PERFORMANCE TESTS OF BROILER STRAINS USED IN LEBANON

By

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Broiler Performance Tests

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ABSTRACT

Broiler performance tests are being conducted by research and government stations all over the world because of the many advantages and benefits these tests have rendered to the broiler industry.

The objective of the experiments reported in this thesis was mainly to evaluate and compare the six major broiler strains used in Lebanon and several other countries of the Middle East. These broiler performance trials are the first to be made in Lebanon and included the following strains: Arbor Acres (A), Cobb (B), Hubbard (C), Hybro (D), Kimber (E) and Pilch (F). All of these strains are the results of crosses with the male carrying Cornish blood which is an English breed and the female carrying White Plymouth Rock blood which is an American breed.

A randomized block design was used in all experiments and these were conducted in the winter, spring, summer and fall of 1963. Two pens were used for each treatment with a total of approximately one hundred birds per treatment. Birds were weighed individually at one day and at intervals of 15 days for the first two experiments up to eight weeks of age, and at seven, eight, nine and ten weeks for the last two experiments. At the end of each experiment, birds were sexed, weighed, slaughtered and then dressed on the Beirut

dressed (head and feet included) and ready-to-cook basis.

In experiment III, five birds from each pen were selected at random at the age of eight weeks. They were weighed, slaughtered and dressed. The half ready-to-cook carcass was weighed and the edible meat separated from bones and weighed while the other half was ground and sample taken for protein, ash, moisture and fat determinations.

This study consisted of both biological and economic evaluations.

A. The biological evaluations included:

1 - Rates of growth of males and females at 2, 4, 6, 7, 8, 9 and 10 weeks of age.

2 - Percent mortality of chicks in all strains.

3 - Feed consumption per bird and feed conversion of all strains at different ages.

4 - Correlation between day-old chick weight and 8-week broiler weight.

5 - Number of days to reach one kilogram of live weight in each strain.

6 - Dressing percentage loss in the Beirut dressed and the ready-to-cook dressed birds.

7 - Broiler performance with respect to season.

8 - Percent bone to ready-to-cook carcass in each strain.

9 - Carcass composition (moisture, protein, fat, and ash) of all strains.

B. The economic evaluations included:

1 - Cost per chick purchased.

2 - Chick cost per broiler sold. This is based on the mortality in each strain; the higher the mortality the higher the chick cost per broiler sold.

3 - Cost of feed consumed per broiler sold.

4 - Total cost (chick and feed) per broiler sold.

5 - Net returns at 7, 8, 9 and 10 weeks per chick started over feed and chick costs.

Data from these broiler performance tests show that the Cobb (B) and Hubbard (C) strains performed best when rates of growth, feed efficiency, age at one kilogram body weight and net returns of all strains are compared. Net returns per broiler sold were found to be closely related to live weight at market age as long as mortality did not differ significantly. Carcass analysis showed that the different strains tested did not differ significantly in percent bones to edible meat nor in carcass composition.

Best results in body weight gains were obtained in the fall, while best feed efficiency was obtained in the summer. As a result of this, the highest net returns per broiler sold were in the summer while the shortest number of days to reach one kilogram of live weight was in the fall.

The influence of chick size on broiler weight at eight weeks varied from one experiment to the other. A statistically significant effect of chick size on 8-week broiler weight was observed in one experiment only and did not seem to vary with different strains.

Market age for maximum net returns per broiler on a single trial basis was found to be nine weeks, but when based on birds housed per square meter on a yearly basis, maximum net returns were found to be obtained at 7-8 weeks of age. This is based on the assumption that broilers are to be marketed by whole batch rather than selected when they reach desired market weight.

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INTRODUCTION

In the early days of broiler production, dual purpose breeds were used to produce broiler chicks. These were relatively slow in growth, taking as long as fourteen to sixteen weeks to reach market weight of about 1.5 kilograms and feed conversion of 4.0 kilograms or more per kilogram of meat.

Competition, among other factors, stimulated poultry breeders to develop a faster growing, more efficient and thus more economical bird. In this regard, cross breeding utilizing the Cornish, White Plymouth Rock and New Hampshire breeds, has been used extensively with remarkable success. Random Sample broiler and production tests, (USDA, 1963) carried on in the U.S.A. and Canada show that broiler strains entered are averaging about 1500 grams at eight weeks with a feed conversion of about 2.10 kilograms of feed per kilogram of live broiler. Unfortunately this remarkable performance has not come about without creating certain disadvantages. One of these is the disappointingly low production of the parent flocks of these strains. The average for all strains is about 45 percent with a feed conversion of nearly 4.5 kilograms per dozen eggs produced.

Poultry keeping as an industry in Lebanon started about 1952. Most of the farms established at the time were triple purpose farms dealing with hatching chicks, raising broilers, and keeping layers for the production of consumer eggs. Specialization took over thereafter, until Lebanon reached the leadership among all Arab countries in all phases of poultry production. It is definite that at the present time, more persons in Lebanon are directly involved in the actual care and management of poultry than are engaged in the raising of any other class of livestock. Poultry raising is essentially a home industry in this country. There are many homes without flocks of poultry, but there are very few flocks of poultry which are not associated with homes.

Tables 1 and 2 taken from a recent Ministry of Agriculture report (1963) show the trend of chick production from 1959 till 1963 in Lebanon and production, imports, exports and consumption of broilers during the same period, respectively.

The comparison presented in table 1 emphasizes the importance of specialized poultry keeping. It also indicates that from the point of view of the entire industry, broilers constitute the primary poultry product and that growth of broiler chick production during the period indicated has been far more extensive than that of layers. The increase in broilers being about 4.5 times while that of layers about 2.5 times. There has been no importation of broilers from 1963 to the present date which is due to the act taken by the Ministry of Agriculture and the Ministry of Economic Affairs in late 1962 and approved by the Council

Table 1 - Chick production from 1959 to 1963 in Lebanon.

Year	Local production	Imports	Exports	*To be used as broilers	% increase from previous year	*To be used as layers	% increase from previous year
1959	1,570,000	999,325	49,810	1,900,000	-	286,000	-
1960	3,392,000	676,738	246,140	3,300,000	73.7	329,000	15.0
1961	6,604,000	683,575	540,636	5,600,000	69.7	401,000	21.9
1962	11,000,000	400,000	700,000	9,350,000	67.0	562,000	40.1
1963	12,940,800	463,488	1,510,307	9,500,000	1.6	685,000	21.9

* Figures include both local production and imports.

of Ministers one year later. This act imposes previously approved quotas for importation of broilers and introduces higher custom tariffs.

Table 2 - Production, imports, exports and consumption of broilers in Lebanon.

Year	Production	Imports	Exports	Local consumption
1959	1,900,000	366,439	42,014	2,224,425
1960	3,300,000	483,177	23,990	3,759,787
1961	5,600,000	365,403	54,136	5,911,267
1962	9,350,000	350,000	80,000	9,620,000
1963	9,500,000	85,304	137,598	9,447,614

Table 2 illustrates a definite increase in broiler production accompanied by a similar increase in exports. Production figures include broilers produced from both locally and imported day-old chicks. The decrease in imports as a result of this higher local production is also obvious. Imports of broilers used to come mainly from Denmark and the U.S.A. Exports of Lebanese broilers are mainly to the Arab countries which used to import dressed broilers from Europe and the U.S.A. This means that Lebanon is competing with these western countries, but does not necessarily mean that the cost of producing broilers in Lebanon is similar to production costs in Europe or the U.S.A. In the opinion of the author, the competition is mainly due to the high costs of transportation from Europe and the U.S.A. to those countries. Analysis of the production costs for 14 broiler farms during the 1960-1961 year performed by Ward and

Fuleihan (1962) showed that it cost the average producer L.L. 2.06 to produce a bird weighing 1000 grams at 7.55 weeks. Feed constituted 50 to 60 percent of the total net cost of production, the chick about 25 percent, labor 4 percent, and annual fixed costs 5.5 percent. These workers emphasized that feed cost and respiratory diseases are two major factors contributing to the high cost of producing one kilogram of live broiler. Dressing and marketing costs amounted to nearly 20 piasters per kilogram of dressed weight. However, it paid to sell broilers dressed since the net returns were 28 piasters higher per kilogram for dressed birds than for live birds.

A kilogram of broiler is produced in Denmark and Holland at about 20 to 35 piasters lower than in Lebanon. The cost per kilogram in the U.S.A. in 1961 was roughly 70 piasters lower than in Lebanon in the same year. In 1964, the cost of production of one kilogram of broiler in Lebanon is approximately L.L. 1.50 (Unpublished data collected by Ministry of Agriculture), while in January 1964, it was L.L. 1.10 in the U.S.A. (Dince, 1964). This is due to lower cost of feed and chicks combined with more efficient management. In the U.S.A., birds are raised up to 9-10 weeks of age when they weigh over 1700 grams with feed conversion of about 2.5-2.6. Fixed costs are higher in Lebanon because of a much greater investment per bird in housing. Mortality of the birds is higher as a result of poorer management practices. Ward and Fuleihan (1962) suggested that the cost of producing broilers could be reduced by:

1 - Marketing the birds between 9 and 10 weeks of age when they should weigh over 1600 grams.

2 - Improving feed conversion through faster growth, less disease and lower mortality.

3 - Purchasing fast-growing broiler chicks and high energy feeds at lower prices.

4 - Liberal ventilation to prevent respiratory diseases.

5 - Training more efficient workers who are able to care for 7,000-10,000 broilers per worker.

6 - Adopting the system of having not more than one age of chicks on a broiler farm. This would make necessary a large scale mechanized poultry slaughter house which could take all the birds from a farm within one or two days.

The above suggestions point out in brief the various factors that influence efficiency of producing broilers which when applied will help broiler producers to decrease their variable costs and increase their net earnings.

The influence of various environmental factors on broiler production has been illustrated by several workers all over the world. An improvement in these environmental factors however will not lead to more efficient broiler production unless the producer is starting with a bird possessing good genetic potential. The Lebanese farmers have so far relied on results of broiler performance and Random Sample tests made in western countries for the selection of their broiler strains. These tests are being conducted by research and government stations all over the world. The popularity of these tests has increased because of the many advantages and benefits they have rendered to the broiler industry.

1 - They have increased competition among broiler breeders for the production of better broiler strains.

2 - They are continuously being used as a guide for the broiler producer in the selection of the most suitable broiler strains for his area.

3 - They have contributed a great deal to our knowledge of the factors that influence most efficient production of broilers.

Several broiler strains are available for broiler producers in Lebanon. The parent stock for all of these strains is being imported from Europe and the U.S.A. The objective of the present study was to evaluate these strains and study the effects of strain on various aspects of broiler performance in one location. The adequacy of performance tests and methods of evaluation have also been considered.

REVIEW OF LITERATURE

Genetic Variation and Covariation in Broiler Body Weight

Since the advent of the broiler industry more than twenty years ago, poultry breeders have been selecting for rapid growth rate in broiler-strain chickens. They have made much progress. However, it has been difficult to separate genetic progress from that resulting from advances in environment for improvement of growth rate. Body weight at broiler age is frequently considered the most important character in a breeding program directed toward improvement of meat-type chickens. Heritability of body weight at different ages up to broiler age has been estimated by a number of workers. The magnitude of an estimate may be influenced, however, by the absolute amount of genetic variation present and the extent to which environmental variation has been controlled during the experiment. Change in body weight estimate of heritability of a population with time may serve to indicate the age at which genetic selection for body weight is most efficient. Since body weight has been a trait of primary interest to broiler-strain breeders for a number of years, considerable attention has been paid to body conformation as measured by breast plumpness, angle, or some other measuring device. Heritability estimates of broiler body weight are generally considered to be in the range where individual selection is most efficient in improving this trait, but little information is available on the heritability of breast angle. Similarly, little is known about the interrelationship of these two traits. Godfrey and Goodman (1956) found that heritability estimates for 9-week body weight averaged about 0.5, while those for 9-week breast angle averaged about 0.4. A positive genetic correlation of 0.5, environmental correlation of about 0.3, and a phenotypic correlation of about 0.3, were found to exist between 9-week body weight and 9-week breast angle. No significant differences due to breed were evident in the estimates calculated.

Poultry breeders are wondering whether they may be approaching the upper limits for rapid increases in growth rate in present day populations. Jaap (1963) found that gain in 8-week body weight from selective breeding was very small in strains already at very high levels of growth rate. This diminished response could not be attributed to inbreeding or genetic drift. It was not improved by attempts to increase genetic diversity using crossbred ancestry. He stated that progress from selection appeared to be more rapid when selection was initiated in strains having a poorer growth rate resulting from their crossbred ancestry involving egg production strains. Jaap and Smith (1959) found that after three generations of selection for large body weight at eight weeks of age, a growth selected line of broiler type chickens averages about one third of a pound larger at eight weeks than the randomized control from which the selected line originated. This change in growth rate was accomplished by maintaining a selection differential of approximately 182 grams for sires and 91 grams for dams. About one third of the selection differential was realized in gain each generation.

Jaap (1960) during a five years study found that the genetic gain in body weight of commercial broilers at nine weeks of age has been estimated to be between 54.5 grams and 68.1 grams per year or a total genetic gain of 272.4 grams in four or five years.

According to Jaap (1960), 8-week body weight in the Maine Broiler Tests averaged an increase of 91 grams per year between 1953 and 1962. This progress has arisen from both genetic and environmental (mainly feed) improvements. Jaap _et al_. (1962) estimated the genetic gain in 8-week weight of commercial broilers to have been 55 grams per generation between 1955 and 1959. Jaap (1963) in his recent data from three populations of diverse ancestry, has demonstrated that genetic progress rapidly diminished when measured by increases in 8-week body weight per generation. This is the first indication that there may be a genetic limit or ceiling to 8-week body weight under the present genetic composition of broiler strains. It is unlikely that this ceiling can be attributed to increased homozygosis from selection, inbreeding or genetic drift. He stated that there appears to be plenty of genetic variation remaining in these populations.

Yao (1959) stated, "the hereditary variation of a quantitative character can be divided into additive and non-additive portions. The additive portion of variation is contributed by the additive effects of gene actions, while the non-additive portion is from the interactions of genes. There are two types of gene interactions - dominance and epistasis. The dominance effect is from the interaction between the allelic genes (loci), while the epistatic effect is from the interaction of non-allelic genes (loci). The heritability estimate (in a narrow sense) of a character for a certain population represents the additive effects of genes, while heterosis in the crossbred progenies indicates the dominance and epistatic effects of genes".

A general observation has been that the more rapid the growth, the higher the feed efficiency or body weight increase per unit of feed. This has been explained on the basis of the slower growing individuals requiring a proportionately larger maintenance. There is also some evidence in poultry, (Fox and Bohren, 1954), that feed efficiency per se, independent of the rate of growth is inherited. There is little justification, however for commercial breeders to practice selection on the basis of feed efficiency.

There has been a great deal of interest in the possibilities of utilizing hybrid vigor in the breeding of poultry.

The best way in which to accomplish this is a highly controversial issue. There are those who advocate cross breeding for both broiler and egg production. Some have found success by crossing strains, more or less distinct, of the same breed. Others believe that only after a period of intensive inbreeding followed by crossing, will it be possible to derive the maximum benefits from heterosis. At the other extreme, there are those who are convinced that a good purebred developed by the conventional methods of closed flock breeding is still the most important method for the future improvement of poultry. This lack of agreement among commercial poultry breeders, and even among experiment station geneticists, is largely a consequence of our inadequate knowledge of heterosis in the fowl. Nordskog and Ghostley (1954) performed an experiment with eight strains representing four breeds: New Hampshire, Rhode Island Red, Barred Plymouth Rocks and Australorps. These were mated in all combinations in each of 3 years. From each mating pen, offsprings were obtained which represented three mating systems - pure strains, strain crosses, and breed crosses. Growth to eight weeks of age appeared to be the most consistent expression of hybrid vigor. The fastest growing crosses in each year were strain cross New Hampshire. The fastest growing crossbreds also involved the New Hampshire breed. On the basis of over-all performance, the strain crosses were intermediate to the crossbreds and pure strains.

Performance of Certain Popular and Experimental Broiler Strains and Crosses

Growth of the broiler industry has stimulated the breeding of poultry for meat producing qualities. Consumers are interested in the amount of edible meat obtained, processors are interested in dressing and eviscerating yields and the breeders are interested in the production of a bird that satisfies both and does it most efficiently.

Hathaway *et al*. (1953) made the following observations on the basis of data collected on one thousand eight hundred chickens grown to twelve weeks using non-broiler strain stocks compared with several broiler stocks:

1 - Males in each lot weighed approximately 20 percent heavier than the females at twelve weeks of age. The broiler strains were heavier than the non-broiler strains at that age.

2 - The Dark Cornish yielded the highest percentage of total edible meat and breast meat based on live and on eviscerated weights. The White Plymouth Rocks ranked second to the Dark Cornish in meat yields. The New Hampshire broiler stocks were consistently low in meat yields.

3 - Body measurements on these birds indicated that the Dark Cornish, although smaller in live weight at twelve weeks, had the greatest breast width. The

New Hampshire lots, which were heavier in live weight, had consistently narrower breasts and yielded a lower percentage of meat than did the Dark Cornish.

4 - Statistical analyses indicated that breast width is the best single measure for predicting percentage breast meat and total edible meat yields in 12-weeks old chickens.

Davis and Hutto (1953) studied 10-weeks old broilers of different breeds. The Reds used were developed from Red Cornish x New Hampshire foundation, Dominant White were developed from White Leghorn x Barred Plymouth Rock foundation, and the reciprocal crosses between the Reds and Dominant Whites. Mean weights for the breeds and crosses were 1312 grams for the Reds, 981 grams for the Dominant Whites, 1158 grams for the Red x White crosses and 1180 grams for the White x Red crosses. Mean percentages of eviscerated carcass to live weights were 69.65, 68.08, 68.89 and 69.38. Body weight and eviscerated percentage were positively associated. Stotts and Darrow (1953) studied four hundred broilers from ten breeds and crosses raised and dressed under uniform conditions. Their data showed that Cornish crossbreds gave consistently higher edible meat yields in both males and females and had significantly higher meat-to-bone ratio than purebreds and Cornish crossbreds. Greater breast yields from Cornish crossbred females appeared to be the major factor increasing yield of breast meat from Cornish broilers. Average breast yields for each breed and cross were highly correlated with edible meat yield (r = 0.84).

Godfrey and Jaap (1952) made a study which involved Rose Comb Black Bantams and Barred Plymouth Rocks, together with F_1, F_2, and F_3 generations and a backcross of F_1(RCB x BPR) males to New Hampshire females. The dominant allele, which increases body size by 10-12 percent was present in the Barred Plymouth Rock, while the Bantams were recessive for this gene. The symbol Z was suggested. Ryan *et al*. (1954) compared five popular commercial broiler strains and crosses and one college Dominant White cross for performance during the winter, spring, and summer seasons. The Red Cornish cross birds were consistenly heaviest at nine weeks followed in order by New Hampshires, Dominant White cross, Wyandotte cross, Indian River cross and White Rocks. The Red Cornish cross showed the highest average feed efficiency. Weight at nine weeks was greatest for the winter brood and significantly lower for the summer. Average mortality for the three breeds varied from 2.6 percent for the White Rocks to 8.1 percent for the New Hampshires.

Phenotypic Correlations of Broilers to Egg and Chick Size

The statistical analysis of Pope and Shaible (1957) revealed that setting weights and hatching weights were highly correlated. They further showed a significant correlation to exist between setting egg weights and chick weights through the fourth week of age for all strains. The strains used by those workers were three different Leghorn strains. Two were inbred lines having 18 generations of inbreeding while the other was a cross. Chick weights at five and six weeks of age were not associated with initial chick or egg weights. They also found that the crossbred strain had a lower coefficient of variability than that of the inbred lines. Godfrey et al. (1953) stated that phenotypic correlations of egg size, age at sexual maturity, and adult body weight with bi-weekly weights to 12 weeks of age indicate that the influence of egg size on early growth decreases rapidly after two weeks of age and has no appreciable effect on weight at broiler age. The influence of egg size continues until after two weeks of age. O'Neil (1955) demonstrated that growth and efficiency of feed utilization to six weeks of age is not related to the percentage size of chick; while Goodwin (1961) stated that the initial effect of egg weight is, to a considerable degree cumulative and can exert a major effect on the ranking of strains at nine weeks of age. Regressions of mean 9-week body weight on mean egg size for several strains indicated that, for each increase of 28 grams per dozen in weight of egg set, the average increase in fryer weight was 30 grams in one trial and 38 grams in a second trial. Similar figures for a trial within a pure strain were somewhat smaller, averaging +13 grams for four hatches. These regressions suggest that the size of a chick at hatching does have an important effect on its growth to fryer age. Tindell and Morris (1964) also found that a highly significant linear effect was present indicating a close relationship between egg weight and broiler weight in favor of broilers from the heavier egg weight groups. There was a strong tendency for the birds of any egg weight group to perform better if they were housed separately as compared to when the groups were intermingled in a pen. This would suggest that if broilers from sub-optimal egg sizes are used, consideration should be given to the separation of these birds during the growing period from broilers hatched from larger eggs. Whether or not the increased weight gains, in combination with less mortality, would mean enough economically to offset the additional time and labor involved would be up to each individual operator to decide. Eggs weighing less than 616 grams per dozen are less desirable for broiler production due to the poorer fertility of such eggs laid by pullets just coming into production. Furthermore, the subsequent chicks weigh less at broiler age and tend to have poorer feed conversion.

Role of Environment on Performance of Chicks up to Broiler Age

There are different factors involved in the growth of different broiler strains. Genotype x environment interaction has been the subject of several investigations over the past decades. Both, the presence and absence of interactions have been reported for economically important traits in poultry. Body weight at market age is frequently considered the most important character in a breeding program directed toward improvement of meat type chickens. Heritability of body weight at different ages up to market age has been estimated by a number of workers. The magnitude of an estimate may be influenced however, by the absolute amount of genetic variation, and the extent to which environmental variation has been controlled during the experiment. Change in the body weight estimate of heritability of a population with time may serve to indicate the age at which genetic selection for body weight is most efficient.

Techniques of Random Sample testing of poultry have not remained static. Some changes have simply evolved while others have resulted from studies revealing biases or inaccuracies of existing methods. Still others have stemmed from studies of ways to make performance testing more efficient. Investigations by Collins _et al_. (1964) showed that the accuracy of strain appraisal is a function of the number of individual chickens, pens, test houses, locations (farms) and repeated tests at the same location. They showed also that for body weight, increasing the number of tests more effectively reduces error than increasing replicate pens. With males, for example, 13 replicate pens in one test are no more efficient than one pen in 2 tests. Likewise, twenty chickens per pen would not provide very efficient testing, and two pens of twenty birds each are less efficient than one pen of sixty chickens. These results also show that replicating tests was more efficient in reducing variation than replicating pens. This is of course to reduce to a minimum the environmental variations.

One of the important environmental factors that change from one test to another is season. Smith et al. (1962) initiated a housing study to compare the effects of four types of poultry houses on growth, feed conversion, and mortality during summer, fall, and winter. The types of houses were: air conditioned; fan ventilated; naturally ventilated and naturally ventilated aluminum. Each housing level was replicated in two locations (North and South rows) and each house was divided into two pens (East and West).

Significant differences in growth were observed between the four housing levels in five of the seven tests. The air conditioned and fan ventilated houses were superior to the conventional and aluminum houses during two of the three summer tests. The trend was reversed during two fall tests and one of the two winter tests. No significant differences were found between the four housing levels in feed conversion and mortality. Temperature appeared to account for some of the difference in performance of the four housing levels. This is in general agreement with the work of Prince et al. (1961) who observed a highly significant linear effect of temperature on feed efficiency; improved feed efficiency being associated with elevated temperature from 45°F to 75°F.

Milligan et al. (1957) measured the effects of poor ventilation on weight and feed conversion in winter and summer to nine weeks of age. Weights were depressed between 68 and 91 grams per broiler as a result of poor ventilation. In summer, the pattern of response to environmental variations did not appear to be influenced by different levels of energy furnished in the diets. In hot weather, the temperature of the drinking water was adjusted to approximately 50°F, 70°F and 90°F during the day. Very warm water depressed growth and feed conversion measurably, but ice water did not benefit results of broilers at six weeks in comparison to water held at 70°F. Floor space studies by the same workers (Milligan et al., 1957) showed that poorer growth occurred in winter when 18 broilers per square meter were allowed instead of 10.8 broilers per square meter. Boone et al. (1961) found that there were definite indications that the season of the year affects the growth rate. The broilers were heaviest during the winter and spring seasons. Siegel et al. (1961) stated that broiler growth is poorer, but feed conversion better during the warmer season. In late fall, the broilers weighed 26 and 199 grams more at three and nine weeks of age, respectively, than those in summer. The mean feed conversion values were 2.40 $\pm$ 0.01 of feed per kilogram gain in the late fall experiment and 2.30 $\pm$ 0.02 in the summer.

Apparently, the most important factor contributing to seasonal variations in broiler performance is temperature. Howes et al. (1962) conducted three experiments using 1,130 Arbor Acre broiler chicks to assess the effects of constant temperature regimes on production over an 8-week period. All chicks were started at 95°F and the temperature was reduced 2°F every other day on all treatments until the treatment temperature was reached. Five temperature regimes between 55° and 95° plus or minus 2°F were used. The heaviest males and females were produced in the cooler environment, whereas the best feed efficiency was obtained in the warmer environment. A comparative group of birds in a conventional house exposed to the outside environment (May - Oct.) was intermediate with respect to growth and feed efficiency. Blood and feather weight was inversely proportional to environmental temperature and the best dressing percentage was obtained from the high and variable treatments. All controlled environments had a superior ratio of bone to edible meat and significantly smaller gizzards and intestines. In two experiments, Prince et al. (1961) found that chicks exposed to a 45°F environment from four to eight weeks of age consumed 295 grams per bird more feed than those in a 65°F environment, while weight gains were not significantly affected. These workers found a high linear decrease in feed consumption resulted from an increase in environmental temperature within the temperature range of 45°F to 75°F. Average decrease in feed consumption amounted to 214 grams per bird or 8.6 percent due to raising the temperature from 45°F to 75°F.

A highly significant effect of temperature on feed efficiency was found to be linear between 45°F and 75°F. The predicted average feed efficiency was 0.351 kilograms and 0.395 kilograms of gain per kilogram of feed consumed for the 45°F and the 75°F. This represented a 12.5 percent increase in feed efficiency attributable to the increase in temperature from 45°F to 75°F.

There is no doubt that nutrition and management are important environmental factors that can influence performance of different broiler strains in Random Sample or performance tests. These two factors, however can be fairly controlled and therefore their influence on performance can be greatly minimized. Our interest here, however, would merely be the interaction of these environmental factors with breed or strain.

Poultry breeders and growers are interested in knowing the performance of various broiler crosses under similar management conditions in order to ascertain the relationships between heredity and environment. Little information is available which pertains to the interaction of broiler crossbreds and environmental factors during various seasons of the year. If such interactions are of major importance, management recommendations may have to be restricted to the specific environmental conditions most favorable to a particular crossbred. The data of Bray et al. (1962) showed a lack of genotype x environment interaction (entry x ration) at a single location. It was suggested that equally balanced rations, although they may differ in type of ingredients are not likely to be a cause of rank reversal of different genotypes. Therefore, considerable confidence may be placed in Random Sample test results when choosing strains of broilers for commercial use even though they may be placed on complete rations differing in the nature of the ingredients but equal in energy and protein.

Efficiency of Growing Broilers to Heavier Weights

The vast growth of the broiler industry in the U.S.A. during the last two decades has been geared to the production of a 1.5 kilograms live weight broiler which now can be grown in about eight to nine weeks on 3.2 kilograms of feed. With the faster growing and more efficient broiler of today, a study was conducted to determine if production efficiency could be increased by rearing the birds to a heavier weight. It is believed that a good market can be developed for heavy broilers or light roasters if their production can be shown to be economical. Wisman et al. (1961) analyzed broiler tests and feeding trials data from various states to determine the optimal market weights. Their analyses indicated that cockerels should be marketed between ten and eleven weeks (2.2 - 2.5 kilograms), pullets at ten weeks (1.6 kilograms), and straight-run chicks at ten weeks of age (1.9 kilograms) in a continual operation. The rate of feed conversion for each sex was about the same beyond nine weeks of age. The males grew at approximately the same rate as the females beyond this age, but the females showed a definite reduction in rate of gain at twelve weeks of age. The males grew faster when they were intermingled with the females in the same pen. Females reared separately were heavier than those intermingled at thirteen weeks of age but not at the earlier age. Intermingled females were lighter in body weight than separately reared females at 13.4 birds per square meter, but not at 10.8 birds per square meter of floor space. The feed conversion for males was better than for females and efficiency paralleled faster gains. They also concluded that the lowest cost occurred at eleven weeks of age for each sex reared separately. The cost was less for males than for females when the combined sexes were reared intermingled rather than separately. The production cost was not only markedly reduced, but the minimum cost appeared one week earlier, or at ten weeks of age. They also stated that broilers grown at 13.4 birds per square meter should be marketed at eleven weeks while those reared at 9.0 - 10.8 birds per square meter should be sold at twelve weeks of age. This was essentially true for each sex whether they were reared separately or intermingled. Baum and Fletcher (1953) found that net profit to producers could be increased by marketing broilers at a later age than usually predicted. Strain and Nordskog (1962) showed that the factors having the largest effect on income over feed costs were 8-week body weight and 8-week feed conversion. They also found that an increase of one unit in the first results in a 9.54 cents increase in net income while a unit increase in the second would decrease net income 16.24 cents.

The application of profit maximizing techniques to large scale commercial fryer farms may result in greater net return to producers through a better allocation of productive factors (equipment, buildings, feed, etc.). Since the transformation of feed into meat is carried on within the fowl, and output is measured in live body weight, any change in the fixed plant, the quality and intensity of application of feed, the managerial practices, and various other factors such as diseases and temperature variations will affect the net return of the farm. Brooks et al. (1957) showed that there was a linear relationship between weight gain and time; and as the total feed input increased after nine weeks of age, there was a decrease in the units of broiler output per unit of feed input.

Influence of Strain on Carcass Yield and Body Composition

Kondra et al. (1960) stated that edible meat as a percent of eviscerated weight was not affected significantly by the level of energy or protein in the diet. Females were superior to males in meat yield as a percentage of eviscerated weight because of the significantly higher proportion of bones in males. Strain and ration differences had significant effects on the regression of total bone weight. Orr (1955) used ten strains and crosses fed two diets and compared them with regard to dressing and ready-to-cook percentages and yield of edible cooked meat. Analysis of variance of chilled dressed weight as a percentage of the live weight showed no significant differences due to strains, sex or diet. Gyles et al. (1954) used forty chickens from each of five breeding groups and dressed them at eleven weeks of age. The average live weight of the purebred was 1.3 kilograms against 1.5 kilograms for the crossbreds. The average unsexed eviscerated dressed carcass expressed as a percentage of live weight was 71.2 for the purebreds against 72.7 for the crossbred. Morrison et al. (1954) compared eight crosses of chickens for yield of salable meat and edible meat. No consistent differences were found between crosses with respect to evisceration loss or yield of edible meat. There was no significant difference between crosses as measured by tenderness and flavor. Stotts and Darrow (1952) showed that the Cornish crossbreds gave consistently higher edible meat yields in both males and females and had a higher meat to bone ratio than purebred and non-Cornish crossbreds. The differences in yield of edible meat in favor of the Cornish crossbreds were statistically significant.

Clayton *et al.* (1960) showed that considerable variation exists among the moisture and fat components of broiler carcasses. A study was undertaken to determine if this variation is due to genetic differences. Seventy-two 9-week old carcasses were analyzed chemically for moisture and fat composition. Moisture percentages ranged from 68.8 to 73.8. Fat percentages ranged from 4.8 to 12.9. Significant differences were observed in both fat and moisture contents of broilers.

MATERIALS AND METHODS

The data presented in this study cover four broiler experiments utilizing a total of 1,800 broilers. These experiments were conducted at the Agricultural Research and Education Center of the American University of Beirut during winter, spring, summer and fall of 1963, respectively. The dates and duration of the trials were as follows:

I. Winter - January 2 to February 27, 1963 (8 weeks).

II. Spring - April 2 to May 28, 1963 (8 weeks).

III. Summer - July 2 to September 10, 1963 (10 weeks).

IV. Fall - October 17 to December 25, 1963 (10 weeks).

A randomized block design was used in all experiments with five pens on the east side of the house as one block and five pens on the west side as the second block. The same house was used for all trials. All birds were wing-banded at one day of age and individually weighed. Feed consumption was recorded for each pen. Feed consumed by birds which had died prior to the completion of the experiment was estimated and taken out from the total amount of feed consumed for that pen. Feed conversion was given as kilograms of feed required to produce one kilogram of live broiler weight at seven, eight, nine or ten weeks of age. Mortality was recorded daily for each pen.

Management of all pens in all the tests was similar.

Heat was supplied by infra-red lamp brooders and one 250 watt lamp was used for every fifty chicks. The duration of the heat supplied in every test differed according to the season. Floor space, feeders and waterers were adequate in every pen during the four tests. Every pen used had an area of 10 square meters in which fifty chicks were raised. Eight linear centimeters of feeder space were provided for every chick and 2.5 linear centimeters of water space were provided per chick. All chicks were vaccinated against Newcastle disease between the 6th and 12th day of age.

A 21.26 percent protein all-mash ration was used throughout the entire study for all four tests. The composition of the chick ration is presented in table 3. This ration has been tested at the Agricultural Research and Education Center and found to be adequate for broilers. It supplies all nutrients known to be required by the chick in amounts that exceed National Research Council requirements.

The commercial strains used in the experiments were designated with letters as follows: Arbor Acres (A); Cobb's (B); Hubbard (C); Hybro (D); Kimber (E); and Pilch (F). The statistical analyses for all experiments were made according to the split plot design discussed by Panse and Sukhatme (1957).

The economic phase of these experiments consisted of studying the net return per broiler sold of every strain at eight weeks for the first 2 experiments and at seven, eight,

Table 3 - Composition of the broiler ration used in all tests.

Ingredients	%
Ground yellow corn	67
Soybean oil meal (44%)	16
Peanut oil meal (50%)	5
Alfalfa meal (17%)	1
Steamed bone meal	1
Broiler concentrate*	10
Calculated analysis	
Protein	21.26
Fat	3.00
Fiber	3.96
Calcium	0.96
Phosphorus	0.79
Productive energy (Cal./kg.)	2176

* Broiler concentrate furnishes the following nutrients per kilogram of ration according to the specifications of the manufacturer: Protein, 5.8%; calcium, 0.64%; phosphorus, 0.37%; sodium chloride, 0.4%; productive energy, 1650 Cal./kg. It also supplies the following vitamins and minerals per kilogram of concentrate: Vitamin A, 60,000 I.U.; vitamin D_3, 15,000 I.U.; riboflavin, 44 mg; nicotinic acid, 242 mg; pantothenic acid, 55 mg; choline, 5390 mg; vitamin B_{12}, 110 mcg; iron, 200 mg; copper, 20 mg; manganese, 500 mg; iodine, 20 mg; cobalt, 10 mg; and zinc, 500 mg.

nine and ten weeks for the third and fourth experiments. The cost per chick purchased varied from L.L. 0.55 to 0.58 delivered at the commercial broiler farms. Mortality cost was estimated and added to the original cost per chick purchased to find out the chick cost per bird at the age assumed to be sold. Feed consumed per pen was estimated (this includes feed consumed by alive and dead birds) and divided by the number of birds to be sold in order to find the feed consumed per broiler sold. This was multiplied by L.L. 0.40 to find the cost of feed per broiler sold. Live weight per broiler at the age assumed to be sold was calculated including the average of males and females in every pen. The market value of one broiler was then estimated by multiplying the live weight per broiler by L.L. 2.00 assuming the average selling price per kilogram of live weight to be L.L. 2.00. The total cost per broiler included only chick cost and feed cost. The other costs such as the fixed and variable costs were not included since it is difficult to estimate them on a commercial basis in a research center as the Agricultural Research and Education Center of the American University of Beirut. On the other hand, these costs will vary from one commercial farm to the other according to the management practices followed by each farm. Moreover, the feed and chick cost represent the major part of the total production cost. For these reasons total cost per chick in all experiments presented in this study includes only chick and feed cost. The total cost per broiler was then deducted from the market value of one broiler to find the net return per broiler.

Experiment I

Four commercial broiler strains were used in this experiment which was conducted in winter. These were strains A, B, C and F. One hundred straight-run day-old chicks were used for each strain with fifty chicks per pen. The chicks were weighed individually at 2-week intervals up to eight weeks of age when they were sexed, slaughtered, and dressed. Two methods of dressing were used. In the first method, broilers were bled, scalded, picked and eviscerated, but head and feet were kept on, and giblets were included. This has been referred to as the "Beirut dressed" which is the most common method of dressing broilers in Lebanon. The second method was the ready-to-cook carcass without head, feet and giblets. The percent dressing loss for each method was calculated on the basis of the loss incurred on the live weight of the birds.

Experiment II

Four commercial broiler strains were also used in this experiment which was conducted in the spring. These were strains A, B, D, and F. One hundred eggs of every strain were hatched on the Agricultural Research and Education Center. The eggs were selected to weigh not more than 62 grams and not less than 58 grams. This was done in order to get uniform weight of all strains at one day of age since egg size is positively correlated with chick weight at one day. The chicks were weighed at 2-week intervals up to eight weeks of age when they were slaughtered and dressed. No sexing at the end of eight weeks was done in this experiment and so figures reported are all averages of males and females. Dressing loss for both "Beirut dressed" and ready-to-cook was calculated as in the first experiment.

Experiment III

Five commercial broiler strains were used in this experiment which was conducted in the summer. These were strains A, B, C, E, and F. The chicks for this experiment were obtained from commercial hatcheries. One hundred chicks were used for each strain with fifty chicks per pen. The chicks were weighed individually at two, four, six, seven, eight, nine and ten weeks of age. They were sexed, slaughtered and dressed at ten weeks. Dressing losses for both methods were also calculated as previously explained for experiment I. Five broilers from each replicate making a total of ten birds from every strain were cut into two equal halves after being dressed to the ready-to-cook stage. One half was weighed and then deboned, and the meat obtained from the weighed half was also weighed. The percentage of bone to ready-to-cook carcass was then calculated. The other half of the carcass was then ground and a sample frozen for body composition analyses. Water, protein, ether extract and ash percentages were determined using AOAC methods (1960).

Experiment IV

This experiment was conducted during the fall of 1963. The same methods for experiment III were used and the same strains tested. One hundred straight-run chicks were used for each strain with fifty chicks per pen. Bone percentage and body composition were not studied in this experiment.

RESULTS

Experiment I

Results of the first experiment including four different strains are presented in tables 4-9. Body weights at 2-week intervals are presented in table 4 for both males and females. It is observed that males and females of all strains did not differ in weight at one day of age. The range for males of all strains is 37-41 grams while for females 36-41 grams. It is obvious from the table that sex differences in body weight increase with age. Difference in average body weights between the sexes was 8 grams or 5 percent at 2 weeks while at 8 weeks the difference was 252 grams or 20 percent. The analysis of variance (table 8) shows that strains differed significantly in body weight at the 5 percent level of probability. Strain B is the highest in body weight at 8 weeks in the case of both males and females, while strain F is the lowest.

The separation of mean body weights at 8 weeks of age by the critical difference method is presented in table 9. The means represent male and female averages of the four strains studied. Body weights of strain B were significantly higher than those of all other strains. Strains A and C did not differ significantly neither did strains A and F.

Table 4 - Comparison of body weight and feed consumption of broiler strains at 2-week intervals - Experiment I.

Period (weeks)	No. of birds		Strain	Body weight (grams)			Feed consumption (grams)
	Male	Female		Male	Female	Average	
0	44	60	A	39	38	39	
	44	54	B	37	36	37	
	39	51	C	41	41	41	
	39	57	F	39	39	39	
			Average	39	39	39	
2	44	60	A	167	158	161	292
	44	54	B	172	168	171	304
	39	51	C	175	161	165	303
	39	57	F	148	146	146	275
			Average	166	158	161	294
4	44	60	A	451	403	423	816
	44	54	B	528	439	456	838
	39	51	C	438	419	422	814
	39	57	F	421	383	394	818
			Average	459	411	424	822
6	44	60	A	903	786	835	1797
	44	54	B	962	848	895	1854
	39	51	C	897	793	811	1805
	39	57	F	876	766	799	1772
			Average	910	798	835	1807
8	44	60	A	1474	1237	1337	3136
	44	54	B	1644	1323	1435	3270
	39	51	C	1513	1273	1379	3139
	39	57	F	1417	1208	1293	3064
			Average	1512	1260	1361	3152

Table 5 - Rate of gain, feed consumption and feed/unit of gain at 2-week intervals - Experiment I.

Period (weeks)	Strain	Weight gain (grams)	Feed consumed (grams)	Feed/gain
0-2	A	122	292	2.39
	B	134	304	2.27
	C	124	303	2.44
	F	107	275	2.57
	Average	122	294	2.41
2-4	A	262	524	2.00
	B	285	534	1.87
	C	257	511	1.99
	F	248	543	2.19
	Average	263	528	2.01
4-6	A	412	981	2.38
	B	439	1016	2.31
	C	489	991	2.03
	F	405	954	2.36
	Average	411	985	2.27
6-8	A	502	1339	2.67
	B	540	1416	2.62
	C	568	1334	2.35
	F	594	1292	2.18
	Average	526	1345	2.56
0-8	A	1298	3136	2.42
	B	1398	3270	2.34
	C	1338	3139	2.34
	F	1254	3064	2.44
	Average	1322	3152	2.38

Rate of gain, feed consumption, and feed efficiency at 2-week intervals are presented in table 5. Strain B had the fastest and strain F the slowest growth during the 0-2 and 2-4 week periods. This is also true when the whole 0-8 week period is considered. The difference (11 percent) between the two strains is affected by disproportionate number of males and females. Calculated on the basis of a 50 percent sex ratio, the difference in favor of strain B rises to about 14 percent. Since strain B had the highest proportion of males and the largest difference in gain between the two sexes and strain F the lowest proportion of males and the lowest difference in gain between the sexes, the effect of disproportionate number of the two sexes is largest for this comparison. For comparison between strains A and C it is practically negligible.

Rate of growth increased with age, increasing from 122 grams in the first two weeks to 526 during the last two weeks. The feed consumption shows a similar increase from 294 grams during the first two weeks to 1345 grams during the last two weeks. The increase in feed consumption is relatively larger than the increase in gain which results in a decrease in feed efficiency with increase in age. The feed requirement per unit gain was relatively high during the first 2 weeks (2.41), lowest from 2-4 weeks (2.01) and highest from 6-8 weeks (2.56).

Percent mortality up to eight weeks is shown in table 6.

Table 6 - Mortality and dressing percentage - Experiment I.

Strain	% Mortality	Dressing percentage			
		Beirut dressed (%)		Ready-to-cook (%)	
		Male	Female	Male	Female
A	0.0	83.6	82.6	70.0	68.8
B	4.9	82.8	82.2	68.6	68.7
C	11.0	82.2	82.3	68.4	69.0
F	2.1	83.1	82.8	69.0	69.1
Average	4.2	82.9	82.5	69.0	68.9

It is obvious that strain C differed in percent mortality from the other strains. The high mortality encountered in strain C was actually due to an outbreak of coccidiosis in one of the pens. Out of 50 birds in one pen only 40 survived to eight weeks while all 51 birds started in the second pen survived.

Dressing percentages on the basis of the Beirut dressed and the ready-to-cook method indicate no strain differences. Females have slightly lower dressing percentages than males when processed on the Beirut dressed basis. This seems to be reversed when birds are dressed on the ready-to-cook basis. The reason for this reversal could possibly be due to relatively heavier head and feet in the case of males as compared to that of females.

Economic analysis of net returns from various broiler strains studied in this experiment is presented in table 7. Net returns per broiler is determined by several factors. The factors which were considered in arriving to the figures presented are: chick cost, feed consumed, body weight at eight weeks, relative number of males to females and mortality. These were the only factors that varied between strains. Net return per broiler differed with different strains. The highest is strain B with a net return of 98.9 Lebanese piasters and the lowest strain C with a net return of 77.0. It is observed from the table that body weight at eight weeks is the main determining factor for net returns in this experiment.

Table 7 - Economic analysis of net returns from various strains of broilers at 8 weeks - Experiment I.

Measurements used	Strain			
	A	B	C	F
Cost/chick purchased (P.L.)	57.0	58.0	56.0	55.0
Chick cost/broiler sold (P.L.)	57.0	60.9	62.9	56.6
Feed consumed/broiler sold[1] (grams)	3138	3180	3399	3061
Cost of feed/broiler sold[2] (P.L.)	125.5	127.2	135.9	122.4
Live weight/broiler at 8 weeks (grams)	1337	1435	1379	1293
Market value of one broiler[3] (P.L.)	267.4	287.0	275.8	258.6
Total cost/broiler[4] (P.L.)	182.5	188.1	198.8	179.0
Net return/broiler (P.L.)	84.9	98.9	77.0	79.6

1 Including the feed consumed by the chicks which died.

2 At 40 Lebanese piasters per kilogram.

3 Assuming selling price at 200 Lebanese piasters per kilogram of live weight.

4 Including only chick cost and feed cost.

Table 8 - Analysis of variance for growth, feed efficiency and net return/broiler - Experiment I.

Source of variance	d.f.	M.S.		
		Body weight	Feed efficiency	Net return
Replication	1	1281.57	0.0000	694.32*
Strain	3	15655.49*	0.0105	241.03
Error (a)	3	816.77	0.0019	32.74
Sex	1	230543.97**		
Strain x sex	3	708.69		
Error (b)		526.09		

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Table 9 - Separation of mean body weight at 8 weeks by the critical difference method*(C.D. = 64.6) - Experiment I.

	Strain			
	B	C	A	F
Mean	1460	1393	1355	1312

* Means not underlined by the same line are significantly different.

Experiment II

Results of the second experiment are presented in tables 10-15. This experiment involved four different strains with approximately eighty birds in each strain with nearly equal number of males and females. Body weights at 2-week intervals are presented in table 10. No distinction between males and females was made in this experiment and therefore data is presented for mixed sexes. It is observed that day-old chick weights of all strains did not differ very much with a range of 39-41 grams. This was due to the fact that eggs before hatching were selected between 58 and 62 grams. Considering averages for all strains, body weights increased 115, 257, 393 and 451 grams for the periods 0-2, 2-4, 4-6 and 6-8 weeks, respectively. This is shown in table 11. The analysis of variance (table 14) shows that strains did not differ significantly in body weight at eight weeks. The difference between the best and the poorest strain is 80 grams.

Feed consumption data is also presented in table 10. Feed consumption of each strain tends to follow body weight, but the relationship is not always very close. If strains D and F are compared, we find that although there are only two grams difference in feed consumed at eight weeks of age in favor of strain D, there are 49 grams difference in live weight in favor of strain F. This means less feed consumed per unit of gain for strain F than for strain D. This is

Table 10 - Comparison of body weight and feed consumption of broiler strains at 2-week intervals - Experiment II.

Period (weeks)	No. of birds	Strain	Body weight (grams)	Feed consumption (grams)
0	78	A	39	
	75	B	41	
	59	D	41	
	80	F	40	
		Average	40	
2	75	A	154	238
	70	B	164	230
	53	D	148	213
	77	F	155	234
		Average	155	229
4	75	A	398	764
	70	B	430	778
	53	D	396	798
	74	F	424	739
		Average	412	770
6	75	A	787	1618
	68	B	838	1700
	52	D	780	1646
	74	F	816	1613
		Average	805	1644
8	72	A	1246	2746
	66	B	1296	2876
	51	D	1216	2736
	71	F	1265	2734
		Average	1256	2773

Table 11 - Rate of gain, feed consumption and feed/unit of gain at 2-week intervals - Experiment II.

Period (weeks)	Strain	Weight gain (grams)	Feed consumed (grams)	Feed/gain
0-2	A	115	238	2.07
	B	123	230	1.87
	D	107	213	1.99
	F	115	234	2.04
	Average	115	229	1.99
2-4	A	244	526	2.16
	B	266	548	2.06
	D	248	585	2.36
	F	269	505	1.88
	Average	257	541	2.10
4-6	A	389	854	2.20
	B	408	922	2.26
	D	384	848	2.21
	F	392	874	2.23
	Average	393	874	2.22
6-8	A	459	1128	2.46
	B	458	1176	2.57
	D	436	1090	2.50
	F	449	1121	2.50
	Average	451	1129	2.50
0-8	A	1207	2746	2.28
	B	1255	2876	2.29
	D	1175	2736	2.33
	F	1225	2734	2.23
	Average	1216	2773	2.28

reflected in better feed efficiency for strain F with respect to strain D as is shown in table 11.

Although strains D and F did not differ significantly in body weights at eight weeks, they were significantly different in feed efficiency at the 1% level of probability (table 14). Strains B and A did not differ in body weight or in feed efficiency at eight weeks of age. Furthermore strains A and B were significantly poorer in feed efficiency than strain F. This indicates that strain differences in feed efficiency may exist under identical ration feeding conditions.

The four strains studied differed in percent mortality when raised under identical conditions. This is shown in table 12. The average for all strains is 11.2. This high mortality was probably due to a sudden change in weather conditions which resulted in an outbreak of certain respiratory disorders in the flock.

Dressing percentages on the Beirut dressed and ready-to-cook basis presented in table 12 indicate no significant strain differences. The range between the lowest and the highest is 83.7-85.8 with an average of 84.6 for the Beirut dressed, while the range for the ready-to-cook is 69.0-71.2 with an average of 69.6 percent.

Economic analysis of net returns from various broiler strains is presented in table 13. The net return per broiler sold did not differ significantly between strains which was mainly due to the fact that strains did not differ significantly with respect to body weight at eight weeks.

Table 12 - Mortality and dressing percentage - Experiment II.

Strain	% Mortality	Dressing percentage	
		Beirut dressed (%)	Ready-to-cook (%)
A	7.7	85.8	71.2
B	12.0	83.7	69.3
D	13.6	84.4	69.0
F	11.3	84.4	69.1
Average	11.2	84.6	69.6

Table 13 - Economic analysis of net returns from various strains of broilers at 8 weeks - Experiment II.

Measurements used	Strain			
	A	B	D	F
Cost/chick purchased (P.L.)	57.0	58.0	56.0	55.0
Chick cost/broiler sold (P.L.)	61.8	66.5	65.0	62.0
Feed consumed/broiler sold[1] (grams)	2870	2988	2836	2861
Cost of feed/broiler sold[2] (P.L.)	114.8	119.5	113.4	114.4
Live weight/broiler at 8 weeks (grams)	1246	1296	1217	1265
Market value of one broiler[3] (P.L.)	249.2	259.2	243.4	253.0
Total cost/broiler[4] (P.L.)	176.6	186.0	178.4	176.4
Net return/broiler (P.L.)	72.6	73.2	65.0	76.6

1 Including the feed consumed by the chicks which died.

2 At 40 Lebanese piasters per kilogram.

3 Assuming selling price at 200 Lebanese piasters per kilogram of live weight.

4 Including only chick cost and feed cost.

Table 14 - Analysis of variance for growth, feed efficiency and net return/broiler at 8 weeks - Experiment II.

Source of variance	d.f.	M.S.		
		Body weight	Feed efficiency	Net return
Replication	1	8	0.0001	51
Strain	3	2234	0.0028**	49
Error	3	622	0.00007	108

** Significant at 1% level of probability.

Table 15 - Separation of feed efficiency means by the critical difference method* (C.D. = 0.025) - Experiment II.

	Strain			
	D	B	A	F
Mean	2.25	2.22	2.20	2.16

* Means not underlined by same continuous line are significantly different.

Experiment III

Results of the third experiment which involved five different strains with hundred birds in each strain are presented in tables 16-26. Body weights at zero, seven, eight, nine and ten weeks are presented in table 16 for both males and females. It is also observed in this experiment as in the previous ones that males and females of all strains did not differ much at one day of age. The range for males of all strains was 35-43 grams while that for females 35-42 grams. It is obvious from the table of body weight that sex differences increase with age. Body weights at one day of age differed only 1 gram while at seven, eight, nine and ten weeks, the difference was 203, 273, 393 and 462 grams respectively. The analyses of variance (tables 22 and 24) show that strains differed significantly at the 1% level of probability at both eight and ten weeks of age.

The separation of mean body weights at eight and ten weeks by the critical difference method is presented in tables 23 and 25. The means represent male and female averages of the five strains studied. The tables show that strain C was significantly higher than all other strains at both eight and ten weeks of age. Strains B and F differed significantly at ten weeks but not at eight weeks of age. Strains F and A differed significantly at eight weeks while they did not differ at ten weeks. Strain E was significantly lower than all other strains at both eight and ten weeks of age.

Body weight averages of males and females for all strains are presented in table 17. It is observed that these averages would differ if compared to body weight averages of males and females in the preceding table. The reason for that is unequal numbers of males and females in each group. The percent of males to the total number of birds used in each strain is presented in the same table. Average body weights based on equal numbers of males and females are presented in table 16. This was done because there is really no reason to believe that sex ratios in the experiment are characteristic of the different strains used.

Feed consumption data is also presented in table 17. It is observed that the feed consumption pattern was the same at the end of each 2-week period for all strains. Strain C was the highest for body weight and feed consumption at eight and ten weeks of age, while strain E was the lowest.

Feed efficiency figures for all strains are presented in table 18. It is shown that the range between the best and the poorest strain is 1.98-2.14, and 2.21-2.36 at eight and ten weeks of age respectively. These differences in feed efficiency were not found to be significantly different (tables 22 and 24).

Percent mortality up to ten weeks is presented in table 18. It is observed in this experiment that the five strains studied did not differ in percent mortality. The range between the lowest and the highest is 1.0-3.0 at ten weeks of age.

The low mortality in this experiment was due mainly to better weather conditions than that encountered in the other two experiments.

Dressing percentages on the basis of the Beirut dressed and the ready-to-cook methods presented in table 18 indicate no strain differences. Females seem to have slightly lower dressing percentages than males when processed on the Beirut dressed basis. This seems to be reversed when birds are dressed on the ready-to-cook basis. The reason for this reversal could possibly be due, as it was stated previously, to heavier heads and feet in the case of males in contrast to that of females.

Carcass composition of various 8-week old broiler strains studied in this experiment is presented in table 19. It is observed that strains did not differ in water, protein, fat, ash or bone percentages. The average of all strains for bone to total carcass percentage was 21.2 with 19.0 percent for the lowest and 22.9 for the highest. The average of water, protein, fat and ash percentages for all strains is 68.6, 18.4, 10.6, and 3.6 respectively. Analysis of variance (table 26) shows that mean square of bone percentage approached significance at the 5 percent level of probability.

Economic analysis of the net returns up to ten weeks of age from various broiler strains studied in this experiment are presented in tables 20 and 21. Net returns per broiler differed with different strains. The highest at seven, eight, nine and ten weeks of age was strain C. The net returns of this strain were 91.3, 118.7, 138.2, and 155.9 at seven, eight, nine and ten weeks respectively. The other strains in their descending order were B, F, A and E for seven, eight, nine and ten weeks of age. It is observed from table 20 that net returns per bird (single trial basis) increases with age for all strains. This is also true for the yearly basis (table 21), while if calculated on the basis of net return per square meter housing space per year, the maximum net return was at eight weeks of age. The differences in increase for the average of all strains of the net return per bird on single trial basis at seven, eight, nine and ten weeks of age are 21.2, 19.9, and 15.2 Lebanese piasters respectively, while on a yearly basis they are 75.3, 44.3 and 11.7 Lebanese piasters. If compared to the net returns per square meter per year, the differences in increase for the average of all strains are +1.79, -2.19, and -5.36 Lebanese pounds respectively.

It is observed from total cost per broiler figures (table 20) that the major reason for highest net returns in the case of strain C is not actually due to its having the lowest total cost per broiler, but rather to its having the highest live weight at eight weeks.

Table 16 - Body weights of males and females of broiler strains at 0, 7, 8, 9 and 10 weeks of age - Experiment III.

Period (weeks)	Strain	Body weight (grams)		
		Male	Female	Average
0	A	35	35	35
	B	42	41	42
	C	43	42	42
	E	35	35	35
	F	40	38	39
	Average	39	38	39
7	A	1196	987	1092
	B	1267	1028	1148
	C	1333	1100	1216
	E	1061	925	993
	F	1247	1025	1136
	Average	1221	1018	1117
8	A	1452	1179	1316
	B	1524	1215	1370
	C	1641	1326	1484
	E	1307	1107	1207
	F	1519	1254	1386
	Average	1489	1216	1352
9	A	1769	1336	1554
	B	1851	1432	1641
	C	1954	1512	1733
	E	1555	1279	1417
	F	1834	1438	1636
	Average	1793	1400	1596
10	A	2044	1517	1780
	B	2124	1629	1876
	C	2212	1695	1954
	E	1773	1454	1614
	F	2055	1601	1828
	Average	2041	1579	1810

Table 17 - Body weights and feed consumption of broiler strains at 2, 4, 6, 7, 8, 9 and 10 weeks of age - Experiment III.

Period (weeks)	Strain	Body weight (grams)	% males to total	Feed consumption (grams)
2	A	190		251
	B	199		243
	C	203		287
	E	170		188
	F	204		243
	Average	193		242
4	A	508		848
	B	574		809
	C	549		885
	E	461		813
	F	515		831
	Average	522		837
6	A	879		1838
	B	937		1575
	C	991		1798
	E	792		1538
	F	910		1715
	Average	902		1693
7	A	1076		2221
	B	1148		2119
	C	1224		2389
	E	985		1997
	F	1128		2264
	Average	1112		2198
8	A	1296		2772
	B	1370		2710
	C	1493		3047
	E	1197		2522
	F	1356		2886
	Average	1342		2787
9	A	1524		3416
	B	1644		3427
	C	1746		3770
	E	1402		3121
	F	1586		3525
	Average	1580		3452
10	A	1746	41.8	4113
	B	1879	49.0	4150
	C	1968	52.0	4439
	E	1597	44.0	3749
	F	1771	38.2	4170
	Average	1792	45.0	4124

Table 18 - Comparison of feed efficiency, percent mortality and dressing percentage of broiler strains - Experiment III.

	Strain					
	A	B	C	E	F	Average
Feed efficiency at:						
7 weeks	2.06	1.85	1.95	2.02	2.01	1.98
8 weeks	2.14	1.98	2.04	2.11	2.13	2.08
9 weeks	2.24	2.08	2.16	2.23	2.22	2.19
10 weeks	2.36	2.21	2.26	2.35	2.35	2.31
% mortality at:						
7 weeks	2.1	2.0	2.0	1.0	1.0	1.6
8 weeks	2.1	2.0	2.0	2.0	1.0	1.8
9 weeks	2.1	2.9	3.0	2.0	1.0	2.2
10 weeks	2.1	2.9	3.0	3.0	1.0	2.4
Dressing percentage at 10 weeks:						
Beirut dressed						
Males	83.5	84.8	85.8	85.2	85.9	84.9
Females	84.2	84.5	84.5	84.9	85.0	84.6
Ready-to-cook						
Males	69.3	70.9	72.2	70.8	72.3	71.1
Females	70.7	71.2	71.8	71.3	71.9	71.4

Table 19 - Effect of strain on carcass composition at 8 weeks of age - Experiment III.

Strain	Bone to total carcass (%)	Water (%)	Protein (%)	Fat (%)	Ash (%)
A	22.9	69.1	19.4	9.3	3.8
B	21.6	68.7	18.2	10.2	3.6
C	19.0	68.8	17.6	10.6	3.5
E	21.7	67.9	18.9	10.4	3.3
F	20.9	68.5	17.7	12.5	3.6
Average	21.2	68.6	18.4	10.6	3.6

Table 20 - Economic analysis of net returns from various strains of broilers at 7, 8, 9 and 10 weeks of age (single trial basis) - Experiment III.

	Strain	Period (weeks)			
		7	8	9	10
Chick cost/broiler sold P.L.	A	58.2	58.2	58.2	58.2
	B	59.2	59.2	59.8	59.8
	C	57.1	57.1	57.7	57.7
	E	55.6	55.6	56.1	56.7
	F	55.5	55.5	55.5	55.5
Feed consumed/broiler sold[1] (grams)	A	2252	2803	3455	4153
	B	2135	2726	3468	4191
	C	2411	3069	3830	4499
	E	2018	2568	3172	3844
	F	2267	2888	3546	4172
Cost of feed/broiler sold[2] P.L.	A	90.1	112.1	138.2	166.1
	B	85.4	109.0	138.7	167.6
	C	96.4	122.8	153.2	180.0
	E	80.7	102.7	126.9	153.8
	F	90.7	115.5	141.8	166.9
Market value of one broiler[3] P.L.	A	215.3	259.1	304.8	349.2
	B	229.6	273.9	328.8	375.8
	C	244.8	298.6	349.1	393.6
	E	197.1	239.4	280.3	319.4
	F	222.5	271.3	317.3	354.2
Total cost/broiler[4] P.L.	A	148.3	170.3	196.4	224.3
	B	144.6	168.2	198.5	227.4
	C	153.5	179.9	210.9	237.7
	E	136.3	158.3	183.0	210.5
	F	146.2	171.0	197.3	222.4
	Average	145.8	169.5	197.2	224.4
Net return/broiler P.L.	A	67.0	88.8	108.3	124.9
	B	85.0	105.7	130.3	148.4
	C	91.3	118.7	138.2	155.9
	E	60.8	81.1	97.3	108.9
	F	79.3	100.3	120.0	131.8
	Average	76.7	98.9	118.8	134.0

1, 2, 3, 4. See table 13, page 49.

Table 21 - Comparison of the net return of broiler strains at 7, 8, 9 and 10 weeks of age - Experiment III.

	Strain					
	A	B	C	E	F	Average
Net return/bird (yearly basis)[1] P.L.						
7 weeks	435.5	552.5	593.4	395.2	515.4	498.4
8 weeks	515.0	613.0	688.5	470.4	581.7	573.7
9 weeks	563.7	677.6	718.6	506.0	624.0	618.0
10 weeks	587.0	697.5	732.7	511.8	619.5	629.7
Net return/sq.m.[2] L.L.						
7 weeks	43.55	55.25	59.34	39.52	51.54	49.84
8 weeks	46.35	55.17	61.96	42.34	52.35	51.63
9 weeks	45.10	54.21	57.49	40.48	49.92	49.44
10 weeks	41.09	48.82	51.29	35.83	43.36	44.08

1 Number of batches/year for the 7, 8, 9, and 10 weeks of age was considered to be 6.5, 5.8, 5.2, and 4.7 respectively.

2 Number of birds/square meter for the 7, 8, 9, and 10 weeks of age basis was 10, 9, 8 and 7 respectively.

Table 22 - Analysis of variance for growth, feed efficiency and net return/broiler at 8 weeks - Experiment III.

Source of variance	d.f.	M.S.		
		Body weight	Feed efficiency	Net return
Replication	1	2279.1	0.0017	21
Strain	4	41807.1**	0.0093	427*
Error (a)	4	782.7	0.0060	55
Sex	1	365770.1**		
Strain x sex	4	2184.0		
Error (b)	5	643.0		

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Table 23 - Separation of means by the critical difference method* - Experiment III.

	Body weight at 8 weeks (C.D. = 55)				
Strain	C	F	B	A	E
Mean	1483.8	1384.8	1369.7	1315.7	1204.6

	Net return at 8 weeks (C.D. = 20.5)				
Strain	C	B	F	A	E
Mean	118.6	105.8	100.2	88.8	81.2

* Means not underlined by same continuous line are significantly different.

Table 24 - Analysis of variance for growth, feed efficiency and net return/broiler at 10 weeks - Experiment III.

Source of variance	d.f.	M.S.		
		Body weight	Feed efficiency	Net return
Replication	1	3354	0.0002	21
Strain	4	64822**	0.0095	720*
Error (a)	4	590	0.0052	96
Sex	1	1053864**		
Strain x sex	4	7236		
Error (b)	5	2327		

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Table 25 - Separation of means by the critical difference method* - Experiment III.

	Body weight at 10 weeks (C.D. = 47.9)				
Strain	C	B	F	A	E
Mean	1952	1876	1825	1781	1612
	Net return at 10 weeks (C.D. = 27.2)				
Strain	C	B	F	A	E
Mean	156.4	148.9	131.6	124.8	109.0

* Means not underlined by same continuous line are significantly different.

Table 26 - Analysis of variance for fat and bone percentage of broilers at 8 weeks of age - Experiment III.

Source of variance	d.f.	M.S.	
		Fat %	Bone %
Replication	1	0.00	3.00
Strain	4	2.25	4.10
Error	4	1.60	0.72

Experiment IV

Results of the fourth experiment are presented in tables 27-35. This experiment involved five different strains with approximately one hundred birds in each strain. The strains used were the same as those used in experiment III. Body weights at zero, seven, eight, nine and ten weeks of age are presented in table 27 for both males and females. It is observed in this experiment as was indicated previously that males and females of all strains did not differ at one day of age. The range for males of all strains was 31-47 grams, while that for females was 30-46 grams. The average of all strains was 40 grams for males as well as for females. It is obvious from the table that sex differences increase with age. Differences in body weight between males and females at seven, eight, nine and ten weeks of age were 183, 253, 333 and 393 grams respectively. The analyses of variance (tables 32 and 34) show that body weight of strains did not differ significantly at eight weeks of age but they did differ at the 5% level of probability at ten weeks of age. Strain C was the highest in body weight at seven, nine and ten weeks of age in the case of both males and females, while strain E was the lowest in case of both males and females at all ages.

The separation of mean body weights at ten weeks by the critical difference method is presented in table 35. The means represent male and female averages of the five strains studied. The table shows that strain C, F, and B did not differ significantly while C was significantly higher than strain A or E. Strain E was significantly lower than all other strains.

Body weight averages of males and females for all strains are presented in table 28. It is observed that these averages differ from body weight averages of males and females presented in table 27. The reason for this difference is due to unequal numbers of males and females in each group. The percent of males to the total number of birds used in each strain is presented in the same table. It is also observed that the strain with the highest body weight at 2-week intervals has the highest percent males to total, but this does not necessarily mean that the strain with the lowest percent males to total should have the least body weight. Strain F which has the lowest percent males to total ranked fourth in body weight at seven, eight, nine and ten weeks of age.

Feed consumption data is also presented in table 28. It is observed that the feed consumption pattern was the same at the end of each 2-week period for all strains. Feed consumption of each strain follows very closely body weights at the end of each 2-week period up to eight weeks. Strain C however has the highest live weight up to ten weeks of age, but this same strain did not consume the highest amount of feed. At the same time strain E was lowest in body weight but did not consume the least amount of feed.

Feed efficiency was significantly different at the 5% level of probability for both eight and ten weeks of age (tables 32 and 34). The separation of means by the critical difference method for feed efficiency is shown in tables 33 and 35. Strains E, A and F did not differ among themselves but they did differ significantly from strain B at eight weeks of age. Strains C and B did not differ significantly in feed efficiency neither at eight nor at ten weeks of age. Strain C did not differ significantly from strains A and F at eight weeks but did differ significantly from strain E. The range between the best and the poorest strain was 2.18-2.48 and 2.48-2.77 at eight and ten weeks of age respectively (table 29). Percent mortality up to ten weeks is presented in table 29. It is observed in this experiment that the five strains studied did not differ much in percent mortality with a range of 2.9-6.9 percent at ten weeks of age. Dressing percentages on the basis of the Beirut dressed and the ready-to-cook methods presented in table 29 indicate no strain differences. Similar to that observed previously, females seem to have slightly lower dressing percentages than males when processed on the Beirut dressed basis, while the reverse is true when birds are dressed on the ready-to-cook basis.

Economic analysis of the net returns up to ten weeks of age from various broiler strains studied in this experiment are presented in tables 30 and 31. Net return per broiler differed with different strains. The highest at seven weeks of age was strain C and the lowest was strain E. Strain B had the highest net returns at eight, nine and ten weeks of age while strain C was second for the same periods. The lowest of all was strain E at all periods studied. It can be observed from studying table 30 that net return per bird on a single trial basis increases with age for all strains. On the yearly basis (table 31), maximum net return is on the ninth week and if calculated on the basis of square meter housing space per year, the maximum net return is at seven weeks of age. The differences in increase for the average of all strains of the net return per birds (single trial basis) between weekly intervals (7-10 weeks) are 16.0, 18.5 and 6.6 Lebanese piasters respectively, while that of the yearly basis are +40.0, +41.3 and -24.2 Lebanese piasters. If compared to the net return per square meter per year, the differences in increase for the average of all strains are -1.30, -2.00 and -7.42 Lebanese pounds respectively.

It is observed from total cost per broiler figures (table 30) that the major reason for highest net returns in the case of strain B is not due to its having the highest live weight at market age as it was observed previously, but actually due to its having the lowest total cost at eight and ten weeks of age.

Table 27 - Body weights of males and females of broiler strains at 0, 7, 8, 9 and 10 weeks of age - Experiment IV.

Period (weeks)	Strain	Body weight (grams)		
		Male	Female	Average
0	A	40	41	40
	B	42	42	42
	C	47	46	46
	E	42	42	42
	F	31	30	30
	Average	40	40	40
7	A	1286	1083	1184
	B	1276	1100	1188
	C	1346	1184	1265
	E	1218	1011	1114
	F	1288	1123	1206
	Average	1283	1100	1192
8	A	1578	1322	1450
	B	1569	1303	1436
	C	1582	1292	1437
	E	1450	1212	1331
	F	1568	1350	1459
	Average	1549	1296	1422
9	A	1869	1539	1704
	B	1903	1564	1734
	C	1925	1555	1740
	E	1743	1441	1592
	F	1898	1576	1737
	Average	1868	1535	1704
10	A	2068	1717	1892
	B	2140	1748	1944
	C	2220	1774	1997
	E	1982	1615	1798
	F	2181	1770	1976
	Average	2118	1725	1922

Table 28 - Body weights and feed consumption of broiler strains at 2, 4, 6, 7, 8, 9 and 10 weeks of age - Experiment IV.

Period (weeks)	Strain	Body weight (grams)	% males to total	Feed consumption (grams)
2	A	170		246
	B	144		177
	C	189		284
	E	153		266
	F	161		255
	Average	163		246
4	A	497		960
	B	444		739
	C	529		967
	E	434		942
	F	489		924
	Average	479		906
6	A	933		2000
	B	900		1734
	C	1009		2033
	E	883		1919
	F	930		1966
	Average	931		1930
7	A	1183		2672
	B	1184		2432
	C	1270		2687
	E	1113		2588
	F	1174		2630
	Average	1185		2602
8	A	1449		3458
	B	1430		3133
	C	1447		3350
	E	1327		3298
	F	1417		3382
	Average	1414		3324
9	A	1705		4289
	B	1726		3966
	C	1759		4149
	E	1590		4131
	F	1674		4201
	Average	1691		4147
10	A	1893	50.5	5219
	B	1936	48.0	4810
	C	2021	55.3	5101
	E	1796	49.5	4985
	F	1896	30.3	5148
	Average	1908	46.7	5053

Table 29 - Comparison of feed efficiency, percent mortality and dressing percentage of broiler strains - Experiment IV.

	Strain					
	A	B	C	E	F	Average
Feed efficiency at:						
7 weeks	2.26	2.06	2.12	2.32	2.24	2.20
8 weeks	2.38	2.18	2.31	2.48	2.38	2.36
9 weeks	2.52	2.30	2.36	2.59	2.51	2.46
10 weeks	2.75	2.48	2.52	2.77	2.72	2.65
% mortality at:						
7 weeks	2.0	2.0	2.0	1.0	1.0	1.6
8 weeks	2.0	2.9	2.0	2.0	1.0	2.0
9 weeks	2.9	2.9	6.9	3.9	2.0	3.7
10 weeks	2.9	2.9	6.9	3.9	2.9	3.9
Dressing percentage at 10 weeks:						
Beirut dressed						
Males	85.8	84.2	84.4	83.5	84.4	84.5
Females	84.4	83.0	83.9	82.3	84.9	83.7
Ready-to-cook						
Males	72.1	70.0	71.0	70.2	70.7	71.0
Females	70.8	70.3	71.2	69.4	71.5	70.6

Table 30 - Economic analysis of net returns from various strains of broilers at 7, 8, 9 and 10 weeks of age (single trial basis) - Experiment IV.

	Strain	Period (weeks)			
		7	8	9	10
Chick cost/broiler sold P.L.	A	58.2	58.2	58.7	58.7
	B	59.2	59.7	59.7	59.7
	C	57.1	57.1	60.2	60.2
	E	55.6	56.1	57.2	57.2
	F	55.6	55.6	56.1	56.6
Feed consumed/broiler sold[1] (grams)	A	2708	3494	4369	5299
	B	2441	3172	4006	4849
	C	2670	3359	4381	5332
	E	2590	3333	4225	5104
	F	2640	3392	4252	5250
Feed cost/broiler sold[2] P.L.	A	108.3	139.8	174.8	212.0
	B	97.6	126.9	160.2	194.0
	C	106.8	134.4	175.2	213.3
	E	103.6	133.3	169.0	204.2
	F	105.6	135.7	170.1	210.0
Market value of one broiler[3] P.L.	A	236.6	289.8	341.0	378.5
	B	236.8	286.0	345.2	387.2
	C	254.0	289.4	351.8	404.2
	E	222.6	265.4	318.0	359.1
	F	234.8	283.4	334.8	379.2
Total cost/broiler[4] P.L.	A	166.5	198.0	233.5	270.7
	B	156.8	186.6	219.9	253.7
	C	163.9	191.5	235.4	273.5
	E	159.2	189.4	226.2	261.4
	F	161.2	191.3	226.2	266.6
	Average	161.5	191.4	228.2	265.1
Net return/broiler P.L.	A	70.1	91.8	107.5	107.8
	B	80.0	99.4	125.3	133.5
	C	90.1	97.9	116.4	130.7
	E	63.4	76.0	91.8	97.7
	F	73.6	92.1	108.6	112.6
	Average	75.4	91.4	109.9	116.5

1, 2, 3, 4. See table 13, page 49.

Table 31 - Comparison of the net return of broiler strains at 7, 8, 9 and 10 weeks of age - Experiment IV.

	Strain					
	A	B	C	E	F	Average
Net return/bird (yearly basis)[1] P.L.						
7 weeks	455.6	520.0	585.6	412.1	478.4	490.3
8 weeks	532.4	576.5	567.8	440.8	534.2	530.3
9 weeks	559.0	651.6	605.3	477.4	564.7	571.6
10 weeks	506.7	627.4	614.3	459.2	529.2	547.4
Net return/sq. m.[2] L.L.						
7 weeks	45.56	52.00	58.56	41.21	47.84	49.03
8 weeks	47.92	51.88	51.10	39.67	48.08	47.73
9 weeks	44.72	52.13	48.42	38.19	45.18	45.73
10 weeks	35.47	43.92	43.00	32.14	37.04	38.31

1 Number of batches/year for the 7, 8, 9 and 10 weeks of age was considered to be 6.5, 5.8, 5.2 and 4.7 respectively.

2 Number of birds/square meter for the 7, 8, 9 and 10 weeks of age basis was 10, 8, 9 and 7 respectively.

Table 32 - Analysis of variance for growth, feed efficiency and net return/broiler at 8 weeks - Experiment IV.

Source of variance	d.f.	M.S.		
		Body weight	Feed efficiency	Net return
Replication	1	2060	0.0001	0.10
Strain	4	10803	0.0241*	1.72*
Error (a)	4	2589	0.0029	0.16
Sex	1	321818**		
Strain x sex	4	746		
Error (b)	5	395		

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Table 33 - Separation of means by the critical difference method* - Experiment IV.

	Feed efficiency at 8 weeks (C.D. = 0.139)				
Strain	E	A	F	C	B
Mean	2.48	2.38	2.38	2.31	2.18
	Net return at 8 weeks (C.D. = 1.1)				
Strain	B	C	F	A	E
Mean	99.5	98.0	92.0	91.8	76.0

* Means not underlined by same continuous line are significantly different.

Table 34 - Analysis of variance for growth, feed efficiency and net return/broiler at 10 weeks - Experiment IV.

Source of variance	d.f.	M.S.		
		Body weight	Feed efficiency	Net return
Replication	1	2691	0.0003	6.57
Strain	4	25143*	0.0362*	469.33**
Error (a)	4	2029	0.0035	25.27
Sex	1	773818**		
Strain x sex	4	1383		
Error (b)	5	1043		

* Significant at 5% level of probability.
** Significant at 1% level of probability.

Table 35 - Separation of means by the critical difference method* - Experiment IV.

Body weight at 10 weeks (C.D. = 88.8)

Strain	C	F	B	A	E
Mean	1997	1976	1944	1893	1798

Feed efficiency at 10 weeks (C.D. = 0.163)

Strain	E	A	F	C	B
	2.77	2.76	2.72	2.52	2.48

Net return at 10 weeks (C.D. = 13.9)

Strain	B	C	F	A	E
Mean	133.5	130.7	112.3	107.4	97.9

* Means not underlined by same continuous line are significantly different.

DISCUSSION

Rate of Growth

Rate of growth is an important factor affecting the economy of meat production. Jeffrey (1943) stated that rapidly growing chickens, in many instances, not only are more efficient in converting feed into body weight, but are also ready for market earlier than the slowly grown chickens, thus tending to reduce both cash and overhead costs. It is observed in table 36 that the highest average for body weight at eight weeks of age for all strains was attained in the fourth experiment. This experiment was performed in the fall and the average body weight at eight weeks was 1414 grams while the lowest average was attained in the second experiment which was performed in the spring with an average of 1256 grams. Comparing these results with table 39 which shows the number of days to reach one kilogram of live weight of all strains, it is obvious that rapidly growing birds are ready for market earlier than slow growing birds. The difference in days to reach one kilogram of live weight between the highest test (fall) and the lowest (spring) is 4.2 days. It is also observed in table 38 that the lowest total cost is in the summer resulting in the highest net return.

Table 36 shows that strain B ranked highest in the four tests average (1383 grams), while strain C ranked highest in the three and two tests average. There is no doubt that body weight at market age has a great influence on the economy of broiler production since we have observed in three experiments that the higher the body weight at market age, the higher the net return per broiler.

In the chicken meat production tests for 1961-62 published by U.S.D.A. (1963), the average of four tests made in the U.S. and Canada for different broiler strains was as follows: Cobb's 1572 grams, Hubbard 1504 grams, Arbor Acres 1448 grams and Pilch 1444 grams at eight weeks of age. These, if compared with the symbols used in this report, will be named as strain B, C, A, and F respectively. The ranking of the various strains for body weight, net return, age at one kilogram body weight and feed efficiency is shown in table 40. Since the season seemed to affect the results and all the strains were not included in each of the four experiments, the ranking is recorded on the basis of the average result of experiments listed in the table. For example, only strains A, B and F were included in all four experiment, so these three strains are compared and ranked on the basis of the average of four experiments. Strain D, on the other hand, was included only in experiment two and so this strain is compared with the results of the other strains in experiment two.

The table shows that in our experiments the ranking has been slightly different from that of the American experiments. The difference is that strain C has done better and B slightly poorer than in the American experiments. None of the strains in our experiments has reached as high body weight as in the American experiments where the highest body weight was 1572 grams as compared to 1484 grams in our experiments.

It is observed in all experiments and with all strains that the rate of growth differed with sex at the 1% level of probability. The difference at eight weeks of age between males and females was found to be around 250 grams on the average for all experiments. The percent males to total therefore has a great influence on the performance of strains and so the higher the number of males in a strain the higher the average body weight of that strain at market age. This has been observed to be true in all experiments studied with minor exceptions. Since the proportion of males to females has a great influence on the performance of the strain, the problem of sexing broiler chicks may be raised. Whether the difference in net return is large enough to justify the sexing of broiler chicks at the hatcheries is a problem which needs further studies. Such a practice would have definite limitations since it would probably double the cost of a broiler chick.

Feed Efficiency

Titus (1960) pointed out that the rate of growth of an animal is dependent on many factors, but is determined largely by the species, sex, age of the animal, the adequacy of its diet, and the quantity of feed it consumes. He stated that a young, actively growing animal normally makes a larger gain in live weight per unit weight of feed consumed than does an older one; that is to say, as an animal increases in weight, the gain it makes, on a given quantity of feed, decreases. He observed that the relationship between live weight and feed consumption in the growing animal follows a rather simple and definite law, known as the law of diminishing returns. The reason according to Titus (1960) is that as the chicken becomes heavier, more of its feed is required for maintenance and a smaller percentage of feed is available for growth since the total feed consumption does not increase at the same rate as the maintenance requirement. Another reason for decreasing feed efficiency with increase in age is the change in the caloric content of the gain in weight. The data presented in the results section illustrates this point very clearly. The average feed efficiencies of all strains in experiment III were observed to be 1.98, 2.08, 2.19 and 2.31 at seven, eight, nine and ten weeks of age respectively, while in experiment IV the averages of all strains were 2.20, 2.36, 2.46 and 2.65 at seven, eight, nine and ten weeks of age.

The average feed efficiency of all strains is presented in table 36. It is observed that the best feed efficiency for all strains at eight weeks of age is in the summer with an average of 2.08. This is due to the low maintenance requirement by the birds during this period, since summer temperatures are above the critical temperature of the bird.

Seasonal Variation

Till et al. (1961) found that live weight gains were lower at the high environmental temperature and less feed was required per pound of gain at such temperatures. Prince et. al. (1961) found a highly significant linear relationship between feed efficiency and environmental temperature in the range of $45^{\circ}F$ to $75^{\circ}F$. The improvement in feed efficiency attributable to the increase in temperature from $45^{\circ}F$ to $75^{\circ}F$ was 12.5 percent. Table 36 shows that the best feed efficiency was obtained in the summer. This is due to less need of calories in the summer for maintenance. Hence feed efficiency for growth varies not only with the innate characteristic of the chicken and the quality of the feed, but also with the environment (temperature, humidity, and disease level).

It is observed in table 36 that the lowest average of all experiments for body weight at eight weeks of age for all strains was attained in the second experiment which was performed in winter and spring. This is due to increased ric need in this season to maintain body temperature. means more feed intake and less body weight gain per of feed which results in poorer feed efficiency.

k Size and Growth Rate

Goodwin (1961) in his study on the influence of chick upon subsequent growth rate suggested that the size of ick at hatching does have an important effect on its th to fryer age. O'Neil (1955) stated that growth and efficiency to six weeks of age are not related to the of chicks. Godfrey et al. (1953) on the other hand ed that the influence of chick size on early growth eases rapidly after two weeks of age and has no apprele effect on weight at broiler age. Tindell and Morris 4) in a recent report found a highly significant linear ct indicating a close relationship between egg weight broiler weight in favor of broilers from the heavier egg ht groups. Table 37 shows a highly significant correla- between chick weight and broiler weight at eight weeks xperiment I only, while no significant effect was found he other three experiment. It is apparent therefore the influence of chick size on broiler weight is not consistant and can be influenced by several factors. able 37, regression data shows that in experiment I an ease of 1 gram in chick weight resulted in an increase 2.8 to 54.0 grams at eight weeks of age.

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Chick Size and Growth Rate

Goodwin (1961) in his study on the influence of chick size upon subsequent growth rate suggested that the size of a chick at hatching does have an important effect on its growth to fryer age. O'Neil (1955) stated that growth and feed efficiency to six weeks of age are not related to the size of chicks. Godfrey et al. (1953) on the other hand stated that the influence of chick size on early growth decreases rapidly after two weeks of age and has no appreciable effect on weight at broiler age. Tindell and Morris (1964) in a recent report found a highly significant linear effect indicating a close relationship between egg weight and broiler weight in favor of broilers from the heavier egg weight groups. Table 37 shows a highly significant correlation between chick weight and broiler weight at eight weeks in experiment I only, while no significant effect was found in the other three experiment. It is apparent therefore that the influence of chick size on broiler weight is not very consistant and can be influenced by several factors. In table 37, regression data shows that in experiment I an increase of 1 gram in chick weight resulted in an increase of 32.8 to 54.0 grams at eight weeks of age.

Dressing Percentage and Carcass Composition

In the Maine production and broiler test (Maine Department of Agriculture, 1963) the percent of eviscerated yield of live weight was 72.42 for males and 71.39 for females, while in the Arkansas meat performance test (Andrews et al., 1958) the average of eviscerated carcass yield of all strains with mixed sexes was 66.9. It is observed in experiment I (table 6) that eviscerated yield (ready-to-cook basis) of males was 69.0 and that of females 68.9, while in experiment II for both males and females it was 69.6 (table 12). In the other two experiments, the dressing percentage was made at ten weeks instead of eight weeks of age. They were 71.1 for males and 71.4 for females in experiment III (table 18) and 71.0 for males and 70.6 for females in experiment (table 29).

Clayton et al. (1960) found that moisture percentage of dressed broilers ranged from 68.8 to 73.8 while fat percentage ranged from 4.8 to 12.9. The range in experiment III (table 19) for moisture was from 67.9 to 69.1 while fat percentage ranged from 9.3 to 12.5.

Kondra et al. (1960) studied the effect of strain, sex and ration on meat yield in chicken broilers and found that females were superior to males in meat yield as a percentage of eviscerated weight due to a significantly lower proportion of bones in females. Gyles et al. (1954) studied the carcass yield between breeding groups and he stated that the average live weight of the purebred was 1271 grams against 1362 for the crossbreds at eleven weeks of age. The average unsexed eviscerated dressed carcass expressed as a percentage of live weight was 71.2 for the purebred against 72.7 for the crossbred.

The data of Stotts and Darrow (1952) show that Cornish crossbreds give consistently higher edible meat yields in both males and females and have a higher meat to bone ratio than purebreds and non-Cornish crossbreds. The difference in yields was found to be statistically significant. Since in our experiments all the strains entered were having the Cornish breed in their blood, it was expected for the eviscerated yield to give high meat to bone ratio in all strains. It is shown in table 19 that the average percent of bones to total eviscerated weight for all strains studied in experiment III is 21.2.

Net Returns and Market Age

Ward and Fuleihan (1962) stated that the production cost per kilogram for 9-week old broilers was L.L. 2.12, or 11 piasters less than for broilers sold at six weeks of age and 2 piasters less than for a 7-week old broiler. They stated that the cost per kilogram of a broiler sold at nine to ten weeks of age weighing 1600 grams to be 20 to 25 piasters less than for the 1000 gram broiler commonly marketed in Lebanon at seven to eight weeks. Their explanation for this is that the constant and fixed costs per bird are spread over a larger number of grams in the older birds. Table 20 in experiment III shows that net return per bird (single trial basis) increases with age for all strains, but the increment decreases with age. According to Ward and Fuleihan (1962) the chick cost and feed cost constitute on the average 75 percent of the total cost. Thus, the 25 percent are fixed costs which should be added to the recorded total cost in this paper (chick and feed cost). If 25 percent is added to the cost recorded in table 20, the cost per broiler at seven, eight, nine and ten weeks will be 182.3, 211.9, 246.5 and 280.5 respectively and the corresponding net returns per broiler 39.8, 56.5, 69.5 and 67.9 piasters or 35.8, 42.1, 44.0 and 37.9 piasters per kilogram of broiler. This trend corresponds with that found by Ward and Fuleihan (1962) but is less pronounced.

It is observed in table 21 that the maximum net return per square meter of housing space was at eight weeks of age in experiment III and at seven weeks in the fourth experiment (table 31). When the highest net returns are obtained at an earlier age on square meter basis than per batch or bird per year basis, it is because the number of birds per square meter and the number of batches per year can be increased with decreasing age at marketing.

In the Maine production and broiler test (Maine Department of Agriculture, 1963) the average calculated days required to make 3 pounds for the Arbor Acre strain was 49 days, Cobb's 48, Hubbard 47 and Pilch 48 days respectively. It is observed in table 39 that the number of days to reach one kilogram of live weight of all strains was 43.9 days in the fall with strain C reaching one kilogram in 41.7 days while strain E reached one kilogram at 45.6 days. This seems to be inversely related to rate of growth; the faster the rate of growth, the lower the number of days required to reach one kilogram of weight.

Table 36 - Average body weight and feed efficiency of all strains in all experiments at 8 weeks of age.

	Body weight (grams) of strains studied						
	A	B	C	D	E	F	Average
Expt. I - Winter (Jan. 2, '63)	1337	1435	1379			1292	1361
Expt. II - Spring (April 2, '63)	1246	1296		1217		1265	1256
Expt. III - Summer (July 2, '63)	1296	1370	1493		1197	1356	1342
Expt. IV - Fall (Oct. 17, '63)	1449	1430	1447		1327	1417	1414
Expts. used to obtain average:							
I, II, III, IV	1332	1383				1332	
I, III, IV	1361	1412	1440			1355	
III, IV	1372	1400	1470		1262	1387	
II	1246	1296		1217		1265	

	Feed efficiency						
Expt. I - Winter (Jan. 2, '63)	2.34	2.28	2.28			2.36	2.32
Expt. II - Spring (April 2, '63)	2.20	2.22		2.25		2.16	2.21
Expt. III - Summer (July 2, '63)	2.14	1.98	2.04		2.11	2.13	2.08
Expt. IV - Fall (Oct. 17, '63)	2.38	2.18	2.31		2.48	2.38	2.34
Expts. used to obtain average:							
I, II, III, IV	2.26	2.16				2.26	
I, III, IV	2.29	2.15	2.21			2.29	
III, IV	2.26	2.08	2.18		2.30	2.26	
II	2.20	2.22		2.25		2.16	

Table 37 - Correlation and regression coefficients of chick weight vs. body weight at 8 weeks of age.

	Correlations (r)					
	Strain					
Expt. No.	A	B	C	D	E	F
I	0.4691**	0.4147**	0.4662**	-	-	0.4808**
II	0.0944	0.0975	-	-0.0334	-	0.1485
III	0.1575	0.1139	0.3110	-	-0.0757	0.1985
IV	-0.00276	0.1326	0.0221	-	0.0377	0.0264

** Significant at 1% level of probability.

Regressions (c)

I	32.82	37.37	54.02	-	-	41.33
II	8.19	8.85	-	-2.23	-	15.38
III	10.28	7.499	22.16	-	4.24	12.89
IV	-0.1929	9.515	1.841	-	2.7755	1.994

Table 38 - Average of all experiments for total cost and net returns of all strains at 8 weeks of age.

	Total cost (P.L.) of strains studied						
	A	B	C	D	E	F	Average
Expt. I - Winter (Jan. 2, '63)	182.5	188.1	198.8			179.0	187.1
Expt. II - Spring (April 2, '63)	176.6	186.0		178.4		176.4	179.4
Expt. III - Summer (July 2, '63)	170.3	168.2	179.9		158.3	171.0	169.5
Expt. IV - Fall (Oct. 17, '63)	198.0	186.6	191.5		189.4	191.3	191.4
Expts. used to obtain average:							
I, II, III, IV	181.8	182.2				179.4	
I, III, IV	183.6	181.0	190.1			180.4	
III, IV	184.2	177.4	185.7		173.8	181.2	
II	176.6	186.0		178.4		176.4	

	Net returns (P.L.)						
Expt. I - Winter (Jan. 2, '63)	84.9	98.9	77.0			79.6	85.1
Expt. II - Spring (Spril 2, '63)	72.6	73.2		65.0		76.6	71.8
Expt. III - Summer (July 2, '63)	88.8	105.7	118.7		81.1	100.3	98.9
Expt. IV - Fall (Oct. 17, '63)	91.8	99.4	97.9		76.0	92.1	91.4
Expts. used to obtain average:							
I, II, III, IV	84.5	94.3				87.2	
I, III, IV	88.5	101.3	97.9			90.7	
III, IV	90.3	102.6	108.3		78.6	96.2	
II	72.6	73.2		65.0		76.6	

Table 39 - Number of days to reach 1 kilogram of live weight in all strains

	Strain						
	A	B	C	D	E	F	Average
Expt. I - Winter (Jan. 2, '63)	46.6	44.7	46.6			47.7	46.4
Expt. II - Spring (April 2, '63)	48.5	47.0		49.1		47.7	48.1
Expt. III - Summer (July 2, '63)	46.3	44.1	42.3		49.5	44.9	45.4
Expt. IV - Fall (Oct. 17, '63)	43.9	44.5	41.7		45.6	44.0	43.9
Expts. used to obtain average							
I, II, III, IV	46.3	45.1				46.1	
I, III, IV	45.6	44.4	43.5			45.5	
III, IV	45.1	44.3	42.0		47.6	44.5	
II	48.5	47.0		49.1		47.7	

Table 40 - Ranking of strains for body live weight at 8 weeks, net returns, age at 1 kilogram live weight, and feed efficiency*.

	Expts. considered	Strain A	B	C	D	E	F
Body weight	I, II, III, IV	2	1				3
Body weight	I, III, IV	3	2	1			4
Body weight	III, IV	4	2	1		5	3
Body weight	II	3	1		4		2
Net returns	I, II, III, IV	2	1				3
Net returns	I, III, IV	4	1	2			3
Net returns	III, IV	4	2	1		5	3
Net returns	II	3	2		4		1
Age at 1 kg. body wt.	I, II, III, IV	3	1				2
Age at 1 kg. body wt.	I, III, IV	4	2	1			3
Age at 1 kg. body wt.	III, IV	4	2	1		5	3
Age at 1 kg. body wt.	II	3	1		4		2
Feed efficiency at							
7 weeks	III, IV	4	1	2		5	3
8 weeks	III, IV	4	1	2		5	3
9 weeks	III, IV	4	1	2		5	3
10 weeks	III, IV	4	1	2		5	3

* Strains are ranked in decreasing order from 1 to 5.

SUMMARY AND CONCLUSIONS

Four experiments utilizing a total of 1800 broilers were conducted at the Agricultural Research and Education Center of the American University of Beirut to evaluate and compare the six major broiler strains used in Lebanon and other countries of the Middle East. The commercial strains used in those studies were: Arbor Acres (A), Cobb (B), Hubbard (C), Hybro (D), Kimber (E) and Pilch (E).

A randomized block design was used in all experiments with two pens and a total of approximately one hundred birds per treatment. In the biological phase of the study, the data collected consisted of body weight, feed consumption, mortality, dressing percentages on the Beirut dressed and the ready-to-cook basis, carcass composition (water, fat, protein, ash), percent bone to ready-to-cook carcass, and number of days to reach one kilogram of live weight.

The highest average in all experiments for body weight at eight weeks of age for all strains was attained in the fourth experiment which was performed in the fall (1414 grams), while the lowest average was attained in the second experiment which was performed in the spring (1256 grams). In experiment I, strains differed significantly at the 5% level of probability; strain B having the highest weight at eight weeks in the case of both males and females, while strain F having the lowest. Strains did not differ in the second experiment at eight weeks of age, while in the third experiment strain C was significantly higher in body weight than all other strains at both eight and ten weeks of age. In experiment IV, significant strain differences in body weight did not appear at eight weeks of age, while they did at ten weeks of age. In this experiment, strains C, F, and B did not differ significantly while strain C was significantly higher than strains A or E. Strain E was significantly lower than all other strains. It was observed in all experiments that sex differences in body weight increase with an increase in the age of the bird.

Mortality was high in the first two experiments due to sudden changes in environmental temperatures, while in the third and fourth experiments mortality was very low. The data presented does not support any real strain differences in mortality up to eight or ten weeks of age.

Feed efficiency did not differ significantly with different strains in either experiment I or III. In experiment II, however, significant differences in feed efficiency appeared at the 1% level of probability at eight weeks, while in experiment IV there were significant strain differences at both eight and ten weeks of age.

A highly significant correlation was obtained between chick weight and broiler weight at eight weeks in experiment I, but no significant correlation was found to exist in the other three experiments. It was observed from a regression analysis of experiment I that an increase of one gram in chick weight resulted in an increase of 32.8 to 54.0 grams at eight weeks of age.

Number of days to reach one kilogram of live weight in all strains was 43.9 days in the fall with strain C reaching one kilogram in 41.7 days. In the spring season, however, it required 48.1 days as an average of all strains to reach one kilogram live weight.

Results of the third experiment showed that broiler strains do not differ significantly in carcass composition or in percent of bones to edible meat. Female birds in all experiments had slightly lower dressing percentages than males when processed on the Beirut dressed basis, and higher dressing percentages than males when dressed on the ready-to-cook basis.

The economic phase of the study was set up to determine net returns per broiler sold in case of each strain at eight weeks for the first two experiments and at seven, eight, nine and ten weeks for the third and fourth experiments. Net returns per broiler followed very closely live weight at market age as long as mortality did not differ significantly. Net returns per bird (single trial basis) in the last two experiments increased with age for all strains, but the increment decreased with age. Maximum net return for experiment III was at eight weeks of age when calculated on the basis of net return per square meter per year, while it was at seven weeks in the fourth experiment. This is because the shorter time the bird is raised, the more birds per square meter and the more batches per year can be raised. Thus, with the same fixed capital, more birds are raised per year leading to increased net returns.

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