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Title EFFECT OF RESTRICTION OF WATER INTAKE ON GROWTH AND FEED CONSUMPTION OF BROILER CHICKENS

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A trial was conducted to determine the effects of increasing levels of water restriction on body weight, feed consumption, feed conversion and mortality of broiler chicks to eight weeks of age. In addition, the effects of water restriction on water:feed ratios, water consumption per pound of body weight and on the percent of toe moisture were observed.

A total of 312 one-day-old broiler chicks were placed on regimens of 10, 20, 30, 40 and 50 percent water restriction after the first week based on ad libitum intake of the control chicks for the previous 24 hours. Water and feed were weighed and recorded daily for all treatments during the eight-week trial. The chicks were bulk weighed weekly by sex and brooded on floor pens under infra-red lamps in a forced-draft ventilated house.

Results indicated that feed consumption, water consumption,

body weight, water:feed ratio and water consumption per pound of body weight were decreased with each increment of water restriction. A significant difference in body weight between males and females was found in all groups throughout the trial. Interactions due to replication, sex x replication and sex x treatment were not present. Water restriction was found to be deleterious to feed conversion with each increment of water restriction. Mortality and percent toe moisture content were not significantly affected by water restriction. Edema and degeneration of the cells lining the tubules of kidneys were the only changes observed in the body tissues of the 50 percent restricted chicks.

For all practical purposes the optimum amount of water consumed by the growing chick to eight weeks of age under conditions of this experiment equals 10.61 pounds per bird.

EFFECT OF RESTRICTION OF WATER INTAKE ON GROWTH AND FEED CONSUMPTION OF BROILER CHICKENS

by

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TABLE OF CONTENTS

LIST OF TABLES

EFFECT OF RESTRICTION OF WATER INTAKE ON GROWTH AND FEED CONSUMPTION OF BROILER CHICKENS

INTRODUCTION

Statement of the Problem

To determine the effects of varying amounts of water restricted consumption upon body weight, feed consumption, feed conversion and mortality of broiler chicks to eight weeks of age.

Importance of the Problem

Water is composed of two atoms of hydrogen and one of oxygen. It is both the cheapest and most plentiful nutrient that poultry consume. Whether water is classified as a feed or not is a subject of debate depending upon the definition of a feed. It is, however, necessary for all classes of poultry. Ewing (24, p. 52) calls water a nutrient of utmost importance to the body. It is an essential constituent of all body tissues and for all life processes. It is, however, sometimes overlooked because it is often taken for granted. Unfortunately, many poultrymen do not appreciate the amount of water poultry require for maintenance of health, growth and egg production.

Relatively little is known of the part water plays in the metabolism of fowl or even of the basic requirements of the fowl for water. Research on the consumption of water by poultry is of interest from the standpoint of both phsyiology and poultry management. All life depends upon water, and appreciation of this truth is realized when we note that poultry will die more quickly when deprived of water than when deprived of all other nutrients (78, p. 138) or of solid feed (56, p. 206). More information is needed on the water consumption of all classes of poultry.

REVIEW OF LITERATURE

The Role of Water in Poultry

The moisture content of the body gradually decreases as the chick matures. Medway and Kare (73, p. 140) reported that the total body water content of the day-old chick is 72.8 percent as compared to 57.3 percent in the adult chicken. It is important that one understands the fundamental role that water plays in the digestion, absorption, metabolism, health, disease and growth of poultry since water is by far the largest, single constituent of the chicken's body.

The functions of water in the body of poultry are numerous. Some of the more important ones include:

1. Regulation of salt concentration in the body (72, p. 79).

2. Softening of feedstuffs in the crop which aids in the maceration of food in the gizzard (12, p. 197).

3. Water helps to regulate body temperature in two ways:

    a. When carbohydrates and fats are digested, heat is produced. Water absorbs this with a minimum rise in temperature, and removes it as latent heat of vaporization (10, p. 118).

    b. Water evaporates readily and cools the body by evaporation through the air sacs, lungs and skin (67, p. 355).

4. The fluids which serve to lubricate such body surfaces

as joints, eyes, muscles and other body tissues are largely composed of water (51, p. 204).

5. Water aids many physiological functions such as swallowing; and it is the principal constituent of such internal fluids of the body as pericardium, synovial, peritoneal, pleural, etc. (34, p. 997).

6. Water catalyzes many reactions in which it has no apparent role, and it is involved in chemical reactions of biological materials such as the processes of oxidation and reduction (34, p. 997) in addition to taking an active role (hydrolysis) in digestion, absorption and assimilation of nutrients (67, p. 355).

7. Water is an essential constituent of blood and lymph. As such, it serves in transporting the end-products of digestion throughout the body (12, p. 197) and in removing the resulting waste products of metabolism (49, p. 243).

All water that is ultimately available to the chicken is ingested, even though it may not be ingested as a form of water as such (47, p. 225). Except when new tissues are being formed, the body's intake of water must balance its output as reported by Best and Taylor (8, p. 20). When output exceeds the intake of water, the body is said to be in negative water balance. This results in dehydration. Conversely, the water balance is positive when the intake of water exceeds the output. Normally, chickens are in a positive water balance during periods of growth or formation of new tissues. Medway and Kare (74, p. 636) found that the growing White Leghorn chick was in a positive water balance from one week of age to 32 weeks.

Water has the highest rate of turnover of any substance in the body (49, p. 243). It is replenished in several ways. It may come from the ingestion of liquids such as water, semisolid and solid foods (8, p. 20). Grains, which account for a large portion of the poultry ration, contain from 8 to 12 percent water based on their air dry weight (12, p. 198). The oxidation of hydrogen from organic nutrients (hydrolysis) such as carbohydrates, fats and protein (72, p. 79) or of the body tissues themselves (8, p. 21) produces water. In addition, water is derived from the polymerization or synthesis of various compounds--a metabolic process which is the reverse of hydrolysis (8, p. 21). Several ways by which the body replenishes its water have been suggested. However, Card (12, p. 198) states that the main source of water for poultry is free water itself.

The water consumed by chickens, except for that stored in the tissues, must be removed from the body as reported by Lippincott and Card (67, p. 305). They also state that the metabolic water formed in the body must be removed. Water is removed from the chicken primarily through the lungs, air sacs, skin, kidneys as urine, eggs if laying and through the intestinal canal in feces (12, p. 159). Hart and Essex (33, p. 668) found that in adult chickens the amount of water lost was 39 g in the feces, 129 cc in the urine and 110 to 114 cc from the lungs as vapor. Since the fowl has no sweat glands, Card (12, p. 159) states that very little water is lost by evaporation from the skin. The exact amount of water voided through these avenues in the chicken is not known because it varies. It varies not only among different species, but under different conditions in the same specie of animal. For instance, Lee et al. (63, p. 196), reported that the rate of evaporation of water from the lungs and air sacs is low (5 g/hr) as long as the respiratory rate is moderate and panting does not occur. With high respiration rate and panting a marked increase occurs (up to 30 g/hr). Similarly, excessive intake of fluids will cause increased amounts of water excretion by the kidney (94, p. 106).

The physiological mechanism of the fowl is suited to the conservation of water. Card (12, p. 251) states that water used in digestion is used again in other ways, and even rather large amounts of water used in carrying away the waste products from the kidneys are largely reabsorbed from the cloaca and used again in various body processes. This last point, though, is somewhat obscure in that both Dixon (21, p. 414) and Loveberg and Taylor (68, p. 1137) report that the reabsorption of water from the cloaca is negligible.

Requirements of Poultry for Water

A chicken drinks by dipping its beak in water accompanied by sucking motions. As the chicken raises its head upward, the water reaches the throat by gravity after which the chicken swallows. If the waterer is in a position that interferes with this motion, the chicken will spill water and wastage will occur causing damp litter around the waterer (43). Generally, poultry take small amounts of water at a time during the day (69, p. 20). This is the reason for so many recommendations stating that water should be available to poultry at all times. This is not necessarily the case, however, since it has been shown that layers will adjust satisfactorily to receiving water at regular intervals throughout the day (71, p. 922).

Many tables have been published on the water consumption of all classes of poultry. They rarely agree and are useful only as guides. Wilkins (96, p. 429) states that these tables must not be taken as maximum requirements since water consumption will vary with factors other than age such as weather, ration, breeding, body size and rate of egg production.

Layers in good production normally consume about 18 to 20 gallons of water per bird yearly under average conditions as reported by Jull (51, p. 256). Heywang (38, p. 187) found that the water consumption per hen per year was approximately 18. 2 and 18. 3 gallons, respectively, in two groups of White Leghorns and 19. 8 and 19. 9 gallons in two groups of Rhode Island Reds. Another author, Parnell (78, p. 374), states that 100 layers under moderate temperatures will consume from 5 to 7.5 gallons of water daily. This is a lot of water. Fuge (27, p. 264) estimated that if 100 layers consumed five gallons of water per day, this would represent 50 pounds of water per day (based on Imperial gallons) or nearly ten tons a year.

The water consumption of growing turkeys was measured by Morehouse (76, p. 153) from hatching to 26 weeks of age. Water consumption per turkey ranged from an average of 45 cc at one week to 557 cc at 26 weeks of age.

The water consumption of the growing White Rock chick was found by Dawson and Siegel (19) to be 1.35 pounds from one to two weeks, 2.69 pounds from two to four weeks, 4.40 pounds from four to six weeks, 5.13 pounds from six to eight weeks and 5.60 pounds from eight to ten weeks of age. The respective water:feed ratios (pounds of water consumed per pound feed consumed) were 2.60, 2.30, 2.00, 1.90 and 1.90. Patrick and Ferrise (80, p. 1365-1366) reported that growing broiler chicks consumed from one to nine weeks of age an average of .23, .46, .82, 1.38, 1.47, 1.78, 1.95, 2.10 and 2.35 pounds of water, respectively. The average water:feed ratio decreased from 4.96 pounds at one week of age to 1.48 pounds at nine weeks. Medway and Kare (74, p. 634) showed that the ratio of water intake to body weight in Leghorns decreased from .45 in the one-week-old to .13 in the 16-week-old chick.

Effect of Limited and Total Water Restriction

Chickens cannot survive very long when deprived of water. A ten percent loss of body water through dehydration and excretion results in serious physical disorders as reported by Romanoff and Romanoff (85, p. 43). It has been reported by Hawk and associates (34, p. 997) that death occurs in man when 20 percent of the body water content is lost; although, Best and Taylor (8, p. 20), stated that a loss of 25 percent of the body water is fatal in humans. Kaupp (56, p. 207) reports that domestic animals will not die until all of the fat of its body and 50 percent of its protein is lost, whereas a loss of ten percent of its body weight through water deprivation will cause death. Johnson (47, p. 225) reported similarly. Under average weather conditions mink cannot survive longer than three days without water in their natural environment, and under farm conditions, one day is apt to be fatal as reported by Gorham and Dejong (30, p. 12).

The length of time animals can withstand water deprivation varies among different kinds of animals and among different species of the same animal. Johnson (47, p. 226) states that range cattle in the Southern Nevada desert areas can survive on drinking water once every other day. One day is spent foraging for food, and the other is spent walking back to the watering hole. Henry and Morrison (35, p. 545) reported that sheep grazing on succulent plants can go for two months without drinking water. Kangaroo rats and pocket mice are highly conservative in their water use as stated by Johnson (47, p. 226). They need neither free water nor green vegetation to sustain life. Desert rats and laboratory rats were deprived of water for ten days by Howell and Jewell (42, p. 120). The average weight loss of the laboratory rat was 35 percent as compared to 17 percent for the desert rat. The experiment showed that the desert rat was able to withstand water deprivation better than the laboratory rat, and reached a plateau in body weight loss while the laboratory rat lost weight progressively throughout the trial. Phillips (81, p. 233) showed that Zebu cattle are better adapted to dry conditions than European-type cattle. The lower requirement for the Zebus was explained partially by the fact that the feces contained a lower moisture content as compared with European-type cattle in the same or similar conditions.

Symptoms associated with water deprivation are numerous. Best and Taylor (8, p. 23) reported that the more notable symptoms of water deprivation in humans include loss of weight, disturbances in acid-base balance--usually toward the acid side, rise in the non-protein nitrogen in the blood, rise in plasma-protein concentration, rise in body temperature as a result of the reduction in circulating fluid, increased pulse rate and reduced cardiac output, thirst, dryness, wrinkling and looseness of skin, exhaustion and collapse. In addition, such symptoms as fever, vomiting, severe hemorrhage, polyuria, general weakness, guantness of the flanks and abdomen and copious sweating have been noted in man (47, p. 225). Henry and Morrison (35, p. 69) state that the processes of mastication, digestion, absorption and assimilation are hindered when animals are deprived of water while the blood thickens and body temperature rises.

Hoffman and Johnson (39, p. 65) report that it is easy to tell chicks that have been without water because in their eagerness to get a drink, they get their plumage wet and have a bedraggled appearance for sometime afterward. Chicks that fail to find water may show considerable dehydration. Dehydration is particularly noticeable in the shanks and some mortality may result as reported by Marble and Jeffrey (70, p. 327). Jull (50, p. 167) states that turkey poults have poor vision for the first few days, and as a result precautions must be taken to see that they find water and feed early. If poults do not find feed and water they starve or at least become retarded, and slimy linings of the gizzard develop. This is substantiated by Hammond (32, p. 477-480) who observed that a lack of water caused poor growth and the development of loose, slimy gizzards in which a ball was frequently formed that plugged the opening to the duodenum. These observations were observed to occur in poults between the fifth and twelfth day after hatching. Feed was found to aggravate the condition. Fisher et al. (25, p. 813) noted a syndrome diagnosed as blue comb disease that repeatedly occurred over a six year period whenever pullets, cockerels or yearling hens were transferred from floor pens to individual cages. It was found that when the affected chickens were given access to feed, but not water, a condition was produced which fitted more nearly the condition known as blue comb disease than when the birds were given neither feed nor water. The cause of the condition was due to the fact that many of the birds were not learning how to drink from the mechanical waterers in the cages.

Limiting water intake reduced feed consumption in cattle as reported by Phillips (81, p. 233-234). The decrease in hay consumed resulting from water restriction was less for the Zebus than for European-type cattle. Water requirements of cattle can be reduced during periods of water shortage by restricting dry matter intake as reported by Winchester and Morris (100, p. 739).

Activity in three-day-old rats, as reported by Cicala and Campbell (14, p. 413-414), decreased gradually during an entire terminal water deprivation period when measured by a stabilimeter-type activity cage. Lepkovsky et al. (65, p. 327) reported that withholding water during meals did not interfere with digestion in rats, but it did definitely decrease appetite and caused a reduction in food intake. In another experiment, Crampton and Lloyd (17, p. 222), showed that restricting the water intake of growing rats reduced voluntary intake of food and consequently inhibited gain in body weight.

Danowski and associates (18, p. 822) found that feeding carbohydrates to dogs reduced their requirement for water. Working with humans, Winkler et al. (101, p. 815), showed that under conditions of limited water supply ingestion of protein is definitely contraindicated . Carbohydrates were shown to be the foodstuffs of choice since its water of oxidation was made available to the body. Food fasting was found to increase negative water balance during water deprivation. It has been shown that during wasting diseases (persistent vomiting, diarrhea, etc.) in man, the body loses water as well as protein and fat (91, p. 107). In convalescence these losses are often replaced with amazing rapidity.

Hens need water for the production of eggs. Biester and Schwarte (10, p. 118) and Clinton (15, p. 467) state that an insufficient amount of water results in decreased egg production. Depriving hens of water for a few hours results in their egg production dropping sharply, and in the course of 48 to 60 hours laying will stop entirely as reported by Ridlen (83, p. 13). In a study by Wilson (97, p. 933), White Leghorn pullets at an environmental temperature of 90° F were deprived of water for 24, 48 and 72 hours in separate tests. A short interruption of egg production was observed in the pullets which had water withheld 24 hours. In the two groups deprived of water for 48 and 72 hours some of the pullets molted but later came back into production. Water deprivation was found to limit feed consumption drastically.

Recently, several studies have been undertaken to find the effect of depriving water for various time periods to control wet droppings in laying hens. Maxwell and Lyle (71, p. 921-922) hypothesized that caged hens drank water beyond their metabolic requirements in relation to floor birds since they were individually housed with water before them at all times, and therefore could be producing wetter droppings because of excessive water intake. It was found that when caged hens were given water for 15 minutes three times a day wet droppings could be effectively prevented, if the cause of wet droppings was due to the chickens drinking water in excess of their needs in the first place. Egg production was unaffected, and there was a slight improvement in feed conversion when water was thus restricted. From moisture determinations of the manure it was found that only about five percent more moisture in the droppings would appear to make them wet. Goodman (29, p. 265) stated that during high temperature periods caged hens drank more water than needed to satisfy body requirements and/or egg production needs. This excess consumption caused hens to excrete wetter droppings. Accordingly, three groups of hens were restricted to water allowances of 15 minutes once every hour, every two hours, and every three hours. No water was available from 4:00 P.M. to 7:45 A.M. each day. All groups produced drier droppings than did controls during the month of July. Egg production was unaffected by the treatments. Another study (43) limiting layers to three, four or five drinking periods daily of 15 minutes each reported essentially the same results that Goodman obtained.

Kare and Biely (54, p. 754) placed New Hampshire chicks on diets containing .9 to 4.0 percent salt, and deprived them of water four to six hours per day. The water-restricted chicks consumed practically the same amount of water per gram of feed consumed as chicks on the same diet with water ad libitum. The water deprived chicks compensated by drinking more when water was before them which resulted in approximately the same feed:water ratios.

In a study conducted by Ross (87, p. 1002), one-week-old New Hampshire chicks were given water 30 minutes three times a day. At the end of six weeks results indicated depressed growth and feed consumption in the water restricted chicks. Feeding chicks with or without water at feeding time does not greatly influence their food intake or the proteolytic activity of the intestinal contents as reported by Lepkovsky and associates (64, p. 394). However, the rate of digestion was slower in chicks fed without water, and decreased glycogen accumulations were found in the liver and leg muscles. More water was found in the crop contents of chicks fed with water than in the crop contents of chicks fed without water. The intestinal contents contained approximately the same percentages of water in each group.

In a study by Fox (26, p. 477-483), White Plymouth Rocks and Rhode Island Red layers were found to have a significantly longer average survival time than White Leghorns when water was deprived at an environmental temperature of 108° F. When water was provided _ad libitum_, White Leghorns had longer average survival times than did either Rhode Island Red and New Hampshire chickens due to the persistency with which the Leghorns continued to drink. In a hot dry atmosphere (106° F), Lee _et al._ (63, p. 201) found that hens which were allowed to drink at pleasure had a smaller rise of rectal temperature and respiratory rate, and a greater rate of evaporation than hens which were deprived of water. When hens were given water by syringe through the mouth into the crop, similar effects were not observed. These hens fared even worse than those deprived of water. In a hot wet atmosphere (85° F, 95 percent R.H.), the sparing effect of access to water was seen in the Australorp but not in the White Leghorn.

Five-week-old crossbred chicks were placed on regimens of restricted feed and water consumption for six days by Conner (16, p. 1340-1343). Growth inhibition was greatest with 25 percent feed, 100 percent water, and least with 100 percent feed, 50 percent water. There was no mortality. The following body weight changes were observed:

Treatment	Grams gain or loss in six-day period
25% feed 100% water	-81
50% feed 100% water	-36
100% feed 25% water	-42
100% feed 50% water	+25
50% feed 50% water	-53
100% feed 100% water (control)	+128

Some growth occurred in chicks on full feed and 50 percent water. Conner stated that in the growing chick it is apparently possible to utilize metabolic water to counteract a deficiency of water supply over a short period. He concluded that feed restriction had a more profound stress than water restriction as far as the effect on growth rate was concerned. Jackson and Smith (44, p. 153) on the other hand, found just the opposite to be true in rats. Young rats were held at a constant body weight for several months by restricted water intake. Food was allowed *ad libitum*. A second group of young rats was given water *ad libitum* and the same amount of food as was voluntarily consumed by the test rats on restricted water. The rats restricted of food made remarkable gains in body weight ranging from 33 to 98 percent. This gain was found to be due solely to the increased water intake since all other factors were held constant. In this way, the importance of water intake on growth, independent of the food consumption, was demonstrated. Therefore, unless specie differences are involved, it would appear that agreement on this point is not yet possible.

Hammond (32, p. 479) in trials with turkey poults showed that lack of water during the first week of life was more deleterious than lack of feed. The presence of feed in the absence of water had more severe effects than the absence of both feed and water. The effect of deprivation of feed and water for 24, 48 and 72 hours after hatching of poults was reported by Chilson and Patrick (13, p. 86-87). The effect on growth and mortality was progressively detrimental and showed that turkey poults should be supplied with feed and water as soon after hatching as possible.

Factors Affecting Water Consumption

There are reportedly many variables which will affect the water consumption of poultry. The amount of water consumed and excreta voided in growing chicks varied almost directly with the protein level of the diet as reported by James and Wheeler (46, p. 467). The relationship between protein level and water consumption was probably related to the well known fact that greater amounts of water are required for the metabolism of protein than for carbohydrates or fat. In a subsequent experiment Wheeler and James (95, p. 500) reported similar results in growing chicks. In addition, they reported that the quantitative effects of soybean meal on water consumption are greater than those of fish and meat protein. Increasing the amount of any of the three protein sources was followed by an increase in water intake, cloacal excreta voided and water content of the droppings.

Patrick (79, p. 157) observed an increase in the weight of droppings excreted as the dietary protein level increased. The amount of water consumed at any particular protein level was influenced by the type of protein being fed. Some protein concentrates were found to increase water requirements of broiler chicks while others decreased water intake.

For each ten ounces of fat a bird oxidizes 10.7 ounces of water is formed (8, p. 21). As fat is deposited in the body it tends to replace water, and conversely, as body fat is burned, it tends to be replaced by water (94, p. 107). For this reason man is often unable to lose weight when restricting calorie intake. If caloric restriction is carried on long enough the weight will eventually drop. Mellanby (75, p. 21) states that complete combustion of 100 g of fat produces about 110 g of metabolic water, whereas 100 g of carbohydrate yields only 55 g of water. Combustion of 100 g of protein yields 41.3 g of water (9, p. 21). This researcher did not believe that fat is deposited as a reserve for water in desert animals as others have postulated; rather it is deposited as a food reserve since fat is the only food substance which animals can store in any quantity. Studies by Schreiber and Elvehjem (89, p. 143) showed that rats fed high fat or high protein diets or both in the presence of water restriction resulted in larger weight loses and higher mortality than occurred with high carbohydrate diets. They partially attributed their results to the little recognized fact that fat as well as protein contributes less metabolic water per calorie than carbohydrate. Bieri et al. (9, p. 239) found that chicks reared from day-old on fat free diet consumed 15 percent more water after 11 weeks. Arscott et al. (3, p. 120) found no consistent increase in water consumption of broiler chicks to eight or nine weeks of age attributable to the use of fat in the ration.

The relation of feed particle size and water consumption has not been clearly established. Eley and Bell (23, p. 661) reported that feed and water consumption, as well as water excreted, increased as feed particle size increased in the rations of broiler chicks. On the other hand, Eley and Hoffman (22, p. 222), observed no relationship between feed particle size on moisture content of droppings, water and feed consumption or weight gains in growing chickens. In a comparison of pelleted and all mash diets, Hoffman and Poitevent (40, p. 42) found that feeding a pelleted mash to broilers reduced the moisture content of the litter; but Morris (77, p. 124) reported that in every instance there was more damp litter where pellets were fed to laying hens than in corresponding hens receiving an unpelleted mash. Arscott et al. (3, p. 120) and Rose and Arscott (86, p. 126) have shown that pelleting materially increases water consumption in broiler chicks.

Water intake of cattle is a function of dry matter consumption and ambient temperature as reported by Winchester and Morris (100, p. 739). Tyler (93, p. 238) reported the opposite in laying hens. Results showed that there was no relationship between dry food intake and water consumption when water and feed were measured at hourly intervals. Lippincott and Card (67, p. 447) state that water intake is related to the consumption of dry matter in non-laying hens, but that this relationship does not hold true when there is a need for increased water consumption such as in high egg production or extremely warm weather. A significant increase in water consumption was shown by Arscott and Rose (2, p. 94) whenever barley was the principal grain constituent in broiler rations rather than corn. Rose and Arscott (86, p. 126) found that increased water consumption in broilers fed a barley base pelleted diet was significantly reduced in the presence of an amylolytic enzyme; however water consumption was still greater than that obtained for corn base rations.

Diets containing penicillin have been shown by Slinger and Pepper (90, p. 328) to reduced water consumption in chicks and poults even though the expected growth response occurred. Penicillin seemed to have a sparing effect on water requirements.

Kleitman (59, p. 340) demonstrated that water intake is only about 1/5 to 1/3 of normal when dogs were deprived of food. Similarly, Squibb et al. (91, p. 220) found that restricting feed intake reduced water consumption in five-week-old New Hampshire chicks.

High environmental temperatures dramatically increase water consumption in poultry. Wilson (98, p. 815) found that water consumption per bird per hour increased in nearly a straight line as ambient temperature rose from 70 to 105° F. Water consumption was doubled in White Leghorn pullets when room temperatures increased from 70 to 95° F. In another study with turkeys, Wilson et al. (99, p. 507), showed that on hot days water consumption varied inversely with the amount of shade and varied directly with air temperature. Squibb and co-workers (91, p. 220) demonstrated in trials with five-week-old New Hampshire female chicks that high environmental temperatures will significantly depress feed intake and growth and increase water consumption.

The temperature of water will also influence the consumption of water by poultry. Ridlen (83, p. 13) stated that chickens prefer water within a range of 50 to 55° F. When the temperature of the water varies from this range, consumption is reduced and wide variations reduce intake sharply. As water temperature approaches 90 to 95° F, water intake is reduced noticeably and at 105° F chickens refuse to drink until thirsty. At 112° F they virtually refuse to drink. The effects of drinking cold water (32° F) and warm water upon White Leghorn pullets subjected to environmental temperatures of 90° F was reported by Wilson (97, p. 933). Both groups responded the same excepting that the cool water lowered body temperature. During very cold weather precaution must be taken to see that the water temperature does not become too low. Although poultry consume more water at high temperature than at cool temperatures, there is a greater chance of poultry getting too little water during periods of low temperature than at other times. This is due either to the chicken's inability to break ice on waterers and/or to the chilling effect of ice cold water (94, p. 825). Prince and Kare (82, p. 1674) studied the reaction of chickens to water at temperatures below ambient. It was observed that the chicken was sensitive to drinking water at temperatures substantially below ambient in terms of feed intake and gain. A report from the University of Illinois, as cited by Leuschner (66, p. 25), showed that hens having access to warm water throughout the winter laid 95.6 eggs, as compared to 87.8 and 80.8 eggs when hens received warmed water only part of the winter or only cold water, respectively. Studying the effects of cold drinking water (slightly above 32° F), Heywang (37, p. 204) found that the temperature of the drinking water had no effect on the rate of yolk absorption, digestion of feed nutrients or growth of young chicks under minimum and maximum air temperatures of 44 and 70° F, respectively, over a period of ten weeks.

The addition of certain minerals and chemicals to diets of all classes of poultry have been shown to increase water consumption. Heuser (36, p. 86) and Halpin et al. (31, p. 103) found that as salt was added to the diet of chicks, increased water consumption occurred. Both found the droppings to be very watery at high levels of salt intake. Heuser observed a direct relationship between the level of added salt and moisture content in the droppings. Roberts (84, p. 672) working with turkeys of various ages and Krista et al. (61, p. 944) with chicks, laying hens, poults and ducklings also showed that water consumption increased as the salt content of the ration increased. Similar results were found by Barlow and associates (4, p. 547). They stated that increased water consumption due to increasing increments of dietary salt illustrated an attempt on the part of the chick to maintain isotonicity of the body fluids.

Researchers at Hy-line (43) found that layers drinking water containing 4,300 ppm of various chemical substances required six percent more water to produce an egg than the same chicken given water with only 1,000 ppm of chemical substances. Molasses was found by Ross (87, p. 1001) to significantly increase the water consumption of growing chicks when added to the diet. Water consumption and fecal moisture were found by Kondo and Ross (60, p. 1136) to be directly related to the amount of sodium or potassium, or both, in chick rations. Blythe and associates (11, p. 912) concluded that the urinary concentrating effect in potassium depletions was not due to excessive water intake when water restriction and potassium depletion was practiced in rats. The addition of sodium bicarbonate to the drinking water of chicks increased water consumption and moisture content in droppings in direct proportion to the quantity of soda added as reported by Witter (102, p. 259). Sturkie (92, p. 1124) added water soluble zinc sulphate at a level of one percent of the drinking water of laying hens and obtained decreased water consumption. The ill effects of the zinc resulted mainly from lack of water consumption since the layers realized that the water was toxic and drank only enough to sustain life.

A pullet's egg contains about 73 percent water (85, p. 312). Ridlen (83, p. 13) states that since the egg contains a large amount of water, water consumption increases as egg production increases. Live weight, air temperature and rate of egg production influenced water consumption in laying hens as reported by Heywang (38, p. 187). Jull (52, p. 29) reported that hens in first-year production laying 180 or 240 eggs consume 130 or 180 pounds of water per bird, respectively. For each dozen eggs produced by a flock, approximately nine pounds of water are required, including that amount needed for body requirements.

The average water consumption was found by Ross *et al.* (88, p. 1079) to be relatively constant (2 cc of water per gram of feed) when comparing slow and rapidly growing chicks regardless of feed consumed or of feed efficiency. The dry weight of the droppings were also fairly constant for all groups. Joiner and Huston (48, p. 975) found that New Hampshire chicks had the largest total water requirement to ten weeks of age followed by White Plymouth Rock and White Leghorn chicks. White Leghorns were found to consume the most water per unit of body weight; White Plymouth Rocks consumed the least amount. It was observed in all groups that water consumed per unit of body weight decreased with age.

Hawk and co-workers (34, p. 316) state that water has a stimulating action on gastric secretion. The drinking of considerable amounts of water has been shown to increase the utilization of various foods. Keane *et al.* (57, p. 22) reported that the addition of 20 percent water to a nine percent protein purified diet significantly increased the rate of gain and protein efficiency ratio (PER) in growing rats. Responses were also obtained at six and twelve percent levels--but not at 18 percent dietary protein. The increased growth rate was found to be true gain, and not water accretion although the reasons for increased rate of gain and PER were not known. In further experiments Keane et al. (58, p. 387) added water to a nine percent protein diet at levels of 0, 5, 10, 15, 20, 25, 30 and 35 percent. Casein was used as the source of protein and sucrose as the source of carbohydrate. The results showed that an increase in PER was obtained with each increment of water up to 35 percent. In the same experiment, a second trial was undertaken to find the effect of different sources of carbohydrate. Cornstarch and dextrin were used and compared with sucrose. The presence of 0, 20 and 50 percent added water to the nine percent protein diet yielded a significant increase in PER when cornstarch or dextrin was used at the 50 percent added water level over that obtained with 0 or 20 percent added water. The addition of 20 percent water yielded a significant increase in PER when sucrose was used as the carbohydrate, but not when cornstarch or dextrin was used.

The fowl is sensitive to small changes in concentration of some flavors as reported by Kare et al. (55, p. 136, 138). Results indicated that the fowl does not respond predicatively to the broad classifications of tastes recognized by man. Using 1,044 chicks in two age groups, Kare and Pick (53, p. 705) found that feed and water intake can be regulated with flavor. They believed that the greater sensitivity for flavors in fluids make the role of additives in water of practical consequences. Broiler studies undertaken by Deyoe and associates (20, p. 1394) demonstrated that chicks preferred water that was flavored with different mixtures over pure water and water plus a flavoring material. The total gain in these chickens did not appear to be affected by the addition of the flavor to the feed. Jacobs and Scott (45, p. 10, 14) found that chicks could discriminate among sucrose and saccharine solutions and water, and preferred sucrose solutions whereas saccharine was avoided. The preference for sucrose was not shown to be related to its caloric value. The presence of sucrose alone or sucrose and saccharine solutions free-choice increased total liquid consumption over pure water alone. Biester and Schwarte (10, p. 75) point out the continuing increase in use of antibiotics and other drugs as additives to feed and/or water for specific disease control. They warn that precautions must be taken in the future to insure that excessive use of these additives in proper amounts will not cause decreased feed or water consumption due to the fact that chickens generally dislike the taste of the drugs presently being used.

EXPERIMENTAL PROCEDURE

A total of 312 day-old White Vantress x Nichols 108 broiler chicks were used in the trial. The chicks were sexed commercially and toe clipped for sex identification so that equal numbers of males and females were available. Where applicable the broilers were subjected to a routine management program established by the Department of Poultry Science at Oregon State University.

Broilers that died were autopsied by the Department of Veterinary Medicine. No vaccinations and/or medications were provided except that of a cocciodstat (Zoamix) employed in the diet. A standard broiler mash developed by the Department of Poultry Science and shown in Table I (p. 31) was fed ad libitum throughout the trial.

The chicks were divided into duplicate lots of 13 males and females each, and assigned randomly to 12 pens making up 6 treatments. Each 3.3'x8' floor pen received a total of 26 chicks. An allowance of 1.02 squ. ft. per bird of floor space was provided. Wood planer shavings were used for litter. The design and placement of equipment was as nearly identical in nature as possible in all pens in which the treatment chicks were placed. The chicks were brooded under infra-red lamps in a forced-draft ventilated room with no outside windows. Twenty-four hours of artificial light were provided. The experiment was initiated in March and terminated at the end of eight weeks in May of 1963.

Table I. Composition of Ration.

Ingredient	Amount
	(%)
Yellow corn, ground	70.3
Soybean oil meal, dehulled, (50% protein)	15.0
Meat and bone meal, (50% protein)	6.0
Fish meal, (70% protein)	5.0
Alfalfa meal, dehydrated, (20% protein)	2.0
Limestone flour	1.0
Salt, iodized	0.3
Vitamin and trace mineral premix[1]	0.25
Methionine hydroxy analogue, (90%)	0.15
Coccidiostat[2]	+
Total	100.00
Calculated analyses	
Protein, (%)	20.9
Fat, (%)	3.9
Fiber, (%)	2.5
Moisture, (%)[3]	11.9
Metabolizable energy, Cal./lb.[4]	1396.0

[1] Nopcosol M-5 (Nopco Chemical Company, Richmond, California), supplies per pound of mixture: vit. A, 600,000 U.S.P.U.; vit. D_3, 200,000 I.C.U.; vit. E, 200 I.U.; vit. K, 100 mg; riboflavin, 600 mg; D-pantothenic acid, 1 g; niacin, 4 g; choline, 40 g; vit. B_{12}, 1 mg; Zn bacitracin, 800 mg; butylated hydroxy toluene, 22.68 g; Mn, 10.8 g; Fe, 3.6 g; Cu, 363 mg; I, 218 mg; Zn, 5 g.

[2] Zoamix (Dow Chemical Company, Midland, Michigan), 227 mg/lb. of diet.

[3] Determined by A.O.A.C. method(41, p. 161).

[4] Based on values compiled by Arscott (1) 1962.

Two birds, one having an apparent sexing injury and the other omphalitis, were replaced with chicks of the same sex and age during the first week. No culling was practiced after the first week.

The trial was designed to show the effects of progressive restriction of water intake up to 50% upon broiler chicks to eight weeks of age. All birds were given free access to water during the first week in order to provide them with ample opportunity to adjust to their environment. In addition, it was felt that because of the possible severity of the treatments, chicks under one week of age were less likely to survive. The control chicks received water *ad libitum* throughout the trial. The quantity consumed by the control chicks was used as a basis for the restricted allowances which began on the first day of the second week. The amount restricted was based on the previous day's *ad libitum* intake for the control birds. This amount was adjusted for mortality when applicable. In this manner, restricted chicks received treatments of 10, 20, 30, 40 and 50% less than the amount of water which the controls consumed. This meant that the control chicks were automatically one day ahead of the treatment chicks; or rather, the water restricted chicks were one day behind the control chicks throughout the trial.

Water and feed were weighed and recorded daily from the first day to the completion of the trial. Both were weighed at the same time each day in the afternoon on a hanging Forschner scale. One feed and two water observations were lost during the first week. They were replaced with a figure computed by taking a simple average of all groups. Relatively little harm was done as water restriction treatments were not commenced until the beginning of the second week.

Water evaporation was also measured daily and the amount of water given the restricted groups included the amount which had evaporated from a waterer of the same design and capacity, in a central location in the room, on the previous day. However, after two days the water restricted groups were observed to drink their ration of water very rapidly (less than 30 minutes) so that there was little if any chance for a significant amount of water to evaporate, and the practice of including the amount of water that had evaporated in the control waterers was discontinued.

For the first ten days the waterers[1] and feeders[2] were placed at floor level so the chicks could eat and drink easily. After this time the waterers and feeders were hung so that the upper edge was at back level. Tar paper was placed under the waterers and cleaned regularly so that the chicks could not track litter into the waterers. After this time the presence of litter in the waterers

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1 Oakes (#505) 5 gal. capacity hanging-type, double-wall, vacuum waterers.

2 Purina (P-16) hanging-type, self-feeders.

was not a problem, and the tar paper was removed. No problem was encountered during the trial with litter in the feeders. All waterers were emptied and cleaned daily. After four weeks the waterers were placed on specially built stands so that the chicks would be less likely to spill water out of the containers when crowding around them.

Each pen contained one waterer until the chicks were four weeks of age after which time another one was added so that there was always enough water space for all chicks. The only exception to this was in the two control lots in which only one waterer in each pen was provided for the eight week period. However, since water was given ad libitum to the controls, there was no need for two waterers since these birds drank more uniformly throughout the day.

Wet and dry bulb thermometer readings were taken in the building twice daily -- one in the morning and one in the afternoon at regular times. These readings were taken in a central location. Relative humidity (R. H.) values were assigned to these readings as taken from Lange et al (62, p. 1392). No attempt was made to control relative humidity in the room. Ambient temperature readings in degrees centigrade (C^o) were also taken twice daily at regular times in the morning and in the afternoon, both inside and outside the building.

All chicks in each pen were bulk weighed weekly by sex. A hanging scale with a suspended platform was used the first six weeks to weigh the birds. After this time the broilers became too large to use the hanging scale, and a platform scale was used with the chicks weighed in coops.

At the end of eight weeks the right outer toe was amputated to the second joint for each chick on experiment. These were weighed, and percent moisture was determined by using A. O. A. C. procedures (41, p. 161). This was done to determine whether water restriction had any effect upon moisture content in the body.

Water, feed consumption and body weights are recorded weekly in pounds on a bird-day basis to correct for mortality in Tables II, IV, and V (p. 38, 40, and 42), respectively. Feed conversion (pounds of feed per pound of live chicken), Table VI (p. 44), was computed by using cumulative feed consumption averages divided by body weight averages. The water:feed ratio (pounds of water consumed per pound of feed consumed) as shown in Table VII (p. 45), was computed by dividing weekly feed consumption in pounds by weekly water consumption in pounds. Water consumption per pound of body weight, as shown in Table VIII (p. 46), was computed by dividing water consumption by body weight on a weekly basis. Dates and cause of mortality are recorded in Table IX (p. 47). Moisture content of the toes are found in Table X (p. 48).

Daily water consumption is shown in Appendix Table I (p. 67 to 68), and daily feed consumption is shown in Appendix Table II (p. 69 to 70). Weekly body weights by sex are recorded in Appendix Table III (p. 71). Appendix Table IV (p. 72) lists the daily temperature readings taken in degrees centigrade (C^{o}) inside and outside the poultry house. Daily wet and dry bulb temperatures in degrees Fahrenheit (F^{o}) with relative humidity (R. H.) values are recorded in Appendix Table V (p. 74). The terms "inside" and "outside" refer to within the poultry house and outside the poultry house, respectively.

Tables that were treated statistically during the experimental period were analyzed by analysis of variance by weeks when the data were recorded as such. Duplicate lot data are shown in the appendices.

The use of asterisks (*) has been standardized throughout this paper. One asterisk (*) denotes significance at the 5% level, and two asterisks (**) denote significance at the 1% level. "Restricted" or "restriction" refers to water restriction when used in conjunction with this trial.

RESULTS

Weekly water consumption per bird for all levels of restriction is shown in Table II (p. 38). *Ad libitum* water consumption for all groups during the first week is also shown. Starting the second week, each restricted tratment received a progressively lower level of water restriction than the next. Since the controls drank increasing amounts of water each succeeding week, the same was found to be true in the restricted groups throughout the trial. Water consumption doubled in the controls the second week after which the percentage increases were relatively smaller for each succeeding week. The water consumption of control chicks corresponded to the weekly water consumption data reported by Patrick and Ferrise (80, p. 1365). The data agree so closely, in fact, that weighing procedures or rounding-off the data alone may have resulted in the small differences found between the two trials. This is in addition to considering all of the many other variables that influence water consumption. Arscott and Rose (2, p. 94) reported that the water consumption through eight weeks for chicks raised on a corn base diet was 10.80 pounds. Controls in this study consumed 10.61 pounds of water through eight weeks of age on a corn base diet which is in accord with Arscott's findings.

Examination of Table III (p. 38) confirms that the actual water

Table II. Effect of Water Restriction on Weekly Water Consumption Per Bird[1,2]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1[3]	.31	.34	.30	.31	.33	.32
2	.61	.55	.50	.43	.39	.31
3	.95	.86	.75	.65	.56	.48
4	1.30	1.13	1.01	.89	.77	.64
5	1.53	1.32	1.17	1.02	.87	.78
6	1.72	1.53	1.36	1.19	1.01	.85
7	1.99	1.78	1.55	1.35	1.17	.98
8	2.20	1.95	1.73	1.51	1.29	1.08
Total	10.61	9.46	8.37	7.35	6.39	5.44

[1] Water consumption computed from Appendix Table I (p. 67).

[2] Bird-day basis to correct for mortality.

[3] Water *ad libitum* for all treatments for first week.

Table III. Water Consumption of Restricted Groups Relative to the Controls

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
	%	%	%	%	%	%
8 weeks	100.00	89.16	78.89	69.27	60.23	51.29

restriction closely adhered to the planned water restriction.

The most serious question concerning the procedure used in restricting water in this trial was whether some individual chicks would learn to drink fast enough when their allotted daily water was given even though there was adequate space for all chicks. Since all the water was consumed within a few minutes in each restricted group, this would have resulted in serious shortages to a few. While this may have happened, it was probably not a serious problem in this trial or mortality would have been higher (Table IX, p. 47). The alternative to the method used in restricting water in this trial would have been to restrict water to individual chicks. However, the amount of water consumed on an individual basis in young chicks would be very small and would have made such an experiment extremely difficult, if not impractical.

In general, weekly feed consumption after the first week decreased with each increment of water restriction as shown in Table IV (p. 40). The weekly feed consumption of the controls in this trial agree closely to those reported by Patrick and Ferrise (90, p. 1366). All groups increased feed consumption throughout the trial. This was not anticipated, for at the beginning of the trial it was thought that with the restricted levels employed, particularly in the 40 and 50% groups, chicks would eventually reach a stage of lower and lower feed consumption and then die. The water restriction

Table IV. Effect of Water Restriction on Weekly Feed Consumption Per Bird[1,2]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1[3]	.22	.19	.19	.19	.22	.20
2	.44	.37*	.37*	.33*	.37*	.31**
3	.63	.62	.59	.50	.58	.49
4	.80	.79	.82	.72	.68*	.64*
5	1.10	.98*	.92**	.89**	.80**	.88**
6	1.33	1.17**	1.09**	1.04**	.97**	.95**
7	1.52	1.40**	1.33**	1.23**	1.16**	1.07**
8	1.71	1.47**	1.42**	1.35**	1.26**	1.15**
Total	7.75	6.99**	6.73**	6.25**	6.04**	5.69**

[1] Feed consumption computed from Appendix Table II (p. 69).

[2] Bird-day basis to correct for mortality.

[3] Water *ad libitum* for all treatments for first week.

regimens used apparently were not severe enough to cause this state. It would have been interesting to have continued this trial to find if this would have happened. It was surprising to find that chicks, even at the lower restriction levels, fared as well as they did. During the last four weeks feed consumption of the restricted groups was significantly lower at the 1% level from the control group, except in one instance in the fifth week where significance at the 5% level for the 10% restricted group was obtained. The total feed consumption through eight weeks in all restricted treatments was significantly lower from the controls at the 1% level.

Weekly body weights appear in Table V (p. 42). Each increment of water restriction after the first week resulted in proportionally lower body weights; however each group gained weight every week. This is an important finding because it shows that with the levels of restriction employed in this trial, even 50% water restriction was not low enough to cause loss of weight. Weekly body weights of the restricted chicks were significantly different from the controls at the 1% level throughout the trial, except in one instance during the second week in which the 10% group was significant at the 5% level. Male and female body weights were recorded separately, and are shown in Appendix Table III (p. 71). As expected, a significant difference in body weight between males and females was found in all groups throughout the trial. Interactions due to replication, sex x replication, and sex x treatment were not evident. The latter interaction is particularly important since it indicates one sex was able to withstand water restriction just as well as the other.

Table V. Effect of Water Restriction on Average Weekly Body Weight Per Bird[1]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1[2]	.22	.22	.21	.21	.23	.22
2	.45	.40*	.38**	.35**	.36**	.32**
3	.77	.68**	.61**	.57**	.57**	.50**
4	1.14	1.01**	.94**	.86**	.82**	.74**
5	1.65	1.41**	1.31**	1.22**	1.14**	1.05**
6	2.16	1.88**	1.73**	1.62**	1.51**	1.38**
7	2.76	2.39**	2.19**	2.04**	1.91**	1.75**
8	3.31	2.91**	2.69**	2.52**	2.39**	2.11**

1 Average of combined weights for males and females as computed from Appendix Table III (p. 71).

2 Water <u>ad libitum</u> for all treatments for first week.

At eight weeks the control chicks averaged 3.31 lb. as compared to 2.11 lb. for the chicks that had water restricted 50%. The 50% restricted chicks weighed 64 percent as much as the control chicks at eight weeks of age rather than half as much. This would indicate that growth is not completely dependent on water consumption. Without feed, chicks will not grow normally. The relative importance of water or feed as influencing growth rate cannot be determined from this trial. It would have been necessary to restrict both feed and water to determine this. Two papers have been published on this subject. Conner (16, p. 1343) working with chicks concluded that growth is more dependent upon feed intake than water consumption while Jackson and Smith (44, p. 153) concluded the opposite with rats. Whether one or the other is more important upon rate of growth has not been clearly established.

Feed conversion, Table VI (p. 44), was computed on an accumulative basis rather than weekly due to the popularity of this method. Feed conversion increased with age. In general, a deleterious effect upon feed conversion resulted with each increment of water restriction. That water restriction did not result in as poor feed conversions as one might have expected is indicated by the general lack of significance between ratios throughout the trial except possibly for the higher restrictions with increased age. The feed conversion of the controls was 2.34 through eight weeks of age as compared to the slightly higher value of 2.40 found in the 10% group. It should be remembered that feed conversion is only a relative ratio. Since both body weight and feed consumption was reduced in the 10% group, it is understandable that only a slight rise in the ratio was noted. The feed conversion ratio of the 50% group was 2.70 through eight weeks of age.

Table VI. Effect of Water Restriction on Accumulative Weekly Feed Conversion[1]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
1[2]	1.00	.86	.90	.90	.96	.91
2	1.47	1.40	1.47	1.49	1.64	1.59
3	1.68	1.74	1.89	1.79	2.05*	2.00
4	1.83	1.95	2.10	2.02	2.26*	2.22
5	1.93	2.09	2.21	2.16	2.32*	2.40*
6	2.09	2.19	2.30	2.27	2.40*	2.51**
7	2.19	2.31	2.42*	2.40*	2.50**	2.59**
8	2.34	2.40	2.50*	2.48	2.53*	2.70**

[1] Feed conversion = lb. feed consumed ÷ lb. live chicken.

[2] Water *ad libitum* of all treatments for first week.

The water:feed ratio was reduced almost in every instance with each increment of water restriction commencing with the second week as shown in Table VII (p. 45). In addition, the ratio was also generally reduced within each treatment with increasing age. Glista and Scott (28, p. 748) observed higher water:feed ratios with increasing levels of water consumption due to higher increments of dietary soybean oil meal. This is in accord with the results in this study showing increased water:feed ratios concurrent with increasing water consumption. Four-week-old female chicks were observed by Kare and Biely (54, p. 754) to have an average water:feed ratio of 1.85, while control chicks of comparable age in this study had an average water:feed ratio of 1.52.

Table VII. Effect of Water Restriction on Weekly Water:Feed Ratios[1]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
1[2]	1.44	1.76	1.58	1.65	1.54	1.62
2	1.40	1.51	1.35	1.30	1.06	1.01
3	1.51	1.40	1.28	1.30	1.00	.99
4	1.62	1.44	1.24	1.24	1.13	.99
5	1.40	1.36	1.28	1.16	1.08	.89
6	1.29	1.31	1.25	1.14	1.04	.90
7	1.31	1.27	1.17	1.10	1.02	.92
8	1.29	1.33	1.23	1.13	1.03	.95
Average	1.37	1.35	1.24	1.18	1.06	.96

[1] Water:feed ratio = lb. water consumed ÷ lb. feed consumed.

[2] Water *ad libitum* for all treatments for first week.

The data in Table VIII (p. 46) show that as chicks mature, they drink less water per pound of body weight with higher increments of water restriction. In addition, they drink less water per pound of body weight with increased age. This observation is in accord with results reported by Medway and Kare (74, p. 634) and Joiner and Huston (48, p. 997).

Table VIII. Effect of Water Restriction on Weekly Water Consumption Per Pound of Body Weight[1]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)
1[2]	1.41	1.55	1.43	1.48	1.43	1.45
2	1.36	1.38	1.32	1.23	1.08	.97
3	1.23	1.26	1.23	1.14	.98	.96
4	1.14	1.12	1.07	1.03	.94	.86
5	.93	.94	.89	.84	.76	.74
6	.80	.81	.79	.73	.67	.62
7	.72	.74	.71	.66	.61	.56
8	.66	.67	.64	.60	.54	.51

[1] Water consumption per pound of body weight = lb. water consumed ÷ lb. live chicken.

[2] Water *ad libitum* for all treatments for first week.

Mortality results are shown in Table IX (p. 47). Significant increase in mortality was not observed for any level of water restriction . Diagnosis of the chicks that died did not indicate that any specific disease condition resulted from water restriction. If water is withheld long enough, mortality obviously will occur in chicks. Conner (16, p. 1341) obtained high mortality in chicks deprived of all drinking water for 13 days. Significant mortality due to restricting water to time periods throughout the day has not been observed except by Kare and Biely (54, p. 754). The cause of mortality in their experiment, however, was due to high levels of salt in both the water and in the feed and not to water restriction per se. Maxwell and Lyle (71, p. 922) observed no increased mortality by restricting water intake to three daily 15 minute periods in layers.

Table IX. Record of Mortality

Treatment	Lot	Mortality[1]	Sex	Diagnosis	Survivors Remaining at End of Eight Weeks[1]
Control	1	none			26
	2	none			26
10% Restricted	1	one - Third Week, Sixth Day	Female	Tumor	25
	2	none			26
20% Restricted	1	none			26
	2	none			26
30% Restricted	1	none			26
	2	one - Fourth Week, First Day	Male	Undetermined	25
40% Restricted	1	none			26
	2	none			26
50% Restricted	1	one - Fifth Week, Sixth Day	Female	Tumor	25
	2	one - Fourth Week, Second Day	Male	Heart Failure	25

[1]Mortality due to treatment not significant at 5% level.

Percent toe moisture content, Table X (p. 48), was not significantly affected by water restriction at any level. The range was from 60.03 percent in the 40% group to 61.23 percent in the 20% group.

Table X. Effect of Water Restriction on the Moisture Content of the Outer Toe of the Right Foot[1,2]

Age in Weeks	Level of Water Restriction (%)					
	0	10	20	30	40	50
	(%)	(%)	(%)	(%)	(%)	(%)
8[3]	60.34	60.64	61.23	60.78	60.03	60.08

[1] Average of combined male and female toe moisture content as taken from Appendix Table VI (p.

[2] Percent toe moisture determined by A.O.A.C. method (41 , p. 161).

An observation of interest was that restricted birds in this trial positioned themselves away from the infra-red lamps during the day. This demonstrates an attempt by the chick to decrease dehydration of the body by avoiding sources of heat. Upon completion of the trial, the restricted chicks were given free access to water. They consumed up to three times the amount of water consumed daily by the controls for a period of 5 days, at which time the chicks were marketed. As previously mentioned, Hoffman and Johnson (39, p. 65) stated that it was easy to tell chicks that have been without water because in their eagerness to get a drink, they get their plumage wet and have a bedraggled appearance for some time afterward. Observations from the trial herein reported confirm this statement.

Blocks of tissue from the liver, kidney, spleen, sartorius (leg) muscle and heart muscle were prepared and sectioned for microscopic examination from one female and one male in the control and in the 50% restricted group. These sections were examined by Dr. E. M. Dickinson, head of the Department of Veterinary Medicine, at Oregon State University. Edema and degeneration of the cells lining the tubules was a noticeable tissue change in kidneys of both the male and female of the 50% restricted group. No such changes were noted in the two control chicks. Significant changes were not observed in the other tissues.

The temperature and humidity readings are given in Appendix Tables IV and V (p. 72 and p. 74). No relationship could be observed between these readings and the occasional variation in results for which no apparent explanation exists.

DISCUSSION

The effect of water restriction has been shown by Crampton and Lloyd (17, p. 222), Phillips (81, p. 234) and others to depress growth in several different animals. Depressed growth due to water restriction have been brought about by depriving water altogether, restricting the amount of intake and restricting water access periodically throughout the day. Most of the trials dealing with water restriction in chicks have been done either by depriving water completely or by restricting the amount of time in which chicks are given free access to water. To the author's knowledge, water previously has not been restricted to chicks in the same way as reported in this trial. Therefore, the results found in other trials dealing with water restriction in chicks by one means or another are not quite applicable to the results found here. However, within limitations, certain comparisons can be made.

Conner (16, p. 1342) restricted the water consumption of four-week-old male chicks to 25 and 50 percent of the amount of water consumed by the controls. While his trial lasted only one week, it is probably more comparable to this trial than any other reported with chicks. The chicks restricted to 25 percent water intake actually weighed less after one week than they did at the beginning of the trial. Some growth resulted in the 50 percent water restricted chicks, but not nearly as much as in the controls. In the trial reported herein, depressed growth resulted with each increment of water restriction which is in agreement with Conner's work. It is interesting that Conner did not believe that chicks would be able to withstand water restriction for a long time with the levels that he employed. His statement was made on the basis of the depressed growth rate observed and changes in endocrine gland size. The results in this experiment indicate that chicks are able to withstand water restriction for longer periods of time than Conner may have thought possible.

The average water consumption in White Leghorn, New Hampshire and White Plymouth Rock chicks was higher at an environmental temperature of 90°F than at variable temperatures as reported by Joiner and Huston (48, p. 975). However, body weight was depressed at 90° F. Results in this paper show that as chicks received more water, body weight increased. The discrepency in results between this report and that of Joiner and Huston is undoubtedly due to the higher environmental temperature prevailing in the experiments of the latter.

It was found by Glista and Scott (28, p. 748) that increasing the level of soybean oil meal in the diet increased water and feed consumption. Yet depressed growth resulted. On the other hand, the study here showed that as water and feed consumption increased body weight increased. Actually, Glista and Scott expected increased, not decreased, body weight with increasing water and feed consumption. They believed that their results were due to the lower biological value of the protein mixture and additional water requirement required for the metabolism of this protein.

Practically all of the trials reported in the review of literature indicated depressed feed intake resulting from water restriction. Results of this trial bear this out. With each increment of water restriction, feed consumption was correspondingly reduced. When Ross (87, p. 1000-1001) restricted the water consumption of chicks to three periods a day, 1/2 hour each, he found the restricted chicks drank slightly more water than the controls which received water _ad libitum_ to six weeks of age. However, feed consumption of the restricted chicks was only 88.9 percent of that of the control chicks. The resultant growth index was 93 in the restricted group as compared with 100 in the controls. This effect on growth was due to the lower feed consumption caused by restricting water intake. The same has been concluded in this trial. Ross's work is substantiated by Lepkovsky _et al_ (65, p. 327) who found that withholding water during meals decreased food intake in rats.

Water restriction had a deleterious effect upon feed conversion in this study. Ross (87, p. 1001) reported that restricting water consumption in chicks to three periods a day, 1/2 hour each, had little effect upon feed conversion. Ross suggested this was due to the fact that feed consumption and body weight indices were approximately the same in water restricted groups resulting in feed conversion ratios approximating those found in the controls. The 30% restricted group in this trial was found to have a slightly, though consistently, better feed conversion than the 20% restricted group, and is probably due to the same reason noted by Ross. A study by Maxwell and Lyle (71, p. 922) is unusual in that they obtained a slight improvement in feed conversion when pullets were restricted to water access three times daily, for 15 minutes at a time, as compared to controls receiving water ad libitum. These results seemed to indicate that layers were drinking water in excess of their needs.

Bi-weekly water consumption in chicks to ten weeks of age was reported by Dawson and Siegel (19). The data agree closely with that observed in this trial, but not quite as closely as do those of Patrick and Ferrise (80, p. 1365).

It could be argued that the data on water consumption in this trial are not quantitative since some water was probably lost. For example, some water was lost by the chick tilting its head back in order to swallow. Small amounts of water also may have been lost by evaporation, even though this water was measured and compensated for by allowing the water of evaporation to be consumed by restricted groups in the early stages when they did not drink their water so quickly. After the first few days evaporation was not compensated for because the restricted groups drank so fast that evaporation of water was of little or no consequence. In addition, water was probably occasionally lost by chicks stepping into waterers. Certain unintentional actions by the operator also could have accounted for some water wastage. Although the exact amount of water lost through the possibilities suggested above is not known, these errors are probably small when compared with the total amount of water consumed. In any event, these losses would probably be similar in any trial of this nature.

The eight week average water:feed ratio was 1.37 in the controls as compared to 1.39 obtained by Patrick and Ferrise (80, p. 1366) in nine-week-old chicks. A comparison of the relative increase or decrease in water:feed ratio with age in the control group in this study and in those of Patrick and Ferrise is as follows:

	First Week	Second Week	Third Week	Fourth Week	Fifth Week
(Present trial)	+	-	+	+	-
(Patrick and Ferrise)	+	-	+	+	-

It is not known if this is a typical pattern, or what the reason would be if it were. Although this same pattern appeared in all six treatment groups in the work by Patrick and Ferrise, it was not mentioned or pointed out by them. This pattern may or may not have some significance. Barott and Pringle (5, p. 67) found that chicks drank approximately 1.6 g of water for each gram of feed consumed on the ninth day after hatching, and in another trial (6, p.161) they found that chicks on the 18th day drank approximately 1.55 g of water per gram of feed. Barott and Pringle (7, p. 28) then extended this work to cover birds from 18 to 32 days of age and found that the water:feed ratio was 1.75. These results fit the above pattern.

Restricting water at the 10% level and higher was found to be deleterious to growth, feed consumption, water:feed ratio, and feed conversion. Therefore, it can be concluded from these results that the optimum consumption of the broiler chick to eight weeks of age is greater than the amount of water consumed following 10% restriction and probably approaches or equals that consumed by the control bird. Accordingly, for all practical purposes the optimum amount consumed approximates the 10.61 lb. per chick obtained by the control chick to eight weeks of age under the conditions of this trial.

SUMMARY AND CONCLUSIONS

From studies involving 312 broiler chicks from one to eight weeks of age in which water was restricted to 10, 20, 30, 40, and 50% of the amount consumed by controls provided with water _ad libitum_, the following conclusions were made:

1. Feed consumption decreased with each increment of water restriction.
2. Increased feed consumption resulted each successive week for the duration of the trial regardless of the amount of restriction.
3. Body weights decreased progressively with each increment of water restriction.
4. All groups gained weight each week throughout the trial.
5. Feed conversion increased with age, and, in general, a deleterious effect upon feed conversion resulted with each increment of water restriction.
6. Water:feed ratios were reduced with more severe water restriction and with increasing age.
7. As chicks matured, they drank proportionally less water per pound of body weight and with higher levels of water restriction.
8. Mortality was not significantly affected by water restriction at any level.
9. Percent toe moisture was not significantly affected by water restriction at any level.
10. Edema and degeneration of the cells lining the tubules of kidneys were the only noticeable tissue changes of both the male and female of the 50% restricted group.

11. For all practical purposes the optimum amount of water consumed approximates the 10.61 lb. per chick by the growing chick to eight weeks of age obtained by the control chick to eight weeks of age under the conditions of this trial.

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APPENDIX

Appendix Table I. Daily Water Consumption for all Treatments on a Per Lot Basis (13 males and 13 females)

Age		Level of Water Restriction (%)											
		0		10		20		30		40		50	
Weeks	Days	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
		(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)
	1	.6	.8	.6	.9	.7	.6	.7	.8	.8	.8	.7	.6
	2	.7	.8	.7	1.0	.8	.8	.8	.7	.8	.8	.7	.9
	3	1.0	1.2	1.1	1.3	1.0	1.1	1.1	1.2	1.3	1.2	1.2	1.2
	4	1.2	1.1	1.0	1.4	1.1	1.2	1.2	1.0	1.3	1.2	1.2	1.1
	5	1.2	1.4	1.5	1.5	1.1	1.3	1.4	1.3	1.4	1.4	1.4	1.4
	6	1.4	1.6	1.5	1.6	1.3	1.5	1.3	1.4	1.6	1.4	1.4	1.5
	7	1.4	1.6	1.6	1.7	1.3	1.7	1.5	1.4	1.7	1.5	1.5	1.5
1	Total	7.5	8.5	8.0	9.4	7.3	8.2	8.0	7.8	8.9	8.3	8.1	8.2
	8	1.6	1.7	1.6	1.5	1.3	1.7	1.7	1.7	1.4	1.3	.8	1.5
	9	1.8	1.7	1.8	1.7	1.5	1.9	1.3	1.7	1.6	1.5	1.1	.9
	10	2.0	2.1	1.8	2.0	1.5	1.5	1.4	1.4	1.3	1.4	1.0	1.1
	11	2.2	2.1	2.3	2.2	2.5	1.3	2.1	1.5	1.3	1.3	1.0	1.0
	12	2.6	2.3	1.8	1.8	1.8	2.0	1.8	.9	1.2	1.1	.7	1.3
	13	2.6	2.6	2.3	2.4	2.3	2.1	1.5	1.9	1.4	1.7	1.1	1.3
	14	3.2	2.9	2.6	2.8	2.5	2.1	2.2	1.4	1.9	1.8	1.6	1.6
2	Total	16.0	15.4	14.2	14.4	13.4	12.6	12.0	10.5	10.1	10.1	7.3	8.7
	15	3.0	2.8	2.8	2.7	1.8	2.5	2.3	1.6	1.8	1.7	1.6	1.2
	16	3.4	3.4	2.7	2.9	2.6	2.4	2.1	2.3	1.7	2.1	1.2	1.8
	17	3.0	2.9	2.8	2.9	2.0	2.9	2.6	2.4	1.9	1.7	1.5	1.1
	18	3.9	3.8	3.5	3.3	3.2	2.8	2.4	1.8	1.9	2.2	2.1	2.3
	19	4.0	3.8	3.1	3.2	2.9	3.2	2.7	2.0	2.4	2.3	2.3	2.0
	20	3.8	3.7	3.3[1]	3.8	3.0	3.2	2.7	2.6	2.3	2.3	1.5	2.0
	21	4.2	3.9	4.0	3.5	3.5	3.0	2.8	3.5	2.3	2.3	2.1	2.0
3	Total	25.3	24.3	22.2	22.3	19.0	20.0	17.6	16.2	14.3	14.6	12.3	12.4
	22	3.9	4.0	3.7	3.3	3.4	3.0	2.8	2.7[1]	2.7	2.5	2.5	2.0
	23	4.7	4.7	3.5	3.8	3.0	3.2	3.0	2.5	2.3	2.4	2.0	2.3[1]
	24	5.0	4.7	4.2	4.4	3.9	4.1	3.2	3.5	3.1	2.8	2.3	2.1
	25	5.1	4.9	3.8	4.4	3.9	3.8	3.4	2.9	2.9	2.9	2.2	2.5
	26	5.1	4.9	4.4	4.3	3.8	4.0	3.5	3.8	2.7	2.9	2.6	2.5
	27	5.1	4.5	4.3	4.6	4.0	4.0	3.5	3.5	3.1	3.2	2.4	2.3
	28	5.3	5.2	4.3	4.3	4.0	4.1	3.5	3.3	3.1	3.0	2.4	2.4
4	Total	34.2	32.9	28.2	29.1	26.0	26.2	22.9	22.2	19.9	19.7	16.4	16.1

Table I (continued)

Age		Level of Water Restriction (%) 0		10		20		30		40		50	
Weeks	Days	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
		(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)
	29	5.0	5.1	4.2	4.5	3.8	3.3	4.0	2.5	2.0	2.2	2.1	2.3
	30	5.7	5.6	4.8	4.7	3.4	4.3	2.4	3.3	2.8	3.8	2.6	2.6
	31	5.3	5.2	4.9	4.8	5.6	4.2	5.1	3.9	4.3	2.7	3.4	4.0
	32	6.2	6.0	4.5	4.5	4.1	4.2	3.6	3.3	3.3	3.1	2.7	2.6
	33	5.8	5.7	5.3	5.2	4.9	4.9	4.2	4.0	3.5	3.3	3.1	2.9
	34	5.5	5.6	5.0	5.2	4.6	4.6	4.1	4.0	3.5	3.5	2.9[1]	2.8
	35	6.4	6.4	4.8	5.0	4.5	4.5	3.9	3.8	3.4	3.4	2.7	2.7
5	Total	39.9	39.6	33.5	33.9	30.9	30.0	27.3	24.8	22.8	22.0	19.5	19.9
	36	6.2	6.2	5.5	5.8	5.1	5.1	4.5	4.3	3.8	3.5	3.1	3.1
	37	5.6	5.7	5.4	5.6	5.0	5.0	4.3	4.2	3.7	3.7	3.0	3.0
	38	7.4	7.5	4.9	5.1	4.6	4.6	4.0	3.8	3.4	3.4	2.7	2.7
	39	6.4	6.4	6.5	6.8	6.0	6.0	5.3	5.0	4.5	4.5	3.6	3.6
	40	6.0	6.3	5.5	5.8	5.1	5.1	4.5	4.3	3.8	3.8	3.1	3.1
	41	5.7	5.6	5.4	5.6	5.0	5.0	4.3	4.2	3.7	3.7	3.0	3.0
	42	7.1	6.9	4.9	5.1	4.6	4.6	4.0	3.8	3.4	3.4	2.7	2.7
6	Total	44.4	44.6	38.1	39.8	35.4	35.4	30.9	29.6	26.3	26.0	21.2	21.2
	43	6.9	6.9	6.1	6.3	5.6	5.6	4.9	4.7	4.2	4.2	3.4	3.4
	44	7.1	8.4	6.0	6.2	5.5	5.5	4.8	4.6	4.1	4.1	3.3	3.3
	45	7.4	7.4	6.8	8.0	6.2	6.2	5.5	5.3	4.7	4.7	3.8	3.8
	46	6.5	6.6	6.4	6.7	5.9	5.9	5.2	5.0	4.4	4.4	3.6	3.6
	47	8.4	8.4	5.7	5.9	5.3	5.3	4.6	4.4	4.0	4.0	3.2	3.2
	48	6.5	6.4	7.3	7.6	6.7	6.7	4.9	5.7	5.0	5.0	4.0	4.0
	49	7.8	7.9	5.6	5.9	5.2	5.2	4.6	4.4	3.9	3.9	3.1	3.1
7	Total	50.6	52.0	43.9	46.6	40.4	40.4	34.5	34.1	30.3	30.3	24.4	24.4
	50	8.1	8.6	6.8	7.1	6.3	6.3	5.5	5.3	4.7	4.7	3.8	3.8
	51	7.7	7.5	7.3	7.8	6.7	6.7	5.9	5.7	5.0	5.0	4.0	4.0
	52	8.1	7.6	6.6	6.8	6.1	6.1	5.3	5.1	4.6	4.6	3.7	3.7
	53	8.6	9.2	6.8	7.1	6.3	6.3	5.5	5.3	4.7	4.7	3.8	3.8
	54	7.2	7.4	7.7	8.0	7.1	7.1	6.2	6.0	5.3	5.3	4.3	4.3
	55	8.3	8.1	6.3	6.6	5.8	5.8	5.1	4.9	4.4	4.4	3.5	3.5
	56	8.9	8.8	7.1	7.4	6.6	6.6	5.7	5.5	4.9	4.9	3.9	3.9
8	Total	56.9	57.2	48.6	50.8	44.9	44.9	39.2	37.8	33.6	33.6	27.0	27.0

[1] Loss of one bird due to mortality as noted in Table IX (p. 47).

Table II. Daily Feed Consumption for all Treatments on a per Lot Basis (13 males and 13 females per lot)

Age		Level of Water Restriction (%)											
		0		10		20		30		40		50	
Weeks	Days	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
		(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)
	1	.3	.4	.3	.3	.3	.2	.3	.4	.4	.3	.3	.4
	2	.5	.5	.3	.7	.4	.4	.5	.4	.4	.6	.5	.3
	3	.8	.7	.6	.7	.8	.7	.7	.8	.8	.7	.7	.7
	4	.7	.8	.7	.6	.7	.8	.6	.6	.7	.9	.7	.7
	5	.8	1.0	.8	1.0	.8	.7	.8	.7	1.0	1.0	1.0	.9
	6	1.2	1.1	.9	1.0	.9	1.0	.9	.9	1.1	1.1	1.0	1.0
	7	1.1	1.1	1.0	1.0	1.1	1.1	1.0	1.1	1.0	1.0	1.1	1.0
1	Total	5.4	5.6	4.6	5.3	5.0	4.9	4.8	4.9	5.4	5.6	5.3	5.0
	8	1.3	1.3	1.2	1.2	1.2	1.3	1.2	1.4	1.1	1.4	1.3	1.0
	9	1.5	1.3	1.1	1.1	1.0	1.2	1.0	1.3	1.2	1.2	.8	.8
	10	1.7	1.5	1.3	1.2	1.3	1.0	1.1	1.2	1.4	1.5	1.2	1.0
	11	1.9	1.5	1.5	1.3	1.5	1.2	1.4	1.1	1.2	1.3	1.4	1.0
	12	2.0	1.5	1.2	1.4	1.6	1.6	1.2	1.0	1.3	1.4	1.0	1.1
	13	1.9	1.6	1.5	1.5	1.6	1.5	1.2	1.2	1.3	1.5	1.2	1.1
	14	1.8	1.8	1.7	1.7	1.6	1.5	1.5	1.5	1.6	1.9	1.4	1.5
2	Total	12.1	10.5	9.5	9.4	9.8	9.3	8.6	8.7	9.1	10.2	8.3	7.5
	15	2.1	2.0	1.9	2.1	1.9	1.8	1.7	1.4	1.8	1.9	1.8	1.5
	16	2.3	2.2	1.9	2.1	2.1	1.8	2.1	1.8	1.7	2.8	1.4	1.6
	17	2.1	2.0	1.9	1.9	1.6	1.7	1.8	1.6	1.5	2.0	1.4	1.3
	18	2.7	2.3	2.4	2.3	2.5	2.0	1.9	1.8	1.7	2.6	2.3	1.9
	19	2.7	2.5	2.6	2.4	2.5	2.4	2.2	1.9	1.9	2.9	2.2	1.8
	20	2.6	2.4	2.3[1]	2.6	2.6	2.2	2.0	1.6	1.8	2.9	2.2	1.7
	21	2.5	2.5	2.7	2.7	3.2	2.5	2.1	2.2	1.8	2.5	2.1	1.9
3	Total	17.0	15.9	15.7	16.1	16.4	14.4	13.8	12.3	12.2	17.6	13.4	11.7
	22	3.0	3.0	2.8	2.7	3.2	2.6	2.5	2.2[1]	2.3	2.6	2.4	2.1
	23	2.6	2.9	2.3	2.7	2.7	2.7	2.6	2.3	2.1	2.8	2.2	2.1[1]
	24	2.8	2.7	2.7	2.7	3.3	3.0	2.7	2.7	2.2	2.3	2.3	2.2
	25	2.9	3.2	2.7	3.0	3.3	3.0	2.9	2.4	2.5	2.9	2.2	2.4
	26	3.0	3.2	2.7	3.0	3.2	3.1	2.6	2.5	2.2	2.7	2.4	2.1
	27	2.9	3.0	3.2	3.3	3.3	3.0	2.7	2.7	2.6	2.7	2.7	2.4
	28	3.2	3.4	3.0	3.1	3.2	3.0	2.9	2.6	2.6	2.9	2.4	2.7
4	Total	20.4	21.4	19.4	20.5	22.2	20.4	18.9	17.4	16.5	18.9	16.6	16.0

Table II (continued)

Age		Level of Water Restriction (%)											
		0		10		20		30		40		50	
Weeks	Days	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2	Lot 1	Lot 2
		(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)
	29	3.8	4.1	3.3	3.6	3.1	3.0	3.3	2.9	2.4	2.9	3.0	2.6
	30	4.0	4.2	3.7	3.4	3.6	3.4	2.9	3.5	2.8	3.5	3.2	3.7
	31	3.7	3.9	3.5	3.4	3.4	3.2	3.2	3.0	3.1	2.8	3.1	3.3
	32	4.4	4.4	3.6	3.6	3.7	3.5	3.3	3.4	3.1	3.5	3.7	3.5
	33	4.1	4.1	3.5	3.3	3.4	3.3	3.2	3.5	2.8	2.6	3.5	2.9
	34	3.9	4.0	3.6	3.7	3.6	3.3	3.2	3.1	2.9	3.1	2.8[1]	3.2
	35	4.2	4.2	3.8	3.8	3.6	3.5	3.2	3.4	3.0	3.1	3.1	2.9
5	Total	28.1	28.9	25.0	24.8	24.4	23.2	22.3	22.8	20.1	21.5	22.4	22.1
	36	5.1	5.1	3.9	4.3	4.1	3.9	3.9	3.8	3.3	3.5	3.6	3.3
	37	4.0	4.3	3.8	3.9	3.7	3.4	3.3	3.3	3.3	3.3	3.3	3.2
	38	5.6	5.5	4.6	4.7	4.5	4.3	4.0	4.2	3.7	3.9	3.4	3.9
	39	5.3	5.2	4.4	4.7	4.4	4.4	4.2	3.9	3.9	3.9	3.8	3.5
	40	4.9	5.1	4.3	4.4	4.1	3.9	3.8	3.9	3.6	3.7	3.5	3.2
	41	4.3	4.4	4.1	3.9	3.9	4.0	3.6	3.5	3.3	3.4	3.0	3.1
	42	5.4	4.9	4.1	4.2	4.0	4.1	3.7	4.0	3.7	3.8	3.2	3.3
6	Total	34.6	34.5	29.2	30.1	28.7	28.0	26.5	26.6	24.8	25.5	23.8	23.5
	43	5.8	5.5	5.2	5.3	5.1	4.9	4.5	4.4	4.5	4.3	3.8	3.8
	44	5.4	6.6	4.8	5.0	4.7	5.0	4.2	4.5	4.2	4.3	4.1	3.8
	45	5.9	5.6	5.2	5.6	5.0	5.2	4.5	4.6	4.5	4.3	3.8	3.8
	46	5.0	5.1	4.8	4.8	4.5	4.9	4.1	4.3	4.2	4.0	3.4	3.4
	47	6.6	6.8	5.3	5.5	5.3	5.0	4.7	4.7	4.5	4.5	4.3	4.1
	48	5.2	5.0	4.8	5.1	5.1	4.8	4.4	4.4	4.1	4.1	3.9	4.1
	49	5.6	5.0	5.0	5.1	4.7	4.7	4.6	4.6	4.3	4.2	3.5	3.5
7	Total	39.5	39.6	35.1	36.4	34.4	34.5	31.0	31.5	30.3	29.7	26.9	26.5
	50	7.0	7.5	5.4	5.4	5.0	5.4	5.0	5.1	4.9	4.7	4.3	4.2
	51	6.1	5.5	5.4	5.2	5.3	5.3	4.8	4.8	4.7	4.5	4.0	4.0
	52	5.9	5.1	5.1	5.2	4.9	5.1	4.9	4.6	4.7	4.4	4.0	3.7
	53	6.9	6.9	5.0	5.3	5.4	5.2	4.7	4.6	4.6	4.5	4.1	4.0
	54	5.9	6.3	5.5	5.6	5.6	5.5	5.3	4.8	4.8	4.7	4.1	4.1
	55	6.5	6.3	5.5	5.5	5.4	5.5	4.9	5.3	5.0	4.9	4.3	4.3
	56	6.7	6.3	5.1	5.5	5.0	5.0	4.9	4.8	4.7	4.5	4.2	3.9
8	Total	45.0	43.9	37.0	37.7	36.6	37.0	34.5	34.0	33.4	32.2	29.0	28.2

[1] Loss of one bird due to mortality as noted in Table IX (p. 47).

Appendix Table III. Weekly Body Weights on a Per Lot Basis Recorded by Sex

	Control Weight Per Male	Control Weight Per Female	10% Restricted Weight Per Male	10% Restricted Weight Per Female	20% Restricted Weight Per Male	20% Restricted Weight Per Female	30% Restricted Weight Per Male	30% Restricted Weight Per Female	40% Restricted Weight Per Male	40% Restricted Weight Per Female	50% Restricted Weight Per Male	50% Restricted Weight Per Female
	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)
First Week												
Lot 1	.23	.20	.23	.20	.20	.22	.22	.21	.24	.22	.24	.21
Lot 2	.24	.20	.23	.22	.21	.22	.19	.22	.24	.21	.24	.20
Second Week												
Lot 1	.46	.41	.41	.35	.35	.38	.38	.35	.38	.34	.34	.29
Lot 2	.49	.42	.42	.41	.39	.38	.32	.35	.39	.32	.35	.29
Third Week												
Lot 1	.81	.72	.71	.62	.62	.62	.61	.55	.59	.52	.55	.46
Lot 2	.83	.70	.72	.66	.63	.58	.55	.56	.64	.52	.53	.45
Fourth Week												
Lot 1	1.17	1.07	1.05	.93	.96	.93	.92	.82	.86	.79	.79	.68
Lot 2	1.25	1.05	1.09	.98	.99	.88	.85	.85	.89	.75	.80	.68
Fifth Week												
Lot 1	1.70	1.55	1.49	1.30	1.39	1.28	1.32	1.13	1.19	1.09	1.11	.99
Lot 2	1.82	1.54	1.52	1.34	1.38	1.20	1.23	1.18	1.24	1.02	1.13	.96
Sixth Week												
Lot 1	2.25	2.02	2.01	1.72	1.84	1.67	1.76	1.48	1.59	1.42	1.47	1.30
Lot 2	2.38	2.00	2.02	1.75	1.85	1.54	1.66	1.57	1.66	1.35	1.46	1.29
Seventh Week												
Lot 1	2.93	2.59	2.60	2.15	2.39	2.06	2.25	1.83	2.04	1.79	1.87	1.65
Lot 2	3.04	2.48	2.62	2.17	2.39	1.90	2.17	1.92	2.10	1.71	1.85	1.62
Eighth Week												
Lot 1	3.53	3.04	3.17	2.63	2.94	2.54	2.77	2.23	2.54	2.23	2.30	1.92
Lot 2	3.68	2.98	3.22	2.62	2.94	2.35	2.66	2.42	2.65	2.12	2.23	1.98

Appendix Table IV. Daily Temperature Readings in Degrees Centigrade

		Outside				Inside			
		Morning		Afternoon		Morning		Afternoon	
Weeks	Day	Hour	Temp.	Hour	Temp.	Hour	Temp.	Hour	Temp.
	1	9:00	6	3:30	11	9:00	14	3:30	21
	2	9:00	8	3:30	11	9:00	17	3:30	22
	3	8:40	9	3:45	10	8:40	18	3:45	21
	4	8:25	6	3:30	12	8:25	15	4:00	21
	5	8:30	3	3:30	11	8:30	13	3:30	22
	6	8:30	5	3:00	7	8:30	16	3:00	20
1	7	8:35	4	2:00	8	8:35	16	2:30	19
	8	8:55	6	3:30	9	8:55	16	4:15	20
	9	8:45	6	2:30	12	8:55	14	2:20	22
	10	8:40	6	3:00	9	8:45	16	3:00	20
	11	8:40	11	3:00	15	8:40	20	4:00	24
	12	8:35	10	3:00	19	8:35	20	4:30	24
	13	9:10	12	2:30	14	9:10	20	3:30	24
2	14	8:30	8	1:30	10	8:30	19	2:00	21
	15	8:30	10	3:00	9	8:30	20	3:00	18
	16	10:15	9	3:00	10	10:15	17	3:00	20
	17	8:40	9	2:00	14	8:40	19	3:00	21
	18	8:45	10	3:00	11	8:45	20	3:30	20
	19	8:20	8	4:00	11	8:20	18	4:30	21
	20	8:20	6	3:30	8	8:20	16	4:00	19
3	21	8:40	6	2:00	10	8:40	18	3:30	16
	22	8:30	8	2:30	10	8:30	18	3:00	18
	23	9:00	7	3:00	8	9:00	17	4:00	18
	24	8:50	4	3:30	8	8:50	17	4:30	18
	25	8:30	5	4:00	12	8:30	15	4:30	18
	26	8:40	10	4:00	13	8:40	18	4:30	18
	27	8:40	12	2:00	17	8:40	18	2:30	20
4	28	8:30	12	3:30	13	8:30	19	4:00	20
	29	8:05	10	2:30	14	8:05	16	4:30	20
	30	8:07	7	4:30	10	8:14	15	5:00	16
	31	8:40	9	2:30	11	8:40	15	3:00	17
	32	8:15	8	4:30	9	8:25	15	5:00	17
	33	8:25	7	4:00	10	8:25	16	4:30	20
	34	8:25	8	4:00	16	8:25	16	4:00	20
5	35	8:35	8	2:30	11	8:35	16	2:30	17
	36	8:15	11	4:30	17	8:15	16	5:00	22
	37	9:10	14	3:00	15	9:10	19	4:00	20
	38	8:20	3	5:30	6	8:20	12	6:00	14
	39	8:25	4	5:30	8	8:20	12	5:30	15
	40	8:10	6	4:30	8	8:25	12	5:00	16
	41	8:00	7	1:30	8	8:15	14	2:00	15
6	42	8:15	7	2:00	6	8:30	13	2:00	14

Appendix Table IV (continued)

		Outside				Inside			
		Morning		Afternoon		Morning		Afternoon	
Weeks	Day	Hour	Temp.	Hour	Temp.	Hour	Temp.	Hour	Temp.
	43	8:20	4	2:30	6	8:30	11	3:00	14
	44	8:00	4	4:00	11	8:00	11	4:30	18
	45	8:10	6	5:00	14	8:25	12	5:30	20
	46	8:05	10	2:30	14	8:25	15	3:00	21
	47	8:05	8	5:00	10	8:20	14	5:30	17
	48	8:45	8	2:00	14	8:25	15	2:30	20
7	49	8:15	9	3:00	14	8:25	16	3:00	19
	50	7:55	9	2:00	13	8:10	13	2:00	18
	51	8:30	10	2:30	13	8:15	12	3:30	24
	52	8:15	10	3:30	19	8:30	18	4:00	24
	53	8:20	8	3:30	10	8:20	16	4:00	19
	54	8:05	8	3:00	9	8:15	15	3:00	19
	55	8:20	8	2:00	10	8:30	15	2:30	20
8	56	8:05	7	3:00	17	8:15	13	5:00	22

Appendix Table V. Daily Wet and Dry Bulb Inside Temperature Readings in Degrees Fahrenheit with Relative Humidity Shown

		Morning				Afternoon			
Weeks	Days	Hour	Wet	Dry	R. H.	Hour	Wet	Dry	R. H.
	1	9:00	47	56	50	3:30	58	70	48
	2	9:00	51	69	24	3:30	57	69	47
	3	8:40	53	63	50	3:45	56	67	49
	4	8:25	51	60	53	4:00	60	74	43
	5	8:30	49	59	47	3:30	61	73	50
	6	8:30	53	63	50	3:00	57	69	47
1	7	8:35	52	61	54	2:30	57	68	50
	8	8:55	55	63	60	4:15	58	69	51
	9	8:55	54	60	68	2:20	62	72	57
	10	8:45	55	64	56	3:00	61	70	59
	11	8:40	59	70	51	4:00	65	77	52
	12	8:35	57	68	50	4:30	63	75	51
	13	9:10	59	69	55	3:30	62	75	47
2	14	8:30	61	68	67	2:00	60	70	55
	15	8:30	58	68	54	3:00	54	62	59
	16	10:15	54	63	55	3:00	62	69	67
	17	8:40	58	67	58	3:00	61	70	59
	18	8:45	59	69	55	3:30	60	67	66
	19	8:20	56	65	56	4:30	60	71	52
	20	8:20	53	61	58	4:00	57	66	57
3	21	8:40	55	65	52	3:30	54	61	63
	22	8:30	56	65	56	3:00	56	64	60
	23	9:00	58	64	70	4:00	58	65	66
	24	8:50	54	63	55	4:30	64	65	95
	25	8:30	53	60	63	4:30	64	66	90
	26	8:40	57	66	57	4:30	58	65	66
	27	8:40	58	64	70	2:30	63	69	72
4	28	8:30	59	66	66	4:00	61	68	67
	29	8:05	54	60	68	4:30	61	68	67
	30	8:14	56	60	78	5:00	58	62	79
	31	8:40	53	58	72	3:00	57	63	69
	32	8:25	55	59	78	5:00	56	62	69
	33	8:25	54	62	59	4:30	60	67	66
	34	8:25	54	60	68	4:00	60	70	55
5	35	8:35	53	59	67	2:30	55	61	68

Appendix Table V (Continued)

		Morning				Afternoon			
Weeks	Days	Hour	Wet	Dry	R. H.	Hour	Wet	Dry	R. H.
	36	8:15	56	60	78	5:00	65	73	65
	37	9:10	64	67	85	4:00	62	69	67
	38	8:20	51	54	82	6:00	52	58	66
	39	8:20	49	54	70	5:30	54	59	72
	40	8:25	51	56	71	5:00	55	60	73
	41	8:15	52	57	71	2:00	55	58	83
6	42	8:30	51	56	71	2:00	54	59	72
	43	8:30	53	58	72	3:00	53	57	77
	44	8:00	52	54	88	3:30	66	67	95
	45	8:25	51	56	71	5:30	62	68	71
	46	8:25	55	59	78	3:00	63	70	68
	47	8:20	54	58	77	5:30	58	63	74
	48	8:25	55	59	78	2:30	63	68	76
7	49	8:25	57	61	78	3:00	60	66	71
	50	8:10	53	57	77	2:00	60	65	75
	51	8:15	54	58	77	3:30	68	78	63
	52	8:30	59	64	74	4:00	65	75	58
	53	8:20	55	60	73	4:00	60	67	66
	54	8:15	54	59	72	3:00	62	69	67
	55	8:30	55	60	73	2:30	62	70	64
8	56	8:15	50	55	70	5:00	62	71	60

Appendix Table VI. The Effect of Water Restriction on the Moisture Content of the Outer Toe of the Right Foot[1]

Treatment[2]	Average Percent Moisture Per Male		Female
Control			
Lot 1	60.40		59.71
Lot 2	60.96		60.30
Average		60.34	
10% Restricted			
Lot 1	60.94		59.96
Lot 2	61.19		60.47
Average		60.64	
20% Restricted			
Lot 1	60.89		61.63
Lot 2	60.90		61.51
Average		61.23	
30% Restricted			
Lot 1	60.91		60.49
Lot 2	61.44		60.27
Average		60.78	
40% Restricted			
Lot 1	59.40		59.65
Lot 2	60.42		60.64
Average		60.03	
50% Restricted			
Lot 1	60.74		60.15
Lot 2	59.63		59.80
Average		60.08	

[1]Percent moisture determined by A. O. A. C. method (41, p. 161).

[2]No significant differences were found in toe moisture content due to treatments at the 5% level.