

# Historical and Current Molting Practices in the U.S. Table Egg Industry

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**ABSTRACT** Induced molting is a management practice used primarily by commercial egg producers to optimize the utilization of their layer flocks. Historically, flocks produced eggs for a laying cycle of 1 yr duration and then were sold. With induced molting, flocks are molted and returned to lay for additional laying periods, thereby spreading fixed costs over longer time and more units of production. It is estimated that today more than 75% of

all flocks are molted as a part of a regular replacement program. The decision to molt or to operate an all-pullet program is based upon comparisons of flock performance and prices for replacement pullets, eggs, and feed. Justification for the use of molting, therefore, is in the higher total productivity of flocks, reduced costs associated with production, and reduced industry investments in breeder farms, rearing farms, and hatcheries.

(*Key words:* induced molt, force molt, molt, recycling of layers, replacement program)

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## HISTORY AND CURRENT USE OF INDUCED MOLTING

The frequency of use of induced molting in the U.S. as a commercial management practice for table egg-producing flocks during the past century can only be inferred due to the lack of national statistics prior to 1967. Over the last century, however, numerous references to the practice appeared in poultry text books (e.g. Rice, 1905; Hutt, 1949; Bell, 2002), university publications (e.g., Rice et al., 1908; King and Trollope, 1934; Knowlton, 1936; Washington State University, 1941; Wilson et al., 1969; Morris, 1970a,b; Swanson and Bell, 1974a,b,c, 1975a,b, 1976), and the popular press (e.g., McClelland, 1946; Thompson, 1955; Hansen, 1961, 1967).

Dozens of research reports including extensive studies of various molting methods have been published in scientific journals. Included in these are a series of important papers on the physiology of molting (e.g., Brake et al., 1979; Brake and Thaxton, 1979a,b; Garlich et al., 1984; Decuypere and Verheyen, 1986). In addition to the above, several exhaustive reviews of the subject have been published in scientific journals (e.g., Wakeling, 1977; Wolford, 1984). The issue of animal welfare and molting with emphasis on alternative molting methods was also reviewed by Bell (1996).

During the 1930s, the practice had gained widespread usage in the Pacific Northwest. By the 1950s, egg producers in California had adopted the practice almost universally. The 1960s and 1970s saw a peak in research regarding

the practice with dozens of papers published in various scientific journals throughout the world. By the mid-1970s, the practice had spread to most major egg-producing regions throughout the U.S. and into many other countries.

In 1999, a national survey conducted by the USDA Animal and Plant Health Inspection Service (USDA, 2000) found that 74.2% of the sites surveyed had molted their last completed flocks, 62.1% had molted their last flocks once, and 12.1% had molted their last flocks twice. Regionally, the southeast region used molting most intensively (93% of the flocks) compared to only 51% for the central region. The USDA National Agricultural Statistics Service lists two states, New York and Maine, as having the lowest percentage (< 0.5%) of molt-induced laying hens of all the 30 states sampled in July 2002. The USDA estimates that, in 2001, 75 million (27%) of the nation's 276 million layers either were actively in or had completed an induced molt at any given point in time. The remainder of the flock was too young to have been molted or were kept for only one egg production cycle.

## GENERAL BACKGROUND

Induced molting is used as a part of a program to optimize the use of replacement pullets on commercial layer farms. With current management systems, farms using the single-cycle (nonmolted) program would require 8.4 new flocks per layer house over a 10-yr period, whereas only 5.7 flocks would be required for a typical two-cycle (one-molt) flock system. This assumes sale at 80 wk for the one-cycle program compared to sale at 110 wk for the two-cycle

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**Abbreviation Key:** AVMA = American Veterinary Medical Association; UEP = United Egg Producers.

TABLE 1. Performance results during the first 10 wk of cycles 1, 2, and 3<sup>1</sup> (Data source: Chilson's Management Controls, Rancho Cucamonga, CA)

Trait <sup>2</sup>	Week of production									
	1	2	3	4	5	6	7	8	9	10
Mortality (%/wk)										
Cycle 1	0.129	0.136	0.137	0.133	0.131	0.127	0.126	0.121	0.127	0.126
Cycle 2	0.444	0.647	0.482	0.218	0.179	0.178	0.183	0.186	0.176	0.164
Cycle 3	0.401	0.609	0.303	0.213	0.177	0.190	0.184	0.191	0.212	0.234
Egg production (%)										
Cycle 1	27.3	47.6	66.0	77.8	84.7	87.1	88.6	89.4	89.4	89.4
Cycle 2	17.2	1.3	1.1	3.6	12.9	29.7	48.8	62.1	72.0	76.8
Cycle 3	16.4	1.2	3.4	9.4	21.1	29.7	49.7	63.8	70.3	73.3
Egg weight (g/egg)										
Cycle 1	45.9	47.5	49.1	50.8	52.3	53.6	54.7	55.6	56.3	56.8
Cycle 2	62.9	62.9	61.9	62.1	61.4	61.9	62.5	63.0	63.8	63.9
Cycle 3	64.1	63.4	61.5	63.0	63.0	62.7	63.1	64.3	64.3	64.1
Feed intake (g/h/d)										
Cycle 1	77.1	81.2	83.5	87.1	90.7	92.1	93.4	94.8	95.7	97.1
Cycle 2	16.4	41.2	72.3	81.1	88.5	94.0	97.2	99.4	100.7	100.7
Cycle 3	26.8	55.7	81.8	87.9	92.9	100.3	100.8	104.3	105.7	99.7

<sup>1</sup>Cycle 1 begins with wk 21; cycle 2 begins with wk 1 of the molt at an average age of 69 wk; cycle 3 begins with wk 1 of the second molt at an average age of 104 wk.

<sup>2</sup>Average number of flocks (wk 1 to 10 of each cycle): cycle 1, 379; cycle 2, 276; cycle 3, 45.

program. As a result, 47% more chickens would be required to keep houses full with the one-cycle option. In general, one brood-grow house would supply enough replacement pullets for only three lay houses when using the one-cycle option, five lay houses for the two-cycle option, and seven lay houses for the three-cycle option. Under the right economic conditions, the economically useful life of a laying flock may be extended from less than 80 wk to 110 wk (+37.5%) or even to 140 wk (+75%) through the judicious use of the molting process.

The American Veterinary Medical Association (AVMA, 2002) has a published position paper that lists numerous key components of an acceptable molting program. These include careful monitoring of the molting procedure relative to weight changes, mortality, egg production, and behavior. Long-term feed and water removal resulting in high levels of mortality is not acceptable. Induced molting is a management practice that should be conducted under careful supervision and control.

## JUSTIFICATION FOR MOLTING

Induced molting is a procedure used to rejuvenate laying flocks for a second or third cycle of production. Molting, in nature or induced by the farmer has the same effect—rejuvenation of the flock with higher egg production, renewal of feathering, and improvements in egg quality (Tables 1 and 2). Following an induced molt at 65 to 70 wk of age, flocks commonly return to egg production, mortality, and egg quality values similar to a 40 to 50 wk flock. This not only lengthens the productive life of flocks but also provides a means of optimizing the use of resources with enhanced returns on investments.

## RELATIVE PERFORMANCE OF MOLTED AND NONMOLTED FLOCKS

Numerous papers have been written comparing various measures of performance in different laying cycles of laying hens. Economic comparisons are heavily dependent upon comparative performance data. Some of this research compared molting results in random sample tests involving multiple strains and breeds of laying hens (e.g., Marble, 1963; Len et al., 1964). Other studies have concentrated on field data from commercial laying flocks (e.g., Bell, 1965; Swanson and Bell, 1970, 1974c; Bell and Swanson, 1974; Bell and Adams, 1992).

Farm-flock data collected in 1997 to 1998 of approximately 25 million White Leghorn laying hens from more than 350 commercial flocks in all regions of the U.S. has been analyzed to compare performance in the first, second, and third cycles of production (Tables 1 and 2). Four performance traits were compared.

### Mortality

Weekly rates of mortality during the 10-wk molting period and at 5-wk intervals are listed in Tables 1 and 2, respectively. Molt mortality rates doubled during the first week of the molt compared to premolt levels. Rates doubled again during the second week. Rates during the third week returned to wk 1 levels, and by wk 4, mortality had returned to premolt levels. Individual flocks demonstrate large ranges in molt mortality during this period due to different molting programs and to strain and management conditions. This variance is why it is recommended that daily mortality should be monitored during this critical

TABLE 2. Performance results at 5-wk intervals during cycles 1, 2, and 3<sup>1</sup>

Trait <sup>2</sup>	Week of production											
	1	5	10	15	20	25	30	35	40	45	50	55
Mortality (%/wk)												
Cycle 1	0.129	0.131	0.126	0.145	0.144	0.143	0.152	0.164	0.180	0.182	0.193	0.245
Cycle 2	0.444	0.179	0.164	0.177	0.189	0.185	0.205	0.212	0.217	0.237	NA <sup>3</sup>	NA
Cycle 3	0.401	0.177	0.234	0.225	0.257	0.269	0.287	0.373	NA	NA	NA	NA
Egg Production (%)												
Cycle 1	27.3	84.7	89.4	88.1	86.0	83.6	81.1	78.9	76.0	73.7	71.1	68.8
Cycle 2	17.2	12.9	76.8	79.1	77.2	74.6	72.1	69.3	66.4	63.9	NA	NA
Cycle 3	16.4	21.1	73.3	73.7	70.9	67.9	64.3	60.6	NA	NA	NA	NA
Egg weight (g/egg)												
Cycle 1	45.9	52.3	56.8	59.0	60.2	61.1	61.8	62.1	62.6	62.9	63.4	63.9
Cycle 2	62.8	61.3	63.8	63.6	63.8	63.5	63.8	64.3	64.6	64.7	NA	NA
Cycle 3	64.1	62.9	64.1	64.0	63.5	63.3	63.8	63.9	NA	NA	NA	NA
Feed intake (g/h/d)												
Cycle 1	77.1	90.7	97.1	98.9	100.2	101.2	101.1	101.3	101.7	101.3	102.7	102.6
Cycle 2	16.4	88.5	100.7	100.6	101.0	101.7	101.5	101.2	98.7	99.4	NA	NA
Cycle 3	26.8	92.9	99.7	101.7	103.9	103.1	102.7	102.7	NA	NA <sup>n</sup>	NA	NA

<sup>1</sup>Cycle 1 begins with wk 21; cycle 2 begins with wk 1 of the molt.

<sup>2</sup>Average number of flocks (wk 1 to 10 of each cycle): cycle 1, 379; cycle 2, 276; cycle 3, 45.

<sup>3</sup>NA = not applicable (too few flocks).

period. The most frequent mortality rate during wk 1 and 2 were 0.10 to 0.19%/wk. Average weekly mortality rates were 0.444 and 0.647% (first cycle) and 0.401 and 0.609% (second cycle) for wk 1 and 2, respectively. Weekly mortality curves increased over time within cycles with similar slopes during the first two cycles with a steeper slope in cycle three. Age appears to be the primary cause of increasing mortality rates, with the exception of the molt period itself. When mortality in first cycle flocks was regressed to corresponding ages for second cycle flocks, total mortality was equal at 105 wk of age.

### Egg Production

Relative egg production rates have been well documented in previous studies. The current study reflects a much larger sample of U.S. flocks and current strains of layers. Egg production during molt decreased to <5% by wk 2 and remained at that level for approximately 3 wk. The highest single week of egg production was reached in wk 8 in the first cycle (89.4%), in wk 13 in the second cycle (79.5%), and in wk 13 in the third cycle (74.7%). Egg production curve slopes in the first and second cycles were comparable but slightly steeper in the third production cycle.

Egg production peaks during the second cycle are commonly around 75 to 85%. In this data base, 7.3% of the flocks peaked at 85% or higher. The author has observed individual flocks peaking at more than 90% for several weeks in the second laying cycle.

### Egg Weight

The most significant difference in performance between cycles is for egg weight. This is particularly evident during

the first 20 wk of lay. Egg weight during the first cycle remains below 60 g per egg until wk 20 of lay. During wk 1 to 10, in the first cycle, eggs average only 52.3 g per egg compared to 62.6 and 63.4 g in the second and third cycles, respectively. A comparison of egg weights during 35 wk of production shows 57.4, 63.4, and 63.7 g per egg for the three cycles, respectively. At typical U.S. price differences for the different egg weight categories, the eggs from the second and third cycles would be worth approximately one cent per dozen more than eggs from first cycle flocks.

### Feed Consumption

Practically no differences in feed consumption were recorded except during the molt period. During the first 10 wk of each cycle, flocks consumed 89.3, 79.2, and 85.6 g of feed per day for first, second, and third cycles, respectively. These differences reflect the feed restriction molting methods used by most producers. Feed consumption rates for entire cycles were 96.3, 95.5, and 97.6 g per day for the first cycle (21 to 76 wk of age), the second cycle (Wk 1 to 40), and the third cycle (Wk 1 to 35), respectively.

### Egg Quality

Typically, most measures of egg quality deteriorate as flocks age. This deterioration includes both interior and external traits. In most cases, reduced egg quality is the most important criterion used to determine when flocks are molted or sold. Improvements in egg quality parameters are very evident after an induced molt (e.g., Len et al., 1964; Noles, 1966; Swanson and Bell, 1975a). In general, albumen quality, candled grade, shell thickness, specific

gravity, and shell texture improve when flocks are molted after 12 mo of lay back to the level 6 mo earlier.

Multiple early molting (Hansen, 1967) was developed to take advantage of the superior egg quality associated with shorter laying cycles. With this program, laying cycles are shortened to approximately 30 wk, and flocks are molted two or more times. This program is still used by commercial egg producers today as indicated by the 12.1% of double-molted flocks found in the USDA survey in 1999 (USDA, 2000).

## METHODS USED TO INDUCE A MOLT

Molting methods are of three basic types: 1) feed removal or limitation, 2) low-nutrient rations, 3) feed additives. Variations in each of these include modifications in the length of treatment, additional associated factors such as lighting program alterations, use of resting rations and periods, and age at initiation of the molt procedure. Molting method research has been actively pursued during the 1960s and 1970s and is currently drawing more attention in replacing traditional feed removal programs. An ideal molting method should be simple to apply, be low in cost, result in low mortality, and lead to high subsequent performance (Swanson and Bell, 1974b).

### *Traditional Feed Removal*

In an informal survey of U.S. poultry nutritionists in 2002, it was discovered that practically all of their industry producer contacts used the feed removal method when molting their flocks. Considerable variation in the details of the molting procedure were evident with feed removed for as little as 5 d to as much as 14 d. A second source of variation is whether or not to include a resting period following feed removal. This period may vary from 0 to 21 d postfast.

Published materials relative to molting methods include general recommendations (e.g., Rice et al., 1908; Knowlton, 1936; Wilson et al., 1967; Morris, 1970b; Swanson and Bell, 1974b; Bell, 1989) and experimental data (e.g., Wilson et al., 1967; Whitehead and Shannon, 1973; Nesbeth et al., 1976a,b; Harms, 1981, 1983; Naber et al., 1984; Bell and Kuney, 1992). United Egg Producers (UEP), in their 2002 Animal Husbandry Guidelines, suggests monitoring molt mortality and body weight loss as an indicator to determine when to place fasted hens back on feed. They suggest the body weight losses should be limited to 30% of the starting weight and that feed should be returned when mortality reaches no more than 1.2% of the starting count (UEP, 2002).

Feed removal programs have received considerable attention relative to the animal welfare issue in recent years, and the AVMA suggests that use of feed restriction programs should be minimized and that additional research is needed to improve the welfare aspects of the molting process (AVMA, 2002). In a similar respect, UEP urges producers and researchers to work together to develop alternatives to feed withdrawal for molting (UEP, 2002).

### *Nonfeed Removal*

These procedures involve either feeding deficient levels of nutrients or the addition of substances in the feed which inhibit egg production. The nutrient restriction procedure is the method of choice in countries that have disallowed feed removal programs. Nutrient restrictions have been successfully employed using marginal levels of salt or sodium (e.g., Nesbeth et al., 1976a,b; Harms 1981, 1983; Naber et al., 1984), calcium (e.g., Douglas et al., 1972; Blair and Gilbert, 1973; Martin et al., 1973), and low-nutrient diets composed primarily of grain, high-fiber feeds, or other low-nutrient feedstuffs (e.g., Bell et al., 1976). Various high concentrations of minerals have been used to halt egg production. Examples of these include zinc, aluminum, and potassium iodide (e.g., Arrington et al., 1967; McCormick and Cunningham, 1984a,b, 1987; Hussein et al., 1989).

Additional research has reported using various additives such as progesterone, enheptin, I.C.I. drug 33828 (Imperial Chemical Industries, Ltd., UK), and others (e.g., Adams, 1955; Pino, 1955; Robblee and Clandinin, 1955; Shaffner, 1955; Bearnse, 1967). Numerous research projects are in various stages of completion at several universities and commercial farms to perfect alternative molting systems that will be acceptable to the egg industry and the general public and to meet the goals of the AVMA and UEP.

## AGE AT MOLT

The data in Tables 1 and 2 describe performance characteristics for three production cycles based upon an average age at molt of 69 wk (first molt) and 104 wk (second molt). Most producers, however, will vary their selection of molting age relative to existing egg quality and the price of eggs. If quality is acceptable and the egg price is high, most producers will delay the regular molt date. If, on the other hand, shell quality is poor and prices are low, an earlier molt may be justified. Ninety percent of U.S. flocks are molted between 60 and 80 wk of age. Flock modeling software is available to make multiple analyses of alternative programs with variable cycle numbers and length (Swanson and Bell, 1975b, 1976).

The molting age for a flock replacement policy is usually scheduled years in advance in order to optimize the use of buildings and equipment. Very little flexibility exists to extend ages beyond that originally planned because of the need to bring new flocks in on schedule. On the other hand, farms with molt programs can move molting dates 5 wk ahead or back if conditions justify it with only minor inconveniences. When flocks are molted young, the second-cycle egg production peaks and rate of lay are higher (Bell and Adams, 1992).

## ECONOMIC ANALYSIS OF INDUCED MOLTING

The economics associated with molting focuses on relative costs and profitability for the individual farmer as well as the facility needs for the farmer and the industry as a

whole. The individual farmer must determine whether or not it pays to molt under a unique set of conditions. When the use of molting becomes widespread, as it is today, the structure of the industry changes and major investments in facilities are modified. The industry no longer has the facilities required to hatch and rear the number of pullets required in an all-pullet program (e.g., White, 1959; Noles, 1969; Parlour and Halter, 1970; Zeelen, 1975).

Few management options have as many obvious effects on performance as those observed in molted flocks. The most obvious, of course, are the large differences in egg production among the one-, two-, and three-cycle programs. In addition, egg quality is commonly abused by exceeding the optimal selling age. Whether or not molting pays is dependent upon the relative performance the producer is able to achieve in each cycle and, of equal importance, the price of eggs and cost of replacement pullets and feed. In many regions of the world, molting is simply not justified due to an imbalance of these factors. If replacement pullets are inexpensive, recycling a layer flock becomes less attractive. If egg prices are high or if farmers have egg production quotas, there is more incentive to produce at a higher rate and therefore molting usually doesn't pay.

In the U.S., the typical farmer uses induced molting because it is estimated that replacement programs that include molting results in at least 30% higher profit margins for the egg producer compared to all-pullet programs. This is based upon a return of \$0.65 per year per hen housed for a two-cycle program compared to \$0.50 for a one-cycle program. Calculations of the relative profitability of alternative programs are complex and require total familiarity of flock performance capabilities and an understanding of the nature of profits and costs in the foreseeable future.

## THE FUTURE OF INDUCED MOLTING

Whether or not induced molting will be used in the future will depend upon the politics of the issue, the demands of the retail and institutional purchasers of eggs, and changes in price-cost relationships. Molting in the U.S. is practically universal in use, and the entire industry structure is dependent upon its continued use. One could say that it took 50 yr before it was a common practice. It would probably take another 50 yr for an alternate program to be implemented.

If molting were eliminated as a replacement option, the nation's flock would increase in size by about 3% as a result of higher house utilization. All-pullet flocks would lay at a 4% higher rate of production compared to two-cycle flocks. Both of these would have adverse effects on egg prices. Higher costs of production would occur as replacement costs increased. An all-pullet industry would produce higher percentages of the less popular egg sizes—medium and small, which are already burdensome to the industry. Egg quality would suffer as egg producers would push their flock's ages beyond the limits of good egg quality. Egg producers would have less flexibility to adjust production to meet market demand.

Since the industry is now organized to take advantage of older hens and fewer replacement pullets each year, a shift back to all-pullet flocks would require an additional 47% more chicks each year. This, in turn, would require a similar increase in breeder flocks, breeder farms, hatcheries, and pullet-rearing farms. One hundred million more male chicks would have to be destroyed each year, and 47% more spent hens would have to be removed.

Induced molting is an industry-wide practice that contributes significantly to industry profits. It is a controversial practice because of perceptions about the way flocks are molted. Molting as a part of an optimum replacement program is here to stay. The method by which the molt is initiated will change, in time.

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