Poultry Breeding

long-term selection studies aim at breaking through the ceiling limiting further improvement of economic traits

I. Michael Lerner

Most breeders of chickens who start with average or below-average commercial flocks have little difficulty in obtaining improvement by selection of economic characters.

The speed with which improvement is obtained will be determined to a considerable extent by the method used—mass selection, family testing, selection by index, or some other plan. Intelligent application of even the least efficient genetic practices may be expected, in most cases, to improve the selected traits.

It is after a more or less successful period of such selection that real difficulties may arise. Following a number of generations of rising production averages, body size, disease resistance—or whatever selection is directed towards—improvement rates usually slow down and eventually may cease altogether. In such cases the breeder is still applying, so far as he knows, a reasonable selection pressure. His stock may still be nearly as variable as it was at the beginning of his improvement efforts. The level of performance for the selected trait may still be below averages reported in other flocks. Yet despite all of these conditions progress seems to have stopped.

The cessation or slowing down of improvement is a problem of great importance. Discovery of efficient methods of overcoming this difficulty requires an understanding of the basic reasons for the slackening of gains in long-term selection programs.

The Division of Poultry Husbandry has several subprojects dealing with this aspect of breeding. One of these concerns itself with continued selection for increased shank length. This character was used because shank length is a good measure of body size—hence of economic importance—and is a relatively simple trait from the biological viewpoint. A recent analysis of data from this experiment has thrown some significant light on the problem of cessation of gains from selection.

The mechanism underlying cessation of selection progress in this case may not account for all other similar cases, but at least one such mechanism was found.

A White Leghorn flock in which mature pullets had an average shank length of 9.69 centimeters—cm—was subjected to selection for an increase in this character. The average length of shank in the succeeding generations of the experimental flock gradually rose as follows:

Generation	Shank length
	cm
0	9.62
1	9.92
2	9.92
3	10.20
4	10.29
5	10.46
6	10.73
7	10.84

Concurrently a control population was carried along without conscious selection for length of shank. In this check group the shank length varied somewhat from year to year, but never rose above 9.89 cm—generation 10—dropping as low as 9.37 cm at one stage—generation three.

Clearly up to the seventh generation, continued progress in the objective sought was being obtained in the experimental flock. In the following four generations, however, at least a temporary cessation of improvement occurred:

Generation	Shank length
	cm
8	10.71
9	10.73
10	10.96
11	10.78

The test provided a clue to the reasons for this cessation. As shank length increased a drop occurred in the reproductive capacity, involving any or all of the factors determining the number of offspring a bird produces: egg number, fertility, hatchability, and chick viability. For instance, in generation two, 4.67 mature pullets were obtained from each selected dam in a four-week hatching period; in generation nine this number dropped to 1.57.

Longer-shanked birds thus seem to produce fewer offspring. At first sight this relationship seems to be a result of inbreeding. The important fact, however, was that in the later generations—but not in the earlier ones—longer-shanked birds produced fewer daughters than their shorter-shanked flockmates of the same generation and degree of inbreeding. Independently of inbreeding, a negative correlation must have arisen between reproductive capacity and shank length.

The average bird is a well-balanced organism with an optimum combination of different properties for reproduction. If a single property is selected towards an extreme condition, a certain amount of tolerance permits some gains to occur. But an attempt to push beyond a limit interferes with the balance, leading to poor reproductive performance. The breeder continues exercising selection pressure, but since his better birds—from the standpoint of the selected trait—do not breed as well as the poorer ones, this selection pressure is counterbalanced to such an extent that little further progress is obtained.

There is some indication that constant maintenance of selection pressure will permit the flock to find a new favorable balance. Gradually other biological properties of the bird will adjust themselves to the extreme type—of shank length in this experiment—and further improvement with some restoration of reproductive capacity may be obtained. This is shown in the last series of measurements:

Generation	Shank length
	cm
12	11.10

The control in this generation stayed at 9.58 cm, almost identical with the original population. The number of mature pullets obtained from each dam, however, increased from the low value of 1.57 to over three. Further generations of selection will be studied.

If this interpretation of the situation is correct sufficient patience may eventually permit the breeder to break through the ceiling for a given trait. This, however, is not a satisfactory solution of the problem. Methods of speeding up the process of readjustment between the extreme expression of a selected character and the other factors in a birds make-up must be sought. There are some indications that the theory advanced from this study may be applicable beyond the particular trait studied here. It is, however, likely that the more complex is the selected character, the more difficult and the longer is the process of finding new balanced combinations. The need for artificial techniques of hastening readjustment is therefore greater for such characters as egg production than for the simpler one of shank length.

I. Michael Lerner is Professor of Poultry Husbandry, University of California College of Agriculture, Berkeley.