The Effects of Natural Selection on Selection Differentials for Egg Production in Long-term Selected and Unselected Control Strains of White Leghorns

R.S. Gowe, R.W. Fairfull and I. McMillan
Centre for Genetic Improvement of Livestock, Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario, N1G 2W1 and Centre for Food and Animal Research, Agriculture Canada, Ottawa, Ontario, K1A 0C6, Canada.

SUMMARY

The effects of natural selection on 273 day part-record egg production were examined by comparing population differentials in selected strains of laying hens. Similar differentials were also calculated for unselected control strains. Viability had the greatest effect on population differentials in both selected and control strains. In the selected strains no other effects of natural selection were evident, probably due to artificial selection for fitness traits. In control strains, the effect of viability was higher and breeders averaged higher egg production than survivors to 273 d. As the average egg production in the control populations remained constant, the difference was probably due to effects that reduced the mean of the survivor population relative to the breeder population that were not wholly genetic. The subclinical effects of some diseases might account for this. Also, hatchability significantly affected differentials for part-record egg production in the control strains.

INTRODUCTION

Few studies have examined the effects of natural selection on the results of a selection process or of analogous effects in unselected controls. This paper examines the effects of natural selection on selected and controls strains of White Leghorns by comparing differentials based on the total population *versus* 1) hens alive at 273 d (part-record period used for selection), 2) breeder hens selected, 3) breeder hens that laid fertile eggs, and 4) breeder hens with chicks hatched. As the selected strains used in this study were selected for fitness traits, the contrast between selected and unselected control strains provides information on the interaction of artificial selection with natural selection.

MATERIALS AND METHODS

The results are based on data from 1971 to 1979 of a long-term selection study at Agriculture Canada. The study was initiated in 1950 and terminated in 1980.

Differentials

The production differences calculated within strain were: between all hens with valid measurements and, respectively, 1) all hens alive at the part-record of selection (viability), 2) breeder hens with eggs set (selection differential for selected strains), 3) breeder hens with fertile eggs, and 4) breeder hens with chicks hatched. All differentials were based on females only.

Strains

Six selected strains and two unselected, control strains from a selection study were used. Pairs of selected strains (1, 3; and 2, 4; and 9, 8) were from different genetic base populations. Strains 5 (unselected control) and 3 (selected) originated by a within family division of a common base population of White Leghorns in 1950. Selected strain 1 derived from strain 3 in 1971 by a within family division of individuals. Matings to start strain 4 (selected) were made in 1951 using a composite of seven Canadian ROP Leghorn stocks and strain 2 (selected) was produced from strain 4 by a within family division of the base population in 1968. Strain 7 (unselected control) was initiated in 1959 using a composite of four North American commercial stocks. Selected strains 8 and 9 originated from strain 7 by a within family division of the base population in 1969.

Selection

Selection was based on a record to 273 days of age (39 weeks). All strains (except controls) were

selected for viability (brooding and rearing, and laying), fertility, hatchability, egg weight, egg specific gravity, Haugh units (albumen height corrected for egg weight), blood spot incidence, and shell shape. Selection for body weight was initiated in 1975. Thus, strains were all selected for the same traits except that one strain from each genetic base was also selected for hen-housed egg production (strains 3, 4 and 8) while the corresponding strain from each base was also selected for hen-day rate of egg production from first egg (strains 1, 2 and 9).

From 1971 to 1979, 28 sires were mated to 224 dams to reproduce the selected strains with 1120 hens and 672 cockerels housed. The unselected control strains used 80 sires mated to 240 dams housing 480 hens and 240 cockerels. During this period the average annual rates of inbreeding for the control and selected strains were 0.15% and 0.88%, respectively.

Management

All-mash diets were fed throughout the study period. All hens were housed one per cage. Females were brooded and reared in group cages and males in floor pens. More detail on strains, selection procedures, management and test procedures can be found in Gowe *et al.* (1973), Gowe (1977), and Gowe and Fairfull (1982, 1985a,b, 1986).

RESULTS

Mean differentials per generation of the selected and control strains from 1971 to 1979 for the two selected egg production traits, hen-day rate of egg production from age at first egg to 273 days of age and hen-housed egg production to 273 days of age, are shown in Table 1. All differentials were significantly greater than zero ($P < .01$). Also, differentials based upon breeder hens with eggs set, breeder hens with fertile eggs, and breeder hens with chicks hatched were significantly greater than that based on viability to the part record of selection as would be expected (Table 1). For the selected strains, there were no significant differences among the differentials based upon breeder hens with eggs set, breeder hens with fertile eggs, and breeder hens with chicks hatched. For the control strains, the differential for breeder hens with chicks hatched was significantly higher than the differentials based upon breeder hens with eggs set and

Table 1. Differentials between all hens with valid measurements and, respectively, all hens alive at the part-record of selection (Alive), breeder hens with eggs set (Breeders), breeder hens with fertile eggs (Fertile), and breeder hens with chicks hatched (Chicks) for hen-day rate of egg production from age at first egg to 273 days of age (HDR) and hen-housed egg production to 273 days of age (HHP)

	Alive	Breeders	Fertile	Chicks
Hen-day Rate, %				
HDR Selected[1]	1.96[a]	6.88[b]	6.88[b]	6.88[b]
HHP Selected[1]	1.62[a]	5.71[b]	5.72[b]	5.72[b]
Controls	4.04[a]	6.38[b]	6.42[b]	6.57[c]
Hen-housed Egg Production, No.				
HDR Selected	3.01[a]	8.59[b]	8.59[b]	8.58[b]
HHP Selected	2.83[a]	10.79[b]	10.80[b]	10.80[b]
Controls	5.16[a]	7.73[b]	7.79[b]	7.95[c]

[1] HDR Selected = strains selected for hen-day rate of egg production from age at first egg to 273 days of age. HHP Selected = strains selected for hen-housed egg production to 273 days of age.

[a,b,c] Values with different superscripts are significantly different ($P < .05$).

breeder hens with fertile eggs which did not differ significantly (Table 1). These results were found for both hen-day rate of egg production from age at first egg to 273 days of age and hen-housed egg production to 273 days of age.

DISCUSSION

Viability ("Alive") had the greatest effect on selection and reproduction with regard to egg production. In the selected strains, viability to 273 d accounted for about a third of the differential for breeder hens with eggs set at the 273 d part-record for both hen-day rate of lay and hen-housed egg production. There were no other effects of natural selection evident in the selected strains. Apparently, selection for fitness traits reduced the effects of natural selection in the long-term selected strains.

In the control strains, the effect of viability was about double that of the selected strains as might be expected; however, the fact that breeder hens with eggs set had a significantly higher mean than those surviving to the part record of selection is not accounted for by selection as the unselected control strains were not selected. Furthermore, as the egg production of the control strains has remained relatively constant (Gowe and Fairfull, 1990), most of this difference probably does not reflect genetic differences. Other factors, such as, mortality between the end of the part-record of selection and reproduction, hens going out of lay before reproduction, perhaps partly the result of subclinical effects of diseases (Gavora *et al.*, 1980; Garwood *et al.*, 1981), must play a part. Compared to selected strains more hens required replacing in the control strains by the end of the first AI (very few hens were replaced after this). As the differential for unselected control strain hens with live chicks was higher than that for breeder hens, hatchability can significantly affect the outcome of reproduction in strains not selected for hatchability. This occurred despite the fact that hatchability was relatively high in the control strains, averaging 87.6% between 1971 and 1979 and 88.5% in 1979.

The major difference between the selected and control strains was selection for fitness traits: viability, fertility, hatchability and egg production. It appears that selection for fitness reduced the effects of natural selection on selection differentials and reproduction. The only major assignable effect of natural selection in selected strains was to increase selection differentials for egg production traits by between 1.5 and 2.0% or from 2.8 to 3.0 eggs to 273 days of age.

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