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Comparison of Growth in Three Varieties of the Japanese Extremely Long-Tailed Chicken Breed (Tosa-no-Onagadori)

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Abstract: The aim of this study is to reveal whether there are differences in live body weights and growth curves based on Gompertz function among three plumage color varieties (black-breasted white, black-breasted red and white) of the Japanese extremely long-tailed chicken breed (Tosa-no-Onagadori, briefly Onagadori), Special National Natural Treasure of Japan. Body weights were recorded every week from hatching to 30 weeks of age. In males, black-breasted red showed higher values than black-breasted white from 13 to 30 weeks of age. In females, black-breasted red was also higher than black-breasted white in body weights at 17, 19 and 26 to 30 weeks of age. Comparing the earliness of inflection points in growth curves among three varieties, the order was black-breasted white>black-breasted red>white in the female and black-breasted red>black-breasted white>white in the male. The differences in the body weights and inflection points are thought to be due to the genetic background differences between varieties. The information from this study will be useful in developing future strategies for conservation and improvement of the Onagadori as valuable genetic resource.

Key words: Body weight, growth curve, native Japanese chickens, Onagadori, plumage color varieties

INTRODUCTION

In Japan, there are approximately 50 breeds of indigenous chickens (Tsudzuki, 2003). Almost all of them were developed for ornamental purposes, e.g. special body shape and plumage, long crowing and cock fighting, as opposed to European and American breeds that were mostly established for meat and egg production (Osman et al., 2006; Goto et al., 2010). Among them, 15 breeds and two groups have been designated as National Natural Treasure of Japan. Especially, the Tosa-no-Onagadori breed (briefly, Onagadori) has been designated as a Special National Natural Treasure of Japan (Tsudzuki, 2003). Males of this breed show no molting in some of tail feathers and saddle hackles and the non-molting tail feathers grow approximately 100 cm in average per year. This breed has three plumage color varieties (black-breasted white, black-breasted red and white) and the black-breasted white is believed to be the original plumage color of the Onagadori. Black-breasted red and white varieties were established by crossing with other breeds (Tsudzuki, 2006). In the recent study based on microsatellite DNA polymorphisms, it was revealed that these varieties have genetically different background (Tadano et al., 2009). Growth is one of the priority traits for improvement and

conservation of not only ornamental breeds but also industrial chickens (The Japanese Fowls Association, 1997; Beiki et al., 2013). However, no comparison of growth has been done so far for three varieties of the Onagadori. Therefore, the aim of this study is to reveal the differences in growth of three varieties of the Onagadori based on live weights measured serially and growth curves estimated with a non-linear model, Gompertz function.

MATERIALS AND METHODS

Data were collected from three different plumage color varieties (black-breasted white, black-breasted red and white) of the Onagadori reared at the Laboratory of Animal Breeding and Genetics, Graduate School of Biosphere Science, Hiroshima University. Body weights were recorded weekly from hatching to 30 weeks of age. Moreover, rate of weekly body weight gain was calculated as follows:

 $R_g = (W_g/W_b) \times 100$

Where:

R_g = Rate of weekly weight gain W_g = Weight gain per week W_b = Body weight before gain Newly hatched chicks were numbered with wing-band for individual identification and reared in a temperature controlled brooder with 24 h lighting until 10 weeks of age. Then, chicks were transferred into a colony room with fluorescent lighting from the ceiling during 0500 and 1900 h. They were grouped in wire meshed cages until 17 weeks of age and thereafter housed individually in wire cages to the end of experiment. Feed and water were provided ad libitum during the experiment. Standard commercial starter diet (0-6 weeks: crude protein (CP), 20%), grower diet (7-10 weeks: CP, 17%), developer diet (11-16 weeks: CP, 15%) and layer diet (17-30 weeks: CP, 17%) were supplied.

In addition to live body weight measuring, growth curves were estimated with a non-linear growth model, Gompertz function (Gompertz, 1825), because this model well fits the growth of chickens (Mignon-Grasteau et al., 1999; Goto et al., 2011). The formula is as below (Norris et al., 2007):

$$W_t = A \times exp [-exp (b-ct)]$$

Where:

Wt = Body weight at time t (age in weeks)

A = Asymptotic body weight of the bird that is the weight at an infinite age

 $b = ln (A/W_0)$

W₀ = Estimated hatching weight of birds

C = Maturation rate

The age at inflection is defined as $1/c \times ln$ (b) and the body weight at hatching W_0 as A x $exp^{(-b)}$ (Laird, 1966). Curve parameters were calculated with statistical software R (version 3. 0. 1; available as a free download form http://www.r-project.org).

RESULTS

Table 1 shows means and standard errors for body weights in three varieties of the Onagadori breed of chickens from hatching (0 week) to 30 weeks of age. From 0 to 12 weeks of age, no significant differences were observed between three varieties in males. Whereas, from 13 to 30 weeks of age, black-breasted red males showed higher values than black-breasted white males. White variety males showed lower values than black-breasted red males at 21 and 23 weeks of age, though there were no differences between white and black-breasted white males.

On the other hand, body weights of females showed different tendency as compared with those of males. No significant differences were observed between three varieties at 0 to 1, 6 to 12, 20 and 22 to 25 weeks of age. Black-breasted red showed higher values than black-breasted white and white at 2 and 3 weeks of age. Black-breasted red also showed higher values than white at 4 and 5 weeks of age, though there was no

difference between white and the other varieties. At the age of 13 to 19, 21, 28 and 29 weeks, body weights of black-breasted red were higher than those of white. Also, Black-breasted red showed higher values than black-breasted white at 17, 19 and 26 to 30 weeks of age.

Table 2 shows the rate of body weight gain in both sexes of three varieties of the Onagadori. At 1-2 week period, black-breasted red showed a significantly higher value than black-breasted white in females. Whereas, at 23-24 week period, black-breasted red showed a significantly lower value than black-breasted white in males. There were no significant differences in the other periods.

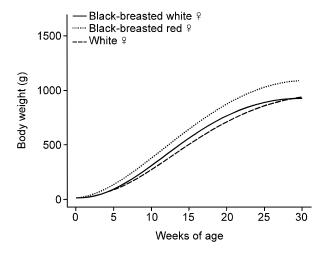


Fig. 1: Average growth curves estimated with the Gompertz function for three plumage color varieties of Onagadori females during the first 30 weeks of age.

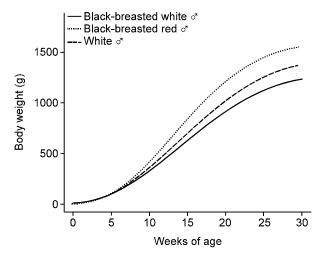


Fig. 2: Average growth curves estimated with the Gompertz function for three plumage color varieties of Onagadori males during the first 30 weeks of age.

Table 1: Means and standard errors for body weight in three varieties of the Onagadori breed of chickens at 0-30 weeks of age

	vallenes											
	Black-breasted white	hite			Black-breasted red				White			
Age (week)	Female		Male	=	Female	_	Male	-	Female		Male	=
0	24.80±0.43⁵	32	24.58±0.58²	23	24.72±0.44²	4	26.15±0.70°	9	23.77±0.51ª	8	24.30±0.64°	œ
-	29.78±0.79⁵	22	30.72±1.14	8	32.33±1.99	œ	33.03±2.31	4	28.68±1.75 ²	5	29.34±2.12	Ŋ
2	38.45±1.27°	32	41.65±1.94 ³⁵	83	49.45±2.56 ^a	7	47.22±4.95**	9	34.42±2.92	œ	43.55±3.75 ^{ab}	ω
က	52.16±1.93⁵	32	58.56±3.23 ^{ab}	23	69.21±5.02	4	63.63±4.87*	9	42.88±5.40 ^b	7	64.59±5.12*	7
4	71.14±3.73ªb	23	79.45±4.78 ^a	23	89.79±5.58 ^a	12	87.07±5.21 ^a	9	51.75±5.10°	7	85.23±4.62 ^a	ω
52	92.71±5.29ªb	32	105.34±8.25	23	112.21±8.32	1	113.20±14.34 ^{2b}	9	67.28±3.66 ^b	80	119.54±8.20	ω
9	111.74±5.92	88	120.00±10.95	20	143.01±9.47	13	141.30±14.61 ^a	9	92.66±4.27 ^a	7	139.05±10.73 ^a	ω
7	147.12±8.75	32	152.77±12.72 ^a	23	185.87±12.84⁵	4	192.97±25.61 ^a	9	120.52±6.80	7	166.40±14.34 ^a	ω
80	195.33±10.73 ^a	32	207.44±16.43	23	236.19±16.06 ²	4	268.85±30.95	9	169.66±11.61	7	226.14±18.82	7
o	247.06±12.31 ^a	32	262.96±20.37°	23	297.09±18.67 ^a	4	343.87±33.04	9	216.23±15.03 ^a	9	286.40±25.63 ^a	Ŋ
10	292.98±13.00°	32	315.55±26.65*	23	364.53±19.72 ^{2b}	13	414.83±30.78	9	254.72±15.90°	7	318.28±24.20₺	ω
7	344.67±13.39°	32	379.42±27.95	23	420.92±23.17 ^{ab}	4	501.03±28.63	9	291.16±25.65°	7	403.36±22.16 ^{ab}	ω
12	412.58±19.28 ^b	32	449.26±28.18 ^{2b}	23	486.48±24.58 ^{ab}	4	586.43±31.34	9	364.28±26.75°	œ	463.15±21.44 ^{ab}	ω
13	451.13±16.21™	ઝ	506.53±32.32°°	ಜ	547.39±24.08 ^{ab}	4	676.12±25.43	9	395.88±25.20°	œ	550.83±19.99 [±]	ω
4	507.78±15.83 [∞]	32	583.40±32.61™	ಜ	600.05±27.30 [№]	4	783.92±25.79	9	461.82±27.37⁴	œ	637.29±16.36 [±]	ω
15	551.04±16.36	32	642.96±34.09°	23	653.40±28.46 [№]	4	851.77±20.86	9	505.50±28.13	œ	699.41±17.99₽	ω
16	600.86±18.23 [∞]	32	700.83±34.64°	23	706.38±27.06°°	4	944.03±23.57 ^a	9	558.34±26.43	œ	773.98±14.92 ^{ab}	ω
17	657.44±14.91°	ઝ	756.87±33.96°	ន	764.05±29.76°	4	1002.70±20.96 ²	9	594.48±23.72°	œ	835.68±19.02 ^{±6}	ω
18	701.38±14.89	ઝ	830.97±38.42°	23	802.84±30.65№	4	1079.25±34.71	9	636.72±24.61	œ	913.31±17.59₽	ω
19	739.69±15.36°	ઝ	887.35±38.38	23	853.77±31.28°	4	1132.20±39.46	Ŋ	671.44±18.31°	œ	981.96±30.66™	ω
20	755.91±18.97°	સ	909.71±38.57°	ಣ	871.99±34.14№	13	1195.80±40.54	9	698.72±25.56°	œ	1007.69±31.11⁴⁵	7
21	790.71±17.27 ⁴	32	956.65±39.57b°	ខ	899.82±28.77∞	1	1295.03±48.15 ²	9	730.32±25.27	œ	1088.24±32.82°	ω
22	810.89±17.45°	32	989.46±44.63b°	23	929.24±29.53°	13	1341.27±48.74	9	767.28±31.89°	œ	1134.58±25.89 ^{ab}	ω
23	837.48±18.29	ઝ	1053.74±38.06 ¹⁰	23	944.91±28.56°⁴	4	1382.70±51.57 ^a	9	782.92±30.77	œ	1181.65±28.12°	ω
24	861.56±18.81	32	1094.69±42.67™	ಜ	969.81±25.51⁰⁴	4	1404.07±51.17⁵	9	800.52±31.20	œ	1208.46±26.03³⁵	ω
25	876.48±19.64	સ	1119.17±46.18№	ខ	984.63±26.90⁰	13	1433.70±30.55	9	814.40±32.37°	œ	1242.18±32.25 ^{ab}	ω
26	876.61±18.44°	32	1159.99±47.84°	23	1012.44±26.36°	1	1464.23±25.47 ²	9	842.68±33.13°	œ	1272.09±24.35 ^{ab}	ω
27	884.36±17.53*	32	1182.06±45.80№	23	1047.39±29.94∞	1	1464.45±37.06°	9	864.08±35.14*	œ	1279.48±35.31 ^{ab}	ω
28	893.59±18.31	સ	1191.24±47.33 ^{bb}	23	1082.84±38.39°	1	1508.85±40.53°	9	889.66±34.57°	80	1311.78±38.67 ^{ab}	ω
29	921.26±17.58°	32	1217.02±51.51 ¹⁰	23	1125.93±42.76°	1	1555.13±39.98	9	918.60±36.83°	80	1338.84±42.48 ^{ab}	ω
30	933.24±20.35	32	1254.71±49.44 ¹⁰	74	1128.59±45.82™	4	1573.72±35.89 ^a	9	954.96±39.04 ^c	8	1397.28±36.65 ^{ab}	ω

**Means with the same superscript letter are not significantly different among varieties at P<0.05 in each week (one way ANOVA followed by Tukey's HSD test)

Table 2: Rate of body weight gain in three varieties of the Onagadori breed of chickens

Age Enable breasbed v/Mile n Male n Fermale n Male n n n N <													
Fermale n Male n n n n n n n n n n n <th>Q Q</th> <th>Black-breasted</th> <th>white</th> <th></th> <th></th> <th>Black-breasted</th> <th>red</th> <th></th> <th></th> <th></th> <th>White</th> <th>_</th> <th></th>	Q Q	Black-breasted	white			Black-breasted	red				White	_	
18 (187,260) 25 24 (188,260) 25 24 (188,260) 25 24 (188,260) 25 24 (188,260) 25 24 (188,260) 25 24 (188,260) 25 24 (188,226) 25 24 (188,260)	(week)	Female	ч	Male	٦	Female	ע	Male	۵	Female	ב	Male	ב
27.92±6.8° 25 3.514±71** 18 53.45±3.9° 8 28.01±5.2° 4 27.22±1.0° 5 28.51±5.0° 3.60±2.66° 20 3.30±5.64 22 24.12±4.2° 14 37.74±9.6° 6 23.0±4.1° 7 7.84±7.8° 3.60±2.66° 20 3.33±5.94 22 24.12±4.2° 12 20.0±2.9° 6 21.0±4.1° 7 7.42±1.8° <td< td=""><td>0-1</td><td>18.16±2.60ª</td><td>22</td><td>24.68±2.67</td><td>18</td><td>26.07±6.16⁸</td><td>8</td><td>26.84±5.35</td><td>4</td><td>22.79±6.93ª</td><td>5</td><td>16.82±8.04</td><td>5</td></td<>	0-1	18.16±2.60ª	22	24.68±2.67	18	26.07±6.16 ⁸	8	26.84±5.35	4	22.79±6.93ª	5	16.82±8.04	5
36.942.16 3.2 40.00444g 2.2 3.3.1941f 7 57.437 BF 36.942.16 3.2 40.00444g 2.2 3.3.1941f 7 57.437 BF 34.014.19 2.0 33.342.94 2.1 32.364.57 12 20.0442.74 6 20.0443.74 7 30.0443.84 2.0 34.014.19 2.0 34.044.94 6 37.444.84 7 30.0445.26 2.0 2.0 2.0 2.0 34.044.94 6 37.444.84 7 30.0445.26 2.0 3.0	1-2	27.92±3.68 ^b	52	33.51±4.71ab	92	53.42±9.39°	œ	28.01±6.23ab	4	27.22±4.09ªb	ς	28.51±5.61 ^{ab}	2
31 000000000000000000000000000000000000	2-3	36.34±3.16 ^a	32	40.90±4.48ª	83	38.69±5.51	4	37.74±9.65	9	33.19±4.15ª	7	57.43±7.86 ^a	7
34,014,19 29 33,732,989 21 32,3644,57 12 28,2241,149 6 299,146,03 7 38,625,58 28,842,969 28 2,044,196 19 250,442,96 13 23,444,44 7 16,183,369 28,842,969 28 2,044,196 19 250,441,96 6 31,824,44 7 30,441,96 28,843,89 32 2,304,200 23 27,422,16 14 40,8843,49 6 36,8843,39 7 20,4845,20 19,824,10 32 2,304,260 23 2,444,89 14 40,8843,67 6 16,8843,39 7 20,4845,20 19,842,260 32 2,3147,62 22 18,142,16 14 10,643,367 6 16,8443,39 7 20,4843,69 19,442,260 32 2,3147,62 22 18,142,16 14 10,643,367 6 10,8443,67 7 20,844,69 10,401,10 32 2,644,64 1 20,244,364 7 20	3-4	31.60±3.63ª	39	33.38±3.94	23	24.12±4.238	12	39.04±9.21	9	22.02±7.29°	9	33.87±7.70	7
26 8492 89 28 20 4441 95 19 26 0443 36* 13 29 8141177* 6 37 434484* 7 16 1643 56* 28 3942 46* 28 24 2043 26* 13 24 9645 99* 6 31 6243 41* 7 20 4045 19* 28 3945 46* 28 24 2043 26* 23 7 4 3645 36* 13 24 9645 39* 6 36 9844 35* 7 20 4045 19* 27 8341 60* 32 27 3422 16* 14 40 2645 89* 6 16 843 37* 7 20 4485 69* 19 842 10* 32 27 3422 16* 14 40 2645 89* 6 16 843 37* 7 20 3485 69* 19 842 10* 32 27 344 69* 22 16 6443 67* 6 16 6843 37* 7 20 4845 68* 10 4041 10* 32 16 6641 30* 23 14 17 2442 57* 6 16 6843 68* 7 20 2483 68* 10 4041 10* 32 16 6641 30* 23 14 14 16 6443 67* 6 16 6443 67* 7 2	4-5	34.01±4.19ª	39	33.73±2.98°	7	32.36±4.57	12	28.22±11.46 ^a	9	29.91±6.03ª	7	39.82±5.56	ω
28 3423 46* 28 24 20243 26* 20 34.36±3 06* 13 34.96±5 39* 6 31.82±34†* 7 20.40±5 19* 34.88±2.83* 32 35.65±2.90* 23 27.42±2 16* 14 40.86±3.43* 6 36.98±3.39* 7 23.46±5.23* 18.88±1.40* 32 27.30±2.00* 22 19.71±1.99* 13 22.25±4.48* 6 19.35±2.7* 6 22.48±6.69* 18.78±1.31* 32 23.12±7.62* 22 19.71±1.99* 13 22.25±4.48* 6 10.35±2.7* 6 22.48±6.69* 10.40±1.83* 31 13.63±2.09* 23 13.77±1.80* 14 10.65±3.80* 6 12.34±3.39* 7 25.92±6.69* 10.40±1.83* 31 15.63±2.09* 23 13.77±1.80* 14 10.65±3.80* 6 12.34±3.30* 7 25.92±6.69* 10.40±1.83* 31 15.84±2.00* 23 13.77±1.80* 14 10.65±3.80* 6 12.24±3.60* 7 25.42±3.66*	5-6	26.48±2.95ª	78	20.44±1.95ª	19	26.04±3.26 ^a	13	29.81±11.77ª	9	37.43±4.84ª	7	16.18±3.95 ^a	ω
34 6812 83 32 35 552 90 23 27 422 10° 14 40 8923 43° 6 36 8924 35° 7 33 46±5 20° 12 8511 60 32 27 3022 0° 23 25 32±10° 14 29 26±2 8° 6 27 88±3 23° 7 33 46±5 0° 18 6511 40° 32 22 124.76° 22 18 61±2 10° 13 21 64±3 6° 6 16 08±4 30° 7 29 28±6 96° 18 78±12 1° 32 22 10±7 10° 13 21 64±3 6° 6 16 08±4 30° 7 29 28±6 96° 10 40±10 10° 31 16 08±1 30° 14 17 24±2 5° 6 16 08±4 13° 7 29 28±6 96° 13 47±1 10° 31 16 08±1 30° 14 16 08±1 30° 6 12 0±24±3 8° 8 16 0±24±3 8° 8 16 0±24±3 8° 8 16 0±24±3 8° 8 16 11 10±24±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8° 16 12 14±3 8°	2-9	28.39±3.46ª	78	24.20±3.26	8	34.36±3.08°	13	34.96±5.99	9	31.82±3.41	7	20.40±5.19ª	ω
27.88±1.60* 32 27.38±2.07* 23 26.35±1.61* 14 29.26±2.85* 6 27.68±3.27* 6 27.3±0.74* 18.68±1.34* 32 19.48±2.66* 22 19.14±1.69* 13 22.25±4.48* 6 19.35±2.7* 6 22.3±6.56* 7 22.3±6.56* 7 22.3±6.56* 7 10.08±4.30* 7 15.58±3.88* 6 10.08±3.07* 7 15.58±3.88* 8 19.08±3.27* 6 22.3±6.56* 7 22.3±6.56* 7 22.3±6.56* 7 10.08±3.07* 7 15.58±3.88* 8 19.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.08* 8 10.08±3.0	7-8	34.68±2.83ª	32	36.35±2.90°	83	27.42±2.16 ⁸	4	40.89±3.43°	9	36.98±4.35°	7	33.46±5.20	7
19.85±1.40° 32 19.49±2.60° 22 19.71±1.99° 13 2.25±4.48° 6 19.35±2.27° 6 23.48±3.65° 18.78±1.31° 32 23.12±7.62° 22 18.61±2.16° 1 7 15.68±3.68° 18.78±1.31° 32 26.65±1.83° 14 17.24±2.87° 6 24.8±4.11° 7 15.68±3.68° 10.40±1.83° 31 16.81±2.00° 23 16.11.39° 14 16.52±4.1° 6 12.3±2.38° 8 16.0±2.29° 10.40±1.83° 31 16.81±2.00° 23 9.51±1.39° 14 16.15±2.41° 6 15.3±2.78° 8 16.0±2.29° 8.71±0.71° 32 11.34±2.39° 22 9.51±1.99° 14 16.15±2.41° 6 15.3±2.78° 8 98.11.40° 8.71±0.71° 32 11.10±1.04° 14 16.5±2.41° 6 15.3±2.78° 8 98.11.41° 8.85±0.66° 31 8.65±1.29° 22 24.4±0.81° 17.5±1.77° 8 15.2±1.77°<	8-9	27.83±1.60ª	32	27.30±2.07 ^a	83	26.35±1.61 ^a	4	29.26±2.85°	9	27.68±3.32ª	9	22.13±0.74 ^a	4
18.74±1.31* 3.2 23.12±7.62* 2.2 18.61±2.16* 13 21.64±3.67* 6 16.08±4.30* 7 29.28±6.96* 19.54±2.21* 3.2 16.06±1.83* 14 17.24±2.67* 6 12.24±1.1* 7 15.58±3.88* 10.40±1.83* 3.1 13.63±2.00* 23 13.17±1.80* 14 16.16±4.48* 6 10.28±2.78* 8 16.11±2.90* 13.47±1.14* 3.1 16.81±2.00* 23 9.54±1.39* 14 16.16±4.48* 6 10.28±2.78* 8 16.11±2.90* 8.71±0.71* 3.2 11.34±2.39* 2.2 9.04±0.88* 14 16.18±0.92* 6 12.08±1.79* 8 16.11±2.90* 16.11±2.90* 8 16.11±2.90* 16.11	9-10	19.85±1.40 ^a	32	19.49±2.60°	23	19.71±1.99ª	13	22.25±4.48°	9	19.35±2.27ª	9	23.48±3.65	5
19,542,21a 32 26,6547,34a 23 16,06±183a 14 17,242,57a 6 24,28±4,11a 7 15,58±3.8a 10,40±1,83a 31 13,63±2,09a 23 13,17±1,80b 14 16,05±3,86 6 12,34±3,38a 8 16,01±2,99a 13,47±1,7a 32 11,68±2,00a 23 9,51±1,39a 14 16,05±3,86a 6 12,34±2,38a 8 16,21±2,99a 8,7±0,08a 32 10,19±1,07a 21 8,65±1,29a 14 10,84±0,92a 6 12,00±1,79a 8 16,11±2,99a 8,92±0,68a 32 10,19±1,07a 21 8,65±1,29a 14 10,84±0,92a 6 12,00±1,79a 8 16,11±2,9a 7,40±0,68a 31 8,65±1,27a 22 8,10±1,04a 6 7,2±1,77a 8 9,11±1,0a 6,85±0,65a 31 8,65±1,27a 22 8,10±1,04a 14 7,5±1,77a 6 8,2±1,02a 8 9,1±1,10a 5,54±0,77a 31 4,50±0,65a	10-11	18.78±1.31ª	32	23.12±7.62ª	23	18.61±2.16	13	21.64±3.67	9	16.08±4.30°	7	29.28±6.96°	∞
10.40±1.83° 31 13.63±2.09° 23 13.71±1.80° 14 16.05±3.86° 6 12.34±3.38° 8 19.60±3.53° 13.47±1.14° 31 16.81±2.00° 23 9.51±1.39° 14 16.15±2.41° 6 16.28±2.02° 8 16.21±2.99° 8.71±0.71° 32 11.34±2.39° 22 9.04±0.88° 14 16.84±0.92° 6 10.28±2.02° 8 9.81±1.40° 8.92±0.68° 31 10.19±1.07° 22 8.04±0.88° 14 7.54±1.79° 6 10.28±2.02° 8 9.81±1.40° 6.85±0.68° 31 8.69±1.00° 22 8.10±1.04° 6 7.27±1.77° 8 7.39±1.72° 5.5±0.46° 31 7.45±1.22° 22 8.42±0.68° 6 7.27±1.77° 8 7.39±1.72° 5.5±0.46° 31 7.45±1.22° 22 8.42±0.68° 1 7.2±1.79° 8 9.3±1.13° 5.5±0.08° 31 7.45±1.22° 22 8.42±0.68° 1 7.2±1.79°	11-12	19.54±2.21ª	32	26.65±7.34	23	16.06±1.83°	4	17.24±2.57	9	24.28±4.11ª	7	15.58±3.88	ω
13.47±1.14* 31 16.81±2.00* 23 9.51±1.39* 14 16.15±2.41* 6 15.38±2.78* 8 16.21±2.99* 8.71±0.71* 32 11.34±2.39* 22 9.04±0.88* 14 8.86±1.89* 6 10.28±2.02* 8 9.81±1.40* 8.92±0.68* 32 10.19±1.07* 21 8.65±1.29* 14 10.84±0.92* 6 10.28±2.02* 8 9.81±1.40* 7.40±0.61* 31 9.7±1.77* 4 7.2±1.04* 6 7.2±1.17* 8 7.96±1.17* 6.85±0.65* 31 7.45±1.22* 22 2.2±0.81* 14 7.5±1.79* 6 8.03±1.08* 8 9.37±0.92* 5.5±0.74* 31 7.45±1.23* 13 6.7±1.73* 5 4.6±1.13* 8 3.7±1.04* 8 3.7±1.02* 5.5±0.74* 31 7.4±0.46* 3 7.2±1.65* 4 6.1±0.44* 7.5±1.17* 8 9.3±1.17* 5.5±0.75* 32 2.2±1.23* 13 6.2±1.73* </td <td>12-13</td> <td>10.40±1.83ª</td> <td>31</td> <td>13.63±2.09ª</td> <td>23</td> <td>13.17±1.80°</td> <td>4</td> <td>16.05±3.86°</td> <td>9</td> <td>12.34±3.38ª</td> <td>œ</td> <td>19.60±3.53</td> <td>ω</td>	12-13	10.40±1.83ª	31	13.63±2.09ª	23	13.17±1.80°	4	16.05±3.86°	9	12.34±3.38ª	œ	19.60±3.53	ω
8.71±0.71* 32 11.34±2.39* 22 9.04±0.88* 14 8.86±1.89* 6 10.28±2.02* 8 9.81±1.40* 8.92±0.68* 32 10.19±107* 21 8.65±1.29* 14 10.84±0.92* 6 12.00±1.79* 8 10.81±1.02* 7.40±0.64* 31 9.67±1.78* 22 8.10±1.104* 14 7.54±1.79* 6 7.27±1.77* 8 7.90±1.17* 6.85±0.66* 31 7.45±1.22* 22 6.43±0.66* 14 6.14±0.46* 5 5.52±1.65* 8 7.39±1.72* 3.60±0.58* 31 7.45±1.22* 22 6.43±0.66* 13 8.29±1.62* 6 3.72±1.09* 8 7.39±1.72* 3.60±0.78* 31 5.39±1.21* 23 2.66±1.50* 13 3.62±1.21* 6 3.72±1.09* 8 4.55±2.06* 3.80±0.80* 32 3.89±0.91* 22 2.8±0.64* 13 3.6±1.21* 6 3.6±1.09* 8 4.5±2.00* 3.80±0.70* <t< td=""><td>13-14</td><td>13.47±1.14ª</td><td>31</td><td>16.81±2.00°</td><td>23</td><td>9.51±1.39ª</td><td>4</td><td>16.15±2.41ª</td><td>9</td><td>15.38±2.78ª</td><td>ω</td><td>16.21±2.99 ■</td><td>∞</td></t<>	13-14	13.47±1.14ª	31	16.81±2.00°	23	9.51±1.39ª	4	16.15±2.41ª	9	15.38±2.78ª	ω	16.21±2.99 ■	∞
8.92±0.68° 3.2 10.19±1.07° 21 8.65±1.29° 14 10.84±0.92° 6 12.00±1.77° 8 10.81±1.02° 7.40±0.61° 31 967±1.78° 22 8.10±1.04° 14 6.29±1.01° 6 7.27±1.77° 8 7.96±1.17° 6.85±0.66° 31 8.69±1.00° 22 6.24±0.81° 14 6.29±1.01° 6 7.27±1.77° 8 7.96±1.17° 6.85±0.66° 31 7.45±1.22° 22 6.24±0.66° 13 6.22±1.66° 8 7.39±1.72° 3.65±0.66° 30 3.58±1.21° 22 2.64±0.66° 13 8.29±1.66° 8 7.32±1.72° 4.50±0.78° 32 3.66±1.50° 13 3.62±1.73° 6 3.67±2.00° 8 4.56±2.06° 2.69±0.80° 32 3.89±0.65° 31 3.62±0.72° 4.28±0.66° 1.57±0.63° 8 4.56±2.06° 3.38±0.65° 31 3.60±0.72° 22 2.81±0.75° 6 3.50±0.73° 8 2.50±0.06°	14-15	8.71±0.71₃	32	11.34±2.39	23	9.04±0.88₃	_	8.86±1.89ª	9	10.28±2.02ª	ω	9.81±1.40	80
7.40±0.61³ 31 9.67±1.78³ 22 8.10±1.04³ 14 6.29±1.01³ 6 7.27±1.77³ 8 7.96±1.17³ 6.85±0.65³ 31 8.69±1.00³ 22 5.24±0.81³ 14 7.54±1.79³ 6 8.03±1.08³ 8 9.37±0.92³ 5.51±0.46³ 31 7.45±1.22³ 22 6.43±0.66³ 14 6.14±0.46³ 5 5.5±1.65³ 8 7.39±1.72³ 3.66±0.59³ 30 3.58±1.21³ 22 3.72±1.33³ 13 6.72±1.73³ 5 4.61±1.30° 8 3.38±1.72³ 4.50±0.78³ 31 5.39±1.21³ 22 2.68±1.63³ 13 8.72±1.03° 8 3.38±1.72³ 2.69±0.07³ 31 6.0±0.07³ 22 4.28±0.64³ 13 3.09±0.75³ 6 3.60±0.74³ 8 2.35±1.18³ 2.95±0.70° 31 6.0±0.03° 22 2.44±0.75³ 13 2.20±1.00³ 8 2.54±0.6³ 1.54±1.6³ 1.05±0.73³ 31 4.61±0.59³ 22 2.4	15-16	8.92±0.68	32	10.19±1.07 ^a	7	8.65±1.29ª	4	10.84±0.92 ^a	9	12.00±1.79ª	æ	10.81±1.02 ^a	ω
6.85±0.65° 31 8.69±1.00° 22 5.24±0.81° 14 7.54±1.79° 6 8.03±1.08° 8 9.37±0.92° 5.51±0.46° 31 7.45±1.22° 22 6.43±0.66° 14 6.14±0.46° 5 5.52±1.65° 8 7.39±1.72° 3.66±0.59° 30 3.58±1.21° 22 3.72±1.33° 13 6.72±1.73° 5 4.61±1.30° 8 7.39±1.72° 4.50±0.78° 31 5.39±1.21° 23 2.66±1.56° 13 8.29±1.62° 6 3.72±1.09° 8 6.14±1.49° 4.50±0.78° 32 3.89±0.64° 13 3.09±0.75° 6 3.07±1.09° 8 6.14±1.49° 2.69±0.78° 31 3.36±0.72° 21 1.38±0.75° 14 1.57±0.63° 6 2.60±0.74° 8 2.52±1.09° 2.95±0.70° 31 4.61±0.59° 22 2.81±0.65° 13 2.60±0.74° 8 2.52±0.6° 1.06±0.79° 31 4.61±0.59° 22 2.44±0.75°	16-17	7.40±0.61ª	3	9.67±1.78ª	23	8.10±1.04ª	4	6.29±1.01 ^a	9	7.27±1.77ª	ω	7.96±1.17	ω
5.51±0.46° 31 7.45±1.22° 22 6.43±0.66° 14 6.14±0.46° 5 5.52±1.65° 8 7.39±1.72° 3.66±0.59° 30 3.58±1.21° 22 3.72±1.33° 13 6.72±1.73° 5 4.61±1.30° 8 9.86±1.15° 4.50±0.78° 31 5.39±1.21° 22 2.66±1.50° 13 8.29±1.62° 6 3.72±1.09° 8 6.14±1.49° 2.69±0.80° 32 3.89±0.91° 22 4.28±0.64° 13 3.62±1.21° 6 3.67±2.00° 8 4.55±2.05° 2.69±0.80° 32 3.89±0.65° 21 1.38±0.79° 13 3.09±0.75° 6 3.67±2.00° 8 4.55±2.05° 2.95±0.70° 31 6.07±0.80° 22 2.81±0.75° 14 1.57±0.63° 6 2.60±0.74° 8 2.35±1.18° 1.84±0.99° 31 2.09±1.02° 22 2.44±0.75° 6 2.73±0.66° 8 2.52±1.69° 1.06±0.79° 32 2.22±0.70°	17-18	6.85±0.65°	3	8.69±1.00	22	5.24±0.81ª	7	7.54±1.79ª	9	8.03±1.08 ^a	æ	9.37±0.92ª	ω
3.66±0.59° 30 3.58±1.21° 22 3.72±1.33° 13 6.72±1.73° 5 4.61±1.30° 8 3.66±1.15° 4.61±1.30° 8 3.62±1.15° 3.62±1.15° 5 4.61±1.30° 8 3.62±1.15° 3.62±1.13° 8 3.22±1.09° 8 4.61±1.49° 6 1.4±1.49° 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.55±2.05° 8 4.18±1.20° 8 4.55±2.05° 8 4.18±1.20° 8 4.55±2.05° 9 4.18±1.20° 8 4.56±2.05° 9 4.18±1.20° 8 4.56±2.05° 9 4.18±1.20° 8 4.56±2.05° 9 4.18±1.20° 8 4.18±1.20° 8 4.18±1.20° 8 4.18±1.20° 8 4.18±1.20° 8 4.18±1.20° 8 4.18±1.20° 8 4.18±1.20° 8	18-19	5.51±0.46°	31	7.45±1.22ª	23	6.43±0.66 ^a	4	6.14±0.46®	5	5.52±1.65°	ω	7.39±1.72ª	∞
4.50±0.78° 31 5.39±1.21³ 23 2.66±1.50³ 13 8.29±1.62³ 6 3.72±1.09³ 8 6.14±1.49³ 2.69±0.80° 32 3.89±0.91³ 22 4.28±0.64³ 13 3.62±1.21³ 6 3.67±2.00³ 8 4.55±2.05³ 2.69±0.80° 31 3.36±0.72° 21 1.38±0.79³ 13 3.09±0.75³ 6 3.0±1.05³ 8 4.18±1.20³ 2.95±0.70° 31 6.07±0.80° 22 2.81±0.75³ 14 1.57±0.63° 6 2.60±0.74³ 8 2.3±1.13³° 1.84±0.99° 31 2.09±1.02³ 22 2.44±0.75³° 13 2.46±2.29³ 6 2.60±0.79³ 8 2.5±1.10³° 0.22±0.73° 32 2.22±0.70³ 22 2.44±0.75³° 14 0.21±3.25³ 6 2.73±0.65³° 8 2.5±1.13³° 1.06±0.79° 32 2.22±0.70° 22 3.42±0.88³ 14 0.21±3.25³ 6 2.09±1.23³ 8 2.5±1.41³ 3.53±0.73° <td< td=""><td>19-20</td><td>3.66±0.59°</td><td>8</td><td>3.58±1.21ª</td><td>23</td><td>3.72±1.33ª</td><td>13</td><td>6.72±1.73^a</td><td>2</td><td>4.61±1.30³</td><td>∞</td><td>3.86±1.15^a</td><td>7</td></td<>	19-20	3.66±0.59°	8	3.58±1.21ª	23	3.72±1.33ª	13	6.72±1.73 ^a	2	4.61±1.30³	∞	3.86±1.15 ^a	7
2.69±0.80° 32 3.89±0.91° 22 4.28±0.64° 13 3.62±1.21° 6 3.67±2.00° 8 4.55±2.05° 3.38±0.65° 31 3.36±0.72° 21 1.38±0.79° 13 3.09±0.75° 6 3.0±1.05° 8 4.18±1.20° 2.95±0.70° 31 6.07±0.80° 22 2.81±0.75° 14 1.57±0.63° 6 2.60±0.74° 8 2.35±1.18° 1.84±0.99° 31 2.09±1.02° 23 1.82±0.65° 13 2.46±2.29° 6 1.56±0.79° 8 2.82±1.69° 0.22±0.73° 31 4.61±0.59° 22 2.44±0.75° 13 2.20±1.00° 6 2.73±0.66° 8 2.56±1.20° 1.06±0.79° 32 2.22±0.70° 22 3.42±0.88° 14 0.21±3.25° 6 3.52±0.67° 8 2.53±1.41° 0.79±0.71° 31 0.79±0.94° 22 3.42±0.88° 14 3.06±1.26° 6 2.09±1.23° 8 2.53±1.41° 3.53±0.73° 3	20-21	4.50±0.78°	3	5.39±1.21ª	23	2.66±1.50ª	13	8.29±1.62ª	9	3.72±1.09°	∞	6.14±1.49ª	7
3.38±0.65° 31 3.36±0.72° 21 1.38±0.79° 13 3.09±0.75° 6 3.30±1.05° 8 4.18±1.20° 2.95±0.70° 31 6.07±0.80° 22 2.81±0.75° 14 1.57±0.63° 6 2.60±0.74° 8 2.35±1.18° 1.84±0.99° 31 2.09±1.02° 23 1.82±0.65° 13 2.46±2.29° 6 1.56±0.79° 8 2.82±1.69° 0.22±0.73° 31 4.61±0.59° 22 2.44±0.75° 13 2.20±1.00° 6 2.73±0.66° 8 2.56±1.20° 1.06±0.79° 32 2.22±0.70° 22 3.42±0.88° 14 0.21±3.25° 6 3.52±0.67° 8 2.59±1.41° 0.79±0.74° 32 2.22±0.70° 22 3.45±0.88° 14 3.06±1.26° 6 2.09±1.23° 8 2.53±1.41° 3.53±0.73° 31 1.98±1.04° 22 3.95±1.37° 14 3.35±0.88° 6 3.51±0.88° 8 2.77±2.15° 1.21±0.82°	21-22	2.69±0.80 8.00 € 1.00	32	3.89±0.91®	23	4.28±0.64ª	13	3.62±1.21 ^a	9	3.67±2.00₃	ω	4.55±2.05	80
2.95±0.70° 31 6.07±0.80° 22 2.81±0.75° 14 1.57±0.63° 6 2.60±0.74° 8 2.35±1.18°° 1.84±0.99° 31 2.09±1.02° 23 1.82±0.65° 13 2.46±2.29° 6 1.56±0.79° 8 2.82±1.69° 0.22±0.73° 31 4.61±0.59° 22 2.44±0.75° 13 2.20±1.00° 6 2.73±0.66° 8 2.56±1.20° 1.06±0.79° 32 2.22±0.70° 22 3.42±0.88° 14 0.21±3.25° 6 3.52±0.67° 8 0.49±1.32° 0.79±0.71° 31 0.79±0.94° 22 3.46±0.92° 14 3.06±1.26° 6 2.09±1.23° 8 2.53±1.41° 3.53±0.73° 31 1.98±1.04° 22 3.95±1.37° 14 3.35±0.88° 6 3.77±1.32° 8 2.17±2.15° 1.21±0.82° 32 1.78±1.35° 14 1.36±2.35° 6 3.51±0.88° 8 4.70±2.42°	22-23	3.38±0.65 3.38±0.65 3.38±0.65	3	3.36±0.72°	7	1.38±0.79ª	13	3.09±0.75₃	9	3.30±1.05³	ω	4.18±1.20 ^a	80
1.84±0.99° 31 2.09±1.02° 23 1.82±0.65° 13 2.46±2.29° 6 1.56±0.79° 8 2.82±1.69° 0.22±0.73° 31 4.61±0.59° 22 2.44±0.75° 13 2.20±1.00° 6 2.73±0.66° 8 2.56±1.20° 1.06±0.79° 32 2.24±0.75° 14 0.21±3.25° 6 3.52±0.67° 8 0.49±1.32° 0.79±0.71° 31 0.79±0.94° 22 3.45±0.92° 14 3.06±1.26° 6 2.09±1.23° 8 2.53±1.41° 3.53±0.73° 31 1.98±1.04° 22 3.95±1.37° 14 3.36±2.35° 6 3.47±1.32° 8 2.17±2.15° 1.21±0.82° 32 1.78±1.35° 21 0.15±1.05° 14 1.36±2.35° 6 3.51±0.85° 8 4.70±2.42°	23-24	2.95±0.70⁰	3	6.07±0.80	23	2.81±0.75 ^{ab}	14	1.57±0.63⁵	9	2.60±0.74™	ω	2.35±1.18ab	∞
0.22±0.73° 31 4.61±0.59° 22 2.44±0.75° 13 2.20±1.00° 6 2.73±0.66° 8 2.56±1.20° 1.06±0.79° 32 2.22±0.70° 22 3.42±0.88° 14 0.21±3.25° 6 3.52±0.67° 8 0.49±1.32° 0.79±0.71° 31 0.79±0.94° 22 3.16±0.92° 14 3.06±1.26° 6 2.09±1.23° 8 2.53±1.41° 3.53±0.73° 31 1.98±1.04° 22 3.95±1.37° 14 3.11±1.19° 6 3.47±1.32° 8 2.17±2.15° 1.21±0.82° 32 1.78±1.35° 21 0.15±1.05° 14 1.36±2.35° 6 3.51±0.85° 8 4.70±2.42°	24-25	1.84±0.99 β	31	2.09±1.02°	23	1.82±0.65ª	13	2.46±2.29 ■	9	1.56±0.79	ω	2.82±1.69	ω
1.06±0.79° 32 2.22±0.70° 22 3.42±0.88° 14 0.21±3.25° 6 3.52±0.67° 8 0.49±1.32° 0.79±0.71° 31 0.79±0.94° 22 3.16±0.92° 14 3.06±1.26° 6 2.09±1.23° 8 2.53±1.41° 3.53±0.73° 31 1.98±1.04° 22 3.95±1.37° 14 3.11±1.19° 6 3.47±1.32° 8 2.17±2.15° 1.21±0.82° 32 1.78±1.35° 21 0.15±1.05° 14 1.36±2.35° 6 3.51±0.85° 8 4.70±2.42°	25-26	0.22±0.73°	3	4.61±0.59°	23	2.44±0.75 ^{ab}	13	2.20±1.00 ^{ab}	9	2.73±0.66 ^{ab}	ω	2.56 ± 1.20^{ab}	80
0.79±0.71* 31 0.79±0.94* 22 3.16±0.92* 14 3.06±1.26* 6 2.09±1.23* 8 2.53±1.41* 3.53±0.73* 31 1.98±1.04* 22 3.95±1.37* 14 3.11±1.19* 6 3.47±1.32* 8 2.17±2.15* 1.21±0.82* 32 1.78±1.35* 21 0.15±1.05* 14 1.36±2.35* 6 3.51±0.85* 8 4.70±2.42*	26-27	1.06±0.79°	32	2.22±0.70 ■	23	3.42±0.88	4	0.21±3.25	9	3.52±0.67	ω	0.49±1.32	ω
3.53±0.73° 31 1.98±1.04° 22 3.95±1.37° 14 3.11±1.19° 6 3.47±1.32° 8 2.17±2.15° 1.21±0.82° 32 1.78±1.35° 21 0.15±1.05° 14 1.36±2.35° 6 3.51±0.85° 8 4.70±2.42° 1.21±0.82° 32 1.78±1.35° 1.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.85° 8 4.70±2.42° 1.21±0.82° 3.21±0.82°	27-28	0.79±0.71 ^a	3	0.79±0.94	23	3.16±0.92ª	4	3.06±1.26°	9	2.09±1.23°	ω	2.53±1.418	ω
1.21±0.82° 32 1.78±1.35° 21 0.15±1.05° 14 1.36±2.35° 6 3.51±0.85° 8 4.70±2.42° .	28-29	3.53±0.73 ∗	3	1.98±1.04ª	22	3.95±1.37	4	3.11±1.19ª	9	3.47±1.32	ω	2.17±2.15 ^a	ω
	29-30	1.21±0.82ª	32	1.78±1.35 ^a	7	0.15±1.05 ^a	4	1.36±2.35°	9	3.51±0.85°	ω	4.70±2.42ª	ω

Table 3: Gompertz model parameters and inflection points for each variety and sex

					Inflection
Varieties	Sex	Α	b	С	Point
Black-breasted	Female	992.0	3.689	0.147	11.188
white	Male	1415.0	4.053	0.123	13.150
Black-breasted	Female	1195.0	3.878	0.133	11.321
red	Male	1707.0	4.179	0.139	12.372
White	Female	1017.0	3.756	0.130	12.410
	Male	1553.0	4.157	0.126	13.169

Gompertz model parameters and inflection points for each variety and sex are shown in Table 3 and the average growth curves estimated with the Gompertz function for three varieties of the Onagadori are shown in Fig. 1 and 2. A values in Table 3 shows the asymptotic body weight of the bird that is the weight at an infinite age. The ranking of asymptotic body weight was blackbreasted red>white>black-breasted white in both sexes. Within the same varieties, sex differences were observed in all three varieties. The female had an inflecting point at age younger (11.188, 11.321 and 12.410 weeks of age in the black-breasted white, blackbreasted red and white, respectively) than the male (13.150, 12.372 and 13.169 weeks in the black-breasted white, black-breasted red and white, respectively). Comparing the earliness of inflection points among three varieties, the ranking was black-breasted white (11.188 week of age)>black-breasted red (11.321 week of age)>white (12.410 week of age) in the female and black-breasted red (12.372 week of age)>black-breasted white (13.150 week of age)>white (13.169 week of age) in the male.

DISCUSSION

Body weight differences among three varieties were observed at many weeks of age, though there were only a few weeks of age at which differences in body weight gain rate were detected among three varieties. At 13 to 30 weeks of age, black-breasted red males showed higher body weight than black-breasted white males, and at 26 to 30 weeks of age, both sexes of the blackbreasted red showed higher values than those of blackbreasted white. Furthermore, asymptotic body weight of the black-breasted red is the highest in the three varieties in growth curve analysis. These differences are thought to be due to the differences in the genetic backgrounds among varieties. The black-breasted white is believed to be the original plumage color of the Onagadori, and the origin of the black-breasted red was in cross between black-breasted white Onagadori and Toutenkou (Tsudzuki, 2006). Toutenkou is also a Japanese indigenous chicken breed which is characterized by black-breasted red plumage and long crowing, and its body size is larger than Onagadori (Tsudzuki, 2003). Therefore, there is a possibility that

genes from Toutenkou breed established the body size of black-breasted red Onagadori larger. Actually, Tadano et al. (2009) revealed on the basis of microsatellite DNA analysis that three plumage color varieties of the Onagadori have different genetic background and suggested that they should be considered as independent genetic units in a conservation strategy. To improve and approximate the genome of the blackbreasted red to that of the original black-breasted white type, it is necessary that black-breasted red are successively backcrossed to black-breasted white. When enough generations (e.g. more than eight generations) have been passed, the body weight of black-breasted red will be similar to that of blackbreasted white, and uniformity of breed will be accomplished between black-breasted white and blackbreasted red.

In growth curve analysis, the female had the inflecting point at young age in comparison with that of the male in all varieties. In addition to this result, some researchers also reported that the female tends to have the inflecting point at age younger that of the male (Barbato, 1991; Mignon-Grasteau *et al.*, 2000; Goto *et al.*, 2011). Usually, ornamental chicken breeders in Japan treat with both sexes similarly in feeding their chickens. Judging from the difference in inflecting points between sexes, feeding program should be changed between sexes. To feed chickens under the best condition, diet for females should be changed from grower diet to developer diet one or two weeks earlier than for males.

In addition to the genetic improvement by backcrosses mentioned above, improvement of feeding program will lead to the better conservation of the Onagadori.

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