

Managing Laying House Temperatures to Improve Flock Performance and Profitability

by Donald Bell, Poultry Specialist, University of California, Riverside

Introduction

A survey of commercial egg laying facilities in 1991 indicated that more than 70% of the laying hens in the U.S. were maintained in controlled environment housing and by the year 2000, this would exceed 82%. The survey also concluded that by the turn of the century, more than 38% of these houses would be cooled with either foggers or evaporative cooling systems. Since this survey was conducted, practically all new housing built in the U.S. has been of the controlled environment type (ref. #1).

Temperature in large commercial layer houses varies with the uniformity of the air delivery system, the effectiveness of the ventilation/cooling system and house insulation to control outdoor temperature extremes, and the planned temperature program by management. Air delivery systems may yield temperature differences from 2° to 15° F. (1.1° to 8.3° C.) between various parts of the house. Achievable summer temperatures in evaporatively cooled housing may be as much as 20° F. (11.1° C.) below that obtainable in non-cooled houses. And, management may have totally different strategies about their management of temperature based upon their own specific needs or experiences (ref. #2).

The correlation between the measured temperature in commercial houses and the “effective” temperature is a big unknown. In many cases, it may be difficult to demonstrate significant relationships because of circumstances beyond your control or ones that are not considered. In other cases, temperature effects may appear to be much greater than expected. This happens when two or more factors work in conjunction to exaggerate responses. Temperature, per se, does not incorporate measurements of air quality, moisture content of the air, presence of radiant heat, or the contribution of air velocity - all of which have a major effect on how animals respond to temperature. Average temperatures, on the other hand, may be difficult to evaluate if they merely represent the “extremes” of temperature during a 24 hour period. Even hourly averages may not truly measure how the bird responds to temperature change. Obviously, the location of temperature sensors relative to the majority of the flock is also an important consideration.

Traditional thinking tells us that certain things will happen when temperature is elevated or depressed. As temperatures increase, egg size is expected to decrease, but at what point does this become an economic problem? As temperatures increase, feed consumption (energy intake) is expected to go down, but is this good or bad? Does temperature change affect all flocks equally, or are there strain, age or seasonal factors which might change the magnitude of the response? How much of the heat problem can be corrected nutritionally (economically) ?

Aspects of the temperature issue have been the subject of hundreds of research papers over the last half-century. Scientists have studied the **question** from many different perspectives and have clearly demonstrated that the issue is indeed, extremely complex. For decades, relatively low (55.0°F., 12.8° C.) temperatures were thought to be ideal when egg production responses were compared. Other scientists demonstrated that this was merely the response of an inadequate intake of essential nutrients. Birds “learn” from exposure to elevated temperatures (acclimatization) and harmful responses may not occur as expected. Temperature patterns (diurnal fluctuation) with comparable “averages” often give superior results compared to constant temperatures.

Through the years, several multi-factor models (equations) were developed to predict the effects of temperature on energy requirements. These models **were** assembled using the results of numerous well controlled experiments, but unfortunately, such experiments do not always have sufficient data to relate more than a few variables at a time. Traditionally, body weight has been the single most important factor considered. In general, approximately two-thirds of energy consumption is associated with body weight and conventional equations increase energy intake predictions by about 15 kilocalories for each .1 pound (45 gram) increase in body weight to support the higher maintenance requirement of the larger bird. This represents a 5% increase in energy needs. An additional 2 kilocalories is necessary for the production of 1 gram of egg mass per day (out of a total of 50 to 55 grams). Other parts of the equation include an allowance for feathering and growth.

Temperature reduces the maintenance requirements about 2 kilocalories per 1° F. (3.6 kilocalories per 1° C.) increase in temperature. This is slightly more with partially defeathered birds. These relationships are intended to apply to flocks of different breeds and ages. The questions arise, “How well do these models correlate to today’s commercial strains at typical house temperatures?” and “How can we more effectively manage our flocks with this knowledge?”

University of California Flock Studies (a progress report)

In 1992, the University of California (UC) initiated a study of flock performance in commercial White Leghorn flocks to explore the relationship of house temperature to various performance traits and the profitability of production. During the next several years, weekly records from 203 flocks (average size: 72,606 hens housed) were assembled from a group of very efficient egg producers located in various parts of the country. All of the data relative to house temperature was from controlled environment housing. These records included egg production and egg weight information, feed and water intake data, body weight records, mortality information, and average house temperatures. An economic index was developed incorporating these measurements and weekly and total flock profitability was determined using standardized prices for feed and

eggs (ref. #3). In all, some 6680 flock-weeks data sets were available for analysis. The total number of hens in the study was 14.7 million. An earlier progress report of this research was presented at the World's Poultry Science Congress held in The Netherlands in 1992 (ref. #4).

Temperature data were available on 187 of the 203 flocks in the study. This data usually represented the daily high and low temperatures averaged for each week. Some companies provided hourly averages from their house computer monitoring systems. The precision of these measurements may be questioned, as they may or may not accurately reflect the "effective" temperature discussed earlier. In general, though, we feel that the data provided are fairly good indicators of temperature, as evidenced by the nature of the results obtained compared to what might be expected.

Figure 1 illustrates the frequency of observations at each temperature (F.). Seventy-seven percent of all observations were between 70 ° and 80 ° F. (21.1 ° to 26.7 ° C.). Figure 2 illustrates the temperature ranges during the summer (July-Sept.) and winter (Jan.-March) months. Interestingly, winter average temperatures were only 5.2 ° F. (2.9 ° C.) below the recorded temperatures for the summer months indicating a remarkable ability to control the temperature environment within relatively small ranges. It must be pointed out, though, that variation exists between any two identical temperatures due to associated humidities, air flow, radiant heat and the degree to which the recorded temperature correlates to the "effective" temperature perceived by the birds (pattern, duration, previous exposure, etc). In the laboratory, such associations can be controlled, but in the commercial setting, they can only lead to additional sources of variation.

The UC data consists of two types of information: 1). complete summaries of each flock for the period 20 to 60 weeks of age. This includes 38 different parameters of performance with some missing data for temperatures, body weights, and water consumption. This data will be used in the future to analyze overall correlations between factors such as sexual maturity, body weights, season, and temperature.. 2). weekly data from 25 to 60 weeks of age for the same flocks. This data is being used in this report and for the development of multi-factor energy prediction models.

The analysis of weekly data consisted of first sorting out and eliminating all records with missing data relative to temperature and the trait being compared. Data was then sorted according to flock age with some 1000 flock-weeks available for each 5-week increment of flock age. A simple linear regression for each flock/age sub-group was then calculated to correlate the effect of incremental changes in temperature on each performance trait including profitability. Where statistically significant, regression curves were calculated for temperatures ranging from 65 ° to 85 ° F. (18.3' to 29.4' C.). This temperature range represents 99% of all the observations.

Figure 3 illustrates the data from this study relative to the effect of season of lay on daily energy consumption. A 13 kilocalorie difference in daily energy intake between the winter and summer months was observed compared to an expected 10-11 kilocalorie difference when traditional equations were utilized with the temperatures observed in the UC study.

Highly significant ($P < .001$) relationships between temperature and all feed traits were observed for each age grouping. Figure 4 shows the effects of age and temperature as they combine to change caloric intake. As temperatures rise, energy consumption differences between young and old flocks tend to diminish. Within age groups, the effects of a 1° F. temperature increase range from a .10% to .66% decrease in energy intake (average .39%). This is significantly less than the non-age-adjusted .67% decrease with the commonly used **Emman's** model (ref. #5). Table 1 compares the UC predictions with the **Emman's** equation with assumptions for body weight, egg mass, feather loss and temperature. The assumptions for body weight and egg mass were those experienced in the current survey. Feather losses were assumed to be minimal for the first four age groupings and slightly more for the remainder.

In general, the UC predictions resulted in 9 more kilocalories at the 70 ° F. (21.1 ° C.) level and 17 more kilocalories at the 80 ° F. (26.7° C.) level. This represents a 3-6% higher energy intake than indicated with the **Emman's** equation. If our assumptions were conservative about the feathering of the flocks in the UC study, a higher energy intake prediction would have been made in our **Emman's** calculations. I doubt that this occurred because of the relatively young flocks in the UC data.

The significance of analyzing this data by age groups is illustrated in Table 2. For example, temperature has very little effect on egg production in the younger flocks, but within the ranges observed, had a positive effect with older flocks. An opposite effect was seen with mortality. Young flocks showed marked increases in mortality rates with increasing temperatures while older flocks were relatively non-affected. Note, this is not to say that older flocks have less mortality (they don't), but only that higher temperatures seem to affect them to a much lesser degree. Egg weight showed little effect of temperature with young flocks, but a significant depression with older flocks.

And, finally, elevated temperatures had no economic benefit for young flocks while older flocks showed definite improvements. Economic benefits increased with each succeeding age group reflecting the increasing savings in feed with minimal effects on average egg values. During the 45 to 60 week period, high temperatures improved profitability by as much as **\$.25** per hen when compared with the lower temperature levels. A continuation of economic advantages due to higher temperatures would be expected beyond the 60 weeks of age limit of the UC study.

It must be pointed out that the management of the flocks in this study would be considered to be superior to that of the industry as a whole as evidenced by their performance results. All of the cooperating farms use feed consumption information to adjust the nutrient density of their diets in order to maintain essential nutrient intake **levels**.

Conclusions

Temperature management will have positive benefits when done correctly. Proper house design is an essential element in allowing maximum benefits from such programs. Air delivery systems must have the capacity to deliver the correct volume of quality air to all parts of the house under both minimum and maximum requirement conditions. The economic impact of the effects of temperature modification must be thoroughly understood and programs must be carefully applied.

Consideration should be made to update current prediction equations for energy intake to reflect the findings of the UC study.

Selected References

1. Bell, Donald, 1993. The egg industry of California and the USA in the 1990's: a survey of systems. *World's Poultry Science Journal*, Vol. 49, March.
2. **D'Alfonso**, Thomas., 1994. Housing temperatures and your bottom line. *Egg Industry*, November/December.
3. Bell, Donald, 1994. Flock performance indexing: What values should we expect? *Egg Industry*, July/August.
4. Bell, Donald & Carol Adams, 1992. Performance responses to temperature as affected by age in table egg flocks. *Proceedings, World's Poultry Congress*.
5. **Hunton**, Peter, 1997. New trends in layer management. *The Cackler Newsletter*, Ontario Egg Producers' Marketing Board, January.

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Tables

Table 1. Comparison of University of California Flock Data and Emman's Equation for Predicting Energy Consumption in 'able Egg Laying Flocks.

Age (Wks)	Body weight (lbs)	Body weight (kg)	Daily egg mass (g)	Feather loss (%)	UC* Temp. 70 F 21.1 C	Emman's Temp. 70 F 21.1 C	UC* Temp. 80 F 26.7 C	Emman's Temp. 80 F 26.7 C
25-29	3.44	1560	50.3	0-15	294	287	281	269
30-34	3.51	1592	52.7	0-15	304	294	293	275
35-39	3.56	1615	52.7	0-15	305	295	297	276
40-44	3.59	1628	51.9	0-15	303	295	300	276
45-49	3.62	1642	51.2	15-25	308	306	299	286
50-54	3.63	1647	50.1	15-25	314	305	298	284
55-60	3.64	1651	48.2	15-25	320	301	299	281
All	3.57	1619	51.4		307	298	295	278

* Significant ($P < .001$) linear regressions using temperature data within age groups.

Table 2. Effects of Increasing Temperature on Various Performance Traits Within the 65 to 85 degrees F. (18.3 to 29.4 degrees C.) Range.

Trait	Younger flocks	Older flocks
Egg production rate	Not significantly different	Significantly higher
Mortality	Significantly higher rates	Very little effect
Egg weight	Very little effect	Significantly lower
Daily egg mass	Not significantly different	Not significantly different
Feed intake	Significantly lower	Significantly lower
Energy intake	Significantly lower	Significantly lower
Feed conversion	Significantly improved	Significantly improved
Water intake	Significantly higher	Significantly higher
Egg income minus feed costs	Very little effect	Significantly higher

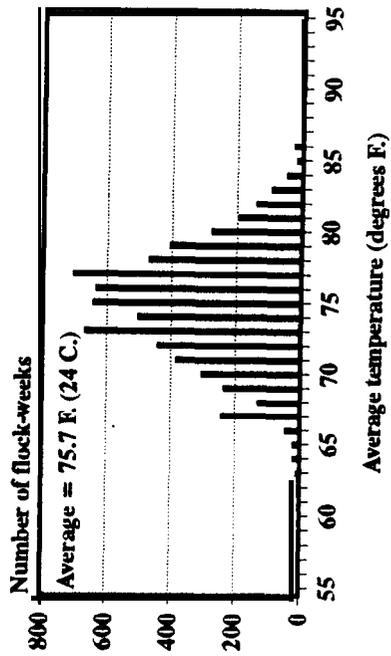
"Managing Laying House Temperatures to Improve Flock Performance and Profitability"

by
Don Bell
Poultry Specialist
University of California
Riverside

University of California National Flock Study - 1992 to 1998

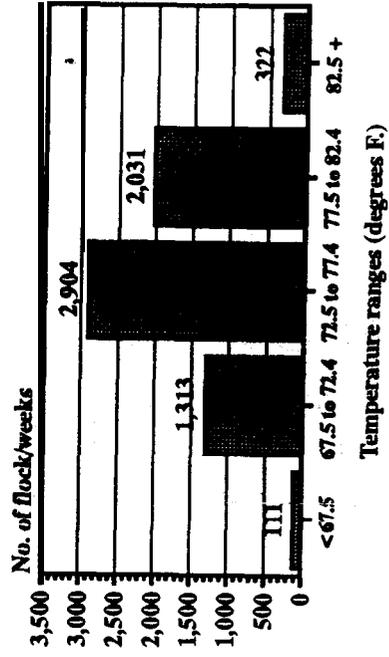
- ◆ 203 flocks
- ◆ Average hens per flock: 72,606
- ◆ Total: 14.7 million hens
- ◆ Multi-state
- ◆ 6680 flock-weeks
- ◆ Controlled environment housing
- ◆ Data available (weekly)
 - ▶ Egg production
 - ▶ Case weights
 - ▶ Feed intake
 - ▶ Water intake
 - ▶ Temperature
 - ▶ Body weight
 - ▶ Mortality
 - ▶ Economic index

Distribution of House Temperatures Weekly average (6680 flock weeks)(all seasons)



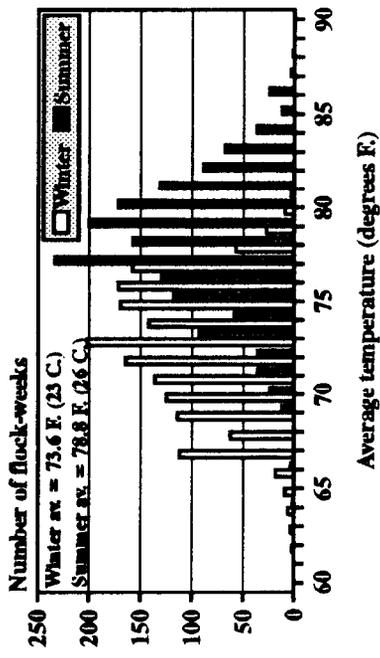
77% were between 70 & 80 degrees F.

Distribution of Weekly House Temperatures National Flock Study (6681 flock-weeks)



Distribution of House Temperatures

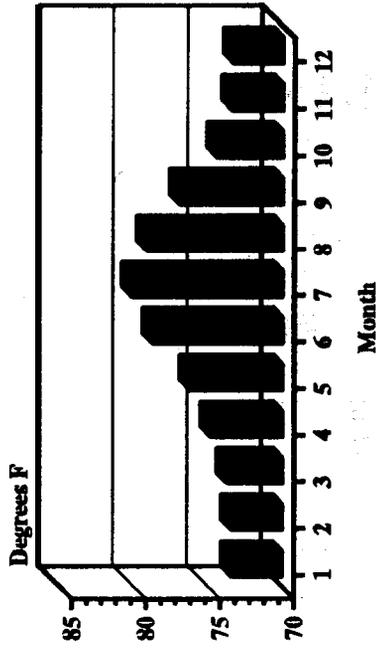
Winter (1696 flock-weeks), Summer (1638 flock-weeks)



National Flock Study, University of California, 1997

Effect of Month of Lay on

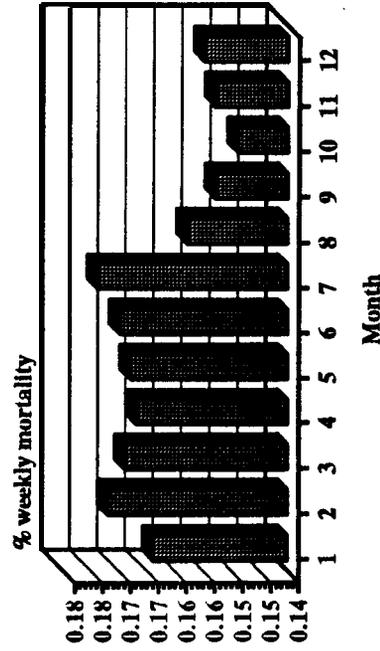
Average House Temperature - (all ages combined)



National Flock Study, University of California

Effect of Month of Lay on

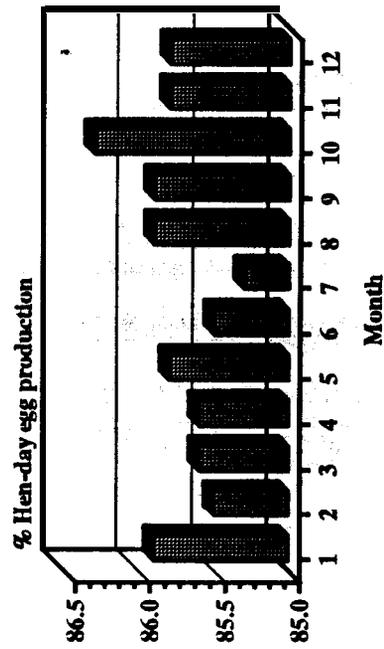
Weekly Mortality % - (all ages combined) (Std. prices)



National Flock Study, University of California

Effect of Month of Lay on

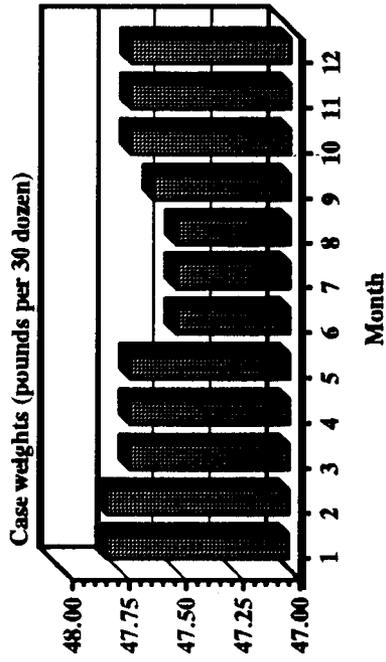
Hen-day Egg Production % - (all ages combined)



National Flock Study, University of California

Effect of Month of Lay on

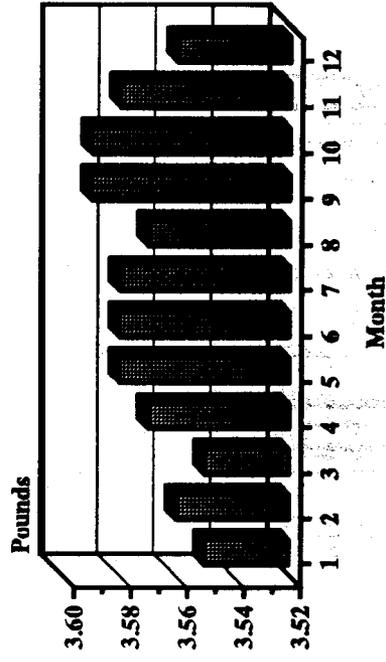
Case weight (lbs) - (all ages combined)



National Flock Study, University of California

Effect of Month of Lay on

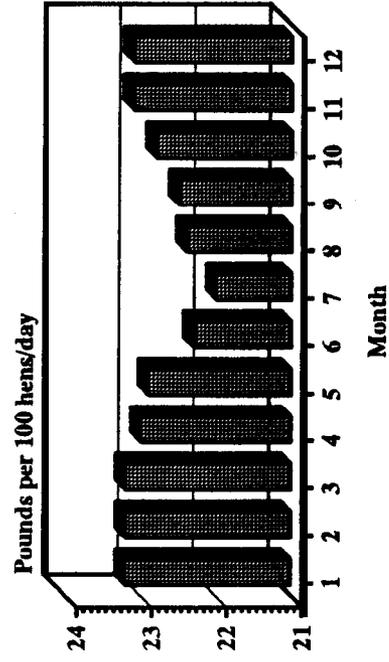
Average Body Weight - (all ages combined)



National Flock Study, University of California

Effect of Month of Lay on

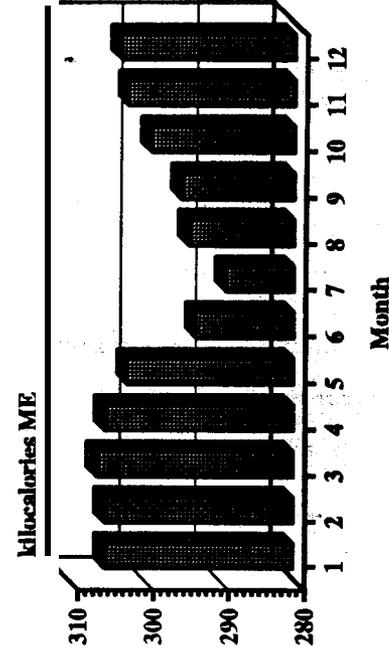
Daily Feed Consumption - (all ages combined)



National Flock Study, University of California

Effect of Month of Lay on

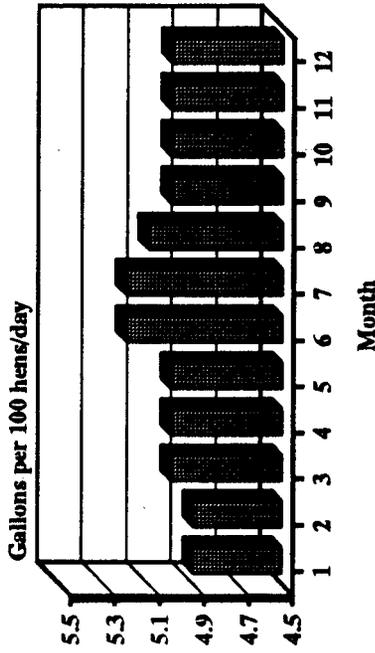
Daily Energy Intake (kilocalories ME) - (all ages combined)



National Flock Study, University of California

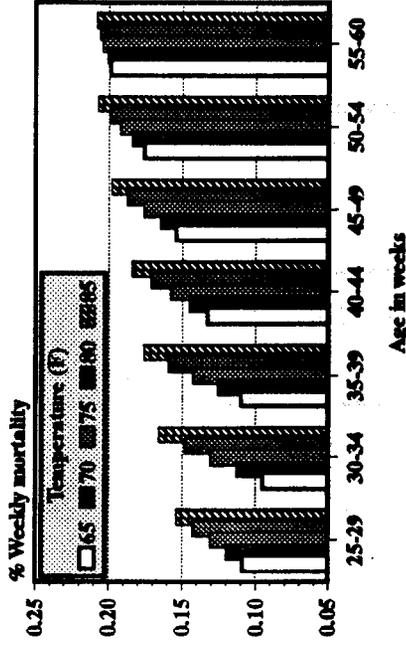
Effect of Month of Lay on

Daily Water Consumption - (all ages combined)



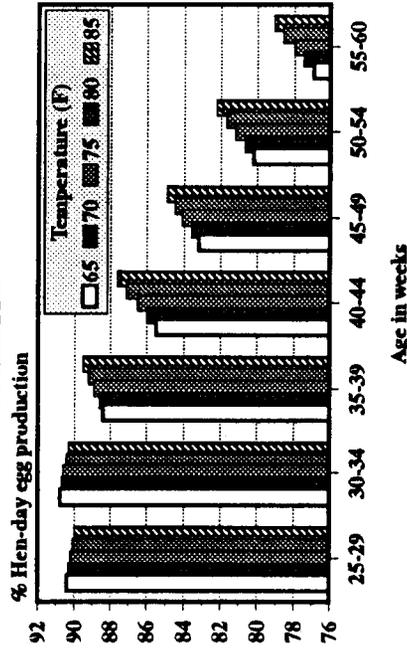
National Flock Study, University of California

The Effect of Age and Temperature on Average Weekly Mortality



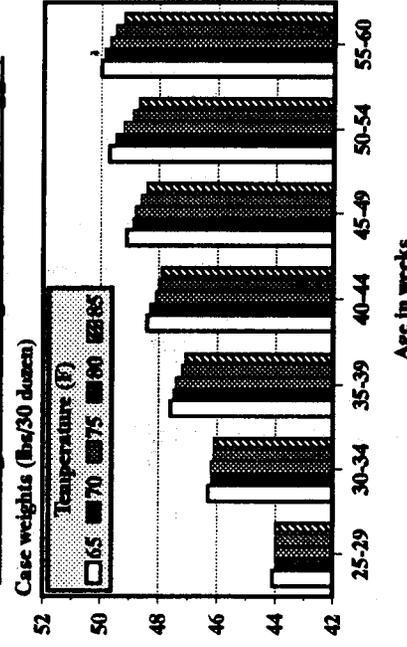
National Flock Study - University of California

The Effect of Age and Temperature on Hen-day Egg Production



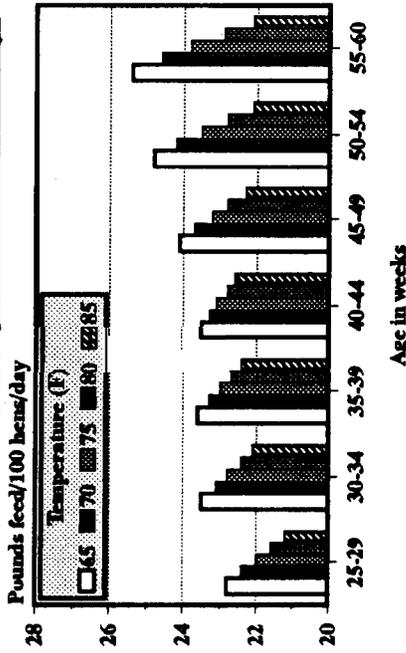
National Flock Study - University of California

The Effect of Age and Temperature on Average Case Weights (30 dozen eggs)



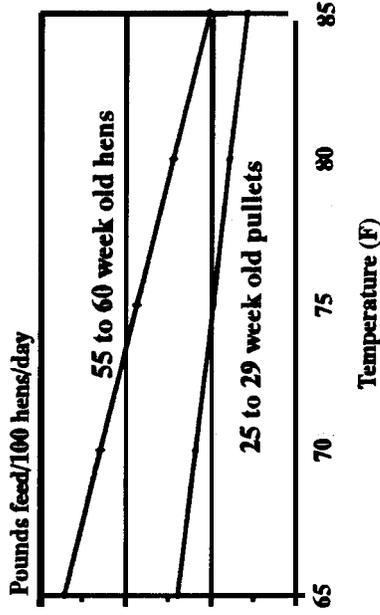
National Flock Study - University of California

The Effect of Age and Temperature on Daily Feed Consumption (lbs/100 hens/day)



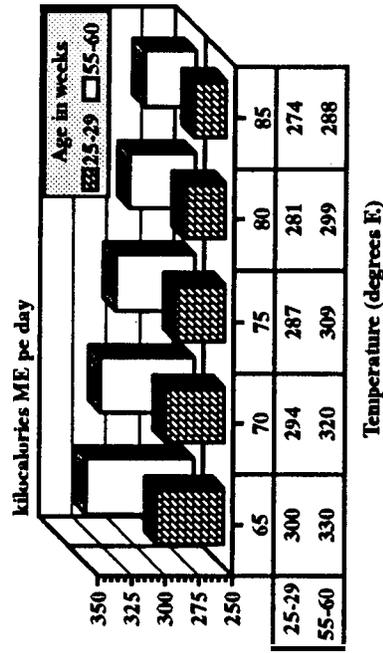
National Flock Study - University of California

The Effect of Temperature on Feed Consumption - Age Effects



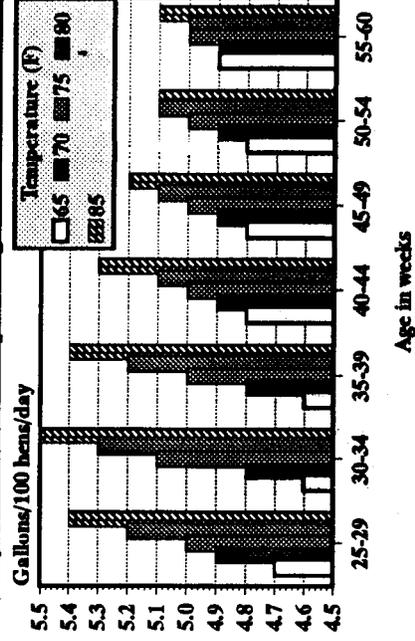
National Flock Study, University of California

The Effects of Age and Temperature on Energy Consumption (regressions)



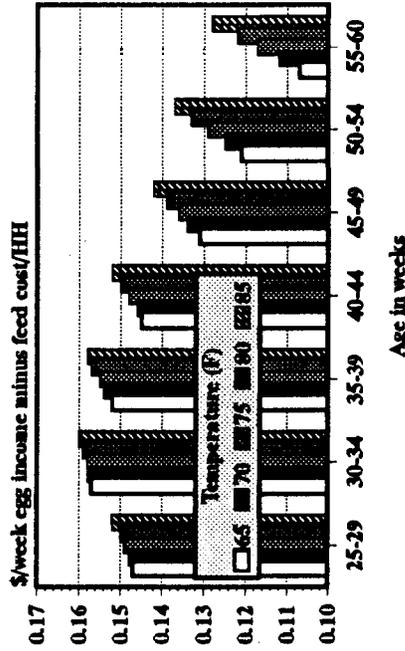
National Flock Study, University of California, 1997

The Effect of Age and Temperature on Daily Water Consumption (gallons/100 hens/day)



National Flock Study - University of California

The Effect of Age and Temperature on Weekly Flock Profitability



National Flock Study - University of California

Comparison of Univ. of California Daily Energy Intake Data with Emman's Equation

Measurements	30-34 wks	40-44 wks	50 to 54 wks
Body wts (lbs)	3.51	3.59	3.63
Daily egg mass (g)	52.7	51.9	50.1
UC @ 70 degrees	304	303	314
Emmans @ 70 degrees	294	295	305
UC @ 80 degrees	293	300	298
Emmans @ 80 degrees	275	276	284

National Flock Study, University of California, 1997

Effects of Increasing Temperatures on Various Performance Traits (65 to 85 degrees F)

Trait	Young Flocks	Old Flocks
Egg prod.	Not signif.	Signif. higher
Mortality	Signif. higher	Very little effect
Egg wt.	Very little effect	Signif. lower
Daily egg mass	Not signif.	Not signif.
Feed intake	Signif. lower	Signif. lower
Energy intake	Signif. lower	Signif. lower
Feed conv.	Signif. improved	Signif. improved
Water intake	Signif. higher	Signif. higher
E.I. - F.C./HH	Very little effect	Signif. higher

National Flock Study, University of California, 1997

Conclusions

1. Temperature management will have positive benefits when done correctly.
2. Proper house design will allow each program to be optimized.
3. Air delivery systems must have the capacity to deliver the correct volume of quality air to all parts of the house under both minimum and maximum requirement conditions.
4. The economic impact of the effects of temperature modification must be thoroughly understood and programs must be carefully applied.