SOMATIC AND Z-CHROMOSOME ADDITIVE GENETIC EFFECTS ON EGG PRODUCTION OF WHITE LEGHORN STRAINS AND STRAIN CROSSES

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SUMMARY

Somatic and Z-chromosome additive genetic effects on egg production were evaluated in three White Leghorn strains and their two-way crosses during the first laying cycle. Egg number of the survivors from hens housed one per cage in a randomized block design was divided into 12 periods of 28 days each, starting at age at first egg. The pattern of age changes in additive and Z-chromosome effects varied among strains, indicating genotypic differences in response to aging. These differences increased on average with age. Lifetime performance of layers may be improved by selecting animals at older ages. This favours individuals with better DNA repair capacity or those which can turn on favourable genes or turn off detrimental genes as required to buffer the negative effects of aging.

Keywords: aging, additive genetic effects, Z-chromosome effects, egg production.

INTRODUCTION

Selection for egg production in egg stock chickens normally uses data from the first laying cycle, with the result that improvement in production occurs largely in this cycle. Most traits deteriorate with advancing age within and across laying cycles. Studies on genetic effects of aging on fitness traits in poultry have shown increased genetic and environmental variation with age (Liljedahl *et al.* 1984; Engstrom *et al.* 1992; Liljedahl *et al.* 1994; Fairfull *et al.* 1997; Liljedahl *et al.* 1997). Also, the pattern of changes with age varied among strains, showing that there are genotypic differences in response to aging (Fairfull *et al.* 1997; Liljedahl *et al.* 1997). Although genetic and environmental variation for some fitness traits have been studied in layers, little has been done regarding the influence of the sex-linked effects that seem to be important for egg production traits (Fairfull, 1990). This paper reports on additive genetic and Z-chromosome effects for egg production and their changes with age during the first laying cycle of commercial White Leghorns from different genotypes.

MATERIALS AND METHODS

Animals and housing. Three strains (1, 2 and 3), were used in a factorial design to produce 9 different genotypes: 3 pure strains and 3 pairs of reciprocal crosses. White Leghorn chicks were produced from pedigree matings using 16 sires and 3 dams per sire (48 dams) for each strain and cross. At about 133 days the hens were housed one per cage in a two-tier, stair step cage system in a randomized block design. Each genotype (strain or cross) was randomly assigned within each of the 16 cage rows representing complete blocks.

Egg production. Egg production was recorded for each hen from 138 to 576 days of age, and measured as egg number from age at first egg (AFE). For statistical analyses, the egg numbers of each hen were divided into 12 periods of 28 days each, beginning from AFE. The data were adjusted by removing dead birds and birds that had less than 20% of production in each of the 12 periods, to account for morbidity.

Statistical analyses. The strain additive genetic effect (A_j), strain Z-chromosome effect (Z_K), and heterosis (H_{jk}) were estimated using the following regression model:

$$Y_{ijkl} = \mu + B_i + \sum_{j=1}^{3} A_j l_j + \sum_{k=1}^{3} Z_k m_k + \sum_{j=1}^{2} \sum_{k=j+1}^{3} H_{jk} n_{jk} + e_{ijkl}$$

Where:

Y_{ijkl} = observation on trait to be evaluated;
B_i = effect of the i^{th} block;
l, m, n = expected proportion of genes from the different genotypes.

The genetic effects were estimated by fitting constants using the general method of Robinson *et al.* (1981). The effects with restrictions imposed (A_j and Z_k) were expressed as deviations from effects not fitted (i.e. A_1 and Z_1). A repeated measures analysis was used to compare genotypes for their performance over time (age), as well as their response patterns over age. The mean value, the linear and the quadratic contrasts across age were calculated for each hen and analyzed by the previous model, with Y_{ijkl} being the contrast of interest.

RESULTS AND DISCUSSION

The egg number changed in a curvilinear fashion (Figure 1), increasing from the first to the second 28 d period, then decreasing gradually with advancing age. The additive and Z-chromosome effects for egg production (Figure 2) are expressed as a deviation from Strain 1. Differences between A_2 and A_1 were significant ($P<.01$) across periods. The A_2 was higher than A_1 throughout the first laying cycle, and this difference increased linearly with advancing age ($P<.05$). The A_3 was lower than A_1 from period 3 to 6. Differences between A_3 and A_1 followed a curvilinear pattern ($P<.01$), increasing through period 4 and decreasing thereafter.

Although the Z-chromosome effects were not significant on average across periods, the difference between Z_2 and Z_1 increased linearly with age ($P<.01$), where Z_2 was higher than Z_1. Differences between Z_3 and Z_1 followed a curvilinear pattern ($P<.07$). The Z_3 was lower than Z_1 around period 4, but at the end of the cycle Z_3 was higher than Z_1. This indicates that the expression of sex-linked genes was influenced by age. Hagger (1985) found significant reciprocal effects for egg number, a good indication of sex-linked effects. Differences in additive genetic effects were more important to explain variation on egg production among genotypes than differences in sex-linked effects. On average, differences in genetic effects increased with advancing age.

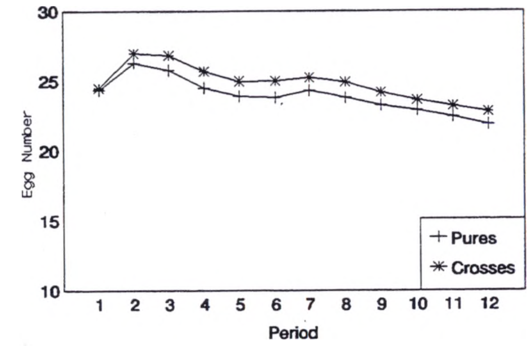

Figure 1. Mean egg number of pure strains and crosses for egg production during the first laying cycle.

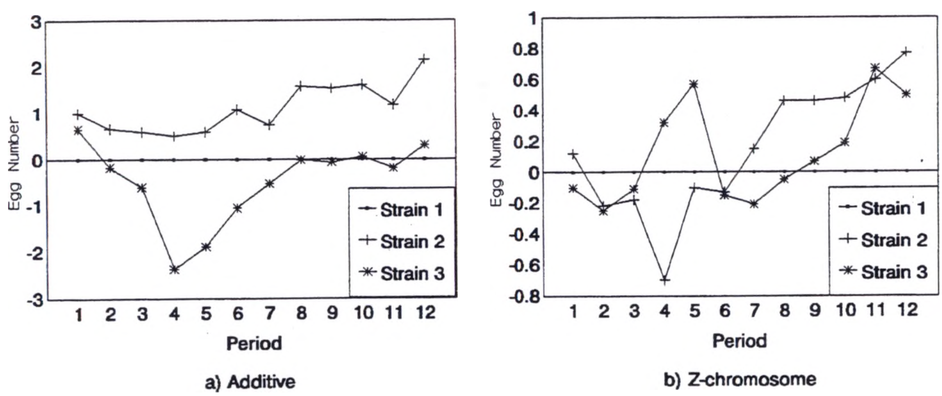

Figure 2. Strain additive (a) and Z-chromosome (b) genetic effects for egg production during the first laying cycle of three strains and their two-waycrosses.

There are only few reports on strain genetic effects in poultry. Liljedahl *et al.* (1997) and Fairfull *et al.* (1997) observed increased divergency with age in additive and sex-linked effects among different genotypes for egg production and viability,respectively. These authors also found different patterns of age change of these effects among strains, which was also the case in the current study. Different genotypes had different ways of dealing with the deleterious effects of aging. Strain 2 had higher additive genetic effects during the first laying cycle. In addition, Strain 2 had a positive Z-chromosome effect at the end of the cycle. This strain, when used as a male line, is expected to improve egg production at the end of the cycle in contrast to strains 1 and 3. Lifetime performance may be improved by selecting animals at older ages. This possibly favours individuals with better DNA repair capacity or those which can turn on favourable genes or turn off detrimental genes as required to counteract the environmental stress during the process of aging.

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