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THE EFFECT OF SEX-LINKED DWARF (DW), NAKED NECK (Na) AND FRIZZLE (F) GENES ON VARIOUS TRAITS IN LAYING HENS UNDER TROPICAL CONDITIONS

ZULKIFLI BIN HJ. IDRUS

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By

ZULKIFLI BIN HJ. IDRUS

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LIST OF ABBREVIATIONS

dw	Dwarf gene
Na	Naked neck gene
NaNa	Homozygous naked neck layers
Nana	Heterozygous naked neck layers
nana	Normal layers
F	Frizzle gene
Dw- ff nana	Normal
Dw- ff Nana	Naked neck
Dw- Ff nana	Frizzled
Dw- Ff Nana	Frizzled naked neck
dw- ff nana	Dwarf
dw- ff Nana	Dwarf naked neck
dw- Ff nana	Dwarf frizzled
dw- Ff Nana	Dwarf frizzled naked neck
PRIN 1	Principal component 1
PRIN 2	Principal component 2

Abstract of thesis submitted to the Senate of Universiti Pertanian Malaysia in partial fulfillment of the requirements for the degree of Master of Science.

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APRIL, 1991

Supervisor : Prof. Dr. Yukio Yamada

Faculty : Veterinary Medicine and Animal Science

A study was carried out to investigate the effect of the sex-linked dwarf (dw), naked neck (Na) and frizzle (F) genes on various quantitative traits in layers and also to identify the appropriate genotypes under tropical conditions. The experimental stock comprised of non-dwarf non-frizzled non-naked neck or normal (Dw- ff nana), naked neck (Dw- ff Nana), frizzled (Dw- Ff nana), frizzled naked neck (Dw- Ff Nana), dwarf (dw- ff nana), dwarf naked neck (dw- ff Nana), dwarf frizzled (dw- Ff nana) and dwarf frizzled naked neck (dw- Ff Nana) genotypes.

The dw was observed to cause a profound reduction in body weight, body conformation, egg production and egg weight. However, the dw reduced feed intake and improved feed efficiency. The dw also had detrimental effect on several egg quality traits.

Body weight and body conformation measurements were not affected by the Na, while feed intake was significantly increased in both dwarf and non-dwarf populations. The Dw- ff Nana hens were observed to have better egg production and egg weight. Shell quality traits were found to improve due to the Na. However, among the dwarf population, the Na had an adverse effect on feed efficiency.

Except for an increase in yolk weight and a decline in egg production, the F had no major effect on quantitative traits. On the other hand, the effect of the Na and F combination on various traits was found to be comparable with the influence of Na.

Genotypes with dw could be improved through long term selection, while the Dw- ff Nana birds appear to be superior in terms of egg production and egg weight but feed the efficiency value attained was inferior compared to genotypes with dw, except dw- ff Nana.

The first principal component of the principal component analysis where the contribution of each trait was equally high, indicated an obvious difference between genotypes with Dw and dw. However, in the second principal component, where only the contribution of shell thickness and shell breaking strength were high, a reverse observation was made. Genotypes with Na were observed to be separated from the others when they were projected into the axis of the second principal component.

Abstrak thesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi sebahagian daripada keperluan ijazah Master Sains.

KESAN GEN-GEN KERDIL (dw), LEHER TIDAK BERBULU (Na) DAN BULU TERBALIK (F) KE ATAS PELBAGAI CIRI-CIRI AYAM PENELUR DI BAWAH KEADAAN TROPIKA

Oleh

ZULKIFLI BIN HJ. IDRUS

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Penyelia : Prof. Dr. Yukio Yamada

Fakulti : Kedoktoran Veterinar dan Sains Peternakan

Suatu kajian telah dijalankan untuk menyelidik kesan-kesan gen-gen kerdil (dw), leher tidak berbulu (Na) dan bulu terbalik (F) serta kombinasinya ke atas berbagai ciri-ciri kuantitatif pada ayam penelur dan juga untuk mengenali genotip-genotip yang sesuai di bawah keadaan tropika. Stok eksperimen terdiri daripada genotip-genotip bukan kerdil bukan bulu terbalik bukan leher tidak berbulu atau normal (Dw- ff nana), leher tidak berbulu (Dw- ff Nana), bulu terbalik (Dw- Ff nana), bulu terbalik leher tidak berbulu (Dw- Ff Nana) kerdil (dw- ff nana), kerdil leher tidak berbulu (dw- ff Nana), kerdil bulu terbalik (dw- Ff nana) dan kerdil bulu terbalik leher tidak berbulu (dw- Ff Nana).

Pengurangan yang jelas berlaku pada berat badan, konformasi badan, pengeluaran telur dan berat telur disebabkan

oleh *dw*. Walau bagaimanapun, *dw* mengurangkan pengambilan makanan dan meningkatkan kecekapan pertukaran makanan. Gen kerdil juga menunjukkan kesan tidak memuaskan kepada beberapa ciri-ciri kualiti telur yang dikaji.

Ukuran berat badan dan konformasi badan tidak dipengaruhi oleh *Na*, manakala pengambilan makanan didapati bertambah dengan bererti di dalam kedua-dua populasi kerdil dan bukan kerdil. Ayam-ayam penelur *Dw- ff Nana* menunjukkan pengeluaran telur dan berat telur yang lebih tinggi jika dibandingkan dengan genotip-genotip yang lain. Kualiti cengkerang, didapati meningkat disebabkan oleh *Na*. Bagi nilai kecekapan pertukaran makanan, *Na* menunjukkan kesan yang kurang memuaskan di kalangan populasi kerdil.

Selain daripada peningkatan pada berat kuning telur dan pengurangan produksi telur, *F* tidak menunjukkan pengaruh penting pada ciri-ciri kuantitatif. Manakala, kesan kombinasi *Na* dan *F* ke atas berbagai-bagai ciri didapati menyerupai pengaruh *Na*.

Genotip-genotip yang mengandungi *dw* boleh ditingkatkan melalui pemilihan jangkamasa panjang. Ayam-ayam *Dw- ff Nana* menunjukkan prestasi yang memuaskan dari segi penghasilan telur dan berat telur tetapi kecekapan pertukaran makanannya adalah kurang memuaskan berbanding dengan genotip-genotip yang mempunyai *dw*, kecuali *dw- ff Nana*.

Komponen prinsipal pertama bagi analisa prinsipal komponen, di mana sumbangan setiap ciri adalah tinggi dan serupa, menunjukkan perbezaan yang jelas di antara genotip yang mempunyai Dw dan dw. Walau bagaimanapun, di dalam komponen prinsipal kedua, di mana hanya sumbangan ketebalan cengkerang telur dan daya pemecahan cengkerang sahaja yang tinggi, keputusan yang berlawanan didapati. Genotip-genotip yang mempunyai Na, terletak lebih tinggi daripada genotip-genotip lain apabila diprojekkan kepada komponen prinsipal kedua, menunjukkan bahawa Na mempunyai kesan positif ke atas kualiti cengkerang.

CHAPTER I

INTRODUCTION

Livestock and cash crop production play a major role in the rural and socioeconomic development of Malaysia. Poultry farming constitutes a major livestock activity in Peninsular Malaysia. In 1990, Malaysia produced 390,000 tons poultry meat and 4.4 billion eggs (Wang, 1991). Advances in Malaysian poultry science have made a significant impact on the development of the local poultry industry. The present Malaysian poultry industry encompasses of breeding, layer and broiler farms, feedmills, veterinary drugs and equipment suppliers etc. There are several large companies where established horizontal and vertical integration systems are adopted (breeding - hatching, feedmilling, egg and broiler production and marketing operation all into one system of management). Total domestic requirement for poultry meat and egg was attained in the early 80's and in 1990 Malaysia exported thirty-six million ringgit worth of poultry meat and eggs to Singapore (Wang, 1991).

In the early days, breeding practices in commercial poultry production were confined towards the improvement of pure breeds. Later, breeders crossed different breeds to enhance production. Changes through successful breeding have contributed to the availability of new synthetic lines which have brought dramatic changes in poultry production.

The introduction of commercial hybrids in Southeast Asia was initiated in the 1960's (Arboleda, 1988). The extensive use of exotic hybrids from USA, Australia and Europe, is one of the main catalysts for the establishment of the present Malaysian poultry industry. Although chickens were first domesticated in the Asian region about 2000 B.C. (Crawford, 1990), the production efficiency of broilers and layers in Southeast Asia is still low. This is in spite of high-tech management system, adequate feed and stringent disease control measures. The probable constrain is the prevailing hot and humid climate which is a disadvantage for optimum production. Bray and Gessel (1961), Payne (1966), Mowbray and Sykes (1971), Wilson et al. (1972), and Davis et al. (1972, 1973), reported that both egg production and egg weight declined at temperatures above 30^{o}C.

Poultry breeders and geneticists are working towards the search for genotypes that produce optimum production under adverse thermal environment. The effects of several major genes on anatomical and physiological traits could be utilized to improve the performance of laying hens in tropical climate. The majors genes of interest are sex-linked dwarf gene, dw, (Panandam, 1985; Mathur, 1985; Khadijah, 1988), autosomal incomplete dominant naked neck gene, Na, (Bordas et al., 1980; Bordas and Merat, 1984; Rauen et al. 1986; Panandam, 1985; Mathur, 1985; Khadijah, 1988) and the autosomal incomplete dominant frizzle gene, F, (Horst, 1987; Haaren-Kiso et al., 1988; Mathur and Horst, 1990). Previous studies on the influence of incorporating Na and dw indicated encouraging results on productive adaptability of laying hens in tropical climate.

Thus, the utilization of major genes, namely, dw, Na and F in the structure of tropical poultry breeding, has great potential. The objectives of the present study include:

1. To investigate the effect of the dw, Na and F and their combinations on various traits in layers.
2. To identify suitable genotypes for optimum production under tropical conditions.

CHAPTER II

LITERATURE REVIEW

Recessive Sex - Linked Dwarfism Gene (dw)

Body size in the domestic fowl varies greatly, from that of the Jersey Giant cock (6.0 kg) to that of the Dutch bantam cock at 0.6 kg. Some major single genes either autosomal or sex-linked were found to have a major effects on skeletal size, muscle mass, skin, feathers and fat deposition although there are several other contributing factors.

There are at least two sex-linked genes which retards body growth in fowls. The recessive sex-linked dwarfism gene is of particular interest to poultry breeders and geneticists world wide since it has great potential in the development of more efficient egg and meat producing strains. According to Somes (1990), this gene has greater dwarfing effect than other type of discovered genes (dominant sex-linked dwarfism, Z and autosomal dwarfism, adw).

Effect on Body Weight and Growth

A number of workers observed that the dw has no effect on body weight of birds early in their lives (Hutt, 1949, 1953, 1959; Rajaratnam et al., 1969; Selvarajah, 1970). Hutt (1959) and Baron (1971) observed that body weight at two and four weeks of age, respectively were reduced due to the effect of dw. On the other hand, Delpech (cited from Merat, 1969) showed that with an approximately similar body weight to that of dwarf chicks, the dwarf chick at hatching had a heavier yolk sac of about 10.2% instead of 7.1% of the whole body weight. This suggests that reduction of tissue growth in dwarf chicks occurred since embryonic life. Thus, the dwarfing effect is manifested progressively according to age.

There are conflicting reports on the relative reduction of body weight, attributable to dw at a given age. It was observed that the size of the adult bird where the dw is introduced would determine the relative reduction of body weight. Mohammadian and Jaap (1972) reported the back crossing of dwarf birds from Leghorn strain to a White Rock type strain caused a reduction of body weight at eight weeks of 37.1% in the first generation and of 19.2% in the third.

Effect on Egg Production Traits

The phenomenon of the dw effect on laying rate is contradicting. Bernier and Arscott (1960), Magruder and Coune (1969), Merat (1969), Quisenberry and Bradley (1971), Quisenberry (1972), Summers (1972), Polkinghorne and Lowe (1973), Doran and Quisenberry (1974) and others who worked on light, heavy and medium (birds weighing up to 2.5 kg) layer type stocks found a decline in laying rate of about 10%. However, Merat et al. (1988) reported dwarf layers benefit more in terms of laying rate, from ahemeral light cycles compared to normal layers.

On the other hand, dw in meat type strains does not produce detrimental effect in laying rate. However, Prod'homme and Merat (1969), Sherwood (1971), Ricard and Cochez (1972), Yamada et al. (1972), and Reddy and Siegel (1977) reported an unchanged or improved laying rate. More recently, Merat (1990) showed that egg number is decreased in layer type stocks and more in the Leghorn light type than in the medium-sized type but not in the meat-type strain.

The contradicting effects of dw on layer and broiler types were investigated by several workers. Jaap and Clancy (cited from Panandam, 1985) reported that meat type pullets have many large growing follicles. Thus, yolk is produced at a more rapid rate than the oviduct is able to form eggs. The lack of synchronization between ovary and oviduct function, results in a high percentage of abnormal eggs (double-yolked, shelless and soft-shelled eggs) and consequently a depression of laying rate. On the contrary, the same workers reported layer type stocks are more compatible with normal laying rate, as the number of large follicles is lower.

According to Jaap and Mohammadian (1969), van Middlekoop (1973), Guillaume (1976), Silber and Merat (cited from Merat, 1984) and Merat (1984), the effect of dw on yolk formation may be due to the decline of growth, whilst van Tienhoven et al. (1966) suggested that the low level of thyroid hormones in the blood stream of dwarf birds could be the explanation for the abnormal yolk formation.

Size is one of the most influencing factors for the sale of eggs (Africa and Paultz, 1968). Due to a high preference of larger eggs by consumers, the incorporation of dw in the laying strain which is associated with smaller sized eggs has been a major setback. A number of workers (Hutt, 1959; Bernier and Arscott, 1960; French and Nordskog, 1969; Merat, 1969; Magruder and Coune, 1969; Raap, 1970; Selvarajah, 1971; Dorminey et al.,1974; Khoo and Beh, 1977; Horst and Petersen, 1979; Sadjadi et al., 1983; Panandam, 1985; Khadijah, 1988) have reported a reduction of egg weight due to dw, in the range of 3% to 14% compared to normal layers. The reduction of egg size could be explained by the high correlation between body weight and egg weight (Guillaume, 1976). However, it was found that dwarf layers are more efficient in terms of average egg size in relation to body size as compared to normal layers (Selvarajah et al., 1970; Bernier and Arscott, 1971; Khan et al., 1983).

Dwarf gene has both beneficial and detrimental effects on egg quality. Selvarajah (1970, 1971) and Selvarajah et al. (1970) reported dw has no modifying effect on egg quality, although Raap (1970), Ricard and Cochez (1972) and Silber and Merat (cited from Merat, 1984), observed reduction of cracked eggs in battery cages, regardless of size among dwarf layers. Bernier and Arscott (1960), Gleichauf (1973), Panandam (1985) and Khadijah (1988) reported dwarf birds laid eggs with thinner shell and lower breaking strength. Carter (1975) suggested that the reduction of cracked eggs was probably due to lower body weight of dwarf hens, thus the weight exerted on the cage floor was reduced resulting in less mechanical pressure on the laid eggs. Other contributing factors are lesser height of drop of egg as the shanks of dwarf hens are shorter and probably the quite temperament of the dwarf birds (Merat, 1990).

The influence of the dw on the quality of the egg contents showed some contradictions. Merat (1970, 1972) reported that the dwarf birds produced eggs with an increased albumen height, while Panandam (1985) and Khadijah (1988) reported the reverse. The contrasting findings were probably due to the differences in climatic environment. Dwarf layers also produced eggs with reduced yolk and albumen weight (Benhoff and Renden, 1983; Panandam, 1985; Khadijah, 1988).

Effect on Feed Consumption and Efficiency

The reducing effect of the dw on feed intake has been widely reported (Hutt, 1959; Bernier and Arscott, 1966; Selvarajah et al., 1970; Quisenberry, 1972; Marks, 1980; Alihussain, 1983; Panandam, 1985; Khadijah, 1988). Marks (1980) reported that the effect of the dw on feed intake was observed immediately after hatching, reducing the first day feed consumption by 20% and the subsequent four to five days by 44%. The reduction in feed intake will occur at all ages of the dwarf birds (Quisenberry, 1972).

Feed constitutes 70% of the cost of eggs. It is therefore the ultimate aim of poultry geneticist to identify genotypes which have a superior feed utilization. Several workers have reported the potential of dwarfs for a better feed efficiency, particularly in the tropics (Mukherjee et al., 1980; Horst, 1988). Dwarf birds showed a better feed efficiency in terms of feed per dozen of eggs ratio (Bernier and Arscott, 1960, 1966, 1972; Arscott and Bernier, 1968; Chamber et al., 1974; Strain and Piloski, 1975) and feed mass per egg mass ratio (Prod'homme and Merat, 1969; Quisenberry et al., 1969; French and Nordskog, 1971, 1973) within the range of 82.1% to 96.2% and 63.7% to 82% from the feed utilization of normal hens respectively. Weaver (1974), based on field data (collected in the USA) reported feed cost expressed in lb per chick produced, showed a gain of 33 % with dw meat type strains.

The probable explanation for the improved feed utilization of dwarfs is likely due to low maintenance requirement (due to small body size) which enable more nutrients to be allocated for egg production (French and Nordskog, 1973; Bernier and Arscott, 1972). However, Hutt (1959) reported that dwarfs require higher maintenance due to their larger body surface as compared to normals. The contradicting findings probably related to climatic factors. Under a hot environment, energy requirement for heat conservation is not crucial and vice versa under a moderate temperature. Despite the fact that dwarfs consumed significantly lesser feed compared to normals but due to reduced egg weight and laying rate, several workers indicated