

EFFECTS OF THE GENES FOR DWARFISM (*dw*) AND NAKED NECK (*Na*) ON CHICK GROWTH AND LIPID METABOLISM ⁽¹⁾

S. P. TOUCHBURN ⁽²⁾ and J. C. BLUM

*Station de Recherches avicoles,
Centre de Recherches de Tours, I. N. R. A.,
37 - Nouzilly*

SUMMARY

In two experiments full sister pairs of chicks, one dwarf (*dw*) and one non-dwarf (*Dw*) were reared in individual cage to five weeks of age. Chicks carrying the sex-linked recessive *dw* gene were identified at hatching by the closely linked fast-feathering gene (*k*). Approximately half of the pairs carried the autosomal dominant gene for naked-neck (*Na*).

Presence of the *dw* gene resulted in about a 30 per cent reduction in weight gain, a reduced body temperature, increased carcass content of lipid and of lipid ¹⁴C activity from injected ¹⁴C labelled acetate. These latter may be a result of either increased lipogenesis or decreased energy expenditure or, more likely, a combination of the two.

Presence of the *Na* gene appeared to cause increased lipogenesis. The naked-neck bird showed increased energy expenditure in a cool environment and perhaps a greater flexibility of body temperature regulation.

An interaction between the *dw* and *Na* genes was apparent under cooler environmental conditions and seemed to arise from the suppression of the thermoregulatory mechanism of the *Na* gene by the *dw* gene, possibly through inhibition of lipid degradation.

INTRODUCTION

A sex-linked recessive gene for dwarfism in chickens was first discovered by HURT (1953). A similar gene which occurred spontaneously in the genetically closed experimental flock at Jouy-en-Josas, France, was reported by MÉRAT (1969). This

⁽¹⁾ Presented to the *Symposium on the Dwarf gene in domestic Fowl*, Tours, France, March 4 and 5, 1971, under the auspices of the *Station de Recherches avicoles, Nouzilly, Institut national de la Recherche agronomique*.

⁽²⁾ On sabbatical leave from The Ohio Agricultural Research and Development Center, Wooster, Ohio 44691, U. S. A.

gene caused a reduction in body weight of 30 per cent in females and 40 per cent in males. It also shortened the long bones and reduced the number and weight of eggs produced by 10 per cent. JAAP and MOHAMMADIAN (1969) reported that the *dw* gene reduced the rate of yolk deposition but did not reduce the rate of egg production. It did lower the per cent of defective eggs produced. These observations pertained to pullets weighing 2.6 kg at 36 weeks of age whereas the mean hen weight of the experimental flock of MÉRAT was 2.2 kg.

MÉRAT and GUILLAUME (1969) provided evidence suggesting that the dwarf birds were slightly hypothyroid, supporting the earlier report by VAN TIENHOVEN *et al.* (1966). This hypothyroidism, however, appeared to be secondary and not the primary cause of the dwarf characteristics.

LECLERCQ *et al.* (1970) reported that feed consumption was practically independent of the energy level of the diet and that the dwarf chicks could withstand severe rationing of energy intake without any ill effects.

GUILLAUME (1969) observed that the feed consumption of dwarfs was only slightly less than that of normal birds while energy expenditure was considerably reduced. The efficiency of protein utilization was significantly inferior and that of energy utilization significantly superior in dwarf chicks which stored much more fat in their bodies than did normal chicks.

The work to be reported here represents a part of the broader goal of studying the metabolic mechanisms involved in this excess lipid accumulation in the dwarf. The naked neck gene which entered the experimental design inadvertently, introduced the aspect of temperature control mechanisms and their relation to lipid metabolism. The information concerning the first reports and description of this autosomal dominant gene were summarized by HUTT (1949).

EXPERIMENTAL METHODS

To provide the experimental chicks and in order to identify dwarf and non-dwarf chicks at hatching, special matings were made using cocks from the experimental flock of MÉRAT. These sires were heterozygous for dwarfism (*Dwdw*) and for early feathering rate (*Kk*), with these sex-linked genes disposed so that either the dominant or the recessive genes were transmitted together. By chance, 3 of the 4 males obtained also carried the dominant autosomal gene for naked neck (*Na*). The cocks were mated by artificial insemination with females of a commercial dwarfed broiler strain, JA 57, of the *Institut National de la Recherche agronomique* (I. N. R. A.) which carried the recessive genes *dw* and *h*.

At time of hatching the chicks were sexed by the vent method and the females were chosen for these studies. They were separated by rate of early feathering as indicated by relative lengths of primary and covert feathers. Classification by feathering rate was verified at 10 days of age; the chicks classified as slow-feathering being non-dwarfs, those classified as fast-feathering being dwarfs. They were further segregated for the normal neck or naked-neck condition. Full sister pairs, one dwarf and one non-dwarf were placed in adjacent individual wire-floored cages in electrically-heated battery brooders in a heated room. The first experiment comprised 20 pairs, 12 of which were normal-neck and 8, naked-neck pairs. The second experiment included 4 normal-neck and 4 naked-neck pairs.

The diet fed was based on corn, soybean meal and fishmeal and provided approximately 3.02 kilocalories of metabolizable energy per gram. The analyzed crude protein levels of the diets were 18.6 per cent in Experiment 1 and 19.2 per cent in Experiment 2. These relatively high-energy diets were intended to stimulate lipogenesis. Feed and water were provided *ad libitum* except that from 2 to 5 weeks of age the chicks were deprived of feed for 4 hours daily from 10.00 to 14.00

hours. This was intended to condition the birds so that they would eat at a maximum rate immediately preceding the injection of ^{14}C -labelled acetate on the final day of the trial.

Individual body weights and feed consumption data were recorded weekly. Body temperature was measured cloacally toward the end of the 4 hour fast period at 5 weeks of age. Approximately 1.5 hours after they had been re-fed on the final day, each chick was injected intraperitoneally with 10 μCi of sodium acetate-2- ^{14}C (specific activity 20.7 μCi per μM) in 1 ml of 0.9 per cent sodium chloride solution. In experiment 2, sodium acetate-1- ^{14}C was used with a specific activity of 22.7 μCi per μM . In Experiment 1, five pairs were sacrificed by bleeding at intervals of 0.5, 1, 2 and 3 hours post injection. In Experiment 2, they were all sacrificed 2 hours after radioisotope injection. The livers were removed, frozen and stored for another study. The carcasses were weighed and frozen at -20°C , then later ground, and freeze dried. Total lipids were extracted from duplicate samples of the lyophilized carcasses by the method of FOLCH *et al.* (1957). The ^{14}C activities of duplicate aliquots of carcass lipid were measured in a liquid scintillation counter after addition of scintillation fluid (toluene plus PPO plus POPOP). The quantities of lipid and the ^{14}C content were related to the fresh killed body weight. The data were analyzed using Student's *t* test; the method of paired comparisons for the effect of the *dw* gene (sister pairs), the simple *t* test for the *Na* gene (comparison of two means). The likelihood of obtaining significant differences in the latter comparisons was poor because of the limited numbers of animals and of the variability among families due to the heterogeneity of the sires. Under these conditions probability levels of 0.1 and 0.2 were taken as indicating tendencies, particularly when all of the traits were considered in relation to each other.

RESULTS AND DISCUSSION

Out of 19 pairs of dwarf : non-dwarf sisters in Experiment 1, one chick exhibiting fast feathering turned out not to be a dwarf according to all other parameters including weight and carcass lipid content. This bird undoubtedly represents a case of crossing-over of the chromosome near the *K* locus which, according to HURT (1959) occurs at an average frequency of 6.6 per cent.

The mean values for body weight gain, feed conversion, body temperature, carcass lipid and lipid ^{14}C content are presented in table 1.

The experimental results are best understood by examining first the data of Experiment 2 which ended March 23, then those Experiment 1 which ended January 21. Although both were conducted in a heated building in heated battery brooders, the seasonal temperature difference appears to have reduced the ambient temperature during Experiment 1 below a critical point which greatly influenced the results.

In Experiment 2 the mean body weight gain to 5 weeks of age in dwarf birds was 73 per cent of that of their non-dwarf sisters. This was similar to the 30 per cent weight reduction resulting from the presence of the *dw* gene reported by HURT (1953) and MÉRAT (1969). Thus, any effect of the *k* gene of increasing growth rate as reported by GOODMAN and MUIR (1965) was minor or insignificant in comparison with that of the *dw* gene. Feed conversion was very slightly superior for the dwarfs in spite of the fact that their bodies contained 15.7 per cent of lipid while their non-dwarf sisters contained only 11.0 per cent. These traits were not different between naked-neck and normal-neck birds. Body temperature was reduced by the *dw* gene and possibly also by the *Na* gene. The per cent of carcass lipid was significantly increased by the *dw* gene but not by the *Na* gene. In contrast, carcass lipid ^{14}C content was greatly increased by both genes, their effects appearing to be additive.

In Experiment 1 the extreme variability encountered in carcass lipid ^{14}C content coupled with the limited number of animals precluded observation of differences in relation to time elapsed after injection. Maximum values were obtained, for example,

TABLE I

Effect of dw gene and Na gene on weight gain, feed conversion, body temperature, carcass lipid and carcass lipid ¹⁴C activity in five-week-old chicks
Effet des gènes dw et Na sur le gain pondéral, l'indice de consommation, la température corporelle, les lipides de la carcasse et l'activité du ¹⁴C dans les lipides de la carcasse chez des poulets âgés de 5 semaines

	Naked neck gene	Experiment 1				Experiment 2			
		Dwarf gene		N° of pairs	P for dw effect	Dwarf gene		N° of pairs	P for dw effect
		Dw	dw			Dw	dw		
Body weight gain (g)	<i>na</i> <i>Na</i> mean	449 428 440	307 340 322	10 8 18	0.001 0.001 0.001	449 455 451	326 326 326	8 4 12	0.01 0.01 0.01
P for <i>Na</i> effect		0.30	0.16						
Feed conversion	<i>na</i> <i>Na</i> mean	2.14 2.19 2.16	2.35 2.28 2.32	10 8 18	0.10 0.05 0.02	2.08 2.06 2.07	2.00 2.00 2.00	8 4 12	0.1 0.3 0.05
Body temperature (°C)	<i>na</i> <i>Na</i> mean	41.25 41.35 41.29	41.19 41.01 41.11	10 8 18	0.10 0.001 0.001	41.36 41.25 41.32	41.14 41.05 41.11	7 4 11	0.05 0.05 0.01
P for <i>Na</i> effect		0.20	0.10				0.30		
Carcass lipid per cent of body weight	<i>na</i> <i>Na</i> mean	12.3 9.2 10.8	16.5 14.5 15.5	11 8 19	0.01 0.01 0.001	11.1 10.9 11.0	15.6 15.8 15.7	4 4 8	0.05 0.05 0.01
P for <i>Na</i> effect		0.02	0.20						
¹⁴ C activity in carcass lipids, thousand d.p.m. per g body weight	<i>na</i> <i>Na</i> mean	4.41 4.56 4.33	6.08 7.26 6.67	11 8 19	0.02 0.01 0.001	4.15 7.23 5.69	8.40 11.42 9.91	4 4 8	0.001 0.02 0.001
P for <i>Na</i> effect			0.20			0.01	0.02		

in some cases one half hour post injection. As a consequence, the carcass ^{14}C values represent the means over all intervals.

Carcass lipid and its ^{14}C content were again very significantly greater in the dwarf chicks. In the naked-neck dwarfs an even greater augmentation of carcass lipid ^{14}C content confirms the additive effect of the genes *dw* and *Na* on the accumulation of labelled precursor in carcass lipids. In the naked-neck non-dwarfs birds, however, the carcass lipid content was significantly diminished whereas the lipid ^{14}C content was similar to that of the normal-neck non-dwarf birds. In comparison to the latter, these naked-neck non-dwarf birds also exhibited a decreased body weight, poorer feed conversion and increased body temperature. In contrast, their naked-neck dwarf sisters, when compared with the normal-neck dwarfs, showed an increased body weight, improved feed conversion and decreased body temperature.

The *dw* gene significantly decreased body weight gain and body temperature while it significantly augmented both carcass lipid content and the lipid content of ^{14}C labelled precursor. This latter effect may be the result of either increased lipogenesis or diminished energy expenditure or, more likely, both.

The *Na* gene appeared to increase both synthesis and degradation of lipid as evidenced by accumulation of labelled precursor on a short term trial without affecting a net accumulation of lipid over the long term 5-week growth test. This gene also seemed to permit greater flexibility in thermoregulation, increasing body temperature in a cool environment and decreasing it in a warm environment.

The *dw* gene reduced body temperature regardless of the ambient temperature. It also apparently suppressed the thermoregulatory action of the *Na* gene, perhaps by limiting the degradation of lipid, and this latter effect was responsible for the interaction observed.

Reçu pour publication en octobre 1971

RÉSUMÉ

EFFETS DES GÈNES DE NANISME (*dw*) ET DE COU NU (*Na*) SUR LA CROISSANCE ET LE MÉTABOLISME LIPIDIQUE DES POULETS

Au cours de deux expériences, des poussins sont associés en couples de vraies sœurs, l'une naine (*dw*), l'autre normale (*Dw*), élevées dans des cages individuelles voisines jusqu'à l'âge de cinq semaines. Les poussins porteurs du gène récessif *dw* lié au sexe sont identifiés grâce au gène étroitement associé *k* qui détermine un emplumement rapide remarquable dès l'éclosion. Dans un couple sur deux environ, les poussins appariés ont le cou nu et sont donc porteurs du gène autosomal dominant *Na*.

La présence du gène *dw* provoque une réduction du gain de poids d'environ 30 p. 100, elle abaisse la température corporelle, augmente l'engraissement et la radioactivité des lipides de réserves néoformés dans les heures qui suivent l'injection de ^{14}C -acétate. Cette dernière influence est expliquée en invoquant, ou un accroissement de la lipogenèse, ou une diminution de la dépense énergétique, ou plus probablement encore les deux à la fois.

La présence du gène *Na* semble déterminer une augmentation de la lipogenèse. Dans un local insuffisamment chauffé, le poussin à cou nu a une dépense énergétique accrue ; il paraît jouir d'une aptitude particulière pour modifier sa thermorégulation selon les conditions externes.

Une interaction entre les gènes *dw* et *Na* apparaît lorsque le milieu environnant est relativement froid. Le gène *dw* pourrait empêcher le fonctionnement du système de thermorégulation propre aux animaux à cou nu ; il interviendrait en inhibant la dégradation des lipides.

REFERENCES

- FOLCH J., LEES M., SLOANE-STANLEY G. H., 1957. A simple method for the isolation and purification of total lipids from animals tissues. *J. Biol. Chem.*, **226**, 497-509.
- GOODMAN B. L., MUIR F. V., 1965. The influence of comb and feathering phenotypes on body weight and dressing percentage in broilers. *Poult. Sci.*, **44**, 644-648.
- GUILLAUME J., 1969. Conséquence de l'introduction du gène de nanisme *dw* sur l'utilisation alimentaire chez le poussin femelle. *Ann. Biol. anim. Bioch. Biophys.*, **9**, 369-378.
- HUTT F. B., 1949. *Genetics of the fowl*. Mc Graw Hill, New York, pp. 117-119.
- HUTT F. B., 1953. Sex linked dwarfism in the fowl. *Genetics*, **38**, 670.
- HUTT F. B., 1959. Sex linked dwarfism in the fowl. *J. Hered.*, **50**, 209-221.
- JAAP R. G., MOHAMMADIAN M., 1969. Sex-linked dwarfism and egg production in broiler dams. *Poult. Sci.*, **48**, 344-346.
- LECLERCQ B., GUILLAUME J., BLUM J. C., 1970. Données sur les besoins alimentaires de la reproductrice naine *Vedette* I. N. R. A. (*dw*) durant les périodes de croissance et de ponte. I. Période de croissance. *14th World's Poultry Congress*, Madrid (in press).
- MÉRAT P., 1969. Étude d'un gène de nanisme lié au sexe chez la poule. I. Description sommaire et performances. *Ann. Génét. Sél. anim.*, **1**, 19-26.
- MÉRAT P., GUILLAUME J., 1969. Étude d'un gène de nanisme lié au sexe chez la poule. II. Fonctionnement thyroïdien. *Ann. Génét. Sél.* **1**, 131-133.
- VAN TIENHOVEN A., WILLIAMSON J. H., TOMLINSON M. C., MAC INNES K. L., 1966. Possible role of the thyroid and the pituitary glands in sex-linked dwarfism in the fowl. *Endocrinol.*, **78**, 950-957.
-