«Research Note»

Effect of Dwarfing Gene *dw* on Erythrocyte Counts, Hematocrits and Hemoglobin Concentrations in Chickens during 1 to 30 Weeks of Age

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Some hematological differences between dwarf (Gifu 20 line) and normal (Gifu 15 line) chickens were studied during the period of growth from 1 to 30 weeks of age. Erythrocyte counts, hematocrits and hemoglobin concentrations were mostly significantly higher for dwarf than for normal chickens. This paradoxical increase appeared to be related with hormonal status in the dwarf chicken.

(*Jpn. Poult. Sci.*, **29** : 151-155, 1992)

Key words : dwarf, growth, erythrocyte, hematocrit, hemoglobin,

Introduction

The recessive sex-linked dwarf chicken is characterized by reduced body weight and shortened shank length together with lower plasma levels of insulin-like growth factor (IGF)-1 and triiodothyronine than in the normal chicken¹⁾. Recently it becomes clearer that IGF-1 as well as growth hormone (GH) stimulates both erythropoiesis and Fe incorporation into reticulocytes and thereby increases blood erythrocyte numbers²⁾, and that there is a linear correlation between blood IGF-1 concentrations and daily red blood cell formation in growing rats³⁾. Considering a low circulating IGF-1 level in the dwarf chicken^{4,5)}, it appeared to be of interest to investigate whether the dwarfing gene exerts its influence on red blood cell numbers and hemoglobin (Hb) contents.

Blood constituents of dwarf birds have so far been compared with normal birds, but the comparison is made only in two age groups : young and adult chickens^{6,7)}. Thus we report here some blood parameters of dwarf and normal cockerels and pullets during their growth period from hatching to adult.

Materials and Methods

Dwarf chicks were obtained from a stock of dwarf chicken (Gifu 20 line) maintained in the Gifu Poultry Breeding Station. The dwarf line was made by repeated backcrosses of *Dwdw* males (at first M-strain, White Leghorn) to *Dw* females (15 line, Rhode Island Red)⁸⁾. The control normal chicks were obtained from the 15 line of this station. Although the 15 line is strictly not a proper control, it has more genes in common with the 20 line than any other strains readily available.

Received Dec. 5, 1991

Chicks were housed in an electric brooder for 4 weeks and thereafter in an unheated brooder. The birds were fed a commercial diet and water ad libitum.

Body weights and shank lengths (shank-toe lengths) were measured at 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25 and 30 weeks of age. Blood samples were taken with a heparinized syringe either by cardiac puncture or venipuncture at the same days of body weight measurement and the following hematological parameters were obtained: erythrocyte count, hematocrit and Hb content. Erythrocytes were counted in a Thoma-type hemocytometer. Hematocrits were determined with the aid of Wintrobe tubes and centrifugation (3000 r.p.m., 30 min.). Hb contents were estimated spectrophotometrically (540 nm) as cyanmethemoglobin. The data were examined for statistical differences by Student's *t* test.

Results and Discussion

In cockerels, body weights of dwarf chickens were significantly reduced during 7 to 30 weeks of age, while in pullets the reduction was not significant up to 13 weeks of age (Table 1). In contrast, the depressing effect of dw gene on skeletal growth was evident at earlier weeks of growth (Table 2). There were significant differences in body weights and shank lengths between male and female chickens of each line (Tables 1 and 2). These results are consistent with those reported partially for these normal and dwarf lines^{8,9)}.

Changes in erythrocyte count, hematocrit and Hb content during growth of chickens are shown in Tables 3-5, respectively. Erythrocyte numbers were rather lower in dwarf male chickens than in normals until 5 weeks of age, but after 7 weeks of age they were consistently higher in dwarf males with significant differences.

Table 1. Body weights (g) (Mean $\pm$ SE, *n* = 10)

Age (week)	NM	DM	NF	DF
1	53 $\pm$ 2	50 $\pm$ 2	39 $\pm$ 1#	47 $\pm$ 2*
3	152 $\pm$ 8	160 $\pm$ 6	136 $\pm$ 4	141 $\pm$ 7
5	299 $\pm$ 7	335 $\pm$ 11*	263 $\pm$ 13#	276 $\pm$ 12#
7	564 $\pm$ 13	529 $\pm$ 10*	450 $\pm$ 16#	441 $\pm$ 17#
9	884 $\pm$ 14	765 $\pm$ 16*	626 $\pm$ 20#	615 $\pm$ 31#
11	1065 $\pm$ 24	905 $\pm$ 25*	800 $\pm$ 23#	756 $\pm$ 41#
13	1339 $\pm$ 26	1067 $\pm$ 22*	1041 $\pm$ 35#	797 $\pm$ 29# *
15	1599 $\pm$ 27	1219 $\pm$ 30*	1195 $\pm$ 31#	844 $\pm$ 26# *
17	1801 $\pm$ 42	1351 $\pm$ 32*	1294 $\pm$ 42#	976 $\pm$ 12# *
19	1977 $\pm$ 42	1470 $\pm$ 44*	1424 $\pm$ 34#	1053 $\pm$ 36# *
21	2137 $\pm$ 45	1552 $\pm$ 71*	1569 $\pm$ 31#	1208 $\pm$ 68# *
23	2200 $\pm$ 40	1727 $\pm$ 45*	1636 $\pm$ 43#	1218 $\pm$ 46# *
25	2265 $\pm$ 36	1719 $\pm$ 47*	1794 $\pm$ 44#	1265 $\pm$ 59# *
30	2346 $\pm$ 49	1633 $\pm$ 40*	1838 $\pm$ 38#	1272 $\pm$ 52# *

NM: normal male DM: dwarf male NF: normal female DF: dwarf female

* *P* < 0.05 NM vs DM or NF vs DF # *P* < 0.05 NM vs NF or DM vs DF

However, this difference observed between normal and dwarf male chickens was not evident in female chickens. Differences in erythrocyte counts between sexes were also significant in both lines : numbers of erythrocyte in males were greater than in females throughout the growing period examined (Table 3).

Changes in hematocrit and Hb content with increasing age were comparable to those in erythrocyte count (Tables 4 and 5). This is consistent with the fact that hematocrit is largely composed of erythrocytes and Hb contents parallel to erythrocyte

Table 2. Shank-toe lengths (cm) (Mean $\pm$ SE, n = 10)

Age (week)	NM	DM	NF	DF
1	5.0 $\pm$ 0.1	5.0 $\pm$ 0.1	4.8 $\pm$ 0.1	4.8 $\pm$ 0.2
3	7.3 $\pm$ 0.1	6.9 $\pm$ 0.1	6.9 $\pm$ 0.1#	6.9 $\pm$ 0.1
5	9.2 $\pm$ 0.1	8.9 $\pm$ 0.1*	8.9 $\pm$ 0.5	8.7 $\pm$ 0.4
7	11.8 $\pm$ 0.1	10.5 $\pm$ 0.1*	10.5 $\pm$ 0.1#	10.0 $\pm$ 0.1#
9	14.6 $\pm$ 0.1	12.3 $\pm$ 0.1*	12.0 $\pm$ 0.1#	10.8 $\pm$ 0.2#*
11	14.9 $\pm$ 0.1	12.3 $\pm$ 0.1*	12.9 $\pm$ 0.1#	10.7 $\pm$ 0.5#*
13	16.3 $\pm$ 0.1	12.2 $\pm$ 0.1*	12.8 $\pm$ 0.2#	10.3 $\pm$ 0.1#*
15	17.0 $\pm$ 0.2	12.5 $\pm$ 0.1*	13.8 $\pm$ 0.1#	10.5 $\pm$ 0.1#*
17	17.6 $\pm$ 0.2	12.9 $\pm$ 0.1*	14.5 $\pm$ 0.2#	10.5 $\pm$ 0.1#*
19	17.3 $\pm$ 0.1	12.3 $\pm$ 0.1*	14.1 $\pm$ 0.2#	10.6 $\pm$ 0.1#*
21	17.5 $\pm$ 0.2	12.9 $\pm$ 0.2*	14.5 $\pm$ 0.2#	11.1 $\pm$ 0.2#*
23	17.2 $\pm$ 0.1	13.2 $\pm$ 0.1*	14.1 $\pm$ 0.2#	10.9 $\pm$ 0.2#*
25	17.8 $\pm$ 0.2	13.1 $\pm$ 0.1*	14.7 $\pm$ 0.2#	11.2 $\pm$ 0.1#*
30	17.3 $\pm$ 0.2	13.3 $\pm$ 0.1*	14.5 $\pm$ 0.1#	10.8 $\pm$ 0.1#*

NM, DM, NF, DF, *, # : See Table 1 !

Table 3. Erythrocyte counts ($\times 10^6/\text{mm}^3$) (Mean $\pm$ SE, (n))

Age (week)	NM	DM	NF	DF
1	2.30 $\pm$ 0.06(6)	2.16 $\pm$ 0.03(7)*	2.17 $\pm$ 0.03(10)	2.00 $\pm$ 0.06(8)
3	2.33 $\pm$ 0.05(9)	2.29 $\pm$ 0.05(8)	2.38 $\pm$ 0.08(5)	2.14 $\pm$ 0.11(7)
5	2.39 $\pm$ 0.02(10)	2.34 $\pm$ 0.02(10)	2.24 $\pm$ 0.06(10)#	2.23 $\pm$ 0.07(10)
7	2.39 $\pm$ 0.02(10)	2.49 $\pm$ 0.04(10)*	2.21 $\pm$ 0.10(7)	2.24 $\pm$ 0.07(8)
9	2.57 $\pm$ 0.19(10)	2.73 $\pm$ 0.19(10)*	2.23 $\pm$ 0.05(8)#	2.27 $\pm$ 0.04(8)#
11	2.49 $\pm$ 0.03(10)	2.67 $\pm$ 0.02(10)*	2.20 $\pm$ 0.08(9)#	2.39 $\pm$ 0.08(8)#
13	2.45 $\pm$ 0.03(10)	2.62 $\pm$ 0.03(10)*	2.41 $\pm$ 0.04(10)	2.42 $\pm$ 0.05(10)#
15	2.61 $\pm$ 0.03(10)	2.74 $\pm$ 0.03(10)*	2.63 $\pm$ 0.08(10)	2.69 $\pm$ 0.05(10)
17	2.78 $\pm$ 0.03(10)	3.06 $\pm$ 0.04(10)*	2.48 $\pm$ 0.04(10)#	2.73 $\pm$ 0.05(10)#*
19	2.82 $\pm$ 0.04(10)	3.20 $\pm$ 0.05(10)*	2.29 $\pm$ 0.05(10)#	2.47 $\pm$ 0.23(10)#
21	2.81 $\pm$ 0.03(10)	3.24 $\pm$ 0.05(10)*	2.53 $\pm$ 0.04(10)#	2.62 $\pm$ 0.04(10)#
23	2.88 $\pm$ 0.04(10)	3.26 $\pm$ 0.03(10)*	2.42 $\pm$ 0.04(10)#	2.57 $\pm$ 0.05(10)#*
25	3.11 $\pm$ 0.04(10)	3.37 $\pm$ 0.02(10)*	2.38 $\pm$ 0.08(10)#	2.38 $\pm$ 0.05(10)#
30	3.68 $\pm$ 0.06(10)	3.94 $\pm$ 0.04(10)*	2.34 $\pm$ 0.04(10)#	2.31 $\pm$ 0.08(10)#

NM, DM, NF, DF, *, # : See Table 1 !

Table 4. Hematocrits (%) (Mean±SE, (n))

Age (week)	NM	DM	NF	DF
1	31.5±0.9(6)	30.6±0.5(7)	33.6±0.5(10)	30.4±0.6(8)*
3	30.7±0.8(9)	30.4±0.8(8)	33.1±0.7(7)#	29.3±1.5(7)
5	30.9±0.4(10)	30.7±0.7(10)	31.5±0.4(10)	30.8±1.0(8)
7	29.1±0.5(10)	30.1±0.5(10)	28.9±0.6(8)	28.3±0.5(8)#
9	30.5±0.4(10)	33.3±0.7(10)*	30.3±0.5(8)	31.1±0.9(8)
11	29.5±0.6(10)	32.0±0.5(10)*	29.8±0.4(9)	31.8±0.5(8)
13	29.3±0.5(10)	32.5±0.8(10)*	32.3±0.5(10)#	33.2±0.7(10)
15	32.4±0.7(10)	36.0±0.7(10)*	33.1±0.8(10)	37.0±0.8(10)*
17	31.4±0.5(10)	39.3±0.8(10)*	33.1±0.5(10)#	36.9±0.9(10)*
19	35.3±0.7(10)	44.7±1.2(10)*	31.8±1.5(10)#	34.7±1.4(10)*#
21	36.3±1.1(10)	44.6±0.9(10)*	30.6±0.6(10)#	33.4±0.5(10)*#
23	39.6±0.7(10)	46.3±0.5(10)*	31.2±0.9(10)#	32.0±1.0(10)#
25	42.5±1.5(10)	48.7±1.0(10)*	31.4±0.3(10)#	31.0±0.6(10)#
30	41.6±0.9(10)	50.0±0.9(10)*	30.0±0.5(10)#	29.8±0.7(10)#

NM, DM, NF, DF, *, # : See Table 1 !

Table 5. Hemoglobin concentrations (g/100 ml) (Mean±SE, (n))

Age (week)	NM	DM	NF	DF
1	8.60±0.28(6)	7.75±0.19(7)*	8.12±0.16(10)	7.22±0.21(8)*
3	8.41±0.18(9)	8.16±0.18(8)	8.62±0.37(7)	7.30±0.27(7)*#
5	7.86±0.06(10)	7.76±0.16(10)	8.57±0.17(10)#	7.65±0.16(8)*
7	7.59±0.16(10)	7.87±0.15(10)	8.05±0.22(8)	8.07±0.16(8)
9	7.67±0.15(10)	8.76±0.19(10)*	8.40±0.25(8)#	8.64±0.28(8)
11	8.21±0.17(10)	8.95±0.19(10)*	8.39±0.19(9)	9.00±0.23(8)
13	7.63±0.17(10)	8.51±0.26(10)*	8.89±0.19(10)#	9.38±0.22(10)#
15	8.48±0.13(10)	9.44±0.24(10)*	9.65±0.03(10)#	11.13±0.30(10)*#
17	8.90±0.18(10)	10.59±0.30(10)*	9.13±0.23(10)	10.30±0.28(10)*
19	10.40±0.21(10)	12.76±0.31(10)*	8.52±0.51(10)#	9.84±0.71(10)*#
21	10.62±0.31(10)	12.95±0.24(10)*	8.83±0.20(10)#	9.85±0.28(10)*#
23	11.02±0.27(10)	12.41±0.29(10)*	8.40±0.34(10)#	8.82±0.36(10)#
25	12.49±0.20(10)	13.32±0.23(10)*	8.62±0.11(10)#	8.50±0.15(10)#
30	12.78±0.27(10)	15.19±0.26(10)*	8.12±0.09(10)#	8.07±0.12(10)#

NM, DM, NF, DF, *, # : See Table 1 !

counts.

The present results on hematological examination in dwarf chickens are in good agreement with previous reports^{6,7)} on dw chickens where dw gene had been incorporated into White Leghorn or a meat stock, and blood samples were taken at 25 and 40 or 68 weeks of age. Accordingly, it is likely that dw gene increases erythrocyte count and thereby hematocrit and Hb when the dwarfing effect on skeletal growth became apparent, irrespective of types of chickens to which the gene was transferred.

This appears to be paradoxical, because the dwarf chicken having a smaller sized body will require less oxygen than the corresponding normal chicken.

The increased number of erythrocyte in dwarfs having low circulating IGF-1 levels also contradict to the findings in mammals^{2,3)} in which there is a positive relation between IGF-1 concentrations and erythrocyte production. However, it is possible that a higher GH level¹⁰⁾ itself stimulates erythropoiesis in the dwarf chicken. In fact, our recent study (WAKITA *et al.* unpublished) revealed that hypophysectomy reduces erythrocyte count, whereas purified chicken GH injection to hypophysectomized chickens restores erythrocyte to sham control level without the restoration of IGF-1 level in circulation. This seems to support our presumption described above : the stimulative effect of GH on erythropoiesis in dwarf chickens, though more studies are clearly required.

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