Egg Production

This is the fifth article in a series of brief progress reports on the application of the science of genetics to commercial agriculture.

application of principles of genetics may hasten improvement of poultry

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Before genetic studies demonstrated the distinction between the *phenotype*—appearance or record of a chicken—and the *genotype*—hereditary make-up—the methods of selection and the breeding programs used by poultry breeders were relatively inefficient. On the other hand, breeding programs recognizing this distinction have been eminently successful in raising the production index of experimental flocks and of flocks operated by commercial breeders.

The *production index* or the *hen-housed average* means the number of eggs produced per original pullet placed in the laying house.

The production index is a measure of the economic worth of a flock of birds which is more accurate than the commonly used *average production* of birds surviving the first laying year. The index takes into account not only production rate but also the ability of the birds to survive under the given conditions of management.

As a single example, the results of one selection experiment may be cited: starting with a flock of S.C.W. Leghorns—with a consistent average production index of 120 eggs per bird, which was representative of commercial flocks—the application of family selection and progeny testing at the University of California resulted in a rapid increase to approximately 200 eggs per year. This average has now been maintained for several generations, fluctuating up to the high point of 218 eggs.

Recent studies in the field of population genetics indicate that the actual methods used in achieving such increases were not necessarily the most efficient ones available to breeders. It should not be taken for granted that the newer genetic knowledge can at this time raise the upper limit of flock production or of the poultryman's income. Rather than that it is the efficiency—relative cost of obtaining the gains and the relative time which it would take to achieve equivalent gains—of breeding that is aided by the present studies in this branch of science.

Population genetics is a field of study which attempts to deal with the genetics of populations—flocks or herds—rather than with that of individuals. It is a relatively new subject and its full potentialities have not been explored as yet.

It is becoming increasingly apparent that the approach to practical problems of selection and mating through population genetics presents a most useful extension of fundamental principles of Mendelism.

The two problems that a poultry breeder ordinarily faces in his program are those of selection and of mating.

It is within the breeder's power to decide which birds in his flock he shall save for breeding and which he shall discard—the problem of selection.

Similarly it is up to the breeder to make up whatever combinations of sires and dams that are possible among the selected birds—the problem of mating.

The aim of the investigator in population genetics in relation to poultry breeding is to discover what particular method of selection; and what particular system of mating is likely to produce the maximum gain in the character desired in the minimum possible time and at a minimum cost.

The procedure such an investigator follows is to determine first of all some of the basic genetic properties of a flock. The degree of heritability is perhaps the most fundamental one of these. It measures the proportion of the variation in the production index which is due to genetic differences between birds and is also a measure of the accuracy with which a genotype can be estimated from a phenotype.

For the production index, the degree of heritability has been found to be low—about .05—as compared to .30 for the production of survivors, and .40 to .50 for characters more easily modified by selection, such as body size or conformation.

Having determined the degree of heritability, it becomes possible to compute theoretically the gains to be expected from selection of varying degrees of intensity by using the different selection methods available. Thus selection on a family basis is apparently capable of producing a greater genetic gain in the production index than that obtained by selection on an individual basis. This is not necessarily true of traits which have a higher heritability.

In a similar manner it becomes possible to compute the gains to be expected from progeny testing. Furthermore, other criteria of selection than the production index itself—such as winter production, viability, other characters which influence the index—can be subjected to the same type of computation.

Most of the work of this type has so far been on a theoretical level but what experimental evidence is available indicates that the fundamental genetic theory underlying these computations is sound. Therefore, it is possible to suggest the type of selection which is likely to produce the most economic gains.

For the production index it appears

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MENDEL'S LAW

The Basis of Mendelism

Mendel's Law is the law observed in the inheritance of many characters in animals and plants. The height, color, and other characters depend on the presence of determining factors—genes—which behave as units. The following example shows the operation of the law: Tallness being due to a factor T and shortness to a factor t, a tall plant, arising by the union in fertilization of two germ cells both bearing the factor T, is TT; a dwarf is tt. Crossing these, crossbreds, Tt, result—called generation F_1. In their formation a process occurs such that germ cells, whether male or female, are produced of two kinds, T and t, in equal numbers. T and t, being thus alternative, are called *allelomorphs*. The offspring, generation F_2 which arise from the chance union of these germ cells in pairs according to the law of probability, are on an average in the following proportions:

$$1TT : 2Tt : 1tt$$

and thus plants pure in tallness—TT—and dwarfness—tt—as well as crossbreds—Tt—are formed. Frequently, the individual Tt is itself indistinguishable from the pure form TT. The factor T is then called *dominant*, and t called *recessive*. Generation F_1, containing only the Tt form, consists entirely of dominants—tall plants—and generation F_2 consists of three dominants—$2Tt$, $1TT$—to one dwarf—tt—which is called recessive.

Such qualitative and numerical regularity has been proved to exist in regard to very diverse qualities or characters which compose living things, both wild and domesticated, as colors of flowers, of hair or eyes, patterns, structure, chemical composition, and power of resisting certain diseases. The diversity of forms produced in cross-breeding by breeders generally results from a process of analytical variation or recombination of the factors composing the parental types.

DRIFT

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counter readings. The necessity of making laborious pollen counts under a microscope was thereby eliminated. At the same time the Geiger counter differentiates between the treated pollen grains and untreated ones which usually contaminate samples collected under field conditions.

The treated pollen was then released in the field under conditions simulating its normal release from the tree.

Later, the pollen was collected along various radii from the point of release. Within approximately 100 feet of the release point, collection was made in petri dishes—small shallow saucers—placed at intervals along the ground or at any desired elevation. At greater distances a vacuum sweeper with a filter paper or other fine screen placed over its intake was used to concentrate on a small surface the particles in a large volume of air. The period of time during which the sweeper was in operation was recorded.

An estimate of the number of pollen grains per unit area in each petri dish was made by centering the dish directly beneath the window of a Geiger tube and at a fixed distance from it. The average 10 one-minute readings was taken; the background count was deducted; and the net count divided by the counts per pollen grain which were previously established from standardization tests, made with known numbers of the radioactive pollen grains uniformly distributed in petri dishes.

A similar method was used to determine the number of pollen grains collected by the vacuum sweeper, providing a sufficiently large number were present to give a significant reading with the Geiger counter. However, at distances of several hundred feet from the point of release even the vacuum sweeper collected too few pollen grains to permit analysis with the Geiger counter. In such cases radioautographs were made by placing the filter paper or other screen on which the pollen had been collected in contact with X-ray film. In this way every individual radioactive pollen grain in a dilute sample was distinguishable on the processed autograph; whereas untreated pollen grains did not activate the film.

An advantage of the radioautograph for analyzing dilute samples is that the size of the image formed by each radioactive pollen grain on the film is several times the size of the pollen grain itself. This, combined with the sharp black-and-white contrast between the pollen grain images and adjacent portions of the autograph, permits a count of the pollen grains in dilute samples without magnification and laborious searching of a large surface. Where the density of pollen grains is so great that their images blend thereby preventing an accurate count on the autograph, there is sufficient radioactivity in the total sample to permit use of the Geiger counter. Thus the counter and autograph complement each other in establishing the entire gradient.

The volume of air which had been sucked through the vacuum sweeper during the collection period was determined by placing a small anemometer directly in front of the intake of the sweeper, fitting it tightly to the attached screen and measuring the velocity of wind sucked through the sweeper per unit time.

During the course of the experiment a continuous record was kept of wind direction and velocity, air temperature, and barometric pressure.

In a recent experiment using 10 millicuries of P32—which costs about $5—approximately 10 billion pollen grains were vacuum infiltrated. This gave each grain an initial activity of approximately one count per minute on the Geiger counter. Since the counter used has a capacity of over 20,000 counts per minute some appreciation is given of the density range that can be analyzed. If, as in this experiment, there are as many as 40,000 pollen grains or more in a single petri dish at the peak of the gradient thus making it initially too hot to count, the dish can be analyzed after a suitable cooling-off period, the length of which depends upon the half life of the radioactive tracer used.

Experiments now in progress seek to establish simultaneously the separate spore gradients from two different points by labeling one lot of spores with P32 and the other lot with a radioactive tracer, such as radioactive sulfur—S35—having an appreciably different half life and energy of radiation. Such information is of value in certain plant breeding experiments.

The above techniques would seem directly applicable to establishing the distribution pattern of agricultural chemicals applied in dust form, with modifications perhaps being required if the size of the dust particles is quite variable. For chemicals applied in spray form, once the tracer is mixed uniformly throughout the solution to be sprayed and the activity per unit volume of solution is determined, Geiger counter readings made on the various collection surfaces should be directly indicative of the volume of solution deposited regardless of particle size of the spray during dissemination.

If, as in certain cases, effectiveness of treatment depends on the amounts of dust or spray deposited on top and bottom leaf surfaces the techniques herein described should readily yield the needed information, providing a radioactive tracer is used which has a sufficiently low energy of radiation that it cannot penetrate the thickness of the leaf.

Radiological health officers have expressed assurance that there is no appreciable health hazard involved in experiments of this type conducted in the field. However, it is advisable for those working within a few feet of the point of release to wear a respirator to avoid inhaling large quantities of the radioactive spores.

Detailed results of the experiments mentioned here and others currently in progress will be published at a later date.

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EGGS

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that selection on the basis of the hen-housed production of pullets to January 1st of their first laying year presents optimum opportunities.

Primary emphasis should be laid on family averages but the superior qualities of individual pullets from good families should not be entirely neglected. This forms a combined family and individual selection basis which can be applied to sister testing and to progeny testing. It seems that sister testing is a more efficient tool than progeny testing, so that for fastest gains only a limited portion—10% to 20%—of the breeding flock should be selected on the latter basis.

The plan suggested may be expected to produce relatively rapid gains in the production index, and also should cut down the current cost of breeding operations to a considerable extent. This follows from the fact that a flock under test need not be individually trapnested after January 1st—except for the birds selected for breeding.

It is possible that even without the science of population genetics, breeders in the field would eventually arrive at similar conclusions by the laborious and costly method of trial-and-error. Many techniques have been developed in the past in such a manner. There is, however, full reason to believe that the understanding of the genetic principles recently gained is bound to lead to more efficient ways of improving breeding procedures and to lead to genetic improvement in egg production more rapidly and with greater certainty than heretofore.

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