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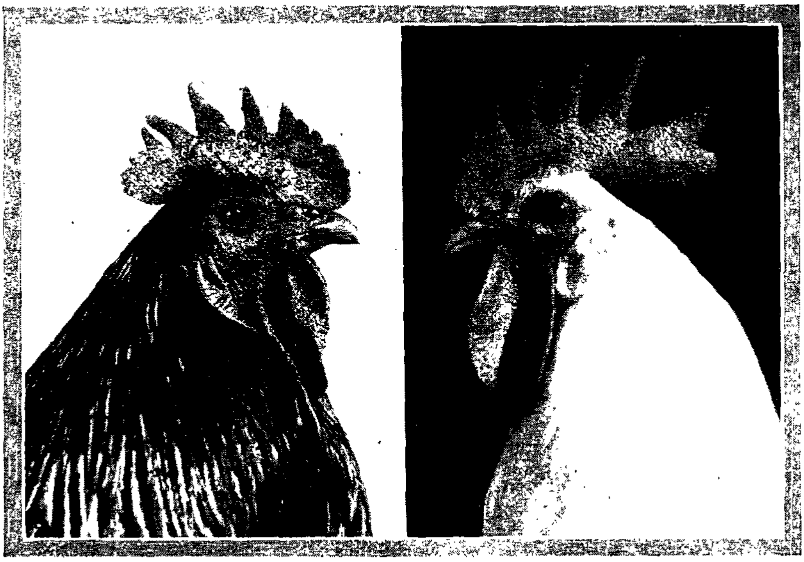

OUTSTANDING BREEDING MALES

THE PROGENY TEST IN POULTRY BREEDING[1]

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HISTORY OF POULTRY BREEDING

The history of poultry breeding extends back about as far as there exists any recorded annals of man. The records would indicate that man's earliest interest in the fowl was aroused by the opportunity it provided for the satisfaction of his gambling instinct. Cock-fighting was one of man's early pastimes. Later the utilitarian qualities of the fowl were considered and this resulted in the development of egg, meat, and general-purpose breeds.

No other domestic animal presents so wide an array of breeds and varieties. The low unit value of the individual has made it pos-

1. Contribution No. 64 from the Department of Poultry Husbandry.

sible, in the case of poultry, for a much larger number of persons to participate in the pleasure and to realize the fascination of constructive breeding.

In spite of the diverse results of his activities, much credit is due the fancier for the development of types of fowl which meet well the needs of the commercial poultryman. For the segregation of the large number of breeds and varieties there were developed exceedingly exacting standards which frequently centered the attention on minute details that were of little utilitarian significance. Nor can the fancier be justly criticized for his methods, for he naturally worked with those characteristics which he could observe and evaluate.

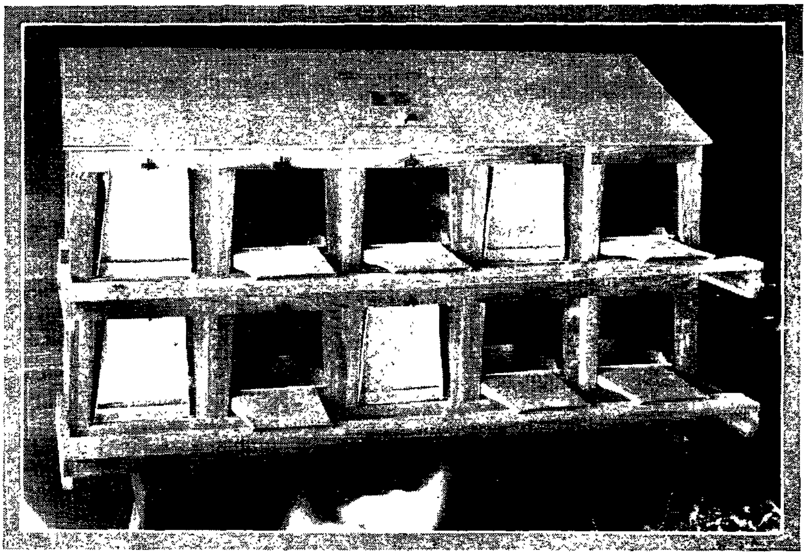

FIG. 1.—A common type of trap nests. Production breeding in poultry had its beginning with the invention of the trap nest. There are now many different types in use, and in choosing among them the primary consideration should be accuracy of records.

With the advent of the trap nest there came a new era in poultry breeding. This device (fig. 1) made it possible to measure easily and accurately the productive performance of a hen. In addition to considering the bird's approach to the ideal for the breed, the breeder could now compare one female with another on the basis of her yield of eggs. Attainment in the latter direction very naturally made its appeal to the average poultryman. The trap nest offered a measure of a quality, egg yield, which public demand has sometimes caused to be unduly emphasized to the neglect of other qualities of equal importance.

We now have within the more popular breeds numerous strains which have recognized distinctive qualities. In these strains utilitarian qualities have been emphasized, and there has been a declining interest in many breeds and varieties which have no marked qualities of this kind to recommend them.

One of the early serious attempts at the utilization of the trap nest in a breeding program for the improvement of the egg production was made by G. M. Gowell[2] of the University of Maine. His program was as follows: Each female was trapnested throughout the year, and only those females having during their pullet year a record of 150 eggs or more were used as breeders. Each year the males heading the flock were selected from dams with records of 200 or more eggs. By the use of such individuals a flock mating was made each year. He had expected this program to increase rapidly the average flock production. However, after following this system for a period of nine years, from 1898 to 1907, the average production of his flock had shown no increase.

If egg production tendencies are inherited it would, at first thought, be difficult to understand the failure of this experiment. Probably the best explanation is to be found in the fact that the males were chosen blindly except that their dams had good records. There is no way of measuring the productive performance of the male, and many of the males used must have had potentialities far below that of their mothers. The fact that the dams used have records above the average is not sufficient to guarantee any improvement in the average of the flock. The results here would indicate that mass matings combined with selection only on the basis of individual records (with no progeny test) on both sides will give very slow or in some cases no improvement.

GENETICAL TECHNIQUE

Genetics is the science which deals with resemblances which are transmitted from one generation to another in plants and animals. This science supplies the theoretical explanation for the results of animal breeding. Probably the most noteworthy contribution of the geneticist to the field of poultry breeding, and more particularly production breeding, has been the genetic point of view which has led to the appreciation of the value of the progeny test. The attention of the geneticist is focused upon the yield of matings of single pairs rather than the massed results with which the earlier biometricians dealt. Raymond Pearl, formerly of the University of Maine, was the first investigator in the field of poultry production to apply genetic methods to the analysis of the factors governing egg production. Although his early deductions[3] are now of little more than historical interest, his contribution is an important one.

The term progeny test as applied to animal breeding refers to the estimation of an individual's value as a breeder by means of the qualities or performance of its offspring. The earlier practice was

2. Gowell, G. M. Poultry experiments in 1902—breeding for egg production. Maine Agr. Expt. Sta. Bul. 93:69-92. 1903.

3. Pearl, Raymond, and Surface, Frank M. Data on the inheritance of fecundity obtained from the records of egg production of the daughters of "200-egg" hens. Maine Agr. Expt. Sta. Bul. 166:49-84. 1909.

to judge an individual by its ancestors as indicated by its pedigree, but more recently the situation has been reversed and now the individual breeding bird is judged by its offspring. The former viewpoint was backward while the more recently adopted one is forward.

The application of the progeny test to breeding operations has brought one important fact to the attention of the poultry breeder. This is that it is not only necessary to consider the results of single pair matings but also to consider all of the offspring of a mating. If egg production is under consideration, it is entire family averages that are of value. Continuous culling is an economical procedure for the average poultryman, but it will defeat the purpose of the constructive breeder. For comparison he must not only have entire family averages, but also know the variability in the number of eggs produced by the individual members of the family. If it is necessary to eliminate poor producers before the completion of the year, the number of individuals so eliminated should at least be taken into consideration in comparing family performance.

APPLICATION OF PROGENY TEST TO PRODUCTION BREEDING

It is doubtless true that much of the rapid progress in improvement of egg production during recent years has been due to the appreciation of the value of the progeny test as a tool by most of the leading breeders. The consistently excellent performance of entries at egg-laying contests from the flocks of successful breeders are usually the offspring of progeny tested matings. This method not only makes it possible to predict with greater accuracy the performance of individuals but also to estimate their value as breeders, thus permitting more rapid improvement of the flock.

The application of the progeny test to production breeding requires the trapnesting of entire families. For purposes of elimination it is very important that the poultryman have the record of a poor-producing family as well as that of good producers. If the purpose is to progeny test a group of cockerels the usual procedure is to organize several breeding pens carrying females of approximately equal egg records. This may be accomplished by using untested females that have just completed their first year of production. It will make possible the testing of the females as well as the males. Each pen is headed by one of the males to be tested. The average production of the daughters is used as a basis for comparison of the ability of the males to transmit egg production tendencies. By the same method it is possible to compare the females within a single pen, and since all of their daughters receive the genetic determiners for egg production on the paternal side from a single male, the test here is more critical than that provided for males.

PREPOTENCY INDEX

If the males to be compared have not been mated to females of similar egg records some compensation must be made for the variability in the dams' records. An index value which might be called the "prepotency index" has been devised for dairy cattle breeding by Dr. H. D. Goodale, of the Mount Hope Farm, of Williamstown, Mass. A modification of this index may be utilized in poultry breeding. Instead of using the average production of the daughters as a basis for comparing the transmitting abilities of males, the average records of both their daughters and mates are considered.

The first step in calculating a male's prepotency index is to compute the average production of the daughters of each female mated with him. The resulting average may be considered a measure of the combined transmitting tendencies of the pair of birds involved. The dam's inherited tendencies for egg production are indicated by her individual egg record, but the male's tendencies are unknown. The difference between the record of a female and those of her daughters should supply some clue as to her mate's ability to transmit egg-production tendencies. A male's breeding value is estimated as follows: One-half the difference between the dam's record and the average of her daughters is added to the average of the daughters in cases where the daughters' records are above the dam's and subtracted from their average when it is below that of the dam. This is based upon the assumption that if a daughter's record is below that of the dam much of the difference is due to the fact that the sire carries high production tendencies to a lesser degree than his mate. If his daughters are superior to their dam the reverse is assumed to be true. The value arrived at is an estimation of a male's inherited tendencies for egg production as indicated by any pair mating. A male's prepotency index is then the average of the estimations obtained from the groups of daughters of his various mates. If the daughters' average is below that of the dams, the male's index will be below, while a group of daughters averaging above their dams will give an index for the sire above the average of their dams. A male which produces, from 230-egg dams, daughters averaging 250 eggs, is more valuable than one which has daughters of the same average production from 260-egg dams. Since the index is based both upon the mates' and daughters' records the latter male would have the lower prepotency index. By use of the index it is possible to compare males mated to females of varying production, but it should be realized that the attempted corrections are sources of considerable error. It is much better, wherever possible, to compare only males whose mates are as nearly comparable as possible. The prepotency index will be found of some value, however, where the above conditions cannot be met, but its shortcomings should be appreciated.

Table I provides an example of how a male's prepotency index is calculated.

The records of each mate's daughters are averaged and an index value is found for each mating by adding one-half the difference between the dam's record and the daughters' average record in case the offsprings' average is above that of the dam, and subtracting where the daughters' average is below. In Table I the daughters of dam 746B had an average production record of 243 eggs. This is less than that of the dam (261 eggs) by 18 eggs and one-half of this,

TABLE I.—METHOD OF CALCULATION OF A MALE'S PREPOTENCY INDEX.

	Egg records of mates and daughters of Sire 921M.				
	Dam 746B Record 261.	Dam 831B Record 253.	Dam 866B Record 298.	Dam 897B Record 245.	Dam 1021B Record 230.
	230	210	262	165	261
	241	186	247	231	243
	200	147	283	265	252
	301	175	303	....	275
Average	243	179	274	220	258
Index	234	142	262	208	272

Prepotency index of male, 223.

9 eggs, is, therefore, subtracted from 243, leaving 234. The value, 234, is the index for the mating of sire 921M to dam 746B. In the case of dam 1021B, one-half the difference between the daughters' and dam's production is added to that of the daughters since the offsprings' average production is better than that of the dam. The male's prepotency index is found by averaging the indexes calculated for each dam. Thus the value, 223, is obtained by averaging the various index values given below the average production of offspring of each mating. Where a number of breeding pens are being used the males are ranked according to their index value.

EXAMPLES OF APPLICATION OF THE PROGENY TEST

Table II presents the results from three matings made in the Kansas Agricultural Experiment Station flock of Single Comb White Leghorns. Provided the females in the three pens are of equal production potentialities, and this is assumed in the application of the progeny test, the average production of the female offspring from each pen should supply a basis of comparison of the males involved.

It is obvious that male 1010M had the highest averaging daughters. The daughters of 902M had an average production of over fifty eggs less than those of 1010M. Male 787M was intermediate but approaching the record of 1010M. For use in succeeding years it is evident that preference should be given to 1010M, while male 902M should be eliminated from the breeding flock. For the selection of cockerels to be used as breeders either 1010M or 787M should be able to supply promising ones. In selecting cockerels the average of each mate's offspring will also be of value. A glance would indicate that among the sons of 787M those produced by 5115 are most promising. Females of a family (fig. 2) so consistently high producing as this are likely to have brothers of similar qualities. The mating of 1010M with 2565A is also very promising for supplying cockerels to be tested.

TABLE II.—THE PROGENY TEST FOR ANNUAL EGG PRODUCTION.

Individual egg records of daughters of Sire 1010M.

Dam 2562A.	Dam 2564A.	Dam 2565A.	Dam 2567A.	Dam 2570A.	Dam 2571A.
235	195	288	207	192	240
202	219	264	166	233	247
254	199	220	231	251	174
	207	219	257	206	224
	222	230		246	
	214	244			
	224	216			
	186	208			
	237	270			

Daughters' average record, 224.3 eggs.

Individual egg records of daughters of Sire 787M.

Dam 3600.	Dam 3947.	Dam 4630.	Dam 4735.	Dam 4957.	Dam 4984.	Dam 5115.
115	169	199	181	236	210	278
232	217	153	117	235	205	269
203	207	167	183	234	217	268
246	210	152	164			253
248	200	192	164			236
	150	150	174			231
	200	221				228
	194	201				227
						223
						220
						212
						206

Daughters' average record, 205.6 eggs.

Individual egg records of daughters of Sire 902M.

Dam 3608.	Dam 3952.	Dam 4376.	Dam 4574.	Dam 4723.	Dam 4984.	Dam 4931.
218	229	75	203	211		141
137	242	61	193	224	203	199
152	160	181		178	155	81
171		175		164	144	118
158		183			142	224
82					224	211
115						186

Daughters' average record, 168.2 eggs.

The results of these matings may be further used for comparing the females used in a breeding pen and for choosing untested daughters to be used as breeders. The 206-egg daughter of female 5115 in the pen headed by 787M is considerably more promising than the single daughter (221 eggs) of 4630 to exceed this mark. Since the choice of any untested individual as a breeder is a risk, the hazard is greatly reduced by confining the choice to uniformly high-yielding families. The average female from a high-averaging family, such as is shown in figure 3, is much more valuable than the high individual from a mediocre family. This is especially true in the choice of a male since in his case we do not have even the egg record, which may be a guide of some value in the selection of untested females. Thus there should be an effort made to perpetuate in the flock the blood of such matings as 1010M by 2564A and 2565A, and 787M by 5115. The value of a progeny-tested breeder cannot be overestimated.

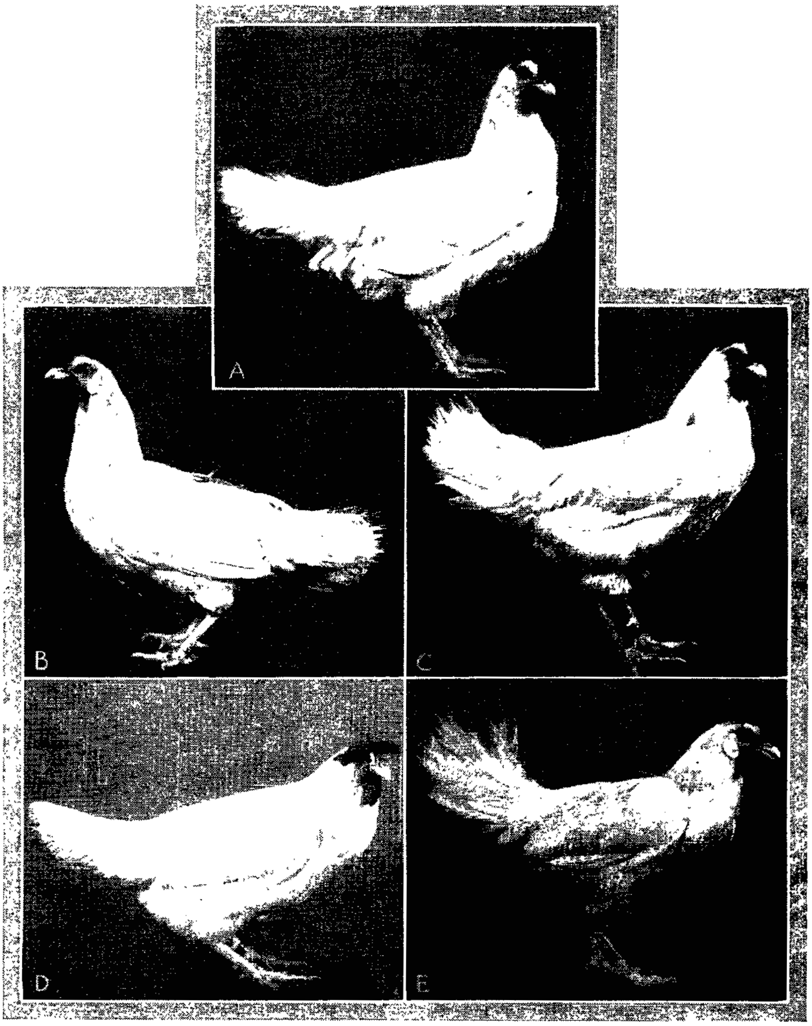

FIG. 2.—Hen 5115 (A) and some of her daughters (B, C, D, and E). This dam produced 12 daughters in one year with an average production of 237.6 eggs and a minimum record of 206 eggs (Table II, sire 787M). (The ragged plumage shows the effects of frequent occupancy of the trap nest.)

DIFFICULTY IN APPLICATION OF PROGENY TEST

One of the most serious handicaps in the application of the progeny test to production breeding is the long period of time required to make the test. If a male is used as soon as he reaches sexual maturity, or at approximately one year of age, he will be starting his fourth year before the test is completed on his first group of daughters. At his second regular breeding season his first group of daughters will only be started in their first year of produc-

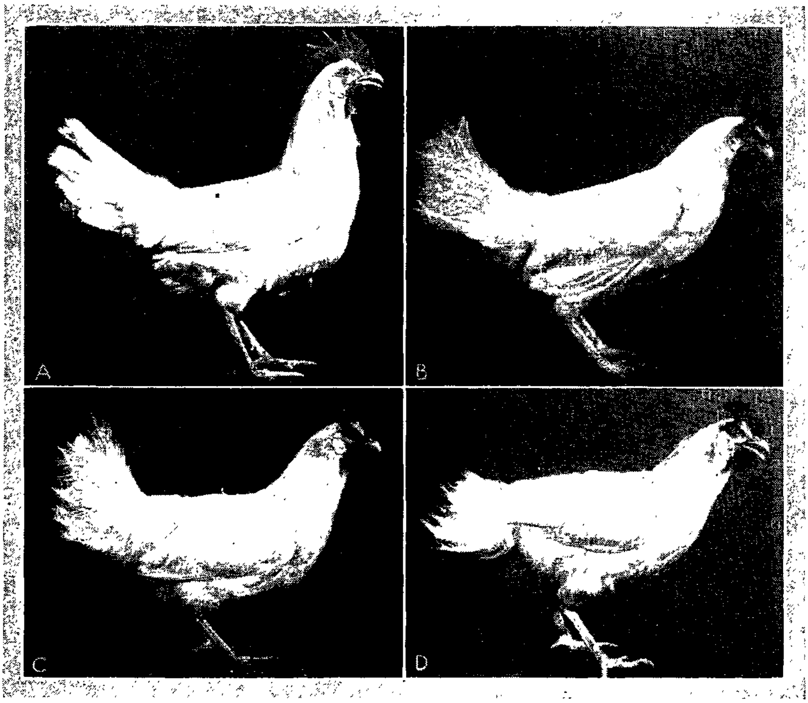

FIG. 3.—Hen 4734 (A) and some of the daughters (B, C, and D) of her high-producing family. This dam produced in a single season 11 daughters with an average production of 237 eggs and a minimum of 200 eggs. This hen herself produced only 243 eggs in her first year of production but demonstrated her value as a breeder when her entire family attained an average record approaching her own.

tion so he will have to be held in reserve until the next year. Many valuable males are lost by disease and accident before their worth is known, since few have a breeding record so long as that of the male shown in figure 4. By the third year many males have had their reproductive capacity reduced by partial sterility, and in the case of females the egg production diminishes in succeeding years. Many breeders use supposedly valuable males repeatedly while the progeny test is being obtained and then discard unsuccessful blood lines and concentrate on the proved ones. This procedure involves rather extensive facilities and much lost motion.

Experimental work at the Massachusetts Agricultural Experiment Station has shown that the annual record should not be considered as a unit since it is determined by a number of independently acting factors.[4] The more important of these factors are age at first egg, intensity or rate of laying, winter pause, broodiness, and persistency.

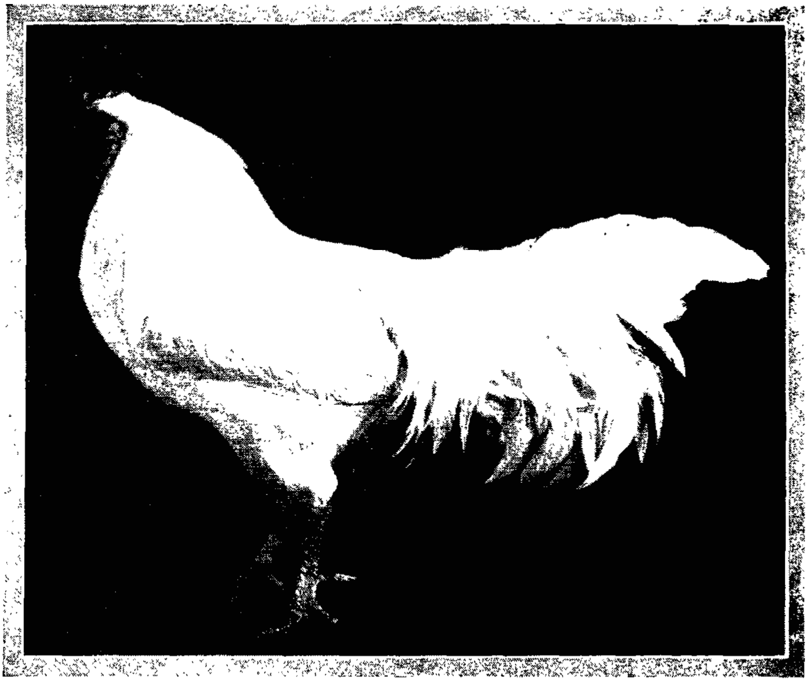

FIG. 4.—This White Leghorn male was used for six breeding seasons. In addition to being a proved sire he also exhibited exceptional standard qualities for his breed.

ency. In breeding for improvement in egg production of the fowl these factors must be considered separately. The breeder should analyze the records from his flock and determine which one of these factors is in most urgent need of improvement and apply the progeny test to each in order of its importance to his stock. Fortunately some of these characteristics are expressed sufficiently early in a pullet's laying year to make it unnecessary to lose a year in applying the progeny test.

4. Hays, F. A. The application of genetic principles in breeding poultry for egg production. Poultry Sci. 4:43-50. 1924-'25.

A SHORT-CUT PROGENY TEST

Any method which will provide a reasonably accurate progeny test and avoid the loss of the second year's service while awaiting the results from a bird's first group of offspring is of considerable value. Any hint as to the relative merits of males used during the preceding year is of value for supplementing the pedigree in choosing cocks to be used again the next year.

Fortunately the influence of two of the most important factors having a bearing on the annual egg record may be checked upon during the early part of the pullet's laying year. These two are age at first egg and intensity (rate of laying). In the case of the smaller breeds, where broodiness is seldom of any importance, intensity probably has a greater influence upon the annual record than any other. Results of studies by Harris and Lewis[5] have shown the correlation coefficient between the early months' production of a pullet and her annual record to be relatively high in the White Leghorn breed. They found the coefficient of correlation between November production and annual production to be54, and between December and annual production to be .65. Since the number of eggs laid during these months may be used as a measure of intensity of production, it may be said that there is an association between rate of laying in the early months of production and the total number of eggs laid during the year. In other words, it may be taken to indicate that there is a definite tendency for the birds of high early rate of laying to have the best annual records. This is probably true because of the fact that the intensity of production is a fairly definitely fixed characteristic which is maintained relatively uniformly throughout the year.

The value of the coefficient of correlation is not sufficiently high to make it possible to use early intensity for predicting accurately the annual production of an individual female, but in the application of the progeny test one deals with family averages and not individual records. The average family intensity and the average family annual production would probably be found to be closely associated. Thus, the average family intensity during the early months of production may be used as a basis for predicting the average family production. Harris *et al.*[6] from a study of 415 White Leghorns found that the average production for October, November or December was a very dependable basis for predicting the average annual production of the group. Even in the later-maturing breeds, most pullets will have laid for at least a 30-day period by the time it is necessary to select stock for the breeding pens of the succeeding year. This would make it possible to check upon the results of the previous season's matings and obtain some indication of the probable breeding value of both the parents used and the offspring which have just reached sexual maturity

5. Harris, J. A., and Lewis, H. R. The interrelationship of the egg records of various periods during the first and second year of the White Leghorn. Poultry Sci. 1:97-107. 1922.

6. Harris, J. A., Kirkpatrick, W. F., Blakeslee, A. F., Warner, D. E., and Card, L. E. The egg records of limited periods as criteria for predicting the egg-production of the White Leghorn fowl. Genetics 6: 265-309. 1921.

The data on age at first egg are also available on most females before the approach of the second breeding season. Any females which have not started to lay by this time may be classed as late maturers.

For making a short-cut application of the progeny test in the case of the smaller breeds, where age at sexual maturity is not a factor of importance, the intensity during the first 30 days has been found satisfactory. The period of 30 days has been chosen since it is long enough to give a dependable average and since a much longer period of production would not be available for the later starters. Also, since most individual egg records show monthly totals, the summa-

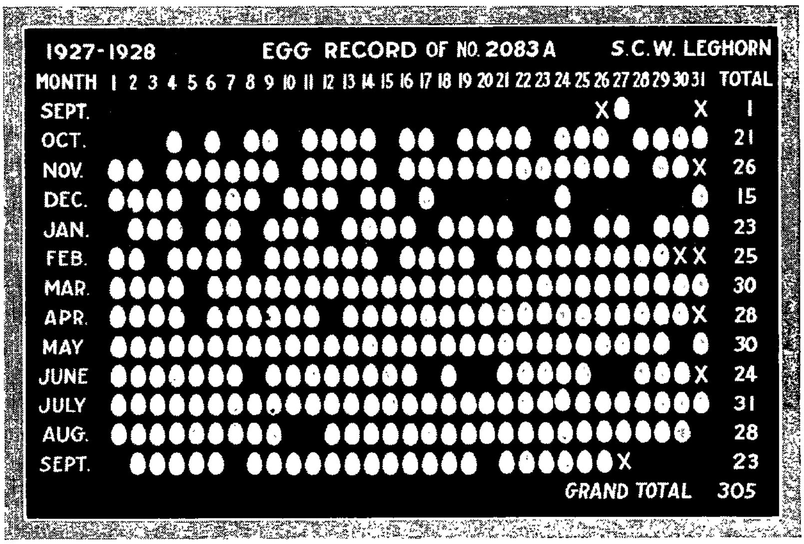

FIG. 5.—This figure shows the distribution of eggs throughout the pullet year for a high-producing female.

tion is already made. If, as sometimes happens, the first few eggs are not produced at the characteristic rhythm they may be omitted. Such birds are the exceptions and the irregularity ordinarily persists only for a few days. If a pause occurs during the first 30-day period the record should be made from another period showing a characteristic rate of production. For the record presented in figure 5, the month of November probably shows more accurately the normal intensity for the female considered.

Table III shows the method of summarizing results on intensity for a White Leghorn mating. The comparison of results is based upon the number of eggs laid during the first 30-day period of production. As is shown at the top of the table the pullets are grouped into five classes increasing by five-egg units and ranging from 10 eggs or less to 26 or more. After the band number of each female in the breeding pen, is shown the number of her daughters falling into the various classes. The male heading the pen is judged by the percentage of his daughters placing in the last two classes, that is, laying 21 or more eggs during the first 30 days. If the offspring of a number of males used during the same year are checked upon in this manner, the males may be graded as breeders on the basis of these percentages. The relative breeding value of the females in a single pen may also be estimated in the same manner, but since the number of offspring is less the results will be somewhat less dependable.

TABLE III.—EARLY INTENSITY OF OFFSPRING OF A BREEDING PEN AS MEASURED BY NUMBER OF EGGS LAID DURING THE FIRST MONTH OF PRODUCTION.

Dam No.	Sire 952M.				
	Eggs for first 30-day period.				
	1-10.	11-15.	16-20.	21-25.	26-30.
5146		1	3	4	4
5165	1		2		1
5330				7	6
5361			3	3	
5411		1	6	3	1
5423			1	2	8
5668				1	5
5701			3	2	1

Percentage showing intensity above 20 eggs, 70.

Since the results on intensity may be taken on pullets before the matings need be made for the succeeding season, a more or less dependable estimate of the breeding value of their sires and dams may be made. This short-cut method is especially valuable for determining which members of a group of males used as cockerels should be used again during the second year. It avoids the loss of the second year's service on the more valuable males. There will seldom be much change of position of males when graded first by the average first month's intensity of their daughters and later by the same females' average annual records. It at least has the value of calling attention to very poor males which should not be used again.

THE SHORT-CUT TEST FOR SELECTION OF BREEDING COCKERELS

A further use of the progeny test, based upon the first month's intensity, is for selection of cockerels for heading a new series of breeding pens. If the choice of cockerels is to be confined to the sons of old males and females upon which the progeny test has already been completed, the field will be much limited in the average flock. Much time will be saved and valuable blood preserved if one has some basis, other than that provided by the pedigree, for selecting the males being used for the first time. The short-cut method provides the desired information since one may not only determine which male used during the preceding season is the most promising, but he may also recognize the most promising pair mating within the best pen. If in a season's breeding the pen headed by sire 952M had shown the largest percentage of high-intensity daughters, then by examination of Table III it would be possible to select the most promising pair mating. It is evident that a son of dam 5330 would be very promising. All 13 daughters of this mating had an intensity of over 20 eggs during the first 30 days, and almost half of this group produced over 25 eggs. Since all of the daughters are so promising it would seem that any son which, of course, must otherwise be chosen blindly, would likely be fairly dependable for the transmission of high-production tendencies.

Much of what has been stated regarding the selection of breeding males will also apply to the females. The choice of the male has been emphasized because of his greater potentialities, due to greater reproductive capacity. The females within a breeding pen may be compared one with another with a fair degree of dependability, but it would not be safe to attempt to compare females in different pens. Due to the limited number of offspring from a single female the comparisons may sometimes be questionable, but the progeny test based upon early intensity at least makes possible the early elimination of the poorer breeding females.

THE SHORT-CUT TEST APPLIED TO DUAL-PURPOSE BREEDS

Since in the lighter-weight breeds neither age at sexual maturity nor broodiness is of great importance, the progeny test based upon early intensity alone is found satisfactory. In the case of the larger breeds age at sexual maturity (first egg) is also usually an important contributing factor. Late-starting pullets have been found not to have the same opportunity of making a good record as those starting to produce at an earlier age. Thus in attempting to predict the breeding performance of birds under consideration it is necessary to consider the effects of age at first egg as well as intensity when dealing with the larger varieties,

Table IV classifies the offspring of a mating on the basis of both early intensity and age at first egg. This table is similar to the one already described except that there have been added spaces for tabulation of the age at first egg. The age is in days and has been divided into 20-day intervals. Any individual of a heavy breed which begins at 220 days or less may be considered as maturing sufficiently early, so any birds falling in the first two columns on age at first egg are classified as early maturers. Then the basis of comparison may be on percentage of early maturers. Those in the last column are birds which have not started to lay at time of classification, and such individuals will usually at that time be old enough to be graded as late maturers.

TABLE IV.—PROGENY TEST FOR AGE AT FIRST EGG AND EARLY INTENSITY.

Dam No.	Sire 988M.									
	Eggs for first 30-day period.					Age in days at first egg.				
	1-10.	11-15.	16-20.	21-25.	26-30.	200 or less.	201-220.	221-240.	241 and above.	Not started.
981A	....	....	2	5	1	2	6	1	1	4
1022A.. .	....	..	2	1	.. .	....	2	1	2	7
1048A	......	......	3	8	3	2	12	4	2	3
5641..... ..	....	3	9	4	....	....	1	5	3	10
8397... . .	....	.. .	1	4	....	....	5	1	1	3
	Percentage of high intensity (21 eggs and above), 57.					Percentage of early maturers (220 days and below), 38 5.				

By the manner in which breeding birds transmit these two characteristics they may be judged in making up matings for the next season. The pair matings which give the best averaging offspring from the two viewpoints may be considered the most promising, and from such matings may breeding cockerels be selected with some degree of confidence. In many cases it may be difficult to find matings promising for both intensity and age at maturity, but in such cases the emphasis should be placed upon the one in which the particular stock is most deficient.

It is not suggested that the regular method of applying the progeny test to the complete first year record be replaced by the short-cut method here outlined. The short-cut is proposed only as a supplement to the regular method, making it possible to avoid some of the delays and the uneconomical withholding of valuable birds while awaiting the results of the mating. It is also appreciated that the short-cut method is not entirely dependable when distinguishing between two males of very similar breeding potentialities, but it will be possible by means of it to distinguish the poorest from the best breeders.

PROGENY TESTING FOR EGG SIZE

In the same manner that has been described for applying the progeny test to egg production may the test be used for breeding for improvement in egg size. Due to market discrimination against the small egg, there is an increasing interest in the problem of breeding for egg size. The usual method of merely selecting for egg size when the eggs go into the incubator is not sufficient. This method of improvement is inadequate, since it frequently may include the larger eggs of a female whose eggs generally are small as well as all the eggs of a female with a fair average egg size but coming from a small averaging family.

Application of the progeny test to breeding for egg size may be made by use of a table (Table V) similar to that used for egg production. The eggs of pullets to be considered should be weighed during the last 15 days before the test is applied. The weighing should be delayed as long as possible to allow the later-starting birds to increase their egg size. The average of egg size for this period will be found satisfactory for classification purposes. The poultryman may place his standard as high as he wishes and compare his pair matings on the basis of percentage of female offspring producing an egg equal to or above the standard. Allowance should be made for the fact that most of the pullets are too young to have reached their normal egg size. In addition to choosing only female breeders which exhibit the desired egg size, one may also limit his choice to those individuals that have proved themselves able to transmit it to a large percentage of their offspring. This permits more rapid improvement of the stock with regard to this characteristic. The choice of breeders is here made in a manner similar to that described for previously discussed characteristics.

TABLE V.—APPLICATION OF PROGENY TEST TO EGG SIZE.

Dam No.	Sire 189M. Egg size in ounces per dozen.					
	21	22	23	24	25	26
7621		2		2		
7700				4	2	1
8142	1	2	1	1		
8346			1	5	5	2
8817			2	7		
8840		1	3	3	2	

Percentage above 23 ounces, 72.

PROGENY TESTING FOR STANDARD CHARACTERISTICS

Most discussions on the application of the progeny test consider only its use for production breeding. It is true, however, that it may be used with much more immediate results for improvement in standard qualities. The advantage in the case of standard characteristics is that classification of the results may be made immediately upon attainment of maturity, or in some instances before, instead of waiting for some weeks or months as is necessary in production matings. The further advantage is that in the case of standard characteristics the quality will be expressed in both sexes and does not necessitate the selection of male breeders blindly.

The application of this progeny test may perhaps be made to a greater advantage for the elimination of defects or disqualifying characteristics. Such features lend themselves more readily for tabulation and summarization. It is, however, just as readily applied to desired qualities where they may be graded and classified.

Table VI was arranged for summarizing some of the defects appearing in a White Leghorn flock. The first column includes those individuals showing none of the defects listed. The occurrence of small feathers on the feet and legs is common in many barelegged breeds. Side sprigs on the combs are also a common disqualification in single comb varieties. Salmon color on the breast is a color defect found in white Leghorns. Our work has also indicated that deformed breast bones are inherited. The table may be varied to care for the conditions met with in any breed or variety. When the offspring are examined at the end of the growing season the defects may be recorded by placing a check mark to the right of the dam's number in the proper column. If a bird shows more than one defect, each corresponding column receives a check mark. Table VI presents the totals for such a system of records. The merits of the different matings may usually be determined by observation, considering the relative number of O.K. and defective individuals.

TABLE VI.—SUMMARY OF DEFECTS OF A MATING.

Dam No.	Sire 160M.						
	O. K.	Down on feet.	Stubs.	Side sprigs.	Crooked keel.	Salmon breast.	Small.
7434	7	1		2	3		
7581	3	8	2		6		1
7666	12			4	1		
7731	15						
7742	5	3			13	2	
8350	6		1	2	14		1
8362	11	3		1	6		

A similar table may be made for desired qualities such as eye color, surface color, undercolor, etc., grading each as good, fair, poor. The above-mentioned characteristics would especially apply to the nonwhite varieties.

Here as in the case of egg production or egg size the most valuable breeders are those which give offspring showing most uniformly the desired traits or which are uniformly free from breed defects. So one may select as breeders not only those birds which themselves approach most closely the breed ideal but which in addition come from families that as a group are superior. Breeding from such individuals will much more rapidly improve the general average of the flock.

PROGENY TESTING FOR SEVERAL CHARACTERISTICS

The problem is much simplified if we consider only one characteristic at a time, and certainly the emphasis should be limited to one. However, the breeder usually cannot entirely ignore all other characteristics when stressing the one. It should be emphasized that one must limit the attention to as few characteristics as possible, for an attempt to breed for too many is likely to result in no advance along any line. To the average breeder, egg number, egg size, body size, and standard characteristics are of major interest. In a breeding program the poultryman must decide which is of great-

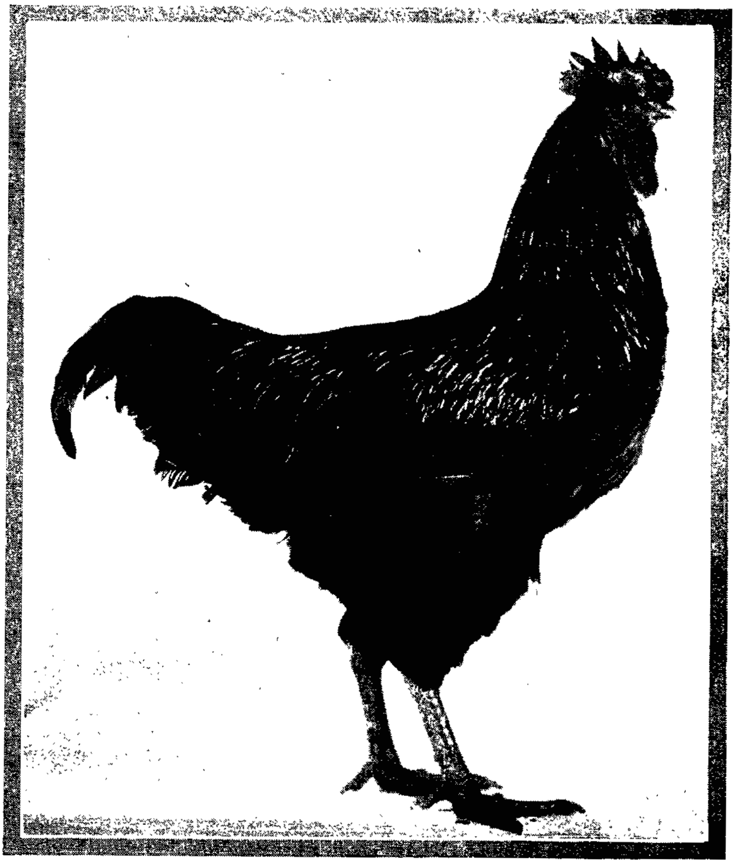

FIG. 6.—A Rhode Island Red male, outstanding for exhibition qualities, and from a dam with a record of 230 eggs during her pullet year. It is desirable wherever possible to combine high egg production and exceptional standard qualities.

est importance to him. The breeder who derives his major income from market eggs may be interested only in the two first mentioned, while the poultryman who sells breeding stock must consider all those mentioned and many others. In a few breeds there is evidence that there may be interference between exhibition and production qualities that makes a combination of the two difficult. Fortunately this is not true generally, and birds such as the one shown in figure 6 are much sought by the average poultryman.

Probably the most successful program considers all characteristics of importance to the breeder but confines the emphasis to one at a time. When sufficient progress is made along one line the emphasis may be changed. The progeny test should be applied to all traits of interest so that ground will not be lost in the others while the one is being improved. Table VII shows the results of the progeny test applied to three characteristics, early intensity, egg size, and standard qualities. The progeny from three breeding pens headed by males A, B, and C are compared.

If egg production is the characteristic being emphasized it is readily seen that male B is by far the most promising, since 84 per cent of his daughters are of high (above 20 eggs) intensity. The egg size of his daughters is also fairly good. A higher incidence of breed defects is found among his offspring, but with both rate of production and egg size being so satisfactory, the defects may be tolerated temporarily. Since the progeny test for standard qualities may be applied to both sexes the number of individuals is approximately double that included in the other two sections of the table. Although the offspring of male C were relatively free from standard defects, his pullets were found to lay very small eggs and their rate of laying was only fair. Male A is, from the viewpoint of egg size and standard qualities of his offspring, as good as B, but since egg production is being emphasized, the low rate of production of his daughters eliminates him.

The most promising pair combination in the pen headed by male B, is with female 8. Her offspring were outstanding for both rate of production and egg size. They were also relatively free from breed defects. If cockerels are to be chosen as breeders, this mating would be a most promising source.

THE SIGNIFICANCE OF THE PEDIGREE

The foregoing discussion indicates that the only dependable measure of a bird's breeding value is the progeny test. If this be true the question then arises as to what value the pedigree has. In reality the pedigree does not have the value placed upon it by many animal breeders. It supplies some history of the performance of a bird's ancestry, but gives no assurance that the same qualities will be transmitted by this bird to its offspring.

A pedigree is a record of the ancestry of the individual and for poultry should include a listing of at least the first-year egg record of the female ancestors. It pictures the lines of descent of the bird, and a study should reveal the degree of inbreeding which has resulted in its production. In some cases the pedigree also includes information on the size and hatchability of the eggs of the female ancestors. The latter information, although of value to the owner of the bird, is not always included because of the unwieldiness which it adds and the labor involved in making the record.

TABLE VII.—SUMMARY OF THE PROGENY TEST APPLIED TO THREE DIFFERENT CHARACTERISTICS IN A SERIES OF BREEDING PENS.

Dam No.	Egg production for first 30 days.				Egg size in ounces per dozen.						Standard qualities.				
	11-15.	16-20.	21-25.	26.	21.	22.	23.	24.	25.	26.	O. K.	Down on feet.	Stubs.	Crooked keel.	Small.
SIRE A															
1		2	5	1			6	1	1		7	1	1		
2		2	1					3			7				
3		3	8	1		2	7	3			12	2	1	3	2
4	3	9	2				10	2	2		17		2	3	1
5		1	4			1	2	2			8	1			
	Percentage above 20 eggs, 52.				Percentage above 23 ounces, 33.										
SIRE B															
6	1	2	1			1	2	1			10		2	1	
7		1	5	1			4	2	1		10		3	1	
8			9	3			7	5			18			2	
9		2	8	4		4	7	2	1		21	1		1	1
	Percentage above 20 eggs, 84.				Percentage above 23 ounces, 32.										
SIRE C															
10	1	6	1		1	3	2	1			12				
11		3	1	1		2	2	1			7			1	
12		1	4	2	3	3	1				10	1			1
13			6	2		4	4				12	2			1
14		1	3	2		3	2	1			9	1			
15	1		3	1		2	2	1			9				
16	2	6	2		1	4	3	2			15			2	1
	Percentage above 20 eggs, 57.				Percentage above 23 ounces, 13.										

To the uninitiated the first pedigree may be somewhat confusing, since it is both detailed and condensed. The usual pedigree lists the ancestry for four generations. It ordinarily reads from left to right giving first the identification numbers or names of the sire and dam. In the next column to the right, inclosed in brackets or squares extending from their respective offspring, are listed the grandsire and granddam of the individual considered. The third column includes the two parents of each of the four grandparents. Thus, the pedigree includes two parents, four grandparents, eight great-grandparents, and sixteen great-great-grandparents. Since it is upon the female ancestors only that production records are available in poultry, the male portion of the pedigree is of value only for tracing the complete ancestry. The production records of the females listed are usually given just below their identification numbers.

Some pedigrees, instead of giving the individual' record, will only state that the dam in a certain generation was one member of a group the production of which ranged between certain extremes. (Fig. 7.) This indicates pen instead of individual pedigreeing, and the work of Gowell, earlier mentioned in this publication, indicates that such selection is not effective.

SIRE 2071M............	♂ 1755M........	♂ 1582M..........	♂ 1222M ♀ 5721 Egg records, 240
		♀ Pen of 12 hens... Egg records, 260-295	♂ .... ♀ .... Egg records
	♀ 6240.......... Egg records, 254	♂ From dams with records above 250	♂ .... ♀ .... Egg records
		♀ .... Egg records, 250-283	♂ .... ♀ .... Egg records
DAM 7321.............. Egg records, 303	♂ 1990M........	♂ 1554M..........	♂ 1515M ♀ 6045 Egg records, 282
		♀ 6430............ Egg records, 202	♂ 1463 ♀ 5834 Egg records, 189
	♀ 7035.......... Egg records, 232	♂ 1625M..........	♂ 1232M ♀ 4864 Egg records, 260
		♀ 6523............ Egg records, 293	♂ 1232M ♀ 5230 Egg records, 255

FIG. 7.—A pedigree showing pen pedigreeing in the sire's ancestry and inconsistent production in the dam's ancestry. Both of these conditions detract from the value of the bird, the history of which the pedigree supplies.

The repetition of the name of any individual in a pedigree indicates inbreeding. The frequency and the position of the repeaters in the pedigree determine how closely the individual is inbred. The listing of an individual in the fourth generation of both the sire and dam of a bird means inbreeding to only a slight degree. However, if the name or number of the same individual appears in two succeeding generations, it indicates the mating of sire to daughter or mother to son, which is rather close inbreeding. If among the four grandparent's in the second generation of the pedigree the same name appears twice it indicates the mating of half brothers and sisters in the parental generation, while if the sire and dam each have the same sire and dam, then there would have occurred the mating of full brother and sister. (Fig, 8.)

SIRE 1461M	♂ 1245M	♂ 1211M	♂ 743M ♀ 4723 Egg records, 263
		♀ 5020 Egg records, 276	♂ 571M ♀ 3270 Egg records, 291
	♀ 5381 Egg records, 302	♂ 971M	♂ 835M ♀ 4072 Egg records, 256
		♀ 4330 Egg records, 285	♂ 775M ♀ 4861 Egg records, 274
DAM 5425 Egg records, 283	♂ 1245M	♂ 1211M	♂ 743M ♀ 4723 Egg records, 263
		♀ 5020 Egg records, 276	♂ 571M ♀ 3270 Egg records, 291
	♀ 5381 Egg records, 302	♂ 971M	♂ 835M ♀ 4072 Egg records, 256
		♀ 4330 Egg records, 285	♂ 775M ♀ 4861 Egg records, 274

FIG. 8.—The pedigree of a bird which is the result of a brother-sister mating. Its sire and dam have the same parents and as a result their pedigrees are duplicates. Consistently good production, such as is shown throughout this pedigree, indicates that a high standard for egg production must have been maintained in the breeding of the strain from which the bird came.

Although experiments have shown that too close inbreeding of poultry will usually result in reduced vigor of the stock, the finding of inbreeding in the pedigree of a bird being purchased should cause the purchaser no grave concern. This is true because the bird, which is usually a male, will be outcrossed when introduced into the flock, and outcrossing has been shown to restore vigor which has been lost by inbreeding. Also any bird which in spite of inbreeding in its pedigree shows good vitality is all the more valuable for this reason. Inbreeding is valuable only where the inbred stock is of superior qualities. To inbreed inferior stock would result in degradation in the same manner that inbreeding of superior birds results in improvement. There is, of course, no incentive to inbreed inferior birds, so that where the inbreeding does not reduce the vigor of an individual it usually is for its improvement.

Poultrymen in general have heard only of the objectionable effects of inbreeding and religiously avoid anything which suggests it. It is intended here to emphasize the fact that inbreeding of not too close a degree is probably the most rapid method of fixing in a strain some of the qualities of a superior individual—an individual which is at least superior with respect to some one quality and certainly not inferior in any others. To line breed from an individual which may be superior for egg production but inferior for other important qualities is a serious error, if it is desired also to maintain a high standard for these other qualities. Inbreeding will tend to accentuate the defects as well as the desirable qualities. An examination of the pedigree will show whether or not inbreeding has been involved in the production of the bird concerned.

The fact that its pedigree fails to show inbreeding is no indication that a bird is any less valuable, for many high-producing birds have resulted with no inbreeding. Although some inbreeding frequently appears in the pedigrees of high producers, superior layers have also resulted from the mating of very distantly, or even unrelated birds. Some high-producing females have been obtained from crossing two rather distantly related strains of the same breed. A White Leghorn hen which laid 305 eggs (fig. 5) at the Kansas State College was from a mating of this kind. So that, judging alone from the information which appears on the pedigree, it is more a matter of the individuals involved than the system of breeding which has been followed.

If it is admitted that high-production tendencies are inherited—and there is no reason for trapnesting unless this is true—then the occurrence of high-producing females in the pedigree enhances the breeding value of the individual involved. An individual high record at the left-hand side of the pedigree is of considerable more value than one at the opposite side, since a bird carries more of its mother's than its great-grandmother's make up. The repeated use of an individual in a breeding program should tend in general to make the strain more like the individual for which it is being line bred. The farther back through the pedigree the high-production tendencies run and the more uniformly high-producing the ancestry has been, the more valuable a bird may be considered as a breeder. In the pedigree, as in the progeny test, a single high producer in a family of low producers is not a very promising breeder.

There are facts of considerable interest to the buyer of a bird which will not be shown on the pedigree. One is the performance of all of his immediate relatives. However, when a pedigree is consistent throughout for high-producing females, there is evidence that there probably were high-averaging families or exceptional birds would not have been available in each generation. A bird the pedigree of which shows a high-producing dam but mediocre ancestry elsewhere in the pedigree is likely to be less valuable than where the female ancestors were uniformly good. So in addition to the egg record of the immediate dam, the average egg production and the number of exceptional layers produced by the flock from which the bird comes should also be considered. These latter conditions will ordinarily be reflected in the average of the females involved in a pedigree. Thus, the pedigree cannot be made a substitute for the progeny test, but it does supply information which, if properly interpreted, is of value in judging the breeding potentialities of the bird whose ancestry it lists.

PUBLICATIONS ON POULTRY

Other recent publications of the station dealing with various phases of poultry husbandry include the following:

Bul. No.

245. A Poultry Survey in Kansas. By Loyal F. Payne and Howard H. Steup. (52 pp., 9 illus.)
247. Poultry Diseases, Their Prevention and Control. By L. D. Bushnell and C. A. Brandly. (106 pp., 32 illus.)
252. Crossbred Poultry. By D. C. Warren. (54 pp., 21 illus.)
256. Farm Production and Consumption of Poultry in Kansas. By Morris Evans and H. L. Collins. (33 pp., 12 illus.)
257. The Poultry Enterprise on Kansas Farms. By Morris Evans. (22 pp., 5 illus.)

Circ. No.

99. Poultry Breeding Records. By Wm. A. Lippincott. (34 pp., 24 illus.)
122. Poultry Management on the Farm. By Loyal F. Payne. (50 pp., 19 illus.)
127. Fitting and Exhibiting Standard-bred Poultry. By H. H. Steup. (37 pp., 17 illus.)
147. Culling Poultry. By Loyal F. Payne and H. H. Steup. (50 pp., 30 illus.)

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