds housed in deep and shallow cages in Exp. 1 and 2. These results agree with findings by Bell (1972), Swanson and Bell (1977), Baiao and Campos (1979), Cunningham and Ostrander (1981), and VanSkike and Adams (1983).

The location of NW had a significant P<.05 effect on egg production only in Exp. 2. Hens in cages with NW located in the back part of the cage laid at a higher rate than those in cages with nipples located in the front part of the cage (79.9 vs. 78.2 %). The number of NW per cage in Exp. 1 and 2 had no significant effects on egg production. These results do not support proposed standards by Anonymous (1987) who reported that the European Economic Community recommended a minimum of two nipples per cage to assure favorable production and bird well-being.

Cage shape had no significant effect on mortality of birds in Exp. 1 and 2. Similar results were shown by Cunningham and Ostrander (1981). But Baiao and Campos (1979), and Robinson (1979) reported that mortality was lower in shallow cages. Hill and Hunt (1980) found that deep caged hens had significantly lower mortality than shallow caged hens. The restriction of feeding space in their shallow cages significantly reduced mortality compared to shallow cages without restricted feeder space.

There was significantly (P<.05) lower mortality in cages where the nipples were located in the front than the back of the cage in Exp. 1 (11.0 vs. 16.4%). Locating the watering devices in the front part of the cage may have made it easier for the birds to obtain water after feeding. This would be especially important in preventing early mortality of birds due to environmental adaptation after housing. In Exp. 2 the location of NW had no significant effect on mortality. These results agree with Cunningham (1987) who found no significant effects on livability due to the location of nipple and trigger cup waterers, but disagrees with results from Exp. 1. Results in Table 2 show that number of NW per cage had no significant effect on mortality in Exp. 1 and 2.

No significant differences were observed for the effects of cage shape on feed consumption (Table 3) in Exp. 1 and 2. These results agree with Bell (1972) who showed that birds in reverse cages (45.7 x 30.5 cm) had no significant differences in overall feed consumption when compared to those in conventional (30.5 x 45.7 cm) cages. But Hill and Hunt (1980), Martin et al. (1980), Cunningham and Ostrander (1981), and Cunningham (1982b) reported that shallow caged birds consumed significantly more feed than deep caged hens. No significant effects were found for location and number of NW per cage on feed consumption (Table 3).

Table 3. Effect of cage shape, location of nipples and number of nipples per cage on performance of egg-type layers, Exp. 1 and 2[1]

Variable	Feed consumption Exp. 1	Exp. 2	Exp. 1	Feed conversion Exp. 2	Exp. 1	Exp. 2
	- - - - g/hd - - - -		- - - - kg/dz - - - -		- - - g egg/g feed - - -	
Cage shape:						
Deep (30.5 x 45.7 cm)	159.7	92.3	2.64	1.42	.270	.469
Shallow (45.7 x 30.5 cm)	157.1	92.4	2.58	1.38	.270	.487
Location of nipples:						
Front	158.8	92.0	2.61	1.41	.269	.476
Back	158.0	92.8	2.61	1.39	.270	.480
Number of nipples:						
1	157.5	92.8	2.57	1.41	.275	.475
2	159.3	92.0	2.65	1.39	.264	.482

[1]Exp. 1, 18-70 wk of age; Exp. 2, 18-62 wk of age.

Results in Table 3 show that cage shape had no significant effect on feed conversion in Exp. 1 and 2 when expressed either as kg/dz or g egg/g feed. These results agree with Cunningham and Ostrander (1981) who found no significant differences between deep and shallow caged hens for feed conversion. But Martin et al. (1980), Cunningham (1982a), and Carey et al. (1986) found that deep caged hens showed better feed conversion than those in shallow cages because the shallow caged hens had more feeder space per bird that allowed them to over consume feed resulting in poorer feed efficiency. Bell (1972) found that reverse caged hens had better feed conversion than those in conventional cages. The poor feed conversion in this study was due to a problem with feed wastage in the early part of the study. No significant effects were found for location and number of NW on feed conversion.

Results in Table 4 show cage shape had no significant effect on egg weight in Exp. 1 and 2. These results agree with those of Swanson and Bell (1977) and Cunningham and Ostrander (1982). In another study, Cunningham (1982b) observed that hens in shallow cages had heavier egg weights and more egg mass than those in deep cages.

Table 4. Effect of cage shape, location of nipples and number of nipples per cage on egg weight and body weight gain, Exp. 1 and 2[1]

Variable	Average egg weight		Body weight gain[2]	
	Exp. 1	Exp. 2	Exp. 1	Exp. 2
	- - - - - - - - g - - - - - - - -		- - - - - - - - % - - - - - - - -	
Cage shape:				
Deep (30.5 x 45.7 cm)	59.2	55.5	29.3	29.3
Shallow (45.7 x 30.5 cm)	57.7	56.2	26.2	26.2
Location of nipples:				
Front	58.5	56.0	28.6	28.6
Back	58.5	55.8	26.7	26.7
Number of nipples:				
1	58.9[3]	55.8	26.6	26.6
2	58.0	56.0	28.7	28.7

[1]Exp. 1, 18-70 wk of age; Exp. 2, 18-62 wk of age.
[2]Body weight gain = (ending body wt − beginning body wt)/begging body wt) x 100.
[3]$P<.06$.

Location of NW had no significant effect on average egg weights in Exp. 1 and 2. These results indicate that egg weight was not affected by nipple location as long as the birds were consuming the water necessary for normal egg production. Results in Table 4 also show that there was a significant trend ($P<.06$) for heavier eggs from hens in cages with one than from those in cages with two NW in Exp. 1 (58.9 vs. 58 g), but not in Exp. 2.

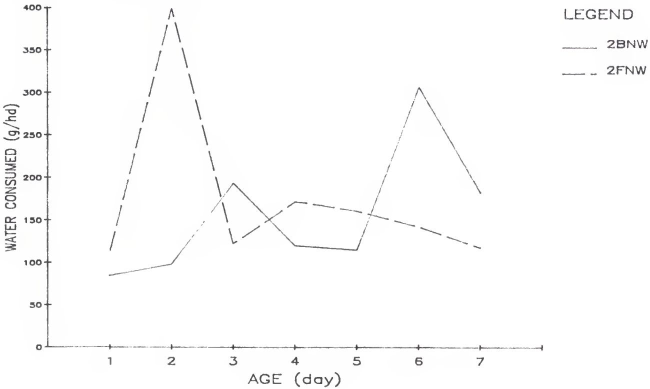
Results in Table 4 show that cage shape had no significant effect on weight gain in Exp. 1 and 2. These results disagree with Cunningham and Ostrander (1981), and Hill and Hunt (1980) who reported that birds in shallow cages had higher weight gains than those in deep cages. Location and number of NW per cage had no significant effects on weight gain in Exp. 1 and 2.

In Exp. 2 there was considerable unexplainable variability in water consumption during the first 7 d post-housing among hens in cages with two NW in front of the cage (2FNW) vs. two NW in back (2BNW) of the cage (Fig. 1). Hens consumed more water from 2FNW than 2BNW during d 2 (399.3 vs. 98.3 g/hd). Whereas hens in 2BNW cages consumed more water on d 6 than 2FNW hens (306.5 vs. 141.7 g/hd). The first 7 d (18 wk) post-housing data analyized as a whole showed no difference for front or back position (Table 5).

Data in Fig. 2 show that in both experiments there was a linear increase in water consumption from housing to peak production. This increase can be attributed to temperatures increasing from upper 20s C to the middle 30s C from July to August in Exp. 1 and lower to middle 30s C in Exp. 2 . Also increasing egg formation (Mongin and Sauver, 1974), maximum intakes occuring just after oviposition and during albumin plumping. They cited Anderson and Hill (1968), who reported that daily water consumption is closely related to the flocks rate of lay and its health status. Consumption was relatively constant from peak production to the end of the experiments (Fig. 3).

The effect of cage shape could not be tested correctly for water consumption of caged layers in Exp. 1 and 2 (Table 5). A linear contrast analysis showed that regardless of the location of the NW, the number of NW per cage had a significant ($P<.05$) effect on water consumption in both experiments (Table 6, Fig. 4 and 5). Hens in cages with one vs. two NW consumed 151.4 vs. 188.9 g/hd from 18-29 wk (Tables 5 and 6), 164.5 vs. 197.0 g/hd from 18-70 wk in Exp. 1 and 180.9 vs. 219.4 g/hd from 18-26 wk (Tables 5 and 6), 185.6 vs. 222.3 g/hd from 18 to 62 wk and a trend

FIG. 1. WATER CONSUMPTION FOR FIRST 7-D POST HOUSING EXP. 2



(P<.06) of 92.2 vs. 165.9 g/hd for the first 7 d (18 wk) post-housing. Figures 4 and 5 show that birds consistently consumed greater amounts of water from two NW than from one NW throughout the entire experiments.

Table 5. Effects of cage shape, location of nipples, number of nipples per cage and position of nipple on water consumption of layers, Exp. 1 and 2

	Age (wk)				
	18-29	18-70	18	18-26	18-62
Variable	------ Exp. 1 -----		---------- Exp. 2 ---------		
	g/hd				
Cage shape:					
Deep (30.5 x 45.7 cm)	114.9	177.9	142.6	195.3	197.3
Shallow (45.7 x 30.5 cm)	113.3	183.6	201.2	204.9	210.7
Location of nipple:					
Front	173.9[3]	183.0[3]	136.3	196.2	199.7
Back	188.9	197.0	165.9	219.4	222.3
Number of nipple:					
1	151.4[2]	164.5[2]	92.2[3]	180.9[2]	185.6[2]
2	188.9	197.0	165.9	219.4	222.3
Position of nipples:[1]					
Right	104.6	104.7	85.1	101.5	100.2
Left	83.6	92.4	80.8	102.1	111.4

[1]Cages containing two nipples.
[2]$P<.05$.
[3]$P<.06$.

Location of the NW had a significant (P<.06) effect on water consumption in Exp. 1 but not in Exp. 2 (Table 5). Hens in cages with NW in front of the cage consumed more water

FIG. 2. WATER CONSUMPTION
BY AGE AT DATA COLLECTION
EXP. 1 AND 2

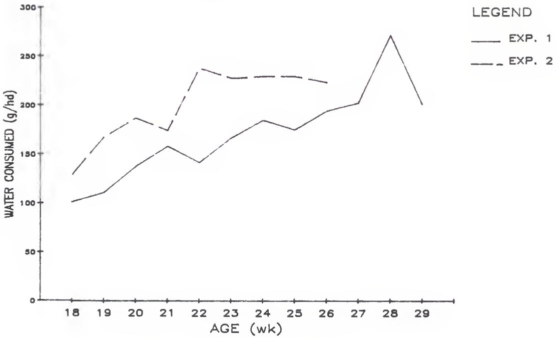


FIG. 3. WATER CONSUMPTION
BY AGE AT DATA COLLECTION
EXP. 1 AND 2

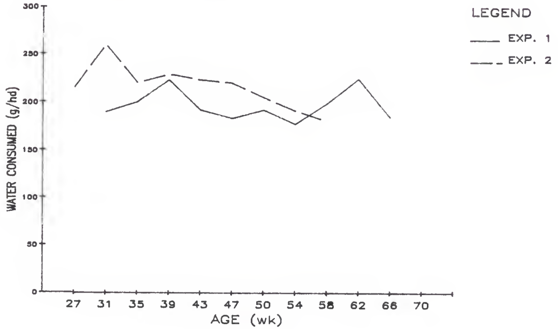


FIG. 4. WATER CONSUMPTION, EXP. 1

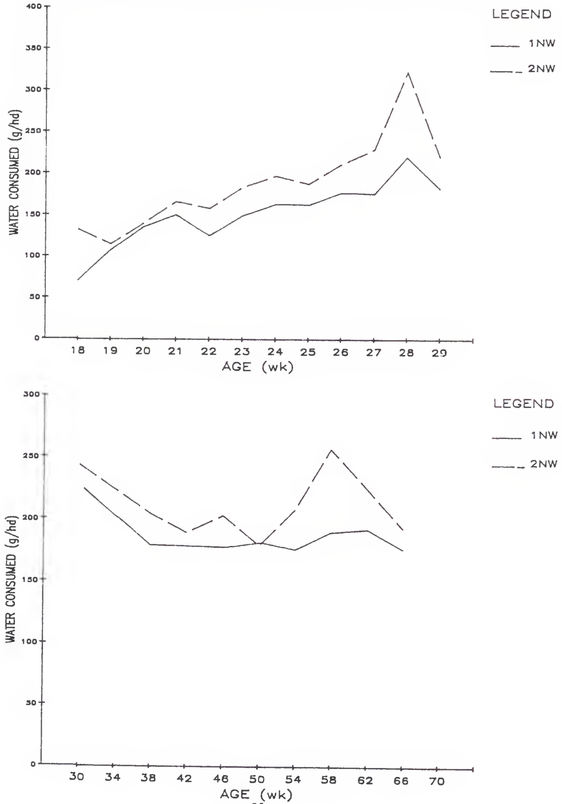


FIG. 5. WATER CONSUMPTION, EXP. 2

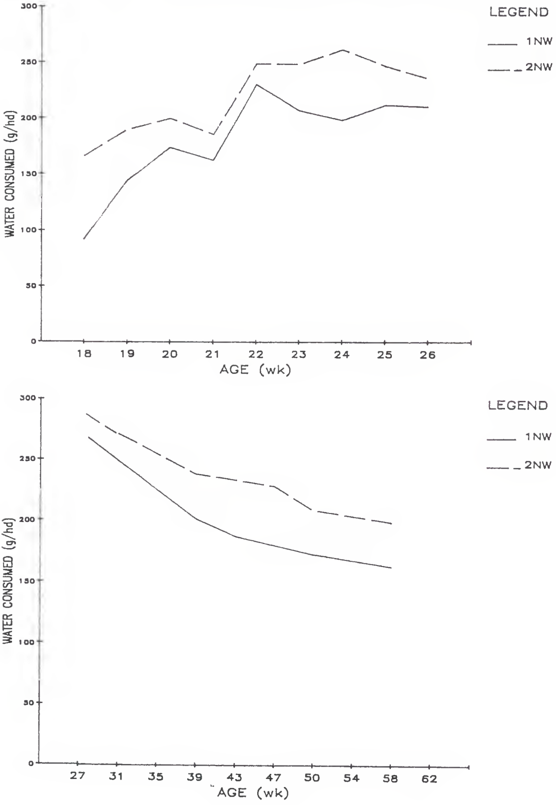


FIG. 6. WATER CONSUMPTION FROM 18-29 WK OF AGE EXP. 1

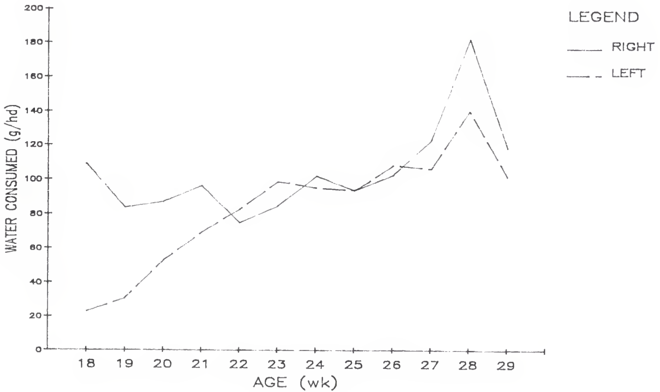


Table 6. Effects of number and location of nipple waterers on the average water consumption of caged layers, Exp. 1 and 2

Exp. 1						
Age	18-29 wk			18-70 wk		
	g/hd					
	Front	Back	Avg	Front	Back	Avg
One nipple	152.9	150.1	151.5	164.2[1]	164.7	164.5
Two nipples	195.0	182.7	188.9	201.8	192.3	197.1
Avg	173.9	166.4		183.0	178.5	

[1]$P<.06$.

Exp. 2									
Age	18 wk			18-26 wk			18-62 wk		
	g/hd								
	Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
One nipple	97.7	86.8	92.2	182.8	179.0	180.9	184.0	187.4	185.6
Two nipples	175.0	157.0	166.0	209.7	229.1	219.4	215.4	229.9	222.3
Avg	136.3	121.9		196.2	204.0		199.7	208.2	

than those in cages with NW at the rear of the cage, 173.9 vs. 166.4 g/hd from 18-26 wk and 183.0 vs. 178.5 g/hd from 18-70 wk in Exp. 1. This could be a result of the front located NW being closer to the feed trough, thus making it easier for hens to obtain water after a feeding bout.

The hens showed no significant overall preference for the right or left positioned NW in two-nipple cages (Table 5). However, there was a significant age effect, hens preferring the right positioned NW during the 18, 19, 20 and 28 wk of age (Fig. 6). As the hens progressed through their laying cycle, there was an increase in usage of the left positioned NW (Fig. 6).

The main observation was that hens in cages with two NW consumed significantly more water than hens in cages with one NW without a commensurate increase in egg production. Two NW per cage increases construction, repair, and replacement costs. Also, overconsumption of water increases the possibility of higher fecal moisture, which can induce fly and odor problems.

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Appendix

Table A-1. KSU chick starter ration fed from 0 to 6 wk of age

Ingredients	Amount per 100 kg
Yellow corn	27.50
Sorghum grain	27.50
Soybean meal (44%)	34.60
Alfalfa meal (17%)	5.00
Distillers solubles	2.00
Limestone	1.50
DiCal	1.00
Salt	0.25
KSU premix	0.50
Trace mineral mix	0.05
Choline chloride	0.01
DL-Methionine 0.05	
Amprol	0.05
Calculated analysis:	
Crude protein	20.9%
Metabolizable energy	2823 kcal/kg
Calcium	0.96%
Phosphorus	0.59%
Methionine	0.39%

Table A-2. KSU pullet grower ration fed from 7 to 12 wk of age

Ingredients	Amount per 100 kg
Yellow corn	28.60
Sorghum grain	28.50
Wheat shorts	10.00
Soybean meal (44%)	24.50
Alfalfa meal (17%)	5.00
Limestone	1.00
DiCal	1.50
Salt	0.25
KSU premix	0.50
Trace mineral mix	0.05
Choline chloride	0.01
DL-Methionine	0.05
Amprol	0.05
Calculated analysis:	
Crude protein	17.9%
Metabolizable energy	2864 kcal/kg
Calcium	0.85%
Phosphorus	0.65%
Methionine	0.33%

Table A-3. KSU pullet finisher ration fed from 13 to 20 wk of age

Ingredients	Amount per 100 kg
Yellow corn	30.70
Sorghum grain	30.70
Ground oats	12.73
Animal fat	1.00
Soybean meal (44%)	21.00
Limestone	0.75
DiCal	2.00
Salt	0.50
KSU premix	0.50
Trace mineral mix	0.05
DL-Methionine	0.02
Amprol	0.05
Calculated analysis	
Crude protein	15.9%
Metabolizable energy	3001 kcal/kg
Calcium	0.80%
Phosphorus	0.73%
Methionine	0.27%

Table A-4. KSU layer ration fed during the egg production period

Ingredients	Amount per 100 kg
Yellow corn	29.49
Sorghum grain	29.49
Soybean meal (44%)	28.49
Alfalfa meal (17%)	2.49
Limestone	3.34
Oyster shell	3.34
DiCal	2.50
Salt	0.24
KSU premix	0.50
Trace mineral mix	0.05
DL-Methionine	0.07
Calculated analysis:	
Crude protein	18.5%
Metabolizable energy	2671 kcal/kg
Calcium	3.21%
Phosphorus	0.81%
Methionine	0.38%

Table A-5. Analysis of variance for egg production, mortality, and age at sexual maturity, 18-70 wk of age

Source of variation	d.f.	Egg production	Age at sexual maturity	Mortality
		- - - - - - - - - - - -	MS - - - - - - - - - - - - - -	
Shape (S)	1	9.17	25.21	164.51
Rep (shape)	2	25.96	29.10	201.92
Location (L)	1	0.13	1.20	287.90*
S x L	1	3.97	5.70	6.37
No. nipples (N)	1	11.39	1.83	64.17
S x N	1	9.56	0.33	3.19
N x L	1	0.45	0.93	110.50
S x N x L	1	14.85	1.83	238.20
Error	30	15.9	10.83	61.02

*P<.05.

Table A-6. Analysis of variance for feed consumption, egg weight, and feed conversion, 18-70 wk of age

Source of variation	d.f.	Feed consumption	Egg weight	Feed conversion	
		---- MS ----			
Shape (S)	1	3123.60	4.73	0.01[1]	0.00[2]
Rep (shape)	2	4340129.16*	1.18	0.20	0.00
Location (L)	1	81254.40	0.02	0.00	0.00
S x L	1	87554.40	0.95	0.00	0.00
No. nipples (N)	1	361771.34	7.59	0.05	0.00
S x N	1	8283.75	0.28	0.01	0.00
N x L	1	138816.60	0.15	0.00	0.00
S x N x L	1	4600416.60	0.11	0.22	0.00
Error	30	518001.02	2.02	0.03	0.00

[1]kg/dz.
[2]g egg/g feed.
*P<.05.

Table A-7. Analysis of variance for water consumption, 18-29 wk of age

Source of variation	d.f.	Water consumption -MS-
Shape[1] (S)	1	---
No. and location nipples(T)	3	71587.80
Rearing waterers (R)	1	2854.31
T x R	3	4783.17
S x T	3	37104.96
S x R	1	12540.32
S x T x R	3	20609.21
Period (P)	11	370812.19**
T x P	33	70513.91
P x R	11	13903.93
Error	121	1240.33
Contrast[2]:		-SS-
INB vs INF	1	165.63
IN vs 2N	1	67729.31
INB vs 2NB	1	25623.73
INF vs 2NF	14	3252.72*
2NB vs 2NF	1	3692.84

[1]Shape could not be tested for correctly.
*P<.05 **P<.01.
[2]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-8. Analysis of variance for water consumption, 18-70 wk of age

Source of variation	d.f.	Water Consumption -MS-
Shape[1] (S)	1	---
No. and Location nipples(T)	3	88596.26
Rearing waterer (R)	1	3511.84
T x R	3	6085.19
S x T	3	21076.74
S x R	1	6755.47
S x T x R	3	20120.60
Period (P)	19	461139.78**
T x P	57	108964.05*
P x R	19	28403.05*
Error	209	1343.46
Contrast[2]:		-SS-
1NB vs 1NF	1	9.70
1N vs 2N	1	84952.67*
1NB vs 2NB	1	30415.22
1NF vs 2NF	1	56547.01
2NB vs 2NF	1	3633.88

[1]Shape could not be tested for correctly.
*P<.05 ** P<.001.
[2]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-9. Analysis of variance for water consumption in right and left position, 18-29 wk of age

Source of variation	d.f.	Water Consumption -MS-
Shape (S)	1	3891.69
No. and location nipples (N)	1	1846.42
S x N	1	12144.58
Rearing waterers (R)	1	3108.82
S x R	1	14473.20
T x R	1	238.54
S x T x R	1	92.39
Location (L)	1	23483.25
S x L	1	8605.35
T x L	1	5175.15
S x T x L	1	11414.34
R x L	1	25.80
S x R x L	1	496.68
T x R x L	1	67118.41
S x T x R x L	11	16476.32
Period (P)	11	135032.12***
S x P	11	11065.45
T x P	11	17143.75
P x R	11	15113.86
S x P x L	11	36531.16
T x P x L	11	20240.21
P x L x R	11	17327.44
Error	88	1387.81

***P<.001.

Table A-10. Analysis of variance for water consumption in right and left positioned nipples, 18-70 wk of age

Source of variation	d.f.	Water Consumption -MS-
Shape (S)	1	16.78
No. and location nipples (T)	1	1816.94
S x T	1	9599.97
Rearing waterers (R)	1	4073.30
S x R	1	9740.48
T x R	1	330.30
S x T x R	1	1844.59
Location (L)	1	12094.46
S x L	1	1744.19
T x L	1	13565.66
S x T x L	1	10200.40
R x L	1	1037.19
S x R x L	1	3870.38
T x R x L	1	20360.33
S x T x R x L	1	27046.35
Period (P)	19	163502.65
S x P	19	30749.65
T x P	19	28271.70
P x R	19	24346.73
P x L	19	64505.68*
S x P x L	19	40170.87
T x P x L	19	31095.45
P x R x L	19	32609.11
Error	152	1889.87

*P<.01.

Table A-11. Analysis of variance for water consumption, 18-29 wk by period

Source of variation	d.f.	Water consumption MS 1	2	3	4
Shape (S)	1	3727.10	0.02	418.20	2.56
No. and location nipples (T)	3	15692.78	501.66	4727.77	1163.90
Rearing waterers (R)	1	2190.24	125.38	2143.69	964.10
T x R	3	3332.31	123.59	3643.61	1547.51
S x T	3	8466.47	4570.55	6153.80	4774.07
S x R	1	15825.64	43.52	841.00	41.60
Error	3	12729.66	2630.04	9302.25	231.88
Contrast:					-SS-
1NB vs INF	1	353.78	167.44	920.20	551.12
1N vs 2N	1	15338.82	186.39	83.72	1113.89
1NB vs 2NB	1	6077.53	492.98	2719.53	701.25
1NF vs 2NF	1	9446.25	8.38	1537.35	429.24
2NB vs 2NF	1	0.18	147.83	3723.84	313.75

Source of variation	d.f.	MS 5	6	7	8
Shape (S)	1	942.49	333.06	825.12	53.65
No. and location nipples (T)	3	5236.01	5191.21	8546.93	3049.85
Rearing waterers (R)	1	0.04	166.41	260.01	727.65
T x R	3	870.55	851.43	848.09	5716.55
S x T	3	4988.63	450.70	4922.65	1811.20
S x R	1	538.24	163.84	60.45	836.65
Error	3	264.98	79.46	360.88	219.90
Contrast:				-SS-	
1NB vs 1NF	1	720.10	1702.36*	141.96	486.72
1N vs 2N	1	4231.50*	433.68	7314.52**	2517.53*
1NB vs 2NB	1	2599.20*	8.82	2492.18*	774.21
1NF vs 2NF	1	1682.00*	1051.11	5045.10*	1860.50
2NB vs 2NF	1	284.41	34.44	1090.44	45.60

*P<.05 **P<.01.

[1]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-11. (con't)

		MS			
		9	10	11	12
Shape (S)	1	207.36	2396.10	1193.70	1562.22
No. and locatio nipples (T)	3	5922.92	11869.20	70930.42	9269.03
Rearing waterers (R)	1	23.04	7106.49	297.56	2753.62
T x R	3	5443.21	11019.06	13521.12	2838.69
S x T	3	2778.01	8811.73	32461.96	3384.86
S x R	1	24.50	8326.56	353.44	1787.17
Error	3	829.88	2628.03	4127.48	282.62
Contrast:			-SS-		
1NB vs 1NF	1	143.65	3.78	760.50	1232.56
1N vs 2N	1	4610.41	11416.92	41943.04*	5704.02*
1NB vs 2NB	1	621.28	4095.12	2211.12	2191.22
1NF vs 2NF	1	5055.15	7589.12	58858.80*	3500.76*
2NB vs 2NF	1	1168.86	448.50	28276.88	2332.44

*P<.05.
[1]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-12. Analysis of variance for water consumption in right and left position, 18-29 wk by period

Source of variation	d.f.	Water consumption MS 1	2	3	4
Shape (S)	1	1588.02	13.70	227.22	156.87
No. and location nipple (T)	1	0.09	73.91	69.72	86.02
S x T	1	3950.12	1350.74	434.72	1951.43
Rearing waterers (R)	1	1743.06	0.02	278.89	874.68
S x R	1	12726.84	645.03	156.25	31.08
T x R	1	957.90	1.96	156.25	307.12
S x T x R	1	1332.25	325.71	778.89	45.22
Location (L)	1	29395.10	11267.29	2093.06	2994.82
S x L	1	292.41	2042.81	277.22	3223.40
T x L	1	1417.52	2590.55	69.72	493.95
S x T x L	1	580.81	105.01	434.72	66.01
R x L	1	576.00	95.0	278.89	12.07
S x R x L	1	9072.56	2025.22	156.25	258.40
T x R x L	1	6.76	125.49	156.25	10206.05
*S x T x R x L	1	637.56	2415.47	2278.89	518.70

Source of variation	Water consumption MS 5	6	7	8
Shape (S)	28.89	260.01	1369.01	153.14
No. and location nipples (T)	142.20	169.65	545.22	22.80
S x T	57.62	22.80	1436.41	90.72
Rearing waterers (R)	22.32	4.30	20.25	1254.93
S x R	293.26	100.50	66.42	250.43
T x R	294.98	47.95	353.44	1757.70
S x T x R	221.26	0.27	418.20	317.73
Location (L)	268.14	777.01	1033.62	0.00
S x L	606.39	330.33	3329.29	367.68
T x L	1464.97	886.55	3950.12	189.75
S x T x L	35.70	1795.64	299.29	3748.50
R x L	88.83	401.00	129.96	1230.25
S x R x L	128.25	245.70	7.56	200.93
T x R x L	6993.14	1453.51	9761.44	7374.51
*S x T x R x L	1000.14	42.57	3393.06	3730.15

*Test hypothesis is using the anova ms for S x T x R x P as an error term.

Table A-12. (con't)

Source of variation	Water consumption MS 9	10	11	12
Shape (S)	743.92	4889.50	5468.60	48.30
No. and location nipples (T)	584.43	724.25	14113.44	1166.22
S x T	500.64	200.93	7700.06	924.16
Rearing waterers (R)	51.48	8803.13	3300.50	1922.82
S x R	9.76	7996.83	3080.25	676.00
T x R	2532.60	17.01	1263.80	203.06
S x T x R	1185.08	73.53	219.75	293.06
Location (L)	109.72	1167.93	7089.64	1115.56
S x L	448.38	82.35	4644.42	549.90
T x L	2457.68	1367.15	1576.09	7335.92
S x T x L	1123.92	1973.58	4349.40	246.49
R x L	659.20	231.80	12577.62	26.52
S x R x L	1016.01	3206.39	10465.29	2275.29
T x R x L	12956.13	4060.87	29601.20	4942.09
*S x T x R x L	3554.78	774.23	19460.25	27.56

*Test hypothesis is using the anova ms for S x T x R x P as an error term.

Table A-13. Analysis of variance for egg production, mortality, and age at sexual maturity, 18-62 wk of age, Exp. 2

Source of variation	d.f.	Egg production	Age at sexual maturity	Mortality
		------------ MS	--------------	
Shape (S)	1	9.22	0.00	174.96
Rep (shape)	2	37.84	4.37	411.43
Location (L)	1	27.67*	6.01	11.70
S x L	1	0.07	16.01	37.60
No. nipples (N)	1	1.39	0.15	3.50
S x N	1	12.01	3.75	192.60
N x L	1	8.10	26.66	12.60
S x N x L	1	16.69	0.06	12.60
Error	30	5.69	8.78	68.62

*P<.05.

Table A-14. Analysis of variance for feed consumption, egg weight, and feed conversion, 18-62 wk of age, Exp. 2

Source of variation	d.f.	Feed consumption	Egg weight	Feed Conversion	
		---MS---			
Shape (S)	1	85705.40	3.48	0.00[1]	0.00[2]
Rep (shape)	2	292082.60	1.64	0.03	0.00
Location (L)	1	80703.33	0.24	0.00	0.00
S x L	1	138384.03	0.61	0.00	0.00
No. nipples (N)	1	62242.60	0.30	0.00	0.00
S x N	1	133906.50	0.12	0.00	0.00
N x L	1	43228.50	0.09	0.00	0.00
S x N x L	1	25979.20	1.45	0.00	0.00
Error	30	46082.03	1.11	0.00	0.00

[1]kg/dz.
[2]g egg/g feed.

Table A-15. Analysis of variance for water consumption, 18th wk of age, Exp. 2

Source of variation	d.f.	Water consumption -MS-
Shape[1] (S)	1	---
No. and location nipples(T)	3	158406.07*
Rearing waterers (R)	1	23129.37
T x R	3	2966.61
S x T	3	79377.60
S x R	1	47310.21
S x T x R	3	61594.64
Period (P)	6	88344.49**
T x P	18	330772.77
P x R	6	95359.68
Error	66	15326.26
Contrast[2]:		-SS-
INB vs INF	1	1679.73
IN vs 2N	1	152183.14**
INB vs 2NB	1	68978.52
INF vs 2NF	1	83553.60
2NB vs 2NF	1	4543.20

[1]Shape could not be tested for correctly.
*P<.05 **P<.06.
[2]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-16. Analysis of variance for water consumption, 18-26 wk of age, Exp. 2

Source of variation	d.f.	Water consumption -MS-
Shape[1] (S)	1	---
No. and location nipples(T)	3	60446.82**
Rearing waterers (R)	1	376.91
T x R	3	1641.99
S x T	3	5190.71
S x R	1	10365.66*
S x T x R	3	17174.48
Period (P)	8	180834.33
T x P	24	47674.20
P x R	8	13868.62
Error	88	1655.30
Contrast[2]:		-SS-
INB vs INF	1	247.58
IN vs 2N	1	534333.62**
INB vs 2NB	1	45133.67**
INF vs 2NF	1	13100.79**
2NB vs 2NF	1	6765.61*

[1]Shape could not be tested for correctly.
*P<.05 **P<.01.
[2]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NB = 2 nipples in front of cage.

Table A-17. Analysis of variance for water consumption, 18-62 wk of age, Exp. 2

Source of variation	d.f.	Water consumption -MS-
Shape[1] (S)	1	---
No. and Location nipples(T)	3	80673.60**
Rearing waterer (R)	1	12228.84*
T x R	3	3301.36
S x T	3	9901.69
S x R	1	11312.33*
S x T x R	3	3445.44
Period (P)	13	248835.42**
T x P	39	654584.48
P x R	13	34643.82*
Error	143	1448.64
Contrast[2]:		
1NB vs INF	1	313.17
1N vs 2N	1	75066.08**
1NB vs 2NB	1	48959.15
1NF vs 2NF	1	27623.03*
2NB vs 2NF	1	5294.33

[1]Shape could not be tested for correctly.
*P<.05 ** P<.001.
[2]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-18. Analysis of variance for water consumption in right and left position, 18-26 wk of age, Exp. 2

Source of variation	d.f.	Water consumption -MS-
Shape (S)	1	1613.85
No. and Location nipples (T)	1	4008.00
S x N	1	995.18
Rearing waterers (R)	1	549.77
S x R	1	2255.47
T x R	1	676.56
Location (L)	1	12.23
S x L	1	466.04
T x L	1	1481.85
R x L	1	4172.54
S x T x R x L	5	89892.93***
Period (P)	8	170496.71***
S x P	8	6955.57
T x P	8	15945.61
P x R	8	5908.75
S x P x L	8	12469.83
T x P x L	8	11082.82
P x R x L	8	19407.93
Error	64	1630.14

***P<.001.

Table A-19. Analysis of variance for water consumption in right and left positioned nipples, 18-62 wk of age, Exp. 2

Source of variation	d.f.	Water consumption -MS-
Shape (S)	1	1223.79
No. and location nipples (T)	1	3088.84
S x T	1	847.31
Rearing waterers (R)	1	6337.47
S x R	1	3504.46
T x R	1	875.44
Location (L)	1	7589.69
S x L	1	5344.55
T x L	1	4896.02
R x L	1	1287.56
S x T x R x L	5	79659.86***
Period (P)	13	190790.86***
S x P	13	8697.20
T x P	13	21465.28
P x R	13	11736.09
P x L	13	48620.82
S x P x L	13	18317.88
T x P x L	13	14656.03
P x R x L	13	26311.78
Error	104	2829.98

***$p < .001$.

Table A-20. Analysis of variance for water consumption, 18th wk of age by period, Exp. 2

Source of variation	d.f.	Water consumption MS 1	2	3	4
Shape (S)	1	6021.76	91839.30**	10363.24	49.00
No. and location nipples (T)	3	9912.34	267921.89**	19381.10	8886.81
Rearing waterers (R)	1	9712.90	1486.10	12111.00	29756.25
T x R	3	3712.90	1392.88	5897.00	2802.12
S x T	3	7624.89	329588.13**	41452.67	9263.37
S x R	1	1292.40	767.29	10160.64	6847.56
Error	3	1519.70	1112.88	3452.75	5982.93
Contrast[1]:			-SS-		
1NB vs INF	1	14.58	3260.28	36.12	427.78
1N vs 2N	1	8244.64	83549.90**	9034.50	3025.00
1NB vs 2NB	1	1761.21	406.12	14637.60	153.12
1NF vs 2NF	1	7472.53	151030.08**	180.50	4278.12
2NB vs 2NF	1	1653.12	181111.71**	10310.48	5434.03

Source of variation	d.f.	MS 5	6	7
Shape (S)	1	576.00	61988.55	81.00
No. and location nipples (T)	3	10243.68	150923.62	21909.37
Rearing waterers (R)	1	430.56	39312.97	25680.06
T x R	3	10572.18	175623.42	13195.31
S x T	3	6675.25	128925.40	673.12
S x R	1	5041.00	753.56	297.56
Error	3	4486.25	51788.65	120.60
Contrast[1]:			-SS-	
1NB vs 1NF	1	12.50	72.00	552.78
1N vs 2N	1	6405.06	96550.02	12939.06
1NB vs 2NB	1	435.12	115921.12	19061.28
1NF vs 2NF	1	7938.00	9793.00	520.03*
2NB vs 2NF	1	4186.41	54301.60	8417.53

*P<.05 ** P<.001.

[1]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-21. Analysis of variance for water consumption, 18-26 wk of age by period, Exp. 2

Source of variation	d.f.	Water consumption MS 1	2	3	4
Shape (S)	1	2956.64	1936.00	3323.52*	984.00
No. and location nipples (T)	3	22629.43	20418.5	2770.73	2368
Rearing waterers (R)	1	3304.19	362.90	610.09	116.10
T x R	3	423.80	2956.45	1174.26	4865.04
S x T	3	11339.65	12626.03	204.18	898.06
S x R	1	6758.60	12.96	1966.92	3.70
Error	3	2933.07	2039.81	226.65	820.68
Contrast[1]:			-SS-		
1NB vs INF	1	239.96	500.86	0.24	144.50
1N vs 2N	1	2174.44*	8190.25	2693.31*	2141.37
1NB vs 2NB	1	9854.07	16726.20*	1708.20*	976.82
1NF vs 2NF	1	11936.22	1.80	1028.31	1168.86
2NB vs 2NF	1	649.02	11727.46	76.88	82.56

Source of variation	d.f.	MS 5	6	7	8
Shape (S)	1	1455.42	1077.48	4475.66	2864.92
No. and location nipples (T)	3	1706.92	1500.35	33488.16	5107.63
Rearing waterers (R)	1	196.00	5435.37	1.44	7.42
T x R	3	3454.28	22733.70	3636.93	1600.78
S x T	3	4903.04	6187.07	5254.16	1633.17
S x R	1	488.41	4273.89	5461.21	109.72
Error	3	1699.14	2002.83	2201.54	2356.06
Contrast[1]:			-SS-		
1NB vs 1NF	1	469.71	91.80	11.28	207.06
1N vs 2N	1	841.00	6818.63	15964.32	4716.25
1NB vs 2NB	1	0.08	11696.85	24708.64*	2397.78
1NF vs 2NF	1	1705.28	74.42	462.08	2318.80
2NB vs 2NF	1	396.21	8089.92	17512.56	184.32

*$P<.05$.
[1]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-21. (con't)

		MS
		9
Shape (S)	1	5241.76
No. and location nipples (T)	3	4630.76
Rearing waterers (R)	1	4212.01
T x R	3	6504.46
S x T	3	6107.39
S x R	1	157.50
Error	3	1190.03
Contrast[1]:		
1NB vs 1NF	1	231.12
1N vs 2N	1	2575.56
1NB vs 2NB	1	489.84
1NF vs 2NF	1	2464.02
2NB vs 2NF	1	1824.08

*P<.05.
[1]1NB = 1 nipple in back of cage.
1NF = 1 nipple in front of cage.
2NB = 2 nipples in back of cage.
2NF = 2 nipples in front of cage.

Table A-22. Analysis of variance for water consumption in right and left position, 18th wk by period, Exp. 2

Source of variation	d.f.	Water consumption MS 1	2	3	4
Shape (S)	1	1166.22	74079.23	9129.80	395.01
No. and location nipple (T)	1	826.56	90555.85	5155.24	2727.01
S x T	1	2232.56	132805.58	13876.84	570.01
Rearing waterers (R)	1	2872.96	1202.35	5783.50	12348.76
S x R	1	835.21	3.33	7404.60	11315.64
T x R	1	1600.00	43.23	1831.84	66.01
Location (L)	1	5041.00	9.45	2371.69	7898.76
S x L	1	576.00	35.10	5670.09	395.01
T x L	1	510.76	53.65	17835.60	16737.89
R x L	1	473.06	49695.55	15079.84	669.51
Error	5	3665.06	56612.00	14516.07	7706.16

Source of variation	MS 5	6	7
Shape (S)	715.56	61864.12	141.04
No. and location nipples (T)	2093.63	27150.80	4208.76
S x T	7482.55	33589.72	92.64
Rearing waterers (R)	992.25	48081.92	16288.14
S x R	6683.06	42631.92	21.39
T x R	1743.06	58915.42	2058.89
Location (L)	3.06	28047.87	2173.89
S x L	36.00	42621.92	12127.51
T x L	64.00	92431.20	276.39
R x L	3630.06	46883.07	199.51
Error	4673.67	57066.32	12169.04

Table A-23. Analysis of variance for water consumption in right and left position, 18-27 wk by period, Exp. 2

Source of variation	d.f.	Water consumption MS 1	2	3	4
Shape (S)	1	62.12	1202.35	1600.00	648.87
No. and location nipple (T)	1	6.62	5863.73	38.44	41.28
S x T	1	72.92	5539.08	800.89	77.88
Rearing waterers (R)	1	6.66	851.18	597.80	1272.70
S x R	1	137.48	12.78	1207.56	324.90
T x R	1	2.30	544.05	200.22	21.85
Location (L)	1	1.45	13127.43	158.76	423.33
S x L	1	.21	315.95	278.89	148.23
T x L	1	153.38	2253.87	5299.84	38.75
R x L	1	65.03	703.57	1.10	86.95
Error	5	561.03	23430.08	34079.77	21653.43

	MS 5	6	7	8
Shape (S)	83.26	376.36	2393.65	1043.29
No. and location nipples (T)	198.10	4044.96	8756.28	92.16
S x T	2127.51	108.16	1951.43	753.50
Rearing waterers (R)	151.90	207.36	4.51	22.56
S x R	511.89	2410.81	4144.14	0.64
T x R	1638.22	123.31	1766.10	338.56
Location (L)	2472.57	2025.00	4539.39	91.20
S x L	7529.90	1239.04	2953.62	62.41
T x L	1732.64	68.89	409.05	256.00
R x L	746.45	10465.29	9413.85	1179.92
Error	24391.99	13123.39	17506.47	14639.88

Table A-23. (con't)

	Water consumption -MS- 9
Shape (S)	1159.40
No. and location nipples (T)	912.04
S x T	524.41
Rearing waterers (R)	3340.84
S x R	372.49
T x R	1861.92
Location (L)	6880.70
S x L	607.72
T x L	2352.25
R x L	918.09
Error	21188.30

EFFECTS OF NUMBER AND LOCATION OF NIPPLE WATERERS ON THE PERFORMANCE OF CAGED WHITE LEGHORN LAYERS

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER'S OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
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1989

In Experiment 1, 384 Babcock White Leghorn hens were placed in the top deck of a row of 30.5 x 45.7 cm. double-deck deep cages and 256 in the top deck of a row of 45.7 x 30.5 cm. shallow cages. Four treatments were compared: 1) one nipple waterer (NW) in the front and center of the cage, 2) one NW in the back and center of the cage, 3) two NW in the front of the cage, 4) two NW in the back of the cage. Each treatment was assigned to a block of four contiguous cages. Two of the four cages contained pullets reared on dome waterers (DW) and two cages contained pullets reared on trigger cups (TCW). There were six blocks per treatment of four deep cages and four blocks per treatment of four shallow cages. Effects of cage shape, number, and location of nipple waterers on productivity, and feed and water consumption were analyzed from 18-70 wk of age.

Cage shape, location and number of nipple waterers per cage did not significantly affect age at sexual maturity or egg production. Cage shape and number of NW per cage had no significant effect on mortality. But there was a significant ($P<.05$) effect of waterer location on mortality, 11.0 vs 16.4% for front and rear location, respectively. No significant differences were found for feed consumption, feed conversion and egg weights. Cage shape had no significant effect on water consumption. There was a trend ($P<.06$) for hens in cages with NW at front to consume more water than those in cages with NW in the back 183.0 vs 178.5 g/hd for 18-70 wk of age. There was a significant difference $P<.05$ between one and two NW per cage for water consumption from 18-70 wk (164.5 vs 197.0 g/hd).

For Experiment 2, birds were weighed and housed at 18 wk in the same layer cages as in Exp.1. Hens raised on TCW consumed significantly ($P<.05$) more water than hens raised on DW (211.4 vs 196.6 g/hd). Cage shape, location and number of NW per cage did not significantly affect age at sexual maturity, mortality, feed consumption, feed conversion, and egg weight. Cage shape and number of waterers per cage did not significantly effect egg production. But hens in cages with NW at the back of the cage laid at a significantly higher rate than those in cages with NW at the front of the cage, 79.9 vs 78.2%. Cage shape, waterer location and position had no significant effects on water consumption. Hens in cages with one NW consumed significantly ($P<.05$) less water from 18 to 62 wk than those in cages with 2 NW, 185.6 vs 222.3 g/hd, respectively.