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EXPERIMENTAL FARMS SERVICE

POULTRY DIVISION
CENTRAL EXPERIMENTAL FARM, OTTAWA

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PROGRESS REPORT
1937-1948

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CENTRAL EXPERIMENTAL FARM,
OTTAWA.

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POULTRY DIVISION

Central Experimental Farm, Ottawa

INTRODUCTION

The last published progress report of the Poultry Division covered the period 1934-36 inclusive. The twelve years, 1937-48 inclusive, upon which this progress report is based, witnessed a steady expansion of the facilities and staff of the Division. During the period, World War II necessitated some retrenchment and interfered to some degree with the obtaining of desired personnel and equipment. As the years pass, inevitably the need for demonstration at the old, established Experimental Farms becomes smaller and the requirement for research greater. The trend has been, therefore, towards not only an increasingly greater amount of research but research of a more fundamental nature.

Much of the work reported is a condensation of material which has already been published in the form of technical papers in scientific journals. Anyone interested in the full details and more technical aspects of such work is referred to this source and the title, journal and publication date of these is shown in this text.

From 1937 to 1946 inclusive the Division was under the direction of George Robertson who retired in 1947. A large part of the work reported was therefore conducted during his term of office. Since 1947, H. S. Gutteridge has been in charge of the Poultry Division.

GENETICS

(Breeding)

Research in genetics occupies an important place in the work of the Poultry Division. Many of the more puzzling results of breeding have been explained by studies in genetics and a foundation laid for further advances in breeding. Since the production of eggs is so important to the poultry industry, major attention has been given to research on the inheritance of egg production but other economic factors have not been overlooked.

INHERITANCE OF EGG PRODUCTION

Superior Sire Project

The evidence accumulated to date suggests the progeny test as one of the most effective means of selecting individuals which are likely to be prepotent for egg production. Logically, if the ability of a bird to pass on its high production possibilities is actually measured by the production of its progeny, such a progeny test should be evidence of the prepotency of that individual. In practice, however, there are many difficulties involved in progeny testing. In the first place, because even full sisters differ greatly in their level of production, even when kept in the same pens, it is necessary to have a large population of full sisters, if their average production is to be representative of the actual production of the daughters of a dam. Unless large populations of full sisters are available, therefore, it is not possible to progeny test a dam with any degree

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of accuracy. Sufficient populations are rarely available even if a dam lays well throughout the breeding season, hatchability of her eggs is good and mortality of her daughters low. Even if a large population of daughters is available, they are from different hatches spread from February to May or longer; and because of differing conditions of weather, brooding and range, the production of the daughters from different hatches is not strictly comparable. These factors increase the variability from daughter to daughter to the point where, for all practical purposes, it is not possible to accurately progeny test a dam.

These limitations, however, do not apply to the sire to the same degree. Since he is mated to 12-15 dams, his progeny will be more numerous and will be more likely to constitute an adequate population. For example, the Barred Rock sires tested in one year on the Experimental Farms System numbered 137. After eliminating dams which laid few eggs, gave poor fertility and hatchability, poor survival of chicks, or high laying-house mortality in their daughters, these sires were progeny tested on 764 dams or 5·6 dams per sire, each of which had to have at least two daughters with complete first-year records. These dams had on the average 5·1 daughters per dam (of varying hatching dates). Each sire in the year under consideration had, on the average, a population of 28·4 daughters alive and completing a year's production on which to base a progeny test. The highest number of daughters per sire was 67 and the lowest 9. The above figures indicate the virtual impossibility of progeny testing dams on the populations provided and the fact that even sires may not have adequate numbers of daughters. If one sire could be mated to 20-30 dams instead of 12-15, the sires' population would be somewhat improved but the difficulty with dam populations would still exist.

While it was appreciated that the above difficulties would be encountered even before a superior sire project was planned, it was felt that a comparison between sires at least would make it possible to choose superior individuals. Accordingly, a project was planned covering twenty-one Experimental Farms and Stations across Canada where poultry was kept in any numbers. This included seventeen Farms with the Barred Rock breed, three with White Leghorns and two with White Wyandottes (at Ottawa both Rocks and Leghorns). The first year's progeny tests covered 150 Barred Rock sires, 16 White Leghorns and 13 White Wyandottes. It may be realized that 150 mated sires, both sexes being pedigreed and the females trapnested, constitutes an immense population. Such facilities for a trial of progeny testing, involving all pedigreed, trapnested birds, are probably unique, and should provide a very satisfactory estimate of whether the progeny test is capable of making sustained improvement in the egg production potential or otherwise.

Plan of the Project.—The plan of the project required a progeny test of all sires in each flock on the Experimental Farms System. Records were taken in an identical manner on all Farms and a yearly report sent to Ottawa for analysis. Perhaps the first requisite of such a test was a standard by which the various sires could be judged as to superiority. This would need to be on a sound statistical basis so that differences in average egg production between sires could be judged as to whether they were real differences due to genetic difference in the sires, or merely to chance. Following extensive analysis of records and a review of appropriate statistical procedures, Tables 1 and 2 were set up. These tables show the number of eggs by which the average production of the daughters of one sire must exceed a set standard or exceed the average of all sires of the flock, in order that any one sire may be rated superior in egg production of his daughters.

Table 1 shows the numbers necessary for comparison of a sire with the average of the sires of the same flock, whereas Table 2 gives a comparison of sires with the overall average of different flocks combined. For example, when a sire is mated to 10 dams, averaging 6 daughters per dam, his progeny average would have to exceed that of all the sires of the flock by 11·33 eggs, or by 23·42 eggs where the sire is being compared with the average for sires from the whole Experimental Farms System, before he could be said to excel the average with any

TABLE 1.—NECESSARY DIFFERENCES BETWEEN THE PRODUCTION OF THE DAUGHTERS OF ANY ONE SIRE AND A FLOCK AVERAGE FOR A SUPERIOR RATING ON A 5% ERROR BASIS.

(This table can apply only to birds under one environment)

No. Daughters per Dam

No. Dams	2	3	4	5	6	7	8	9	10	11	12
2	36·29	31·30	28·47	26·63	25·33	24·36	23·62	23·01	22·52	22·10	21·76
3	29·63	25·55	23·24	21·75	20·69	19·90	19·28	18·79	18·39	18·05	17·77
4	25·66	22·62	20·13	18·84	17·91	17·22	16·70	16·27	15·92	15·63	15·38
5	22·95	19·79	18·01	16·84	16·02	15·41	14·94	14·56	14·25	13·98	13·75
6	20·96	18·06	16·43	15·38	14·62	14·06	13·64	13·29	13·00	12·77	12·57
7	19·39	16·73	15·22	14·25	13·54	13·03	12·62	12·30	12·04	11·81	11·63
8	18·14	15·64	14·23	13·32	12·67	12·19	11·81	11·66	11·27	11·05	10·87
9	17·11	14·76	13·42	12·55	11·94	11·48	11·14	10·84	10·61	10·41	10·24
10	16·24	14·00	12·73	11·91	11·33	10·89	10·56	10·33	10·07	9·89	9·72
11	15·48	13·34	12·14	11·35	10·81	10·40	10·57	9·80	9·61	9·43	9·28
12	14·82	12·78	11·63	10·87	10·35	9·95	9·64	9·39	9·20	9·03	8·88
13	14·22	12·27	11·17	10·45	9·94	9·56	9·26	9·03	8·83	8·67	8·54
14	13·72	11·83	10·76	10·07	9·57	9·21	8·93	8·70	8·50	8·36	8·23

TABLE 2.—NECESSARY DIFFERENCES BETWEEN THE PRODUCTION OF THE DAUGHTERS OF ANY ONE SIRE AND A FARM AVERAGE FOR A SUPERIOR RATING ON A 5% ERROR BASIS.

(This table can apply to birds under different environments)

No. Daughters per Dam

No. Dams	2	3	4	5	6	7	8	9	10	11	12
2	41·75	37·42	35·09	33·62	32·60	31·85	31·27	30·83	30·45	30·15	29·89
3	35·88	32·88	31·01	29·89	29·13	28·57	28·15	27·82	27·54	27·32	27·13
4	32·88	30·17	28·74	27·85	27·22	26·78	26·45	26·17	25·96	25·78	25·63
5	30·78	28·51	27·29	26·53	26·02	25·65	25·37	25·15	24·97	24·82	24·69
6	29·31	27·32	26·29	25·63	25·18	24·87	24·63	24·43	24·28	24·15	24·05
7	28·23	26·47	25·53	24·97	24·58	24·30	24·08	23·92	23·77	23·67	23·57
8	27·39	25·88	24·97	24·44	24·10	23·85	23·67	23·51	23·39	23·29	23·21
9	26·71	25·27	24·51	24·05	23·74	23·51	23·33	23·19	23·10	23·00	22·93
10	26·16	24·82	24·15	23·72	23·42	23·23	23·06	22·96	22·85	22·77	22·70
11	25·69	24·46	23·84	23·44	23·18	22·98	22·85	22·73	22·64	22·57	22·50
12	25·30	24·17	23·57	23·21	22·96	22·80	22·67	22·55	22·47	22·40	22·34
13	24·97	23·90	23·36	23·01	22·78	22·62	22·50	22·40	22·32	22·26	22·21
14	24·68	23·67	23·16	22·85	22·62	22·49	22·37	22·27	22·21	22·15	22·10

degree of safety. Having a larger number of dams mated to a sire decreases the difference necessary at a slightly greater rate than does an increase in the number of daughters per dam. Obviously, factors of management can vary so greatly from one poultry plant to another and have such a profound effect upon production that the reason for requiring a difference to be double that of sires on the same plant can be appreciated. Moreover, sires that pass this test in competition with those on the whole Experimental Farms System should be very superior and have been rigorously tested.

Provided that it is possible to determine which are the superior prepotent sires by the above procedure, the problem, no less exacting in nature, is to determine how these superior sires can be utilized to improve the egg production of the flocks on which they are used. A review of the information available at the time suggested that if possible this should be accomplished without inbreeding. While concentrating the good qualities of the birds, inbreeding also concentrates any undesirable characteristics. Lethal or semi-lethal genes are apt to appear much more frequently and under these conditions such a large proportion of the birds must be culled as to greatly reduce the practicability of making progress in egg production by this means. In view of these possibilities, it was decided that superior sires wherever found on the Experimental Farms System would be brought to Ottawa and their blood concentrated on a segment of the Ottawa flock. Theoretically, the continued pouring of superior blood year after year into a portion of one flock should raise appreciably the production of that portion of the flock over that of the remainder. If this proved not to be the case, then present breeding procedures throughout the industry, where poultrymen purchase males or chicks from so-called superior breeders to mate on their own flocks, would be considered as useless as a means of increasing the production level of a flock. At the same time, it would be possible to send sons of these superior matings to Branch Experimental Farms across the country, and if any progress was being made these in turn should produce progeny superior for egg production to the rest of the flock on the Farm concerned.

Each year the data from all Branch Farms are summarized at Ottawa and a complete report on all sires made. The superior sires are specifically noted as well as their degree of superiority. This report goes out to each Farm with analyses and comments on the progress of the project. Where superior sires have occurred arrangements are made to transport them to Ottawa for use in the concentration of superior blood on the Ottawa line.

In view of the results obtained in this project it is essential that the full basis of testing both on the male and female side should be indicated. In connection with this project and the whole breeding plan, the practice in all matings is to use in order of preference—

(1) an old proven sire.

(2) the son of a proven sire out of a superior dam.

(3) the son of a proven sire.

(4) the son of a superior dam.

(5) a male whose sisters have shown uniformly high production.

Superior dams would be those which have given high production in their daughters preferably from more than one male, but, because of the difficulty of progeny testing them accurately, whether such superior dams are truly so is problematical. On the female side, the preferential order of choice for mating would be—

(1) the daughter of a proven sire out of a superior dam.

(2) the daughter of a proven sire.

(3) the daughter of a superior dam.

(4) females whose sisters have given a uniformly high production.

Thus the breeding program at Ottawa and the Branch Farms, while emphasizing the progeny tested individuals, also uses family records as evidenced by production of sisters of both males and females.

One other factor should be noted, namely, that selections of males were made on a partial progeny test in January to save a generation, the final disposition of progeny therefrom depending on the full progeny test when completed. It was felt that such a partial progeny test gave an excellent indication of the potentialities of a sire and the individual could be mated in late January or February of the same year. The validity of this procedure has since been strengthened by the published work of other investigators.

Results of the Superior Sire Project.—During the first year, 1936-37, six males were found to significantly exceed the average for the whole Experimental Farms System. Only one was still alive at three years of age and was brought to Ottawa and mated with a select section of the Ottawa flock, supplemented by a few importations of outstanding females from one Branch Station. Four additional males significantly exceeded the average at their own Farm and were retained there for breeding. From the one male brought to Ottawa, eleven sons were sent out to Branch Farms to be tested as sons of a superior male. Each year the above activities have been repeated up until the end of the period covered by this report (1948).

Results of this work are summarized in three tables. Table 3 shows the average annual egg production per bird for the Stations taking part in this test from 1935-36 to 1947-48 production years. Table 4 shows the difference in egg production between the progeny of the superior line sires and the comparable sires of the flock at Ottawa, for the years 1939-40 to 1945-46, for Barred Rocks and White Leghorns. The same data are shown for the progeny of sires from the Ottawa superior line which were sent to the Branch Stations for testing under local environments, and in contrast with their own regularly mated sires. After seven years, selection was less intense both at Ottawa and at Branch Stations. Actually, the valid comparison of superior and ordinary line was practically ended at that time. Table 5 shows the average production of the flocks of a sample of the Branch Stations that used a sufficient number of sires from the Ottawa superior line to constitute a reasonable test.

An outstanding feature of the overall production figures for the Experimental Farms, for a 13-year period, is the variability from year to year. Variations so great as these, involving many laying birds, could not be attributed only to differences in the genetic potential of the birds. Superior or very inferior sires are rare and are unlikely to occur even twice in the same year in flocks of the size kept in these Farms. The production of the progeny of one sire, or even two sires, would not appreciably affect the average for the whole flock. On the other hand, environmental factors such as weather conditions, green growth on range, presence or absence of disease, management during the laying year, and many other such factors, are known to have a marked effect upon production levels from year to year.

Table 3 shows the fluctuating production levels from year to year. Five stations, or approximately 30 per cent have a production which is well maintained from 1935-36 to 1947-48. Of the Stations which show appreciably higher production at the end of the thirteen years, three made almost all their increase within the last one to three years. In most cases the increase was so sudden and so large as to preclude the likelihood of its being genetic in nature. Four Stations had a fairly sudden and maintained increase dating from the control of some disease condition such as parasitism or a change in general management of the plant under a new supervisor.

TABLE 3.—AVERAGE ANNUAL EGG PRODUCTION PER BIRD FOR STATIONS OF THE EXPERIMENTAL FARMS SYSTEMS, 1935 TO 1948[1]

—	1935–36	1936–37	1937–38	1938–39	1939–40	1940–41	1941–42	1942–43	1943–44	1944–45	1945–46	1946–47	1947–48
Barred Plymouth Rock Farms													
Agassiz, B.C.	209	216	211	216	213	209	226	218	209	209	201[3]	234	250
Brandon, Man.	192	207	209	204	206	205	215	214	213	218	218	215	224
Charlottetown, P.E.I.	219	201	200	221	215	206	212	205	217	219	238	226	217
Fredericton, N.B.	201	185	191	193	212	205	219	211	218	210	219	231	228
Harrow, Ont.	240	197	227	250	239	229	250	234	235	236	246	248	253
Kapuskasing, Ont.	207	203	228	214	216	213	206	210	[3]	232	227	221	229
Lennoxville, Que.	192	202	198	194	202	200	201	198	197	214[3]	223	243	231
Lethbridge, Alta.	193	....	207	195	198	205	210	210	206	205	203	218	214
Morden, Man.	(213)	(213)	(213)	213	212	216	230	227	238	229	223	232	224
Normandin, Que.	(213)	213	207	213	223	222	217	229	221	227	232	240	244
Ottawa, Ont.	194	204	216	205	213	213	203	200	217	221	202	208	220
Scott, Sask.	198	196	203	213	216	202	224	223	214	234	217	213	....
Ste. Anne de la Pocatiere, Que.	214	203	207	219	[3]	232	231	228	227	230	235	236	252
Average	206·5	203·3	209·0	211·5	213·7	212·1	218·8	215·9	217·7	221·8	221·8	228·1	232·2
White Leghorn Farms													
Kentville, N.S.	....	....	229	240	192	216	227	232	245	224	259	258	246
Ottawa, Ont.	....	219	209	207	215	220	215	208	196	214	221	226	249
Saanichton, B.C.	....	225[2]	229[2]	229[2]	....	216	214	211	230	234	233	215	218
White Wyandotte Farm													
Lacombe, Alta.	....	204	200	219	222	199	218	217	209	207	205	196	178

[1] Some Stations not shown because of incomplete records, change of breed or transferring to turkey work.
[2] At Windermere, B.C.
[3] Drastic change in management or disease control.

TABLE 4.—DIFFERENCE IN EGG PRODUCTION BETWEEN PROGENY OF SIRES OF SUPERIOR AND ORDINARY LINES, IN FAVOUR OF SUPERIOR LINE, FOR TWO BREEDS, AT OTTAWA AND ALL FARMS, 1939 TO 1946

Year	Ottawa						All Farms					
	Barred Rocks			White Leghorns			Barred Rocks			White Leghorns		
	No. of		Net Diff.	No. of		Net Diff.	No. of		Net Diff.	No. of		Net Diff.
	*S. Sires	O. Sires		S. Sires	O. Sires		S. Sires	O. Sires		S. Sires	O. Sires	
1939–40	2	10	1·2	2	7	10·7	17	68	5·9	2	7	10·7
1940–41	3	10	9·0	5	2	40·8	13	54	11·6	10	9	24·9
1941–42	5	10	21·0	9	5	10·0	11	34	8·6	12	15	15·7
1942–43	6	11	15·0	7	7	4·0	19	61	9·9	9	10	6·0
1943–44	4	8	13·0	9	4	−1·0	12	56	6·7	13	16	−11·7
1944–45	4	9	3·8	5	6	4·0	14	80	3·8	7	9	3·3
1945–46	3	10	1·0	3	7	4·0	13	34	−3·0	6	9	4·0

*S. Sires—Superior line sires.
O. Sires—Ordinary line sires.

TABLE 5.—COMPARISON OF EGG PRODUCTION OF PROGENY OF SUPERIOR LINE MALES (A) WITH THAT OF OTHER LINES (B) ON THE SAME FARM, 1939–1946

Farm	A	B
Agassiz, B.C.	213	215
Brandon, Man.	212	211
Charlottetown, P.E.I.	213	211
Harrow, Ont.	232	240
Morden, Man.	223	228
Scott, Sask.	221	216

In order to examine general trends more critically, the mean production levels for all Experimental Farms combined must be considered. In spite of definite setbacks in five years out of the thirteen, there was an overall increase of 26 eggs or 2·0 eggs per year for the Barred Rocks. Forty per cent of the total increase occurred during the last two years. The reason for the increase cannot be determined exactly since no unselected control flock was maintained. It is apparent, however, that a small increase was made—attributable probably to both environment and heredity. The White Leghorn flocks were so few in number that their overall averages would hardly be valid. It should be stated that the Experimental Farms under consideration are continuously improving conditions of incubation, brooding and rearing, disease control, laying house management, and nutrition. An overall improvement of some magnitude should be expected on these grounds.

The data of Table 4 are much more critical than those of Table 3 because of the fact that superior-line birds are being compared with those of other lines in the flock under the same environmental conditions. It is apparent that with both breeds the production of the superior line was significantly higher than that of the remainder of the flock at Ottawa, on two or three occasions. This superiority was unfortunately not maintained, however. In both breeds, after seven years of concentration of the blood of prepotent sires the superior line did not exceed the other lines of production.

In the case of the comparison between superior- and ordinary-line sires at the Branch Farms, the figures are almost identical: there was an increase in production, but at the end of seven years no greater production from the superior-line birds. Unless superiority can be maintained, the use of superior-line birds is of limited value. These data suggest that no permanent improvement of a genetic nature has been made.

Table 5 adds somewhat to the above information in that at Stations where several sons of males of the superior line were used in any one year, the average production is compared with that at the same Experimental Farm when superior males were not used. The production levels do not differ appreciably in any instance.

Discussion.—In consideration of the data available, two outstanding facts must be noted:

(1) The overall average increase (Barred Rocks) over 13 years of pedigree breeding under the superior sire project amounted to 2·0 eggs per year, a large proportion of which increase could easily be attributable to improvements in environment which certainly occurred.

(2) Comparisons made between the so-called superior line and other lines not containing superior-line blood, and under the same environment, whether at Ottawa or on the Branch Farms, at the end of seven years showed no difference in production in favour of the superior line.

While such a result was not anticipated, the data do show reasons why this situation could exist.

One of the foremost reasons is undoubtedly the fact that truly superior individuals are rare indeed. For example, in a typical four-year period in twenty-one flocks, only 30 sires were found to be truly superior and of these only 11 were alive to be used in the following breeding season. Actually, for Rocks and Leghorns, 12 and 16 per cent respectively proved significantly superior to other sires on their own Farm but only 5 and 8 per cent respectively were still alive when their superiority was known (2½ years). In the case of the truly prepotent birds, namely, those which were sufficiently prepotent to be superior over sires of all flocks, 4 and 8 per cent of the sires used proved superior to this degree but only 1 per cent of Rocks and 4 per cent for Leghorns were alive to be used again. It must be borne in mind that whereas superior sires only are considered for reasons already explained, the female side of the breeding was the best obtainable in these flocks and superior dams and the productive level of sisters of males were factors also considered. It should be noted further that in the case of superior sires that died before they could be used after proving their superiority, the progeny from their first matings were cherished for use in the breeding work as were also their sisters and progeny, and in some cases these were sent to Ottawa in lieu of the deceased sire. It seems apparent that attempts to improve egg production by rigorous progeny testing, with due consideration to family as well as progeny, are hampered by the serious difficulties of rare occurrence of truly superior individuals and high mortality of such birds, even when the testing is carried out upon an immense scale.

A second difficulty often encountered relates to the fact that sires which have proved themselves significantly superior on a most rigid statistical basis, often do not show superiority in subsequent matings. The reason for this is not clear. It is of course virtually impossible to mate a sire to the same females, or to a group consisting largely of the same females, year after year for several years because of factors such as mortality and morbidity in the females, poor production on their part, lack of fertility and hatchability, preferential mating and for other reasons. Even so, such sires were mated to the very best females on both a production and family basis and it is, therefore, difficult to explain the above-mentioned fact. In addition to the problem of rare appearance of superior individuals, and their loss by death before use, there is the inability of some sires to repeat the evidence of their superiority.

The final difficulty, and the most serious, is the fact that, over the approximately thirteen years of this project, increases in production which could possibly be attributed solely to genetic causes have been either non-existent or uncertain, and much too small to justify the time and expense involved. For example, during the first six years of the project, 841 sires were involved, mated to approximately 8,000 dams and producing 30,000 daughters to go into the laying pens to test these sires. The best of blood was involved judged on a production basis. To take an extreme example, consider a sire whose progeny alive at the end of the laying year numbered 31 with an average production of 275 eggs and a mortality of only 4 per cent. The blood of these prepotent sires, poured continuously into a segment of the flock at Ottawa, showed at the end of seven years a greater production for Barred Rocks of only 1 egg per bird over that of the remainder of the flock and of 4 eggs for White Leghorns. For the sons of the superior line which were used on the Branch Stations, after seven years the production for Rocks was inferior by three eggs, (an insignificant difference), whereas the Leghorns were superior by four eggs.

None of these differences even approach significance, and it must be considered that the superior line at Ottawa and the progeny at the Branch Stations, while they may have been genetically superior to the average, were not able to impress their superiority on their progeny in any lasting way. Under the circumstances, in spite of the great care in setting up rigid standards for superiority it may be questioned whether they were indeed genetically superior. One factor which must be considered is that prior to the start of this project, and particularly during its course, these were largely closed flocks and practically no outside blood was brought in. When sires from these flocks were brought to Ottawa, therefore, there was a distinct outcross involved and blood from this superior line at Ottawa when sent to the Branch Stations also represened an outcross on their stock. It might be expected that some degree of heterosis would result in increased production under these conditions. Such an effect might be expected to be most pronounced during the first few years of introduction of such blood. The temporary increases actually occurring may be partly due to this factor.

The question arises as to whether the prepotent sires obtained were used in the most effective manner, in this project. From the genetic standpoint, the most logical method of maintaining the prepotent qualities of these sires would be to mate them to close relatives such as brother × sister or sire × daughter, thus concentrating their good qualities through increasing homozygosity. Results have indicated that undesirable characters including lethal genes are also concentrated in this process. Selection must be very rigorous under these conditions and much stock discarded, a very uneconomical procedure. To avoid inbreeding, the blood of these sires was deliberately brought to Ottawa to increase the proportion of prepotent blood in a small segment of that floock without inbreeding.

It is now possible to see that since this process did not improve production, some other line of approach such as inbreeding might have been more fruitful. In any case, until such has been attempted in a controlled way the question cannot be answered. The superior sire project is, however, being revised with that in mind. It seems evident, however, that if continued concentration of the blood of sires rigidly selected for true prepotency will not raise the production level of a segment of a flock on which it is concentrated, indiscriminate sale of stock even if superior, would mean a much greater dilution of such blood than was the case in this project. Such conditions would presumably offer little hope of improving production levels.

One step in this superior sire project has not been referred to, namely, the setting up of a test of selected as opposed to random-bred stock. It could be assumed that the stock with which the superior line was being compared was itself being successfully selected for genetic improvement of egg production. Thus, the findings are in reality, that more rigid progeny testing and concentration of superior blood lines did not prove to be more effective than selection at a less intense level.

The most critical analysis of this situation would be possible where a flock was divided equally into a group which was random mated year after year and another which was selected on a family and progeny test basis. If both halves were housed together, reared together, and only separated briefly for the breeding season, one would be an adequate control on the other. On the basis of the results obtained in this project, it might be expected that the random-bred group would not be exceeded over a period of years by the selected group. Such a test has been in operation for four years on one Branch Station, and for two years on another, with no indication as yet of significant differences in average production. On still another Station a flock which has been random bred for many years is being contrasted with a selected Station flock. The results of these tests will be awaited with interest.

Summary.—Family and progeny tests for the selection of sires on the basis of egg production of daughters were conducted on 21 Experimental Stations for over a period of 13 years. These tests have shown only a nominal increase in egg production. In addition to the improvement in genetic origin, environmental factors must receive some credit for the increase.

The concentration of the blood of the few selected sires that were considered superior year after year upon a segment of the Ottawa flock has failed to produce a line consistently superior in egg production to the remainder of the flock at Ottawa.

The sons of these selected "superior sires", possessing a large proportion of "superior" blood, when used at Branch Stations also failed to raise consistently the egg production of that portion of the flock possessing their blood above the level of the rest of the flock.

Based on the results of this project it must be stated that the testing of sires, as applied, including consideration of dams and sisters of the sires used, has failed to bring about the expected increase in egg production of the flock. It must be assumed, therefore, that such breeding procedures, unless more exacting methods are used, are of questionable or very limited value in improvement of egg production in flocks of a reasonably high production level.

Publications.—

The inheritance of egg production in the domestic fowl. I. General consideration. Scientific Agriculture, 16:11. 1936.

The inheritance of egg production in the domestic fowl. II. Increase in production, their extent and characteristics with a discussion of causal factors. Scientific Agriculture, 17:6. 1937.

The inheritance of egg production in the domestic fowl. III. Differences in transmitting ability of dams, and the degree of dam-daughter correlation. Scientific Agriculture, 17:6. 1937.

The inheritance of egg production in the domestic fowl. IV. Reliability of progeny tests of sires. Scientific Agriculture, 17:6. 1937.

New Breeds

Large White.—In 1938, work was begun in developing a new breed which might combine several of the economically important traits of different breeds and thus find a place among the present day breeds of commercial importance. The aim was to combine the following characteristics: white feathers, fast feathering, white flesh, white eggs, good egg production and egg size, and satisfactory meat type. Thus, since all the birds are white, selection on the basis of colour would be unnecessary, but to establish fast feathering would be an asset in the proper dressing of broilers. The white skin was thought desirable for ease of obtaining proper finish of carcass. White eggs are considered better from the point of view of accurate grading. All the above characteristics could be established by suitable breeding methods and selection.

The four original breeds used in the synthesis of the Large White were: White Leghorns, Light Sussex, Barred Rock and Dark Cornish. Crosses were established which were backcrossed for three generations to Barred Rocks. From then on, the procedure was to mate the resulting birds, heterozygous for the simple traits such as feather colour, skin colour and rate of feathering, and to extract the pure types. This objective was achieved in comparatively few generations and from then on it was a matter of selection for other features which are inherited on a multiple factor basis and are thus slower to respond. A disappointing feature was that the very superior meat type of the Dark Cornish was not easily retained although the Large White to date has been classed as equal to, or better than the Barred Rock in breast width and market conformation. With the large proportion of Barred Rock blood infused in this breed, egg colour at the outset was dark brown. Selection has brought this to a point where most of the birds are laying light or tinted eggs and an occasional white one. Selection according to body type and comb size has been aimed at a type similar to the Barred Rock. Examples of the breed are shown in Figure 1.

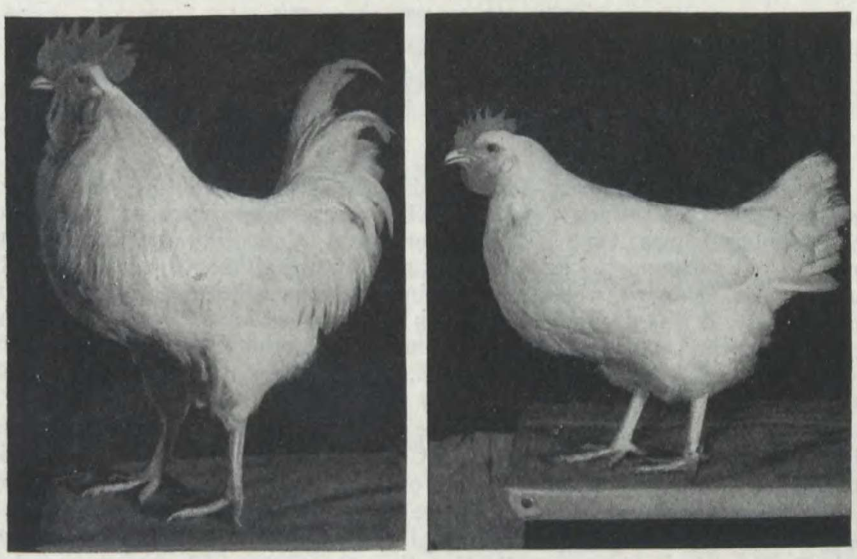


Figure 1—Large White Breed.—A general purpose breed combining some of the best characteristics of a number of breeds.

Conditions not known to exist will often crop up upon recombination of genes such as occurred in the development of the Large White. One such feature was the occurrence of "tight" feathering. This was first noticed in 1945 when birds of this breed were being killed and dressed by use of the semi-scald and plucking machine. Average plucking time, outside of hand finishing, was 93·9 seconds for a sample of Large Whites and about 59·0 for Barred Rocks. Tight feathering, which may be due to heavier musculature in the feather follicles, shows considerable variation between birds and can therefore probably be eliminated by selection. Sexual maturity is reached slightly earlier than in Barred Rocks. Egg production is gradually improving and it is felt that before very long this breed should be available for distribution after it has been tested at the various Branch Farms as to its response under different conditions of environment.

The Large Whites have been crossed with different breeds and have been found to combine satisfactorily with several, especially the New Hampshires, in the production of broilers. The white colour, being dominant, results in a broiler with a clean finish and very satisfactory fleshing. A summary of the performance of the pullets is given in Table 6. For comparison, the rate of sexual maturity of Barred Rocks is included.

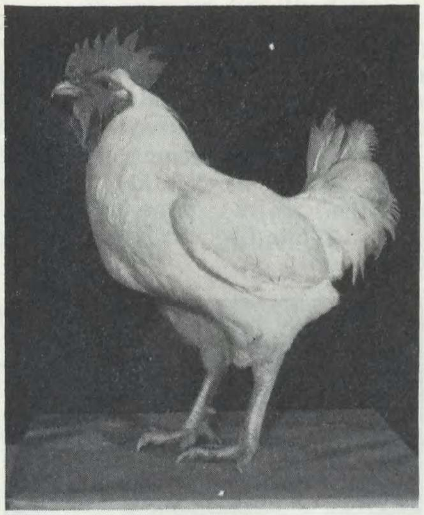
TABLE 6.—ANNUAL EGG PRODUCTION. MORTALITY AND RATE OF SEXUAL MATURITY OF LARGE WHITES AND RATE OF SEXUAL MATURITY OF BARRED ROCKS

Year	*No. surviving	% mortality	Average egg production	Average egg weight (gm.)	Average days to first egg	Barred Rocks Average days to first egg
1941-42.......	70	22·3	206	60·6	205	208
1942-43.......	83	56·3	183	60·3	194	201
1943-44.......	94	25·4	199	61·1	189	207
1944-45.......	81	28·7	198	58·8	191	197
1945-46.......	109	23·2	188	59·8	194	206
1946-47.......	208	16·9	193	60·3	191	200
1947-48.......	243	15·9	202	59·6	180	188

* Alive at the end of the laying year.

Broad Breasted White.—The Cornish game represents the acme of meat quality in the fowl. When the Large White breed was originated, it was hoped that the superior meat type of the former would be incorporated into this breed. However, it was found the type desired, namely one similar to the Barred Rock, could not be achieved while still retaining the broad breast of the Cornish. Consequently, it was decided to establish a new breed having as its main feature the broad "meat type" of the Cornish but having other blood to help overcome some of the bad features of the Cornish, chief of which are low egg production and poor hatchability.

In 1942 the first matings were made involving White Leghorn, Light Sussex, and Rhode Island Red. Then Dark Cornish was introduced. The resultant type was similar to White Cornish due to the white feathering factor contributed by the White Leghorn. The birds are close feathered like the Cornish but single combed. Shank colour in most birds is white but yellow is still being retained since there is some indication that the yellow skin is associated with better fleshing.



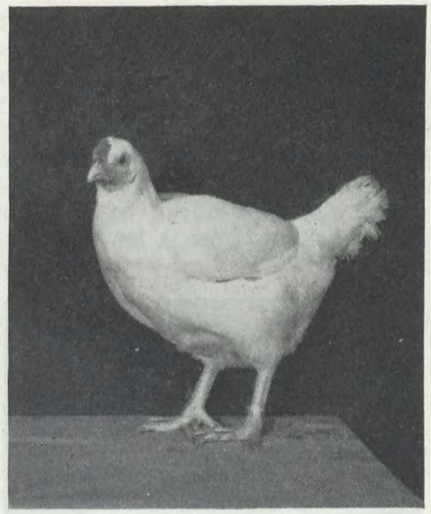


Figure 2—Broad Breasted White Breed. The blocky type of this breed can be judged from the illustration. Meat qualities of this type are excellent.

To date, this breed (Figure 2) has compared exceedingly well with other breeds as far as meat qualities are concerned. It is not so wide in conformation as the original Cornish but is distinctly superior to any of the standard breeds. Its main value may be in crossing with other breeds. White or light-coloured plumage results in the cross and this is of advantage. Crosses have been made with Barred Rocks, White Leghorns, New Hampshires and Large Whites; in every case there has been a significant improvement in fleshing. Also there was little or no reduction in egg production and hatchability due to the infusion of the Broad Breasted White blood.

Egg production of the pure breed is considerably lower than that of most utility breeds but is vastly better than that of the Cornish. It is felt that it can be improved to the stage where keeping this breed for its superior market qualities will be warranted in areas where emphasis is on meat production.

The laying house performance of the Broad Breasted White is summarized in Table 7.

TABLE 7.—ANNUAL EGG PRODUCTION, MORTALITY AND RATE OF SEXUAL MATURITY OF BROAD BREASTED WHITES

Year	*No. surviving	% mortality	Average egg production	Average egg weight (gm.)	Average days to first egg
1941-42	16	36·0	191	56·7	207
1942-43	4	32·1	145	58·0	209
1943-44	5	81·8	172	53·6	204
1944-45	46	11·7	194	54·3	213
1945-46	43	8·3	176	55·0	210
1946-47	47	24·1	178	56·9	200
1947-48	81	16·0	161	54·4	203

* Alive at the end of the laying year.

Small White.—The Large White, after its development, appeared to segregate into two types, one of which was a small strain. This was maintained with the object of developing a small breed, economical in the use of feed and yet laying around 200 eggs of normal size per year. The females would average about 3 to 3·5 pounds, thus effecting a saving on feed required for body maintenance.

The Small White breed, soon after its development, became characterized by small, blocky conformation. In 1943, few individuals were kept because of the pressure of other work. In 1944, some of the females were mated to a Large White male of small size, a few were mated to a White Leghorn Bantam. In the following year, this blood was infused into the breed.

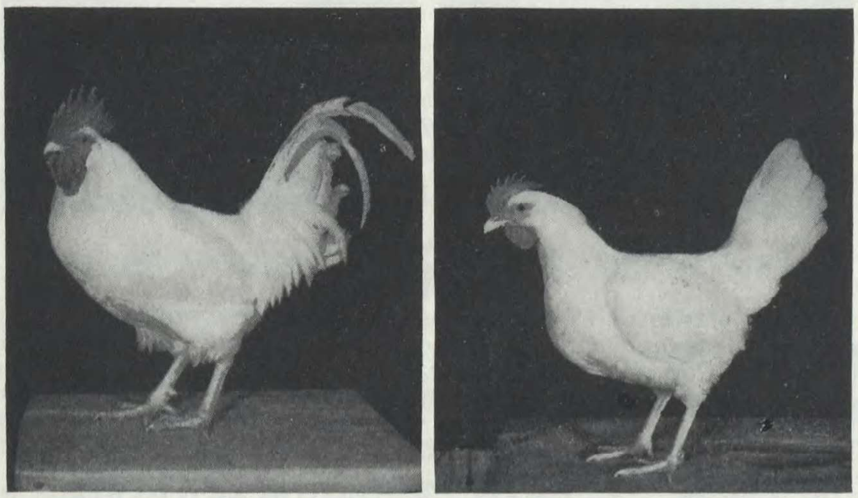


Figure 3. Small White Breed. A small breed, heavy in relation to size, exceptionally fine in meat type and with efficiency of egg production the main objective.

At present, the Small White breed is characterized by small size, uniformity of body type, excellent conformation and fleshing, production of a large proportion of white eggs, and fairly good hatchability and livability. Low egg production and broodiness are disadvantages which probably outweigh the good points. Whether the productive ability can be improved sufficiently to make its lower feed consumption a feature of economic importance is debatable but it is felt that this is necessary before the breed becomes of any commercial value.

The performance to date of this breed is summarized in Table 8. A pair of Small Whites is shown in Figure 3.

TABLE 8.—ANNUAL EGG PRODUCTION, MORTALITY AND RATE OF SEXUAL MATURITY OF SMALL WHITES

Year	*No. surviving	% mortality	Average egg production	Average egg weight (gm.)	Average days to first egg
1941-42	24	46·9	194	52·5	189
1942-43	33	27·8	163	48·4	190
1944-45	21	12·0	207	59·5	179
1945-46	84	9·5	175	48·7	196
1946-47	35	17·3	183	54·8	190
1947-48	76	15·6	160	50·7	189

* Alive at the end of the laying year.

Predicting Egg Production by Physical Characteristics

Many attempts have been made to judge the future egg production of a pullet by physical condition, alertness, brightness of eye and various body measurements. Little success has been attained and body measurements have rarely been shown to be related to subsequent production. If a number of characteristics are combined it was felt that some degree of accuracy of selection should be attainable.

In two different years four individuals graded Barred Rock pullets on the basis of physical characteristics and at the end of the laying year these were related to actual production. The results are shown in the following table.

TABLE 9.—THE RELATION BETWEEN GRADING OF BARRED PLYMOUTH ROCKS AS TO PRODUCTIVE CAPACITY AND ACTUAL PRODUCTION, FOR FOUR GRADERS

Year	Grader	Grade					
		A		B		C	
		Number	Production	Number	Production	Number	Production
1939	W	85	225·5	78	211·6	10	177·4
	X	64	222·4	95	214·8	14	200·8
1942	Y	69	205·7	69	200·7	58	188·0
	Z	58	191·6	114	202·6	24	197·2

Two operators W and X were quite successful, the groups grading A, B and C differing significantly in egg production. Other graders were not so successful indicating that while the birds which will produce better can be selected when the birds are going into the laying house, keen observation and much experience are probably necessary.

The Effect of Culling of Sires' Daughters on the Accuracy of the Progeny Test for Egg Production

It is obvious that if pullet flocks are culled by removing all the low producers, the average egg production of the daughters of a sire would be higher than would be representative of the inherited ability of his progeny to produce eggs. Since culling is often permitted in breeding work and breeding policies, it would be advantageous to know what effect such culling would have and whether some method of culling could be used which would still give a reasonable estimate of the actual production of the daughters. This would permit the culling of inefficient birds without appreciable loss to the breeding records.

A study of this matter using the data from large populations of birds indicated that groups of daughters could be compared on a reasonably accurate basis so long as approximately the same percentage of the birds was culled from all groups being compared. Culling probably should not exceed 25 per cent of the total of birds and much less if the populations are small.

Publication—

On the validity of progeny tests of sires obtained on culled populations of daughters. Scientific Agriculture 19:1:1-6, 1938.

The Effect of Age of Breeding Stock on the Performance of Their Progeny

Some evidence has been presented to indicate that increasing age of hens has the effect of lowering hatchability of their eggs. No effect on the performance of their progeny has been suggested nor has hatchability been considered to be affected by age of breeding males.

In response to a contention that the quality of breeding males, judged by the performance of their daughters, was impaired with age, data were compiled, from results of all Experimental Farms, on the performance in the laying pen of progeny of males and females used several years in succession.

Egg-Laying Contests

From 1919-20 to 1938-39 egg-laying contests were carried out on the Experimental Farms. These contests were the basis for registration of birds which had reached or exceeded the standard of 200 eggs averaging two ounces each or better in 365 days. Average egg production per surviving bird was 122·5 eggs in the first contest and 201·7 eggs in the 1938-39 contest, the last held. These contests served a very useful purpose in focussing the attention of the public on better breeding, feeding, housing, etc., to obtain greater and more efficient production.

Relative Importance of Environment and Heredity in Growth and Egg Production

Attempts are often made to compare the egg production of stock from one breeder with that of another. Strictly speaking, this is not possible on any fair basis unless both strains are reared and kept under the same environment. This fact is too little understood throughout the country and when one man's strain gives a higher production than that of another it may be lightly assumed that the difference is genetic in nature.

To obtain information as to the relative importance of these two factors, a project was carried out in which an exchange of hatching eggs of Barred Plymouth Rocks was made between two Branch Farms and the Ottawa Farm. Each Experimental Farm supplied the other with an adequate sample of hatching eggs and in return received a sample from each of the others. The birds were raised intermingled at each location. At any one Farm, therefore, there were three strains under one environment while each strain was being raised under three different environments. Differences between strains in any one environment would be largely due to strain whereas differences for any one strain under the three environments would be due to the effects of environment.

The criteria used during the growth period were, body weight, breast angle, circumference of tibia, length of keel, height of keel, length of tibia and length of femur. Breast angle is the measured curve of the breast which would indicate plumpness of the breast, circumference of tibia also is a measure of fleshing or muscling of the bird; length and height of keel are measurements of depth and length of the breast muscle; length of tibia and femur are measurements of bone length and therefore of size.

The following conclusion could be drawn from the results obtained.

Conclusions With Respect to Growth.—

1. Environment had a much greater effect than heredity upon the course of growth during the period of rapid development.

2. The relative effect of environment upon fleshing characteristics, as indicated by breast angle (fullness of breast), and circumference of tibia, was even more marked than upon growth.

3. Skeletal growth, as indicated by length of keel, height of keel, length of tibia and length of femur, differed significantly between different environments and different strains at 16 weeks of age, indicating both an environmental and hereditary influence, the former having a greater effect on the average.

4. At 24 weeks of age, no significant effect of environment upon body weight was apparent. The effect of heredity, on the other hand, appears to have become relatively more marked, causing significant differences between strains for both body weight and breast angle. Apparently the environmental influence decreased somewhat whereas the influence of heredity became more marked at the approach of maturity.

5. Significant effects of both environment and heredity on skeletal size were apparent at 24 weeks of age. The effect of both factors was approximately equal.

6. It would appear that in commercial strains of Barred Plymouth Rocks, under good conditions of management, control of growth rate and fleshing during the period of rapid development is largely dependent upon environmental factors such as feeding, housing and prevalence of disease. As maturity approaches, inheritable factors become more evident and environmental effects less apparent.

7. The strains and environments upon which these findings are based are typical of those prevailing on carefully managed poultry plants. Since environmental conditions on general farms and marginal enterprises would almost invariably be much less favourable than those of the poultry plants used herein, the greater effect of environment found in these data may be considered to be close to a minimum expression of that effect.

The pullets raised in connection with the growth period of this experiment were carried through a laying year at the respective Experimental Farms.

Egg production from time of first egg to September 4, and for the full laying year, egg weight, days to first egg, body weight at first egg, greatest body weight and mortality, were used as a basis to determine whether environment or heredity had the greatest effect.

Conclusions drawn from this experiment with respect to egg production.—

1. Egg production to September 4 and for the laying year was influenced by environment to a much greater degree than by heredity. Since this was the case even though the actual environments compared in this experiment differed to only a moderate degree, the importance of improvement of environment as a means of increasing egg production is emphasized by these results.

2. "Days to first egg" was also affected by environment to a very great degree and by heredity only to a limited extent. The economic importance of early sexual maturity adds weight to the value of this finding.

3. Body weight at first egg was affected directly by both environment and heredity and to a similar degree.

4. Egg weight and maximum body weight were affected by both factors. Heredity, however, was the most potent factor in governing maximum body weight.

Publications.—

The relative effect of environment and heredity upon body measurements and production characteristics in poultry. I. Period of Growth. Scientific Agriculture, 22:6, 1942.

The relative effect of environment and heredity upon body measurements and production characteristics in poultry. II. Period of egg production. Scientific Agriculture, 22:8, 1942.

PHYSIOLOGY AND REPRODUCTION

EXPERIMENTS WITH FOWL SPERMATOZOA

The recent trend towards the use of artificial insemination on poultry breeding plants, especially amongst the breeders of turkeys, has prompted the investigation of some of the fundamental physiology underlying the production of fowl spermatozoa.

Since most of the work in the field of sperm physiology has been carried out with mammalian spermatozoa it was necessary to see how much of this knowledge could be applied to fowl spermatozoa. Fowl spermatozoa can survive in the oviducts of females for from two to three weeks, while mammalian spermatozoa can only survive for a very limited time following insemination into the female reproductive tract. This difference indicated that there would be physiological differences in the production of the spermatozoa.

Experiments showed that fowl spermatozoa are similar to mammalian spermatozoa in that they had to pass through a "ripening" process following their production in the testis of the male. However, other experiments demonstrated that the male sex hormone (testosterone) did not influence the "ripening" process as it has been shown to do in mammals. As the spermatozoa pass down the vas deferens of the male reproductive tract they gradually gain the ability to move. It was shown that this gain in the power to move was directly correlated with the increase in the functional or fertilizing ability of the spermatozoa.

An experiment was conducted to ascertain the time of the day of the greatest activity in the growth and development of spermatozoa in the testis and interestingly enough, the greatest activity was found to take place during the night.

Since fowl produce over a billion spermatozoa in a single ejaculation of about 1 c.c. it was thought that fowl semen might be diluted so that semen from superior males could be used more extensively. Experiments conducted to test various diluents were not very successful although it was shown that 100,000,000 spermatozoa or more were needed per insemination to achieve maximum fertility. Very little progress was made in preparing a suitable practical diluent for use in poultry work. More experimental work should be conducted in this field.

The effect of X-rays on fowl sperm was studied. With each increase in radiation (over 8,300r), there was a distinct decline in motility and associated with this was a corresponding decline in the fertilizing power of the semen.

Publications.—

Preparation of avian sperm smears for microscopy. Science, 83 (2161): 532, 1936.

Motility and fertilizing capacity of fowl sperm in the excretory ducts. Proceedings of the Society for Experimental Biology and Medicine, 33:255-257, 1935.

Fowl sperm immobilization by a temperature-media interaction and its biological significance. Quarterly Journal of Experimental Physiology, 27 (3): 281-291, 1938.

The effect of testis hormone on the preservation of sperm life in the vas deferens of the fowl. Journal of Experimental Biology, 15 (2): 186-196, 1938.

Functional changes in fowl sperm during their passage through the excurrent ducts of the male. Journal of Experimental Zoology, 79 (1): 71-92, 1938.

Diurnal rhythm of mitotic activity in the seminiferous tubules of the domestic fowl. Poultry Science, 21 (2): 130-135, 1942.

The effect of dilution and density on the fertilizing capacity of fowl sperm suspensions. Canadian Journal of Research D, 16: 281-299, 1938.

Some aspects of the biological action of X-rays on cock spermatozoa. Physiological Zoology, 27 (3): 289-319, 1944.

Sex Differences in Chick Weights

It was found that there was a difference in the body weight of freshly-hatched chicks depending upon the sex of the chick, even though the weight of the eggs from which they came may have been identical. This was found to be due to more efficient utilization of the shell by the male chicks presumably for the building of bones.

Publications.—

The existence of a sex difference in the weight of day-old chicks with further data on egg weight chick weight relationship. Scientific Agriculture, 20 (10): 586-591, 1940.

Evidence of a sex differential in the utilization of shell calcium by the chicken embryo. Scientific Agriculture, 21 (6): 315-319, 1941.

GENETIC STUDIES

Fast Feathering

In order to incorporate the character for fast feathering into the Barred Rocks, a typically slow-feathering breed, a superior Barred Rock male was mated with two New Hampshire females. The best male from these matings was backcrossed to Barred Rock hens. An occasional fast feathering pullet chick from this mating was kept and the remainder discarded. As a result of crossing over in the sex chromosome, barring and fast feathering were combined.

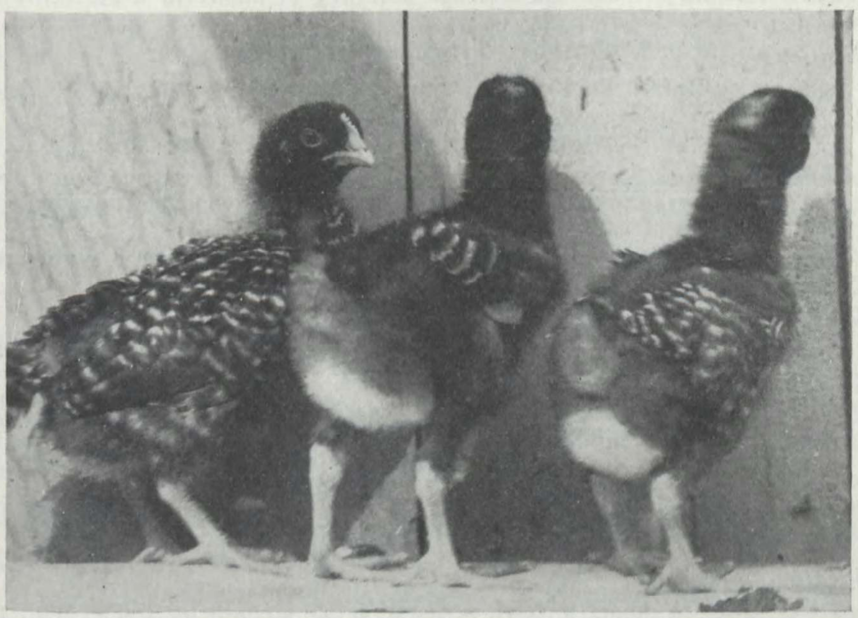


Figure 4.—Barred Rock chicks of same age illustrating fast and slow feathering. The one on left is fast feathering.

These chicks were raised and tested for purity of the factor for extension of melanin pigment. The impure ones were discarded and the remainder kept as a foundation for a fast feathering strain. The strain has performed satisfactorily in every respect as compared with the original slowfeathering Barred Rocks. Its additional advantages are improved appearance and hardiness of the chicks. Moreover, the chickens can be dressed properly at the broiler stage, hitherto impossible because of a predominance of pin feathers.

Autosexing

The feature of autosexing, or the ability to separate sexes of chicks at hatching time, is one of considerable importance to the commercial hatcheryman who can then guarantee his chick sales of certain breeds as either male or female without having to employ the assistance of an expert vent sexer. Considerable work has been done with some autosexing breeds, particularly in Great Britain, where a number of them have been developed.

In 1939, plans were carried out to develop such a breed using segregates which were discarded in the development of the Large White breed. The gene for barring in the Barred Plymouth Rocks was to be substituted for the gene for non-barring in the Rhode Island Reds resulting in what were called "Barred Reds". This breed was kept in small numbers until 1942 at which time, due to the development of sight sexing in Barred Rocks, it was more or less discontinued. It was later carried on by the University of British Columbia, the birds being known as "Redbars".

Sight Sexing of Barred Rocks

The technique of separation of sexes of Barred Plymouth Rock chicks by down and leg colour was mastered and in 1940 a bulletin was published illustrating the method and the variations that occur between males and females in head spots and leg colour. An average accuracy of about 96·4 per cent was reached.

Publication.—

Sight sexing Barred Rock chicks. Farmers' Bulletin No. 102, 1946 Revision.

Gynandromorphism and Lateral Asymmetry in Fowl

Gynandromorphs have both male and female characteristics and rarely occur in poultry or animals. Lateral asymmetry is the condition in which the right and left sides of a bird are not equally developed.

These two subjects of particular interest to the geneticist were studied and the following publications show the details of this work.

Publications.—

Gynandromorphism and lateral asymmetry in birds. Proceedings of the Royal Society of Edinburgh, 63-II-(9):114-134, 1937-38.

Lateral Asymmetry in the fowl. Proceedings of the Seventh World's Poultry Congress and Exposition, 61-64, 1939.

Breast Ridge in the Domestic Fowl

A characteristic designated as "breast ridge" was found in Cornish fowl and crosses of this breed. Its mode of inheritance was investigated.

Publication.—

Breast ridge in domestic fowl, a new dominant character linked with pea comb or another expression of the pea comb gene. American Naturalists, 74:382-384, 1940.

Body Size in Relation to Weight of Sex Organs

The criterion most naturally used in assaying the effect of sex hormones is the weight of the sex organs. In investigations at this laboratory, it was observed that there was a decided influence of body weight on the weight of sex organs of baby chicks. Experimental data were obtained which showed the importance of considering the factor of body weight in assaying the effect of sex hormones by the weight of the sex organs.

Individually pedigreed White Leghorn and Barred Rock chicks were sexed and weighed at hatching time and weighed again at 7 days and at 17 days when they were killed and the weights taken of the ovaries and oviducts in the females and testes in the males as well as the Bursae Fabricii in both sexes.

Conclusions were as follows:

(1) There is a breed difference in weights of testes and bursae between males of White Leghorn and Barred Rock breeds. This is particularly striking in the case of the bursae.

(2) The apparent correlations between the weights of some organs are actually spurious when either the body or the bursa weight is held constant. When either of these two are held constant, the degree of association between the remaining variables is sharply reduced.

(3) Other correlations are undisturbed when either ovary, oviduct or testis weight is held constant.

Publication.—

Body size as a factor in interpreting the effect of hormone injections in baby chicks. American Journal of Physiology, 129(2):283-288. 1940.

The Inheritance of Yellow Pigmented Heads in the Domestic Fowl

The mode of inheritance of a yellow pigmented type of head which occurred in the Barred Rock flock was investigated and reported upon.

Publication.—

The inheritance of yellow pigmented heads in the domestic fowl. American Naturalist, 59:378. 1935.

Linkage tests with the yellow head and dominant white plumage and white-skin characteristics in domestic fowl. Scientific Agriculture, 17(7):451. 1937.

Egg Quality

Quality in eggs, particularly as affecting albumen and yolk is very important. Experiments indicated that fresh eggs which were stored in high quality condition did not deteriorate as rapidly as those in fair quality only. It was found that the percentage of firm white, condition of firm white, yolk weight, yolk colour, strength of yolk membrane and mineral content of shell and of the whole egg were characteristics of each individual bird and that selection to improve these characters might be successful.

Publications.—

A method of measuring the strength of the yolk membrane. The U.S. Egg and Poultry Magazine, 41(12):48-50. 1935.

Correlations between certain fresh and storage measurements of egg yolk and white. Proceedings of the 6th World's Poultry Congress 2:224-226. 1936.

Effect of heredity on interior egg quality and shell composition. Poultry Science, 27(1):17-27. 1938.

FIGURE 5. Effect of male testicular hormone (testosterone propionate) on comb growth of male chicks. Note difference in breed reaction (Barred Rock, left—White Leghorn, right).

HORMONE STUDIES

The sex hormones, estrogens (female) and androgen (male) have important effects on poultry which suggested that some method of determining their potency when given to chicks should be investigated. A number of such hormones were assayed according to a technique worked out by this Division.

Publications.—

Relative potency of certain synthetic estrogens when administered orally to chicks. The American Journal of Physiology, 147 (3): 582-590, 1946.

Observations on effect of esterified androgen on sex eminence of the chick. Endocrinology, 30 (5): 767-772, 1942.

Effect of sex hormones, separated and combined, on the proliferation and hydration of combs and cloacae of male chicks. Endocrinology, 30 (1): 102-106, 1942.

Dramatic response of the chick oviduct to estrogen. Poultry Science, 22 (4): 330, 1943.

Figure 6.—Effect of male testicular hormone (testosterone propionate) on size of cloaca. Note breed difference and extreme development of cloaca as in the laying hen.

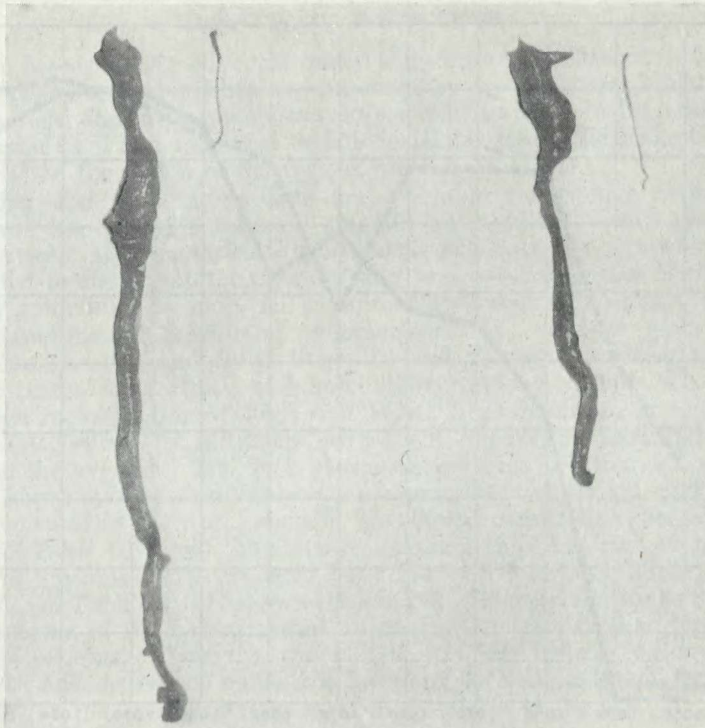


Figure 7.—Effect of female hormone (estradiol dipropionate) on development of oviduct. Barred Rock, left; White Leghorn, right. Oviduct weight increases were obtained up to 80 times the control.

HATCHABILITY

Specific Gravity of Eggs as a Measure of Hatchability

Research has shown that the strength of egg shells can be measured with a considerable degree of accuracy by using a series of salt solutions which indicate the specific gravity of a certain egg. Since this is little affected by variations in albumen or yolk content, it follows that differences in specific gravity indicate difference in shell quality. Furthermore, when eggs have a specific gravity above a certain level (1.078 for Barred Rocks and 1.086 for White Leghorns), they have decidedly better hatchability than eggs below that level. There is also a definite relationship between specific gravity and fertility. These relationships are shown graphically for White Leghorns in Figure 8.

Further work on this problem involved specific gravity measurements over two years on nine Branch Farms: in every case the superior hatching power of eggs which sink at the critical point for each breed was confirmed. There were marked differences between Farms in the proportion of strong to weak-shelled eggs. This could sometimes be attributed to environment. The greatest improvement in hatchability by separating eggs into sinkers and floaters and discarding the floaters is achieved where the average shell strength of the flock is not good. Further evidence showed that a significantly greater proportion of chicks hatched from eggs of low specific gravity die during early life than is the case in the high group.

It has recently been shown that not only do hens differ as to specific gravity of their eggs but there are also definite family differences which indicate the possibility of selection of strains with superior egg shell quality.

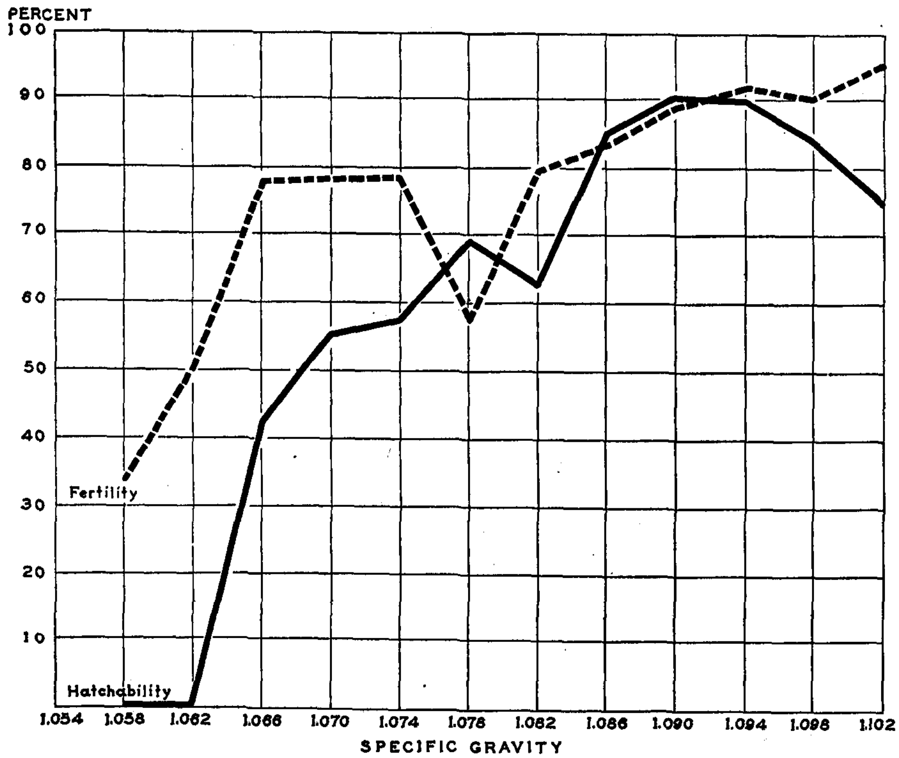


Figure 8.—Relation of specific gravity of the egg to fertility and hatchability in Leghorns.

Publications.—

The relation of specific gravity to hatching power in eggs of the domestic fowl. Scientific Agriculture, 21 (2): 53-62, 1940.

Further data on the relation between shell strength, potential hatchability and chick viability in the fowl. Scientific Agriculture, 22 (11): 698-704, 1941.

Abortive Parthenogenesis in the Domestic Chicken

Abortive parthenogenesis is the partial development of the unfertilized germ of an egg.

Publication.—

Abortive parthenogenesis in the domestic chicken. Anatomical Record, 91 (3): 247-251, 1945.

Pre-oviposital Embryonic Deaths in Chickens

In the belief that many eggs which are classed as infertile may actually be germs which were fertilized and alive but died even before the egg was laid, experiments were conducted using special techniques worked out at the Division. It was found that the above is actually the case in many instances.

Publication.—

Proof of the existence of pre-oviposital embryonic deaths in chickens and their bearing on the relation between "fertility" and "hatchability". Canadian Journal of Research, D. 23: 129-138, 1945.

Relative Influence of Heredity and Environment on Fertility and Hatchability in Wyandottes

Certain breeds often rank consistently high or low in relation to other breeds as far as egg production, fertility and hatchability are concerned. White Wyandottes have been shown in some cases, in certain locations, to be much inferior to breeds such as White Leghorns or Rhode Island Reds. This has been attributed (Hutt) to the action of deleterious genes.

Hatching and brooding records are available for twenty farms of the Experimental Farms System across Canada since 1923. Until 1941, White Wyandottes were kept on three of these farms and data are presented for part of this period to show that the poor fertility and hatchability of White Wyandottes may sometimes be more an environmental factor than genetic.

The Experimental Station at Summerland, B.C., always gave excellent results in hatchability and chick livability and through seventeen years was average or better for fertility and hatchability, among various Experimental Farms which included Barred Rock and White Leghorn flocks as well. In the four years (1937-40) it led all others, with about 20 to 30 per cent higher hatchability than the average. The flock of the Experimental Station at Saanichton, B.C. was above average particularly in percentage of fertile eggs hatched. The Experimental Station at Lacombe has shown consistently poor results in this regard. Table 10 shows the standing of these three Stations in relation to the other 18 Stations which included both Barred Rocks and White Leghorns. For example, in Table 10 it is shown that in 1931 Summerland ranks 8th among 21 poultry flocks of the Experimental Farms System in regard to fertility and hatchability of eggs. Over the years 1931 to 1940 inclusive, Summerland's standing was 2·8. As can be noted, the Lacombe flock ranks low in fertility and hatchability.

TABLE 10.—RELATIVE STANDING OF THREE WYANDOTTE FLOCKS ON THREE EXPERIMENTAL FARMS, OUT OF A TOTAL OF 21 FLOCKS OF DIFFERENT BREEDS AS REGARDS FERTILITY AND HATCHABILITY OF EGGS

Year	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	Average Standing
Summerland	8	1	8	2	1	4	1	1	1	1	2·8
Saanichton	5	6	10	6	5	3	11	10	13	12	8·1
Lacombe	19	11	13	14	8	19	17	17	17	18	16·3

TABLE 11—SUMMARIZED DATA ON FERTILITY AND HATCHABILITY COLLECTED IN 1941 AND 1942

Collected at	Summerland Females		Lacombe Females	
	Fertile	Fertile hatch	Fertile	Fertile hatch
	%	%	%	%
Summerland 1941	77·3	89·6	80·6	90·3
Lacombe 1941	78·3	78·4	51·5	64·4
Lacombe 1942	98·1	72·4	98·9	71·4

An exchange of stock was arranged between Summerland and Lacombe. At each farm a group of mature pullets was selected at random and half were interchanged. They were maintained through the winter and mated in the spring. One year's data, as well as an additional year's at Lacombe, are presented and show that in this case the difference was not genetic and the necessity is also shown of testing whether a flock or strain of birds kept in one location is actually superior genetically, or not.

Publication—

Relative influence of heredity and environment on fertility and hatchability in Wyandottes. Empire Journal of Experimental Agriculture, 14(53):25-30,1946.

DETECTION OF FERTILITY IN FRESH, BROKEN-OUT EGGS

A technique was worked out whereby it is possible to distinguish fertile from infertile eggs by examining the broken-out yolks after applying certain dyes.

Publication.—

Macro- and microscopic methods of detecting fertility in unincubated hen's eggs. Poultry Science, 23(4):266-269, 1944.

The accuracy of the macroscopic method in identifying fertile, unincubated germ disks. Poultry Science, 24(3)281-283, 1945.

EFFECT OF VARIATION IN ATMOSPHERIC PRESSURE ON INCUBATOR TEMPERATURE

Marked temperature variations in the incubation of eggs are not considered conducive to maximum hatchability. In many thermostatically-controlled machines, temperature is regulated within certain narrow limits by the action of four-inch wafer thermostats.

It was found that temperature changes beyond the normal variations occurred and these coincided with changes in atmospheric pressure. Thus, when air pressure increases, the wafer is squeezed and requires more heat to expand it to the point where the electric current to the heater is cut off, and therefore the incubation temperature rises. The reverse holds true when air pressure decreases. This condition may be responsible for a change in incubation temperature of 2 to 3 degrees in the extreme. It can be counteracted by using a different type of thermostat, relying entirely upon the principle of expansion and contraction of metals with temperature changes.

HATCHING SUMMARY

The average hatching results for the Experimental Farms System are recorded in Table 12. These results are based mainly on Barred Rock flocks with three White Leghorn flocks and one White Wyandotte included; hens rather than pullets were used in nearly all cases.

TABLE 12.—HATCHING SUMMARY FOR ALL EXPERIMENTAL FARMS, 1936-48

Year	Eggs set	Fertile	Fertile eggs hatched	Total eggs hatched
		%	%	%
1936	82,030	82·6	64·3	53·1
1937	55,896	84·2	66·9	56·4
1938	64,066	83·8	67·5	56·6
1939	44,779	83·6	69·9	58·4
1940	44,824	86·0	69·4	59·7
1941	42,673	85·9	69·3	59·5
1942	43,168	87·1	72·8	63·4
1943	38,985	87·0	72·7	63·3
1944	45,543	85·9	68·7	59·1
1945	40,100	87·9	71·9	63·0
1946	41,598	85·7	71·6	61·4
1947	40,846	85·3	72·3	62·1
1948	44,798	83·5	74·4	62·1

From Table 12 it will be noted that a gradual increase is shown, particularly in per cent of fertile eggs hatched. This can be attributed mainly to improvements in incubation facilities. During the early part of the period considered, improvements in nutrition and management no doubt played a large part.

NUTRITION

Experiments in Fattening of Poultry

A large amount of research work was conducted on the subject of best methods and feeds for preparing poultry for market. This subject had up to the time of the inauguration of this research received relatively little attention in the form of reliable controlled research. The excellent regulations covering grading of dressed poultry in Canada and the price premium established for quality in the dressed carcass made this subject a very important one. The relative value of the various cereal grains and of supplements and the most precise methods of management had not been tested. It was decided, therefore, that this subject merited serious attention and as a result, facilities for controlled tests of this type were set up and nine separate experiments were conducted. The results of the work were published in technical papers to the same number in *Scientific Agriculture,* as noted at the conclusion of this section of the report. All factors relating to feeding and management which were felt to be of sufficient economic importance to merit attention were investigated in this series of tests. At their conclusion, a bulletin was issued on the subject of fattening poultry for market, based largely on the findings of this research.

Birds of 26 to 28 weeks of age were used for these tests and they were fattened in batteries where individual feed consumption could be measured. The gain in weight and the increase in fat of the birds were the principal criteria of whether the feeds or treatments were satisfactory or otherwise. The actual grading of the dressed carcasses was also used. The various experiments and the findings are shown for each test separately.

Experiment No. 1

The following treatments were given the birds.

Group A.—Dry mash, and skim-milk to drink—both before the birds at all times.

B.—Wet mash composed of two parts of skim-milk to one part of mash—birds kept in pens rather than fattening crates.

C.—Ground raw potatoes in wet mash, equal parts of potatoes and mash by weight, mixed with one part of skim-milk to one part of the mash-potato mixture.

D.—Restricted feeding—wet mash composed of two parts of skim-milk to one part of mash.

E.—Control group—wet mash composed of two parts of skim-milk to one of mash.

The mash mixture used consisted of two parts of ground oats to one part of ground barley.

Restriction of feed for group D was accomplished by calculating the amount of food to be given on the basis of the surface area of each bird and at a level of 85 per cent of expected consumption on the basis of previous fattening data.

Conclusions

(1) Wet mash was decidedly superior to the feeding of dry mash with milk to drink.

(2) The feeding of the above wet mash to the birds in fattening crates was very much superior to the same treatment when fed to birds confined to pens.

(3) The wet mash containing raw potatoes was almost equally as efficient as the wet mash alone.

Experiment No. 2

The treatments accorded the birds were as follows:

Group A.—Ground yellow corn.

B.—Control—two parts of ground oats to one part of ground barley.

C.—Cooked potatoes—one part of ground oats, ground barley mash (as for pen B) to one part of mashed potatoes.

D.—Ground wheat.

E.—Meatmeal—ground oats; ground barley mixture as for Pen B, plus 10 per cent of meatmeal.

In addition to the feeds above set forth, one-half of each group was allowed fifteen minutes to consume their feed while the other half was allowed one-half hour.

Where ground grains are indicated, the whole grain, finely ground, was used. In the case of the cooked potatoes, as little water as possible was added during cooking and they were steam cooked in a double boiler. Hence all added water was evaporated and nothing was drained off from the potatoes and discarded.

Conclusions

1. While corn and wheat gave similar weight increases in fattening, judged upon the basis of the efficiency with which these grains were used, corn was decidedly superior to wheat as well as to all other feeds used in this test.

2. The use of a wet mash of two parts of ground oats to one part of ground barley mixed with skim-milk gave less satisfactory results than those obtained with the same ration supplemented with 10 per cent of meatmeal.

3. A mixture of equal parts of the above mash (2 oats : 1 barley) and cooked potatoes, the whole mixed with skim-milk, gave inferior results.

4. A feeding period during fattening of fifteen minutes duration was equally as efficient as one of thirty minutes.

Experiment No. 3

Ground corn having shown itself superior to other grains and mixtures as set forth under experiment No. 2 above, it was decided that this grain would be used as the control and other feeds or treatments compared therewith. Accordingly, test No. 3 consisted of the following treatments.

Group A.—Ground yellow corn plus 5 per cent of feed molasses.

B.—Ground yellow corn plus 5 per cent of ground oyster shell.

C.—Ground yellow corn plus 5 per cent of mutton fat.

D.—Control group—ground yellow corn.

In addition to gain and increase in fat, the birds in this test were graded by an official grader according to the government grading standards for dressed poultry with the following results.

Grade	Molasses	Calcium Carbonate	Mutton fat	Corn
	%	%	%	%
A	47·3	55·0	74·3	57·5
B	52·7	45·0	25·7	42·5

Conclusions

1. The addition of 5 per cent mutton fat to a fattening ration improved the gain, the efficiency of use of feed, the increase in percentage of fat, and the percentage of A-grade birds.

2. The addition of 5 per cent calcium carbonate (ground oyster shell) to a fattening ration improved palatability as indicated by a slight increase in feed consumption.

3. The addition of 5 per cent of molasses to a fattening ration did not affect gain in weight, feed consumption or increase in fat. Fewer A-grade birds were produced by this addition, however,

Experiment No. 4

The treatments contrasted in this test were the following:

Group A.—Ground yellow corn including 10 per cent mutton fat.
B.—Ground yellow corn including 10 per cent beef fat.
C.—Ground yellow corn including 10 per cent corn oil.
D.—Ground yellow corn including 10 per cent mutton fat, 10 per cent meatmeal and 5 per cent ground oyster shell.
E.—Normal range rearing without fattening.

All fattening feeds were mixed with skim-milk. The animal fats were rendered and mixed quickly while hot with the ground grain to avoid lumping.

In addition to the above, one third of each group was killed after one week, two weeks, or three weeks fattening. Also one-half of the birds on each treatment were given feedings twice daily whereas the other half were fed three times daily. The grading results are given in Table 13.

TABLE 13.—DRESSED GRADES OF BIRDS UNDER EXPERIMENT 4

	Feed					Length of fattening period*			No. of feedings*	
	Mutton fat	Beef fat	Corn oil	Complex ration	Range	1 wk.	2 wk.	3 wk.	2 feedings daily	3 feedings daily
	%	%	%	%	%	%	%	%	%	%
Grade A.......	91·4	94·4	73·5	69·4	19·4	70·2	93·5	83·3	78·6	85·9
Grade B.......	8·6	5·6	26·5	30·6	80·6	29·8	6·5	16·7	21·4	14·1

* Exclusive of range group.

Conclusions

1. Crate fattening was greatly superior to ordinary range rearing methods for the production of gain, increase in fat and grading of the dressed bird.

2. Beef fat and mutton fat were very satisfactory additions to the fattening mash, giving excellent gains, fat increase, and market grade, and producing a fat of desirable firm texture. A level of 10 per cent of mutton fat had a tendency to impart its flavour to the fat of the bird.

3. Corn oil, while giving very satisfactory gains and fat increase, did not maintain either gains or increase for as long a period, and a fat was produced which was decidedly soft even to the extent of producing some free fluid fat in the abdomen of some birds.

4. In crate fattening, 2 feedings daily were as efficient as 3 feedings for weight gain and fat increase.

5. With well reared cockerels of roaster age, 2 weeks of fattening gave greater and more economical gains and fat increase than 1 week, but 3 weeks of fattening was not justified by the results obtained.

Experiment No. 5

The treatments tested in this experiment were as follows:

Group A.—Ground barley.
B.—Ground buckwheat.
C.—Ground yellow corn.
D.—Ground oats.

In addition, one half of the birds of each group had their feed wet mixed with skim-milk one feeding in advance, as is common commercial practice, whereas the remainder were given fresh-mixed feed. One half of each of these groups in turn had 5 per cent bonemeal added to the ration.

Conclusions

1. Ground yellow corn proved to be markedly superior to ground oats and ground barley for production of gain and increase in fat in crate fattening.

2. Ground buckwheat gave as great gains as yellow corn but required considerably more feed than the former per unit of gain. Buckwheat was definitely inferior to corn in its ability to increase fat.

3. Ground oats and ground barley were of approximately equal value for gain and fat production and were definitely inferior to corn and buckwheat.

4. The premixing of fattening feed one feeding in advance, with holding at room temperature, had no effect upon gains but reduced the increase in percentage fat.

5. The addition of bonemeal to the fattening mash, at a level of 5 per cent had no beneficial effect upon gains, fat increase, or whiteness of the dressed carcass.

Experiment No. 6

In this experiment both factors of management and feeds were under test as follows:

Group A.—Fattened at an average temperature of 36·4°F.—range 23 to 48°F.
B.—Fattened at an average temperature of 53·1°F.—range 46 to 62°F.
C.—Fattened at an average temperature of 59·5°F.—range 49 to 70°F.

These temperatures were attained for group A by using a shed with open double doors thus giving little protection from outside temperatures, which in this latitude during early November, are relatively low. By so doing, fattening conditions throughout the surrounding country were simulated, but with additional severity since these birds were not closely grouped as is usually the case but were individually caged and unable to crowd for warmth; they also were on wire floors which tend to accelerate the heat loss from the body. Since the water in the drinking cups was often frozen in the morning, it will be appreciated that more severe conditions will rarely be met with in actual practice. For groups B and C a heated room divided by a temporary canvas partition was used. It was not found possible to hold down the temperature of group B to approximately 50°F., as was desired, but the mean differences in temperatures of 16·7°F. and 6·4°F. cover a very satisfactory total range.

One-half of the birds of each of these groups received ground yellow corn as their cereal ration while the remaining birds were given ground hulled oats. It should be noted particularly that since a preliminary test showed commercial finely-ground oat groats to be pasty and unpalatable because of fineness of grinding, the hulled oats used in this test were quite coarsely ground and proved highly satisfactory from the standpoint of palatability.

One-half of these groups in turn had their mash mixed with skim-milk and the other half with water. All groups had water to drink. The results are given in table 14.

TABLE 14.—DRESSED GRADES OF BIRDS UNDER EXPERIMENT 6

Fattening Treatment	Grade A	Grade B	Milk-fed class
	%	%	%
Mean Temp. of 36·4°F.	83·33	16·67	31·25
Mean Temp. of 53·1°F.	82·98	17·02	27·66
Mean Temp. of 59·5°F.	85·42	14·58	25·00
Ground hulled oats	80·56	19·44	48·61
Ground yellow corn	87·32	12·68	7·04
Skim-milk mixed	92·96	7·04	32·39
Water mixed	75·00	25·00	23·61

Conclusions

1. Coarsely-ground hulled oats were definitely superior to ground yellow corn for the production of gain in fattening. Since the latter grain has been shown to be consistently superior to ground oats it seems to be quite apparent that the removal of the hull from the oat grain is responsible for the superiority of hulled oats. In spite of this superiority for oats, ground yellow corn was equally efficient for the production of fat as indicated both by increase in percentage fat and by grading of the dressed carcasses. This confirms previous work indicating corn to be singularly efficient among the cereal grains in the production of fat.

2. Skim-milk proved greatly superior to water as a mixer for a fattening mash in production of grain. It was also somewhat more efficient in the production of fat as indicated by increase in percentage fat and by grading.

3. The temperature condition under which the birds were fattened had no marked effect upon the gains made, and the lowest mean temperature, 36·4°F., showed a tendency to superiority in this respect. A greater feed consumption for maintenance of body temperature was evident at the lower temperature. Under practical conditions, the temperature of the fattening room is probably of only limited significance since the extreme range in this test was 23° to 70°F.

4. The feeding of a white grain such as ground hulled oats had a very great effect on the production of white-fleshed birds, while the use of skim-milk as a mixer for the fattening mash produced a further whitening effect.

Experiment No. 7

The experiment in this instance, rather than being an actual test of feeds and treatments, represents analyses of data already obtained in previous tests to study the economics of various methods of preparing poultry for market. To this end, crate-fattened cockerels, range-fed cockerels and capons were contrasted on a cost basis.

Some of the data shown herein were obtained from a fattening test previously reported. This particular test was chosen for several reasons: first, because an excellent but not unusually high response to fattening treatment was obtained, and second, because the test was controlled by a group of related cockerels which remained under the usual range conditions, data from which were valuable as a standard for comparison of treatments. These data were further supplemented by unpublished data on capons, which, while taken from related birds during the same period as the above-mentioned test, were not actually a part of that experiment. For purposes of reference, it should be stated that the data used were those of group B (crate fattened) which received ground yellow corn including 10 per cent beef fat as a fattening mash, and group E which were kept on range, complete details of both being discussed in Experiment No. 4. The range group considered in this analysis had adequate range on alfalfa fields and received scratch grain night and morning with a growing mash mixture available in hoppers at all times. The gains recorded are from starved weight to starved weight in all instances with the exception only of those of the capons. In calculating feed costs for both the range cockerels and capons, a consumption of 2 parts of grain to 1 of mash was used as being a satisfactory approximation to usual conditions. On the crate-fattened and range-fed birds, actual commercial gradings were available, while for the capons the condition of fatness as accurately determined by the method of sampling previously reported upon, plus the appearance of the dressed carcasses, were used as the basis of an estimate of grading.

The feed prices quoted are actual as are also the dressed poultry prices which were those being paid to country shippers at the time of the experiment. In this connection, it should be noted that all gradings were made on a commercial basis exclusive of the degrading effect of skin tears, too many pin feathers, etc., which are under the control of the producer. The grading allowed, therefore, is the best that could be obtained and presupposes great care on the part of the producer in proper killing and handling of the dressed birds. The feed consumption to 7 lb. weight or to the commencement of fattening is taken from extensive data on cockerels and capons published in mimeographed form from this Division. No attempt has been made to calculate labour, equipment or interest costs in this work since they vary over such a wide range and should be estimated by each individual operator in the light of his own circumstances. It should be pointed out that crate feeding involves crates, but since they are satisfactorily made of waste or very cheap lumber they do not constitute a heavy cost.

Conclusions

1. Crate feeding was the most efficient method and was productive of very high quality stock. A total profit over feed cost of approximately 59 cents per bird was shown for this method of finishing. The extremely high efficiency of the fattening period was evidenced by a feed cost per pound of gain of 6·92 cents for the crate-fattened birds, as against 18·24 cents and 23·25 cents, for the range cockerels and capons respectively.

2. Caponizing for market was the next most efficient method and was very economical because of the lower feed requirement of capons during the rearing period and their relatively high degree of fatness even when killed off range. A total profit over cost of feed of 48 cents per bird after deducting the cost of caponizing was realized in these tests.

TABLE 15.—COSTS AND RETURNS ON CRATE-FATTENED COCKERELS, UNFATTENED COCKERELS AND CAPONS. EXPERIMENT 7.

Treatment	Gain in 2 wk.	Feed consumption		Feed cost		Value of gain			Profit over feed cost	Profit due to crate feeding or caponizing	Average feed consumption to 7 lb. weight	Feed cost to 7 lb. weight	Value of dressed bird at 7 lb. weight	Profit over feed cost	Total profit over feed cost at marketing
		Mash	Milk	Actual	Per lb. gain	Weight gained	Increase in grade	Total							
	lb.	lb.	lb.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	lb.	cts.	cts.	cts.	cts.
Crate-fattened cockerels...	1·21	4·21	4·41	8·37	6·92	19·36	11·89	31·25	22·88	23·82	39·00	76·00	112	36·0	58·9
Range-fed cockerels......	0·42	4·14	....	7·66	18·24	6·72	....	6·72	−0·94	....	39·00	76·00	112	36·0	35·1
Capons....................	0·31	3·90	....	7·21	23·25	4·96	10·78	15·74	8·53	4·47*	35·00	68·00	112	44·0	48·5

* Charge of 5 cts. per bird deducted to cover cost of caponizing.

Cost allowed for various feeding stuffs:—ground yellow corn 1·5 cts. lb.; beef fat 2·5 cts. lb.; skim-milk 0·20 cts. lb.; starter mash 2·75 cts. lb.; growing mash 2·25 cts. lb.; scratch grain 1·65 cts. lb.

Calculated value for dressed carcasses: Grade B—16 cts. lb.; Grade A—18 cts. lb.

3. Killing of cockerels for market directly off range was the least economical procedure in that gains were low and at a relatively high feed cost, and market quality was such as to draw a much lower market evaluation than either crate-fed cockerels or capons. A total profit over feed cost of 35 cents per bird was shown for these birds.

Experiment No. 8

As indicated in experiment No. 6, ground oat groats were superior to corn in producing gain in fattening but the latter was superior in that more fat was laid down. Since in experiment No. 5, ground corn had proved much superior to ground oats it was assumed that these varying results must mean that the relatively high efficiency of the groat was the result of removing the hull which is not digestible by chickens. As a check on this assumption, half of a large sample of oats was machine-hulled and the other half not so treated. Any difference in results of feeding these would of necessity be due to the only difference between the grains, i.e. presence or absence of hull. As a control, a group was also carried on ground yellow corn. A fourth group received equal parts by weight of ground oats and ground yellow corn.

One-half of the birds of each of the above groups had the grain finely ground and the remainder, coarsely ground. One-half of these groups had their mash mixed with skim-milk and the other with unwatered whey. The results are given in Table 16.

TABLE 16.—THE EFFECT OF FEED ON THE PERCENTAGE OF DRESSED MARKET GRADES UNDER EXPERIMENT 8

	Milkfed A	Grade A	Total A	Milkfed B	Grade B	Total B	Total milkfed	Total grade A
	%	%	%	%	%	%	%	%
Ground oats groats	80·6	....	80·6	99·4	....	99·4	100·0	0·0
Ground oats	61·1	2·8	63·9	30·6	5·6	36·2	91·7	8·3
Ground yellow corn	76·5	8·8	85·3	11·8	2·9	14·7	88·3	11·7
Ground oats-grain corn 50: 50	71·4	2·9	74·3	22·8	2·9	25·7	94·2	5·8
Skim-milk mixed	71·8	4·2	76·0	21·1	2·8	23·9	92·9	7·1
Whey mixed	72·8	2·9	75·7	21·4	2·9	24·3	94·2	5·8
Fine grinding	78·9	4·2	83·1	12·7	4·2	16·9	91·6	8·4
Coarse grinding	65·7	2·9	68·6	30·0	1·4	31·4	95·7	4·3

Conclusions

1. Previous work was confirmed in that ground oat groats proved to be more efficient than ground oats for the production of gain in body weight. It was concluded that the lower efficiency of ground oats was due to the large proportion of hull characteristic of this grain. Ground oat groats also proved significantly more efficient than ground yellow corn or a combination of equal parts of ground oats and yellow corn. On the basis of these and previously reported data ground oat groats is undoubtedly the most efficient of the common grains (corn, buckwheat, wheat, barley and oats) for the production of gain in body weight in fattening. Oat groats were not significantly superior to oats, yellow corn or a combination of equal parts of these grains in bringing about the deposition of fat.

2. Ground oats were considerably less efficient than the other grains or the combination tested in this experiment for efficiency of production of gain.

3. A combination of equal parts of ground oats and ground yellow corn gave a significantly greater increase in percentage fat than the theoretical expectancy on the basis of the fat increase made by these grains when fed singly. In this instance the combining of these grains brought about a marked associative complementary effect.

4. Medium-fine as opposed to coarse grinding of the grains used in this test gave a superior dressed carcass when visually graded on the basis of fatness.

5. Fattening rations when mixed with unwatered whey gave similar results to those obtained from skim-milk.

Experiment No. 9

In this experiment further information on previous findings was sought. In experiment No. 2 it was shown that 10 per cent of meatmeal definitely improved fattening when added to a basal mixture of 2 parts of ground oats to one of ground barley. Since, in the same experiment, ground yellow corn proved to be superior to the oats:barley mixture it was felt to be worthwhile to determine whether meatmeal was capable of producing increased gain and fattening when supplementing a more efficient ration such as yellow corn.

Again, in experiment No. 6, skim-milk was shown to be superior to water as a mixer to such a degree that the possibility of the small amount of dry matter in the milk consumed being responsible for such a marked improvement could be questioned and perhaps the high riboflavin content of the milk be considered to be responsible.

In this experiment two groups of 40 birds were treated as follows:

Group A.—Ground yellow corn

B.—Ground yellow corn 10 per cent meatmeal (50 per cent protein)

One-half of each of these groups received their ground mash soft-mixed with water, the other half having a quantity of pure crystalline riboflavin, at a level equivalent to that found in skim-milk, added to the water used in mixing the wet mash. This was calculated on the basis of 2·2 micrograms of riboflavin per gram of liquid skim-milk. The riboflavin was refrigerated and kept away from light until the moment of mixing with the water when it was immediately made into a wet mash and the feed given at once to the birds. It is felt that any loss of vitamin value would be negligible under these conditions.

These groups were again subdivided in treatment; one-half had water to drink between feedings (7.00 a.m. and 5.00 p.m.) until within 1 hour of feeding time; the other half had no drink available and were forced to rely on the moisture from the wet mixed feed, the proportion of fluid to mash being 1:1 (51 per cent moisture).

Conclusions.—

1. The addition of 10 per cent of meatmeal to a fattening mash of ground corn gave a very large increase in gain in weight over that of the same mash not thus supplemented.

2. When the birds were permitted access to drinking water between feedings their gain in weight was very greatly increased.

3. The riboflavin content of skim-milk apparently does not explain the previously established much greater efficiency of skim-milk than water in fattening.

Publications.—

Methods and rations for fattening poultry. Scientific Agriculture, 17 (16): 340-358, 1937.

Methods and rations for fattening poultry. II. Experimental technique and comparative value of fattening rations. Scientific Agriculture, 18 (4): 198-206, 1937.

Methods and rations for fattening poultry. III. The effects of various fats, number of feedings and length of fattening period. Scientific Agriculture, 21 (6): 350-357, 1941.

Methods and rations for fattening poultry. IV. The relative value of certain cereal grains, of bonemeal and of premixing of feeds. Scientific Agriculture, 21 (9): 517-521, 1941.

Methods and rations for fattening poultry. V. The comparative effect of hulled oats and yellow corn, of skim-milk and water, and of varying temperatures. Scientific Agriculture, 21 (10): 607-612, 1941.

Methods and rations for fattening poultry. VI. The comparative economy of range rearing, crate fattening and caponizing for production of roasters. Scientific Agriculture, 21 (11): 711-716, 1941.

Methods and rations for fattening poultry. VII. The comparative effect of single grains and mixtures of grains, of fine or coarse grinding, and of mixing with skim-milk or whey. Scientific Agriculture, 23 (8): 500-505, 1943.

Methods and rations for fattening poultry. VIII. The value of a protein supplement, of added riboflavin, and of water to drink between feedings. Scientific Agriculture, 23 (11): 647-650, 1943.

Fattening poultry for market. Pub. 745, Farmer's Bulletin 115, Department of Agriculture, Ottawa, 1946.

Estrogen Treatment of Male Chickens

It was shown that the estrogens (hormones which bring about female characteristics in animals), when given to male birds, have a feminizing effect on improving skin quality and increasing the amount of fat in the carcass. A wide range of synthetic estrogens are available for this purpose. It was felt desirable to test the more promising of these for their efficiency for the above purpose. Since drugs of this type have to be used with some caution it was necessary to be sure that no residues of the drugs remained in the tissues of the birds which might be harmful to humans who might consume the carcasses.

Some of the estrogens tested were dienestrol diacetate, dianisyl hexadiene, dimethyl ether of diethylstilbestrol, diethylstilbestrol dimethyl ether of dienestrol and dimethyl ether of hexestrol. These were found to have varying levels of efficiency for fattening male birds for market. Some were found to have residues in the tissues which had an undesirable effect on the humans consuming the chickens. As a result of this work, the Department of National Health and Welfare decided to prohibit the use of these drugs for this purpose in Canada until such time as reliable information was available indicating some estrogens which were completely harmless to humans.

Publications.—

The influence of ingested estrogens on feed intake, metabolic rate and lipemia in male fowl. Endocrinology, 39:2, 149-154, 1946.

The quantitative recovery of synthetic estrogens from tissues of birds (gallus domesticus), the response of the birds' testis, comb and epidermis to estrogen and of humans to ingestion of tissues from treated birds. Endocrinology, 41: 4, 282-294, 1947.

Effects following estrogen administration to male birds. Vol 1, Eighth World's Poultry Congress Report, Copenhagen, Denmark, 1948.

Fecundity and Reproductive Ability in Closely Confined Fowl

A study was made of the effect of caging birds in laying batteries on their production and metabolism of calcium. It was found that production was much more uniform in cages than in laying pens, there being fewer very high or very low producers. There was a tendency to consume less calcium in the cages resulting in poorer egg shells and the bones of the birds sometimes became depleted in calcium.

Publication.—

Fecundity and reproductive ability in closely confined birds. Scientific Agriculture 17: 359, 1937.

Efficiency of Feed Utilization and Determination of Feed Intake

In spite of the fact that great care may be exercised in measuring the weight of feed being wasted from feed troughs, the waste has proved to vary between 8·02 and 16·09 per cent. Little confidence can therefore be placed in consumption figures based on weighing of feed. When 0·5 per cent Ba SO_4 (barium sulphate) was added to the feed of three groups of birds and the Ba SO_4 in the oven-dried droppings determined, the weight of feed utilized by the birds could be calculated from the ratio of the mineral in feed to that in the faeces. Since Ba SO_4 determination is a laborious task, the possibilities of using weight of oven-dried excreta as a criterion of feed consumption was investigated. For each of three groups of five birds for 11 days, the average errors per determination were 0·2, 0·5 and 1·1 per cent, an extremely small error. Using weight of droppings to determine feed intake has therefore considerable merit.

Publication.—

A measure of efficiency of feed utilization and the errors attached to determination of feed intake. Poultry Science, 26: 668, 1947.

Feather Picking

The picking of each others' feathers is a condition found quite generally throughout the country in flocks of various breeds. This institution has been no exception in encountering this condition and over a period of years the Poultry Division has conducted research on this problem. Preliminary observation was confirmed by early research on the subject to the effect that under ordinary circumstances, even when feather picking is severe, there is very little, if any, reduction in the egg production of birds affected. Under cold winter conditions, if birds are partially denuded, unquestionably there would be a slightly higher feed consumption to offset more rapid heat loss from the body in an effort to maintain body temperature. Perhaps the most serious aspect of the condition is when feather picking is carried to the point of drawing blood, and ensuing cannibalism. This trouble is experienced in some cases, although rarely, at this institution.

At the Experimental Station at Harrow, Ont., feather picking in laying pullets was completely controlled by the feeding of steeped alfalfa hay. Good quality alfalfa hay is steeped overnight in cold water. In the morning the water is drained off and the moist alfalfa fed in tubs. With very few exceptions, this gave complete control of the picking and presumably the palatability of this alfalfa encouraged such high consumption that control was effected. It was not possible to coax birds to consume sufficient dry alfalfa to reduce the incidence of feather picking beyond a slight degree.

These results raised the question as to what quality in alfalfa might be responsible for this control. The birds were raised on green alfalfa range and it must be assumed that whatever the factor responsible, it could not be stored in the body in sufficient quantities to carry the birds through the laying year. There is also the possibility that the factor was being eliminated continuously in the eggs, since birds in pens with higher production levels were more severe in their feather picking. Still another factor could not be eliminated from consideration, namely, the possibility that feather picking is largely a vice and that the availability of steeped alfalfa kept the birds occupied and reduced the tendency to pick feathers.

A comparison of the situations at Harrow and at Ottawa revealed the fact that at the former Station no picking occurred while the birds were growing on range but only subsequently during egg production. At Ottawa, however, picking was also evident on range indicating possibly a much greater degree of deficiency of some factor in the soil or green growth of the Ottawa range. Whereas Harrow alfalfa fed at Harrow in quantities prevented the condition, Ottawa alfalfa perhaps might not be expected to do so since it did not prevent it on range.

Most of the evidence up to this point suggested a deficiency of some type and this was strengthened by the later observation that birds raised on one of the Ottawa ranges picked very heavily during the egg production period whereas those raised on another range did not pick.

Research Conducted

Over a period of years both at Harrow and Ottawa this problem has been under investigation. In reporting upon the research carried out, it should be mentioned that feather picking is an extremely uncertain criterion of the deficiency condition. In the first place, it is difficult to measure, and secondly small, unmeasurable factors, probably of management, interfere with the expression of the deficiency and sometimes duplicate pens on the same treatment give dissimilar results. Some of the more pertinent research projects will be reviewed briefly in chronological order.

Liver Meal.—On the assumption that a vitamin or mineral deficiency might be involved, 2 per cent of liver meal was added to the ration. Because a slightly smaller amount of picking seemed to occur in the liver meal pens, the amount of liver meal was increased to 4 per cent but no appreciable diminution of picking was measurable.

Addition of Bulk.—Assuming that the feathers might be picked in an effort to ingest coarse material to supplement a ration otherwise too finely ground or too low in fibre, 2 per cent of oat hulls was added to the mash with no apparent preventive effect.

Steeped Alfalfa.—The feeding of steeped, Ottawa-grown alfalfa had no apparent effect in elimination of picking, suggesting that alfalfa grown on the same soil as that used for range apparently had no beneficial effect even though steeped and consumed in quantity. Harrow alfalfa was therefore brought to

Ottawa and Ottawa alfalfa sent to Harrow. The result suggested definitely that Harrow alfalfa did indeed contain some factor which was fairly effective in controlling the condition at Ottawa as well as Harrow whereas Ottawa alfalfa again had relatively little if any preventive effect.

A finding of some importance in this test was that where Harrow alfalfa was burned, and the ash fed in the mash, protection was practically as complete as when the steeped alfalfa was fed.

Miscellaneous Treatments.—The feeding of 4 per cent of pure dried sulphite paper pulp to increase the fibre and bulk of the ration gave no evidence of preventive value. Also the feeding of 1 per cent of sterilized soil from the poultry range had no effect, and indeed seemed to aggravate the condition, suggesting the possibility of some toxic factor in the range soil.

In view of the findings up to this point the evidence seemed to suggest that a mineral deficiency of the soil or a toxic mineral in the soil might be involved. As a result, the literature was thoroughly reviewed with these possibilities in mind and spectrographic analyses of alfalfa ash, soils and other materials were made to determine, if possible, what elements might be present in samples of material which showed preventive effects, and not present in other materials which were ineffective, and vice versa, as well as the relative concentration of elements present in both. The error involved in quantitative spectrographic analysis is such, however, that presence or absence of elements rather than their concentration were the most reliable data from such analyses. As a result of this work, the following elements were fed singly and in combination: aluminum, iron, cement (for silicon), gallium, zinc, nickel, cobalt, molybdenum, barium, sodium, (as bicarbonate), magnesium, boron, chlorine, iodine, bromine and strontium. No definite preventive value could be consistently demonstrated with these elements. Since sea salt contains all known mineral elements this also was obtained and fed with some suggestion of control value. Common salt sometimes seemed effective, at other times ineffective. From all this research the following tentative conclusions seem justified.

(1) Feather picking is not caused by lack of bulk or fibre in the ration.

(2) Vitamin deficiency does not appear to be a contributing factor.

(3) A mineral deficiency of soils seems to be the most likely cause.

If it be granted that a soil factor, presumably mineral in nature, is a possible cause the resolving of this problem must involve more accurate mineral analysis for trace elements than has yet been possible in these tests.

Research on this project had to be temporarily discontinued during the war because of lack of facilities and personnel.

Level and Source of Protein in Poultry Production

Economical Production of Growth in Pullets.—Some of the most costly ingredients of the poultry ration are the various high protein materials so essential to normal growth, production and reproduction. At any time, but particularly in time of scarcity, a reduction in the level of these ingredients of feed mixtures without appreciable loss in efficiency of the birds is very important. Such a condition existed during World War II and research was started to endeavour to determine the lowest satisfactory level of such ingredients. Research at many institutions has shown that certain vegetable proteins, which are cheaper than animal proteins such as meatmeal and fishmeal, may be successfully substituted for animal proteins. This phase of protein utilization was also made a part of the investigation. Still another factor investigated was the utilization of pasture in rearing when various levels and sources of proteins were being fed. The project was divided into two phases, the first dealing with the rearing phase and the second covering the period of egg production.

Level and Source of Protein in Rearing.—Three lots of 100 Barred Rock pullets were raised to maturity on low, medium and high levels of protein from an animal source and these were duplicated with a vegetable source of protein. Each lot had available the same amount of pasture area to range upon. The rations fed were balanced so that the only differences in the feeds were the levels of proteins. The actual feeding schedule was as follows:

1— 7 weeks inclusive—mash only.
8—10 weeks inclusive—4 parts mash : 1 part grain.
11—13 weeks inclusive—3 parts mash : 1 part grain.
14—16 weeks inclusive—2 parts mash : 1 part grain.
17—19 weeks inclusive—1 part mash : 1 part grain.
20—22 weeks inclusive—1 part mash : 2 parts grain.
23—24 weeks inclusive—1 part mash : 3 parts grain.

As a result of the above feeding schedule, the actual protein levels fed were: for animal protein—low 12·66 per cent, medium 14·69 per cent, high 17·13 per cent; for vegetable protein—low 12·00 per cent, medium 14·34 per cent, high 17·02 per cent.

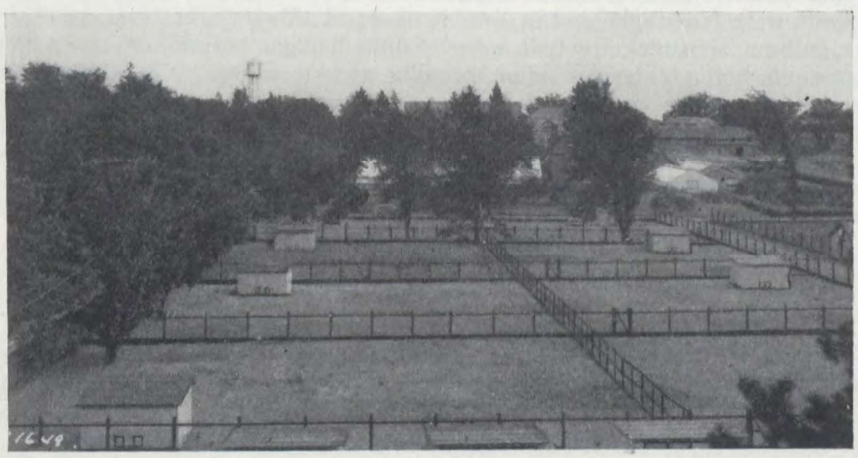


Figure 9.—Effect of quality and level of protein in the ration on pasture utilization. Enclosures at left housed birds which received animal protein; at right, vegetable protein. Foreground, low protein, background, high protein. Note degree of utilization by the birds, especially the right foreground where the birds had a low vegetable protein ration and the left background whereas high animal protein ration was fed with the consequence that the birds ate little pasture. August, 1942.

Results.—

Six groups of approximately 100 pullets each were raised under closely identical conditions and fed rations comparable in all known respects except level or source of protein. The following observations are made as a result of this study.

Pullets which received 17 per cent protein from either a vegetable or animal source during 24 weeks of growth attained significantly greater body weights on the average at that age than did pullets on rations containing 14·5 or 12·5 per cent of protein. The differences between the higher levels were small, the greatest being 5·5 per cent. Each of the higher levels proved considerably more satisfactory than the 12·5 per cent levels. At all levels, animal protein was significantly more efficient on the average than vegetable protein, but, with the exception of the lowest level, these differences were small.

On the basis of efficiency of utilization of the protein per unit of body weight produced, the 14·5 per cent animal protein ration was slightly superior to the 12·5 per cent and to the 17 per cent condition.

It is also concluded that a protein level of 12·5 per cent using increasing ratios of scratch grain as above is too low for satisfactory results.

Vegetable protein, when making up 99 per cent of the total protein of the ration, on the average cannot be expected to give as good results as animal protein under conditions similar to those pertaining during this experiment. Results obtained were reasonably satisfactory, however, and in time of scarcity of suitable animal feeds, or where price differentials are more in favour of the vegetable protein supplements than was the case in this instance, they would fill a very useful place in the poultry feeding program even up to almost complete substitution for animal protein feeds.

Publication.—

Level and source of protein in poultry production. I. As related to economical production of growth in pullets. Scientific Agriculture, 24:4, 164-175, 1943.

Level and Source of Protein in Egg Production.—Barred Rock pullets which had been reared on low (12·5 per cent), medium (14·5 per cent) or high (17·0 per cent) protein levels, of which the supplementary protein came from either animal or largely vegetable sources, were continued during the period of egg production on low (12·5 per cent), medium (14·5 per cent) or high (16·5 per cent) protein levels. These birds were equally divided between laying batteries and laying houses. The following information was derived from these tests.

Results.—

A level of 12·5 per cent of protein was too low for satisfactory production of eggs. This group was inferior in egg production, egg weight, average body weight, days to first egg, and feed consumption to those on each of the higher levels of protein.

A level of 16·5 per cent of protein was superior to one of 14·5 per cent only in egg size and days to first egg. Feed efficiency was greater for the group receiving 14·5 per cent protein, and production at this level was the most economical of that at any level.

Animal protein supplements gave superior results to vegetable protein even though the latter was supplemented by 2·5 per cent of powdered buttermilk. The differences were small, however, except in the case of sexual maturity as measured by days to first egg, in which a difference of 10 days was recorded in favour of the animal protein mixture. In economy of production and in hatchability, the animal protein supplement was also superior to a moderate degree.

Pullets which were kept in the cages of a laying battery were very much superior in all respects to those which were kept in laying pens. The degree of superiority is evidenced by the difference of approximately 26 eggs per bird. As the pullets used were moderately late-hatched for the area (May 15), it does not follow that so great a difference should necessarily be expected with early-hatched birds, which would normally be in production before the onset of very cold weather.

Mortality was similar for all treatments with the exception of the high protein level where a death rate significantly higher than that of the medium and low protein groups was experienced.

Publication.—

Level and source of protein in poultry production. II. As related to economical production of eggs. Scientific Agriculture, 24(5):240-249. 1944.

THE EFFECT OF VITAMINS D_2 AND D_3 IN FISH OILS AND OF IODOCASEIN ON SHELL QUALITY

It is common observation that even when suitable and adequate levels of calcium and vitamin D_3 are supplied in the ration of laying pullets, the quality of egg shell from high-producing birds very often leaves much to be desired. It has also been observed that strength of egg shell diminishes towards the close of the laying year. In an attempt to determine possible causes for these conditions, two assumptions were made: first, that whereas vitamin D_3 is known to produce satisfactory calcium metabolism in bone formation in the chick, in which case calcium in the calcium phosphate form is involved, it might not be so efficacious as vitamin D_2 where purely calcium carbonate egg shell is concerned; and second, that reduction of shell quality with the advancing laying year might result from a lowered rate of metabolism brought about by increased temperatures of summer, shortening hours of daylight and lowered feed consumption or by a combination of these or similar factors.

A logical approach to an answer to the first assumption would be the addition of a vitamin D_2 source to the ration, and in the second instance stimulation of metabolic processes through thyroid administration.

An experiment was conducted in which oil containing vitamin D_2 was used as well as that containing D_3 and a synthetic thyroid product known as iodocasein which is known to simulate the thyroid and consequently speed up metabolism. The strength of the shell was determined by determining the specific gravity of the whole egg, a very accurate method.

The results obtained suggested that the thyroprotein (iodocasein) had a marked beneficial effect on strength of egg shell to the extent of completely arresting the usual downward trend in strength coincident with the warm summer season.

This work was repeated for greater reliability of results and these findings were confirmed.

Publications.—

The effect of vitamins D_2 and D_3 in fish oils and of iodocasein on shell quality. Poultry Science, 25:1. 1946.

The effect of natural and synthetic vitamins D_2 and D_3 and of thyroprotein on egg shell quality. Poultry Science, 26:2. 1947.

EGG SHELLS AS A SOURCE OF CALCIUM FOR LAYING BIRDS

Under conditions of large-scale breakage of eggs for drying a vast quantity of egg shells is available. The value of these shells was tested as a source of calcium for the egg shell of laying birds. Pens of birds were given the standard oyster shell ad libitum while other pens received dried egg shells in both cases before them at all times. The strength of shell of the eggs produced when the birds were on both sources of calcium did not differ significantly. Somewhat more egg shell was required than oyster shell, for the same purpose.

Publication.—

Egg shells as a source of calcium for laying birds. Poultry Science, 24:1. 1945.

Substitution of Hoof and Horn Meal for Standard Animal Protein Ingredients of the Starter Mash

Research at the University of Wisconsin suggested the possibility of making use of hoof and horn, a by-product of the slaughter house, as a substitute for or supplement to the meatmeal and fishmeal of poultry rations. Work over the years has shown this material to be a relatively poor protein source. The Wisconsin workers used a new technique, grinding the material very fine for incorporation in rations. In response to requests from the Feed Controller and in view of the wartime scarcity of protein feeds, this product was subjected to research in 1944, as follows:

Tests were made using a complete mash typical of the best commercial rations and containing shorts, middlings, ground wheat, ground oats, cerogras, fishmeal, meatmeal, dried buttermilk, soybean oil meal, bonemeal, cod liver oil, iodized salt, ground oyster shell, manganese sulphate, corn starch and riboflavin (crystalline). Cerogras made up 4 per cent of the ration; fishmeal, 3 per cent; meatmeal, 1 per cent; dried buttermilk, 3 per cent; soybean oil meal, 1 per cent. This ration was calculated to be adequate in all the then known vitamins. The protein level of this basal ration and all experimental rations was at 18·6 per cent, the balancing being accomplished by the use of corn starch, which did not exceed 6 per cent of the ration in any instance. With one exception, the hoof meal was ground to the same specifications as that recommended by the Wisconsin workers, namely, less than 60 mesh.

Hoof and horn meal was used at levels of 6·41, 3·78, and 2·48 per cent, in substitution for 100, 67, and 45 per cent of the protein of the animal protein feeds which were reduced proportionately. Comparable figures for vegetable protein substitutions were 3·58 and 2·35 per cent for 75 and 45 per cent substitution. The amounts of protective ingredients such as Cerogras, cod liver oil and manganese sulphate were adequate in all rations.

In addition, two groups were included at the same level of protein, one of which was fed hoof and horn meal ground to an average fineness exceeding 60 mesh, and the other was less than 150 mesh.

Results.—

(1) At eight weeks of age, the group receiving the basal ration containing standard feeds was 28 per cent heavier than its nearest competitor, which had 45 per cent of its animal protein replaced by an equivalent amount of hoof and horn meal.

(2) As substitution of ground hoof and horn meal increased from 45 to 67 to 100 per cent, body weight decreased significantly and uniformly, indicating that the ground hoof and horn meal was not an efficient substitute in this ration for fishmeal, meatmeal and buttermilk powder for promoting growth.

(3) The group on vegetable protein basal ration was 8·5 per cent heavier than its nearest competitor, which had 45 per cent of its supplementary vegetable protein replaced by an equivalent amount of hoof and horn meal.

(4) As substitution of ground hoof and horn meal increased from 45 to 75 per cent, body weight decreased significantly and uniformly, indicating again the inability of ground hoof and horn to replace efficiently supplementary protein from a vegetable source.

(5) Very finely ground hoof meal (minus 150 mesh) did not produce significantly greater weight than the minus 60 mesh grind.

These results do not confirm those obtained at Wisconsin. There it was found that a level of 4 per cent of powdered swine hoofs could replace satisfactorily twice the quantity of standard animal protein supplements. This test does not give any information as to whether or not 150 to 200 per cent substitution, for example, would be successful. In view of the apparently doubled efficiency in the Wisconsin work, it was considered to be unnecessary to go to such high levels in these tests. It should be noted that substitution of powdered hoof and horn meal exceeded the Wisconsin 4 per cent by approximately 2½ per cent in one of these groups. Two apparent deficiency symptoms were evidenced in the form of "notched beak" lesions and severe necrosis of the beak. These appeared particularly in the group in which the least substitution by hoof and horn meal was made. They also appeared to varying degrees at other levels of substitution, but not on either basal ration. These conditions are difficult to explain, but apparently were satisfactorily taken care of on both the animal protein and the vegetable protein basal rations. It has been calculated that any known vitamin deficiency should not exist in view of the makeup of the basal part of all rations exclusive of the animal or vegetable supplements. The nature of the deficiencies evidenced is being investigated. Tentatively, therefore, it may be presumed that 100 per cent substitution of the animal protein of a standard well balanced ration by ground hoof and horn meal cannot be expected to give as satisfactory gains as are obtainable on the standard ration.

Whether the fact that the Wisconsin supplement was ground swine hoofs whereas the one used in these tests was made up of 65-70 per cent cattle hoofs, 20-30 per cent calf and hog hoofs and 5-10 per cent horn could have had any bearing on the results cannot be answered by the results of these tests.

HOUSING AND EQUIPMENT

The Effect of Heat, Insulation and Artificial Light on Egg Production and Feed Consumption of Pullets

Increasing the physical comfort of laying birds under both extremes of environmental temperature often has been the subject of investigation. Protection against extreme cold naturally has been a problem of greater economic importance, however, and most controlled research has been in that direction. Artificial heat, insulation, and the provision of adequate ventilation under varying conditions, have been the principal subjects of experiment.

Temperature conditions during the winter months are very extreme in the area represented by the Central Experimental Farm, Ottawa. Under these circumstances the benefits of artificial heat and insulation should be evident if such benefits exist. From the winter of 1932-33 to that of 1942-43, experiments were conducted dealing with the effects of heat and insulation. In 1939-40, artificial light also was used in a controlled way. The results of these tests are reported below.

Experimental Procedure

With the exception of the experiment of 1942-43, which will be described separately, all tests were carried out in a 10-pen continuous laying house, each pen measuring 16 by 16 feet. Since it is important to establish the degree to which the birds were protected from the outside elements in the least protected pens (control pens) the following description is given and applies to all pens except for the modifications of greater insulation or artificial heat which will be noted.

Control pens (uninsulated).—Floor—concrete; ceiling—straw loft of 1″ x 3″ boards, 1″ apart under joists with 12″ of unpacked straw in loft above; roof—2″ x 4″ rafters, ¾″ sheathing, building paper and cedar shingles; rear wall—1″ tongue and groove boarding with battens, building paper on 2″ x 4″ studs, with building paper and ⅞″ shiplap, making a 4″ dead air space; front wall—⅓ wood (single boarded) ⅓ glass and ⅓ cotton (screens), all three types of construction running the full length of the pen.

Semi-insulated pens.—Same construction as above except: ceiling—½″ insulation board under straw loft; rear wall—¾″ V-joint over ½″ insulation board built over shiplap of inner wall lining; front wall—1″ boarding with battens, 2″ x 4″, sheathing and ¾″ V-joint over ½″ insulation board on studding under windows; glass substitute (cel-o-glass) replaced cotton screens.

Insulated pens.—Same as semi-insulated pens except: front wall—⅓ glass and ⅔ wood (¾″ V-joint over ½″ insulation board—no cotton or cel-o-glass screens).

Tightly boarded, insulated partitions separated uninsulated pens from semi-insulated and these in turn from insulated pens. Replicate pens within the above were separated by reasonably tight temporary partitions.

In terms of insulation as estimated from data published, the uninsulated pens had back and side walls of approximately 4·14 insulating value, whereas the semi-insulated and insulated pens had walls of 6·65 insulating value. The insulated pens, however, had the benefit of 6·65 insulating on the front wall over ⅔ of the front area, whereas the semi-insulated had such insulation over only ⅓ of the front wall. The uninsulated pens had a ⅓ front wall area of insulating value of 1·53, the remainder being glass and cotton of very low insulating value. Ceiling insulation was identical for the insulated and semi-insulated pens (½″ insulation board) but much lower for the uninsulated pens with straw loft. The hinged ventilating doors at each end of the house over the straw loft were kept closed throughout thus making a dead airspace of the loft.

The nature of the heat supply will be dealt with under separate headings. Temperatures were taken in the middle of the pen, 6" above the floor. Night temperatures were taken at mid-level of the birds above the roosts and amongst them, by recording thermographs except for the 1932-33 and 1933-34 experiments when floor temperatures were used throughout. Humidity was taken by recording thermohygrographs or by sling psychrometer. All ventilation was by adjustment of windows or cotton screens hinged at the bottom with side baffles thus permitting entry of air only at the extreme top front of the house. Barred Plymouth Rock pullets, distributed equally among pens according to date of hatch, were used in all experiments. Where artificial heat was supplied hot water pipes under the roosts were the source of heat.

Results 1932-33

TABLE 17.—THE EFFECT OF HEAT AND INSULATION ON EGG PRODUCTION AND FEED CONSUMPTION, 1932-33

	Number of birds	Mean temp.	Body weight gain	Feed consumption	Feed for maintenance of body temp.	Egg production
		°F.	gm./bird	gm./bird/day	gm./bird/day	gm./bird/day
Heated (3 pens)	225	51·2	78·4	106·5	49·8	29·3
Semi-insulated	50	42·6	86·5	117·3	54·6	32·8
Uninsulated	50	38·0	90·6	114·9	53·8	31·3

The results as indicated in the table show no difference of any significance between the two degrees of insulation and the heated condition. The saving in feed in the heated pens of approximately 1·6 lb. of feed per bird per year is a negligible quantity and would not justify the application of heat under conditions similar to those at Ottawa.

Results 1933-34

The above work was repeated during this year but changes in the heating and ventilation systems were made sufficient to reduce the great variability in temperature experienced during the first tests. On occasion, however, it could not be kept from going above 60°F. The lowest temperatures recorded were—heated 40°F., semi-insulated 19°F., uninsulated 16°F.

TABLE 18.—THE EFFECT OF HEAT AND INSULATION ON EGG PRODUCTION AND FEED CONSUMPTION, 1933-34

—	Number of birds	Mean temp.	Relative humidity	Body weight gain	Feed consumption	Feed for maintenance of body temp.	Egg production
		°F.	%	gm./bird	gm./bird day	gm./bird day	gm./bird day
Heated	55	50·6	61	245	95·3	44·1	22·8
Heated	55	49·9	63	248	100·7	46·7	24·0
Semi-insulated*	55	45·6	86	245	103·4	49·2	22·6
Semi-insulated	55	43·8	85	338	106·3	50·3	23·1
Uninsulated	55	42·1	86	283	104·2	50·3	20·5
Uninsulated	55	39·1	87	500	113·5	53·8	24·2

* No ventilation.

No significant differences occurred in egg production and the feed saving in the heated pens was only 1·5 pounds annually.

The pen shown in Table 18 as semi-insulated, with no ventilation, is of particular interest. In it the cotton screens when closed, provide the only source of air. Kept closed continuously throughout the test, the screens on this pen were covered over with insulation board so that the only ventilation which the birds received was the undoubtedly very small change of air which took place through cracks around windows and partitions between pens. The result, as shown by the table, was a warmer pen than its duplicate by 1·8°F., with a higher relative humidity by 1 per cent. The condition of absolute humidity was much greater than is indicated by Table 18, however, since the walls and litter were continuously wet from condensed moisture and there was a heavy concentration of ammonia in the air. Carbon dioxide, determined from samples taken with mine flasks under the roosts at night was 0·73 per cent in this pen as compared with 0·28 per cent in one of the heated pens. Under these conditions the performance of the birds was the equal of that of any other treatment, and it would appear that birds can stand low temperatures with high humidity and relatively heavy concentration of ammonia and carbon dioxide, over an extended period, very well indeed.

Results 1939-40

In these tests one pen was heated electrically so that the variation in temperature was very small, viz. plus or minus 4°F. A full insulated pen without heat was also used.

Lowest temperatures experienced inside the pens for the different treatments were: heated 40°F., insulated 28°F., semi-insulated 26°F., uninsulated 26°F. Lowest outside temperature was 19°F. below zero.

TABLE 19.—THE EFFECT OF HEAT AND INSULATION ON EGG PRODUCTION, 1939-40

—	Number of birds	Mean temp.	Relative humidity	Feed consumption	Egg production to March 20	Egg production to Sept. 4
		°F.	%	gm./bird day	No.	No.
Heated	55	45·3	81	129·7	87·7	195·7
Insulated	55	37·1	91	132·8	86·2	193·3
Semi-insulated	55	39·2	88	133·5	93·4	192·5
Uninsulated	55	37·8	88	136·0	89·0	194·4

Again differences were not significant. An interesting fact emerged in that the greater glass area in the semi-insulated pen was responsible for a 2°F. higher temperature than that in the fully insulated pen because of added warmth from the sun shining through glass.

Results 1941-42

This test resembled that of the previous year but the birds of one pen were heated at night only by electrical wires under the roosts.

Lowest temperatures experienced inside the pens for the different treatments were: heated 56°F., heated 51°F., heated (night) 42°F., insulated 32°F., semi-insulated 35°F., uninsulated 22°F., uninsulated 20°F. Lowest outside temperature was 21°F. below zero.

TABLE 20.—THE EFFECT OF HEAT AND INSULATION ON EGG PRODUCTION AND FEED INTAKE, 1941-42

	No. of birds	Temperature			Body weight gain	Feed consumption	Feed for maintenance of body temp.	Egg production
		Day	Night	Mean				
					gm./bird	gm./bird day	gm./bird day	gm./bird day
Heated..............	30	57·6	61·1	59·9	298·9	125·1	55·4	37·9
Heated (night only)...	30	52·3	59·9	57·4	255·4	132·2	59·3	39·2
Heated..............	30	54·0	55·5	55·0	233·6	129·6	56·9	41·2
Insulated............	55	42·9	44·3	43·8	183·2	142·1	66·4	37·3
Semi-insulated*.......	55	49·9	50·4	50·2	254·0	126·8	58·0	35·9
Uninsulated..........	55	42·6	45·2	44·3	264·2	149·8	69·6	39·8
Uninsulated..........	55	42·0	43·4	42·9	230·9	147·3	67·8	39·7

* Restricted ventilation.

Table 20 shows the results obtained. The pen heated at night only was 5·3°F. colder during the day than the warmest of the heated pens. Also, by restriction and control of ventilation the semi-insulated pen had a uniform day-and-night temperature approximately 7°F. higher than the insulated pen. This was accomplished without the excessive dampness characteristic of non-ventilated pens by judicious adjustment of ventilation during the warmest portion of the day. The greater window space of this pen again contributed to the higher temperature achieved and nullified the effect of complete insulation. Differences in egg production are not significant and production was quite good for the completely uninsulated pens. The greatest difference in feed required for maintenance was 14·2 grams per bird per day for a temperature difference of 15·6°F. On this basis, the application of heat saved 4·7 lb, of feed per bird annually.

Results 1942-43

In the test very cold pens were used, the lowest temperatures of the heated pens being 28°F. and 20°F. respectively and the unheated pen 4°F. below zero. The lowest outside temperature was 36°F. below zero. The test was designed for the sole purpose of determining how great would be the extra feed consumption in the cold pen. The mean temperature was 32°F. in the cold pen and 52·3°F. in the heated. The saving of feed was 1·9 pound per bird per year. Lowered activity and ruffling of feathers of the birds in the cold pen, thus preserving their heat and energy, seemed to be the explanation for this relatively small saving through the use of heat.

Lighted Vs. Unlighted Pens

A comprehensive test of laying birds, one-half of which were housed in lighted pens during the winter months to give a 13-hour day, and the other half in unlighted pens, showed higher egg production during the winter for the lighted birds by 22 eggs per bird, but only 3·3 eggs per bird covering the laying year to Sept. 4. The use of lighting during the winter period is warranted only when the price of eggs justifies the extra expense.

Summary

From consideration of the data obtained the following conclusions seem justified:—

1. Increasing the environmental temperature of laying pullets by the use of artificial heat and insulation over a range of 37·8°F. to 59·9°F. had no effect upon egg production. Even when temperature was thermostatically controlled to a range of 4°F. in the heated pen no improvement in production was obtained.

2. The maximum saving in feed accomplished through the decreased requirement of feed for the maintenance of body temperature under heated conditions was 4·7 lb. per bird annually with a mean saving of 2·85 lb. The mean inside pen temperature range in these tests was from 32°F. to 59·9°F.

3. Restriction of ventilation to a minimum, all ventilators being completely closed with a resulting temperature of 45·6°F. and very high humidity and carbon dioxide content of the air, had no detrimental effect upon egg production.

4. The reduction of window area in an attempt to supply more insulation is not justified under conditions similar to those in this test since the effect of reducing window space by one-half, because of exclusion of sunshine, nullified the effect of complete insulation and gave equal or higher mean temperatures in the uninsulated pens.

5. The use of artificial illumination significantly increased egg production during the winter months but resulted in approximately the same annual production.

It is concluded that laying pullets will produce well under a very wide range of temperatures and conditions of humidity, and that neither artificial heat nor insulation, as herein defined, would be justified under temperature conditions similar to or less severe than those experienced in this area. These conclusions have been arrived at under conditions of severe cold and therefore constitute a severe test of the housing conditions investigated.

Publication.—

The effect of heat, insulation and artificial light on egg production and feed consumption of pullets. Scientific Agriculture, 25:1. 1944.

Feed Hoppers and Troughs for Poultry

For some years it had been observed that the feed wastage from the types of feeders commonly in use was quite excessive under conditions of careless handling. Therefore, it was decided to redesign this type of equipment in an attempt to improve it.

The fundamental observation was made that grain or mash will not pile up against a retaining partition at more than a 45° angle. Consequently the front wall of a trough must have a minimum vertical height above the point at which the feed is supplied into the trough at least equal to or greater than the horizontal distance from the front wall to the point of supply. At the same time the tendency for mash to pack and bridge, in a bin, and thus prevent the free flow of feed into the trough, had to be overcome. The hopper bins were therefore designed to be wider at the bottom than at the top thus avoiding the problem of the sides of the bin providing support for the mash.

Taking these various points into consideration, the illustrated field hopper (Figure 10) was designed. It has solved the waste problem and assures continuous self-feeding. An improvement was introduced by building the hopper of galvanized iron instead of wood.

Adaptation of the same principles led to the design of a small hopper for chicks varying in size from 2 to 16 weeks old. In this design, a movable wire grill adjusts the flow of mash to the size of the trough in conformity with the size of the birds. This is shown in Figure 11.

The ordinary V-shaped hopper in which the two sides are set at 90° with a 1- or 1½-inch lip at the top of the sides will obviously hold no more feed safely than a 1- to 1½-inch deep layer resting on each side. This provides a fairly small supply of feed when levelled out in the bottom of the V-trough and it therefore requires very careful attention to avoid filling the troughs beyond their non-spilling capacity.

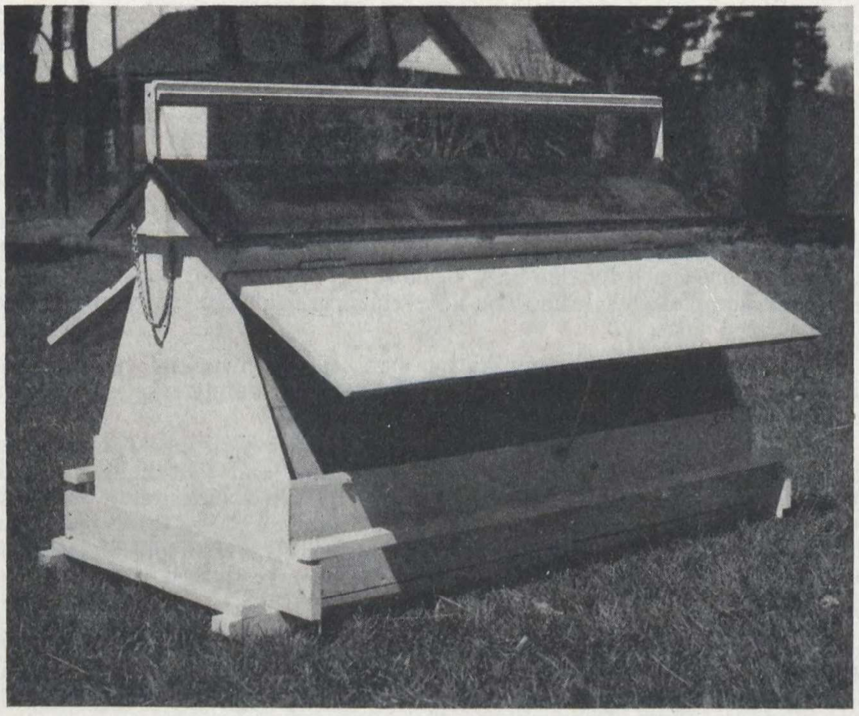


Figure 10.—Wasteproof range hopper designed at the Central Experimental Farm.

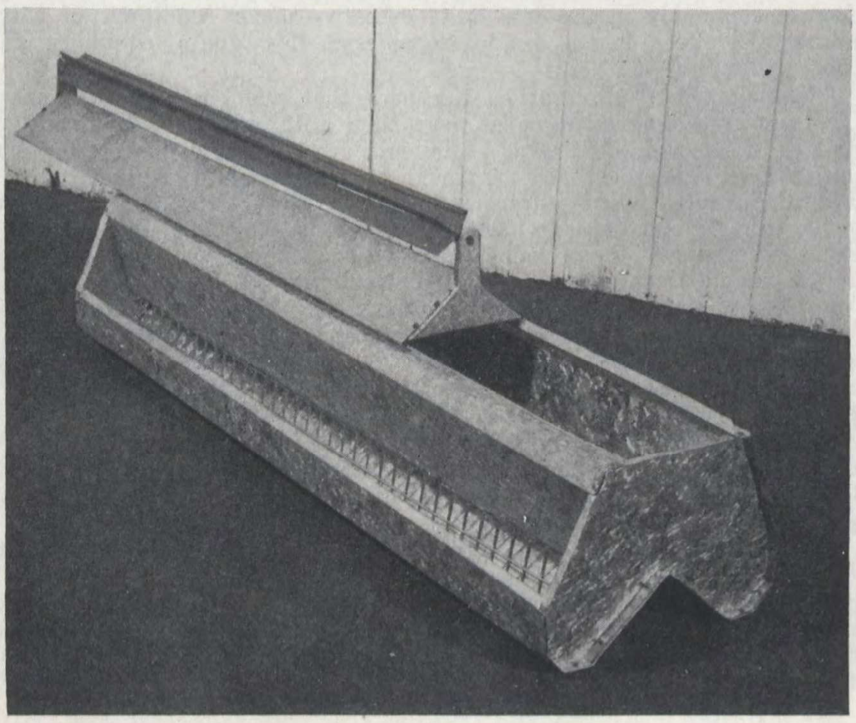


Figure 11.—Metal chick hopper, wasteproof and suitable for a wide range of ages of chicks.

MANAGEMENT

Suitability of Several Sizes of American Anthracite and Bituminous Coal for use in Brooder Stoves

During the war a scarcity of the standard fuel for coal burning brooder stoves developed and a number of substitutes were therefore tried experimentally. Standard type coal burning brooder stoves were used in colony houses during late winter, the lowest outside temperature experienced being 12° F. below zero with a wind velocity of 10 miles per hour. These conditions constituted a severe test of the fuels used. The fuels used were nut-size anthracite as a control and equal portions of pea- and stove-size anthracite, pea-size anthracite alone and nut-size bituminous. It should be noted that the range of quality of bituminous coal is so great that care must be exercised to choose one of similar quality to that used in these tests.

It was found that all these fuels could be used satisfactorily but in some cases much more attention to the management of the stove was required than in the case of nut-size anthracite. For example the 50:50 pea- and stove-size anthracite mixture was better when fed into the stove as a layer of stove size, followed by a layer of pea size, etc. The pea size when used alone had to have more draft and to be stirred up from time to time. Too much of this fuel could not be added at one time—not more than half filling at a time—otherwise the fire was retarded too much. In the case of bituminous coal (nut size), this fuel caked and soon after firing it bridged, caked and had to be broken down with the poker or the fire would go out. Attention to the fire at fairly frequent intervals and last thing at night was essential. This fuel is so volatile that it must not be left while it is unchecked or a fire could result. Greater details as to the handling of the various fuels can be seen in the publication listed below.

Publication.—

Suitability of several sizes of American anthracite and of bituminous coal for use in brooder stoves. Scientific Agriculture, **23:12, 741-746. 1943.**

Breast Blisters and Relative Body Depth

Breast blisters are a blister-like development found on the keel of birds. They rarely occur in females but being present in the male they greatly reduce the market value of the carcass of fryers or roasters. A microscopic examination of the tissues involved suggested that these blisters, usually filled with fluid, are developed probably to act as a cushion between the keel and the roost if the pressure on the keel is sufficient to cause inflammation. An apparatus was devised which measured the pressure of a bird's keel on the roost electrically. It was found that the deeper-bodied birds were the ones which developed the blisters but depth alone was not the answer. Birds which were deep but at the same time sufficiently well muscled to be heavy were most susceptible. This explained why even deep birds did not develop blisters until they reached a certain minimum body weight. White Leghorns being proportionably shallower and lighter in weight rarely developed such blisters.

Publication.—

Relative body depth an exciting cause for development of keel bursae in chickens. Scientific Agriculture, **24:591. 1944.**

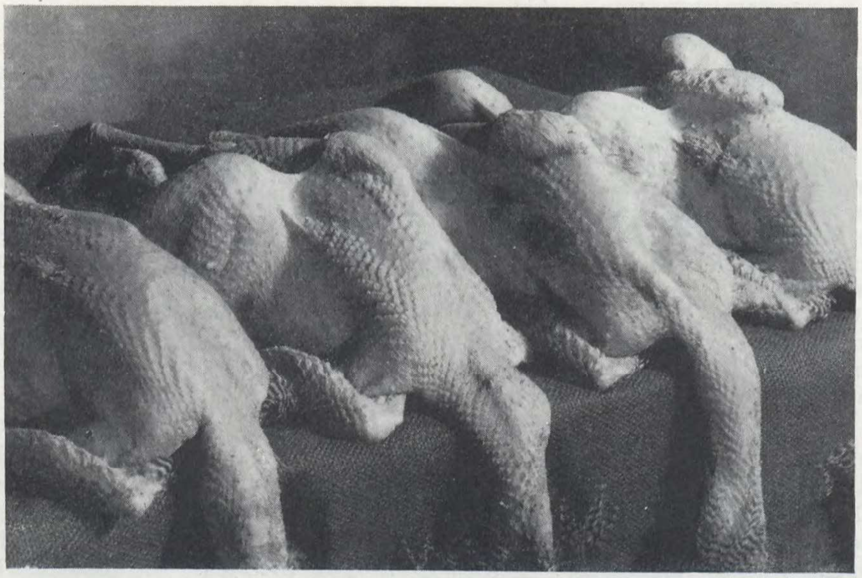


Figure 12.—Normal breast at left and varying degrees of keel bursae (breast blister).

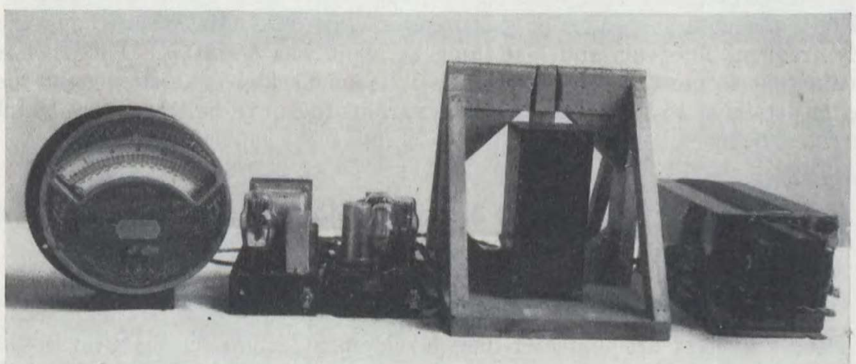


Figure 13.—Apparatus for measuring pressure of bird on roost.

Crooked Keels in Market Poultry

The factor of crooked keels in market poultry is one which can be of some concern, since, if present in dressed birds to a marked degree, it will result in a lowering of the grade and reduction in returns. The incidence of crooked keels is governed by a combination of factors: environmental, nutritional, and genetic. Their appearance may be detected at 6 weeks of age and they can become very marked by the time birds reach broiler age.

Conclusions of a series of experiments on crooked keels are:

(1) There is a marked breed difference in the tendency to produce crooked keels. White Leghorns are more prone to this tendency than are Barred Rocks. There is a difference between sexes, males having a greater incidence than females.

(2) There is a noticeable family difference. Among birds raised under the same environment one family had 80 per cent crooked keels while 100 per cent of the birds in another family had straight keels.

(3) Environment plays a major part in the prevention of crooked keels. Age at roosting and width of roosts are factors. Roosts 4 inches wide, as opposed to 1½ inches, reduced the percentage of crooked keels in White Leghorn males as much as 60 per cent.

(4) Early-roosting birds are most prone to crooked keels between 8 and 12 weeks. There is a definite body-weight relationship also. Rapidly-growing birds are sometimes more subject to the condition.

(5) Present diets are probably adequate from the standpoint of providing the nutritional requirements for preventing crooked keels. When other influencing factors are eliminated, the birds which still develop crooked keels are probably some that have special nutritional requirements.

(6) Hormones play a part in the incidence of crooked keels because of their influence on calcium metabolism. Estrogen administration at certain levels plays a part in reducing the number of crooked keels. However, increasing body weight, combined with narrow roosts, counteracts the effect of estrogen. The feeding of thyroprotein causes the reverse condition, a greater incidence of crookedness.

MARKETING

Dressed Poultry

Quantitative Determination of Breast Conformation in Poultry.—The grading of dressed poultry in Canada has developed to the point where quality in the carcass is well appreciated and has become remunerative to the producer who will pay attention to it. Perhaps the most important characteristic of a high quality bird is good muscling the most important evidence of which is a well rounded, smoothly-fleshed breast. In order to conduct research on this important subject it was necessary to devise some method of accurately measuring the conformation of the breast. This proved to be very difficult. An instrument, an illustration of which is shown, was finally worked out which satisfactorily supplied this measure for both turkeys and chickens.

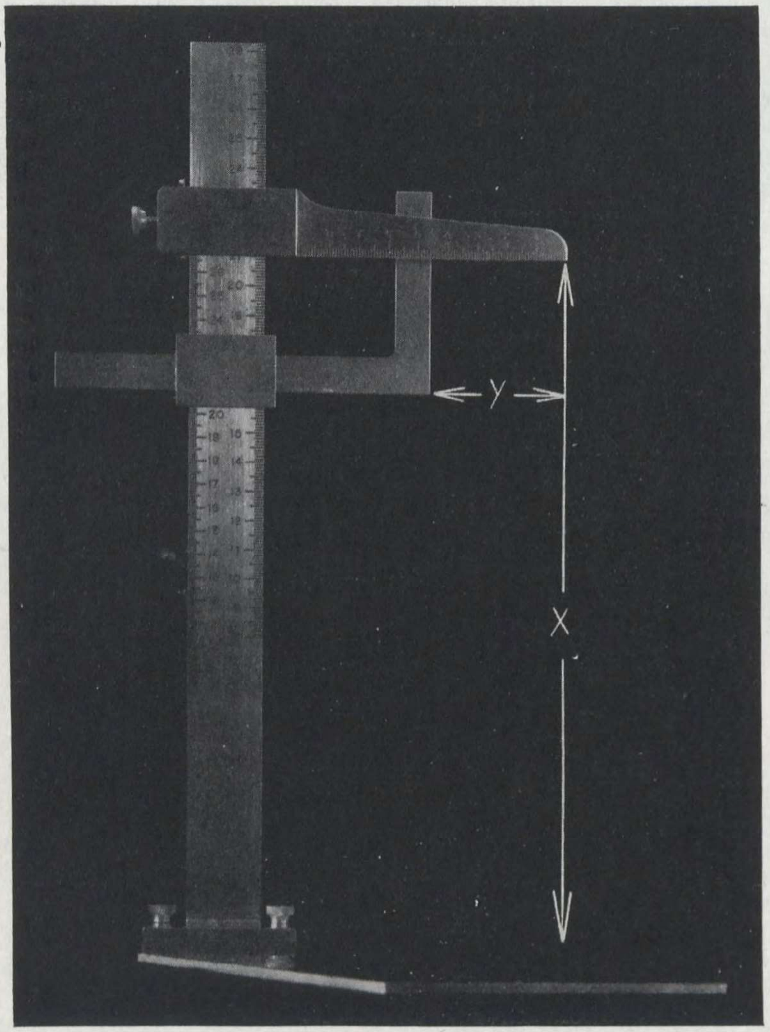


Figure 14.—Gauge for measuring broadness of breast in poultry.
X—depth of bird from point of keel to surface of back
Y—one-half breadth of breast, one-fifth below point of keel.

Application of this technique showed that families of birds differed significantly in this respect thus encouraging the belief that improvement in conformation of breast could be made by selection toward that end. An interesting point noted was that whereas chickens have a tendency to narrower breasts as their bodies become deeper, turkeys, which are deeper in body, tend to have broader and rounder breasts.

Publications.—

Measuring roundness of breast in live turkeys. U.S. Egg and Poultry Magazine, 51:206. 1945.

Quantitative determination and segregation of breast conformation in poultry. Poultry Science, 27:506. 1948.

Determination of Fleshing Characteristics in Market Poultry.—Some studies of the fleshing characteristics of chickens and turkeys were made.

It was found that, on the average, in any group of dressed birds from the same strain and of the same age, the heavier birds had the highest market grade. Since size is so important in grading it was necessary to take this factor into consideration and measurement of the leg bone provided a good index of the size of the bird. Starved live weight when related to the length of this leg bone gave a good indication of muscling or fleshing. On this basis a fleshing index was worked out which quite accurately represented the fleshing of the bird. When conformation of breast was also worked into the measurement a satisfactory grading index for body conformation was established.

The application of these measurements to breeds of turkeys showed the degree to which Broad Breasted Bronze and Beltsville Small White turkeys were relatively of better conformation than Standard Bronze or Bourbon Red turkeys of either sex. A graphic depiction of this fact is seen in the illustrated cross-sections of various breeds of turkeys, chicken and a pheasant. This indicates clearly the relative degree of muscling of the breast particularly. (Figure 15). This is further shown in figures in table 21.

TABLE 21.—RELATION OF BREAST AND LEG MUSCULATURE TO LIVE WEIGHT IN DIFFERENT VARIETIES OF POULTRY

—	Live body weight	Breast	Legs	Legs as % of breast	Legs+breast as % of remainder of live weight
	gm.	gm.	gm.		
Broad-Breasted males	11,277	2,224·4	1,884·0	84·7	57·60
Bronze males	9,625	1,770·2	1,675·1	94·6	55·40
Bourbon males	8,331	1,480·9	1,320·6	89·2	50·51
White males	7,916	1,409·1	1,204·6	85·5	49·34
Bronze females	5,971	1,117·9	1,024·8	91·7	56·12
B.P.R. males	3,082	386·1	620·3	160·7	47·03
Leghorn males	2,137	254·6	378·9	148·9	42·17
Cornish males	3,232	510·2	708·8	138·9	60·45
Pheasant males	1,201	294·7	256·5	87·0	70·53

The data showed that Leghorns are by far the most long-legged, proportionately. Rocks and Bourbon Red turkeys have proportionately about equal length of leg. The female Bronze is markedly shorter in leg than the male of this breed and both are shorter in leg than the Small Whites, whereas the Broad Breasted Bronze turkeys are proportionately an outstandingly short-legged breed.

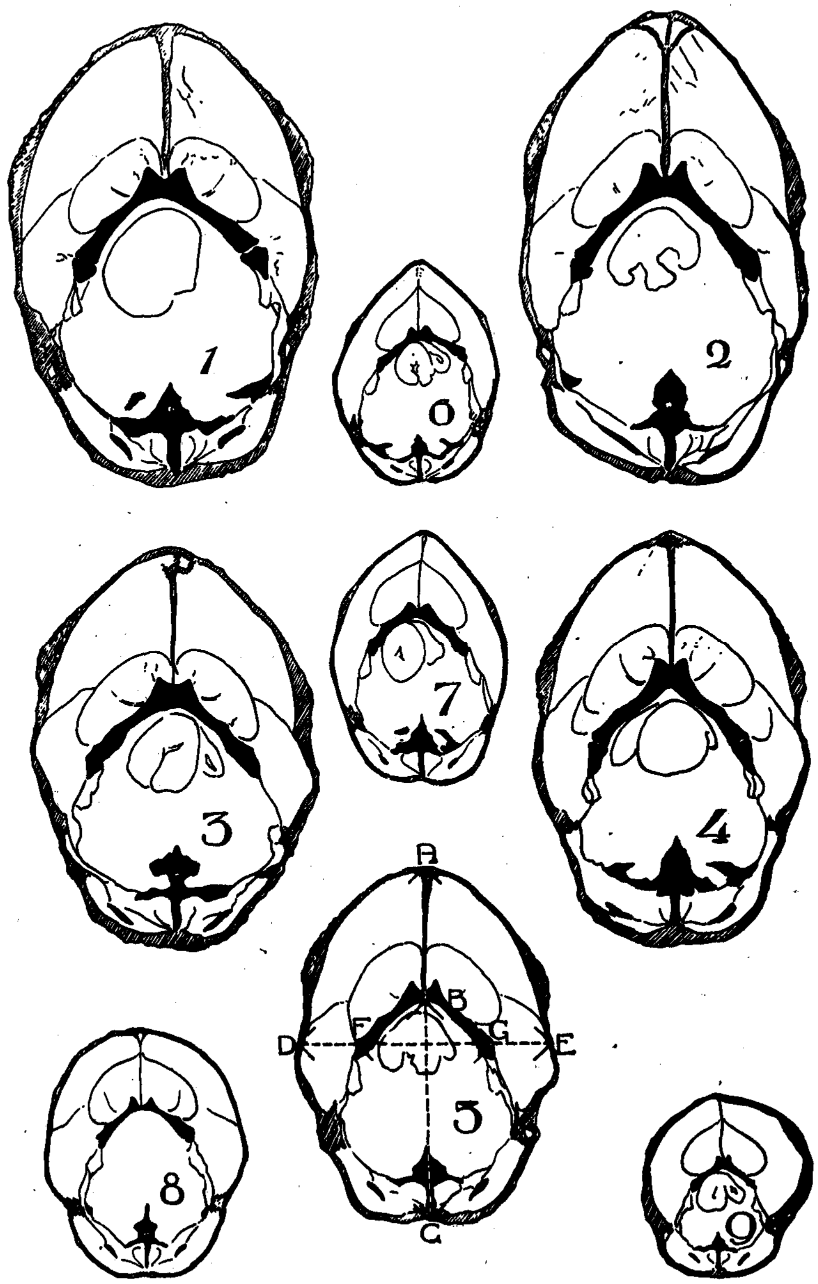


Figure 15.—Tracings from cross-sections cut just forward of the anterior point of the keel.

1 Broad Breasted Turkey male 2 Standard Bronze Turkey male
6 White Leghorn male
3 Small White Turkey male 4 Bourbon Red Turkey male
7 Barred Rock male
8 Dark Cornish male 9 Ringnecked Pheasant male
5 Standard Bronze Turkey female

(29.2 per cent of natural diameter) White areas are muscle, cross hatched areas are fat, black areas are bone.

Publications.—

Determination of fleshing characteristics in market poultry. I. Chickens. Scientific Agriculture, 24:3,135. 1943.

Determination of fleshing characteristics in market poultry. II. Turkeys. Scientific Agriculture, 24:10,481. 1944.

Bleeding Volume

The bleeding of market birds in killing fails to remove much blood. Even in carefully killed packs of birds, blood is left in the veins and capillaries, which detracts from the appearance of the carcass (reddening of skin) and are unsightly and unappetizing in the cooked bird. Dicoumarol, a substance which prevents clotting of the blood was fed to birds at the rate of 30 milligrams each, 48 hours before killing. Only 7 per cent more blood was removed by this method however. It appeared that clotting was definitely slowed down and it may be assumed, therefore, that when the heart stops and there is no longer any pressure in the system little further drainage of blood can occur even though its clotting power be reduced or removed.

ECONOMIC STUDIES

Economic Aspects of Poultry Keeping in Canada

A study of the economy of utilization of feed by the laying chicken was made. This analysis showed that a very small proportion of the feed of a laying hen goes into the production of eggs, most of it being used to maintain the body and for activity, growth or fat increase. This is the explanation for the greater efficiency of lighter birds in producing eggs (e.g. a White Leghorn can produce 182 eggs per year on 69 pounds of feed while a heavier bird like a Barred Rock will use 76 pounds of feed to maintain her body without any egg production).

Table 22 shows the relation of level of production to net income. This information is based on the above data and the following feed prices: starter mash, $92 per ton; growing mash, $81; and grain, $71 per ton. In addition, chick mortality of 10 per cent, a price of 16 cents for day-old chicks, and $120 per month for labour are taken into consideration.

TABLE 22.—RELATION OF LEVEL OF PRODUCTION TO NET INCOME

Production	Cost of raising and maintaining one hen (18 mo.)	Cost of production	Total cost	Sale of meat 31c per lb.	Sale of eggs 35·6c per doz.	Total Income	Balance
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
			Heavy	Breeds			
8 doz.	5 83	0 33	6 16	1 11	2 85	3 96	−2 20
12 "	5 83	0 50	6 33	1 11	4 27	5 38	−0 95
15 "	5 83	0 62	6 45	1 11	5 34	6 45	±0
18 "	5 83	0 75	6 58	1 11	6 41	7 52	+0 94
			Light	Breeds			
8 doz.	4 58	0 33	4 91	0 86	2 85	3 71	−1 20
12 "	4 58	0 50	5 08	0 86	4 27	5 13	+0 05
15 "	4 58	0 62	5 20	0 86	5 34	6 20	+1 00
18 "	4 58	0 75	5 33	0 86	6 41	7 27	+1 94

The importance of high production and the greater economy of the lighter breed are clearly shown by the above table. These figures are only useful to show the situation on the basis of the conditions and costs used. On any other level of costs the appropriate data could also be calculated.

Publications.—

A study of the energy required for maintenance, egg production, and changes in body weight in the domestic hen. Scientific Agriculture 19:542. 1939.

Economic aspects of poultry keeping in Canada with special reference to egg production. Scientific Agriculture 19:551, 1939.

Economic aspects of poultry keeping in Canada. II. Relationship between prices of feed and eggs and their effect on the return to the poultryman for labour and management. Scientific Agriculture, 22:448. 1942.

Pullet Mortality and its Economic Significance

A study of the economic significance of mortality indicated that the flocks exhibiting the highest genetic potential for egg production were also the most resistant to various diseases. It was calculated that mortality accounts for a loss of 25·4 eggs for each bird that began the year in Canadian flocks. Applying this figure to the 24·5 million hens in Canada in 1937, the total loss of eggs would amount to approximately 52 million dozen eggs in that year.

Publication.—

Pullet mortality and its economic significance. Proceedings Seventh World's Poultry Congress. 434. 1939.

TURKEYS

Various tests have been carried out on methods of feeding and management of turkeys.

Different protein levels have been used in feeding turkey poults, the conclusion being reached that a higher protein level produces a growth stimulus which is lost later in life. Skim-milk as a protein supplement was found to have limited values. It was found to be more economical to feed mash and grain, free choice, as compared with an all-mash ration of which they consumed about 1·2 pounds more per pound body weight than where grain was provided. Feed consumption data for different breeds of turkeys up to maturity were obtained.

Data which have been accumulated indicate the greater feed economy of the larger turkey, such as the Broad Breasted Bronze (Figure 16) as compared with a smaller breed, for example, the Beltsville Small White. Therefore, if the latter type is raised in order to produce a family-size turkey a slightly greater relative cost is involved. It is in this regard turkey work at this institution is being concentrated, at the present, mainly on body size and fleshing qualities of turkeys with a view to developing a medium-sized turkey with good fleshing and not too large a size difference between sexes.

Range vs. Wire Rearing.—Turkeys have been raised on wire (Figure 17) and on range in various years. A greater economy in feed costs is obtained with range rearing, especially where there is a plentiful supply of pasture available. One of the advantages of rearing on wire is slightly earlier finishing and less danger of blackhead infection. However, turkeys have been raised on range over a number of years with relatively small losses from blackhead. Factors which are helpful in this regard are sanitary management practices, rotation of pasture and isolation from chickens.

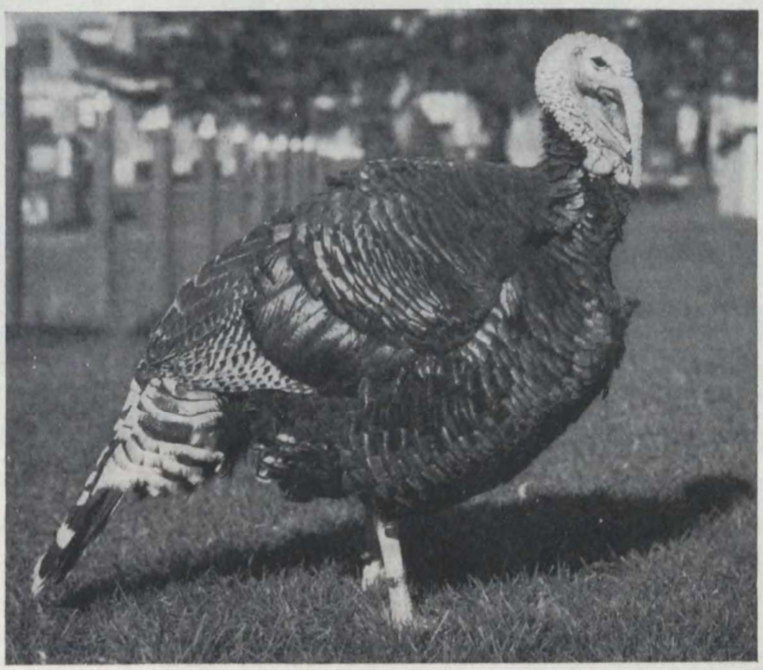


Figure 16.—A Broad Breasted Bronze Turkey Tom of exceptional quality.

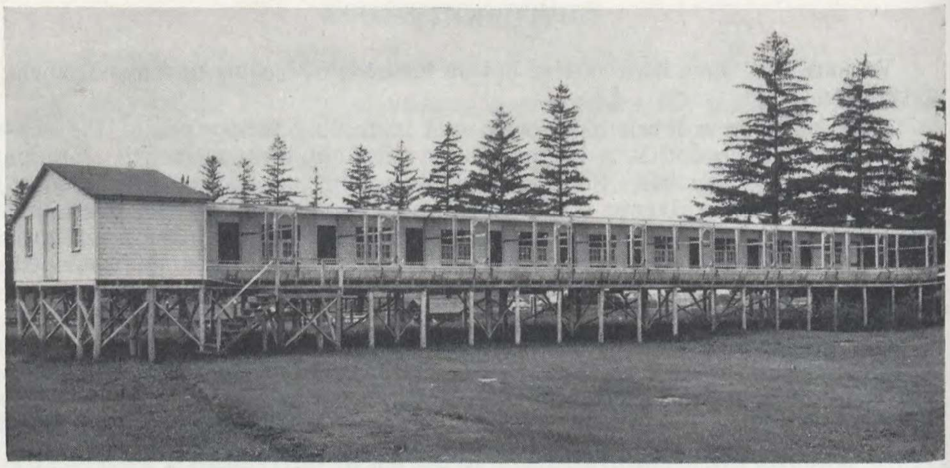


Figure 17.—A slatted floor turkey house adaptable for brooding, rearing, and breeding purposes.

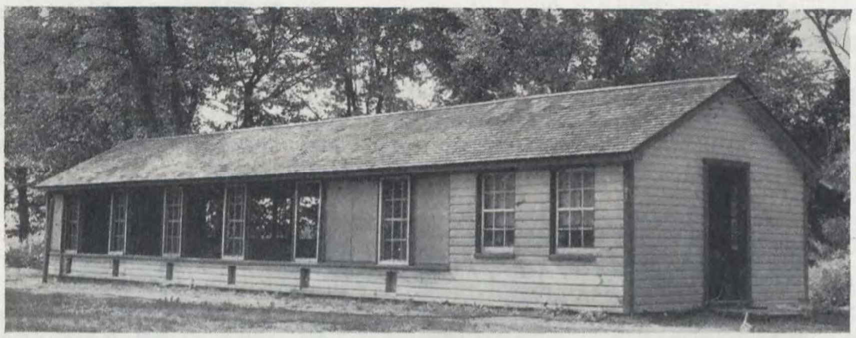


Figure 18.—Duck house at the Waterfowl Sanctuary of the Poultry Division. Can be adapted for the use of young or old stock.

Smoking Turkey Meat.—Treating of dressed turkeys with Old Hickory Smoked Salt, either by means of a brine solution or by manual application, failed to produce a favourable result, judging by the results of sampling of the finished product by about twelve individuals. A similar reaction was obtained with regard to turkey meat which had been placed in brine and subjected to smoke in a smoke-house. The consensus of opinion was that the original flavour was more desirable than a smoked flavour.

WATERFOWL

A waterfowl plant (Figure 19) is maintained, on a demonstration basis, at this institution, and several varieties of ducks and geese are kept. White Pekin, Khaki Campbell, Indian Runner, Muscovy, Mallard, Rouen, and Cayuga, are some of the more important varieties of ducks. Geese of the following breeds are on the plant: Chinese, Toulouse (Figure 19), Pilgrim, Embden, African, Canada, and Snow. The last two mentioned are wild varieties. Some breeding stock is sold and experimental work has been carried out on different phases of feeding and management.

Feeding trials with White Pekin ducks on relatively inexpensive rations show growth rates and feed efficiency up to nine or ten weeks of age that are hard to duplicate in other fowl. If kept beyond ten weeks, any profit which might have been derived is soon lost because of the amount of feed required for maintenance. Complete figures on growth and feed consumption for the more common meat breeds have been accumulated; these are available on request.

A feeding test, where vegetable protein in the form of soybean oil meal and alfalfa leaf meal was substituted for animal protein (meatmeal), showed no loss in growth rate because of this substitution, when measured up to 12 weeks of age.

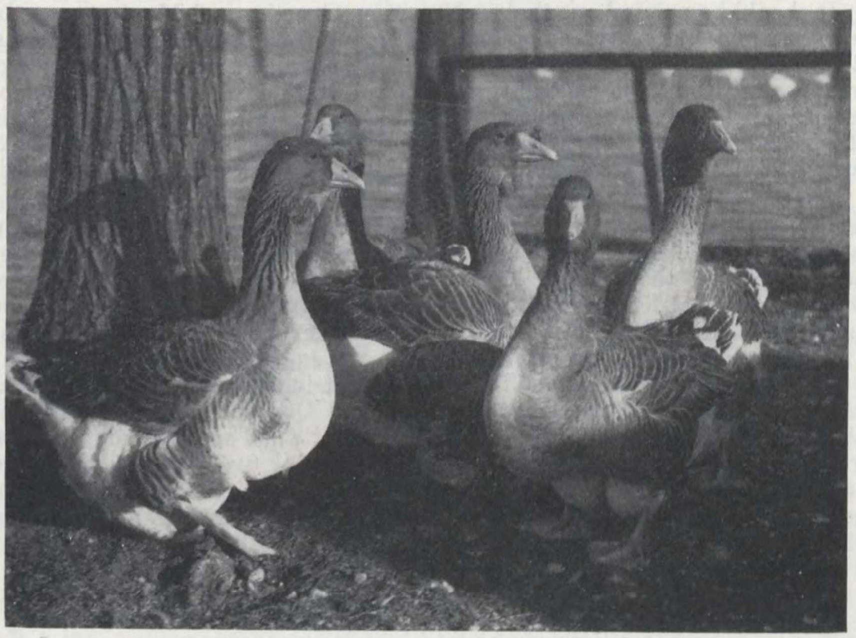


Figure 19.—Young Toulouse Geese, thrifty and of excellent type.

ORGANIZATION OF THE POULTRY DIVISION

Experimental Farms Service

The principal responsibility of the Poultry Division is that of research. The Division is, therefore, organized largely on this basis. In the conducting of research in the biological field, the basic sciences involved are very likely to be of great importance. Two of the principal sections into which the work is divided are Nutrition and Genetics. A further subject division for research might well be stated as Management, which covers research in housing and ventilation, equipment, marketing, economics and a number of other phases applicable to the poultry industry.

Under Nutrition is considered all research which is applicable to the feeding of domestic poultry. This is a very important branch of the research work and involves chemistry and biochemistry, physiology, biometry and other sciences.

The Genetics section is similarly organized and involves the same basic sciences to a degree but particularly the science of genetics. All matters which pertain to improved breeding come under this section.

Management involves housing and ventilation, litter, floor space per bird unit, provision of adequate equipment for both rearing and laying birds, methods of handling and feeding birds, and cost studies for ordinary poultry as well as turkeys and waterfowl.

It should be pointed out that in Nutrition, Genetics and Management, many projects require the active co-operation of a number of the Branch Stations, in order that they may be successfully carried out. Projects are, therefore, designed, in many cases, to be conducted at a number of Stations so that sufficient populations of birds are available when required and also in order that different environmental conditions will be involved, thus providing information as to the extent to which any findings are generally applicable under different climatic conditions.

The expense involved in equipping a poultry plant with the necessary specialized personnel and facilities to conduct research in all the major fields of poultry husbandry is considerable and none of the Branch Stations are so fully equipped. However, five of the stations have the necessary organization to do effective research work in at least one of the major fields of nutrition, genetics or management while a sixth Station is equipped to conduct research work in all phases of turkey production. Also eight Stations are equipped to carry out some of the less technical phases of poultry work, either individually or in co-operation with other Stations or the Poultry Division at Ottawa. Another six Stations maintain smaller flocks and conduct experimental work on problems which more particularly affect their districts. Finally, there are five remotely located sub-stations which maintain very small flocks and hence conduct only a limited amount of experimental work. Poultry are kept on 25 Branch Stations in addition to the Poultry Division at Ottawa.

ACTIVE PROJECTS

Breeding, Genetics and Cytology

P. 1.111 The feasibility of selection based on the progeny test as a method for increasing the egg producing ability of fowl.

P. 1.112 Pedigree breeding for egg production.

P. 1.113 The evaluation of the breeding potential of full sisters.

P. 1.114 An evaluation of the progress made in egg production through many generations of selection.

P. 1.121 Breeding for viability.

P. 1.131 Breeding for fertility and hatchability.

P. 1.132 The study of inheritance of hatchability in chickens.

P. 1.133 The duration of fertility of semen from White Wyandotte and New Hampshire males when inseminated into both breeds of females.

P. 1.134 The duration of fertility in different breeds of turkeys.

P. 1.135 Investigation of methods of management of geese and of methods of incubation of their eggs to produce maximum fertility and hatchability.

P. 1.136 Investigation of the feasibility of using artificial insemination in goose breeding.

P. 1.141 A study of mode of inheritance of breast conformation in egg production strains of poultry.

P. 1.142 The improvement of the Broad Breasted White breed of fowl for meat production.

P. 1.151 Mode of inheritance of egg shell strength.

P. 1.152 A study of factors affecting egg shell quality. The use of a penetrometer in measuring egg shell strength.

P. 1.153 Relation of specific gravity of the egg to its hatching power and to chick livability.

P. 1.154 Influence of genetics on response to vitamin D.

P. 1.155 A study of the hereditability of certain types of deterioration in the eyes of White Leghorn production stock and of their relation to egg production, mortality and other economic characteristics of the birds.

P. 1.156 The measurement of the genetic variation in feed efficiency both between and within breeds of turkeys and the determination of the effectiveness of selection for improvement in this characteristic.

P. 1.21 Studies of the mode of inheritance of characteristics determined by one or few genes. These characteristics may or may not have immediate economic importance.

P. 1.211 The determination of the genotypic basis for lack of colour in white mutants of the Light Sussex breed of poultry.

P. 1.221 Studies in formal genetics.

Nutrition

P. 2.111 Vitamin feeds for chicks.

P. 2.112 Metabolism in the fowl. Effect of vitamins.

P. 2.113 The interrelationship of riboflavin, Niacin, Biotin, Pantothenic Acid and Folic Acid, etc., in turkey poult nutrition.

P. 2.121 The use of rape-seed oil-cake meal in starting and finishing rations for turkeys

P. 2.122 A study of the value of mustard seed oil-cake meal for growth, egg production and reproduction.

P. 2.123 A study of the value of dried lobster body meal for the growth of chickens.

P. 2.131 Studies upon mineral metabolism in poultry (*a*) Calcium metabolism (*b*) Phosphorous metabolism.

P. 2.132 A study of the relative effectiveness of oyster shell, clam shell and native limestone, with or without insoluble grit, on egg production, hatchability and egg shell strength of pullets.

P. 2.133 The use of thiouracil, thiobarbital and other synthetic goiterogenic chemicals in the fattening and finishing of market turkeys.

P. 2.134 A study of the effect of certain trace elements upon poultry during growth and production.

P. 2.135 Kelp meal in the ration for laying hens.
P. 2.136 Kelp meal in the ration of growing chicks.
P. 2.141 Synthetic hormones and hormone-like substances in turkey nutrition.
P. 2.171 Snow vs. water.
P. 2.211 Methods and rations for fattening and finishing broilers (*b*) Various rations.
P. 2.212 Methods and rations for fattening and finishing roasters. (*b*) Various rations.
P. 2.213 Substitutes for fresh green feeds.
P. 2.214 Green feed crops and their management for poultry ranges.
P. 2.215 Perennial and biennial grasses and legumes for pasture.
P. 2.216 Methods and rations for fattening and finishing turkeys. (*b*) Comparative value of different rations.
P. 2.217 The study of the value of severely frosted wheat as a poultry feed.

Physiology

P. 3.11 Sex hormone studies.
P. 3.12 Metabolism in the fowl. Effect of hormones.
P. 3.13 The duration of fertiliy in various breeds and strains of fowl (Broad Breasted Whites, Large Whites, Barred Rocks, and White Leghorns) following artificial insemination with different doses of semen.
P. 3.14 Genetic and physiological differences in the spermatozoa of the domestic fowl.
P. 3.15 The relationship of the morphology of spermatozoa to its fertilizing capacity.
P. 3.16 Fertility in White Wyandotte males as related to the histological development of certain endocrine glands and the quality of semen produced.
P. 3.17 A study of fertility and hatchability in the chicken—the influence of thyroid therapy (protamone) of the male White Wyandotte and New Hampshire on the duration of fertility of their semen.
P. 3.31 Determination of the natural thyroxine secretion rate of turkeys of various ages.

Management

P. 4.11 Methods of feeding layers.
P. 4.12 Relation of granulation of poult starter mashes to: (1) Pressure Necrosis (2) Palatability (3) Gain in body weight.
P. 4.13 A study of the effect of fineness of grinding grains on the palatability of all-mash rations for laying hens.
P. 4.15 A study of different methods of feeding an all-mash ration to laying hens.
P. 4.21 Growing turkeys under confinement.
P. 4.22 A determination of the factors contributing to breast blisters in market poultry.
P. 4.51 Methods and rations for fattening and finishing broilers. (*a*) Crate vs. pen.
P. 4.52 Methods and rations for fattening and finishing turkeys. (*a*) Range vs. confinement.

Houses and Equipment

P. 5.11 Ventilation and temperature of poultry houses.
P. 5.12 The relative efficiency of various ventilation systems for laying houses under prairie conditions.
P. 5.13 A study of requirements in ventilation, insulation and temperature control in laying houses under rigorous winter conditions.
P. 5.41 Best type or make of brooder.
P. 5.42 Best kind of litter.
P. 5.52 Control of temperature in poultry houses by the use of bimetallic expansion units.

Testing

P. 6.11 Comparison of breeds for broilers.
P. 6.12 Comparison of breeds for roasters.
P. 6.13 Comparison of breeds for egg production.
P 6.14 A critical test of the comparative commercial value, as broilers and roasters, of several strains and crosses of meat breeds of fowl.

P. 6.15 A test of the effect of different environments on the producing ability of Harrow strain Barred Rocks.

P. 6.21 Effects of certain commonly-used insecticides, vermicides and seed-treating compounds when included in the diet of growing turkeys.

P. 6.31 A comparison of floor radiant heating and standard hover methods for brooding chicks.

P. 6.32 A comparison of brooding methods for chicks.

P. 6.33 A study of the usefulness of a bentonite material as a nest litter for laying hens.

Economics of Poultry Production

P. 8.11 Incubation costs (*a*) Total cost per egg unit.

P. 8.12 Incubation costs (*b*) Fuel costs per egg unit.

P. 8.21 Brooding costs (*a*) Cost of feeding.

P. 8.22 Brooding costs (*b*) Fuel costs.

P. 8.31 Cost of producing broilers.

P. 8.41 Costs of egg production.

P. 8.51 Costs and gains in fattening roasters.

P. 8.61 Best hatching date for egg production.

P. 8.62 Total cost of producing stock.

P. 8.63 A study of the economics of early hatching and of methods of maintaining egg production in early hatched pullets.

Disease Control

P. 10.11 Control and eradication of Laryngotracheitis. (*a*) By continuous vaccination followed by non-vaccination.

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