CONDUCTING a survey for the purpose of locating superior breeding stock among the poultry flocks of the United States and other countries turned out to be an interesting and instructive undertaking.

In some respects, more progress has been made in the development of breeds of chickens than is the case with any other class of domestic livestock. As compared with cattle, sheep, and swine, all of which are used to produce food for human beings, the chicken is a small creature, and one that is capable of reproducing itself in relatively large numbers. Intense selection is therefore possible, and if proper care is exercised considerable progress can be made in a relatively short time in combining a number of desired characteristics, both those that are of economic importance and those that are not. There is a widespread impression that great progress has been made in poultry breeding in modern times, and in a very real sense this is true. Yet it is also true that for the most part the data submitted on the survey forms were so meager as to be practically valueless in the search for stock of superior breeding worth. As for foreign countries, very few replies were received from the breeders to whom the survey records were sent.

Though this lack of results is significant and striking as a bald fact, too hasty conclusions should not be drawn from it. A quest for poultry stock of superior breeding worth is bound to be extremely difficult because there are thousands of poultry breeders and different standards are involved. For the most part, breeders are concerned not only with the number of eggs laid but also with their size, shape, and hatchability, and with such matters as the size of the birds and the extent to which they conform to the standards for the breed or variety being kept. Birds that do not come up to par in one or more respects are often culled from the flock, and rarely does it happen that a poultry breeder keeps all of the progeny of a given mating. For economic reasons he is obliged to cull the loafers among his layers, and since small eggs are objectionable from a market standpoint, birds that lay small eggs are not kept for breeding purposes. In most flocks so much culling is practiced that it is a very difficult matter
to secure an accurate index of the breeding worth of the sires and
dams; for superior breeding worth is not a matter of producing a few
good layers—it is a matter of getting high average production in all
of the progeny of the breeding stock.

The survey showed that practically all poultry breeders cull their
pullet flocks rather stringently. In fact, the culling is so stringent in
many flocks that an analysis of the results obtained was out of the
question. Some breeders have been using as few as 20 to 30 female
breeders each year. Quite a number trap nest a portion only of the
pullets raised from their pedigree matings. Again, most of the breeders
to whom the survey records were sent had never determined the
average egg production of the pullets that were allowed to finish their
first laying year; they could give only the production records of the
pullets that qualified for official Record of Performance. In the case
of many flocks, then, the records kept are far from complete. More-
over, some flocks may be noted not only for their laying ability but
also for small egg size or poor hatchability.

Finally, from the standpoint of conducting a survey, there is the
difficulty involved not only in the large number of progressive poultry
breeders, but in the much greater number of breeding birds used.
Even in the case of males, this number would run into thousands, for
some breeders have from 30 to 50 pen matings each year, and the
number of hens would be many times that. Just to list the results
obtained over a period of years from the flocks of a score of poultry
breeders would be a formidable task. And even with these breeders
the story would not be complete, for it is practically impossible to
classify the breeding stock with respect to their relative superiority
in five or six characteristics which are being bred for simultaneously.

The Present Situation and the Need for Further
Scientific Research

NOW the significance of all this comes out very strongly when it is
realized that, in spite of the number of breeders and the extent of
the breeding stock, the average egg production per bird per year in the
country as a whole is abnormally low, being approximately 80 eggs,
according to census estimates. Yet the average income per State
from poultry products sold in 1929 was about $18,000,000, of which
about two-thirds was from eggs and one-third from market poultry.
The average farm egg sales in 1929 amounted to $151, whereas the
average farm market-poultry sales amounted to $84. According to
the census of 1930, over 85 percent of all farms had poultry flocks, so that
over 5 million farmers are directly concerned in the future development
of the poultry industry. In 1933 the farm value of poultry products
amounted to $653,652,000 and accounted for approximately 20 percent
of the total farm value of livestock and livestock products. There are
approximately 400,000,000 adult chickens kept annually on American
farms, and they produce eggs at the rate of about 60,000 every minute,
day and night. From insignificant beginnings poultry raising has
developed until it is now one of the most important branches of
agriculture.
Many poultrymen fail to realize that heredity is inescapable. Every year too many poor producers are kept and used for breeding. Mediocrity tends to reproduce itself, and if egg production is to be increased, the most careful selection of the breeding stock is essential. But the problem goes deeper than this. For the poultry industry as a whole, it is of the first importance to develop strains of fowl that will produce eggs more efficiently. The cost of production and reproduction should be reduced. The very size and wide extent of the industry makes this all the more important.

How is improvement to be brought about? In industry, commerce, and agriculture alike, progress depends to a large extent on research. Industrial and commercial concerns in many cases have established extensive laboratories that are well equipped and staffed with research men of high caliber. Agriculture cannot organize research work on this basis. It is dependent, for the most part, on the Federal Department of Agriculture and the State experiment stations to solve problems of the first magnitude facing the industry.

THE HEART OF A PROGRAM FOR FURTHER PROGRESS

In many respects the State experiment stations and other institutions have made notable contributions to the science of poultry raising. In the problems of rearing and feeding, the stations have contributed much scientific information that enables poultry producers to make the most out of such hens as they may have. Important as these things are, however, the intrinsic qualities of the flocks are in no way altered. An ideal environment and a perfectly balanced diet will never make a good layer out of a hen that does not possess the characteristics upon which productivity depends. This is where the art of breeding necessarily enters the picture. The experiment stations should be expected to contribute much to the rather meager fund of
knowledge possessed by most poultry breeders concerning the inheritance of the characteristics that determine productivity, and the size and quality of eggs.

With few exceptions, however, the State experiment stations have done very little in paving the way for the development of stocks of superior breeding worth. At many of the stations, lack of funds makes it impossible to maintain a breeding flock of sufficient size to provide for the adequate selection of breeding stock. A few stations carry on breeding work with three or four different breeds or varieties instead of concentrating efforts on one breed or variety. At most of the stations some culling of the pullet progeny is practiced, and this, as will be made clear later, materially lessens the value of the results obtained.

What most poultry breeders want to know is how to develop males and females of superior breeding worth so that they can be used to raise the level of egg production and increase the average size and improve the quality of eggs laid by the flocks of the country. The poultry breeder also wants to know how to reduce the annual cost of flock replacements; he wants good hatchability and low chick and adult mortality. The experiment stations could render valuable service in this direction by conducting research studies on:

1. The inheritance of egg production, using a reasonably large number of matings and keeping a random sample of each of the families produced.
2. How to combine good average egg size with good production.
3. Whether or not it is possible to develop strains of high layers that are resistant to specific diseases.
4. How best to combine good hatchability with good egg production and good egg size.
5. Whether or not any inbreeding is desirable or necessary to develop high-laying strains; that is, is it advisable to secure a relatively high degree of homozygosity as a step in producing breeding stock of superior worth?
6. Whether or not worthwhile results in breeding for increased egg production, good egg size, and improved interior quality can be secured through cross-
breeding; that is, is heterozygosity which is kept under control likely to secure the desired results?

(7) The extent to which environment rather than inheritance may be responsible for the variability that normally occurs in breeding for quantitative characteristics, such as egg production.

(8) The best methods of selecting breeding stock to accomplish the objects sought, and of giving proper weight to records of production, pedigree, and progeny test.

There are valid reasons why research workers should take the lead in the solution of these vital problems, which may well be considered the heart of any program for further progress. For economic reasons, most private poultry breeders cannot afford to experiment with matings merely for the sake of finding how things will turn out. The poultry breeder has to count the cost, and it is most natural for him to mate what he believes to be the best to the best on the chance that he will get the desired results. Trap-nesting and pedigree breeding is time-consuming and expensive, and since most poultry breeders have

THE production record, the pedigree, and the progeny test provide three means of identifying the dam of superior breeding worth. A superior sire is identified by the production record of his dam, his own pedigree, the average egg production of his full sisters, and the kind of progeny he produces. It can be said with a reasonable degree of certainty that in the present state of the poultry-breeding industry of the United States, the selection of breeding stock on the basis of the progeny test is the most important step in the development of a balanced breeding program.

to make a living out of their work, they can hardly be expected to keep all the progeny secured from different matings, or even to keep a random sample. But a random sample is necessary if an accurate index is to be obtained of the breeding worth of a mating or a flock, and it is the business of the experimenter to retain a random sample for the purpose of getting at all of the factors involved. Nor could the private breeder afford such an experiment as submitting a diverse flock to the worst possible environmental conditions, including disease, to see what might emerge from the trial in the way of resistant stock. Yet an experiment of this sort might yield some very significant results.

In other words, there are numerous problems that poultry breeders, if left to themselves, could never solve. A comprehensive project on the effects of varying degrees of inbreeding on egg production, hatchability, and other characteristics is outside their field. They could probably never solve the principles involved in cross-breeding, however important such problems may be in practical breeding.
operations. They should never be expected to undertake experiments to determine whether or not it is possible to develop disease-resistant strains. For many reasons, it is clear that if a number of problems of major importance facing the poultry-breeding industry are to be solved, the work must be undertaken by the scientists.

Progress in Tracing the Inheritance of Traits in Poultry

RESEARCH in such problems is in line with what has already been accomplished by the Federal and State experiment stations. They have not by any means been idle in genetic research,
and they have made contributions to scientific knowledge concerning inheritance in poultry. The manner of the inheritance of a large number of color, morphological, and physiological characteristics have been determined rather precisely.

A few of these are of considerable practical importance. The barring of the Barred Plymouth Rock is dominant to nonbarring and is sex-linked—that is, the factor that determines this characteristic is located in the chromosome that is associated with sex. When a Rhode Island Red male is mated with a Barred Plymouth Rock female, the chicks at hatching time can be separated according to sex, thus making it possible for broiler producers to purchase the cockerels and egg producers to purchase the pullets. The down of the male chicks is black at hatching time except for a white spot on the top of the head, and the beak and shanks are yellow; the down of the female chicks is solid black in color, and the beak and shanks are very dark or almost black. Other sex-linked crosses involving other breeds and varieties can be made. Broodiness has been shown to be due to two dominant, complementary genes, and in at least one breed sex-linked genes have been observed to be involved. Slow rate of feathering is dominant to rapid rate of feathering and is sex-linked.

These are examples of characteristics of practical importance; but it must be admitted that most of the characteristics that have been traced down genetically have little economic significance.

While on the subject, however, it might be well to summarize what these characteristics are. They come under three general headings: (1) Color traits, which are among the most conspicuous of all the characteristics chickens possess and constitute the basis for differentiating the varieties of a breed; (2) morphological traits, which relate to form and size, such as the shape of the comb, the presence or absence of a crest, feathered or nonfeathered shanks, and the type of feathering over the body; and (3) physiological traits, which relate to functional activity, such as hatchability of eggs, broodiness, and rate of feathering.

Most of the traits or characteristics whose inheritance has been definitely traced are listed in table 1. A few words of explanation are necessary. Column 1 gives the trait. Column 3 tells whether the factor or gene that determines this characteristic is located in what is known as an autosomal or body chromosome, or whether it is in a sex chromosome (sex-linked). Column 2 tells whether the trait is dominant or recessive.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Dominant or recessive</th>
<th>Autosomal or sex-linked</th>
</tr>
</thead>
<tbody>
<tr>
<td>White plumage</td>
<td>In White Leghorns, almost completely dominant to color.</td>
<td>Autosomal.</td>
</tr>
<tr>
<td>Do</td>
<td>In White Dorkings, Langshans, Minorcas, Plymouth Rocks, Wyandottes, recessive to color.</td>
<td>Do.</td>
</tr>
<tr>
<td>Do</td>
<td>In some strains of Rose Comb White Bantams and White Silkees, recessive to color.</td>
<td>Do.</td>
</tr>
<tr>
<td>Black plumage</td>
<td>Dominant to recessive white.</td>
<td>Do.</td>
</tr>
<tr>
<td>Blue plumage</td>
<td>Due to heterozygous condition of color genes.</td>
<td>Autosomal and sex-linked</td>
</tr>
<tr>
<td>Buff plumage</td>
<td>A multiple gene characteristic dominant to recessive white and recessive to black, and recessive to &quot;silver.&quot;</td>
<td>Sex-linked.</td>
</tr>
<tr>
<td>Silver plumage</td>
<td>&quot;Silver&quot; in Columbian, silver-laced, and silver-penciled varieties dominant to &quot;gold&quot; in red, buff, golden-laced, and golden-penciled varieties.</td>
<td></td>
</tr>
</tbody>
</table>

38143*—36—61 × 953
### Table 1.—Dominant and recessive characteristics in chickens—Continued

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Dominant or recessive</th>
<th>Autosomal or sex-linked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barred plumage</td>
<td>In Plymouth Rocks, dominant to nonbarring.</td>
<td>Do.</td>
</tr>
<tr>
<td>Red-splashed white plumage</td>
<td>In Campines, dominant to nonbarring.</td>
<td>Do.</td>
</tr>
<tr>
<td>Albino</td>
<td>Recessive to solid color and to color pattern.</td>
<td>Do.</td>
</tr>
<tr>
<td>White skin and shank color</td>
<td>Dominant to yellow skin and shank color.</td>
<td>Sex-linked.</td>
</tr>
<tr>
<td>Dark skin and shank color</td>
<td>Recessive to nondark skin and shank color.</td>
<td>Do.</td>
</tr>
<tr>
<td>Rose comb</td>
<td>Dominant to single comb.</td>
<td>Autosomal.</td>
</tr>
<tr>
<td>Pea comb</td>
<td>Do.</td>
<td>Do.</td>
</tr>
<tr>
<td>Walnut comb</td>
<td>Dominant to rose, pea, and single comb.</td>
<td>Do.</td>
</tr>
<tr>
<td>Side sprigs</td>
<td>Recessive to normal comb.</td>
<td>Do.</td>
</tr>
<tr>
<td>Cerebral hernia</td>
<td>Dominant to absence of crest.</td>
<td>Do.</td>
</tr>
<tr>
<td>Crest</td>
<td>Dominant to absence of nuch and beard.</td>
<td>Do.</td>
</tr>
<tr>
<td>Muff and beard</td>
<td>Dominant to nonfeathered shanks.</td>
<td>Do.</td>
</tr>
<tr>
<td>Naked neck</td>
<td>Recessive to normal feathering.</td>
<td>Do.</td>
</tr>
<tr>
<td>Feathered shanks</td>
<td>Recessive to normal feather development.</td>
<td>Do.</td>
</tr>
<tr>
<td>Vulture hock</td>
<td>Dominant to loose feathering.</td>
<td>Do.</td>
</tr>
<tr>
<td>Rumplessness</td>
<td>Incompletely dominant to normal plumage.</td>
<td>Do.</td>
</tr>
<tr>
<td>Long tail</td>
<td>Dominant to normal plumage.</td>
<td>Do.</td>
</tr>
<tr>
<td>Hen feathering</td>
<td>Dominant to rapid feathering.</td>
<td>Sex-linked.</td>
</tr>
<tr>
<td>Frizzle plumage</td>
<td>Dominant to normal wing.</td>
<td>Autosomal.</td>
</tr>
<tr>
<td>Silkie plumage</td>
<td>Dominant to normal feathering.</td>
<td>Do.</td>
</tr>
<tr>
<td>“Frayed” feathers</td>
<td>Dominant to normal feather development.</td>
<td>Do.</td>
</tr>
<tr>
<td>Close feathering</td>
<td>Dominant to normal condition; lethal when homozygous.</td>
<td>Do.</td>
</tr>
<tr>
<td>Slow feathering</td>
<td>Recessive to normal embryo development; lethal when homozygous.</td>
<td>Do.</td>
</tr>
<tr>
<td>Flightless</td>
<td>Recessive to normal</td>
<td>Do.</td>
</tr>
<tr>
<td>Crooked neck</td>
<td>Dominant to four-toed condition.</td>
<td>Autosomal and sex-linked.</td>
</tr>
<tr>
<td>Creeper condition</td>
<td>Dominant to late sexual maturity.</td>
<td>Do.</td>
</tr>
<tr>
<td>An embryo lethal</td>
<td>Dominant to nonbroodiness.</td>
<td>Do.</td>
</tr>
</tbody>
</table>

Among the numerous characteristics listed in table 1, it is apparent that many are what might be called superficial characteristics that have practically no significance in determining the breeding worth of birds used for transmitting egg- and meat-producing qualities to their progeny. A few of the characteristics listed in table 1 are of considerable economic importance and some have a direct bearing on the development of strains of fowls of superior breeding worth. For instance, a poultryman endeavoring to develop a high-laying strain should naturally pay close attention to such characteristics as nonbroodiness and early sexual maturity in the selection of his breeding stock. As time goes on, it is anticipated that the inheritance of other characteristics of economic importance will be investigated.

### The Background and the Early History of Poultry Breeding

So much for the present situation and the present needs in poultry breeding as these stand out under the searching light of an effort to survey superior germ plasm. The problem of developing superior breeding stock, however, must be considered as a whole. While
Experimental science has made great contributions and should make still greater ones in the future, much responsibility also lies with the practical breeders. Although poultry breeders have perhaps made greater progress in developing strains of superior breeding worth than breeders of any other class of livestock, it is safe to say that they have not by any means gone as far as they could.

The third section of this article will discuss what might be done by breeders to put into practice certain sound principles developed from present knowledge. But present knowledge has grown out of past practice and experimenting. It would be well, then, to survey earlier developments briefly, in order to get some picture of the progress that has been made and to evaluate the worth of some major developments. This will be done in the following section.

**Figure 4.**—The barring of the Barred Plymouth Rock is sex-linked. Since the female is heterozygous for sex and has one sex chromosome only, it is transmitted to her sons but not to her daughters so that her adult sons are barred but her adult daughters are black. This illustration shows the Rhode Island Red sire (A), the Barred Plymouth Rock dam (B), the barred son (C), and the black daughter (D).
EARLY HISTORY OF POULTRY

No class of domestic livestock offers such a bewildering variety of body types, head furnishings, color patterns, and other characteristics as the domesticated chicken of today. There are chickens with single combs, rose combs, pea combs, walnut combs, red ear lobes, white ear lobes, crests, muffles, and beards, feathered shanks, non-feathered shanks, four toes, five toes, white skin, yellow skin, black skin, silkie feathers, frizzled feathers, white plumage, black plumage, buff plumage, blue plumage, red plumage, and color patterns of various kinds; and there are chickens that lay white-shelled, brown-shelled, and blue-shelled eggs. Take your choice of these and other characteristics, and in due time a chicken could be produced to meet your fancy. Thus, the lordly Brahma, with pea comb and feathered shanks, is a very different bird from the diminutive Rose Comb Bantam. The squatty Creeper stands in striking contrast to the upright Exhibition Game that can pick crumbs off a 2-foot table. The Leghorn with its graceful feather contour is quite different in build from the boat-shaped Cornish fowl.

The progenitor of the modern fowl was the wild cock whose call resounded through the bamboo jungles of India. In China the domestication of the cock dates back to as early as 1400 B.C., and in India, when the Aryans had reached the Ganges in 1000 B.C., domestic fowls were quite common. They were transported northward and westward against the line of Aryan invasion and reached Persia at an early date.

The first European distribution was overland rather than by sea, and in Gaul, England, and among the Germans, the Romans found flocks of domestic fowls well established. The first chickens to reach the New World were brought by Columbus on his second voyage in 1493. During the seventeenth and eighteenth centuries breeding stock was imported from China, England, and other countries.

The sport of cock fighting exercised a tremendous influence not only in the domestication of wild birds but also in the subsequent
distribution of the fowl. A verse written about 300 B.C. says that four things may be learned from a cock—to fight, to get up early, to eat with your family, and to protect your spouse when she gets into trouble. For centuries cock fighting has been a favorite pastime in southern and western Asia, Java, Borneo, Sumatra, and the Philippines. From India the sport was introduced into Persia and thence into Greece. Natives of Java and Sumatra have been known to stake all of their property on a cock fight, and if that was lost, they sometimes staked their wives and children.

In the United States, the real beginning of the poultry industry was contemporary with the founding of the first homes in Jamestown in 1607. In the early days poultry raising was still essentially a home enterprise, and as farming areas were opened up and homes established, farm flocks increased in numbers.

**FIGURE 6.** Slow feathering is dominant to rapid feathering and is sex-linked, so that when a White Leghorn male is mated to a Jersey Black Giant female the sons are slow-feathering, as shown in *A*, and the daughters are rapid-feathering, as shown in *B*.

**THE COMING OF POULTRY EXHIBITIONS**

The first poultry exhibition in the United States was held in Boston in 1849. From that time onward hundreds of poultry shows have been held annually. The early exhibitions gave impetus to the growing interest in the then known breeds and varieties of fowl, for by that time several countries had each developed characteristic races. China had produced its massive breeds with feathered shanks, India its fighting cocks, Italy its small-bodied birds with nervous dispositions, England its breeds excelling in fleshing properties, and the United States the numerous breeds known in the early days.

The holding of poultry exhibitions had the effect of encouraging poultry breeders to pay considerable attention to such characteristics as type, feather contour, and color markings. In fact, so much attention was given to the perfection of characteristics of minor economic importance that vigor and qualities of greater economic importance were often sacrificed. In those days poultry breeders were occupied in evolving plumage colorations in bewildering variety, and they produced birds differing widely in body type and feather
structure, thus demonstrating the relative plasticity of the original stock. What was accomplished within recent times by breeding from selected variants is apparent from the large number of breeds and varieties of fowl that now exist. With all their beauty of form and color markings, some breeds turned out to be better than others as flesh producers and some were noted for their laying ability.

Thus over a period of several centuries man first kept chickens for sport, then for pleasure, then for utility; and breeding first concentrated on fighting qualities, then on feather form and color pattern, and finally on egg and meat production.

In the early days of American agriculture grain was cheap, and inasmuch as chickens feed largely on grains and were able to utilize much "waste," it was soon found that eggs and poultry meat could be produced quite cheaply. Eggs came to occupy a unique place in the American dietary, the demand increased, and gradually an extensive farm-poultry industry developed, along with a commercial industry of no small proportions.

Along with this development, definite attempts were gradually made to improve the quality of breeding stock from an economic standpoint. Farm-flock records were kept, selection was practiced, egg-laying contests were started, and finally record-of-performance work was undertaken. Each of these methods has its value and each has its shortcomings.

**WHAT FARM-DEMONSTRATION-FLOCK RECORDS SHOW**

Although, as already noted, the average egg production of the birds of the country as a whole is very low, in some States there are numerous flocks whose level of production is maintained at approximately 150 eggs per bird year after year. In a number of the States the extension poultry specialist connected with the State agricultural college arranges with a group of the more progressive farmers to keep accurate annual records of egg production and feed consumption. These flocks are called farm demonstration flocks, and the records secured from them serve a very useful purpose in impressing upon flock owners the necessity of securing a good level of egg production to make a reasonable labor income.
The females of each demonstration flock are selected at the beginning of each laying year for vigor and for external characteristics indicative of good laying ability. The males are selected for vigor and type. In some States the work has been carried on for a number of years, and it is interesting to note that during recent years the average egg production per bird has been near the 150 egg level. The data in table 2 give the records of egg production per bird during 1927 to 1933, inclusive, for five States.

**What most poultry breeders want to know is how to develop males and females of superior breeding worth so as to raise the level of egg production, increase the average size and improve the quality of eggs, and reduce the annual cost of flock replacements.**

... There are valid reasons why research workers should take the lead in the solution of the following vital problems, which may well be considered the heart of any program for further progress:

1. The inheritance of egg production.
2. How to combine good average egg size with good production.
3. Whether or not it is possible to develop strains of high layers resistant to specific diseases.
4. How best to combine good hatchability with good production and good egg size.
5. Whether or not inbreeding is desirable or necessary to develop high-laying strains.
6. Whether or not worth-while results can be secured through cross-breeding or controlled heterozygosis.
7. The extent to which environment rather than inheritance is responsible for variability in breeding for such characteristics as egg production.
8. The best methods of selecting breeding stock and giving proper weight to production, pedigree, and progeny test.

The data in table 2 indicate that for a period of 7 years very little, if any, progress was achieved in increasing production over the level at the beginning of the period. Moreover, since improved methods of feeding and flock management should be expected to raise the level of production over a period of years, it is quite apparent that the mass selection of breeding stock, which has been the usual practice for these flocks, is relatively ineffective in increasing egg production. As a matter of fact, no one has ever presented evidence showing
that the level of egg production is raised through the mass selection of breeding stock. In order to secure increased egg production, owners of farm demonstration flocks would be well advised to secure males for breeding purposes that are the progeny of sires and dams that have been proved to be superior in breeding worth.

Figure 8.—All dressed up for the fight. The proper training of fighting cocks is quite an art. Cock fighting exercised a considerable influence on the domestication of the fowl.

TABLE 2.—The average annual egg production per bird for each of 7 consecutive years in farm-demonstration flocks in 5 States

<table>
<thead>
<tr>
<th>Year</th>
<th>Indiana</th>
<th>Maine</th>
<th>Missouri</th>
<th>New Hampshire</th>
<th>Ohio</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1927</td>
<td>130</td>
<td>138</td>
<td>142</td>
<td>145</td>
<td>149</td>
<td>145</td>
</tr>
<tr>
<td>1928</td>
<td>153</td>
<td>142</td>
<td>150</td>
<td>155</td>
<td>149</td>
<td>150</td>
</tr>
<tr>
<td>1929</td>
<td>145</td>
<td>150</td>
<td>147</td>
<td>148</td>
<td>151</td>
<td>148</td>
</tr>
<tr>
<td>1930</td>
<td>152</td>
<td>147</td>
<td>145</td>
<td>150</td>
<td>149</td>
<td>149</td>
</tr>
<tr>
<td>1931</td>
<td>145</td>
<td>153</td>
<td>154</td>
<td>157</td>
<td>155</td>
<td>153</td>
</tr>
<tr>
<td>1932</td>
<td>138</td>
<td>161</td>
<td>147</td>
<td>157</td>
<td>150</td>
<td>151</td>
</tr>
<tr>
<td>1933</td>
<td>140</td>
<td>159</td>
<td>143</td>
<td>163</td>
<td>145</td>
<td>150</td>
</tr>
</tbody>
</table>

THE LAYING CONTESTS

Apparently the first organized effort to stimulate interest in the identification of superior laying stock was the holding of laying "trials" in England as early as 1897. These trials were for short periods only, but they were followed by trials of about 1 year's duration, the first of which began in 1912. From that time on an officially conducted laying competition has been held every year at the Harper-Adams Agricultural College. The first 12-month laying competi-
tion was inaugurated, however, in 1902 in New South Wales, Australia, and was held at the Hawkesbury Agricultural College. In Canada the first officially conducted laying contest was started in British Columbia in 1911, and in the United States the Storrs egg-laying contest, in Connecticut, was started in the same year. During the past decade egg-laying contests have been held in several countries and the results secured have been quite interesting.

Four things in particular have been brought forcibly to the attention of poultrymen through the results secured at the laying contests:

1. A pen of 10 birds in a contest frequently averages over 250 eggs per bird in a year.\(^1\)
2. It has been shown that among 100 pens in any one contest there is usually great variation in laying ability, some pens averaging as many as 100 eggs per bird more than others.
3. Improved methods of feeding and management, including the use of artificial lights, during recent years have resulted in securing higher average egg production records quite independent of any improvement in breeding quality that may have taken place.
4. The most progress in breeding for increased egg production has been made with varieties such as White Leghorns, Black Langshans, Australorps, White Wyandottes, and Rhode Island Reds. In other words, in parti-colored varieties, where the poultry breeder has to select his breeding stock on the basis of perfection in color pattern in addition to egg-laying ability, an additional burden is added to the breeding program that may do much to prevent progress in dealing with characteristics of economic value.

### A Comparison of Results

Since three of these egg-laying contests have been running for a considerable number of years, it is interesting to compare the results at intervals. The data are given in table 3. The records of the leading varieties only were selected. The average annual egg production per bird for a period of 3 consecutive contest years was determined; then, following an interval of several years, another average was determined for another 3 consecutive contest years. In the case of the Australian contest conducted at Hawkesbury Agricultural College, there is an interval of approximately 25 years between the two averages determined; in the case of the United States contest conducted at Storrs Agricultural College, the interval between the two averages is approximately 15 years; in the case of the English contest conducted at Harper-Adams Agricultural College, the interval between the two averages is approximately 10 years.

The data given in table 3 show that in each of the three varieties of Australian birds, there was an increase in the second 3-year average over the first 3-year average as follows: White Leghorns, 2 eggs; Black Langshan, 28 eggs; Black Orpingtons, 27 eggs. It is to be noted that the White Leghorn level of production during the first 3-year period was comparatively high—so high that after approximately 25 years the level was raised but 2 eggs per bird. Because the Black Langshan and Black Orpington level of production during the first 3-year period was lower than the White Leghorn level, greater progress was possible; during the 25-year interval the black varieties caught up to the White Leghorns.

During the first 3-year period the level of egg production of the three American varieties was comparatively low, so that in an interval of 15 years a considerable increase could be achieved in each of the three varieties. As a matter of fact, starting on a lower level than the

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\(^1\) The ancestors of the domestic fowl sometimes laid about 15 eggs in each of two clutches during the year.
FIGURE 9.—Four interesting characteristics that show the extent to which variation has taken place among descendants of the wild fowl: A shows a Rumpless bird, rumplessness being dominant to the normal condition; B shows a Japanese Long Tailed fowl, this characteristic being incompletely dominant to normal tail; C shows a Creeper fowl, a characteristic which is dominant to normal and is lethal when in a homozygous condition, so that eggs containing two genes for the Creeper characteristic never hatch; D shows a Black Breasted Malay Game, its long legs and upstanding character being in striking contrast to the squatty appearance of the short-legged Creeper.
birds in other contests, the Storrs averages for each of the three varieties exceed by a considerable margin the averages obtained at the other two contests during the last 3-year period.

### Table 3.—The average annual egg production per bird for each of two 3-year periods for the leading varieties in Australian, United States, and English egg-laying contests

<table>
<thead>
<tr>
<th>Item</th>
<th>White Leghorns</th>
<th>Black Langshans</th>
<th>Black Orpingtons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia (Hawkesbury Agricultural College):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 years, 1908-11</td>
<td>192</td>
<td>171</td>
<td>173</td>
</tr>
<tr>
<td>3 years, 1932-35</td>
<td>194</td>
<td>199</td>
<td>200</td>
</tr>
<tr>
<td>United States (Storrs Agricultural College):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 years, 1915-18</td>
<td>159</td>
<td>169</td>
<td>157</td>
</tr>
<tr>
<td>3 years, 1930-33</td>
<td>235</td>
<td>217</td>
<td>220</td>
</tr>
<tr>
<td>England (Harper-Adams Agricultural College):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 years, 1922-25</td>
<td>186</td>
<td>186</td>
<td>169</td>
</tr>
<tr>
<td>3 years, 1931-34</td>
<td>187</td>
<td>192</td>
<td>166</td>
</tr>
</tbody>
</table>

William F. Kirkpatrick, in charge of the Storrs contest, has stated that during the past 5 years the average egg production of each pen of 13 birds has been determined on the records of the 10 highest ones. Since 1922 artificial lights have been used in the laying pens from 9 to 10 p.m. daily, and during the past 7 or 8 years the New England conference rations have been used, subject to slight changes from time to time. The extent to which these modifications in computation and management account for the increase in the level of egg production cannot be determined, but it may be safely assumed that during the last 15 years there has been a substantial increase in the laying ability of the birds entered in the contests.

During an interval of 10 years in the English contest, there was little change in the level of egg production of the three varieties.

It should be pointed out in connection with the results secured at egg-laying contests conducted over a period of years, that not all of the increase in egg production achieved is due to the breeding methods followed by the breeders who enter birds in the contests. Indeed, in many contests a great deal of the increase in levels of egg production has been due to improved methods of feeding and management at the contests.

### Drawbacks of the Laying Contests

Another point should be noted at this time concerning the achievement of the laying contests. Although the contests have shown that relatively high average egg production is possible, the influence of the contests on poultry-breeding methods practiced by the majority of the poultry breeders has apparently been of little consequence. This is evident from the fact that, in the United States at least, the average egg production of all birds in the country has improved very little over
a long period of years. As a matter of fact there are four serious limitations in the laying contests as they have been developed.

(1) Many poultry breeders become so interested in winning first place in a contest, because of the advertising value resulting therefrom, that the use of the contests in determining the best breeding methods has been seriously neglected.

(2) The contests are so few in number in the United States that it is impossible for them to be of great service to the majority of poultry breeders.

(3) Because of the limited number of birds that can be entered by an individual poultry breeder, the amount of information gained from the birds entered is often very limited when applied to the selection of superior sires and dams in his home flock.

(4) The results secured from a few specially selected birds that are entered in a contest do not often represent the breeding worth of the flock at home.

If substantial progress in breeding for increased egg production is to be achieved among the thousands upon thousands of farm and commercial flocks that are used for breeding purposes each year, something other than laying contests must be developed.

**RECORD-OF-PERFORMANCE ACCOMPLISHMENTS**

The egg-laying contests served as the foundation for what is known in various countries as record-of-performance work carried on by poultry breeders on their home premises. Although the contests served the purpose of establishing official records of egg production, no provision was made for the official recognition of the hatching eggs, baby chicks, and breeding stock produced by contest birds. This is what record-of-performance work provides for, and since it is possible to include many times as many birds as could be accommodated in laying contests, it is obvious that record-of-performance work should be of far greater service to the industry than laying contests.

In the United States the record-of-performance work is sponsored by the United States Record of Performance Federation, an organization of private breeders. The work has been carried on in 17 States, and in each State it is under the supervision of an official State agency. Of the numerous minimum requirements that must be met before official recognition is given to adult stock, hatching eggs, and baby chicks, only the more important features need be given here.

It is entirely a voluntary matter whether or not a poultry breeder takes up record-of-performance work. Pullets entered in the record-of-performance project are trap-nested on the breeder's premises, and during the year an official State inspector makes at least seven unannounced inspections, trapping and weighing the birds and weighing the eggs during each inspection. The breeding pens are inspected during the hatching season, and complete records of egg production of the pullets and breeding hens, as well as incubation and hatching records, must be sent regularly to the offices of the official State agency.

In order to qualify as a record-of-performance—abbreviated to r. o. p.—female, a bird must lay 200 or more eggs averaging at least 2 ounces each in 365 days from the date of laying the first egg. R. o. p. males are the sons of r. o. p. females that were mated to an r. o. p. male whose dam laid at least 225 eggs averaging 2 ounces or more each during her first laying year. R. o. p. hatching eggs can be produced only by an r. o. p. breeding pen, and r. o. p. chicks can be produced only from r. o. p. hatching eggs. The chicks secured from each r. o. p. dam are hatched separately and banded with sealed wing bands at hatching time. Thus the sire and dam of each chick produced are known.
Progress Achieved by the R. O. P. Method

Some conception of the progress achieved by record-of-performance breeders may be gained from the data in table 4. This table gives the percentage of birds that qualified for r. o. p. out of the original number entered in record-of-performance work at the beginning of the year.

Figure 10.—There is great variation among domestic fowls of today in the kind and degree of plumage development. A shows a Frizzled fowl, frizzling being incompletely dominant to normal plumage. B shows a Silkie fowl, the silky condition of the plumage being due to the fact that the barbules of each feather are hookless; silky plumage is recessive to normal plumage. C shows a Sultan male with its crest, muff, and beard, each of the characteristics being dominant to its absence. D shows a Naked Neck fowl, a characteristic that has been inherited from an early strain of Transylvania fowls. In not a few cases have exploiters advertised the Naked Neck bird as the progeny of a cross between the turkey and the chicken, whereas adult birds from such a cross have never been developed so far as is shown by accurate accounts that can be relied upon.

The data were obtained from three States in which a relatively large number of each of three different varieties were entered in record-of-performance work during the last 7 years. The data in table 4 show that among the three States there are considerable differences in the percentage of birds that qualified for r. o. p. These differences may have been due to differences in the breeding worth of the sires and dams of the pullets entered in the
State record-of-performance projects. On the other hand, the differences may have been due to slightly different standards adopted for qualification, inasmuch as in some States more attention was given to standardbred quality, as distinct from production, than in other States.

Table 4.—Percentage of birds in each of 3 varieties qualifying for r. o. p. in 3 States

<table>
<thead>
<tr>
<th>Year</th>
<th>Connecticut</th>
<th>Michigan</th>
<th>New Jersey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White Leghorns</td>
<td>Rhode Island Reds</td>
<td>Barred Plymouth Rocks</td>
</tr>
<tr>
<td>1927-28</td>
<td>10.7%</td>
<td>10.4%</td>
<td>2.2%</td>
</tr>
<tr>
<td>1929-30</td>
<td>22.3%</td>
<td>20.2%</td>
<td>14.6%</td>
</tr>
<tr>
<td>1930-31</td>
<td>20.0%</td>
<td>17.4%</td>
<td>19.6%</td>
</tr>
<tr>
<td>1931-32</td>
<td>23.4%</td>
<td>24.1%</td>
<td>26.6%</td>
</tr>
<tr>
<td>1932-33</td>
<td>20.3%</td>
<td>26.6%</td>
<td>26.9%</td>
</tr>
<tr>
<td>1933-34</td>
<td>24.5%</td>
<td>28.8%</td>
<td>20.2%</td>
</tr>
</tbody>
</table>

The most interesting observation to be noted in connection with the data in table 4 is the fact that for the most part relatively few birds qualify for r. o. p. Most of the birds fail to qualify because they do not lay 200 eggs, and some that lay 200 or more eggs fail to qualify because their eggs do not average 2 ounces in weight. Poultry breeders should realize that the smaller the percentage of birds in a flock that qualify, the more limited is the amount of selection possible among the qualified birds that are needed for breeding purposes. They should also realize that usually the fewer the number of breeders used and the fewer the number of matings made each year, the slower the progress to be expected in breeding for increased egg production.

Culling Pullets Lessens the Value of Results

A matter of great importance that tends to retard progress that might otherwise be achieved in record-of-performance work is the fact that many of the pullets originally entered in the project are culled before being allowed to complete their first laying year. Disease and sickness are sufficiently good reasons for some of the culling, but other pullets are culled because they start laying very late in life or lay at a very slow rate or lay very small eggs or for other reasons. Of course, a considerable amount of this culling is undoubtedly justified on purely economic grounds; the poultry breeder must make a living out of his business, and he feels justified in culling the birds that, he feels certain, have all the earmarks of uneconomical producers. At the same time, the practice of culling pullets during their first laying year tends to destroy what is known as the random sample of a population.

What all progressive poultry breeders must sooner or later realize is that the best way of determining the relative merits of the sires and dams used each year is to keep a random or representative sample of their progeny. When only selected pullets are kept, it becomes impossible to tell whether the breeding birds from which they came were really capable of producing stock of high average merit. The pullets culled out as being too poor to keep may more
nearly represent the breeding worth of their sires and dams than the pullets that were kept. This is a point that cannot be emphasized too strongly. A few prodigies of production are only "a drop in the bucket." It is the average production that must be constantly raised.

The Three-P Program—Production Record, Pedigree, and Progeny Test

A practical breeding program intended to produce superior germ plasm, which means superior breeding stock, must rest on a three-point base: Production record, pedigree, and progeny test.

Each of these must be given due weight. At the same time, each has its pitfalls, and if the breeder does not beware of them, he will find that his results fail to come up to expectations.

At the beginning of this article, certain serious shortcomings in present scientific knowledge and experimental practice were pointed out. In spite of this, there is now a respectable body of knowledge pertinent to poultry breeding, and both experimental work and the practice of some progressive breeders throw a good deal of light on the proper use of the production record, the pedigree, and the progeny test. These points, as well as certain other aspects of poultry breeding, will now be discussed in some detail. The great need for further research and experiment is obvious; but there is also no doubt that a wider use of present knowledge would result in considerable improvement in the poultry situation as a whole.

THE VALUE AND THE DRAWBACKS OF PRODUCTION RECORDS

With a few outstanding exceptions, most of the poultry breeders in the United States apparently attach considerable significance to the first-year records of the females. Many of them seem to assume that, since a record of 200 eggs is the minimum requirement for record-of-performance qualification, all birds laying 200 or more eggs are bound to be good breeders. Moreover, there is a widespread belief that the higher the first-year record of the dam, the more eggs will her pullet progeny lay. In other words, it is claimed that the number of eggs a bird lays during her first laying year is a criterion of her breeding worth.

Data have been obtained from different sources which show that actually the first-year production record of a female is only of very limited value in predicting her breeding worth, especially when the breeding females are selected on the basis of having laid 200 or more eggs during their first laying year, as is the case in record-of-performance work in the United States. A true test of the relationship that normally exists between the egg production of dams and the egg production of their daughters could be made only in the case of dams not selected on the basis of first-year egg-production records and complete families of daughters—that is, where no culling of pullets was practiced during the first laying year. Insofar as is known, however, no such
data exist for the simple reason that in practically all projects on breeding for increased egg production, the dams are selected to a greater or less extent on the basis of their first-year records.

However, data are available which show the relationship between the egg production of selected dams and the egg production of unselected daughters, the records of all daughters except those that died being included. In table 5 are given data on Rhode Island Reds at the National Agricultural Research Center, Beltsville, Md., and on White Leghorns at the Mount Hope Farm, Williamstown, Mass., the latter having been very kindly supplied by H. D. Goodale. The Beltsville dams were selected on the basis of having laid a minimum of 200 eggs their first laying year, whereas in the case of the Mount Hope Farm dams the minimum given in table 5 is 181 eggs. Insofar as is known, except for flocks maintained at the Massachusetts Agricultural Experiment Station and at a private breeding establishment in California, the two flocks providing the data for table 5 are the only ones in the country in which all pullets that lived were allowed to complete their first year of laying, embracing 365 days from the date of the first egg in the case of each pullet.

<table>
<thead>
<tr>
<th>Range in egg production of dams</th>
<th>Average egg production of daughters</th>
<th>Range in egg production of dams</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beltsville Rhode Island Reds</td>
<td></td>
<td>Beltsville Rhode Island Reds</td>
</tr>
<tr>
<td>181-190</td>
<td>192</td>
<td>251-260</td>
<td>291</td>
</tr>
<tr>
<td>191-200</td>
<td>197</td>
<td>261-270</td>
<td>200</td>
</tr>
<tr>
<td>201-210</td>
<td>188</td>
<td>271-280</td>
<td>197</td>
</tr>
<tr>
<td>211-220</td>
<td>205</td>
<td>281-290</td>
<td>179</td>
</tr>
<tr>
<td>221-230</td>
<td>192</td>
<td>291-300</td>
<td>208</td>
</tr>
<tr>
<td>231-240</td>
<td>192</td>
<td>301-310</td>
<td>222</td>
</tr>
<tr>
<td>241-250</td>
<td>199</td>
<td>311-320</td>
<td>220</td>
</tr>
</tbody>
</table>

1 Data from an unpublished paper given at the Poultry Science Association meeting, 1935.

The data in table 5 show no apparent relationship between the egg production of the dams and that of the daughters among the Beltsville Rhode Island Reds, but they show a slight relationship between the egg production of dams and that of the daughters among the Mount Hope Farm White Leghorns.

Relationship of Daughter and Dam Production Relatively Low

It is interesting to observe that the average egg production of the daughters of each of the first six groups of Beltsville dams was considerably higher than the average egg production of the daughters of each of the comparable groups of the Mount Hope Farm dams. The Beltsville data were obtained from matings of yearling and older hens made in 3 consecutive years, 1928 to 1930, inclusive, the dams being mated to males whose dams laid 200 or more eggs during their first laying year. The Mount Hope Farm data were obtained from pullet matings made during the years 1923 to 1929, inclusive, and Dr. Goodale has stated that the low-producing dams listed in the table
were used mainly during the first 2 or 3 years. Moreover, the sires he used each year were selected on the basis of the records of egg production made by their sisters up to February 1, from which it may be assumed that the males selected one year were somewhat superior to the males selected the preceding year. The use of sister-tested males should in itself tend to increase the egg production of the daughters raised each succeeding year, even if the dams' records of egg production had been the same for each of the 7 years.

Even so, it is apparent that the relationship between dam and daughter egg production is of a relatively low order. For instance, the group of dams with a range in production of 201–210 eggs had daughters that averaged 168 eggs, whereas the group of dams with a range in production of 271–280 eggs had daughters that averaged 188 eggs. The average egg production of these groups of dams differed by approximately 75 eggs, but their daughters' averages differed by only 20 eggs. The White Leghorn data show, however, that on the average the higher the egg production of the dams the higher the egg production of the daughters.

Those who hold that the egg-production record of a selected dam is an index of her breeding worth should examine carefully the source of the data on which their belief is based. In table 5 it is shown that the Mount Hope White Leghorn dams that laid from 201 to 210 eggs had daughters that averaged 168 eggs each, and the dams that laid from 281 to 290 eggs had daughters that averaged 208 eggs each, the difference in the average egg production of the two groups of daughters being 40 eggs. On the other hand, the Beltsville Rhode Island Red dams that laid from 211 to 220 eggs had daughters that averaged 205 eggs, whereas the Mount Hope White Leghorn dams that laid from 211 to 220 eggs had daughters that averaged 161 eggs, there being a difference of 44 eggs in the average production of daughters that came...
from dams with the same records. The difference in the average egg production of daughters of dams with similar records was 4 eggs greater than the difference in the average egg production of daughters of dams that differed in egg production by approximately 80 eggs. Then again, those who claim that the first-year record of egg production of a bird is a good index of her breeding worth, would have great difficulty in accounting for the fact that the Beltsville dams with a range of 201–210 eggs and the Mount Hope dams with a range of 271–280 eggs produced daughters that had exactly the same average egg production.

Although the selection of dams on the basis of their first-year records of egg production is thoroughly justified, the data in table 5 show that the production records by and of themselves are of limited value. Dr. Goodale has expressed the idea very well as far as it per-

THERE are approximately 400,000,000 adult chickens kept annually on American farms, and they produce eggs at the rate of about 60,000 every minute, day and night. . . . It is clear, then, that egg production is a matter of great economic importance. It has been shown by surveys that the average number of eggs laid per bird per year is one of the chief factors that determine the revenue obtained from a flock. Yet average production in the country as a whole is abnormally low—approximately 80 eggs per bird per year, according to census estimates. . . . Many poultrymen fail to realize that heredity is inescapable. . . . For the poultry industry as a whole, it is of the first importance to develop strains of fowl that will produce eggs more efficiently. The cost of production and reproduction should be reduced.

tains to the data from the Mount Hope Farm birds when he says "that on the average there is a definite relationship between the egg records of dams and those of daughters." Some poultrymen have assumed, however, that if it can be shown that in certain flocks there is a slight correlation between dam and daughter egg production, then it must follow that in all flocks the selection of breeding stock on the basis of individual records would rather quickly raise the level of egg production. These poultrymen usually overlook the conditions involved in selecting the breeding stock in those flocks where a dam-daughter correlation has been shown to exist, and they fail to realize that these conditions do not apply to the great majority of poultry breeding flocks throughout the country—including those in record-of-performance work. Most poultry breeders in the United States cull their pullet flocks rather closely and many of them use individual records of egg
production as the sole basis for selecting their breeding stock. While poultry breeders should be encouraged to select their breeding stock on the basis of production records, they should be cautioned not to attach too much significance to those records.

If the first-year egg-production records of a female served as an accurate index of her breeding worth, as some have claimed, the problem of breeding for increased egg production would be comparatively simple. The data in table 6 show how divergent are the results sometimes secured from two groups of daughters produced by the same dam mated in different years to the same or to different sires. These data were obtained from the National Agricultural Research Center, the first five dams in the table being Rhode Island Reds and the second five White Leghorns. The daughters’ averages given in the table were determined for all daughters produced by each mating except for birds that died.

<table>
<thead>
<tr>
<th>Dam no.</th>
<th>Sire no. —</th>
<th>Dam’s production</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First year</td>
<td>Second year</td>
<td>First year</td>
</tr>
<tr>
<td></td>
<td>Rhode Islands Reds:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6024</td>
<td>176</td>
<td>176</td>
<td>212</td>
</tr>
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<td>6027</td>
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<td>176</td>
<td>206</td>
</tr>
<tr>
<td>6401</td>
<td>334</td>
<td>334</td>
<td>233</td>
</tr>
<tr>
<td>3829</td>
<td>325</td>
<td>338</td>
<td>216</td>
</tr>
<tr>
<td>6142</td>
<td>351</td>
<td>368</td>
<td>212</td>
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<tr>
<td>White Leghorns:</td>
<td></td>
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</tr>
<tr>
<td>2786</td>
<td>50</td>
<td>249</td>
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</tr>
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<td>3472</td>
<td>100</td>
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<td>235</td>
</tr>
<tr>
<td>3728</td>
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<td>3845</td>
<td>91</td>
<td>248</td>
<td>292</td>
</tr>
<tr>
<td>3287</td>
<td>100</td>
<td>249</td>
<td>230</td>
</tr>
</tbody>
</table>

The data in table 6 show that the same dam when mated to the same sire may produce daughters in two different years that differ in average egg production by as much as 40 eggs. When mated to different sires the daughters of the same dam in successive years differ by as much as 60 eggs.

Dr. Goodale has kindly submitted a table bearing on the very diverse results secured from dams with similar records of egg production. The data are arranged in table 7 according to the magnitude of egg production of the dams.

<table>
<thead>
<tr>
<th>Dam no.</th>
<th>Dam’s production</th>
<th>Dam’s production of daughters</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 310</td>
<td>280</td>
<td>11</td>
<td>137</td>
</tr>
<tr>
<td>H 632</td>
<td>280</td>
<td>11</td>
<td>220</td>
</tr>
<tr>
<td>H 179</td>
<td>280</td>
<td>7</td>
<td>167</td>
</tr>
<tr>
<td>G 1460</td>
<td>282</td>
<td>11</td>
<td>201</td>
</tr>
<tr>
<td>G 284</td>
<td>284</td>
<td>10</td>
<td>255</td>
</tr>
<tr>
<td>G 709</td>
<td>286</td>
<td>11</td>
<td>167</td>
</tr>
</tbody>
</table>

Table 6.—The average egg production of each group of daughters of dams mated to the same and to different sires in 2 different years.

Table 7.—The average egg production of each group of daughters of dams with similar records of egg production.
Shortcomings of Individual Records

It is unfortunate for the poultry-breeding industry that many poultry breeders attach so much importance to individual records of production, especially since it has been shown that progress in breeding for increased egg production is bound to be achieved very slowly as long as a record of egg production is the only basis used in selecting the breeding stock.

There are several reasons why the record of a bird’s egg production may not be nearly so significant in indicating her breeding worth as many poultry breeders are inclined to believe. Egg production is a quantitative characteristic that is easily influenced by environmental conditions and by the diet given the laying stock. Poorly balanced diets, improper methods of feeding, poor housing conditions, sudden changes in temperature, internal and external parasites, and diseases of various kinds all significantly decrease production. There may be a vast difference between the number of eggs a bird actually lays and the number she might have laid if she had been kept under ideal conditions. Rarely do ideal conditions prevail, however, that enable a bird to lay the number of eggs of which she is potentially capable.

THE IMPORTANCE OF PEDIGREE

By pedigree breeding in poultry is meant the mating of birds with pedigrees and keeping account of the parentage of the chicks produced so that their pedigrees are a matter of record. A bird’s ancestry sometimes gives considerable information of value regarding its probable worth as a breeder. Of two birds with the same first-year egg-production records, the one with a good ancestry is to be preferred to the one of poor ancestry. The chances are greater that the former will give better results in breeding than the latter; the chances are greater—but there is no guarantee that a bird of good ancestry will always produce good progeny.

Although a good pedigree is of importance in selecting breeding stock, there are certain limitations in the application of pedigree selection. For instance, very little significance can be attached to individual records of egg production of ancestors beyond the third generation. Then again, the greater the variation in the environmental conditions—including diet, method of housing, and the use of artificial lights—to which a flock is subjected over a period of years, the less reliance can be placed upon the ancestors’ records of production in the selection of progeny for future breeding purposes.

The data in table 8, pertaining to Beltsville Rhode Island Reds and Mount Hope Farm White Leghorns, show that the higher the egg production of the three nearest female ancestors of both sire and dam, the higher is likely to be the average egg production of their progeny. In the case of each flock, the environmental conditions were kept as uniform as possible from year to year.

Judging from the data in table 8, it is apparent that the selection of breeding stock on the basis of ancestors’ records of production to the third generation is of considerable importance. As a matter of fact, the more information there is in the pedigree concerning the records of egg production of the sisters of parents and grandparents, and the more information there is concerning the breeding performance of parents and grandparents and their relatives, the greater the value of the pedigree in selecting breeding stock.
The table below shows the average egg production of daughters according to the range in average egg production of the three nearest female ancestors of both sire and dam.

<table>
<thead>
<tr>
<th>Range in average egg production of daughters</th>
<th>Average egg production of daughters</th>
<th>Range in average egg production of the three nearest female ancestors of both sire and dam</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beltsville Rhode Island Reds</td>
<td>Mount Hope Farm White Leghorns 1</td>
<td>Beltsville Rhode Island Reds</td>
<td>Mount Hope Farm White Leghorns 1</td>
</tr>
<tr>
<td>209-217</td>
<td>186</td>
<td>254-262</td>
<td>199</td>
</tr>
<tr>
<td>218-226</td>
<td>197</td>
<td>263-271</td>
<td>213</td>
</tr>
<tr>
<td>227-235</td>
<td>199</td>
<td>272-280</td>
<td>216</td>
</tr>
<tr>
<td>244-248</td>
<td>176</td>
<td>281-289</td>
<td>222</td>
</tr>
<tr>
<td>245-253</td>
<td>208</td>
<td>290-298</td>
<td>219</td>
</tr>
</tbody>
</table>

1 Data from an unpublished paper given at the Poultry Science Association meeting, 1935.

The significance of progeny testing

The supreme test of the worth of a bird as a breeder is the kind of progeny it produces. Thus in the case of a dam it is not her individual laying record that counts so much as the average laying record of her daughters, which is quite a different thing. Strangely enough, the first impetus given to progeny testing in breeding for increased egg production was the failure resulting from an attempt to develop an egg-laying strain through the selection of female breeders based entirely on their first-year records of egg production. Apparently, the first attempt at a State institution to improve egg production through selection was made by the late G. M. Gowell of the Maine Agricultural Experiment Station. Gowell's work was carried on some 35 years ago with Barred Plymouth Rocks, and the records show that over a period of 9 years the practice of selecting female breeders on the basis of their first-year trap-nest records failed to produce an increase in the level of egg production among the pullets raised each year.

The work of Gowell, however, laid the foundation for later work which demonstrated the significance of the progeny test in breeding for increased egg production. Continuing the breeding work with the Barred Plymouth Rock at the Maine Station, Raymond Pearl demonstrated that by selecting cockerels and pullets for future breeding purposes each year from among the best families of that year, a steady increase in the level of egg production was achieved. Cockerels and pullets to be used as breeders were selected from among the progeny of sires and dams that proved to be superior in breeding worth to other sires and dams. The progeny-test method of selecting breeding stock has been used consistently for a period of years in the breeding of Rhode Island Reds at the Massachusetts Agricultural Experiment Station, where F. A. Hays has achieved outstanding results.

It is particularly important for poultry breeders to be able to identify sires of superior breeding worth because the average sire has about 10 times as many chicks as the average dam. A practical way of applying the progeny test to sires without trap-nesting either the dams or their daughters has been suggested by A. L. Hagedoorn of the Netherlands. Separate breeding pens are maintained in each of which one male is mated to the usual quota of females. The chicks from each sire are banded at hatching time so that the pullets can be distinguished from the pullets secured from other sires. The laying pullets from each sire are placed in separate houses or pens.
and by comparing the average egg production of the pullets of each sire, the breeder is able to determine which sires were superior in breeding worth.

The difference in breeding worth of sires mated to trap-nested Rhode Island Red dams having minimum first-year records of 200 eggs and White Leghorn dams having minimum first-year records of 225 eggs is shown in table 9. The data were obtained from a few of the matings made at the National Agricultural Research Center. The records of egg production of all daughters placed in the laying houses, except for birds that died, were used to compute the average for each of the different groups of daughters. The mortality among Rhode Island Red daughters was 9.17 and among the White Leghorns 13.26 percent. The average egg production of all the Rhode Island Red daughters was 192.03 and of all the White Leghorn daughters 192.85.

<table>
<thead>
<tr>
<th>Sire no.</th>
<th>Average egg production of sire’s mates</th>
<th>Number of daughters</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td>173</td>
<td>223</td>
<td>48</td>
<td>210</td>
</tr>
<tr>
<td>100105</td>
<td>242</td>
<td>49</td>
<td>216</td>
</tr>
<tr>
<td>1334</td>
<td>231</td>
<td>31</td>
<td>211</td>
</tr>
<tr>
<td>1338</td>
<td>238</td>
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<td>206</td>
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<tr>
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<td>242</td>
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<td>1335</td>
<td>250</td>
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<tr>
<td>351</td>
<td>232</td>
<td>75</td>
<td>171</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sire no.</th>
<th>Average egg production of sire’s mates</th>
<th>Number of daughters</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td>173</td>
<td>223</td>
<td>48</td>
<td>210</td>
</tr>
<tr>
<td>100105</td>
<td>242</td>
<td>49</td>
<td>216</td>
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<td>1334</td>
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<td>1335</td>
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<td>192</td>
</tr>
<tr>
<td>351</td>
<td>232</td>
<td>75</td>
<td>171</td>
</tr>
</tbody>
</table>

1 These sires were used in 2 consecutive breeding seasons.

The data in table 9 make it quite clear that certain sires were much superior to others from the standpoint of transmitting laying ability to their daughters. The sons and daughters of sires nos. 173 and 3 are likely to be much better breeders than the sons and daughters of sires nos. 351 and 50.

Random Versus Selective Sampling

It has been pointed out previously that the cooperative survey on plant and animal improvement revealed the fact that comparatively few poultry breeders keep sufficiently complete records to make possible an analysis of their results. The fact was also brought out that in many cases rather rigid culling of the pullet flocks is practiced each year, so that a random sample of the progeny population is not retained for the purpose of identifying the superior sires and dams.

On the other hand, there are some poultry breeders who carry on progeny-testing work on an extensive scale and who, from the various matings made, retain either all of the progeny or a sufficiently large number to make it possible to concentrate breeding work among families that have been developed from superior sires and dams. The record made of a random sample of the progeny, of course, gives the

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most accurate index of the breeding worth of the breeder's flock or mating. For instance, a poultry breeder in Idaho sold one of his customers 400 White Leghorn chicks, and the 197 pullets that were raised averaged approximately 238 eggs per bird.

As compared with the other classes of domestic livestock, so many more matings can be made and so many more offspring can be produced in 1 year by even a few breeders of chickens that it would be practically impossible to encompass within the space allotted to this article the results secured from any but a small proportion of the more outstanding matings. An enumeration of the outstanding matings made by the leading poultry breeders during the past 2 or 3 years would make a very formidable list. Moreover, except for certain details, the various matings tell the same story. Rather than give the results of a large number of matings, it was deemed advisable to give a few illustrations of the results secured by a few of the leading poultry breeders. The results these men have obtained show what is possible in a well-planned breeding program involving progeny testing and the use of sires and dams that have proved to be of superior breeding worth. For this purpose, the data submitted by the following breeders are presented here: A, Washington, White Leghorns; B, Connecticut, Barred Plymouth Rocks; C, California, White Leghorns; D, Massachusetts, White Leghorns and Rhode Island Reds; and E, Massachusetts, Rhode Island Reds.

The data in table 10 give the average egg production of the daughters of different sires used by the poultry breeders mentioned. Owing to the fact that some culling of the daughters of certain sires was practiced during the first laying year, as indicated in table 10, it is not possible to ascertain a true measure of the breeding worth of the sires in these cases. At the same time, even in these cases most of the sires had a sufficiently large number of daughters with a high average egg production to justify the poultry breeders in regarding these sires as of superior breeding worth.
Table 10.—The average egg production of daughters of different sires used in a few private breeding flocks

<table>
<thead>
<tr>
<th>Poultry breeder</th>
<th>Variety</th>
<th>Sire no.</th>
<th>Average egg production of sire's mates</th>
<th>Number of daughters</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>White Leghorns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>28</td>
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<td></td>
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<td></td>
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<td>218</td>
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<tr>
<td></td>
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<td></td>
<td>G11</td>
<td>284</td>
<td>114</td>
<td>163</td>
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<td></td>
<td>1</td>
<td>263</td>
<td>130</td>
<td>245</td>
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<td>277</td>
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<td>1</td>
<td>268</td>
<td>26</td>
<td>234</td>
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<td>4</td>
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<td>25</td>
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<td></td>
<td></td>
<td>13</td>
<td>257</td>
<td>32</td>
<td>255</td>
</tr>
</tbody>
</table>

1 In these groups of daughters, culling during the first laying year was practised to some extent.
2 These sires were used for 2 or more breeding seasons.

Identifying Superior Sires and Dams

Particular mention should be made of the data submitted by C and D. When the questionnaires were sent to a number of leading poultry breeders, they were asked to give the results of some outstanding sires and the results of some inferior sires. Both of the poultrymen mentioned were good enough to include data on inferior sires as well as superior ones. Since neither of these poultrymen culled pullets during the first laying year, it is possible to make fairly accurate appraisal of the breeding worth of the different sires involved.

C, for instance, knows full well that sire no. G10, whose mates’ average was 264 eggs and daughters’ average was 219 eggs, is greatly superior in breeding worth to sire no. G11, whose mates’ average was 285 eggs and daughters’ average was 163 eggs. Likewise, D, with his White Leghorns, would pick sire no. 1, whose mates and daughters averaged 283 and 243 eggs, respectively, over sire no. 5, whose mates and daughters averaged 255 and 152, respectively. D’s Rhode Island Red sire no. 1 was mated to females that averaged 252 eggs and his daughters averaged 242 eggs whereas sire no. 5, although mated to females that averaged 270 eggs, had daughters that averaged only 165 eggs.

Although it has been pointed out previously that the ability to identify and make use of sires of superior breeding worth is of paramount importance in raising the level of egg production of the flocks of the country, nevertheless it is highly important to be able to identify a female of superior breeding worth, if for no other reason than
to produce more superior males. Some of the poultry breeders submitted data giving the average egg production of the daughters of a few of the dams they have used. The data of A and B, given in table 11, for White Leghorns and Barred Plymouth Rocks, respectively, are sufficient to show what can be accomplished.

Table 11.—The average egg production of daughters of different dams of outstanding breeding worth as reported in a survey of poultry breeding

<table>
<thead>
<tr>
<th>Breeder and variety</th>
<th>Dam no.</th>
<th>Dam's production</th>
<th>Number of daughters</th>
<th>Average egg production of daughters</th>
<th>Breeder and variety</th>
<th>Dam no.</th>
<th>Dam's production</th>
<th>Number of daughters</th>
<th>Average egg production of daughters</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, White Leghorns</td>
<td>Y 308</td>
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<td>23</td>
<td>243</td>
<td>K33916</td>
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<td>Y 417</td>
<td>260</td>
<td>39</td>
<td>233</td>
<td>3232</td>
<td>258</td>
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<td>255</td>
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<td>230</td>
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</tr>
</tbody>
</table>

1 These birds were used 2 or more years.

Even though some of the daughters of the different White Leghorn dams listed in table 11 were culled during their first laying year, it is apparent that all of the dams are birds of considerable merit as determined by the progeny test. There was practically no culling in the case of the Barred Plymouth Rock groups of daughters.

It might be well to mention here that the most progressive breeders use every means available to identify superior sires and dams in their flocks. Among other things, in addition to the kind of progeny produced by different sires and dams, the production records of their sisters are usually taken into consideration. For instance, A’s White Leghorn dam no. A2711 had 11 sisters that averaged 240 eggs; dam no. A3131 had 12 sisters that averaged 256 eggs; dam no. G2235 had 12 sisters that averaged 255 eggs; dam no. P262 had 10 sisters that averaged 240 eggs. B’s Barred Plymouth Rock dam no. 3232 had 18 sisters that averaged 200 eggs and dam no. 3779 had 12 sisters that averaged 219 eggs.

Then again, many poultry breeders give considerable weight to pedigree in selecting their breeding stock. Such breeders should always remember, however, that certain things which the breeder may practice tend to lessen the value of the pedigree. As already pointed out, the greater the extent to which the diet and environmental factors governing egg production have been changed from year to year, the less significant are the records of egg production of the birds appearing in the pedigree of an individual. Again, it should always be kept in mind that the greater the extent to which culling was practiced in previous years, the less the value of the records of the birds that were retained and that appear in the pedigree.

It is apparent, therefore, that even under the best of circumstances there are a number of handicaps, to say nothing of the expense involved, under which the average poultry breeder must labor in his
efforts to select sires and dams of superior breeding worth. Then again, since the chicken is a relatively short-lived creature and since sires and dams may be 3 or 4 years old by the time they have been proved to be of superior breeding worth by the progeny test, it is apparent that if their “blood” is to be perpetuated, their sons and daughters must be used for future breeding purposes. The use of these sons and daughters is sound breeding practice because they have a far greater chance of being superior breeders than the sons and daughters of unproved sires and dams.

Figure 13.—It is from dams of superior breeding worth that superior males are obtained. The Rhode Island Red hen (A) laid 239 eggs and had 7 daughters that laid an average of 208 each. The Rhode Island Red hen (B) laid 248 eggs and had 10 daughters that laid an average of 245 each. It is from such families of sisters whose average egg production is high that good breeding brothers are to be obtained.

It Is the Family That Counts

The following examples will serve to emphasize the importance of selecting for breeding purposes males and females that are members of good families. At the National Agricultural Research Center three Rhode Island Red sires, nos. 330, 334, and 338, gave such satisfactory results in their first breeding season that they were used a second season. No culling was practiced among the daughters during their first laying year. The average egg production of the daughters produced each of the 2 years has already been given in table 9, but for the sake of convenience to the reader they are repeated here: Sire no. 330: First group of daughters, 201 eggs; second group, 195 eggs. Sire no. 334: First group of daughters, 211 eggs; second group, 205 eggs. Sire no. 338: First group of daughters, 206 eggs; second group, 192 eggs.

Sires nos. 330 and 334 were half brothers on their sire’s side. The dam of no. 330 was one of the eight sisters that averaged 213 eggs, and no. 330 had five sisters that averaged 236 eggs. The dam of no. 334 was one of four sisters that averaged 222 eggs, and no. 334 had four sisters that averaged 214 eggs. The dam of no. 338 was one of two sisters that averaged 225 eggs, and no. 338 had 16 sisters that
averaged 235 eggs. A son of no. 334 produced 58 daughters that averaged 205 eggs. This son had six sisters that averaged 214 eggs. The intelligent selection of breeding stock on a family basis, which is the essence of progeny testing, is the surest way of making progress.

Some Main Objectives and Methods in Poultry Breeding

IT IS all too true that many poultry breeders have been carrying on their breeding operations for years without having the slightest knowledge of the various egg-production characteristics their birds possess. On the other hand, the more progressive breeders, by their system of carefully tabulated records for individual birds and for the results secured from various matings, are well fortified with specific information that makes possible intelligent selection of males and females for future breeding.

CHARACTERISTICS DETERMINING EGG PRODUCTION

Poultry breeders have found that the observations made in the breeding of Rhode Island Reds during the last 30 years at the Massachusetts Agricultural Experiment Station have been of great help in deciding which birds to select as breeders. For a number of years the work at the Massachusetts station was under the direction of Dr. Goodale, who was followed by F. A. Hays. The station has made important contributions to the knowledge of the mode of inheritance of various characteristics of economic importance in poultry. Among other things, it has been observed that there are five principal characteristics that determine the number of eggs a bird lays during her first laying year.

Briefly, in order to lay well a pullet should possess the five following characteristics: (1) Early sexual maturity; (2) good rate of laying; (3) non broodiness; (4) absence of winter pause; and (5) persistence of production.

Numerous poultry breeders and workers at some of the State experiment stations take these five characteristics into consideration in the selection of layers to be used as future breeders. An analysis of the egg-production records of Rhode Island Reds and White Leghorns at the National Agricultural Research Center shows, however, that in these flocks winter pause has not been of great importance.

By sexual maturity is meant the age of the bird in days at the time she begins laying. Rate of laying is determined by figuring, on a percentage basis, the number of eggs laid from the date of the first egg to a given date in relation to the total number of days involved; or rate may be determined on the basis of average size of the winter clutch, as Hays has done. A clutch is the number of eggs laid during successive days without any intervening days of no production. Broodiness is a simple characteristic to determine; the number of times a pullet goes broody and the length of time are usually taken into consideration, or the percentage of birds in the flock that go broody is considered. Persistence of production simply means that
the pullet continues laying well toward the close of her first laying year, which is 365 days from the date of the first egg. In the case of the Beltsville flocks, persistence of production was determined by the number of eggs laid during August and September. In the case of the Massachusetts flocks, persistence was determined on the basis of the length of time laying continued from the date of the first egg.

If a White Leghorn or Rhode Island Red pullet is to lay approximately 200 eggs during her first laying year, the White Leghorn should commence laying at about 180 days of age and the Rhode Island Red at about 190 days. Pullets of both breeds should lay at about the rate of 60 percent. There should be practically no broodiness. They should lay approximately 25 eggs during August and September.

Each of these characteristics can be developed in a flock by the adoption of a sound breeding program. The results obtained with the Massachusetts Rhode Island Reds show what can be accomplished. The data given in table 12 were kindly supplied by Dr. Hays.

Table 12.—Increase in level of egg production with improvement in four characteristics in Rhode Island Reds at the Massachusetts Agricultural Experiment Station

<table>
<thead>
<tr>
<th>Year</th>
<th>Pullets</th>
<th>Sexual maturity</th>
<th>Rate of laying</th>
<th>Non-broodiness</th>
<th>Persistence</th>
<th>Average egg production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Days</td>
<td>Percent</td>
<td>Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1920</td>
<td>162</td>
<td>200</td>
<td>2.7</td>
<td>54</td>
<td>331</td>
<td>200</td>
</tr>
<tr>
<td>1921</td>
<td>440</td>
<td>211</td>
<td>3.3</td>
<td>55</td>
<td>304</td>
<td>198</td>
</tr>
<tr>
<td>1922</td>
<td>565</td>
<td>197</td>
<td>2.7</td>
<td>71</td>
<td>322</td>
<td>200</td>
</tr>
<tr>
<td>1923</td>
<td>472</td>
<td>209</td>
<td>2.4</td>
<td>73</td>
<td>323</td>
<td>189</td>
</tr>
<tr>
<td>1924</td>
<td>422</td>
<td>196</td>
<td>2.5</td>
<td>67</td>
<td>327</td>
<td>196</td>
</tr>
<tr>
<td>1925</td>
<td>533</td>
<td>192</td>
<td>3.1</td>
<td>58</td>
<td>330</td>
<td>205</td>
</tr>
<tr>
<td>1926</td>
<td>479</td>
<td>195</td>
<td>2.7</td>
<td>81</td>
<td>331</td>
<td>205</td>
</tr>
<tr>
<td>1927</td>
<td>551</td>
<td>185</td>
<td>3.5</td>
<td>90</td>
<td>321</td>
<td>197</td>
</tr>
<tr>
<td>1928</td>
<td>509</td>
<td>196</td>
<td>3.4</td>
<td>72</td>
<td>335</td>
<td>215</td>
</tr>
<tr>
<td>1929</td>
<td>507</td>
<td>197</td>
<td>3.4</td>
<td>87</td>
<td>330</td>
<td>208</td>
</tr>
<tr>
<td>1930</td>
<td>461</td>
<td>191</td>
<td>3.7</td>
<td>78</td>
<td>349</td>
<td>214</td>
</tr>
<tr>
<td>1931</td>
<td>462</td>
<td>188</td>
<td>3.8</td>
<td>84</td>
<td>344</td>
<td>234</td>
</tr>
<tr>
<td>1932</td>
<td>577</td>
<td>202</td>
<td>3.3</td>
<td>88</td>
<td>338</td>
<td>222</td>
</tr>
<tr>
<td>1933</td>
<td>504</td>
<td>194</td>
<td>3.3</td>
<td>95</td>
<td>342</td>
<td>214</td>
</tr>
</tbody>
</table>

1 Average number of eggs per clutch.

Since many poultrymen who keep Plymouth Rocks, Rhode Island Reds, Wyandottes, and similar breeds often experience difficulty in eliminating broodiness from their flocks, it is interesting to note that the number of birds in a flock that go broody, as well as the length of time they spend in being broody, can be materially reduced if every time a hen goes broody she is banded with a celluloid band and is never used as a breeder. The economic importance of reducing broodiness is shown by the difference in egg production between Beltsville Rhode Island Reds that went broody and those that showed no broodiness. The birds that went broody once or oftener during the year averaged 180 eggs, while those that did not go broody averaged 205 eggs.

**BREEDING FOR EGG QUALITY**

Egg production is not the only criterion for determining the breeding worth of sires and dams. There are four other characteristics, of interest to consumers as well as producers, that should be taken into consideration in the development of breeding stock that will best
meet the needs of the poultry industry. Housewives want eggs for cooking and baking purposes that have the following four qualities: (1) Good size, (2) uniform shell color, (3) sound shell texture, and (4) good interior quality.

These are the four characteristics that poultry breeders should attempt to develop in their breeding stock. They are all transmitted by inheritance. It is true, of course, that very little is known concerning the exact manner in which these characteristics are inherited, but it has been established that the proper selection of breeding stock will soon lead to considerable improvement. The method of selecting for each of the four characteristics is exactly the same as outlined for improving egg production. For each characteristic the poultry breeder should select birds for breeding purposes on the basis of the kind of eggs laid by each individual, the kind of eggs laid by the ancestors, and the kind of eggs laid by the progeny. In other words, selection is based on production, pedigree, and progeny test.

![Figure 14](image)

**Figure 14.**—The progeny test tells the tale. Here are two brother Rhode Island Reds that produced entirely different results when mated to dams with similar records of egg production. The daughters of the sire (left) laid an average of 160 eggs each, while the daughters of the sire (right) laid an average of 220 each. Here is a case where the egg-production record of the sire's dam and the pedigree were of no avail in determining the difference in their breeding worth. The sons and daughters of the superior sire are likely in turn to be much better breeders than the sons and daughters of the inferior sire. If practical poultry breeders are to make the most progress in breeding for increased egg production, they must select their breeding stock on the basis of what the progeny test reveals.

Since this method of selection has already been discussed at some length with respect to the development of high-laying strains, it is not necessary to go into details again. There are certain things, however, that it would be well to emphasize and that every poultry breeder should always keep in mind in his regular breeding practice.

There is a tendency for body size to be associated with egg size; that is, in any given flock the largest birds usually lay the largest eggs. Most poultry breeders and flock owners could do quite a bit toward increasing the average size of eggs laid by the flock as a whole by culling out the smallest birds every year. Among the birds that are left, those that lay very small eggs should be culled rather than used in the breeding pen. This is quite important because it has been found that pullets that lay very small eggs at commencement of laying are very likely to lay small eggs for the rest of the year.
Also, it has been found that in many cases the heavier producers in a high-laying strain lay smaller eggs than the average producers. This is not to say that high production and good egg size cannot be combined in the same bird, for this has been accomplished a thousand times over by poultry breeders. The point is that more rigid selection of the breeding stock must be practiced because two characteristics instead of one are involved.

One of the most important things to keep in mind in developing a strain noted for good egg size is to select males as breeders that are the sons of dams that lay a good-sized egg. The market standard is a 2-ounce egg, and that is why females qualifying for record of performance are required to lay 200 eggs or more averaging at least 2 ounces in weight. Since a record-of-performance male can be secured only from a record-of-performance female, it is obvious that the program should do much toward improving egg size in the flocks of the country through the widespread distribution of record-of-performance males for breeding purposes.

The problem of securing uniformity of shell color is of greater importance in White Leghorns and other "white egg" breeds than in "brown egg" breeds. The average housewife has less objection to varying shades of brown in a dozen brown eggs than to a few tinted eggs in a dozen white ones. In some flocks of white-egg breeds quite a few of the birds may lay tinted eggs. By trap-nesting, these offenders can be identified and eliminated from the flock. But that is not enough; the poultry breeder should go through his records and identify the sire and dam of the pullets laying the tinted eggs, and not only remove the sire and dam from the breeding pen but avoid using any of their progeny as breeders. This is just one example of applying the progeny test in changing the breeding qualities of a strain of fowls.

Very little is known concerning the inheritance of shell texture, and for the most part, providing the diet is satisfactory, most flocks lay eggs that are reasonably sound in that respect. In case a number of birds in a flock are found to produce eggs with thin shells, resulting in excessive breakage, offenders should be located, and they, and all closely related birds likely to transmit the defect, should be removed from the flock.

During the last 5 years more attention has been given to interior egg quality than during the previous 25 years. This is because many housewives have become more discriminating about the color of yolk and the quality of white or albumen. Color of yolk is controlled more by feeding than by breeding, but the percentage of thick white is apparently inherited. At any rate, H. J. Almquist and L. W. Taylor at the California Agricultural Experiment Station, and C. W. Knox and A. B. Godfrey at the National Agricultural Research Center, have shown that in the flocks they studied, individuals differed in the percentage of the thick white of their eggs. The results obtained indicate that by proper selection a strain of fowls could be developed that would lay eggs having a high percentage of thick white.

**INHERITANCE OF REPRODUCTIVE ABILITY**

In addition to breeding for production and quality of eggs, the poultry breeder is naturally interested in doing everything possible to reduce the cost of replacing his flock from year to year. Surveys conducted
in different parts of the country on the economics of egg production have shown that for the most efficient production of eggs, the flock should be comprised of approximately one-third yearling hens and two-thirds pullets. This means that about two-thirds of the flock must be replaced every year.

In order to reduce the annual cost of replacements, the poultryman must secure good fertility and good hatchability, and there must be low pullet mortality, which means that there must be resistance to disease. A well-rounded breeding program must take these three characteristics into consideration because of their great practical importance in the development of strains that reproduce themselves most efficiently.

There is little specific evidence bearing on the inheritance of fertility, although in one or two cases results have been secured which indicate that fertility is an inherited characteristic. Low fertility may be due to a variety of causes, some of which have nothing to do with heredity. For instance, a male may refuse to mate with one or more of his consorts but may mate several times daily with certain other consorts. Such a case is known as preferential mating and although it is a matter of common occurrence, it can usually be remedied by replacing the unmated females with others. Sometimes lack of fertility is due to the physical inability of a male and a female to copulate, as in the case of birds with extremely short backs. Severely cold weather tends to lower fertility and too many males or too few males in a flock will also result in lowering fertility.

Occasionally a male may be sterile, that is, his germ cells may be incapable of fertilizing female cells. Likewise, some females are sterile or nearly so. Then again, there may be physiological incompatibility between male and female cells of certain males and females so that fertility is abnormally low.

In the average flock, however, the problem of securing good fertility seems to be largely one of proper management of the breeding stock. It is obviously of great importance to secure good fertility from a male that has proved to be of superior breeding worth. Moreover, if such a male could be mated to 50 or 100 hens instead of approximately 15, as is usually the case, much more rapid improvement would be possible. Quite recently, J. P. Quinn and W. H. Burrows, at the National Agricultural Research Center, have demonstrated that it is possible to secure good fertility from hens artificially inseminated with semen secured from male birds by manipulation. This discovery makes possible the mating of a large number of hens to one male. If a certain male was the son of a good producer, had an excellent pedigree, and by the progeny test proved to be of superior breeding worth, and if he could subsequently become a sire of several hundred superior progeny, he would indeed be a benefactor to the poultry industry.

Hatchability is an inherited characteristic, and improvement can be secured through adopting proper methods of selection. The same principles of selection apply as in breeding for other characteristics. A hatch of 65 percent of all eggs set, or 75 percent of the fertile eggs laid by a dam, is a good standard for the selection of sires and dams that should be retained for further breeding purposes, and particular attention should be paid to the selection of cockerels for breeding that are the sons of dams having high hatchability.
SELECTION FOR FLESH PRODUCTION

Although the main objective of most poultry breeders is to develop increased egg-laying ability in their flocks, nevertheless, fleshing properties are of considerable economic importance, especially in the case of such breeds as Orpingtons, Plymouth Rocks, Rhode Island Reds, and Wyandottes. Good body type and size are desirable in order that the largest possible amount of meat may be produced by any surplus cockerels that are sold as broilers or roasters, and by any hens that are sold for market after serving their purpose as egg producers.

N. F. Waters, formerly at the Rhode Island Experiment Station, secured results from crosses between Light Brahmas and White Leghorns that showed that the inheritance of body size is a very complex problem. Black Rose Comb bantams and Barred Plymouth Rocks were crossed at the National Agricultural Research Center, the results secured indicating that a large number of genes are involved in the inheritance of body size.

Even though comparatively little is known concerning the inheritance of body size, poultry breeders are wise in culling out, as most of them do, all small-sized cockerels and pullets in the fall of the year. This is important even in Leghorns. In addition, adult birds that do not attain a satisfactory weight for the breed should be culled before the breeding pens are made up.

It is particularly important to cull out all birds that grow at a slow rate, especially those that are inclined to have bare backs or are otherwise poorly feathered during the growing period.

HEREDITY OF DISEASE RESISTANCE

Perhaps the besetting sin of the poultry industry is the high mortality that occurs in the country’s crop of pullets produced each year. In many flocks of pullets, a mortality of 30 or 40 percent is not uncommon. What is worse, during the past few years losses seem to have been on the increase. This has taken place in spite of the long-standing urge to breed for vigor, in spite of the various State sanitation campaigns for waging war on worms and for growing healthy pullets, and in spite of the vast amount of research conducted on numerous poultry diseases.

The results of three lines of research work indicate that perhaps it may be possible by breeding to develop strains of fowls resistant to infectious disease. At the Illinois Agricultural Experiment Station, E. Roberts and L. E. Card found that chicks from certain hens were much more resistant to infection by the organism causing pullorum disease than were chicks from other hens. The results secured led them to believe that it may be possible to develop strains of domestic fowl highly resistant to pullorum disease. At the Iowa Agricultural Experiment Station, W. V. Lambert, and C. W. Knox demonstrated that four generations of selection combined with some inbreeding resulted in a marked increase in the resistance of their birds to fowl typhoid. At the University of British Columbia a group of workers observed marked differences in the resistance of different strains to fowl paralysis. The results secured from these experiments with pullorum disease, fowl typhoid, and fowl paralysis are encouraging and suggest the need for much more work on similar lines. Studies
on the inheritance of infectious diseases are problems for public institutions, however, rather than for the practical poultry breeder.

On the other hand, certain results have been obtained from breeding methods practiced by poultry breeders that suggest that pullet mortality can be reduced. From a variety of sources it has been determined that mortality among the pullet progeny of pullet breeders is frequently greater than among the pullet progeny of hen breeders. Undoubtedly too many poultrymen use as breeders some immature pullets and others lacking in vigor which because of mortality or selection would not get into the hen breeding pen. It is obvious that families showing a high incidence of mortality from a particular disease should be discarded and their progeny should not be used as breeders.

INBREEDING, OUTBREEDING, AND CROSS-BREEDING

Having taken the proper steps in the selection of the breeding stock by considering production records, pedigree, and the results secured from progeny testing, the next step for the poultry breeder to determine is whether he shall practice inbreeding, outbreeding, or cross-breeding in making his matings.

Inbreeding is the mating of relatives; and since there are degrees of relationship, such as brothers and sisters, uncles and nieces, and cousins, so there are degrees of inbreeding. The poultry breeder who starts with a breeding flock of 50 birds and does not introduce any birds from outside sources for a period of years is bound to practice a considerable amount of inbreeding as time goes on. The closest form of inbreeding is the mating of brother and sister, and the next closest form is either the mating of father and daughter or son and mother. Many poultry breeders are often in a quandary as to how closely they should practice inbreeding for the purpose of retaining the desirable characteristics which some of their breeding stock have been shown to possess. The question in the mind of the average breeder is whether or not inbreeding will tend to develop heavy laying as a fixed characteristic in his flock.

Unfortunately, there is very little evidence bearing on the effects of close inbreeding on egg production, although several breeders have tried it at different times and have secured variable results. Most of the experiments in close inbreeding have been made to study its effects on hatchability of eggs and variability of progeny. From these studies it has been concluded in general that hatchability tends to decrease and embryo and chick mortality tends to increase with inbreeding.

L. J. Cole and J. G. Halpin of the Wisconsin Agricultural Experiment Station inbred brother and sister Rhode Island Reds for 4 years and observed a marked decline in vigor to such an extent that in the fourth year hatchability was so low the experiment had to be discontinued. Another inbreeding experiment started subsequently produced similar results.

The results secured at the Connecticut and Massachusetts Agricultural Experiment Stations by L. C. Dunn and F. A. Hays, respectively, at the National Poultry Institute of England by J. C. Dunkerly, and at the National Agricultural Research Center, Beltsville, show that close inbreeding brings a decrease in egg production. It has been shown, however, that close inbreeding is not so harmful in some...
strains of birds as in others. Moreover, less intense forms of inbreeding should prove advantageous in many cases.

Inbreeding is not injurious merely by reason of the close relationship of the individuals that are mated. The only injury resulting from inbreeding comes from the inheritance received. If undesirable characteristics become manifest in the inbred birds, it is only because these undesirable characteristics existed in the original stock, where they were able to persist for generations under the protection of more favorable characteristics.

A poultry breeder with a flock of good stock might wisely mate closely related individuals occasionally. At the same time, the closer the degree of inbreeding practiced in any flock, the more rigid should be the selection of the progeny, and consequently the greater the number of individuals necessary from which to select future breeders.

Among the various ways in which inbreeding can be carried on almost indefinitely, especially if a relatively large number of matings are made every year, is to use one individual or his or her progeny repeatedly in the breeding project. This form of inbreeding is popularly referred to as line breeding. Matings are made up each year in such a way that a superior male or female or their progeny is mated to unrelated stock and to a few distantly related birds, thus perpetuating the desirable qualities of the superior birds and avoiding the possible ill effects that may result from too close inbreeding.

There is another sense, however, in which inbreeding is highly important. It is the quickest method by which characteristics, good or bad, can be isolated, made homozygous in a strain, and studied accurately from the standpoint of inheritance. Thus it becomes a powerful means for bringing out desired traits. If these are found to be combined with undesirable traits in the inbred strain, the latter may be subordinated by well-controlled crossing. This method is extensively used in plant breeding; indeed, it is responsible for most of the valuable achievements in cross-fertilized crops in recent times. In animal breeding, it must be considered as still an experimental technique too costly and perhaps too difficult for use except in research work. The full possibilities of this technique in poultry breeding are yet to be explored.

Many poultry breeders are so strongly prejudiced against practicing inbreeding to any extent that they make a point of securing breeding stock of the same breed or variety, but unrelated to their own, from some other poultry breeder. This is popularly called outbreeding. The results obtained from outbreeding are sometimes satisfactory and sometimes very unsatisfactory; it all depends on the qualities possessed by the two strains of the same variety that are crossed and how these strains "nick," as old-time breeders would say. J. Holmes Martin at the Kentucky Experiment Station has carried on some outbreeding work which demonstrates this point. A poultry breeder who has a well-bred flock should try a few experimental matings before venturing on a wholesale program of crossing all of his breeding stock with birds of another strain.

Cross-breeding, or mating two different breeds or varieties, is sometimes practiced with a view to combining the desirable qualities of each. Broiler producers resort to cross-breeding quite extensively because it has been found that cross-bred chicks usually grow faster, especially during the first 10 or 12 weeks, than purebred chicks of
the parental breeds that are crossed. Research work at the Maine and Kansas Agricultural Experiment Stations by Raymond Pearl and D. C. Warren, respectively, have shown that cross-breeding generally tends to increase hatchability and decrease chick mortality. In other words, hybrid vigor is involved. On the other hand, research work at the National Agricultural Research Center has shown that if two strains having low hatchability are crossed, hatchability is usually increased, whereas if two strains having high hatchability are crossed it is not increased. Cross-breeding usually results in more broodiness in the progeny.

At the Kansas Station Warren crossed White Leghorns with Rhode Island Reds and White Leghorns with Jersey Black Giants and observed that for the most part the cross-bred birds laid better than the purebred birds. During recent years the sale of cross-bred chicks from commercial hatcheries has apparently been on the increase, but poultrymen who purchase them should always keep in mind that the results in egg production secured from the cross-bred pullets are determined by the quality of the parental stocks that are crossed. Generally speaking the mating of high-producing females of one breed to males of a low-producing breed should not be expected to produce cross-bred pullets that will lay as well as their high-producing purebred dams. On the other hand, the crossing of two highly developed laying strains may be very much worth while.

Warren crossed high-production strains of White Leghorns from Kansas and from the Pacific coast. The stimulation from crossing was not as apparent as when breeds were crossed, but the females showed better egg production and hatchability than either of the parent strains. However, chick mortality and weight at 8 weeks were not improved.

A Plan for the National Distribution of Superior Breeding Stock

IN SPITE of the many unsolved problems and the lack of much information of a fundamental nature concerning the art of poultry breeding, it is cheering to report that the poultry industry has taken steps to distribute the "blood" of such superior breeding stock as is being produced. Going on the theory that it is worth while to make the best of what we have, representatives of the industry in the United States have organized a voluntary National Poultry Improvement Plan. This is a plan that has very great significance. If it works out well, it should not only result in improving the existing situation; it should mean that any real results of research in the future could be put to practical use in the industry as a whole with a minimum of delay.

In each State the regulations of the improvement plan are under the supervision of an official State agency. This represents the poultry interests of the State and also an official body such as the college of agriculture or the State department of agriculture or both.
The United States Department of Agriculture has been cooperating with the States in putting the plan into effect, beginning in July 1935, on a uniform basis among the States.

The plan provides for official recognition of various classes of breeding stock, hatching eggs, and baby chicks produced by poultry breeders, and various classes of chicks distributed from hatcheries. The hatcheries occupy a unique place in the poultry industry because they can do a great deal of good by distributing chicks of superior quality, or they can do a great deal of harm if only a few of them distribute chicks of inferior quality. There are approximately 12,000 hatcheries in the country and they have an egg capacity at one setting of approximately 300,000,000 eggs. If all of them operated at full capacity during the normal hatching season they would produce practically as many chicks as are raised annually in the United States, that is, over 750,000,000. It is obvious, therefore, that the hatcheries are important in any plan for the improvement of the farm and commercial flocks of the country.

The flocks used to produce the different classes of eggs provided for in the plan must be carefully selected by a representative of the
official State agency, and provision is made for their subsequent inspection by an official State inspector. The females of each flock are carefully selected for vigor and characteristics indicating laying ability and the males are rigidly selected for vigor and qualities indicating good breeding. Flocks used to produce certain classes of eggs must be mated to males produced by record-of-performance breeders.

Official recognition is given to females that lay a minimum of 200 eggs during the first laying year, providing the eggs weigh on the average 2 ounces each. Record-of-performance males can only be secured from record-of-performance matings. One of the best features of the improvement plan provides for the official recognition of sires and dams that prove to be of superior breeding worth as determined by the progeny test.

Hatching eggs used to produce each of the different classes of chicks provided for in the plan must each weigh a certain minimum amount and they must be uniform in shape and sound in shell texture, and in the case of the "white-egg" breeds the eggs must be free of tints. The egg-weight requirements of the plan are very important because in too many cases hatchery operators are inclined to set undersized eggs, which usually hatch into undersized chicks.

Another most important feature of the improvement plan provides for the official recognition of flocks that have been tested for pullorum disease and have had all reactors removed. The testing work must be done by properly qualified persons using one of three different specified methods of testing. Widespread testing and removal of all reactors should result in great benefit to the poultry industry because the organism causing the disease is transmitted from the infected dam to her chicks through the medium of the egg, and flocks of chicks highly infected usually suffer heavy mortality.

Very briefly, the improvement plan provides for the distribution of superior breeding stock produced by poultry breeders who carry on record-of-performance work. This superior breeding stock is sent to owners of flocks that supply eggs to hatcheries. The hatcheries in turn distribute chicks to farm and commercial flock owners. Thus the influence of superior breeding stock is carried right through to the farm and commercial flocks kept for egg production. There is no doubt that the level of egg production of the flocks of the country can be increased considerably by more widespread distribution of sires and dams of superior breeding worth. The poultry-improvement plan will succeed to the extent that poultry breeders and hatchery operators appreciate the possibilities that lie ahead and fulfill the obligations resting upon them.

THE RESPONSIBILITY OF THE POULTRY BREEDER

A portion of this article has dealt with the need of superior breeding stock in order to make farm and commercial poultry production more efficient and more profitable. Most of the previous discussion has had to do with the various factors involved in identifying superior breeding birds and ways and means of increasing their numbers. It need only be pointed out here that the desired objectives will not be gained, however, unless poultry breeders appreciate their responsibility.
It may be taken for granted that, for the most part, superior breeding stock can be developed only by a class of superior poultry breeders. In fact, the greatest need of the poultry industry is greatly increased numbers of poultry breeders who not only know how to raise and manage chickens properly but who have a sound knowledge of the more fundamental problems involved in the selection and mating of breeding stock. Superior breeding stock can be developed only through the adoption of a sound breeding program.

It must be a balanced program, combining high egg production, good rate of growth, good body size for the breed, efficient flesh production, eggs of good size and desirable interior quality, good fertility and hatchability, and low chick and pullet mortality. To accomplish these things with any degree of success is a formidable task. Since inheritance plays such an important role in the development of these numerous characteristics, it becomes apparent that numerous matings are necessary and the largest possible number of progeny should be kept to provide for the wisest selection of the most superior sons and daughters of the most superior sires and dams.

Poultry breeders must learn that the best breeders cannot be selected from their external appearance alone; it is the genes that count. For instance, the White Leghorn has white plumage because it carries a gene that prohibits the development of pigment. But the White Leghorn also carries the sex-linked gene for barring, as certain crosses have demonstrated. Now the average White Leghorn breeder would not suspect the presence of the sex-linked gene for barring in his stock, but it is there just the same. Then again, the White Plymouth Rock carries a gene for the extension of black pigment to all parts of its plumage, but the bird is white because it lacks a certain gene for the production of pigment. And so it is with many breeds and varieties; there is "more than meets the eye." Likewise with stock that is being bred for such characteristics as egg production, egg weight, and low mortality. Breeding tests tell the tale.

The poultry breeder should know how to measure the results he secures. Of course, he knows how to count and weigh eggs and weigh birds, but he must be able to do much more than that in order to make the most progress. It is the average results that are secured from large families obtained from each mating that serve as the best measure in selecting superior sires and dams. Moreover, the breeding stock and their progeny should be kept under as uniform conditions as possible from year to year.

The production record, the pedigree, and the progeny test provide three means of identifying the dam of superior breeding worth. A superior sire is identified by the production record of his dam, his own pedigree, the average egg production of his full sisters, and the kind of progeny he produces. It can be said with a reasonable degree of certainty that in the present state of the poultry breeding industry of the United States, the selection of breeding stock on the basis of the progeny test is the most important step in the development of a balanced breeding program.

Future progress in poultry-breeding work will depend on the kind of poultry breeders that carry on the work. The chicken presents the possibilities; upon the poultry breeders rest the responsibilities.
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WATERS, N. F.  

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Appendix

Experiment Station Research Workers in the United States Who Have Carried on Poultry-Breeding Research Work

California: L. W. Taylor, University of California, Berkeley; V. S. Asmundson, Experiment Station, Davis.
Illinois: Elmer Roberts, animal genetics, University of Illinois, Urbana.
Iowa: W. V. Lambert, genetics, Iowa State College, Ames; N. F. Waters, animal husbandry, Iowa State College, Ames.
Kansas: D. C. Warren, Kansas State College, Manhattan.
Kentucky: J. Holmes Martin, University of Kentucky, Lexington.
Louisiana: C. P. Upp, Louisiana State University, Baton Rouge.
Maine: W. F. Dove, biology, University of Maine, Orono.
Massachusetts: F. A. Hays, Massachusetts State College, Amherst.

Experiment Station Personnel Supervising Poultry-Breeding Projects

Alabama: D. F. King.
Idaho: C. E. Lampman.
Indiana: R. E. Roberts.
Mississippi: G. R. Sipe.
Missouri: E. M. Funk.
New Jersey: W. C. Thompson, C. S. Platt.
New Mexico: L. N. Berry.
North Carolina: C. H. Bostian, R. S. Dearstyne.
Oklahoma: L. B. Thompson, L. Morris, R. Penquite.
Oregon: F. L. Knowlton.
Utah: B. Alder.

Poultry-Breeding Research Workers at Other Institutions

California: C. H. Danforth, Stanford University.
Illinois: L. V. Domm, University of Chicago.
Massachusetts: H. D. Goodale, Mount Hope Farm, Williamstown.
New York: L. C. Dunn, Columbia University, New York City.

Poultry-Breeding Research Workers in the United States Department of Agriculture

Morley A. Jull, National Agricultural Research Center, Beltsville, Md.
Charles W. Knox, National Agricultural Research Center, Beltsville, Md.
Joseph P. Quinn, National Agricultural Research Center, Beltsville, Md.
Albert B. Godfrey, National Agricultural Research Center, Beltsville, Md.
Marlow W. Olsen, National Agricultural Research Center, Beltsville, Md.

Research Workers Who Have Made Outstanding Contributions in Poultry-Breeding Work But Not Now Actively Engaged Therein

California: T. H. Morgan, California Institute of Technology, Pasadena.
Maryland: Raymond Pearl, Johns Hopkins University, Baltimore.