SINGLE AND COMBINED EFFECTS OF TROPICALLY RELEVANT MAJOR GENES ON PERFORMANCE OF LAYERS

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SUMMARY

The additive and nonadditive effects of Naked neck (Na), Frizzle (F) and Dwarf (dw) genes on performance of layers in controlled normal temperature controlled high temperature (temp. 32°C, r.h. 45%) in Germany and tropical open housing (temp. 28±6°C, r.h. 60-80%) in Malaysia have been investigated. Combination of the two genes or three genes does not yield a totally additive effect but the combined expression is reduced by negative interactions among the genes. The magnitude of these interactions among genes are different for different gene combinations as well as environments. In respect to production traits the Naked neck gene followed by Frizzle had a favourable effect under heat stress while where effect of dwarf is especially acting on productivity measured as feed efficiency. Actual performance tests under specific environmental condition is neccessary to indentify the most suitable gene combination for the specific purpose and location.

INTRODUCTION

Domestic fowl belongs to the genetically best known species. Genetic studies in fowl have already identified over 250 loci with more than 60 biochemical markers and 30 factors for morphological and pigment modifiers and many major genes with specific effects on anatomical or physiological characteristics are known and documented by various workers (eg. Somes, 1980). The special advantage of using major genes lies in the intention of specifically targetted and fast genetic improvement in quantitative traits. Among these, the genes which can improve the adaptability and productivity mainly through improving the efficiency of thermoregulation and metabolism should receive special emphasis in tropical poultry breeding. Several such genes are being naturally propogated in the local fowl of the tropics, wrongly associated with low productivity (Horst, 1988) which need to be investigated and exploited fully for developing efficient breeding stock specially suitable to the local environmental conditions.

Among these major genes, the significance of Naked neck (Na), Frizzle (F) and Dwarf (dw) genes for productive adaptability of layers under heat stress has been revealed in a series of investigations under controlled normal and high temperature conditions in Germany (Horst et al., 1986; v. Haaren-Kiso et al., 1988; Mathur and Horst, 1989). The autosomal incompletely dominant Naked neck gene causes a complete loss of feathers around the neck and general reduction of about 20 - 30% in overall feathering intensity in heterozygous (Nana) condition

while upto 40% in homozygous (NaNa) state associated with widening of apterial tracts (Horst et al., 1986; Mérat, 1986). These direct phenotypic effects mainly increase insensible heat loss through exposed body surface which proves specially useful in birds which do not have sweat glands. A similar mode of inheritance is observed for frizzle gene responsible for curly shape of feathers which improves the heat defence mechanism through better circulation of hot air around the body. Relatively more investigated is the sex linked dwarf gene causing a drastic reduction of about 30 per cent in body size in recessive condition and improving the efficiency of thermoregulation through proportionate increase in body surface and reduced basal metabolism (Männer, 1988). The gene is also presumed to exist in multiple allelic forms. More important are the indirect effects of these genes on other characteristics also improving overall production under stressful environment.

Although first favourable results were achieved in climatic chambers, practically and scientifically more interesting is the knowledge of these genes under natural tropical condition. Therefore, in this study the finding were extended to an actual test under natural humid tropical conditions in Malaysia. This study additionally explores the interaction of individual major genes with the environments, interactions among the major genes and the interactions of their combinations to constant heat stress as well as the composite tropical environment.

MATERIAL AND METHODS

Eight genetic groups of layers, each carrying a different combination of the three major genes were tested simultaneously in controlled normal temperate (temp. 18-22°C, r.h.70-80%) and high temperature (temp. 32°C, r.h. 45%) housing in Germany and tropical open housing (temp. 28±6°C, r.h. 60-80%) in Johore Bahru/Malaysia. A total of 2280 records obtained in two consequitive experiments were analysed separately for a pair of controlled normal and controlled high temperate conditions and another pair of controlled normal and open tropical housing. The models for least-squares analyses (SAS computer programme) included fixed effects of the two expriments, the environmental combination, the three major genes and their first, second and third order interactions with respective environments.

RESULTS AND DISCUSSION

In context with earlier research, the observed depressive effect of high temperature as well as of humid tropical location are again evident on all the genotypes regardless of gene combination (Table 1). Furthermore, the depression is higher in controlled constantly high temperature condition than in the tropical open housing, revealing an important compensation of the stressful effect by diurnal and seasonal variations as well as other environmental factors in humid tropics. On the other hand, there are wide differences in the interactions of different gene combinations with the three environmental conditions supporting earlier findings in emphazising the need

for actual performance tests under the specific locations and environmental conditions (Mathur and Horst,1988).

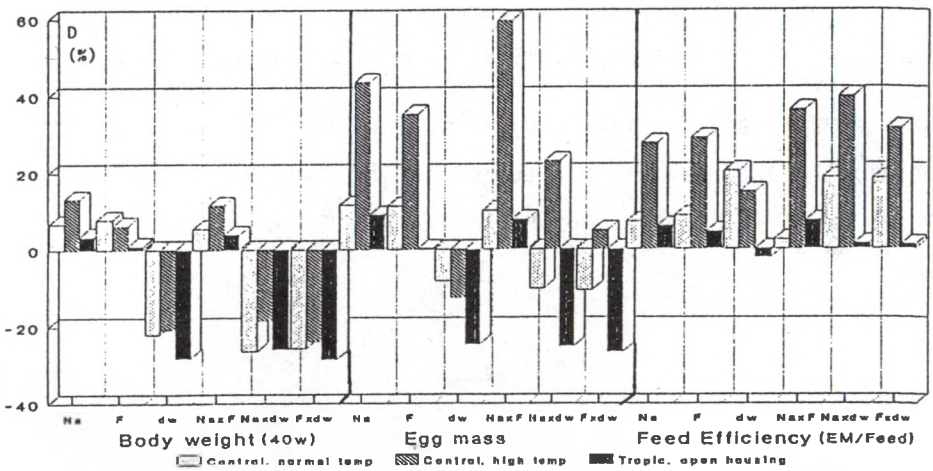
Table 1: Performance of layers carrying different combinations of major genes under controlled normal temperature, controlled high temperature and tropical open housing conditions

Genotype	N			Body weight 40w(g)			Egg mass (kg)			Feed Effi.(Feed/Em)		
	CN	CH	TO	CN	CH	TO	CN	CH	TO	CN	CH	TO
nana ff Dw-	185	131	78	2275	1927	1995	15.1	9.4	13.8	0.272	0.228	0.310
Nana ff Dw-	83	81	80	2428	2179	2063	16.9	13.5	15.0	0.291	0.291	0.328
nana Ff Dw-	104	88	107	2450	2045	2013	16.8	12.8	13.8	0.296	0.294	0.324
nana ff dw-	114	83	81	1774	1528	1433	13.9	8.3	10.4	0.328	0.261	0.303
Nana Ff Dw-	82	82	66	2398	2147	2073	16.6	15.1	14.9	0.279	0.310	0.332
Nana ff dw-	96	99	79	1674	1572	1480	13.6	11.6	10.3	0.323	0.318	0.314
nana Ff dw-	115	107	111	1692	1466	1428	13.5	9.9	10.1	0.322	0.300	0.313
Nana Ff dw-	72	74	82	1546	1471	1437	12.8	12.3	11.4	0.304	0.335	0.350

CN=Controlled normal temperature CH=Controlled high temperature TO=Tropical open housing
Gene notations: Na - Naked neck, reduced feathering intensity; F - curly feather struture;
dw - Dwarf type

A comparison of the genotypes containing either of the three genes, with the normal type within each environment reveals an orderly pattern of ranking with respect to Naked neck, Frizzle and Dwarf genes (Fig. 1).

Fig. 1 Individual and combined effects of tropically relevant majorgenes on performance of layers



D = Deviation of the genotype carrying the gene or combination normal type within the environment

The favourable effects of Naked neck and Frizzle genes are higher under controlled constantly high temperature than in the open tropical houses whereby the effect of frizzle is very low for productivity in humid tropics. On the other hand the dwarf gene causes a drastic reduction in body size with resultant decrease in productivity much more in the tropics; but this gene has favourable effect on basal metabolism and thereby improving feed efficiency in controlled high temperature.

Comparison of combined effects of two genes with respective single effects reveals that the gene effects are not totally additive but they are associated with smaller but negative gene x gene interaction effect, reducing the superiority of the two gene combination. Despite of this, a combination of the two feathering genes still proves most favourable in terms of growth and production in controlled high temperature. In case of tropical environment, the effect of Frizzle gene itself is low and the negative gene x gene interaction effect is equally large, yielding no additional advantage of such gene combination on production traits. Combination of Dwarf gene with either of the feathering genes reduces the additive as well as non additive effects. On the other hand its favourable effect on productivity, measured as feed efficiency is of considerable magnitude.

REFERENCES

v.HAAREN-KISO, Andrea; HORST, P. and VALLE ZARARTE, Anne 1988. Proc. XVIII World's Poultry Congress, Nagoya/Japan, 386-388

HORST, P., RAUEN, H.W. and KHOO, T.H. 1986. Proc. VII. European Poultry Conference, Vol. 1, 191-195

MATHUR, P.K. and HORST, P. 1989. Proc. Meeting working group III WPSA, Genotype x environment interactions in poultry production, Jouy-en-Josas, France, Ed. INRA, 83-96

MATHUR, P. K. and HORST, P. 1988. Proc. XVIII World's Poultry Congress, Nagoya/Japan, 383-385

MÄNNER, K. 1989. Habilitation, FU Berlin, FRG

MERAT, P. 1986. World's Poultry Sc.J., Vol. 42, No. 2, 124-142

SOMES Jr.,R. G. 1980, J. of Heridity 71:168-174