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Reproductive Efficiency of Broiler Breeder Females as Influenced by Post Peak Feed Allocation and Long Ahemeral Days

by

Adam Abboud Bruce Spies ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master of Science

In

Animal Science

Department of Agricultural, Food and Nutritional Science

Edmonton, Alberta

Spring 2000

0-612-60179-X

University of Alberta

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Degree: Master of Science

Year this Degree Granted: 2000

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Reproductive Efficiency of Broiler Breeder Females as Influenced by Post Peak Feed Allocation and Long Ahemeral Days** submitted by Adam Abboud Bruce Spies in partial fulfilment of the requirements for the degree of Master of Science in Animal Science.

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ABSTRACT

Two experiments were conducted to determine the effect of long ahemeral days and body weight on early egg production and morphological characteristics, and feed allocation after peak production in broiler breeder hens.

In the first trial, 64 pullets were separated into a 2 X 2 factorial with two day lengths (24 h and 28 h) and two body weight groups (high [HBW] and low body weight [LBW]) until 30 wk of age. The hemeral photoschedule was 14L:10D while the ahemeral photoschedule was 14L:14D. Egg numbers were not increased by the 28 h day (24 h=25.4 ± 1.4 eggs; 28 h=23.1 ± 1.4 eggs). Egg formation time was consistently longer for the 28 h hens as compared to the 24 h. Mean egg weight was higher for the 28 h birds (55.1 ± 0.3 g) compared to the 24 h birds (53.0 ± 0.3 g). The 28 h hens had higher proportional breast muscle weight, smaller livers and oviducts and lower ovary weight as compared to the 24 h birds. The data indicated that while egg size can be increased with the use of long ahemeral days early in lay, this may be at the expense of egg numbers.

In the second trial, 96 pullets were exposed to one of four post peak feeding allocation treatments. Twenty four hens each at peak egg production received the maximal peak feed for 1 (1wk), 3 (3wk), 5 (5wk), or 7 (7wk) wk after peak. These post peak feeding allocations had no effect on parameters associated with egg production, including egg production, incubation traits, and carcass or ovary characteristics at 56 wk of age. Significant differences were seen when looking at the absolute yolk weight at 36 wk of age for the 5wk hens. Although this was not a long term trend, the 5wk hens had significantly smaller yolks (17 ± 0.3 g) as compared to the other treatments (1wk=18.0 ±

0.3 g, 3wk=18.5 ± 0.3 g, 7wk=18.3 ± 0.3 g). Our results showed that the 1 wk post peak fed hens, that were maintained at target body weights, consumed less feed without reducing the number of hatching eggs per hen housed, when compared to the hens fed peak feed for 3, 5, or 7 wk. The results indicate that different post peak feeding levels can be used with broiler breeder hens without significantly affecting egg production, egg weight and egg characteristics, hatchability and fertility, and carcass and ovary morphology. However, in industry, where broiler breeders are not individually caged, there may be less flock uniformity and consequently more variation in production.

ACKNOWLEDGEMENTS

I would like to thank the Canadian Broiler Hatching Egg Marketing Agency, Alberta Agriculture Research Institute and Shaver Poultry Breeding Farms Ltd. for their financial support of this project. Also I would like to thank Lilydale Co – operatives Ltd. for their generosity in letting us use their hatchery facilities. Financial support received through the Alberta Egg Producers Board Scholarship was greatly appreciated.

I was also fortunate to have been able to work with the staff from the Alberta Poultry Research Centre. Lyle Bouvier, Nigel Davidson, Giles Hines, and Shawn Rankin were committed to their work and in turn mine. The expertise of animal technician Felicity Dennis made my job a little less worry some. I could not have completed my masters if not for her. My colleagues Nancy Joseph, Ruth McGovern, Kim Thorsteinson, Jerry Emmanuel, and Tom Inglis all helped me extensively over the duration of my masters. Robert Renema and Gaylene Fasenko (the best research associates ever) have also been very helpful and a model for something I would like to become, also, if not for Rob's statistical expertise this thesis would not have turned out the way it did. I would also like to thank Martin Zuidhof for his assistance in analysing the egg laying data.

I also thank Doug Korver, John Feddes, and Cynthia Paszkowski for serving on my committee and, especially to Doug Korver and John Feddes for, making my time at the University of Alberta a little bit easier. Also, this masters would not have been undertaken if not for the encouragement and support of Dr. Hank L. Classen. His support has opened my eyes to the exciting world of poultry science, and he has also been my mentor, showing me the success that can be achieved and how to reach it. I owe my supervisor Dr. Frank E. Robinson a great deal. His commitment in building a bridge between research and industry has sculpted my ambitions and changed my focus for the better, I thank him for it.

My parents, Bruce and Matil Spies, and my sisters Lisa and Catharine have always been much support, even when I wasn't sure what I was going to do next. The foundation on which I was raised has always been an inspiration and has given me the ability to succeed in all aspects of life, also ensuring a healthy balance.

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1. INTRODUCTION

1.1 BACKGROUND

1.1.1 Introduction

As the modern broiler breeder female is a genetic compromise between two very different selection criteria, she must both possess the genetic ability to grow rapidly and be a very efficient producer of hatching eggs for broiler production (Robinson *et al.*, 1993). Genetic selection has focused on increased meat production characteristics in the progeny, and in doing so, has impaired the reproductive ability of the broiler parents, causing unsatisfactory production of hatching eggs and a greater number of abnormal eggs (van Middelkoop, 1972). Broiler breeder reproduction has been impaired by increasing age at first egg (Bruggeman *et al.*, 1998) and decreasing ovulation frequency (Robinson and Wilson, 1996), both thought to be problems associated with an increased growth rate (Goerzen *et al.*, 1996). These issues have encouraged researchers to review the management of broiler breeders females, studying such issues as fertility and feeding (Goerzen *et al.*, 1996), age and sperm penetration (Bramwell *et al.*, 1996), and nutrient diet dilution (Zuidhof *et al.*, 1995), just to name a few. Therefore, managers of broiler breeder flocks are faced with the challenge of managing the reproductive performance of a bird selected primarily for meat production, altering such management tools as lighting, feeding, and age at photostimulation. With this challenge, primary breeder companies are continually refining their management guides and suggesting stricter quantitative feed restriction in order to improve the reproductive efficiency of broiler breeders.

1.1.2 The Broiler Breeder Industry

During the past 50 years, advances in management of broiler breeders has encouraged the evolution of the industry from backyard seasonal production of replacement stock to an intensive industry dominated by a small number of breeding companies. There are five separate levels of production in the poultry-breeding pyramid (Figure 1-1). At the top of the pyramid are the elites, which are continually being selected to improve the genetic potential of a breeding companies stock and, as a consequence maintain their own populations. Further down the pyramid, below the elites, are the great grandparents, grandparents, and parents or broiler breeders. At the bottom are the broiler chickens, which are a product of a terminal cross between the male of the male lines, selected for growth, and the female of the female lines, selected primarily for egg production.

The broiler breeder industry has developed a broiler chicken with the ability to grow to market weight within a shorter period of time than earlier stocks (Singh, 1993). However this genetic advantage has come at a cost, with ascites (Muirhead, 1987), sudden death syndrome (Gardiner *et al.*, 1988) and bone disorders (Riddell, 1975) accounting for a high percentage of total mortality. It is also evident that these disorders can be reduced if not eliminated by reducing growth rates to less than potential (Classen *et al.*, 1991). Like her progeny, the broiler breeder hen also experiences a reduced level of health due to this intensive selection pressure. Unfortunately primary breeder companies will most likely not sacrifice broiler growth performance to improve broiler breeder reproductive performance.

1.1.3 Recent Trends

Past production has been short of demand, even with substantial increases in bird placements (Smook, 1999), although, with increases in bird placements, consumer demand will be able to be met in the future.

Good management is critical for optimal broiler breeder performance. The greatest challenge in this industry is controlling body weight since genetic selection has favoured very rapid growth. Robinson and Wilson (1996) showed that high body weights are negatively correlated with egg production, by showing that full fed hens produce fewer eggs. Work by Hocking (1993) showed that high body weights at first egg increase the incidence of atretic follicles and internal ovulations. Also, Goerzen *et al.* (1996) makes clear that feed restriction improves reproductive performance by demonstrating that over weight birds have reduced duration of fertility.

1.2 REPRODUCTION IN DOMESTIC FOWL

1.2.1 Introduction

Over the past 50 years there has been an emphasis on the need for efficiency of food production. With this need, poultry breeders have focused their attention on a few avian species, characterised by a high rate of production, to be selected for this need to be met. The domestication of poultry would have been fruitless if not for the technologies and breakthroughs that came with it, such as artificial incubation technology. Poultry production would continue to depend on a maternal cycle in which hens lay a clutch of eggs, incubate them for 21 days, and rear their young for several weeks before returning to another sequence of egg production. It is also noteworthy that application of 20th century science to development of breeds of turkey hens that will lay without displaying maternal behaviour has not been as successful as the selection programs for chicken hens (Proudman, 1998). The study of reproductive physiology in birds, in the past 25 years, has advanced from our extrapolations of our knowledge of mammalian reproduction to descriptions derived from examinations of the physiological mechanisms that control reproduction in avian species.

1.2.2 The Ovary

An interaction between the circadian rhythm and the physiological systems controlling the rate of follicular maturation is involved in the physiological control of egg production in the hen. Alternatively, rate of lay in individual hens is regulated by an interaction between genetic potential (Shanawany *et al.*, 1993), nutrition (Waldroup and Hellwig, 1995), body weight (Bjerstedt *et al.*, 1995), social position, and environmental conditions (Robinson *et al.*, 1993). The precise way in which these factors interact has not yet been determined, although considerable work has taken place to understand the horomonal changes that take place during the ovulatory cycle. These neuroendocrine events concert the release of fully formed egg yolks from the ovarian follicles and directs the subsequent addition of membranes, protein, water, and calcium carbonate onto the ovum. These events culminate in an oviposition of an egg that functions biologically to propagate a species.

The ovulatory cycle of the hen spans the period of one ovulation to the next. The ovulatory cycle length of a hen is determined both by the duration of follicular maturation and the photoschedule, which, in turn, determines the occurrence of the open period for preovulatory luteinizing hormone (LH) release. The ovary of the hen normally contains a hierarchy of five to ten large yolky follicles, several small vitellogenic follicles, and thousands of small white follicles. The major difference between the small white and large yellow follicles is their content of yellow yolk, although immature follicles contain several layers of granulosa cells that subsequently become a monolayer in a large yolky follicle (Solomon, 1991). In addition, the theca layer and its vascular supply are less well developed in an immature follicle. Each follicle in the hierarchy is subjected to each preovulatory surge of LH. Measured as the accumulation of mass, follicular growth occurs exponentially after recruitment into the hierarchy of follicles that are depositing yellow yolk (Etches *et al.*, 1983).

The neuroendocrine control of follicular function is mediated by interaction of gonadotrophin releasing hormone (GNRH) from the hypothalamus, the gonadotropins from the pituitary gland, and the ovarian steroids from the follicular hierarchy. Light energy passes through the skull to stimulate photoreceptors in the hypothalamus (Sauveur, 1996). The hypothalamus plays a central role in the regulation of ovarian function. When day length is of sufficient length to initiate reproductive development, light energy stimulates nerve impulses in the hypothalamus. In the presence of high or rising concentrations of progesterone and this nerve impulse, GNRH is released into the hypothalamic/pituitary axis portal system from the hypothalamus (Knight *et al.*, 1984). The avian hypothalamus produces two types of GNRH, GNRH-I and GNRH-II. The capacity of GNRH-II to induce LH synthesis was reported to be several times greater than GNRH-I, but would appear unlikely that GNRH-II is an important physiological regulator of LH, since unlike GNRH-I it is present in only small amounts (Sharp *et al.*, 1987). The function of LH is to promote steroidogenesis and to stimulate ovulation (Robinson *et al.*, 1988). Plasma concentrations of LH in the hen are regulated by positive feedback systems that involve the gonadal steroids. Progesterone is produced by the granulosa cells of the largest preovulatory follicle, and its production in vitro is stimulated by the addition of LH (Etches *et al.*, 1983). This increase in plasma progesterone initiates a positive feedback response from the hypothalamus which increases the secretion of GNRH into the hypothalamic portal system. The increase in GNRH triggers an increase in the secretion of LH that, in turn, promotes the secretion of progesterone from the largest preovulatory follicle. It also appears that progesterone may also start the enzymatic changes that result in the breakdown of the follicular wall during ovulation (Tanka *et al.*, 1987; Nakada *et al.*, 1994). The small ovarian follicles and all but the largest of the yellow yolky follicles produce androgens and estrogens (Robinson and Etches, 1986). Plasma concentrations of estrogens have usually been observed to increase 1 or 2 h before the rise in the concentration of LH and progesterone (Lague *et al.*, 1975). High concentrations of estrogens, either alone or with androgens, are required to sensitise the hypothalamic pituitary axis to the positive feedback effects of progesterone (Wilson and Sharp, 1976) to stimulate vitellogenin formation in the liver (Redshaw and Follett, 1972), to regulate calcium metabolism (Etches, 1987), to stimulate and maintain a functional oviduct, and to maintain secondary sexual characteristics.

1.2.3 The Egg and its Formation

The egg contains the organic and inorganic materials required by the developing embryo. The packaging material is the shell, and numerous amino acids, lipids, minerals, and vitamins that are required by the embryo, as it grows from a zygote to a chick, are stored in the yolk and albumen.

The female reproductive tract is commonly referred to as the oviduct. In birds it is responsible for receiving the ovum into the infundibulum within 15 min after ovulation and providing the appropriate environment for fertilisation, as chickens have the ability to store sperm in the sperm storage tubules, which are in the infundibulum, for 3 to 4 weeks (Brillard, 1993). After ovulation the oviduct is then responsible for secreting the albumen in the magnum, shell membranes in the isthmus, and shell and cuticle in the shell gland. Calcification of the egg occurs in the shell gland where water is imbibed through the membranes into the albumen which gives the egg its characteristic shape. The vagina is the short section of the reproductive tract connecting the shell gland to the cloaca. Oviposition of the complete egg is associated with a behavioural repertoire that compels a hen to seek out an appropriate nesting site. Co-ordination of these events involves mechanical stimulation of the tract by the passage of the ovum, and after the egg spends some time in the vagina, is expelled by the action of a muscular sphincter.

1.2.4 Factors Influencing Egg Size

While the output of eggs is the primary factor involved in the profitability of hatching egg production, the weight of the eggs is also of considerable importance. This is particularly important in markets where a minimum egg weight is set by commercial hatcheries. The sizes of eggs, and also the composition of eggs, are dependent on the hen's nutritional status, body weight, age, strain, and lighting schedule. Egg weight is highly heritable and therefore can be easily manipulated by genetic selection. This genetic control of egg weight is highly correlated with body weight, so the selection for a larger hen tends to produce a larger egg and vice versa, although the genetic correlation of body weight with rate of lay is negative (Hutt, 1949). While this positive correlation is useful when describing the relationship between egg weight and body weight within a genetically defined strain, it is not useful when comparisons are made between stains.

Age is also a major determinant of egg size in poultry (Thorsteinson, 1999). At the onset of lay, egg weight is much smaller than in the subsequent weeks. The onset of sexual maturity can be retarded by restricting nutrient intake and/or exposing pullets to non – photostimulatory lighting regimes (Copper and Barnett, 1977). This will also prevent the production of small eggs that are unsuitable for the commercial egg market, where they receive less monetary returns, and hatching egg markets which have a minimum weight restriction. The increase in egg size with age is a result of an increase in egg components, yolk, albumen, and shell, although these increases are not proportional (Thorsteinson, 1999). The increase in calcium carbonate secretion as the hen ages is insufficient to overcome the simultaneous increases in egg size and, consequently, the thickness of the shell declines. This results in the observed difficulty in the maintenance of shell quality at the end of the laying year. As the hen ages she produces fewer but larger eggs (Bahr and Palmer, 1989). The interval between ovulations increases from 24 – 25 to 26 – 27 h or more as the hen ages. The result is a shorter sequence and a decrease in egg production (Bahr and Palmer, 1989).

Nutrient intake of the hen will also influence egg size. Protein intake, when the energy requirements for maintenance, activity and egg production are provided by non – protein sources, is especially influential (Waldroup and Hellwig, 1995). The influence of protein level on egg size is well established, that is, an increase in a hen's intake of balanced protein will result in an increase in egg size (Proudfoot *et al.*, 1988). Additionally, Joseph *et al.* (1998, unpublished data) demonstrated that broiler breeder hens fed a 18% crude protein diet had significantly higher egg weights by 29 wk of age than hens fed 16% crude protein diet. The major effect of protein appears to be a response to the essential amino acid methionine, but also appears that total protein level may also be a factor (Roland, 1980). Many reports have indicated that performance of hens can be optimised on low protein, essential amino acid supplemented diets, there always appears to be an increase in egg weight with higher protein diets. However, attempts to increase egg size by increasing both dietary protein level as well as supplemented methionine, have not been successful (Summers, 1993). The influence of dietary fat and energy concentration of the diet has also been reported to increase egg weight (Mannion and Mcloud 1984).

While protein level and/or amino acids and energy are the main dietary factors influencing egg size, they must be in balance with adequate quantities of amino acids consumed for egg size to be maximised (Summers and Robinson 1995). However, factors influencing partitioning of nutrients, especially temperature must also be taken into account. The effects on egg size caused by changes in dietary components are achieved through different physiological mechanisms; changes in protein or amino acid content affect primarily the deposition of albumen, whereas changes in the consumption of linoleic acid alter yolk formation (Leeson and Summers, 1997). March and MacMillan (1990) found that egg weight in Leghorn hens was consistently higher with diets higher in linoleic acid, but yolk weights were increased only slightly. This implies that linoleic acid is not only important for increases in yolk, but also other components of the egg, such as the albumen (Zimmerman, 1997). Also anything causing reduced feed intake will reduce egg size. Lighting schedules and their effect on egg size will be discussed in detail later.

1.2.5 Monitoring Reproductive Success

The lack of emphasis on the individual in the flock, and the extensive use of statistics to describe the welfare and reproductive success of the group distinguish the poultry industry from other livestock enterprises. Information on the physiology of reproduction, however, has been derived primarily from studies of individual birds. Therefore, statistics describing the group are means of individual bird performance that have an associated variance that is often not stated. Many of the commonly used measurements of reproductive performance, including body weight, egg production, egg weight, and hatchability, in the poultry industry encompass several physiological states. The application of one measurement without knowledge of physiological interaction of other measurements can provide misleading information regarding the reproductive performance of individuals within the flock.

1.3 BROILER BREEDER MANAGEMENT

1.3.1 Introduction

Breeder management guides are continually being developed and refined to assist in maximising egg output and managing the growth potential of broiler breeders. It appears that broiler breeders are being encouraged to reproduce at their maximum limit by primary breeders (Ross Breeders Inc., 1999). This is being achieved by allocating them just the optimum amount of nutrients to maximise reproduction and maintain growth, as allocating them deficient or excess nutrients are detrimental to their reproduction. With the use of different management procedures, reproduction in broiler breeders is continually being affected.

1.3.2 Performance Objectives

Broiler breeders' reproductive performance is evaluated by the use of total egg numbers, proportion of unsettable eggs, age at first egg, chicks produced per hen, and peak egg production. However, managing a broiler breeder really involves managing her ovulatory cycle and the ovary itself. One husbandry program can no longer be used for all stains of broiler breeder, due to the degree of specialisation within each company (Robinson *et al.*, 1993). This section will discuss two main management tools, lighting and feeding.

1.3.3 Effect of Lighting

In practical terms, photoperiodism can be seen as the ability of broiler breeders to respond reproductively when exposed to changes in daylength. It has been attributed to the need to increase survival of young, as the warm days of summer are near in temperate climates. Most birds in temperate climates are seasonal breeders, who responding positively to increasing photoperiods, by initiating reproduction from the hypothalamus with GNRH, and negatively to decreasing photoperiods (Morris, 1994). The light is received through photoreceptors in the hypothalamus that fix energy contained in photons into a biological signal or neural impulse. The neural impulses are then amplified by the endocrine system to control ovarian function and a number of reproductive functions, behaviours, and secondary sexual characteristics (Morris, 1994).

Birds display different responses to differing photoperiods (increasing or decreasing). Terms that become important when discussing this are critical, marginal, and saturation daylength. Critical daylength is the minimal length of the photoperiod (usually 11 - 12 h) that will stimulate the secretion of LH, which initiates egg formation (Sharp, 1984). Saturation daylength is the length of photoperiod that stimulates maximum LH secretion, and any increase beyond this photoperiod length will have no effect on LH secretion (Sharp, 1984). Marginal daylength is the median between critical and saturation daylength, in which increasing daylength beyond this value will cause an increase in LH secretion (Sharp, 1984).

Little data is published on the effect of light intensity on ovarian morphology, however, much data on the minimum light intensity required to elicit a photoperiodic response have been published. Morris and Bhatti (1978) concluded that light intensity of the photoperiod must be ten - fold greater than the light intensity of the scotoperiod. The threshold intensity at the feed trough for white light simulation of the photoperiodic mechanism in cage Leghorn pullets lies between 0.9 and 1.7 lux (Lewis *et al.*, 1999). However, very dim lighting, below the threshold, required for stimulation of a photoperiodic response, may shift the biological clock with unexpected consequences (early sexual maturity) and, as a result, there is no known intensity of dim light that can be equated with darkness.

The main objective when designing a lighting schedule for broiler breeders is to delay the oviposition of the first egg until egg weights are a suitable weight for setting. As a consequence, lighting programs for broiler breeders are reduced to 8 h of light for birds as young as 4 d of age, and maintained at this length until 22 wk of age. While some breeder companies recommend an increase in photoschedule of 6 h at this time (fast photoperiod; FP), some suggest a 1 h increase at 19 wk of age, followed by gradual increases to 16 h of light by peak production (slow photoperiod; SP). Robinson *et al.* (1998a) reported observing larger but fewer large yellow follicles ($\geq$10 mm) in hens in a SP treatment, and the eggs laid by these hens also displayed higher hatchability (Robinson *et al.*, 1998b).

Intermittent lighting (two or more intervals of a light dark cycle, which cumulatively add to 24 h) can be satisfactorily used with broiler breeders, although floor eggs can become a major problem (Proudfoot, 1980). Proudfoot (1980) reported larger eggs, with no reduction in egg numbers from various strains of broiler breeders exposed to an 2L:3D:10L:9D regime compared to a conventional 14L:10D. An intermittent lighting schedule would be appropriate for a commercial setting, although would come with its own management implications.

An ahemeral photoschedule is one in which the photophase and scotophase do not add up to 24 h. That is, the cumulative day length, light plus dark cycle, is not that of a natural day or hemeral day. Short ahemeral days (<24 h) have mainly been used in selection programs for identification of individual hens with follicular maturation rates of less than 24 h (Morris, 1973). Long ahemeral days (>24 h) have been used to match follicular maturation rate with daylength to result in oviposition of an egg each day (Shanawany, 1990).

A positive result of long ahemeral days early in lay is increased egg size. Egg size is thought to be increased due to additional hours of yolk deposition in ahemeral days, compared to hemeral days (Shanawany, 1990). Proudfoot (1980) investigated the effect of a long day ahemeral lighting treatment, 14 h of light followed by 13 h of dark per day (14L:13D), on broiler breeders from 24 to 64 wk of age. It was reported that birds exposed to a long day ahemeral lighting scheme displayed a heavier initial egg weight (0.5 g) compared with the eggs from hens on a hemeral day (14L:10D). Results regarding egg production have been inconsistent. Proudfoot (1980) reported that total hen housed egg production was consistently higher for birds on a hemeral day as compared to birds that were on a 14L:13D ahemeral day. However, Foster (1968) stated that egg production increased significantly with increasing light:dark cycle length. This inconsistency in results regarding long ahemeral days and egg production are likely due to the difference in genotypes used, ahemeral program and bird age.

Another application of ahemeral days is to determine the practical follicular maturation interval for various genotypes. Exposing hens to 22 – 28 h photoperiods can be used to determine the shortest day length at which hens will lay an egg each day. Highly efficient layers on 22 h days can be used to identify hens with follicular maturation rates of less than 24 h.

1.3.4 Effect of Feeding

The challenges faced in developing feeding programs for broiler breeders are difficult ones. Feed restriction is a necessary management technique for broiler breeders to prevent obesity - related problems (Robinson *et al.*, 1993). Most commercial broiler breeders are feed restricted during rearing and breeding to limit body weight (Leeson and Summers, 1997). Such restriction programs can reduce body weight and mortality, improve feed efficiency, and improve egg fertility, shell quality, and production (Pym and Dillon, 1974). Most management guides recommend that feed intake be increased as birds start to reach peak egg production to accompany the increased demand on the body of both growth and increasing egg production. At some point, typically around 32 wk of age, egg production declines, and feed intake is reduced to take into account the decreased nutrient needs for egg output.

As there is a strong negative relationship between body weight (BW) and reproductive efficiency in domestic fowl (Siegel and Dunnington, 1985), most of the current production advantages seen in the broiler chicken today pose a number of problems to those involved in the management of their parents, the broiler breeders.

Therefore it is obvious that measures must be taken so broiler breeders do not fully express their genetic potential for growth. Current recommendations for feeding broiler breeder hens are on the basis of average daily production in g of feed/bird/day or kcal of feed/bird/day. Therefore, after peak egg production, feed allocations may remain too high before being reduced, causing excess fat deposition with the possibility of reproductive failure. It has also been reported that the advantages seen in restricting feed intake of broiler breeders during the prebreeding and breeding periods are still questionable (Leeson and Summers, 1983). Although this statement was made at a time when the growth potential of broiler breeders was not as high as it seems to be today.

As egg production declines after peak egg production it is uncertain whether it is due to an excess energy intake or if feed has been reduced too quickly, hence, producers may be over or under – feeding after peak egg production. Primary breeders currently recommend various degrees of feed restriction for each strain that permit a narrow range of growth curves to be followed in different environments (Fattori *et al.*, 1991). The optimality of these prescribed standards has not been documented and this raises interest in feed allocation levels below current recommendations.

Much work as been done to analyse the effects of *ad libitum* feeding verses restricted feeding on growth and reproductive characteristics. The degree of restriction has been documented to have a profound effect on reproduction. The effect of energy intake on ovarian morphology has been analysed by Robinson *et al.* (1993), with the final conclusion that as energy intake increases follicular development will increase. These increases are seen in increased number of large follicles (Yu *et al.*, 1992). In the same paper it was also observed that throughout lay birds that were full fed had, on average, two or more large follicles than did hens that were feed restricted. These follicles were included in the hierarchy in the form of double or triple hierarches (Robinson *et al.*, 1991a). It should be clarified that increased follicle development seen in response to overfeeding does not result in a significant increase in egg production (Robinson *et al.*, 1991b), and can be further reduced by ovarian regression (Yu *et al.*, 1992). *Ad libitum* feeding, during the breeding period rather than in the rearing period, had a significant influence on *in vitro* steroidogenic capabilities of ovarian follicles by increasing the hormonal capabilities of the F_2 follicle (Yu *et al.*, 1992).

Other major challenges faced in developing feeding programs for broiler breeders include conditions of limited access to feed while attaining a high degree of uniformity in body weight, the constantly changing genetic make up of the broiler chicken, and the lack data from floor - kept hens (Summers and Robinson, 1995)

1.3.5 Conclusions

This chapter outlines the criteria necessary for reproductive efficiency in broiler breeder hens. With this criteria comes decisions to be made by managers of what management procedures to use. As consumer and industry demands are continually changing, genetic improvements are necessary. In order to see where we have come from, and for further genetic improvement, scientific research must be carried out.

1.4 INTRODUCTION TO CHAPTERS

Two experiments were conducted in order to determine the effects of two management practices. The use of long ahemeral days on broiler breeders and its effects are not well documented. Chapter 2 focuses on the effects of body weight and long ahemeral days on early egg production parameters and morphological characteristics of broiler breeder hens. Chapter 3 discusses feeding after peak production by looking at the effects of feed allocation and withdrawl.

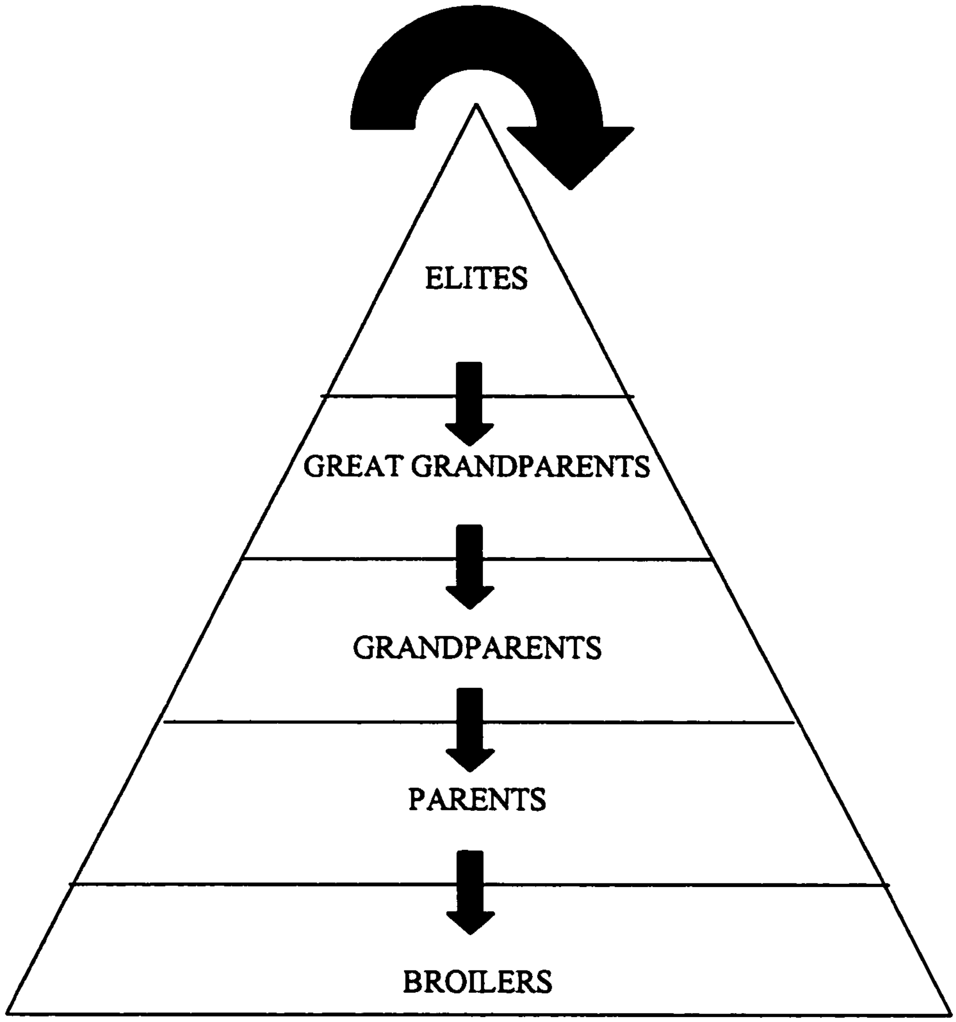

FIGURE 1-1. Standard poultry breeding pyramid, used in the meat type chicken industry to produce a commercial broiler. At the top of the pyramid are the elites, which re - populate themselves and are continuously being selected to improve the genetic potential of a breeding companies lines. The great grandparents, grandparents, and parents or broiler breeders are populated by the group above them and reflect improvements in a certain strain in as many generations they are away from the elites. At the bottom are the broiler chickens. The triangular shape indicates the increase in bird numbers moving down the pyramid.

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2. THE EFFECTS OF BODY WEIGHT AND LONG AHEMERAL DAYS ON EARLY PRODUCTION PARAMETERS AND MORPHOLOGICAL CHARACTERISTICS OF BROILER BREEDER HENS

2.1 INTRODUCTION

Typically, the first eggs laid by broiler breeder pullets may be smaller than the minimum size set by commercial hatcheries. It has been shown that early egg size can be influenced by the hen's nutritional status (Waldroup and Hellwig, 1995), BW (Summers and Leeson, 1983), age at photostimulation (Robinson *et al.*, 1996) and genotype (Shanawany *et al.*, 1993a), but photoschedule may have an effect as well (Etches, 1996).

An ahemeral photoschedule is one in which the photophase and scotophase do not add up to 24 h. That is, the cumulative day length, light plus dark cycle, is not that of a natural day or hemeral day. Short ahemeral days (<24 h) have mainly been used in selection programs for identification of individual hens with follicular maturation rates of less than 24 h (Morris, 1973). Long ahemeral days (>24 h) have been used to match follicular maturation rate with day length to result in oviposition of an egg each day (Shanawany, 1990). Long ahemeral photoschedules introduce a potential limitation in that there are less days per week than a regular week with seven 24 h days, which would reduce the maximum rate of lay to less than seven eggs per week. This may hold back some hens with fast follicular maturation rates, but would benefit those with longer rates of follicular maturation.

A positive result of long ahemeral days early in lay is increased egg size. Egg size is thought to be increased due to additional hours of yolk deposition in ahemeral days, compared to hemeral days (Shanawany, 1990). Proudfoot (1980) investigated the effect of a long day ahemeral lighting treatment, 14 h of light followed by 13 h of dark per day (14L:13D), on broiler breeders from 24 to 64 wk of age. It was reported that birds exposed to a long day ahemeral lighting scheme resulted in heavier initial egg weight (0.5 g) compared with the eggs from hens on a hemeral day (14L:10D). Shell quality, as measured by specific gravity, showed an improvement, with the eggs from hens on a long ahemeral lighting scheme having higher specific gravity than eggs from hens on a hemeral day. This effect of increased shell quality from eggs laid by hens on a long day ahemeral lighting scheme has also been shown by Shanawany *et al.* (1993b) and Lewis *et al.* (1994). Long day ahemeral lighting increases shell thickness by extending egg formation time, presumably because the eggs spend more time in the shell gland. Results regarding hen housed egg production have been inconsistent. Proudfoot (1980) reported that total hen housed egg production was consistently higher for birds on a hemeral day as compared to birds that were on a 14L:13D ahemeral day. However, Foster (1968) stated that egg production increased significantly with increasing light:dark cycle length. This inconsistency in results regarding long ahemeral days and egg production are likely due to the difference in genotypes used, ahemeral program and bird age. Shanawany (1990) reviewed the influence of long day ahemeral lighting schemes on the quality of eggs. Shanawany reported that both shell weight and yolk weight depend on a curvilinear function of light:dark cycle length. For long day ahemeral lighting schemes, both yolk and albumen weight increased linearly with light:dark cycle length up to 29 h, following which weight decreases.

The objective of this experiment was to determine whether egg size and egg production could be increased in young broiler breeders through the use of long ahemeral days from 22 to 30wk of age and to determine if this possible egg weight increase is due to an increase in yolk weight, albumen weight or shell weight. Also, the effect of this photoschedule on ovarian and carcass morphology was also investigated at 30 wk of age. It was also determined if the results occured to the same extent in slightly high and low BW birds.

2.2 MATERIALS AND METHODS

Two hundred Shaver Starbro broiler breeder pullets were acquired as day old chicks. Prior to arrival the pullets were vaccinated for Marek's disease, and on arrival were wing banded. Birds were reared in floor pens, 50 pullets / pen, in a light tight facility with straw litter. Feed and water for the first 3 wk were provided on an *ad libitum* basis. From 3 wk of age to 21 wk of age, the pullets were feed restricted to maintain BW at the targets recommended by Shaver Poultry Breeding Farms Ltd. During the 3 to 21 wk of age period, feed was allocated on a 5/2 feeding program (restricted from feed 2 d / week). All diets were wheat based, fed in mash form and formulated to meet or exceed NRC (1994) requirements (Table 2-1). The photoschedule during rearing was as follows: 24L:0D for the first 3 d followed by 8L:16D, from 3 d to 22 wk of age.

At 20 wk of age, all pullets were weighed and 64 pullets of appropriate BW were selected and assigned to one of two groups, those that had a slightly high BW (HBW) (2134 g ± 8.4) and those that had a slightly low BW (LBW) (1677 g ± 8.2), as compared to the target BW (1900 g). Thirty-two pullets from each group were assigned to individually illuminated laying cages at 21 wk of age. At 22 wk of age the birds were exposed to one of two photoschedules. Thirty-two birds, 16 HBW and 16 LBW, were exposed to a typical hemeral day, 14L:10D (24 h), and the remaining 32 birds, 16 HBW and 16 LBW, were exposed to a long ahemeral day 14L:14D (28 h). The total feed allocation (on a weekly basis) from 22 wk of age until 30 wk of age was the same for each photoschedule group (Table 2-2). The 24 h birds received one seventh of the weekly feed allotment each day, the 28 h birds received one sixth of the weekly feed allotment each light:dark cycle. Each bird was weighed at seven hemeral day intervals and feed was restricted to maintain BW at the targets recommended by the breeder.

The production of normal and defective (without an intact shell) eggs was recorded daily (7 times a week for the hemeral hens and 6 times a week for the ahemeral hens) for each hen. Oviposition records were used to determine total egg production, total settable egg production (≥ 52 g, intact shell), number of ovulations and percentage of defective eggs. The time of lay for each egg was recorded electronically. On each side of the egg tray, an infrared transmitter and receiver were mounted. The infrared source was pulsed every six seconds and the pick up signal was monitored. The pick up signal disappeared when an egg interrupted the beam. The PC would scan all the pick up outputs every 30 s. When the signal was 0, the PC software would store the time the pick up output initially became 0. Another software program written in Quick Basic calculated the time between lay over the time of the experiment for each bird, but if the time exceeded a defined limit (32 h for the 24 h birds and 36h for the 28 h birds) it was considered a pause. This data was used to calculate sequence length.

Each normal egg (intact shell, single yolk), regardless of size was weighed and broken open to determine the weight of its components (yolk, albumen and shell). At 30 wk the birds were killed by cervical dislocation for the study of ovarian morphology and carcass characteristics. The hens were weighed and dissected to determine weights of breast muscle, abdominal fat pad, liver, intact ovary, stroma and oviduct. Shank length, number of large (>10mm) and small (>5mm, <10mm) yellow ovarian follicles were also recorded.

Data were analyzed as a 2 X 2 factorial design with main effects of day length and BW. Data were subjected to two-way analysis of varience using General Linear Models (GLM) procedures of SAS (SAS Institute Inc. 1994). Differences between means were evaluated using Fisher's protected Least Significant Difference (LSD) procedure (Peterson, 1985). Unless otherwise stated, treatment effects were considered significant if $P<0.05$.

2.3 RESULTS AND DISCUSSION

2.3.1 Egg Production

Photoschedule had little effect on egg production parameters. Age at first egg, total egg production, settable egg production, number of ovulations, and percent hen day production were not affected by day length. The 28 h birds laid significantly fewer double yolked eggs, at 0.3% of production while the 24 h birds had 0.9% (Table 2-3). Body weight alone did not affect egg production. Significant interaction effects were only seen when looking at total double yolked egg production, where the 24 h HBW hens had significantly more double yolked eggs at 1.0% of total egg production, followed by the 24h LBW birds (0.8%), 28h LBW birds (0.4%) and the 28h HBW birds (0.1%). Egg interval, or time between consecutive eggs, was consistently longer for the 28 h hens (Figure 2-1), as a consequence, the 28 h hens laid fewer eggs at 29 wk of age (Figure 2-2). However, the 28 h hens laid larger eggs from 26 to 29 wk of age (Figure 2-3). Also, the mean time between consecutive ovipositions, sorted by sequence length, was significantly longer for the 28 h birds as compared to the 24 h birds (Figure 2-4). Interestingly, figure 2-5 demonstrates that the 28 h hens laid most of their eggs in the dark period. Etches (1995) explains the increased frequency of the open period by the increase in the photoschedule, with the open period able to run freely in the absence of an environmental cue such as photoperiod. These two attributes of an increased photoschedule provide evidence for the association of circadian oscillators in the process that controls the timing of ovulation and warrant further study of the links between the timing of the preovulatory LH surge and the circadian clocks (Etches, 1984).

Egg production of hens exposed to two different light:dark cycles is a response to photosensatory perception. While the 24 h hens laid at a given rate, it appears that the, overall, 28 h birds laid less. This indicates that while day length is increased, egg production decreases, suggesting a follicle is ovulated after every initiation of the photophase. Therefore, when each consecutive photophase is spaced further apart, the release of consecutive follicles will also be further apart. As a result, maximum egg production will occur with the optimum balancing of these two events. The results of this experiment indicate that with the Shaver Starbro strain the effect of a 28 h day on egg interval, being longer than the average egg interval while on a 24 h day (24.9 h), will increase the egg interval (26.2 h), decreasing total egg production.

This effect of a long ahemeral photoschedule reducing lay in broiler breeders is consistent with the results of Shanawany and Prichner (1992). This particular study sorted experimental birds on the basis of sequence length, the hens that laid less than or equal to six eggs per sequence produced more eggs on the 28 h day decreasing their egg interval from 34.2 h to 30 h. The birds that laid greater than six eggs per sequence, laid less eggs on the 28 h day, increasing their egg interval from 27 h to 29 h. Both of the groups had an increase in egg weight. Siopes and Neely (1997) reported that ahemeral lighting can be used for the first 5 wk, or more, after photostimulation to increase egg size in turkey hens, however, 13 wk after photostimulation this effect was no longer present. Similarly, Hawes *et al.* (1991) reported that brown egg laying hens on a 26 h photoschedule had increased egg weights for the last three wk of the ahemeral schedule, but cumulativly there was no egg weight increase. However, egg production, as studied in White Leghorn hens on a 28 h ahemeral photoschedule, was significantly increased for the first eight wk of production (Fitzsimmons and Newcombe, 1991). It can be concluded, that based upon the hen's egg interval while exposed to a hemeral day, a long ahemeral photoschedule could be used to improve egg production as well as egg weight. However, if the egg interval is too long the increase in egg weight may be at the expense of egg numbers.

2.3.2 Egg Quality

The effects of a 28 h ahemeral day on egg quality are shown in Table 2-4. Significant increases in average egg weight, egg specific gravity and absolute and proportional shell weight, were seen in the 28 h birds compared to the 24 h birds. Average egg weight was increased from the 24 h birds (55.1 g) to the 28 h birds (53.0 g). The main effect of BW and the effect of the interaction did not affect egg quality parameters (Table 2-4).

This is consistent with the results of Morris (1973) and Proudfoot (1980). The significant increase in egg weight between the 28 h hens and the 24 h hens was due to a combination of yolk, albumen and shell weight, but shell weights were the only parameter significantly different. Similar results are corresponded by Morris (1973), who reported significant increases in both albumen weight and shell weight with long ahemeral days. This increase in shell weight and egg specific gravity suggest that the increase in day length may add to shell formation time, and therefore mineralization.

2.3.3 Body Composition

At 30 wk of age, the 24 h birds were 70 g heavier in BW than the 28 h birds (Table 2-5). Proportional breast muscle weights were 15.3% and 15.9% of the live body weight for the 24 h and 28 h birds, respectively (Table 2-5). The proportional oviduct weight represented 2.4% of the live body weight for the 24 h birds and 2.1% for the 28 h birds. The 24 h birds had a significantly higher number of large yellow follicles (7.1) than the 28 h hens (6.3). Body weight had a significant effect on shank length, proportional fat pad weight, and proportional oviduct weight, in respective order at

108mm and 106mm, 2.6% and 2.2%, and 2.2% and 2.3 % for HBW and LBW, respectively (Table 2-5). Interaction had no effect on BW or any carcass parameter.

When considering the effect of day length on the body composition and ovarian morphology, it is evident that the distribution of nutrients was different when hens are exposed to a 24 h or 28 h day length. While the 28 h birds had a higher proportional breast muscle weight and fat pad weight, relative to body weight, the 24 h birds had proportional higher oviduct and ovary weight, relative to body weight. The higher ovary weight can be attributed to the greater number of large yellow follicles. Zimmermann and Nam 1989), in a trial comparing White Leghorns on a hemeral and ahemeral (27 h) photoschedule, reported that the feed needed for reproduction (feed/egg) was not significantly different between groups. These results were confirmed by Hawes *et al.* (1991). The interval between consecutive feeding alters body enzymatic systems affecting carbohydrate metabolism, fat storage, and protein formation (Fabry and Tepperman, 1970). Correspondingly, numerous studies have examined the metabolic and anatomical adaptations to intermittent feeding in chickens (Simon and Rosselin, 1979). In one trial, in which broiler chicks were feed restricted at various frequencies to study growth and body composition, it was reported that as the interval between consecutive feedings increases, so does body protein, but body fat decreases (Yu *et al.*, 1990). Feeding frequency affects fat metabolism. Less frequent but larger meals promote obesity (Cohn, 1963) because food intake in excess of the need for growth and maintenance is stored as fat (Lin, 1981). The present experiment does not demonstrate a significant increase in proportional body fat (fat pad) but does demonstrate the increased proportional body protein (breast muscle). The ability for the hens to gain body protein while experiencing an energy deficit is evident, but little is known of the mechanisms involved.

In can be concluded that a 28 h ahemeral lighting schedule should be used only for a strain of broiler breeder whose egg interval is greater than or equal to 28 h. If a long ahemeral day length is to be only used to increase egg size, it is advised that, while egg size will increase, the majority of increases will be in the less beneficial component of the egg, the shell. The suitability of long ahemeral days for increasing egg production late in lay needs to be examined, however, an increase in egg weight at that time is a disadvantage, not an advantage.

TABLE 2-1. Calculated composition[1] of nutrients in experimental diets

	Starter	Grower	Layer
Nutrient	0 to 3 wk	3 to 20 wk	20 to 30 wk
AME (kcal/kg)	2900	2700	2750
Crude protein (%)	18.0	15.0	15.5
Calcium (%)	1.0	0.9	3.2
Available phosphorus (%)	0.7	0.6	0.5
Lysine (%)	0.9	0.8	0.8
Methionine (%)	0.4	0.4	0.4

[1] According to National Research Council (NRC 1994) guidelines

TABLE 2-2. Feed allocations for broiler breeder hens on a 24 h (14L:10D) and 28 h (14L:14D) light : dark cycle

Age (wk)	Feed allocation (g / light : dark cycle)	
	28h[1]	24h
22	120	103
23	128	110
24	135	116
25	141	121
26	146	125
27	154	132
28	162	139
29	170	146

[1] 28h feed / d = (24h feed / d x 7)/6

TABLE 2-3. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) and BW (high BW (HBW) and low BW (LBW)) on production parameters of broiler breeder hens from sexual maturity to 30 wk of age

	Age at first egg (d)	Total egg production	Total settable egg production[1]	Total double yolked egg production (%)[2]	Total number of ovulations
Day length					
24 h	179.3	25.4	23.7	0.9^{a}	26.3
28 h	178.3	23.1	21.7	0.3^{b}	23.3
SEM	1.2	1.4	1.4	0.2	1.4
BW					
HBW	178.1	23.5	21.6	0.6	24.1
LBW	179.5	25.0	23.8	0.6	25.6
SEM	1.2	1.4	1.4	0.2	1.4
Interactions					
24 h x HBW	179.5	24.0	21.6	1.0^{a}	25.0
24 h x LBW	179.1	26.9	25.9	0.8^{ab}	27.6
28 h x HBW	176.6	23.0	21.7	0.1^{b}	23.1
28 h x LBW	179.9	23.1	21.6	0.4^{ab}	23.5
SEM	1.7	1.9	1.9	0.3	2.0

^{a,b}Means within a main effect or within the four interactions with no common superscript differ significantly ($P<0.05$)

[1] Total settable egg production = eggs ≥ 52 g with an intact shell and single yolk

[2] Percent of total egg production

TABLE 2-4. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) and weight (high BW (HBW), and low BW (LBW)) on broiler breeder normal egg[1] characteristics from sexual maturity to 30 wk of age

	Average egg wt.	Specific Gravity	Yolk wt.		Albumen wt.		Shell wt.	
Day length			(g)	(%)[2]	(g)	(%)[2]	(g)	(%)[2]
24 h	53.0[b]	1.0848[b]	13.8	26.0	34.3	64.7	4.9[b]	9.3[b]
28 h	55.1[a]	1.0889[a]	14.2	25.7	35.4	64.3	5.5[a]	10.0[a]
SEM	0.6	0.0009	0.2	0.2	0.5	0.2	0.1	0.1
BW								
HBW	53.4	1.0865	13.8	25.8	34.5	64.5	5.2	9.7
LBW	54.7	1.0872	14.2	25.9	35.3	64.4	5.3	9.7
SEM	0.6	0.0009	0.2	0.3	0.4	0.3	0.1	0.1
Interactions								
24 h x HBW	52.6	1.0851	13.7	26.0	34.0	64.7	4.9	9.3
24 h x LBW	53.4	1.0846	13.9	26.0	34.6	64.7	5.0	9.3
28 h x HBW	54.3	1.0879	13.9	25.6	34.9	64.4	5.4	10.0
28 h x LBW	56.0	1.0898	14.4	25.8	35.9	64.2	5.6	10.0
SEM	0.9	0.0012	0.2	0.3	0.7	0.4	0.2	0.2

[a,b] Means within a main effect or within the four interactions with no common superscript differ significantly ($P<0.05$)

[1] Eggs with an intact shell and single yolk

[2] Percent of fresh egg weight

TABLE 2-5. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) and weight (high BW (HBW), and low BW (LBW)) on carcass composition and ovary characteristics of broiler breeder hens at 30 wk of age

	BW	Shank	Breast muscle wt.		Fat pad wt.		Liver wt.		Oviduct wt.		Ovary wt.		Stroma wt.		LYF[2]	SYF[3]
Day length	(g)	(mm)	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]		
24 h	2987^a	107	458.8	15.3^b	69.5	2.3	61.0^a	2.0	71.4^a	2.4^a	66.0^a	2.2	9.2	0.3	7.1^a	15.8
28 h	2827^b	107	449.2	15.9^a	70.6	2.5	56.3^b	2.0	58.8^b	2.1^b	58.0^b	2.1	9.2	0.3	6.3^b	17.1
SEM	32.2	0.6	7.5	0.2	4.1	0.1	1.3	0.03	1.2	0.03	2.1	0.1	0.4	0.01	0.2	1.2
BW																
HBW	3009^a	108^a	472.3^a	15.7	79.4^a	2.6^a	60.2	2.0	65.5	2.2^b	63.9	2.1	9.7	0.3	6.9	17.8
LBW	2806^b	106^b	435.7^b	15.5	60.7^b	2.2^b	57.2	2.0	64.7	2.3^a	60.1	2.1	8.8	0.3	6.4	15.0
SEM	32.2	0.02	7.5	0.2	4.1	0.1	1.3	0.03	1.2	0.04	2.1	0.1	0.4	0.01	0.2	1.2
Interactions																
24 h x HBW	3052	108	468.3	15.3	76.4	2.5	62.3	2.0	70.5	2.3	68.2	2.2	10.1	0.3	7.4	18.8
24 h x LBW	2923	107	449.3	15.4	62.6	2.1	59.8	2.0	72.4	2.5	63.8	2.2	8.4	0.3	6.8	12.8
28 h x HBW	2965	108	476.3	16.1	82.5	2.8	58.0	2.0	60.6	2.0	59.7	2.0	9.3	0.3	6.4	16.9
28 h x LBW	2689	105	422.2	15.7	58.8	2.2	54.6	2.0	57.0	2.1	56.3	2.1	9.2	0.3	6.2	17.3
SEM	45.5	0.9	10.6	0.3	5.7	0.2	1.9	0.05	1.7	0.1	2.9	0.1	0.6	0.01	0.3	1.7

[a,b,c] Means within a main effect or within the four interactions with no common superscript differ significantly ($P<0.05$)

[1] Percent of live body weight

[2] Number of large yellow follicles (>10mm)

[3] Number of small yellow follicles (>5mm, but <10mm)

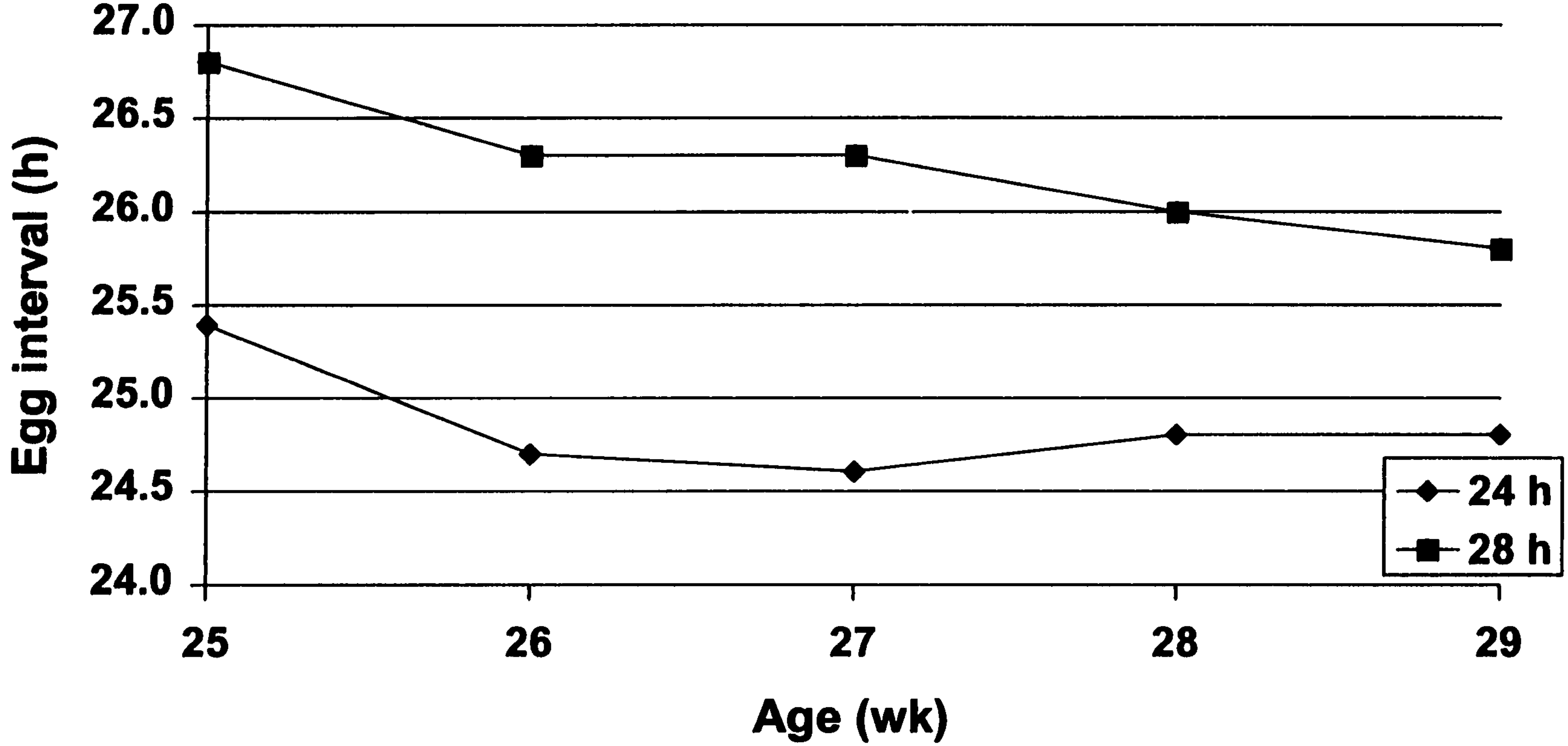

FIGURE 2-1. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) on the egg interval of broiler breeder hens from 25 to 29 wk of age.

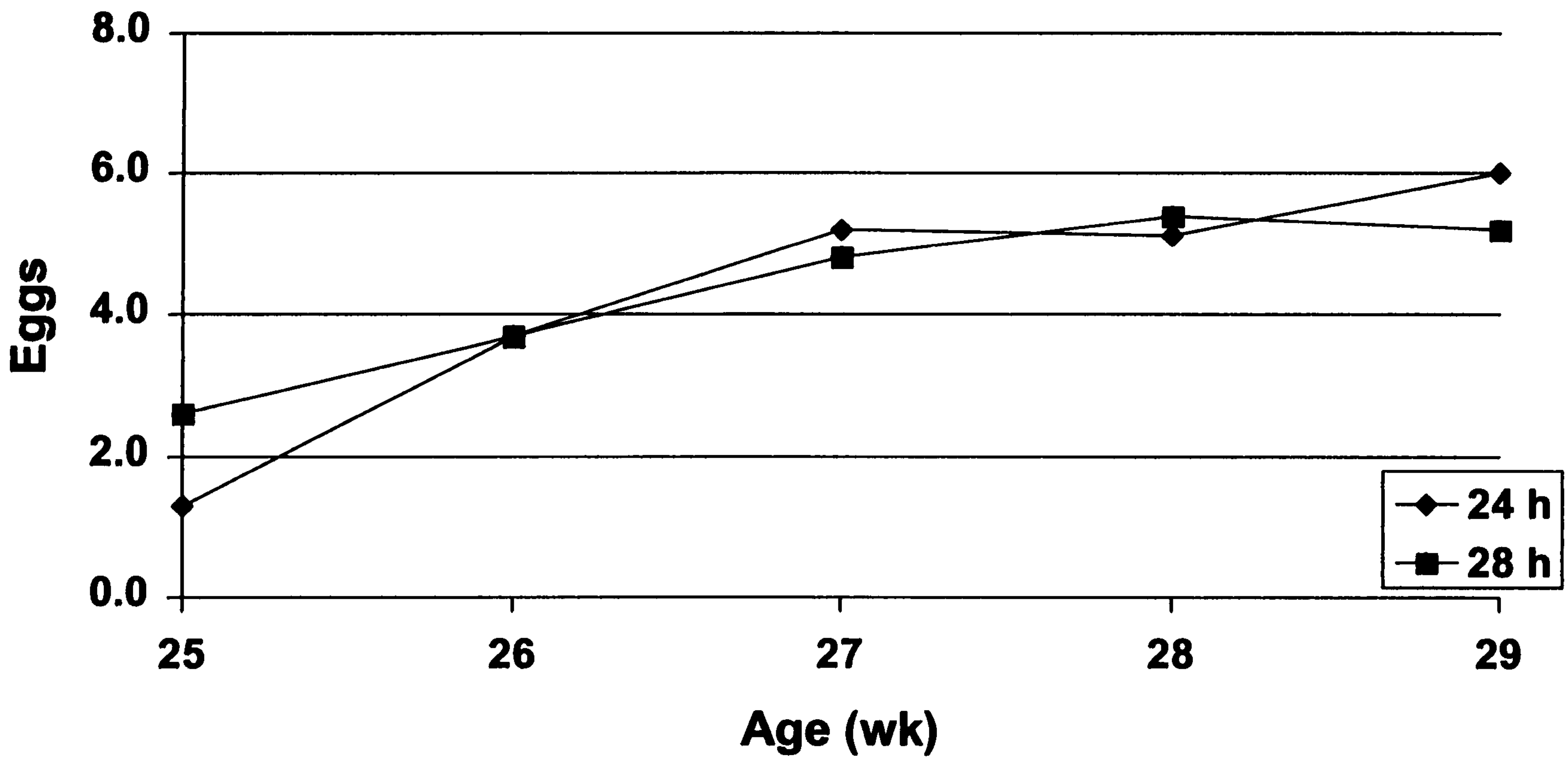

FIGURE 2-2. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) on average egg numbers per wk of broiler breeder hens from 25 to 29 wk of age.

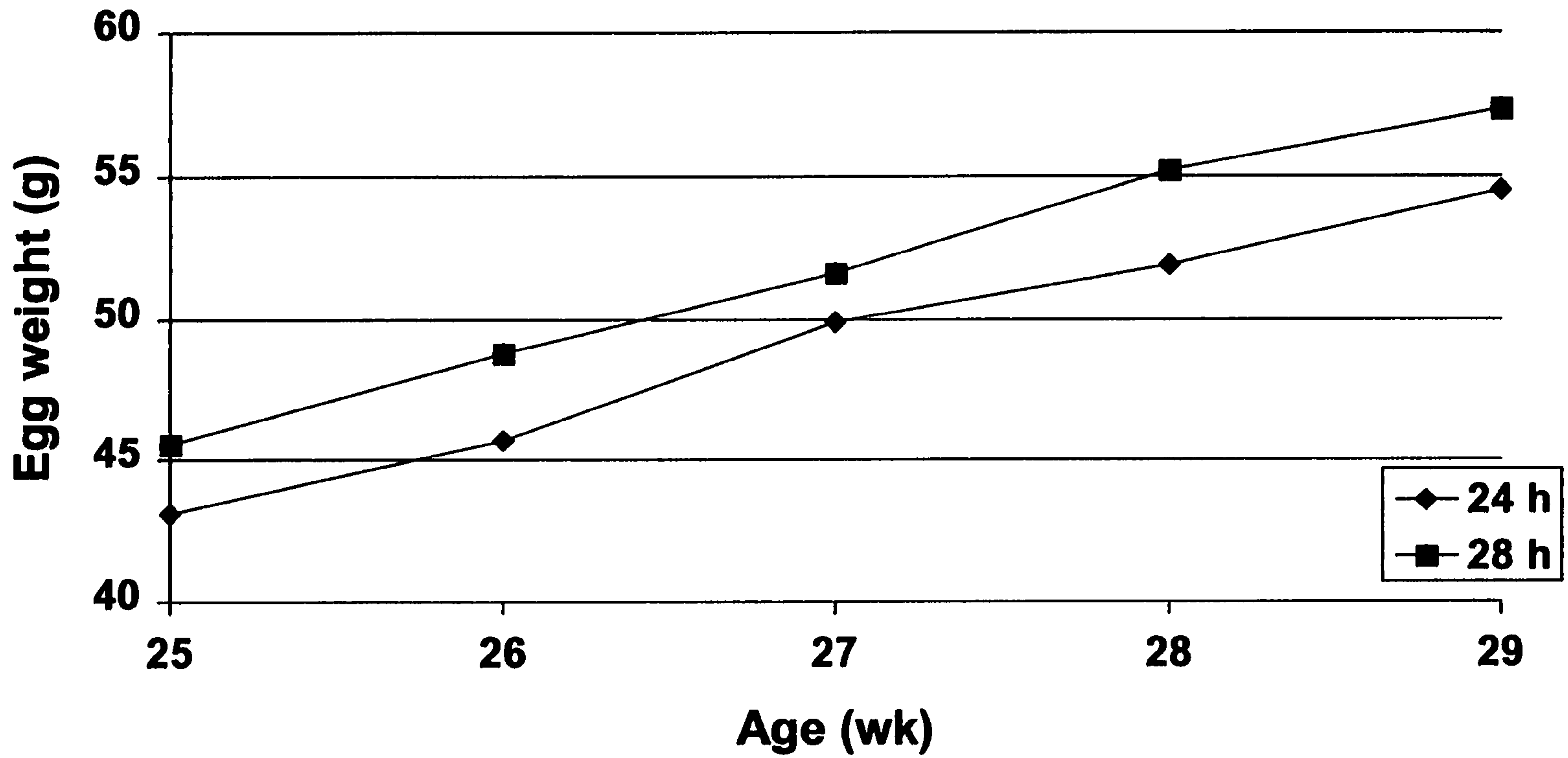

FIGURE 2-3. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) on average egg weight per wk of broiler breeder hens from 25 to 29 wk of age.

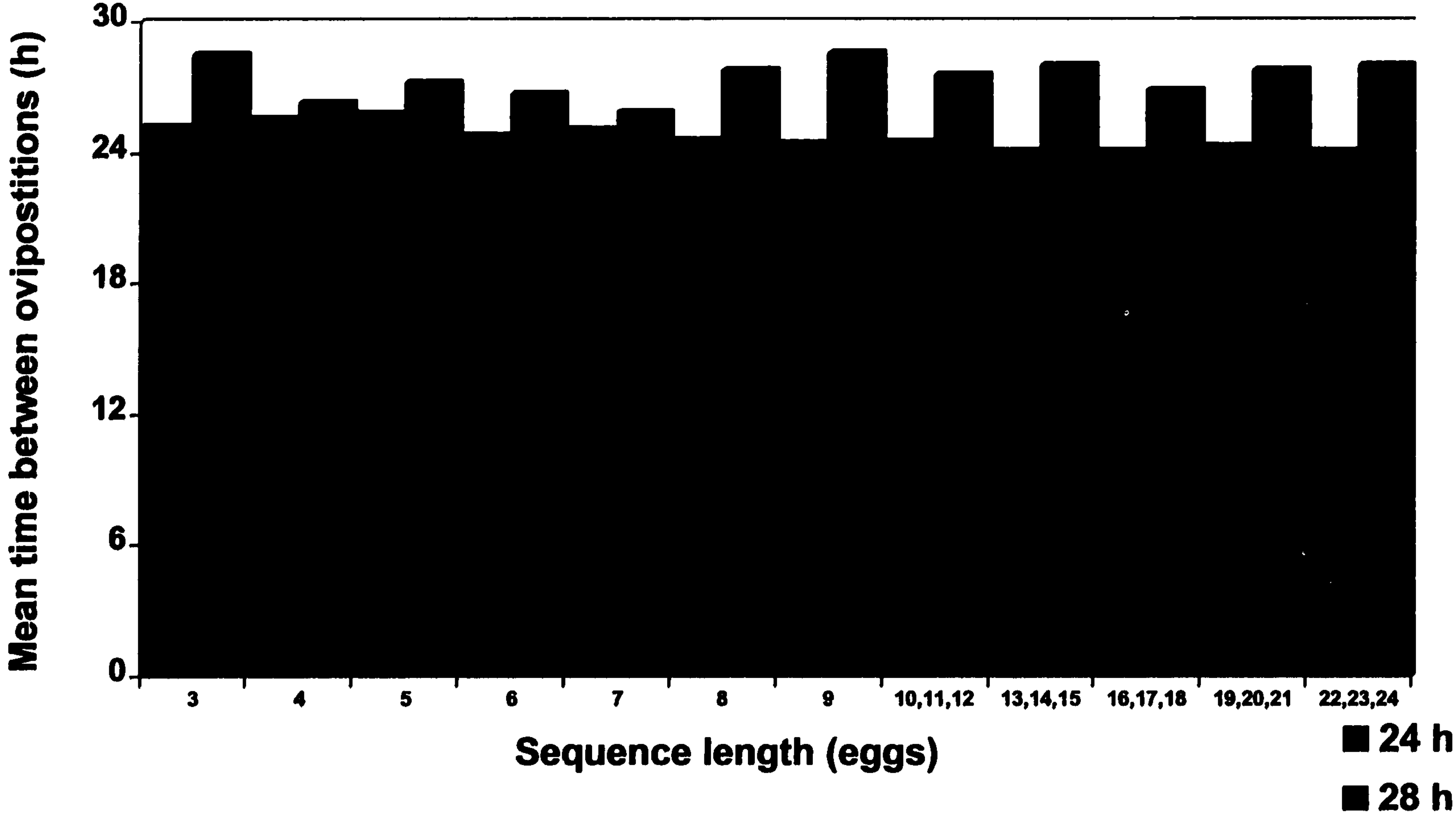

FIGURE 2-4. Effect of day length (14L:10D (24 h) and 14L:14D (28 h)) on mean time between consecutive ovipositions as it varies with sequence length for broiler breeder hens from 25 to 29 wk of age.

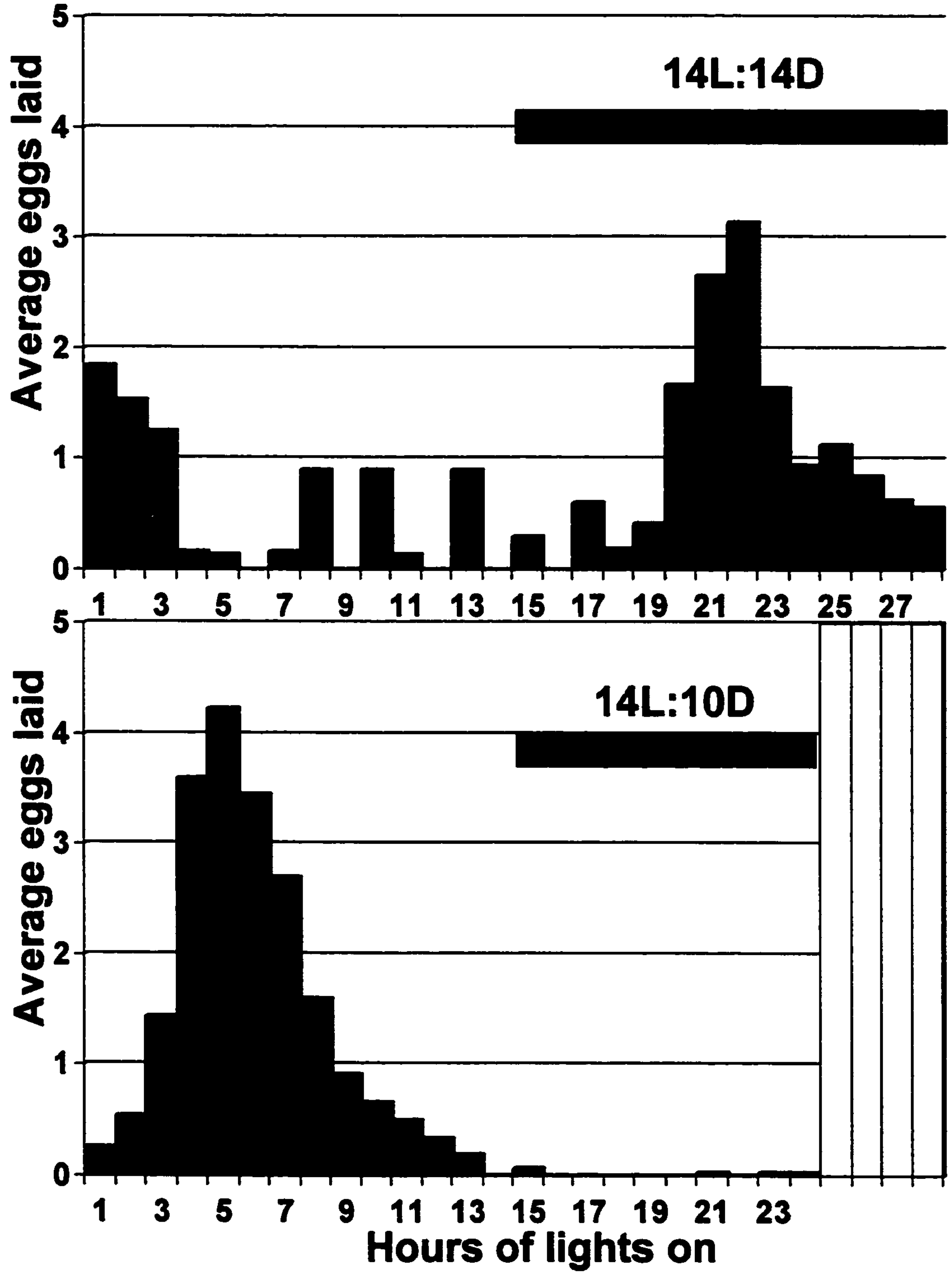

FIGURE 2-5. Effect of day length (14L:10D and 14L:14D) on the average eggs laid each hour after dawn for broiler breeder hens from sexual maturity to 29 wk of age. Each dark period is shown as a solid rectangle.

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3. THE CONSEQUENCES OF FEED ALLOCATION AFTER PEAK PRODUCTION IN BROILER BREEDER HENS

3.1 INTRODUCTION

It has been well established that there is a strong negative relationship between BW and reproductive efficiency in domestic fowl (Robinson *et al.*, 1993). Most of the current capacity for rapid growth seen in the broiler chicken today pose a number of problems to those involved in the management of their parents, the broiler breeders. It is obvious that measures must be taken so broiler breeders do not express their potential for growth and feed restriction is used to prevent obesity - related problems (Robinson *et al.*, 1993).

As egg production declines after peak egg production it is uncertain whether this decline is due to an excess energy intake or if feed has been reduced too quickly. Feed allocations may be kept too high before being reduced, causing excess fat deposition with the possibility of reproductive failure (Robinson *et al.*, 1993), or be reduced too quickly causing lack of sufficient nutrients, also with the possibility of reproductive failure (Robinson *et al.*, 1993). Therefore, after peak egg production, ideal feed allocation is a balance between overfeeding and underfeeding. Reproductive failure can be classified by alterations to egg production (increased age at sexual maturity (Katanbaf *et al.*, 1989), poor rate of lay (Robbins *et al.*, 1986), and termination of laying period due to death or ovarian regression (Yu *et al.*, 1992b)), and by alterations to chick production (the production of unsettable eggs (Yu *et al.*, 1992b), infertility (Bacon and Nestor 1979), and embryonic death (O'Sullivan *et al.*, 1991)).

Management guides recommend that feed intake be increased as birds start to reach peak egg production to accompany the increased demand on the body of growth and increasing egg production. Primary breeders currently recommend various degrees of feed restriction for each strain that permit a narrow range of body weight gain to be allowed for different environments. The degree of goodness of fit seen between target recommendations and actual performance is not known with certainty (Fattori *et al.*, 1991).

There is a considerable diversity of opinion as to the level of feed allocation (Fattori *et al.*, 1991) or the optimum timing and duration of feed restriction over both the rearing and breeding period (Yu *et al.*, 1992a,b). Current literature regarding feeding or energy level and broiler breeder hens does not specifically focus on post peak egg production. Attia *et al.* (1995), by determining the effect of reduced ME (94% or 88% the recommended level) intake on broiler breeders from photostimulation onward, stated that hens receiving the highest and recommended level of ME produced the most eggs per hen. In this same trial Attia *et al.* (1995) also stated that no changes were seen in egg weight, shell weight, shell characteristics, and proportions of albumen and yolk. Spratt and Leeson (1987) found that 385 kcal ME / d was adequate to maintain normal egg production during peak production of caged broiler breeder hens, which is about 100 kcal/bird/day less than what primary breeders recommend (Shaver Poultry Breeding Farms, 1994). This trial dealt with three levels of ME, and the effect on carcass fat and protein was opposite, as the low ME group had the lowest carcass fat and the highest carcass protein. Fattori *et al.* (1991) stated that proportional decreases in feed allocation resulted in a corresponding decrease in body weight, the frequency of double yolked eggs, and number of day in production.

The objective of this experiment was to determine the effects of the length of post peak feeding on egg production including egg size and egg components. The effects of post peak feeding on hatchability and carcass and ovarian morphology at 54 wk of age were also investigated.

3.2 MATERIALS AND METHODS

Two hundred Shaver Starbro broiler breeder pullets were acquired as day old chicks. Prior to arrival, the pullets were vaccinated for Marek's disease, and on arrival at the Alberta Poultry Research Centre, were wing banded. Birds were reared in floor pens, 50 pullets / pen, in a light tight facility with straw litter. Feed and water were provided on an *ad libitum* basis for the first 3 wk. From 3 to 21 wk of age weekly group BW measurements were taken and the pullets were feed restricted to maintain BW at the targets recommended by Shaver Poultry Breeding Farms Ltd. During this time period, feed was allocated on a 5/2 feeding program (restricted from feed 2 d / week) until 20 wk of age. All diets were wheat based, fed in mash form and formulated to meet or exceed NRC (1994) requirements (Table 3-1). The photoschedule during rearing was as follows: 24L:0D (24 h of lights followed by 0 h of dark) for the first 3 d followed by 8L:16D, from 3 d to 22 wk of age.

At 20 wk of age the 96 pullets closest to the 20 wk target BW were selected and assigned to individual laying cages. At time of housing, hens were assigned to one of four feeding treatments, 1 (1 wk), 3 (3 wk), 5 (5 wk), or 7 (7 wk) wk. These treatments were based on varying duration of maximal feeding. At this time the birds were fed individually, on an every day basis, and weighed at week intervals. At 22 wk of age the birds were photostimulated by increasing the photoschedule to 14L:10D. The total feed allocation from photostimulation until peak production was identical for all birds (Figure 3-1). After peak production, the duration for which the peak feed allocation was offered was varied, lasting 1, 3, 5, or 7 wk after peak production (Figure 3-1). Feed was allocated for the 1 wk group of hens to maintain BW at the targets recommended by Shaver Poultry Breeding Farms Ltd., feed removal rate for the 3 wk, 5 wk, and 7 wk hens was identical but after the designated maximal feeding time.

Beginning at sexual maturity, each hen was artificially inseminated at weekly intervals, with 0.05 ml of fresh, undiluted pooled semen from 60 Shaver Starbro males, maintained in the same facility. Starting at 29 wk of age, all settable eggs (egg weight ≥ 52 g, intact shell, and single yolk) were shipped weekly to a commercial hatchery (Lilydale Co-operatives Ltd., Edmonton, AB, T5C 1R9) and incubated. On the day of hatch, all non – hatched eggs were broken open and the fertility and stage of embryonic development determined by macroscopic examination. Embryonic death was assigned to one of three 7 d subdivisions of incubation. Percent fertility, hatchability, dead in shell (pipped but dead), cull chick, and hatchability of fertile eggs were calculated on an individual hen basis. Fertility was defined as the number of fertile eggs per 100 eggs set. Hatchability was defined as the number of eggs hatched per 100 set. Cull chicks are defined as chicks that were not dead but did not hatch successfully or had a low chance of survival per 100 set. Hatchability of fertile eggs set was defined as the number of chicks hatched per 100 fertile eggs.

The production of normal and defective (without an intact shell or single yolk) eggs and their weights was recorded daily for each hen. Oviposition records were used to determine total egg production, total settable egg production ($\geq$ 52 g, intact shell), number of ovulations, sequence lengths and percentage of defective eggs. At 28 wk of age and every 4 wk following (32, 36, 40, 44, 48, 52 wk of age), two normal eggs per hen (intact shell, single yolk), regardless of size, were weighed and broken open to determine the weight of its components (yolk, albumen and shell). At 54 wk the birds were killed by cervical dislocation for the study of ovarian morphology and carcass characteristics. The hens were weighed and dissected to determine weights of breast muscle, abdominal fat pad, liver, intact ovary, stroma and oviduct. Shank length, number of large (>10mm) and small (>5mm, <10mm) yellow ovarian follicles were also recorded.

Data were analysed as a one way analysis of variance using General Linear Models (GLM) procedures of SAS (SAS Institute Inc. 1994). Incubation trait data was analysed either before peak production or at intervals of 5 wk after peak production. All other data were analysed per data collection period (weekly for the egg production, egg wt, and body weight data and every four wk for the egg characteristic data). Differences between means were evaluated using Fisher's protected LSD procedure (Peterson, 1985). Unless otherwise stated, treatment effects were considered significant if $P<0.05$.

3.3 RESULTS AND DISCUSSION

3.3.1 Egg Production

Post peak feeding length had no effect on parameters associated with egg production (Table 3-2), including total number of sequences, average sequence length, prime sequence length (being the longest sequence (Robinson et al., 1990)), total eggs, total settable eggs, total shell less eggs, total double yolked eggs, and total eggs with abnormal shells. This lack of significance is also seen when looking at the sequence length analysis (Figure 3-2).

In a trial in which broiler breeder hens were used to determine the effects of quantitative feed restriction below breeder recommended levels, Fattori *et al.* (1991) determined that hens fed 16 or 24 % below recommended levels have lower hen day production to 64 wk of age. But Fattori *et al.* (1991) also stated that production would likely continue at acceptable levels to industry for several more weeks. In this same paper it was also stated that birds fed 16 or 24 % below recommended levels laid fewer double yolk eggs. This is also concurred by Katanbaf *et al.* (1989). Yu *et al.* (1992a), in a trial where broiler breeder hens were either feed restricted or fed *ad libitum* in the rearing and breeding period, noted an increased incidence of defective eggs from birds that were either feed restricted in the rearing or breeding period. These results are not consistent with our own and, in comparison to these other trials, may indicate an inadequate sample size.

3.3.2 *Egg Size and Characteristics*

Table 3-3 shows significant treatment differences in yolk weight at 36 wk of age, where the 5 wk hens had significantly larger yolks, as a proportion of egg weight, but these yolks were smaller in terms of gross weight. These results did not persist throughout the remainder of the trial. Also, shell proportional and gross weight was greater at 40 wk of age for the 5 wk hens (Table 3-3). These results also did not persist throughout the remainder of the trial. Overall egg weights were the same, except for the 5 wk birds which had smaller eggs, this difference was due to albumen weight only (Table 3-3) and is unexplainable. Figure 3-3 shows egg weight from 25 – 55 wk of age.

Fattori *et al.* (1991) stated that egg weight and characteristics were not affected by feeding level over the whole production period. These results are consistent with our results. Fattori *et al.* (1991) noted that specific gravity was improved when hens were fed 16 or 24 % less the standard feeding regimen. This is explained to be due to the numerical decrease in egg weight, and therefore a smaller air cell. Also, increasing only the crude protein level of breeder diets from 14% to 18% is reported to increase egg size and production (Joseph *et al.*, 1998, unpublished data). In contrast, Brake (1990) found that increasing feed and energy intakes had negative effects on eggshell quality. Our results did not support their findings and indicated that daily feed allotment had no influence on egg weight or egg characteristics.

3.3.3 *Fertility and Hatchability*

Post peak feeding length had no effect on incubation traits, including fertility, embryonic death, deads, culls, hatchability, and hatchability of fertile eggs (Table 3-4).

The lack of an effect of post peak feeding length (energy allotment) on fertility and hatchability, is in agreement in part by Brake (1990), who showed that increased energy allotment had no influence on hatchability. However, he showed an improvement in fertility by the addition of 4 % fat to the diet. In addition, Pearson and Herron (1981) showed that dietary energy influenced fertility in the last third of the production. Fattori *et al.* 1991) reported results similar to ours, feeding restriction treatments had no significant effects on fertility of total hatchability at any age. Small differences in BW, in general, do not influence fertility to any great extent (Fattori *et al.*, 1991), in part because when hens are inseminated frequently, sperm storage problems are not identified (Goerzen *et. al.*, 1996). Katanbaf *et al.* (1989) observed a difference in fertility in relation to level of feed allocation, with fertility being significantly lower in *ad libitum* fed hens. Hence, in naturally mating flocks, overweight hens may exhibit sperm storage difficulties, due to fat infiltration into sperm storage glands at the uterovaginal junction (McDaniel *et al.*, 1981). There is considerable evidence that embryo viability is affected by high BW, with losses due to late dead embroys (O'Sullivan *et al.*, 1991), low hatchability (Yu *et al.*, 1992b), reduced egg shell quality (Katanbaf *et al.*, 1989), and double yolked eggs (Williams and Robinson, 1989).

3.3.4 Body Weight and Body Characteristics

Figure 3-4 shows BW from 20 to 55 wk of age. Significant differences in BW were observed from 35 – 55 wk of age with the 5 and 7 wk hens having a higher BW than the 1 and 3 wk hens by the end of the trial. Table 3-5 shows the effect of post peak feeding length on carcass and ovary characteristics at 55 wk of age. The 5 and 7 wk hens had larger proportional fat pad weights, which was similar to the 3 wk hens but different from the 1 wk hens. Post peak feeding length had no effect on shank length, breast muscle weight, liver weight, oviduct weight, ovary weight, stroma weight, or the number of large and small yellow follicles.

The lack of significance in body characteristics is evidence of lack of severity of feed withdrawal. Excess energy intake is mainly stored as fat, which gradually results in increased body weight (Pearson and Herron, 1981). Spratt and Leeson (1987), in a trial which altered energy and protein intake of broiler breeder hens, stated that increases in BW are due to increased carcass fat (fat pad), which is consistent with our results. Yu *et al.* (1992a), in a trial where broiler breeder hens were either feed restricted or fed *ad libitum* in the rearing and breeding period, stated that the weight of the abdominal fat pad did not register the changes as quickly as the weight of the liver. This is true because fat is first metabolised in the liver then transported for use elsewhere in the body then if in excess transported to the fat pad for storage. These results were not consistent with ours, as we saw no change in liver weight. Yu *et al.* (1992b), noted that feed restriction at 18 wk of age in broiler breeder hens did not alter ovary weight, number of yellow follicles, or ovarian development. These results complement ours. The effect of energy intake on ovarian morphology has been analysed by Robinson *et al.* (1993), with the final conclusion that as energy intake increases follicular development will increase. These increases are seen in increased number of large follicles (Yu *et al.*, 1992b). In the same paper it was also observed that throughout lay birds that were full fed had, on average, two or more large follicles than did hens that were feed restricted. These follicles were included in the hierarchy in the form of double or triple hierarches (Robinson *et al.*, 1991a). It should be clarified that increased follicle development seen in response to overfeeding does not result in a significant increase in egg production (Robinson *et al.*, 1991b), and can be further reduced by ovarian regression (Yu *et al.*, 1992b).

In a practical industry setting, broiler breeders would not be housed individually as in this trial, taking away the competitive nature of broiler breeders when they are fed. So, regardless of when feed removal is begun in industry some broiler breeders will be at a disadvantage and be forced on a reduced diet allotment sooner, as the more aggressive hens will successfully eat their share first. Therefore, in industry, there may be less flock uniformity and consequently more variation in production. Also, in industry there is variability in when peak production occurs, as peak production was monitored daily this may not occur in industry. Our results showed that the 1 wk post peak fed hens consumed less feed and their BW remained at target levels, without reducing the number of hatching eggs per hen housed, when compared to the hens fed peak feed for 3, 5, or 7 wk. The results indicate that different post peak feeding levels can be used with broiler breeder hens without significantly affecting egg production, egg weight and egg characteristics, hatchability and fertility, and carcass and ovary morphology.

TABLE 3-1. Calculated composition[1] of nutrients in experimental diets

Nutrient	Starter 0 to 3 wk	Grower 3 to 20 wk	Layer 20 to 30 wk
AME (kcal/kg)	2900	2700	2750
Crude protein (%)	18.0	15.0	15.5
Calcium (%)	1.0	0.9	3.2
Available phosphorus (%)	0.7	0.6	0.5
Lysine (%)	0.9	0.8	0.8
Methionine (%)	0.4	0.4	0.4

[1] According to National Research Council (NRC 1994) guidelines

TABLE 3-2. Effect of peak feeding (1 wk, 3 wk, 5 wk, or 7 wk) on parameters associated with egg production from first egg to 55 wk of age

Peak feeding	Number of sequences	Average sequence length (d)	Prime sequence length (d)	Total eggs	Settable eggs[1]	Soft shell eggs (%)[2]	Shell less eggs (%)[2]	Double yolked eggs (%)[2]	Abnormal shell (%)[2]
1 wk	41.5	4.0	20.0	157.7	156.0	0.7	0.6	0.3	0.1
3 wk	46.9	3.7	16.5	160.0	156.8	1.7	0.6	0.4	0.5
5 wk	39.3	4.4	23.9	159.6	154.5	3.2	1.0	0.6	0.3
7 wk	42.0	3.9	23.4	159.0	153.9	2.0	1.1	0.7	1.3
SEM	2.1	0.3	3.1	4.1	4.4	1.4	0.3	0.2	0.5
P value	0.08	0.47	0.31	0.98	0.97	0.65	0.56	0.48	0.35

[1] Eggs whose wt $\geq$ 52 g
[2] Percent of total eggs

TABLE 3-3. Effect of peak feeding (1 wk, 3 wk, 5wk, or 7wk) on broiler breeder normal egg [1] characteristics every four wk from 28 wk to 52 wk of age

Age (wk)	Average egg wt. (g)	Egg Specific Gravity	Yolk wt. (g)	Yolk wt. (%)[2]	Albumen wt. (g)	Albumen wt. (%)[2]	Shell wt. (g)	Shell wt. (%)[2]
28								
1 wk	52.1	1.081	14.1	26.9	33.1	63.0	4.9	9.4
3 wk	53.9	1.081	14.4	26.6	34.5	63.5	5.0	9.2
5 wk	50.8	1.081	13.7	26.8	32.2	62.8	4.9	9.5
7 wk	52.2	1.078	13.8	26.3	33.9	63.4	4.8	9.1
32								
1 wk	58.7	1.079	16.7	28.1	36.6	61.5	5.4	9.1
3 wk	59.4	1.079	16.8	28.4	37.3	62.8	5.4	9.0
5 wk	56.7	1.080	16.0	27.9	35.3	61.4	5.4	9.3
7 wk	58.6	1.078	16.5	28.0	36.7	62.0	5.4	9.1
36								
1 wk	61.2	1.077	18.0[a]	29.3[b]	37.7	61.3	5.5	9.0
3 wk	62.4	1.077	18.5[a]	29.7[b]	38.2	61.3	5.6	9.0
5 wk	58.2	1.074	17.0[b]	29.2[a]	35.8	61.5	5.4	9.3
7 wk	62.2	1.077	18.3[a]	29.3[b]	38.3	61.1	5.6	8.9
40								
1 wk	62.9	1.076	18.7	29.5	38.7	61.1	5.6[b]	8.9[b]
3 wk	64.1	1.074	17.6	27.2	37.2	57.6	5.8[b]	9.1[b]
5 wk	62.0	1.076	18.1	29.2	37.5	60.3	6.3[a]	10.2[a]
7 wk	63.9	1.077	19.1	29.6	39.0	60.2	5.8[b]	9.0[b]
44								
1 wk	65.0	1.079	19.6	30.1	39.4	60.5	5.9	9.1
3 wk	65.1	1.080	19.6	29.9	39.8	60.6	6.0	9.2
5 wk	63.3	1.078	19.0	29.9	38.7	60.7	5.7	9.0
7 wk	65.4	1.078	19.7	30.0	39.8	60.5	5.8	8.9
48								
1 wk	66.4	1.074	20.2	30.5	40.1	60.1	6.0	9.0
3 wk	65.3	1.074	20.0	30.6	39.2	59.8	5.9	9.0
5 wk	64.7	1.073	19.7	30.2	39.2	60.2	5.8	8.9
7 wk	66.8	1.074	20.3	30.6	40.5	60.9	6.0	9.1
52								
1 wk	66.9	1.078	20.7	30.8	40.5	60.2	5.9	8.8
3 wk	67.0	1.079	20.3	30.2	40.6	60.4	6.0	8.9
5 wk	65.1	1.077	19.9	30.5	39.3	60.4	5.7	8.7
7 wk	68.0	1.078	20.8	30.5	41.2	60.5	5.9	8.7
SEM	0.9	1.2	0.8	1.3	0.7	0.6	0.4	0.6
Overall								
1 wk	61.9[a]	1.078	18.3	29.3	38.0[a]	61.1	5.6	9.0
3 wk	62.4[a]	1.078	18.2	28.9	38.1[a]	60.8	6.0	9.7
5 wk	61.0[b]	1.077	18.5	30.3	36.9[b]	60.5	5.6	9.2
7 wk	62.4[a]	1.077	18.4	29.2	38.4[a]	61.3	5.6	9.0
SEM	0.3	0.4	0.3	0.5	0.3	0.2	0.1	0.2

[a,b] Means within the main effect with no common superscript differ significantly ($P<0.05$)

[1] Eggs with an intact shell and single yolk

[2] Percent of fresh egg weight

TABLE 3-4. Effect of peak feeding (1 wk, 3 wk, 5wk, or 7wk) on incubation traits of broiler breeder normal eggs [1] from 29 to 55 wk of age

Age (wk)	Average eggs set per hen	Fertile (%)	Dead Stage – 1 (%)[2]	Dead stage – 2 (%)[3]	Dead stage – 3 (%)[4]	Dead chick (%)	Cull Chick (%)[5]	Hatchability (%)	Hatch of fertile (%)
29 - 30									
1 wk	6.0	93.7	2.8	5.2	2.7	0.0	1.9	80.1	85.5
3 wk	6.0	91.8	1.9	3.0	1.2	0.0	0.4	85.3	92.9
5 wk	6.1	90.1	2.0	4.8	1.2	0.0	0.0	82.1	91.1
7 wk	6.0	93.5	1.0	3.6	1.4	0.0	0.9	86.6	92.6
31 - 35									
1 wk	5.5	93.5	1.5	1.5	0.8	0.6	0.4	88.7	94.9
3 wk	5.3	93.3	2.5	3.2	0.3	0.0	0.5	86.8	93.0
5 wk	5.6	93.6	3.7	2.2	0.8	0.5	0.1	86.3	92.2
7 wk	5.6	93.1	1.2	1.4	2.1	0.3	0.6	87.5	94.0
36 - 40									
1 wk	4.9	97.2	2.0	1.7	1.0	0.2	0.8	91.5	94.1
3 wk	4.6	96.6	2.2	3.3	0.7	0.0	1.2	89.2	92.3
5 wk	4.9	95.4	3.1	3.0	1.5	0.3	0.5	87.0	91.2
7 wk	4.7	97.2	0.8	2.8	1.4	0.0	0.2	92.0	94.7
41 - 45									
1 wk	4.8	94.7	0.9	1.9	2.5	0.0	0.5	88.9	93.9
3 wk	4.7	95.3	1.2	1.2	2.2	0.0	1.0	89.7	94.1
5 wk	4.8	93.4	2.9	3.5	2.2	0.2	1.0	83.6	89.5
7 wk	4.8	92.5	2.1	3.3	1.4	0.0	0.6	85.1	92.0
46 - 50									
1 wk	4.6	96.4	1.7	2.6	2.4	0.6	0.9	88.2	91.5
3 wk	4.5	92.6	1.1	2.4	2.5	0.0	0.7	85.9	92.8
5 wk	4.5	92.4	2.5	3.3	1.5	0.2	0.7	83.9	90.8
7 wk	4.5	93.6	1.6	3.5	2.2	0.0	0.3	86.0	91.8
51 - 55									
1 wk	4.3	96.1	3.1	2.2	4.2	0.0	0.7	85.9	89.4
3 wk	4.2	95.3	2.6	2.8	2.0	0.1	0.4	87.2	91.5
5 wk	4.2	93.7	3.3	2.1	1.8	0.4	0.5	85.6	91.4
7 wk	4.0	92.1	1.7	1.5	2.4	0.1	0.5	85.9	93.3
SEM	0.2	1.8	1.0	3.0	2.0	0.1	0.5	3.5	3.0
Overall									
1 wk	5.0	95.6	1.8	2.2	1.9	0.2	0.8	88.7	92.8
3 wk	4.9	94.5	1.7	2.2	1.3	0.1	0.5	88.7	93.9
5 wk	5.0	93.9	2.5	2.6	1.4	0.2	0.4	86.8	92.4
7 wk	4.9	94.5	1.3	2.4	1.8	0.1	1.0	87.9	93.0
SEM	0.06	0.6	0.5	0.5	0.5	0.5	0.5	1.3	1.2

[1] Eggs with an intact shell and single yolk
[2] Embryonic mortality from 1 – 7 d of incubation
[3] Embryonic mortality from 8 – 14 d of incubation
[4] Embryonic mortality from 15 – 21 d of incubation
[5] Cull being chicks that are alive but not hatched or lacking survivability

TABLE 3-5. Effect of peak feeding (1 wk, 3 wk, 5 wk, or 7 wk) on carcass characteristics and ovary characteristics of broiler breeder hens at 55 wk of age

	BW	Shank length	Breast muscle wt.		Fat pad wt.		Liver wt.		Oviduct wt.		Ovary wt.		Stroma wt.		LYF[2]	SYF[3]
Peak feeding	(g)	(mm)	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]	(g)	(%)[1]		
1 wk	3478[b]	107	520.7	15.0	135.6[c]	3.9[b]	51.3	1.5	71.0	2.1	59.6	1.7	9.0	0.3	5.0	11.5
3 wk	3506[b]	107	520.6	14.9	155.6[bc]	4.5[ab]	51.9	1.5	70.7	2.0	58.6	1.7	7.8	0.2	5.0	11.7
5 wk	3706[a]	106	547.1	14.8	170.8[ab]	4.6[a]	55.9	1.5	73.2	2.0	59.1	1.6	8.5	0.2	5.1	10.4
7 wk	3704[a]	106	534.1	14.4	183.9[a]	5.0[a]	55.1	1.5	72.8	2.0	57.3	1.5	8.2	0.2	5.0	10.0
SEM	50.6	0.72	11.0	0.3	9.4	0.2	1.7	0.1	2.2	0.1	1.9	0.1	0.4	0.1	0.1	0.9
P values	0.01	0.94	0.27	0.48	0.01	0.02	0.17	0.97	0.81	0.85	0.90	0.26	0.23	0.16	0.84	0.45

[a,b,c] Means within the main effect with no common superscript differ significantly ($P<0.05$)

[1] Percent of live body weight

[2] Number of large yellow follicles (>10mm)

[3] Number of small yellow follicles (>5mm, but <10mm)

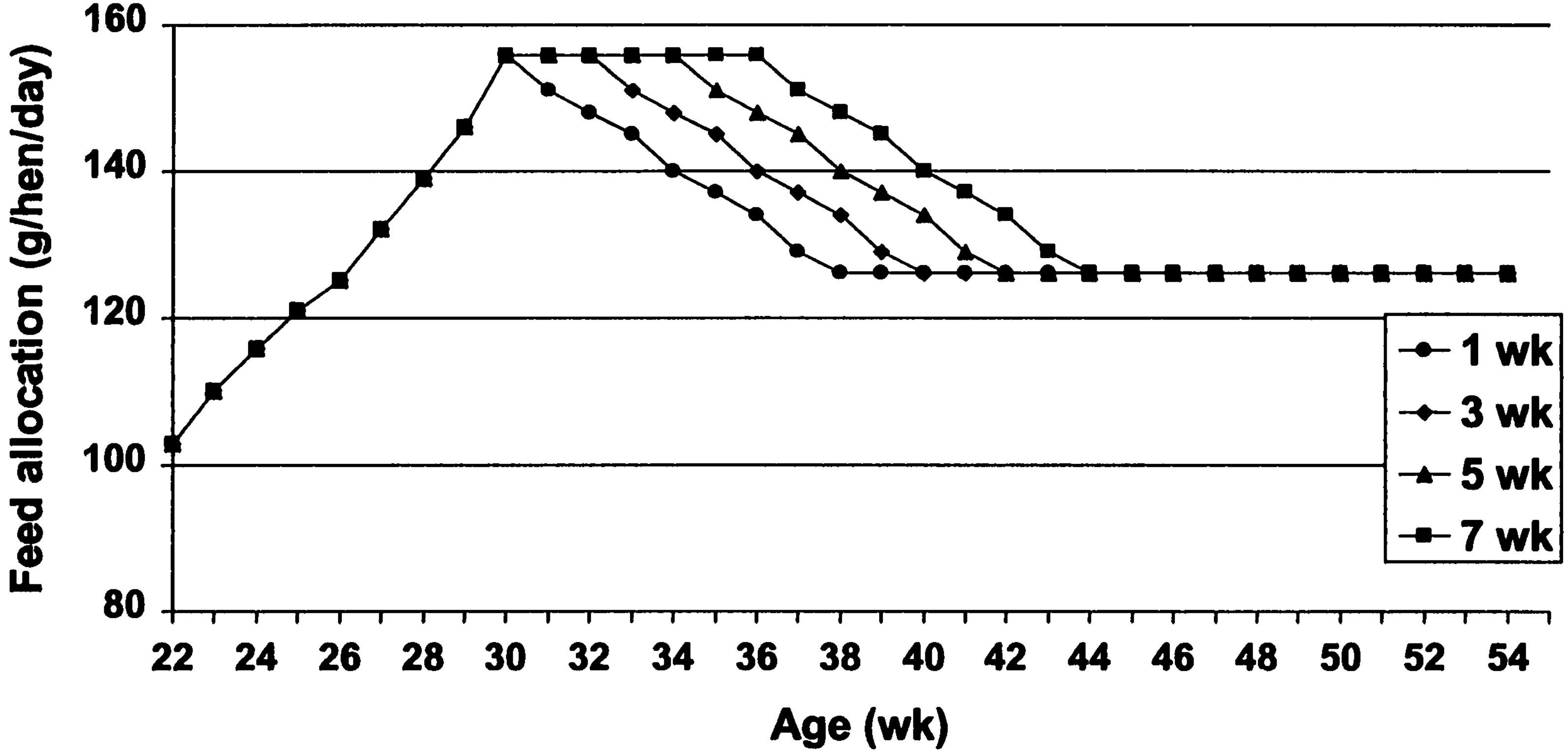

FIGURE 3-1. Feed allocations from 20 wk - 54 wk of age for different lengths of maximal feeding after peak egg production (1 wk, 3 wk, 5 wk, and 7 wk)

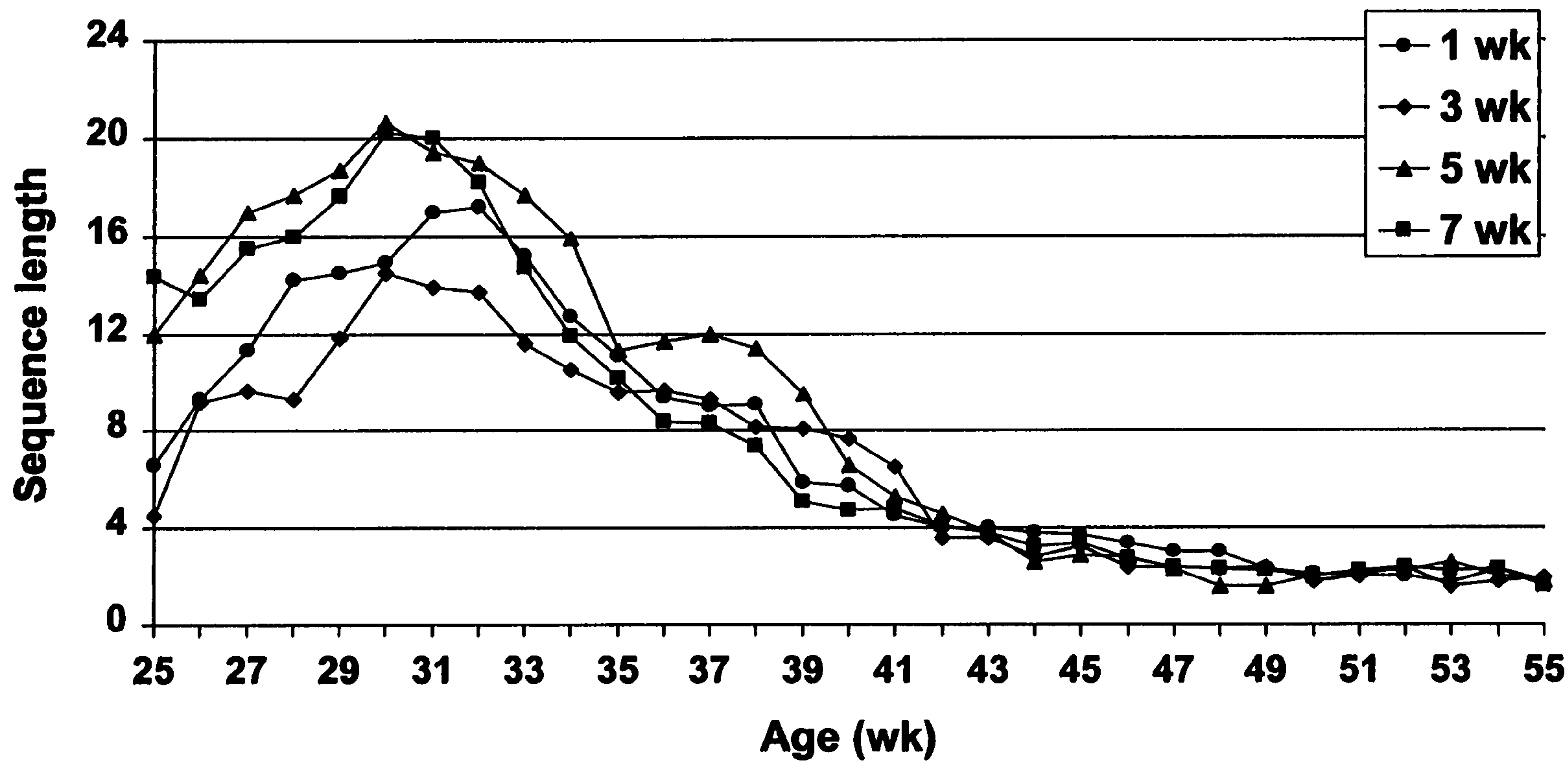

FIGURE 3-2. Sequence length from 25 wk - 55 wk of age for different lengths of maximal feeding after peak egg production (1 wk, 3 wk, 5 wk, and 7 wk)

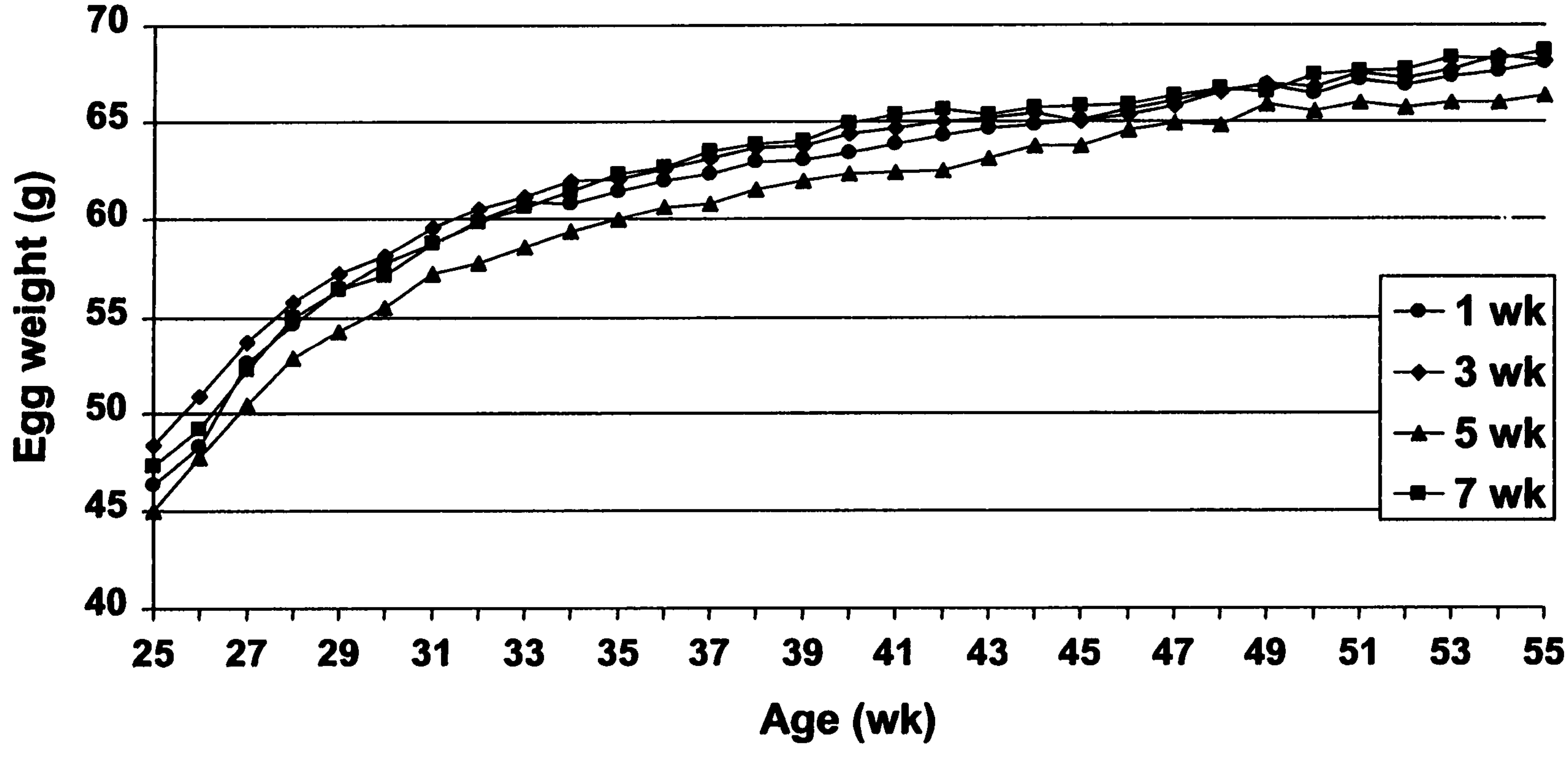

FIGURE 3-3. Egg weight from 25 wk - 55 wk of age for different lengths of maximal feeding after peak egg production (1 wk, 3 wk, 5 wk, and 7 wk)

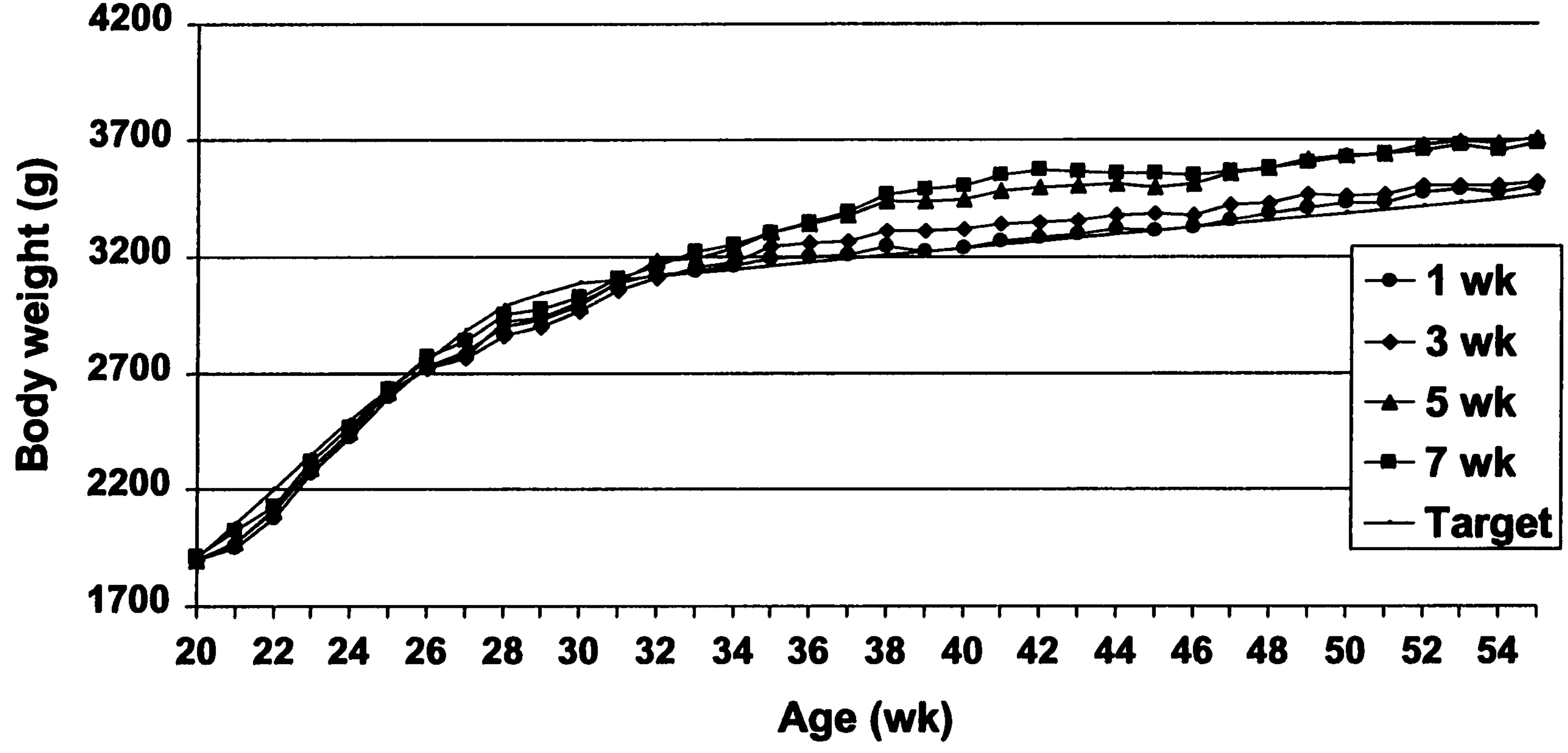

FIGURE 3-4. Body weight from 20 wk - 55 wk of age for different lengths of maximal feeding after peak egg production (1 wk, 3 wk, 5 wk, and 7 wk)

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4. GENERAL DISCUSSION AND CONCLUSIONS

4.1 INTRODUCTION

The modern broiler breeder female is a genetic compromise between two different selection criteria. While she must possess the genetic ability to grow rapidly, she must also be a very efficient producer of hatching eggs for broiler production (Robinson et al., 1993). The current research had two primary objectives. The first was to determine the effect of long ahemeral days and body weight on early egg production parameters and morphological characteristics of broiler breeder hens. The second objective was to determine the consequences of feed allocation after peak production in broiler breeder hens.

4.2 GENERAL DISCUSSIONS

When broiler breeder pullets begin to lay, their eggs may be smaller than the minimum size acceptable to commercial hatcheries. Interestingly, it has been shown that early egg size can be influenced by the hen's nutritional status (Waldroup and Hellwig, 1995), BW (Summers and Leeson, 1983), age at photostimulation (Robinson *et al.*, 1996) and genotype (Shanawany *et al.*, 1993), but photoschedule may have an effect as well (Etches, 1996). With this in mind much research has been done to determine the effects two of these management issues, lighting and feeding.

Lighting is a vital part of any egg laying fowl's success of reproduction, and long ahemeral days are an important tool of lighting. Much of the work dealing with ahemeral days has been conducted with Leghorns. There is very little data published on the effects of long ahemeral days on broiler breeders. Chapter 2 deals with the effects of a long ahemeral day and body weight on early egg production parameters and morphological characteristics of broiler breeder hens. Ahemeral photoschedules are ones in which the photophase and scotophase does not add up to 24 h. Short ahemeral days (<24 h) have mainly been used to select for hens with follicular maturation rates of less than 24 h (Morris, 1973). Long ahemeral days (>24 h) have been used to match follicular maturation rate with day length to result in oviposition of an egg each day (Shanawany, 1990).

A positive result of long ahemeral days early in lay is increased egg size. Egg size is thought to be increased due to additional hours of yolk deposition in ahemeral days, compared to hemeral days (Shanawany, 1990). It can be concluded, from this thesis that based upon the hen's egg interval while exposed to a hemeral day, a long ahemeral photoschedule could be used to improve egg production as well as egg weight. However, if the egg interval is too long the increase in egg weight may be at the expense of egg numbers. When considering the effect of day length on the body composition and ovarian morphology it is evident that the distribution of nutrients was different when hens are exposed to a 24 h or 28 h day length. While the 28 h birds had a higher proportional breast muscle weight and fat pad weight, relative to body weight, the 24 h birds had proportional higher oviduct and ovary weight, relative to body weight. The higher ovary weight can be attributed to the greater number of large yellow follicles. Zimmermann and Nam (1989), in a trial comparing White Leghorns on a hemeral and ahemeral (27 h) photoschedule, reported that the feed needed for reproduction (feed/egg) was not significantly different between groups. The trial described in chapter 2 did not demonstrate a significant increase in proportional body fat (fat pad) but did demonstrate the increased proportional body protein (breast muscle). The ability for the hens to gain body protein while in an energy deficit is evident, but little is known of the mechanisms involved.

In can be concluded that a 28 h ahemeral lighting schedule should be used only when it is being used on a strain of broiler breeder whose egg interval is greater than or equal to 28 h. If a long ahemeral day length is to be only used to increased egg size it is advised that while egg size will increase the majority of increases will be in the less beneficial components of the egg, the shell. The suitability of long ahameral days for increasing egg production late in lay needs to be examined, however, an increase in egg weight at that time is a disadvantage not an advantage.

Feed restriction is a necessary management technique for broiler breeders to prevent obesity and consequently the problems associated with obesity (Robinson et al., 1993). Most commercial broiler breeders are feed restricted during rearing and breeding to limit body weight. Most management guides recommend that feed intake be increased as birds start to reach peak egg production to accompany the increased demand on the body of growth and increasing egg production. At some point, typically around 32 wk of age, egg production declines, and feed intake is reduced to take into account the decreased nutrient needs of egg output. Current literature regarding feeding or energy level and broiler breeder hens does not specifically focus on post peak egg production, although, has been well documented for other periods or the whole production cycle. Attia *et al.* (1995), while determining the effect of reduced ME (94% or 88% the recommended level) intake on broiler breeders from photostimulation onward, stated that hens receiving the highest and recommended level produced the most eggs per hen. In this same trial Attia *et al.* (1995) also stated no changes were seen in egg weight, shell weight, shell characteristics, and proportions of albumen and yolk. Spratt and Leeson (1987) found that 385 kcal ME / d was adequate to maintain normal egg production during peak production of caged broiler breeder hens. Fattori *et al.* (1991) stated that proportional decreases in feed allocation resulted in corresponding decreases in body weight frequency of double yolked eggs, and number of days in production.

The lack of an effect of post peak feeding length (energy allotment) on fertility and hatchability in Chapter 3, is in agreement in part by Brake (1990), who showed that increased energy allotment had no influence on hatchability. However, he showed an improvement in fertility by addition of 4 % fat to the diet. The lack of significance in body composition results is evidence of lack of severity of feed withdrawal. Excess energy intake is mainly stored as fat, which gradually results in increased body weight (Pearson and Herron, 1981). Spratt and Leeson (1987), in a trial which altered energy and protein intake of broiler breeder hens, stated that increases in BW is due to increased carcass fat (fat pad), which is consistent with our results.

The results of the study in Chapter 3 indicate that different post peak feeding levels can be used with broiler breeder hens without significantly affecting egg production, egg weight and egg characteristics, hatchability and fertility, and carcass and ovary morphology. The 1 wk post peak fed hens consumed less feed and their BW remained at target levels, without reducing the number of hatching eggs per hen housed, when compared to the hens fed peak feed for 3, 5, or 7 wk.

4.3 CONCLUSIONS

Lighting seems to be one of the most important management tool for achieving optimal reproductive efficiency. Using long ahemeral days seems to be useful in terms of increasing early egg size, but this may be at the expense of egg numbers. These results have shown that there is an egg size difference between hens which were on a 24 h day as opposed to a 28 h day. There was no difference between egg numbers between these two groups to 30 wk of age, and it was not studied what might happen after this time. Also, interestingly egg lay time was shifted to the dark period in the hens exposed to the 28 h day, this has been reported in Leghorns by Etches (1996), but has not yet been shown in broiler breeders. This is most likely due to an extension of the open period. As far as feed allocation after peak is concerned, based on results reported in Chapter 3, it is not of consequence. Neither egg size nor production were affected, except for the overall egg weight in the 5 wk peak fed birds, which may be due to a small sample size.

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