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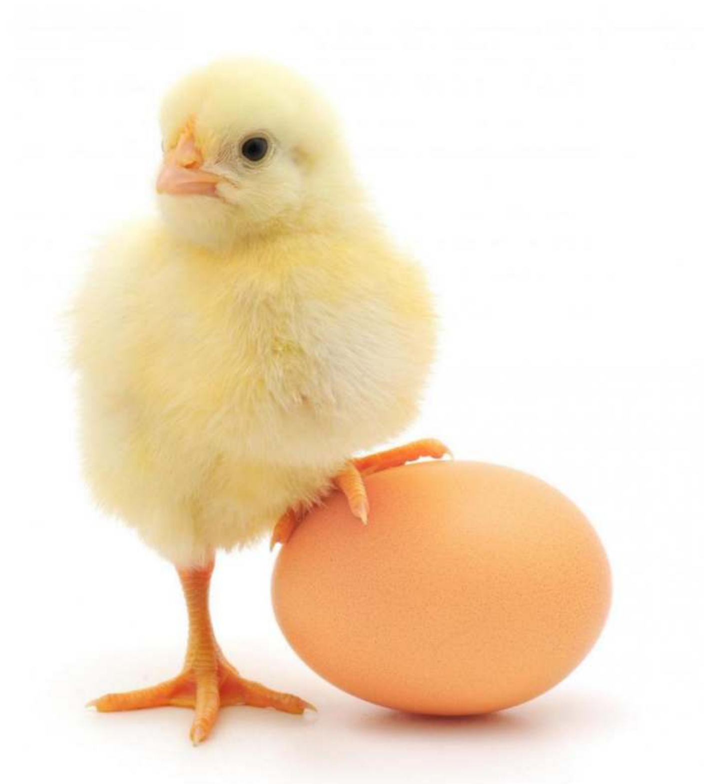

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Research Article

Growth and Morphological Traits for Two Lines of Native Japanese Chicken, Oh-Shamo

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Abstract

Objective: This study investigated the morphological traits and growth patterns for two lines of Oh-Shamo. **Methodology:** A total of 31 offensive (OFF) line (17 males and 14 females) and 32 defensive (DEF) line (17 males and 15 females) were used. The body weight of each individual was recorded every week from hatching to 30 weeks old. In addition to measuring body weight, growth curves were estimated using the Gompertz function. Eight somatometrical measurements were recorded every 5 weeks. **Results:** It was shown that the estimated asymptotic body weight and somatometrical measurements in OFF line were larger than those in DEF one regardless of sex. It was found that significant increases of lengths in femur, tarsometatarsus and tibiotarsus in OFF males were longer than others ($p<0.05$) and the body weight and length/diameter of each body part in OFF groups was more than those in DEF ones and those in males were higher than in females ($p<0.01$). The lengths of tibiotarsus and tarsometatarsus were estimated as hypogrowth in the OFF male group, but as tachyauxesis in the DEF female group. **Conclusion:** These results suggest that there were significant differences between OFF and DEF in their somatotypes, especially in the tibiotarsus.

Key words: Genetic resource, growth curve, Oh-Shamo, somatotype

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

There are approximately 50 breeds of native Japanese chickens and almost all of them were bred in Japan for crowing, special plumage and fighting traits[1]. In the past, these breeds were seldom used for egg and meat production despite having good quality eggs and meat. Thus, they are not only rare ornamentals but also valuable genetic resources for improving commercial chickens. However, the population sizes of these indigenous chickens have declined rapidly due to the reduction of breeders by aging and/or depopulation in rural areas.

Oh-Shamo, a breed declared as a National Natural Treasure of Japan[1] is characterized with long-legged, body in a more upright position and wings in high position on the body and had been originally bred for cockfights. Recently, they are kept as ornamentals and used as a parent stock to produce Japanese crossbred broilers (namely "JAS-jidori")[1,2]. Most of the Oh-Shamo parents have been supplied from the hatchery managed by the Ministry of Agriculture, Forestry and Fisheries of Japan, but also some from private breeders for the ornamentals. Those Oh-Shamo derived from private breeders are divided into two lines based on vestige of fighting style, namely offensive (OFF) and defensive (DEF) fighting lines. In addition, the OFF line chickens had been selected largely than the DEF ones. As for Oh-Shamo derived from the hatchery, there are many reports about cross-fertilization or growth performance[3,4]. On the other hand, there are a few reports for Oh-Shamo derived from breeders concerning body weight and shank length[5] and QTL analysis for egg traits using OFF line and white leghorn[6-8]. Although, Komiyama *et al.*[9] showed the difference between Oh-Shamo in Okinawa prefecture and in the main island of Japan based on morphological and growth-related traits, there are no reports comparing the two lines (OFF and DEF) of Oh-Shamo, especially about morphological and growth traits in the DEF line.

The aim of this study was therefore to investigate growth and morphological traits of the two lines of Oh-Shamo derived from a private ornamental breeder, in order to use these valuable indigenous bioresources for improving meat-type chickens.

MATERIALS AND METHODS

Animals: Fertile eggs were collected from two lines (OFF and DEF) of the indigenous Oh-Shamo which consisted of one male and three females each. The incubation conditions were 37.7±0.2°C and 65±5%, respectively. The newly hatched chicks were wing-banded for individual identification and grouped in a temperature controlled room with 24 h lighting until 6 weeks post-hatch. Then, birds were transferred into a colony room that was illuminated by overhead fluorescent lights from 0800 to 2200. In the colony room, they were grouped in steel wire mesh cages until 17 weeks of age and each pair of sex kept in experimental cages (50×36×60 cm) to the end of investigation. Standard commercial starter (0-6 weeks: CP 20%), grower (7-10 weeks: CP, 17%) and developer (11-30 weeks: CP, 15%) diets were provided *ad libitum* and the birds had free access to water under all housing conditions. Ambient temperature was decreased linearly from 32°C at 1 day of age to reach 22°C at 4 weeks of age. The number of birds used for data analysis was 17 (male OFF), 14 (female OFF), 17 (male DEF) and 15 (female DEF). Experiment was conducted in accordance with the regulations of the Animal Experiment Committee of Hiroshima University.

Growth curve: Body weights were recorded from day old to 30 weeks old every 1 week period. The widely used non-linear growth model, Gompertz function was fitted to estimate the mean age-live weight relationship[10]. Briefly, the mathematical relations of these models are as follows:

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

where, W_t is weight at time t (age in weeks), A is the asymptotic body weight of the animal, that is, the weight at an infinite age. The parameter b is equal to $\ln(A/W_0)$, where, W_0 is the estimated hatching weight of animals. Maturation rate is estimated by c. Furthermore, birds were regarded as sexual mature when assessed by the sperm in male and the egg-laying in female.

Morphological measurement: Following the previous studies[11,12], 7 lengths and a diameter of body part were measured every 5 weeks. The length of head-body was measured from the tip of the beak to the edge of caudal vertebra when the bird was placed on its back while keeping the neck and trunk horizontally on the same plane. For each length of femur, tibiotarsus, tarsometatarsus, humerus or antebrachium, maximum length of long bone was measured with distinguishing from the appearance. The 3rd digit length was measured from its bottom to the tip without the talon. The diameter of the tarsometatarsus was measured at the thinnest part in the anteroposterior direction. Each length or diameter was measured using a ruler and caliper with a precision of ±0.1 mm.

Using the aforementioned data, allometry theory ($y = bx^a$) was applied to estimate the coefficient of relative growth of each length or diameter to the head-body length. According to Zar[13], the parameter a in the regression curve ($\log y = a \times \log b + \log b$) was calculated and estimated as isometric growth, tachyauxesis or hypogrowth when a is equal with, bigger than or smaller than 1, respectively.

Statistical analysis: Data were analyzed by one or two-way ANOVA with respect to the effects of line and sex. A *post hoc* test was done using the Scheffe test. Statistical significance was set at $p<0.05$. Data were expressed as Mean±SD.

RESULTS

The growth curves, asymptote (g) and inflection point (weeks) estimated with the Gompertz function in both lines of Oh-Shamo are shown in Fig. 1 and Table 1. In the initial body weight, a significant effect of line was observed ($p<0.01$), but no significant effect of sex and interaction was detected. There were the significant differences between both lines and sexes in the asymptote ($p<0.01$). As for the inflection point, a significant effect of line or sex was detected ($p<0.01$). The sexual maturation of the male might be at 22-26 weeks old based on microscopic detection of sperm. Also, courtship behavior became observable at 19-25 weeks old. In females, the initial egg-laying was found at 26-29 weeks old, thus maturation seemed to occur at this time. However, there were no differences between both lines and sexes in their period of sexual maturation.

Figure 2 shows the development of each body parts in both lines of Oh-Shamo. In all groups, each head-body length showed increase until 25 weeks old ($p<0.05$). It was found that significant increases of lengths in femur, tarsometatarsus and tibiotarsus in OFF male were greater than others ($p<0.05$). The tarsometatarsus diameters continued to increase after

Table 1: Initial body weight (g), asymptote (g) and inflection point (weeks) in the Gompertz model for each line and sex

	OFF		DEF		p		
Parameters	Male	Female	Male	Female	Line	Sex	INT
Initial body weight	41.1±2.4	41.0±2.9	36.0±1.7	36.0±2.1	**	ns	ns
Asymptote	4243.9±263.6	3202.7±364.3	3415.2±237.8	2272.7±169.3	**	**	ns
Inflection	11.0±0.8	10.4±1.0	9.9±0.6	8.8±0.5	**	**	ns

INT: Interaction, ns: Non-significance, values are Mean±SD, **Level of statistical significance ($p<0.01$)

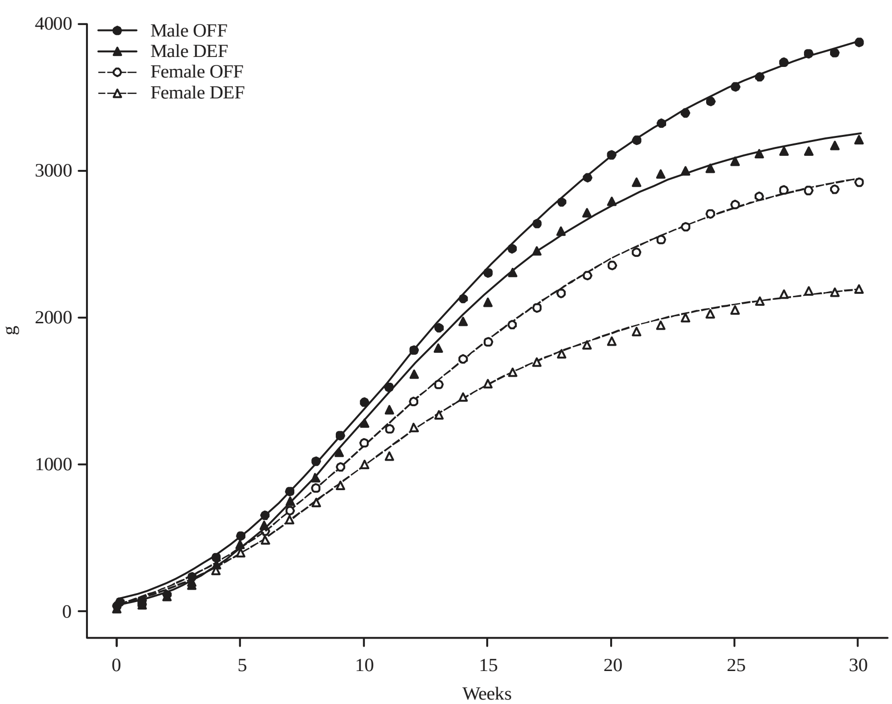

Fig. 1: Average growth curves estimated with the Gompertz function for two lines of Oh-Shamo for 30 weeks

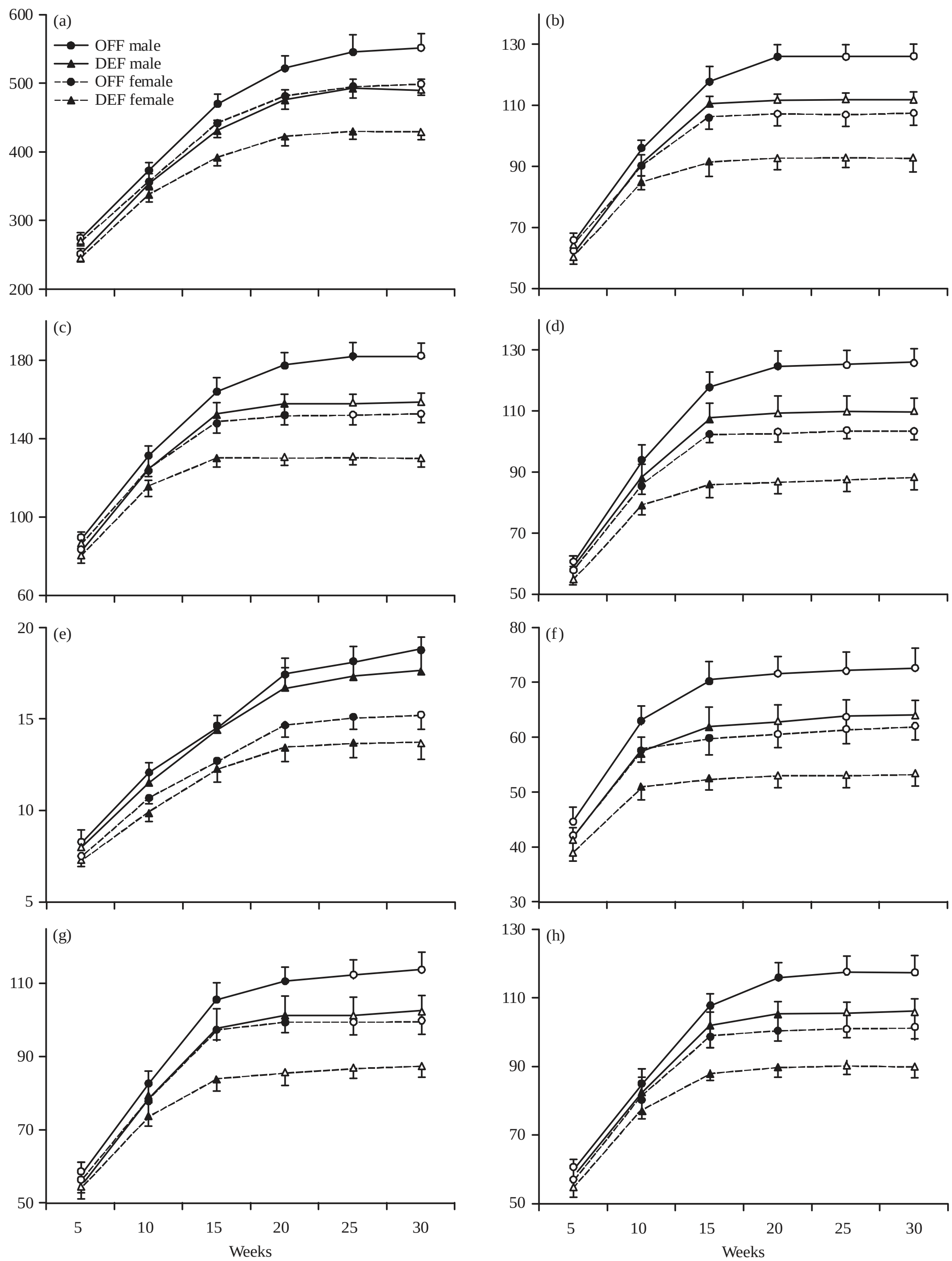

Fig. 2(a-h): Developments of head-body, femur, tibiotarsus, tarsometatarsus, third digit, humerus and antebrachium for two lines of Oh-Shamo for 30 weeks. (a) HBL, (b) FML, (c) TBL, (d) TSL, (e) TSD, (f) TDL, (g) HML and (h) ABL. A filled circle or triangle indicates that a value is significantly higher than the previous one just before ($p<0.05$)

reaching a plateau in their length. The length of the third digit continued to increase until 15 weeks old ($p<0.05$). The increase in humerus and antebrachium lengths showed similar trends in all groups.

Body weight and length/diameter of each body part at 30 weeks old are shown in Table 2. In all parameters, those in OFF groups were more than those in DEF and those in males were higher than in females ($p<0.01$). In the relative

Table 2: Body weight (g) and somatometrical values (mm) at 30 weeks old

	OFF		DEF		p		
Parameters	Male	Female	Male	Female	Line	Sex	INT
BW	3879.3±201.3	2925.8±332.2	3216.9±204.5	2196.2±143.9	**	**	ns
HBL	551.1±20.9	498.2±16.5	489.6±14.9	427.7±11.2	**	**	ns
FML	126.1±3.9	107.2±3.7	111.8±2.4	92.8±3.0	**	**	ns
TBL	182.0±6.4	152.4±4.6	158.4±4.5	129.7±4.5	**	**	ns
TSL	152.7±4.6	103.3±2.9	109.9±4.3	88.3±3.8	**	**	ns
TSD	18.8±0.7	15.2±0.8	17.7±1.0	13.7±0.9	**	**	ns
TDL	72.7±3.5	61.7±2.3	64.0±2.6	53.2±2.2	**	**	ns
HML	117.4±4.8	101.3±3.1	106.0±3.7	90.0±2.9	**	**	ns
ABL	109.3±4.3	96.3±3.6	98.9±3.8	84.9±3.2	**	**	ns

BW: Body weight, HBL: Head-body length, FML: Femur length, TBL: Tibiotarsus length, TSL: Tarsometatarsus length, TSD: Tarsometatarsus diameter, TDL: Third digit length, HML: Humerus length, ABL: Antebrachium length, INT: Interaction, ns: No significance, values are Mean±SD, **Level of statistical significance ($p<0.01$)

Table 3: Relative values to the length of head-body at 30 weeks old

	OFF		DEF		p		
Parameters	Male	Female	Male	Female	Line	Sex	INT
FML	0.229±0.008	0.215±0.009	0.229±0.005	0.217±0.008	ns	**	ns
TBL	0.331±0.013	0.306±0.009	0.324±0.008	0.303±0.009	*	**	ns
TSL	0.228±0.009	0.208±0.007	0.224±0.008	0.206±0.009	ns	**	ns
TSD	0.034±0.002	0.031±0.002	0.036±0.002	0.032±0.002	**	**	ns
TDL	0.132±0.006	0.124±0.004	0.131±0.005	0.125±0.004	ns	**	ns
HML	0.213±0.012	0.203±0.006	0.217±0.007	0.210±0.006	**	**	ns
ABL	0.199±0.009	0.194±0.010	0.202±0.009	0.199±0.008	*	*	ns

FML: Femur length, TBL: Tibiotarsus length, TSL: Tarsometatarsus length, TSD: Tarsometatarsus diameter, TDL: Third digit length, HML: Humerus length, ABL: Antebrachium length, INT: Interaction, ns: Non-significance, values are Mean±SD, *,**Level of statistical significance ($p<0.05$, $p<0.01$)

Table 4: Coefficient of relative growth (a) and correlation to the length of head-body and growth type

	Line-sex	a±95% CI	CC	Growth type
FML	OFF-male	1.018±0.047	0.974	IG
	DEF-male	1.070±0.051	0.973	TA
	OFF-female	1.113±0.075	0.956	TA
	DEF-female	1.175±0.066	0.945	TA
TBL	OFF-male	0.947±0.037	0.981	HG
	DEF-male	1.003±0.042	0.979	IG
	OFF-female	1.038±0.058	0.970	IG
	DEF-female	1.052±0.052	0.957	TA
TSL	OFF-male	0.919±0.045	0.971	HG
	DEF-male	1.013±0.051	0.970	IG
	OFF-female	1.001±0.067	0.957	IG
	DEF-female	1.092±0.059	0.948	TA
TDL	OFF-male	1.295±0.106	0.924	TA
	DEF-male	1.427±0.108	0.934	TA
	OFF-female	1.357±0.157	0.884	TA
	DEF-female	1.519±0.115	0.906	TA
HML	OFF-male	0.999±0.041	0.979	IG
	DEF-male	1.056±0.045	0.978	TA
	OFF-female	1.030±0.056	0.971	IG
	DEF-female	1.057±0.042	0.971	TA
ABL	OFF-male	1.028±0.048	0.974	IG
	DEF-male	1.065±0.048	0.975	TA
	OFF-female	1.068±0.063	0.966	TA
	DEF-female	1.158±0.056	0.959	TA

FML: Femur length, TBL: Tibiotarsus length, TSL: Tarsometatarsus length, TDL: Third digit length, HML: Humerus length, ABL: Antebrachium length, 95% CI: 95% confidence interval, CC: Correlation coefficient, IG: Isometric growth, TA: Tachyauxesis, HG: Hypogrowth, values are Mean±SD

values to the length of head-body (Table 3), there were significant differences between OFF and DEF in their somatotypes. In particular, the tibiotarsus length in OFF groups was longer than that in DEF groups while the tarsometatarsus, humerus and antebrachium lengths in DEF groups were more than those in OFF groups ($p<0.01$-0.05).

The coefficient of relative growth and correlation to the length of head-body and growth type are shown in Table 4. The data showed high correlation coefficients ($r = 0.884$-0.983) and significant effects of all coefficients of relative growth ($p<0.01$). The coefficients of relative growth without the third digit length were approximately 1.0. It was found that the third digit length was estimated as tachyauxesis in all groups. The lengths of the tibiotarsus and tarsometatarsus were estimated as hypogrowth in the OFF male group, but as tachyauxesis in the DEF female group.

Table 5 shows the correlation between each leg length (femur, tibiotarsus or tarsometatarsus) and the third digit length or the tarsometatarsus length at 30 weeks old. Statistical analysis showed a positive correlation between each leg length and the third digit length or the tarsometatarsus length ($p<0.01$-0.05).

Table 5: Correlation between each leg length and the third digit length or the tarsometatarsus length

Parameters		Weeks 5	10	15	20	25	30
TDL							
OFF-male	FML	0.465	0.448	0.538*	0.531*	0.590*	0.578*
	TBL	0.298	0.496*	0.500*	0.505*	0.492*	0.510*
	TSL	0.223	0.465	0.658**	0.698**	0.676**	0.750**
DEF-male	FML	0.201	0.442	0.483*	0.543*	0.626**	0.539*
	TBL	0.162	0.378	0.550*	0.601**	0.659**	0.586**
	TSL	0.065	0.377*	0.688**	0.670**	0.823**	0.659**
TSL							
OFF-male	FML	0.382	0.284	0.674**	0.881**	0.712**	0.768**
	TBL	0.425	0.440	0.808**	0.883**	0.856**	0.818**
	TSL	0.346	0.411	0.591*	0.895**	0.853**	-
DEF-male	FML	0.350	0.388	0.482*	0.531*	0.683**	0.608**
	TBL	0.452	0.379	0.719**	0.699**	0.565*	0.604**
	TSL	0.317	0.562	0.878**	0.935**	0.886**	-

TDL: Third digit length, TSL: Tarsometatarsus length, FML: Femur length, TBL: Tibiotarsus length, *,**Level of statistical significance ($p<0.05$, $p<0.01$)

DISCUSSION

It has been reported that there is no difference in microsatellite DNA polymorphisms between the OFF and DEF lines[14]. However, the present study revealed that there were significant differences between the two lines in growth, body weight and lengths of body parts. As compared with other native Japanese chicken breeds such as Onaga-Dori, Tosa-Jidori, Ukokkei and Hinai-Dori[15], both lines showed larger values in all parameters of the Gompertz function than all of the aforementioned breeds. Although there was little information about morphology and somatometrical measurements for these lines, it was reported that body weights for OFF and DEF males were 4-6 and 3-4 kg, respectively[16]. Both actual and estimated values observed in the present study were similar to these data. As weight details for these lines are unknown, there are reports that body weights for Oh-Shamo are 5,600-5,620 g (male) and 4,875-4,900 g (female)[17,18]. The OFF and DEF lines in the present study were derived from game birds[18] and they had been selected under 5 kg. Thus, it is reasonable that both body weight and asymptote in the present study were lower than the aforementioned body weights. Nishida *et al.*[19] showed that the game birds from the Philippines were 1968.2 g in weight and were less than those in both lines in the present study. There is a possibility that the Philippine birds were allowed to exercise as part of training for fights while both Japanese lines reared in cages have low muscular development because of lack of exercise. From these results, the body weights of the different lines of the same breed of chicken, Oh-Shamo varied according to their use (fightings, ornamentals or meat production). Therefore, it is important for appropriate management purposes to record their body weight and/or somatotype for each line according to their particular use.

The present study revealed that lengths of legs (especially, tibiotarsus length) in OFF line were longer than those in DEF line. It is likely that OFF line had been selected using the criteria of long legs, which could allow birds to jump higher because the desired ability of OFF line birds is to attack by kicking after high jumps[16]. The ratio of tarsometatarsus diameter to the length of head-body in OFF line was lower than that in the DEF one and its diameter had lower development than the length in OFF line. Thus, it is necessary for rearing OFF line at an early stage to prevent excessive load on their legs. In contrast, the fighting style of DEF line was mainly to suppress the opponent using the neck or beak without jump[16], therefore, it was likely that long legs were not desirably selected for the DEF line. Also, the ratios of humerus and antebrachium lengths to the head-body length in the DEF line were higher than those in the OFF ones. The Oh-Shamo is long-legged, stands in a more upright position and with wings in high position on the body and OFF line birds are especially taller and larger than DEF ones. Thus, there is a possibility that the differences of these forelimb parameters might be due to the need of low centroid in OFF line birds.

Comparing between the OFF and DEF lines, it was revealed that growth rates for most somatotype measurements in OFF line were higher than those in DEF line and those in males were higher than in females. These observations were supported by the results of the inflection points derived through the Gompertz function. Additionally, it is thought that there is a remarkable difference between lines after 20 weeks because the leg-related parameters in OFF males still continued to develop even beyond that time. These results indicated that it might be necessary for selection of the lines to be reared until sexual maturation (21-30 weeks old). On the other hand, there is a possibility that future somatotypes could be estimated when referring to the third digit and tarsometatarsus lengths at 15 weeks old as the criteria for selection, because there were positive correlations between the leg-related parameters (femur, tibiotarsus and tarsometatarsus length) and the length of the third digit that developed and reached a plateau fast.

CONCLUSION

This is the first report about the details of growth and morphological measurements in two lines of Oh-Shamo derived from ornamental breeders. The present results provided the information from each line that is useful for breeding of crossbreds (e.g., considering the quantity of thigh, it is preferable to choose OFF line birds as a parent stock). In addition, the information in the present study could be used for appropriate management on the basis of growth and morphological measurements. Further research on the meat quality and quantity in these lines is needed when considering parent stock for breeding of crossbreds showing excellent quality and quantity.

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