POULTRY MANAGEMENT STUDIES — IV

Performance of Single Comb Rhode Island Reds Hatched Out-of-Season in Hawaii

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AGRICULTURAL EXPERIMENT STATION

Bulletin 108 *April 1953*

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POULTRY MANAGEMENT STUDIES
IV. PERFORMANCE OF SINGLE COMB RHODE ISLAND REDS HATCHED OUT-OF-SEASON IN HAWAII

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A systematic study has never been made in Hawaii on the influence of out-of-season hatching on the performance of laying chickens, although it was generally believed that chicks hatched during the spring months were the most profitable. This belief may have been influenced, in part at least, by the conclusions investigators had drawn from studies conducted in other geographical areas. Card *(2)* in New York State hatched Single Comb White Leghorn chicks during each month of the year and found that April- and May-hatched pullets laid the most eggs, while those hatched in January laid the fewest. On the other hand, the "fall" and "winter" pullets grew faster to 24 weeks of age than pullets hatched in the spring, and eggs produced by them contained a higher percentage of thick albumen during the summer months. Upp and Thompson *(8)* undertook a similar study in Oklahoma. They found little difference in average egg production between the winter and spring hatches, while pullets hatched in the summer and fall gave decidedly lower production. When ranked by season according to the value of eggs produced, the spring hatch was the most desirable followed in descending order by the winter, summer, and fall hatches. Moreover, adult mortality was much lower for the spring-hatched pullets than for those hatched during the other seasons. Jeffrey and Platt *(5)* concluded from a 3-year study of out-of-season hatching that pullets hatched in New Jersey during the spring were more profitable than those hatched in the fall or winter. Spring-hatched pullets were superior on the average to those hatched during the fall and winter in converting feed into body weight to 24 weeks of age, in converting feed into eggs, in annual egg production, in viability during the laying year, and in production of large eggs. On the other hand, fall-and winter-hatched pullets grew faster than spring-hatched birds, were larger at the end of their laying year, and produced higher quality eggs during the summer months.

Most of the replacement stock intended for egg production in Hawaii is brought from the mainland either as hatching eggs or chicks. Although local poultrymen have attempted from time to time to produce chicks, the supply has either been too small or undependable for large-scale commercial egg producers. As a consequence, most commercial hatcherymen in Hawaii sell chicks from mainland-produced eggs or sell chicks sent to them from selected mainland breeding farms and hatcheries. Even in this way it has not always been possible for the commercial hatcheryman to procure adequate supplies of hatching eggs during the late summer and fall months. It has been found that the percentage of infertility was greater and hatchability lower during this time of the year than in the other seasons. Studies by Upp and Thompson *(8)*, Parker and McSpadden *(6)*, and Heywang *(4)* have shown that high summer temperatures on the mainland are responsible, in part, for decreased fertility. Furthermore, most mainland poultry breeders do not produce the same volume of production-bred chicks or hatching eggs in the summer and fall as they do in the late winter and spring, and it is therefore difficult for local hatcherymen to procure out-of-season production-bred stock. Then, too, the expanding broiler industry has created a demand for broiler-bred chicks on a year-round basis. This has tended to reduce the need on the part of local hatcherymen to procure out-of-season business, and no serious attempts have been made to stimulate interest in out-of-season hatches of production-bred stock among the commercial egg producers. Furthermore, there has been comparatively little demand from the commercial egg producer for out-of-season chicks.

During the past few years a trend has developed in Hawaii in which more eggs were sporadically produced during the spring months than could be sold within a period of 7 days. These eggs were stored under refrigeration or sold at a sacrifice. Should commercial flocks continue to expand in size as they have during the past few years, it is possible that this trend may be aggravated. Honolulu is a "pocket" market that is not capable of absorbing a large increase of local eggs without concomitant price reduction competitively geared to that of table eggs imported from the Mainland. This springtime "flush" is due, in part, to the large number of spring-hatched pullets purchased annually. If fewer replacement chicks were purchased in the spring and more were purchased during the other seasons, it is probable that seasonal peaks would become less extreme and the supply of table eggs more uniform throughout the year. In his discussion on poultry farm management, Card *(3)* reported that in some commercial egg-producing sections on the Mainland, poultrymen hatch or buy baby chicks throughout the year at intervals of 2 or 4 weeks, and continually replace birds that have died or ceased to lay. On some farms this replacement may be as high as 7 percent a month.

This study was undertaken to procure data on the comparative performance of chickens hatched during the four seasons of the year. Aside from its economic implications, such a study would be of interest also to poultry scientists and zoologists who are concerned with the environmental contribution to the variation that occurs between individuals and their families. Since the equable climate in Hawaii is very agreeable to humans, a study conducted under the conditions of this experiment should provide additional and contrasting data to that obtained by other investigators under more fluctuating and extreme environmental conditions.

MATERIALS AND METHODS

This investigation was undertaken with a strain of Single Comb Rhode Island Reds that had been imported in 1947. The sires and dams that were mated to produce the experimental chicks represented the first generation hatched in Hawaii, but little was known of their genetic superiority or limitations except that they conformed phenotypically to the description of that breed and variety given in the AMERICAN STANDARD OF PERFECTION *(1)*. In order to reduce to a minimum genetic variation between the four hatches, young, mature cockerels and pullets were mated by means of artificial insemination, and the eggs were pedigree hatched. The same matings were repeated insofar as possible so that siblings from each mating were studied in each hatch. To ensure an adequate supply of chicks, hatching eggs were collected and stored at 55° F. during a period of 14 days. In this way 144 chicks were hatched on January 4, 1949; 151 chicks on March 29, 1949; 158 chicks on July 12, 1949; and 155 chicks on October 4, 1949. Thus the winter hatch was represented by the pullets hatched in January, and the spring, summer, and fall hatches by those hatched in March, July, and October, respectively.

Every effort was made to provide similar housing, feed, and management to the four groups. All chicks in this study were housed to 4 weeks of age in an Oakes battery brooder. The chicks were then vaccinated against fowl pox and moved to grower batteries. At 6 weeks of age they were vaccinated with formalin-inactivated Newcastle Disease vaccine and moved to wire-wall, wire-floor developer pens. Each hatch was subjected to continuous illumination to 6 weeks of age; however, the light intensity fluctuated during the daylight hours in accordance with the brightness of the sun's rays. The cockerels and pullets were separated at 6 weeks of age, or as soon as possible thereafter, and reared separately. At 18 weeks of age, 60 pullets were picked at random, legbanded, and vaccinated again with formalin-inactivated Newcastle Disease vaccine. They were then placed in wire-wall, wire-floor layer pens where each pullet was provided 3 square feet of floor space and 4 inches of hopper space. Drip water founts provided water in each pen. The 60 pullets were housed in two adjacent layer pens of a multiple unit house and eight pens in a row housed the entire project. No culling was exercised throughout this study, and data were collected until each group of hens reached 30 months of age. For convenience of analysis

Table 1. Formulas of rations fed to each of the four hatches

	RATIONS		
INGREDIENTS (1)	Chick Starter	Grower	Layer
Ground barley	0.0	9.0	0.0
Ground yellow corn	30.0	21.0	30.0
Cracked yellow corn	0.0	20.0	0.0
Ground oats	8.25	0.0	19.0
Ground wheat	20.0	17.5	30.0
Whole wheat	0.0	10.0	0.0
Herring Meal	5.0	4.2	5.5
Meat scrap	5.0	0.0	0.0
Soybean oil meal	26.0	12.5	9.0
Alfalfa meal	5.0	4.2	5.0
Defluorinated phosphate	0.0	0.6	1.0
Ground oyster shell (2)	0.25	0.5	0.0
Iodized salt	0.5	0.5	0.5
Manganese sulfate, gm.	10.0	5.0	5.0
Choline chloride, gm.	125.0	0.0	15.0
Delsterol, gm. (3)	15.0	10.0	30.0
Fortafeed, gm. (4)	0.0	30.0	10.0
Riboflavin, mg.	160.0	0.0	50.0

(1) The unit of measure is pound(s) unless otherwise specified.
(2) Cracked oyster shell fed *ad libitum* to laying chickens.
(3) Delsterol = 2,000 AOAC units of vitamin D per gram.
(4) Fortafeed (Lederle) = guaranteed minimum concentration of 4,000 micrograms each of riboflavin, calcium pantothenate, and niacin plus 22,000 micrograms of choline chloride per gram.

and presentation and in recognition of the fact that most commercial egg producers do not keep yearling hens, the data presented in this bulletin deals with observations covering three periods; namely, the grower stage to 18 weeks of age, subsequent performance to 78 weeks of age, and yearling performance from 78 to 130 weeks of age.

The rations shown in table 1 were fed to each of the four hatches. The starter ration was fed until the experimental chicks were 6 weeks of age, the grower ration was fed to 18 weeks of age, and the layer ration was fed to the end of this investigation.

RESULTS

PERFORMANCE TO 18 WEEKS OF AGE

No real difference in fertility was observed among the four lots of eggs, even though the same matings were repeated during the four seasons by means of artificial insemination. As shown in table 2, fertility ranged from 71.3 to 81.2 percent, being highest for eggs set during the summer months. Had natural matings been permitted and replacements added to the flock throughout the year, it is likely that fertility would have been better. There was, however, a real difference in hatchability among the four lots of fertile eggs, the spring hatch being lowest. Due to a prolonged shipping strike on the west coast of the Mainland, local feed distributors had imported feed via the Gulf ports. Possibly the quality of the feedstuffs then available was so inferior as to result in a deficient breeder's ration. In view of this possibility it is not likely that season,

Table 2. Performance data of the four hatches to 18 weeks of age

Characteristic	Unit of measure	Hatches: Jan. 4	Hatches: Mar. 28	Hatches: July 12	Hatches: Oct. 14	Statistical analysis: Method of analysis	Statistical analysis: Variation significant (2)
Percentage fertility (1)	Percent.	79.8	71.3	81.2	75.8	Chi square	No
Percentage hatchability	Percent.	76.7	54.7	83.2	85.7	Chi square	Yes**
Percentage mortality to 6 weeks of age	Percent.	6.8	6.0	3.2	2.5	Chi square	No
Percentage mortality to 12 weeks of age	Percent.	9.9	8.6	7.0	8.4	Chi square	No
$\bar{x}$ Body weight of pullets at 12 weeks of age	Pounds	2.65	2.54	2.46	2.48	Variance	Yes**
$\bar{x}$ Body weight of pullets at 18 weeks of age	Pounds	3.86	3.73	3.76	3.75	Variance	No

(1) All hatching eggs procured by means of artificial insemination.
(2) Double asterisk indicates a degree of variation not likely to occur more than one time in 100 due to chance alone.

as such, influenced hatchability, since it has been reported in numerous publications that the springtime is the natural time for optimum hatchability. In this study the eggs hatched better in the summer and fall months than in either of the other two periods.

The ability of chicks to survive to 6 weeks of age was not influenced by season of hatch. As shown in table 2, mortality due to all causes ranged from 2.5 to 6.8 percent. The fall hatch suffered the lowest mortality, followed in ascending order by the summer, spring, and winter hatches. Similarly, there was no real difference in mortality among the four hatches to 12 weeks of age. At that time the percentage mortality ranged from 7.0 to 9.9. The summer hatch showed the least mortality, followed in sequence by the fall, spring, and winter hatches.

The average body weight at 12 weeks of age of the pullets hatched during the winter, spring, summer, and fall were 2.65, 2.54, 2.46, and 2.48 pounds, respectively. An analysis of the individual bod yweights showed there was a statistically significant difference among the four groups of pullets, but the difference between any two means was not significant when measured by the fiducial limits ($P<0.05$). In this study, the "winter" pullets grew fastest and the "summer" pullets grew slowest. The difference in body weight of 0.08 pound between the spring and summer hatches contrasts with the pattern in certain commercial broiler sections on the Mainland. There, growth rate may be depressed as much as 0.40 pound to 10 weeks of age when high summer temperatures prevail.

When the pullets were weighed at 18 weeks of age, their body weights were similar and not significantly different. At that time the pullets averaged, in sequence of hatching, 3.86, 3.73, 3.76, and 3.75 pounds. Although the winter-hatched pullets still were heaviest, the body weights of the other three groups were similar.

PERFORMANCE OF PULLETS FROM SEXUAL MATURITY TO 78 WEEKS OF AGE

The average age at which the pullets attained sexual maturity (age at first egg) varied significantly among the four hatches. The "fall" pullets reached maturity at an average age of 172.6 days, which was significantly earlier than that shown by the spring and summer hatches. The "winter," "spring," and "summer" pullets matured on the average in 174.4, 181.5, and 181.8 days, respectively.

A real difference was also observed in the average weight of the first 10 eggs laid by the pullets in each hatch. The "summer" pullets initially laid the largest eggs, while the "winter" pullets laid significantly smaller eggs. As may be seen in table 3, the pullets from the four hatches laid eggs that averaged 46.1, 49.0, 50.0, and 48.5 grams. Since "medium" eggs weigh 49.6 to 56.6 grams, only the spring and summer hatches produced eggs that, on the average, were graded medium. This relationship between age at sexual maturity and egg size is in agreement with mainland observations; namely, early maturing pullets, in general, initially lay smaller eggs than do later maturing pullets.

The total number of eggs laid to 78 weeks of age by each group of 60 randomly selected pullets differed significantly among the four groups. The

Cumulative egg income in dollars per bird (hen-day basis)

Winter hatch	.31	2.88	5.52	7.67	9.54	11.07	12.39	13.08				
Spring "			1.45	3.96	6.22	7.98	9.64	11.26	12.83			
Summer "				.19	2.03	4.09	6.17	8.24	10.35	12.04	12.96	
Fall "						1.24	3.46	5.75	7.93	9.45	11.29	13.17

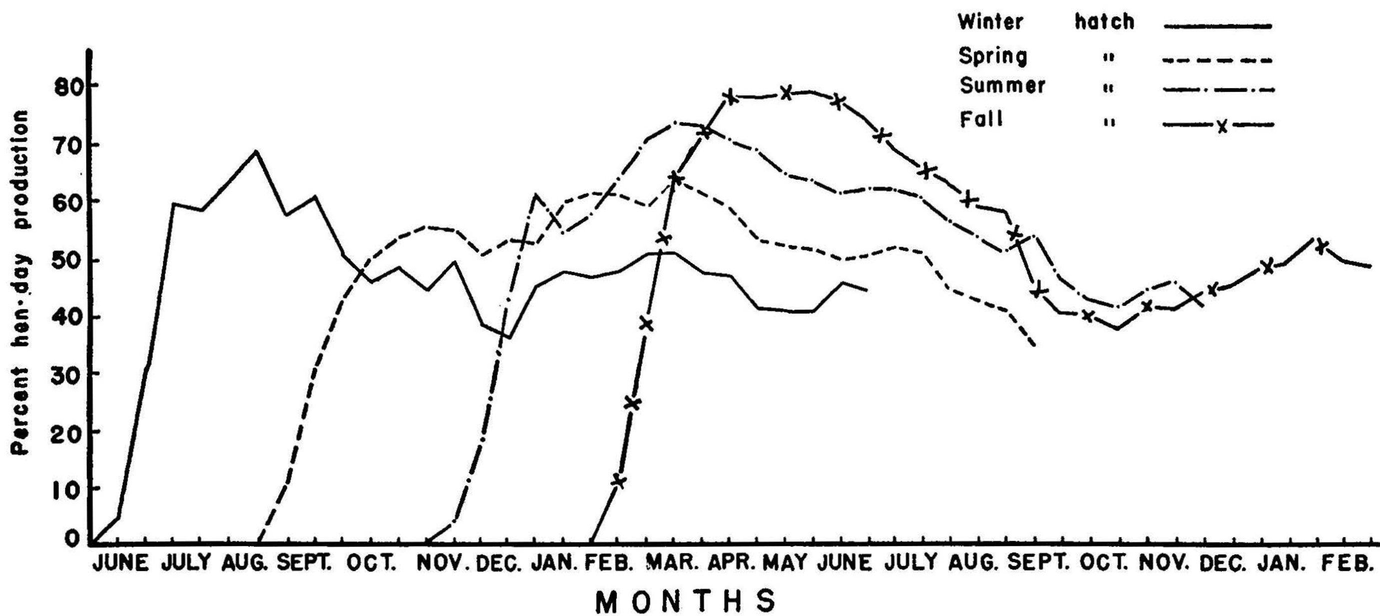

Fig. I. Biweekly hen-day egg production and cumulative income of the four hatches to 78 weeks of age.

"winter" pullets laid 8,803 eggs; the "spring" pullets, 9,552; the "summer" pullets, 9,644; and the "fall" pullets laid 10,923 eggs. In terms of hen-house production (total eggs divided by number of pullets housed), the four hatches averaged 146.7, 159.2, 160.7, and 182.0 eggs, respectively. In the same sequence, their hen-day production was 46.9, 50.0, 53.8, and 55.3 percent. Thus, by both methods of analysis the fall hatch was most productive, followed in descending order by the summer, spring, and winter groups.

The egg production curves for the four groups shown in figure 1 indicate that changes in climatic conditions were effective in modifying the rate at which the pullets laid throughout the year. The winter hatch reached a biweekly hen-day production peak of 68.0 percent 12 weeks after the first egg was laid. Thereafter, production dropped as the birds were exposed to strong gusts of wind, and they reached their lowest rate of lay during the winter months. Although production increased again as the weather improved, the rate of lay ranged between 41.0 and 51.0 percent thereafter. As may be seen in figure 1, the spring-hatched pullets matured during the onset of inclement weather and, by the twelfth week of lay, their peak production was only 55.5 percent. Their production improved as the weather moderated and reached its peak 30 weeks after the first pullet matured. Moreover, their rate of egg production remained

Table 3. Performance data from sexual maturity to 78 weeks of age

Characteristic	Unit of measure	Hatches: Jan. 4	Mar. 28	July 12	Oct. 4	Statistical analysis: Method of analysis	Variation significant (2)
Number housed	Pullets	60	60	60	60		
Age at sexual maturity	Days	174.4	181.5	181.8	172.6	Variance	Yes**
Weight of first 10 eggs per pullet	Grams	46.1	49.0	50.0	48.5	Variance	Yes**
Average body weight from 24 to 78 weeks	Pounds	5.93	5.85	5.73	5.83	Covariance	Yes*
Total production	Eggs	8,803	9,552	9,644	10,923	Chi square	Yes**
Hen-house production	Eggs	146.7	159.2	160.7	182.0	Chi square	No
Hen-house production	Percent.	37.1	41.1	41.6	46.4	Chi square	No
Hen-day production	Percent.	46.9	50.0	53.8	55.3	Covariance	No
Hen-house mortality	Percent.	28.3	36.7	35.0	36.7	Chi square	No
Total feed consumption (1)	Pounds	122.1	120.4	123.1	125.2	Covariance	No

(1) Based on biweekly feed measurements from date of hatch to 78 weeks of age.
(2) Single asterisk indicates a degree of variation not likely to occur more often than one time in 20 due to chance.

above 50.0 percent until they had been in production for 11 months. The summer-hatched pullets matured during the season of shortest daylight. By the twelfth week of egg production, their rate of lay was 57.5 percent. Thereafter, with improved weather, production reached a peak of 73.5 percent and remained comparatively high until the following September when strong tradewinds forced production below 50 percent. The fall hatch began to lay in February and they attained the highest rate of egg production. By the twelfth week of production, they attained a rate of 78.0 percent, and their production was highest throughout the summer until the fall tradewinds depressed production. The performance of the four flocks definitely showed that the ability of Rhode Island Red pullets to produce eggs was impaired during practically any portion of her laying year by gusty tradewinds and short daylength. Figure 1 also shows that the hen-day cumulative income of the four groups was practically the same due to compensatory changes in egg prices that existed during the course of this investigation, despite the differences noted in their rates of egg production.

Hen-house mortality to 78 weeks of age ranged from 28.3 to 36.7 percent among the four groups. The "winter" pullets suffered 28.3 percent mortality, while the other three hatches lost 36.7, 35.0, and 36.7 percent. Paradoxically, the winter hatch had the lowest total number of eggs and the lowest hen-house and hen-day production records, as well as the lowest hen-house mortality, while the fall hatch showed the highest total number of eggs, the highest hen-house and hen-day production records, and the highest hen-house mortality. Apparently, rate of egg production and length of time in production prior to death can markedly affect these relationships.

When the total feed consumed by the pullets in each hatch was calculated from date of hatch to 78 weeks of age, it was found that no real difference existed among the four lots. As shown in table 3, the average feed consumption of the groups ranged from 120.4 to 125.2 pounds.

EGG MEASUREMENTS TO 78 WEEKS OF AGE

No real difference was found among the four hatches in the percentage of double yolk and meat- and blood-spot eggs, as well as shell thickness, yolk index, and albumen index. The data on these measurements are shown in table 4. There was, however, a highly significant difference among the four hatches in the percentage of broken eggs. The winter-hatched pullets produced 6.0 percent broken eggs, the spring hatch produced 5.2, the summer hatch 3.8, and the fall hatch 5.1 percent. In this comparison the "summer" pullets produced the smallest percentage of broken eggs. Furthermore, the summer hatch produced the largest percentage of eggs that weighed 56.7 grams (2 ounces) or more during the first laying year, while the winter hatch produced the smallest percentage of large eggs. Upon analysis, there was a statistically significant difference in the percentage of large eggs produced by the four hatches to 78 weeks of age. These data are also shown in table 4 on opposite page.

EFFICIENCY OF EGG PRODUCTION TO 78 WEEKS OF AGE

When the value of all eggs produced by each of the four hatches was calculated on the basis of prevailing wholesale egg quotations current in

Table 4. Summary of egg measurements to 78 weeks of age

Characteristic	Unit of measure	Hatches				Statistical analysis	
		Jan. 4	Mar. 28	July 12	Oct. 4	Method of analysis	Variation significant
Double yolk eggs	Percent.	0.0058	0.0017	0.0037	0.0075	Covariance	No
Shell thickness (1)	Inch	0.0109	0.0109	0.0111	0.0112	Variance	No
Broken eggs	Percent.	6.0	5.2	3.8	5.1	Covariance	Yes**
Meat- and blood-spot eggs	Percent.	8.4	3.4	4.5	3.8	Variance	No
Thick divided by total albumen (1)	Percent.	60.5	59.6	60.2	59.4	Variance	No
Height divided by diameter of yolk (1)	Percent.	36.6	37.0	37.1	36.6	Variance	No
Large eggs (over 56.7 grams)	Percent.	47.8	62.5	72.0	61.7	Covariance	Yes**

(1) Average of one day's sample taken every 14 days.

Honolulu at the time the eggs were produced, it was found that the "winter" pullets produced eggs valued at $626.49, the "spring" pullets produced eggs worth $633.10, the "summer" pullets produced $603.61, and the "fall" pullets, $655.15. This income, however, did not reflect the true income of each group, since all eggs, including those that were broken or contained meat and blood spots, were included in the calculations. When the defective eggs were omitted, it was then found that the value of eggs produced by the four hatches was $536.28, $578.65, $556.74, and $596.84, respectively. These values, on the other hand, represent an underestimate of the gross returns since commercial poultrymen would expect to obtain additional income from the sale of broken eggs. The analysis indicated that the fall-hatch produced eggs with the greatest gross value, followed in descending order of value by the spring, summer, and winter hatches. Unlike Mainland studies, the "summer" pullets produced eggs that were worth more than those laid by the "winter" pullets.

When the total feed consumed during the laying year was divided by the dozens of eggs produced by each group during the year, the "fall" pullets showed the greatest economy of feed conversion. They required 5.61 pounds of feed to produce a dozen eggs, while the summer hatch required 5.89 pounds of feed, the spring hatch required 6.01 pounds of feed, and the winter hatch required 6.31 pounds of feed. Not only did the fall hatch produce the greatest value of eggs, they laid with greater economy than any of the other three hatches. In contrast with mainland data, the summer-hatched pullets were more economical in conversion of feed into eggs than were the winter and spring hatches.

When the biweekly hen-day income was calculated for the four hatches, it was found that the "fall" pullets had the greatest biweekly egg income.

Table 5. Efficiency of egg production and feed consumption to 78 weeks of age

Characteristic	Unit of measure	Hatches: Jan. 4	Mar. 28	July 12	Oct. 4	Statistical analysis: Method of analysis	Variation significant
Total egg income (1) and (2)	Dollars	626.49	633.10	603.61	655.15	Variance	No
Biweekly hen-day egg income (1) and (2)	Cents	46.7	45.8	46.3	47.0	Variance	No
Loss due to meat and blood spots, and broken eggs	Percent.	14.4	8.6	8.3	8.9	Chi square	No
Corrected egg income	Dollars	536.28	578.65	556.74	596.84	Chi square	No
Total feed consumption	Pounds	4,635.6	4,788.2	4,736.2	5,107.7	Chi square	Yes**
Feed per dozen eggs	Pounds	6.31	6.01	5.89	5.61	Chi square	No

(1) Calculations based on prevailing weekly wholesale egg quotations current in Honolulu at the time eggs were produced.
(2) All eggs regardless of defects, such as meat and blood spots, were included in these calculations.

Throughout the first laying year their average hen-day income for each 14-day period was 47.0 cents. The winter, spring, and summer hatches showed an average biweekly hen-day income of 46.7, 45.8, and 46.3 cents, respectively.

PERFORMANCE OF HENS FROM 78 TO 130 WEEKS OF AGE

When this phase of the study was initiated, there were 43 hens remaining from the January hatch, 38 hens from the March hatch, 39 hens from the July hatch, and 38 hens from the October hatch. A summary of their performance from 78 to 130 weeks of age is shown in table 6.

The fall-hatched hens were again the superior egg producers. As in the preceding year, their performance was best when measured by either hen-house or hen-day production. The performance data of the spring-hatched birds was somewhat inferior to that of the summer hatch during their first year of production, but their performance as hens was superior. During both years of observation, the birds hatched during the winter season showed the poorest egg production performance. When the hen-day production of the four hatches was analyzed, it was found that the derived F value between hatches was significant ($P<0.05$).

A very uniform drop in second-year egg production was noted when the comparison between the pullet and hen years was made on a hen-house production basis. When calculated in this manner, the winter-hatched hens laid 64.7 percent as well as they did during their pullet year. Similarly, the spring, summer, and fall-hatched birds laid 66.7, 61.4, and 67.5 percent as well, respectively. When the comparison was based on hen-day production, the second year performance was 62.4, 70.8, 57.4, and 70.9 percent as good as that of the pullet year, respectively. Thus, the fall-hatched birds not only laid better than the other seasonal hatches during their second year of lay, they also showed the lowest percentage change in first and second year production. On the other hand, the summer hatch, which had performed better as pullets than either the winter or spring hatches, showed the poorest comparison between first and second year performances.

The average body weights of the four hatches during the second year of production were 6.83, 6.65, 6.21, and 6.53 pounds. Upon analysis, the difference in body weight between hatches was highly signifiicant ($P<0.01$). The superior increase in body weight of the winter-hatched hens may have been influenced by the fact that this group had been the poorest egg producers.

There was a significant difference in the average feed consumption of the four groups ($P<0.01$). In order of hatch, the average hen consumed 85.0, 84.7, 85.1, and 91.7 pounds of feed from 78 to 130 weeks of age. Although the average "fall" hen consumed the most feed, she was actually most efficient in converting feed into eggs. As may be seen in table 8, this group required 7.54 pounds of feed to produce a dozen eggs, whereas the winter, spring, and summer hatches required 9.50, 7.88, and 8.44 pounds, respectively.

Table 6. Performance data of yearling hens from 78 to 130 weeks of age

Characteristic	Unit of measure	Hatches: Jan. 4	Mar. 28	July 12	Oct. 4	Statistical analysis: Method of analysis	Variation significant
Number housed	Hens	43	38	39	38		
Total production	Eggs	4,080	4,039	3,845	4,666	Chi square	Yes**
Hen-house production	Eggs	94.9	106.3	98.6	122.8	Chi square	No
Hen-house production	Percent.	26.0	29.1	27.0	33.6	Chi square	No
Hen-day production	Percent.	29.2	35.4	33.5	39.8	Variance	Yes*
Hen-house production of first year	Percent.	64.7	66.7	61.4	67.5	Chi square	No
Hen-day production of first year	Percent.	62.4	70.8	57.4	70.9	Chi square	No
Yearling hen-house mortality	Percent.	20.9	26.3	38.5	31.6	Chi square	No
Average body weight	Pounds	6.83	6.65	6.21	6.53	Covariance	Yes**
Total feed consumed	Pounds	85.0	84.7	85.1	91.7	Variance	Yes**

The yearling hen-house mortality suffered by the four groups of hens is shown in table 6. The winter hatch, as in the pullet year, suffered the lowest hen-house mortality.

EGG MEASUREMENTS FROM 78 TO 130 WEEKS OF AGE

No real difference was found among the four hatches in shell thickness and yolk index. There were, however, significant differences ($P<0.01$) in percentage of broken eggs, incidence of meat and blood spots, albumen index, and percentage of large eggs. The winter hatch produced the highest percentage of broken eggs (18.4 percent), the lowest percentage of meat- and blood-spot eggs (4.1 percent), the highest percentage of thick albumen (65.8 percent), and the lowest percentage of large eggs (82.0 percent). In contrast, the fall hatch produced the smallest percentage of broken eggs (10.4 percent), the highest percentage of meat- and blood-spot eggs (9.7 percent), and the lowest percentage of thick white (60.1 percent).

In contrast with her pullet year, the average hen produced thinner-shelled eggs (2.0 percent), more broken eggs (158.2 percent), a higher percentage of meat- and blood-spot eggs (100.0 percent), and a smaller yolk index (6.4 percent). However, the albumen index during the yearling production year was superior to that of the pullet year (3.8 percent).

There was a significant difference ($P<0.01$) in the percentage of large eggs produced by each group. Of the eggs laid by the winter and spring hatches, 82.0 and 83.0 percent, respectively, were equal to or heavier than 2 ounces. In contrast, 97.0 percent of the eggs laid by the summer hatch and 94.5 percent from the fall hatch were "large."

Table 7 summarizes these data.

Table 7. Summary of egg measurements from 78 to 130 weeks of age

Characteristic	Unit of measure	Hatches: Jan. 4	Mar. 28	July 12	Oct. 4	Statistical analysis: Method of analysis	Variation significant
Double yolk eggs	Percent.	0.0	0.0	0.0	0.0		
Shell thickness (1)	Inch	0.0108	0.0109	0.0108	0.0107	Variance	No
Broken eggs	Percent.	18.4	11.3	11.6	10.4	Variance	Yes**
Meat and blood spots	Percent.	4.1	9.6	9.7	9.7	Variance	Yes**
Thick divided by total albumen (1)	Percent.	65.8	61.3	61.6	60.1	Variance	Yes**
Height divided by diameter of yolk (1)	Percent.	34.1	34.5	34.2	35.1	Variance	No
Large eggs (over 56.7 grams)	Percent.	82.0	83.0	97.0	94.5	Variance	Yes**

(1) Average of one day's sample every 14 days.

EFFICIENCY OF EGG PRODUCTION FROM 78 TO 130 WEEKS OF AGE

There was a significant difference in total egg income among the four hatches ($P<0.01$). As shown in table 8, the total value of eggs produced by the four lots ranged from $279.03 to $342.65. When the eggs containing meat and blood spots, as well as broken eggs, were omitted from these calculations, the values ranged from $217.93 to $273.78. As in the pullet year, the fall-hatched birds produced eggs of greatest value and the winter-hatched hens produced eggs of least value. In both years the value of eggs produced by the spring hatch was greater than that of the summer hatch. As would be expected, there was a significant difference in biweekly hen-day egg income among the four hatches ($P<0.01$), the winter hatch showing the smallest and the fall hatch the largest earning. In contrast, the winter hatch required the most feed to produce a dozen eggs (9.50 pounds), while the fall hatch required the least feed (7.50 pounds). These data are shown in table 8.

Table 8. Efficiency of egg production and feed consumption from 78 to 130 weeks of age

Characteristic	Unit of measure	Hatches				Statistical analysis	
		Jan. 4	Mar. 28	July 12	Oct. 4	Method of analysis	Variation significant
Total egg income (1) and (2)	Dollars	281.20	281.81	279.03	342.65	Variance	Yes*
Biweekly hen-day egg income (1) and (2)	Cents	28.5	34.6	32.4	40.4	Variance	Yes**
Loss due to meat and blood spots, and broken eggs	Percent.	22.5	20.9	21.3	20.1	Chi square	No
Corrected egg income	Dollars	217.93	222.91	219.60	273.78	Chi square	Yes*
Feed per dozen eggs	Pounds	9.50	7.88	8.44	7.54	Chi square	No

(1) Calculations based on prevailing weekly wholesale egg quotations current in Honolulu at time eggs were produced.
(2) All eggs regardless of defects, such as meat and blood spots, were included in this calculation.

Under the conditions of this experiment, pullets were more efficient and profitable than hens. When the data from the four hatches were combined, it was found that as hens the same flock required 39.8 percent more feed to produce a dozen eggs than they did as pullets. Furthermore, the average biweekly hen-day egg income of the hens was only 73.1 percent that of the same flock when they were pullets. It should be noted, however, that the latter value was subject to variations in wholesale egg prices which were not constant throughout the two periods of comparison.

DISCUSSION AND CONCLUSIONS

This study has shown that differences in flock performance may be influenced by the season of the year when the chicks were hatched. Admittedly this project dealt with a limited population and variations in the quality of feed did occur; but, in the main, most of the effects noted may be ascribed to the interrelationship of the chicken and its climatic environment, since the same parents produced the four hatches and the same rations were fed to each hatch.

In interpreting the data obtained from this study, with the Hawaii poultryman's point of view in mind, it would appear that commercial production of chicks should be efficient throughout the year. No trend in fertility or hatchability was detected in this study even though the same matings were repeated at intervals from January through October, 1949. These data suggest that climate is not a factor to deter year-round production of chicks in Hawaii. Nor was any seasonal effect noted on livability of chicks to 12 weeks of age. Growth rate to 12 weeks of age, on the other hand, was somewhat superior for the winter- and spring-hatched chicks, although subsequent body weight measurements at 18 and 24 weeks of age indicated no real difference between the four groups of pullets.

Egg production is the major source of income to the commercial egg producer, the sale of cockerels and stew hens being of lesser importance. Thus, differences observed in egg production among the four hatches are of tremendous importance. In this study the fall-hatched pullets laid the most eggs, and, in spite of a high hen-house mortality record, their hen-house production record was best. When the monetary values of these eggs were compared, the fall-hatched birds were also superior to the other lots, followed in order by the spring, winter, and summer hatches. In terms of efficiency of feed conversion into eggs, the fall-hatched birds were again superior to the other lots, followed in order by the summer, spring, and winter hatches.

The evidence of this investigation suggests that the commercial egg producer would enjoy a greater, more uniform return from his investment and for his labor if he adopted, at a minimum, a bi-seasonal replacement program, with possibly more emphasis on fall- rather than spring-hatched chicks. Such a procedure would result in more frequent and, therefore, more efficient use of his poultry houses and equipment. It would also tend to create a more orderly flow of eggs into the Honolulu market, thereby helping to prevent the springtime "glut" and stabilizing egg prices. It is the opinion of the authors that uniform egg prices throughout the year would lower buyer's resistance encountered during periods of short supply and encourage a favorable habit that should reflect in greater annual consumption. Out-of-season hatching should also enable the egg producer to raise more chicks annually with the same capital investment in brooding facilities, and the immediate replacement of dead or inefficient layers should decrease the costs of labor and overhead per unit of product. After all, a commercial producer of eggs is a manufacturer. He converts raw products into food for human consumption. In Hawaii, to date, he has found a market for his entire product. He might be compared, for example, with a manufacturer of linen goods who operates 12 weaving machines. Would it be logical for the linen manufacturer to stop the production of one weaving machine every other month, and thus be at half capacity at the end of the year despite a market for his total output? Most likely the linen manufacturer would run his 12 weaving machines on a two or three shifts per-day basis the year round, if the market could absorb his total output. For the same reason the egg producer should keep every laying cage or pen filled to capacity the year round and thus reduce as much as possible his production or "manufacturing" cost per unit of product.

This study has also shown that the maintenance of an ordinary flock through a second year of production is inefficient. In this study, the layers during their second year of production required 39.8 percent more feed to produce a dozen eggs. In addition, their biweekly hen-day egg income was only 73.1 percent that of their pullet year. These phenomena were also observed among Single Comb White Leghorns that were maintained under similar conditions through two years of production *(7)*. According to these data, the regular replacement of pullets at the time or just preceding their annual molt should result in a greater volume of production at a lower cost per unit of product.

This investigation has clearly demonstrated the need for wind protection of pullets during their first laying year. Regardless of season of hatch, the rate of egg production was either retarded or markedly reduced when Rhode Island Red pullets were exposed without wind protection during the fall and early winter months when strong, gusty tradewinds were prevalent in Hawaii. These data suggest the need of protective devices to shield laying pullets from this condition. Rosenberg and Tanaka *(7)* had found that Single Comb White Leghorns were also very sensitive to strong winds, their production dropping even more than that of the Rhode Island Reds'.

SUMMARY

It was found that pullets hatched in the fall produced the most eggs and showed the highest hen-house and hen-day production records. In this study the pullets hatched during the summer laid better and the winter-hatched pullets laid poorer than those hatched in the spring. The fall-hatched pullets produced eggs of greatest market value, followed in descending order by the pullets hatched in the spring, summer, and winter. The "fall" pullets showed the greatest economy of feed conversion. They required 5.61 pounds of feed to produce a dozen eggs, while the summer-, spring-, and winter-hatched pullets required 5.89, 6.01, and 6.31 pounds of feed, respectively. The "fall" pullets also showed the greatest biweekly egg income, followed in descending order by the winter, summer, and spring hatches.

No significant effect of season was observed on fertility, hatchability, livability, and body weight of pullets taken at 18 weeks of age. When they were weighed at 12 weeks of age, however, the "winter" pullets were significantly heavier than the other three groups, followed in sequence by the spring, fall, and summer hatches. The ability of unprotected pullets to produce eggs was definitely affected by season, on the other hand. The performance of the four flocks showed that the ability of a Rhode Island Red pullet to produce eggs was impaired during practically any portion of her laying year by gusty tradewinds and short daylength.

This study has also shown that the maintenance of an ordinary flock through a second year of production is inefficient. When the performances of the four flocks were combined, the same birds as hens required 39.8 percent more feed to produce a dozen eggs and their biweekly hen-day egg income was 73.1 percent that of their pullet year. In contrast with her pullet year, the average hen produced thinner-shelled eggs (2.0 percent), more broken eggs (158.2 percent), a higher percentage of meat- and blood-spot eggs (100.0 percent), and a smaller yolk index (6.4 percent). The albumen index during the yearling production year was superior to that of the pullet year (3.8 percent).

The evidence of this investigation suggests that the commercial egg producer would enjoy a greater, more uniform return from his investment and for his labor if he purchased replacement chicks at regular intervals throughout the year, concentrating primarily on fall- and spring-hatched chicks. Out-of-season hatching should also enable the egg producer to raise more chicks annually with the same capital investment in brooding facilities, and the immediate replacement of dead or inefficient layers should decrease the costs of labor and overhead per dozen of eggs.

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ACKNOWLEDGMENT

The authors gratefully acknowledge the assistance of Mr. A. L. Palafox, Junior Poultry Husbandman, in collecting the biweekly egg measurements.

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