

RESEARCH NOTES

Research Note: Differences in Major Histocompatibility Complex Gene Frequencies Associated with Feed Efficiency and Laying Performance¹

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ABSTRACT Associations between egg production and feed efficiency and the genes of the major histocompatibility complex (MHC) of the chicken were investigated. Breeders were selected on the basis of indexes incorporating information on body weight and egg mass, with or without feed consumption information. Over 1,000 progeny were serotyped for the erythrocyte antigen B (Ea-B) after the 6th generation of selection. The B^2 and B^{13} haplotypes accounted for over 75% of the *Ea-B* gene pool in all lines. Comparing each index-selected line with the control, B^2 significantly increased in frequency at the expense of B^{13} . This study further implicates MHC-linked genes as important in the physiology of growth and reproduction in the chicken.

(Key words: egg mass, body weight, feed consumption, major histocompatibility complex, *Ea-B*)

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INTRODUCTION

The major histocompatibility gene complex (MHC) has been associated with growth and reproductive traits in a variety of species, including swine (Rothschild *et al.*, 1984), mouse (Goldbard *et al.*, 1982), rat (Kunz *et al.*, 1980), and human (Reznikoff-Etievant *et al.*, 1984). Reports have also related certain alleles of the chicken MHC with reproductive characteristics (Briles and Allen, 1961; Allen and Gilmour, 1962; Gilmour and Morton, 1970; Nordskog *et al.*, 1973; Simonsen *et al.*, 1982; Gavora *et al.*, 1986). The chicken *B* blood group system (Briles *et al.*, 1950) serves as a genetic marker for the MHC in the domestic fowl (Schierman and Nordskog, 1961).

The objective of the present study was to further investigate the relationships of the chicken MHC (*B* complex) with traits of growth and reproduction. Lines of chickens that had been subjected to long-term selection for body weight, egg mass, and feed consumption were blood-typed to determine whether the selection for characteristics of growth and reproduction had changed the frequency of *B* haplotypes in each line.

MATERIALS AND METHODS

Populations. The White Leghorn chickens used in this study were selected from lines maintained for research at Iowa State University since 1963. Originally, two populations, S1 (possessing *B* alleles B^1 , B^2 , B^{19} , and B^{21}) and S2 (possessing *B* alleles B^{13} , B^{14} , B^{19} , and B^{21}), were derived from crosses of three inbred lines obtained from a commercial source (Hy-Line International, Johnston, IA). Each year, breeders were mated in a scheme designed to equalize numbers of progeny produced per genotype (Nordskog *et al.*, 1973). Lines S1 and S2 were crossed to produce the R population, which contained *B* haplotypes B^1 , B^2 , B^{13} , B^{14} , B^{19} , and B^{21} (Wing and Nordskog, 1982). In 1977, Lines C and D were selected from Population R. Line C was selected for a high ratio of egg mass to body weight at 32 wk, and Line D was selected for a high ratio of egg mass to feed consumption at 32 wk. In 1978, three sublines (2 replicate selected lines and 1 control line) were formed from each of the C and D lines, initiating the present selection experiment.

Index selection. Two selection indexes were constructed: Index 1 = b_1 BW32 + b_2 EM1 - b_3 FC1, and Index 2 = b_1 BW32 + b_2 EM1, where BW 32 is grams of body weight at 32 wk, EM1 is mean grams of eggs produced per day and FC1 is mean grams of feed consumed per day from 30 to 34 wk of age, and b_1 , b_2 , and b_3 are weighing coefficients (Hou, 1985). Selection for high values of Index 1 was applied to the two replicate selected sublines of Line C.

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Selection for high values of Index 2 was applied to the two replicate selected sublines of Line D. A third subline within each line (C or D) served as a control and was selected with a "zero selection differential" on each index. For each subline, 8 sires were mated to 6 dams each. This represented approximately 40% of the females and 17% of the males available per generation. The results of the index selection on feed efficiency for egg production will be reported elsewhere (Hou and Nordskog, in preparation). Index selection was carried out for six generations before progeny were blood-typed.

Blood-typing. One thousand and ninety-five chicks were blood-typed at 6 wk of age with alloantisera specific for the *B* blood group. The antisera were produced by alloimmunizations designed to produce reagents monospecific for a single *B* blood group. The blood-typing assay was carried out by microhemagglutination, using equal volumes of test red blood cells (2% v/v phosphate-buffered saline) and a previously determined hemagglutinating dilution of each alloantisera.

RESULTS AND DISCUSSION

The blood-typing results are presented in Table 1. The two most frequent *B* haplotypes, B^2 and B^{13} , represented more than 75% of the gene pool for each line. Haplotype B^{14} was present at a low frequency. Haplotypes B^{19} and B^{21} were present at extremely low frequencies or absent from some lines. Haplotype B^1 , which had been present in predecessor populations, was no longer present in any of these lines. This

may relate to the extended selection period of the experiment and the poor overall fitness of B^1 haplotype birds (Briles and Allen, 1961; Nordskog *et al.*, 1973).

The *B* haplotype frequencies of B^2 and B^{13} differed significantly between selected and control lines (Table 1). Regardless of whether selection was based on Index 1 or Index 2, B^2 increased in frequency and B^{13} decreased. The B^{14} haplotype also increased significantly in Index 1-selected lines, although it did not in Index 2-selected lines.

The results suggest that selection of chickens for growth, efficiency, and reproduction changed the frequency of *B* haplotypes in each line. Selection had similar effects on the two major haplotypes, B^2 and B^{13} , regardless of whether feed consumption was included in the index. Although random genetic drift cannot be completely ruled out, this source of variation was minimized by replicating each selected line and maintaining a control line for each selection index.

The present study concurs with the study by Simonsen *et al.* (1982) in Scandinavia, and the study of Gavora *et al.* (1986) in Canada, in that the predominant *B* haplotypes responded differently to the selection pressures applied. There are important differences, however, among the three studies. The criteria for selection in the three studies were different economically important traits. In the Scandinavian project, reproductive traits (egg number, egg size, or egg mass) were used for selection. In the Canadian study, two strains were selected for egg produc-

TABLE 1. *B* haplotype frequencies of selected and control lines

<i>B</i> haplotype	Control ¹ (n=378)		Index 1 ² (n=371)			Index 2 ³ (n=346)		
	(f)		(f)	(I-C ⁴)	(P ⁵)	(f)	(I-C)	(P)
B^2	.62		.73	+ .11	<.0001	.74	+ .12	<.0001
B^{13}	.28		.03	- .25	<.0001	.14	- .14	<.0001
B^{14}	.10		.23	+ .13	<.0001	.11	+ .01	.3121
B^{19}	.00		.00	.0001	+ .01	.0179
B^{21}	.00		.01	+ .01	.0122	.00	.00	...

¹ Mean of 1 control line each for Index 1 and Index 2.

² Mean of 2 replicated lines selected on Index 1, for body weight, egg mass, and feed consumption.

³ Mean of 2 replicated lines selected on Index 2, for body weight and egg mass.

⁴ Deviation of *B* haplotype frequency of selected lines from control lines.

⁵ Probability determined by 2 × 2 contingency tables.

tion and related traits, and another strain was selected for Marek's disease (MD) resistance in addition to production traits. In the present study, selection was based on characteristics of growth, efficiency, and reproduction: body weight, egg mass, and (in Index 2) feed consumption. Another important difference between the three studies was the base population which was used. Although each represented commercial egg-laying stock, the populations originated at different times from different commercial lines and this resulted in different *B* haplotypes being subjected to selection. In the Scandinavian study, the predominant haplotypes were *B*¹⁵ and *B*¹⁹, with *B*¹⁵ increasing and *B*¹⁹ decreasing in frequency under selection. In the Canadian study, the predominant haplotypes were *B*², *B*¹⁹, and *B*²¹. The frequency of *B*¹⁹ was reduced in the MD-resistance-selected strain, but about the same in control and production-selected strains. The frequency of *B*²¹, and the combined frequency of *B*² and *B*²¹, increased in all selected strains. Haplotypes *B*² and *B*¹³ were the predominant haplotypes in the present study. The low frequency of *B*¹³ in the other two studies precludes direct comparison of the effects of selection on this haplotype. The significant increase in the frequency of *B*² in each selected line of the present study, however, supports the suggestion of Gavora and colleagues (1986) that inclusion of *B*², in combination with *B*²¹, should be beneficial in commercial Leghorn stocks. The results of the present study add to the mounting evidence from studies on diverse species (Kunz *et al.*, 1980; Goldbard *et al.*, 1982; Simonsen *et al.*, 1982; Rothschild *et al.*, 1984; Gavora *et al.*, 1986) that the MHC is involved in the physiology of growth and reproduction, as well as disease resistance.

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