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Comparison of Growth Curves of Four Breeds of Japanese Native Chicken, Onaga-Dori, Tosa-Jidori, Ukokkei and Hinai-Dori

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Abstract: The objective of this study was to compare the growth curve parameters for body weight of Japanese native chickens (Onaga-dori, Tosa-jidori, Ukokkei and Hinai-dori) using a non-linear model, Gompertz function. The data were collected from the four indigenous breeds together with two foreign breeds (White Plymouth Rock and Brown Leghorn) that were reared from 0 day old to 20 weeks of age. Breed differences were observed in the growth parameters. The predicted mature weight of the Hinai-dori was heavier than the other three Japanese native breeds. Tosa-jidori was observed to be late maturing and lighter at maturity, while Ukokkei was shown to have a higher growth rate. The development of growth curves for indigenous breeds may be useful in selecting native Japanese chickens that have rapid growth at early ages.

Key words: Growth curve, Onaga-dori, Tosa-jidori, Ukokkei, Hinai-dori, Japanese native chickens

INTRODUCTION

During the early 1990's, scientists and livestock producers became particularly concerned about the potential loss of indigenous breeds and a programme was launched by the FAO for the genetic conservation of poultry resources (FAO, 2007). There are approximately 50 native chicken breeds in Japan (Tsudzuki, 2003). Almost all of them were developed for special plumage, crowing and fighting characteristics as opposed to European and American breeds that were mostly established for meat and egg production. However, the study of Japanese native breeds as genetic resources has received very little scientific attention and current research efforts have been directed primarily towards enhancing commercial production systems.

Growth curves reveal time-dependent non-linear changes of the body or organ weights in animals and the generated equations can be used to predict the expected weight of a group of animals at a specific age (Tzeng and Becker, 1981; Cooper, 2005; Ahmadi and Golian, 2008). It has been found that it is possible to select animals using the shape of the growth curve (Emmerson, 1997; Mignon-Grasteau *et al*., 2000). In a number of studies, growth trend parameters have been found to be highly heritable and have been successfully used in selection studies (Mignon-Grasteau *et al*., 1999, 2000; Deeb and Lamont, 2002). However, extensive research has not been done to determine the production potential of Japanese native chicken breeds. Their growth and other production parameters have not been adequately studied. The aim of this study is to estimate growth curves and their parameters using the non-linear model, Gompertz function to determine the age-live weight relationships and to further examine whether there are breed differences in the growth parameters of four Japanese indigenous chicken breeds.

MATERIALS AND METHODS

The data were collected from four Japanese chicken breeds, the indigenous Onaga-dori (ONA), Tosa-Jidori (TJI), Ukokkei (UKO) and Hinai-dori (HNI) breeds, together with two foreign breeds, White Plymouth Rock (WPR) and Brown Leghorn (BL). All breeds were kept at the institute, reared from 0 day old to 20 weeks of age. The newly hatched chicks were wing-banded for individual identification and housed in a temperature controlled brooder (Zenkei-N type, Zenkeien Manufacturing Co. Ltd., Shizuoka, Japan) with 24 h lighting until 10 weeks posthatch. Then, birds were transferred into a colony room that was illuminated by overhead fluorescent lights from 0500-1900 h. In the colony room, they were grouped in steel wire mesh cages until 17 weeks of age and reared

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Table 1: Number of observations for various ages in each breed and sex

Age	ONA		TJI		UKO		HNI		WPR		BL	
(week)	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0	11	21	19	12	19	15	28	24	24	14	11	15
1	11	21	19	12	18	15	28	24	24	14	11	15
2-5	11	21	19	12	19	15	28	24	24	14	11	15
6	11	21	19	12	17	15	28	24	24	14	11	15
7-13	11	21	19	12	19	15	28	24	24	14	11	15
14	11	21	19	12	19	14	28	24	23	14	11	15
15	11	21	16	12	19	14	28	24	23	14	11	15
16	11	20	16	9	19	14	28	24	23	14	11	15
17	11	20	16	9	19	13	28	24	23	14	11	15
18	11	20	13	7	19	12	28	24	16	12	11	15
19	11	20	13	7	19	11	28	24	15	12	9	13
20	11	20	13	5	18	11	28	24	15	12	9	13

ONA: Onaga-dori, TJI: Tosa-jidori, UKO: Ukokkei, HNI: Hinai-dori, WPR: White Plymouth Rock, BL: Brown Leghorn

individually in experimental cages to the end of investigation. They were vaccinated similarly and were subjected to the same managerial, hygienic and climatic conditions. Standard commercial starter (0-6 weeks: CP, 20%), grower (7-10 weeks: CP, 17%) and developer (11-20 weeks: CP, 15%) diets were provided *ad libitum* and the birds had free access to water under all housing conditions. Body weights were recorded at day old and at the end of each 1 week period. Table 1 shows the number of observations for the age groups. The handling of birds was performed in accordance with the regulations of the Animal Experiment Committee of Hiroshima University.

The widely used non-linear growth model, Gompertz function was fitted to estimate the mean age live weight relationship (Mignon-Grasteau *et al*., 1999). The mathematical relations of these models are as follows:

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

Where:

W_t = Weight at time t (age in weeks)
A = The asymptotic body weight of the animal that is the weight at an infinite age
b = $\ln(A/W_0)$
W_0 = The estimated hatching weight of animals
c = Maturation rate

Finally, the initial specific growth rate is defined as b×c, the age at inflection as 1/c x ln(b) and the body weight at hatching W_0 as A x $\exp^{(-b)}$ (Laird, 1966). To calculate the curve parameters, NLIN procedure of SAS 9.01 (SAS Institute Inc., Cary, NC, USA) was used.

RESULTS AND DISCUSSION

Gompertz model parameters and inflection points for each breed and sex are shown in Table 2. The average growth curves provide a visual representation of growth for the different breeds and sexes are shown in Fig. 1 and 2. The values of coefficients of determination (R^2) were high for all indicating a significant relationship between age and weight in each breed and sex. Based on R^2, this model seemed to be appropriate in describing the association between age and body weight (Table 2).

Table 2: Gompertz model parameters and inflection points for each breed and sex

Parameters	Sex	A	b	c	Inflection point	R^2
ONA	Male	1905.8	4.968	0.109	14.676	0.998
	Female	1298.7	4.677	0.113	13.611	0.998
TJI	Male	1164.5	4.310	0.101	14.536	0.999
	Female	1057.9	4.047	0.089	15.657	0.997
UKO	Male	1412.3	5.038	0.144	11.195	0.998
	Female	1093.0	4.623	0.161	9.526	0.999
HNI	Male	2684.9	4.442	0.117	12.726	0.999
	Female	1726.9	4.182	0.133	10.579	0.999
WPR	Male	4572.0	4.530	0.114	13.309	0.999
	Female	2632.3	4.346	0.142	10.361	0.999
BL	Male	1756.4	4.851	0.160	9.885	0.997
	Female	1342.9	4.363	0.160	9.222	0.997

ONA: Onaga-dori, TJI: Tosa-jidori, UKO: Ukokkei, HNI: Hinai-dori, WPR: White Plymouth Rock, BL: Brown Leghorn

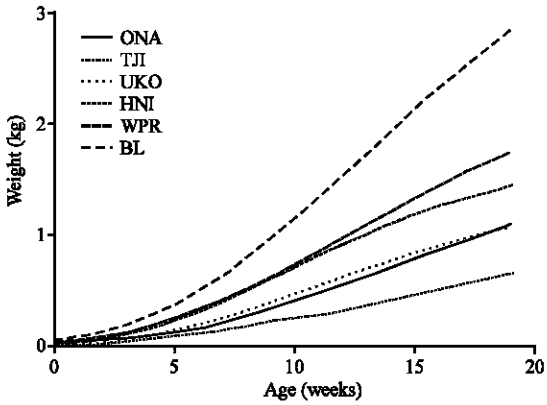

Fig. 1: Average growth curves estimated with the Gompertz function for male chickens during the first 20 weeks. ONA: Onaga-dori, TJI: Tosa-jidori, UKO: Ukokkei, HNI: Hinai-dori, WPR: White Plymouth Rock, BL: Brown Leghorn

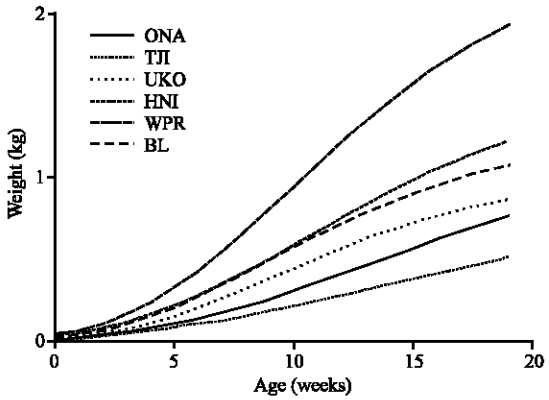

Fig. 2: Average growth curves estimated with the Gompertz function for female chickens during the first 20 weeks. ONA: Onaga-dori, TJI: Tosa-jidori, UKO: Ukokkei, HNI: Hinai-dori, WPR: White Plymouth Rock, BL: Brown Leghorn

Many researchers found high coefficients of determination for Gompertz in previous studies of growth curves in chickens (Tzeng and Becker, 1981; Mignon-Grasteau *et al*., 1999; Norris *et al*., 2007).

Differences between breeds were observed in the Gompertz function parameters. Based on calculated A, the ranking in descending order of asymptotic body weight was WPR>HNI>ONA>BL>UKO>TJI in the male and WPR >HNI>BL>ONA>UKO>TJI in the female.

Excluding the foreign breed WPR, the predicted mature weight in HNI was heavier than those in other Japanese native breeds. The ranking of estimated maturation rate (c) was BL>UKO>HNI>WPR>ONA>TJI in the male and UKO>BL>WPR>HNI>ONA>TJI in the female. Similar tendencies were found in both initial specific growth rate (b x c) and inflection point indicating 37% of adult body weight (Mignon-Grasteau *et al*., 2000) namely, the UKO and BL were higher, whereas the TJI was lower than other breeds. Given the fact that all breeds were raised under similar conditions, it can be assumed that there is a higher genetic variation for each parameter of the Gompertz function in chickens. When evaluating these native Japanese chickens from both maturation weight and growth rate viewpoints, it seemed that the HNI was the most suitable for rapid genetic improvement of meat-chickens. In fact, it is used to produce crossbred meat chickens in Japan (Tsudzuki, 2003; Kubo *et al*., 2009).

Differences between sexes were also observed. Almost all of males had higher asymptotic body weight (A), b and the inflection point and lower maturation rate (c). They are in good agreement with other reports using poultry (Talpaz *et al*., 1991; Mignon-Grasteau *et al*., 2000; Cooper, 2005). In contrast in the male TJI, the inflection point was lower and the maturation rate was higher than those in the female. The reason for this difference seen between TJI and others is unclear. Further observations should be carried out to estimate the growth curve in TJI.

CONCLUSION

The growth curve generated by the Gompertz function is appropriate for describing the correlations with weekly body weights and the results showed evidence that there are breed differences in the growth of native Japanese chickens. The development of growth curves for indigenous breeds may be useful in selecting native Japanese chickens that have rapid growth at early ages.

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