Growth curve of the body weight, body length and tail length in the cotton rat (*Sigmodon hispidus*)

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Introduction

Since Armstrong (*Armstrong* 1939) used the cotton rat as a laboratory animal for the first time for studying poliomyelitis infection, cotton rats have been used for experimental filariasis studies (*Müller-Kehrmann* 1988, *Tanaka* 1965, *Tanaka & Arai* 1967) and extensively in biomedical research (*Vaux-Peretz et al.* 1991). Growth curves of normal animals have been reported previously in many kinds of species and may be used to evaluate the normal growth process. However, little information is available on the growth curve of cotton rats. We have previously reported body surface area (*Ohwada & Katahira* 1993), hematological findings (*Katahira & Ohwada* 1993) and blood chemistry reference values (*Ohwada et al.* 1993). In this study, growth curves of the body weight, body length and tail length of this species were measured.

Materials and methods

Animals: 30 cotton rats, 18 males and 12 females, born from 4 mother animals in the Experimental Animal Center of Fukushima Medical College, were used for measuring 1–24 days growth curve of body weight. Moreover, 25 animals, 13 males and 12 females, born from a further 4 mothers were used for measuring 1–20 weeks growth curve of the body weight. The body weights were measured on a balance scale (Orientec Corporation, CX-600, 600 g of capacity) to the nearest 0.1 g.

Measurements of the body weight (BW), body length (BL) and tail length (TL) in 147 cotton rats, 71 males and 76 females were carried out under diethylether anaesthesia. The measuring of BW, BL and TL was done only once in every animal. For the measuring of BL and TL, the animals were placed on their abdomen on a wooden board with their legs restrained by adhesive tape. For body length, the length between the nose and the tail end was measured. The tail length was measured between the root and end of a tail.

All animals were kept in plastic cages with sterilized wood chips as contact bedding. The animals were maintained on a 13-hour light cycle at room temperature of 21–24°C and humidity of 50–60 %. They were provided with commercial food (Oriental Yeast Co. Ltd., CMF) and tap water from a 250 ml bottle *ad libitum*. The data were analyzed with a statistical software package (VIEW Flex Co., Ltd) for personal computer (NEC, PC-9801 DA2).

Results

Fig. 1 illustrates growth curves of the BW in male and female cotton rats. Mean values and standard deviation (SD) are indicated on each figure. No significant differences in the mean BW were observed between male and female cotton rats, aged 1–2 weeks. However, significant sex differences in the BW were observed at 3 weeks after birth ($P < 0.05$). Fig. 1A shows BW growth curves for a period of 20 weeks. Fig. 1B and C show growth curves separately for males and females during 24 post-natal days. The means and SDs of the BW in one-day-old males and females were 6.59 ± 0.52 g ($n = 18$) and 6.62 ± 0.54 g ($n = 12$), respectively. The variance of these va-

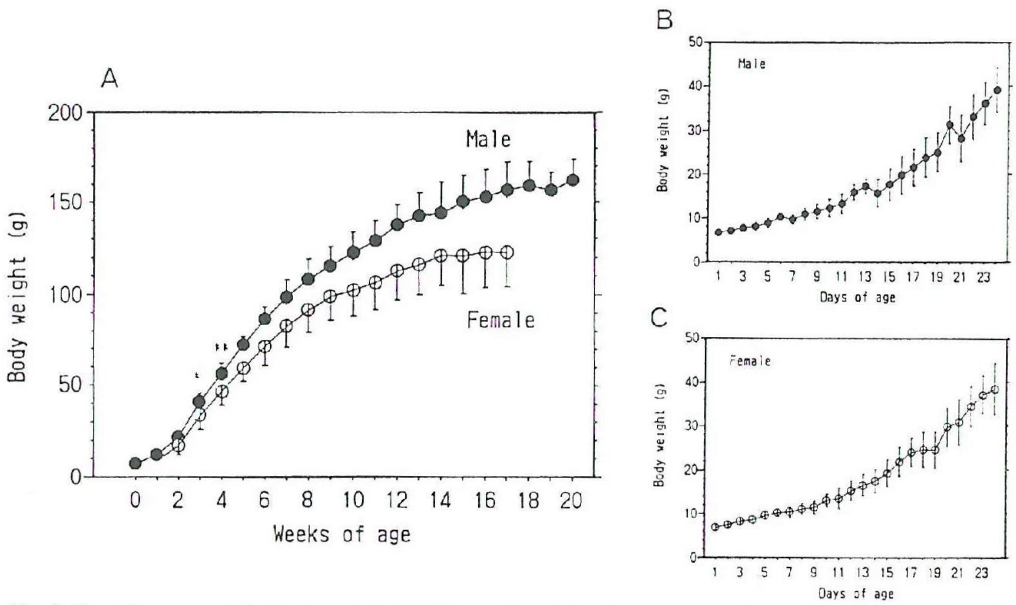

Fig. 1. Growth curves of the body weight (BW) in male and female cotton rats for a period of 20 weeks (A). B and C in the figures show growth curves separately for males and females during 24 post-natal days. Vertical bars indicate mean ± SD.
*, **: $P < 0.05$ and $P < 0.01$ for significance of sex difference.

lues was not significantly different between males and females.

Results of the BLs are shown in Fig. 2. The BLs in one-day-old male and female cotton rats were 8.33 ± 0.36 cm (mean ± SD, n = 10) and 7.82 ± 0.69 cm (n = 5). At 7th week after birth, the BLs in males and females were 22.24 ± 0.65 cm (n = 10) and 22.89 ± 0.44 cm (n = 10), respectively. At 20th week, the BLs were 26.56 ± 0.61 cm (n = 7) and 25.37 ± 0.42 cm (n = 6) in males and females. No significant differences in the mean BLs were observed in any growth stages between male and female cotton rats.

Fig. 3 shows growth curves of the TL in male and female cotton rats. TLs in one-day-old males and females were 2.98 ± 0.12 cm (n = 10) and 2.88 ± 0.28 cm (n = 5). The TLs in 2-week-old males and females were 6.58 ± 0.44 cm (n = 12) and 6.06 ± 0.60 cm (n = 10). At 7th week after birth, the TLs in males and females were 9.57 ± 0.21 cm (n = 10) and 9.78 ± 0.23 (n = 10). Moreover, their values were 10.91 ± 0.45 cm (n = 7) and 10.42 ± 0.40 cm (n = 6) at 20th week. No significant difference in the mean TLs were observed at any age between males and females.

Relationships among the BW, BL and TL of cotton rats are indicated in upper figures for males and lower figures for females of Fig. 4. In each case, the relationships among BW, BL and TL were non-linear. The quadratic polynomial equations in male cotton rats were

$$BL\ (cm) = 8.07 + 0.23 \times BW\ (g) - 0.00068 \times BW\ (g)^2,$$
$$TL\ (cm) = 2.79 + 0.11 \times BW\ (g) - 0.00037 \times BW\ (g)^2 \text{ and}$$
$$TL\ (cm) = -2.21 + 0.67 \times BL\ (cm) - 0.0068 \times BL\ (cm)^2.$$

The equations in females were

$$BL\ (cm) = 7.90 + 0.24 \times BW\ (g) - 0.00082 \times BW\ (g)^2,$$
$$TL\ (cm) = 2.80 + 0.11 \times BW\ (g) - 0.00042 \times BW\ (g)^2 \text{ and}$$
$$TL\ (cm) = -1.80 + 0.62 \times BL\ (cm) - 0.0054 \times BL\ (cm)^2.$$

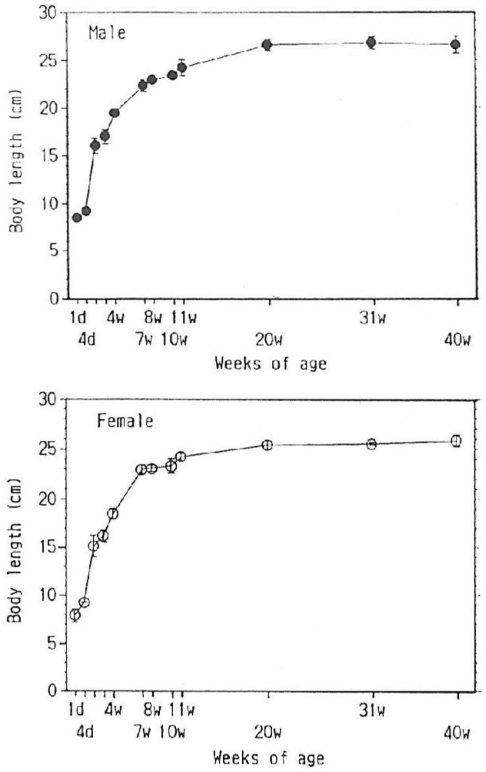

Fig. 2. Body length (BL) curves in cotton rats for a period of 40 weeks. The upper and lower figure are BLs in males and females, respectively. 1d and 4d on the abscissa are respectively 1 day and 4 days after birth.

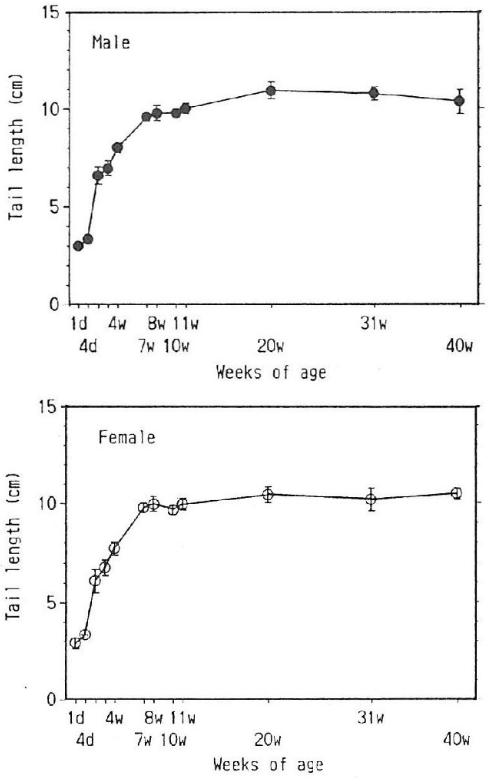

Fig. 3. Tail length (TL) curves in male (upper) and female (lower) cotton rats during 40 weeks. 1d and 4d on the abscissa are respectively 1 day and 4 days after birth.

Correlation coefficients between BW (g) and BL (cm) in males and females were 0.988 and 0.989. Those between BW (g) – TL (cm) in males and females were $r = 0.987$ and $r = 0.986$. For BL (cm) – TL (cm) correlations, both $r = 0.997$ for males and females. All of these correlations were highly significant ($P < 0.001$).

Discussion

Differences in growth curves for weight and body size at various developmental stages, attainment of puberty, litter size, and many other parameters of growth are largely polygenic (*Tajima et al* 1989). Growth, as measured by efficiency of food conversion and basal metabolism, has been shown to exhibit interstrain variation and, in some instances, evidence of polygenic heredity.

Tanaka (1965) reported that the maximum, minimum and mean of young from 158 litters in the cotton rat were 9, 1 and 4.4 respectively. Furthermore, the average BW of male cotton rats was 100 g at 12 weeks after birth, whereas female cotton rats reached 100 g only after 19 weeks (*Tanaka & Arai* 1967). The weaning rate and the survival rate for the third months were 40 % and 45 %, respectively (*Tanaka & Arai* 1967). On the other hand, the maximum, minimum and average

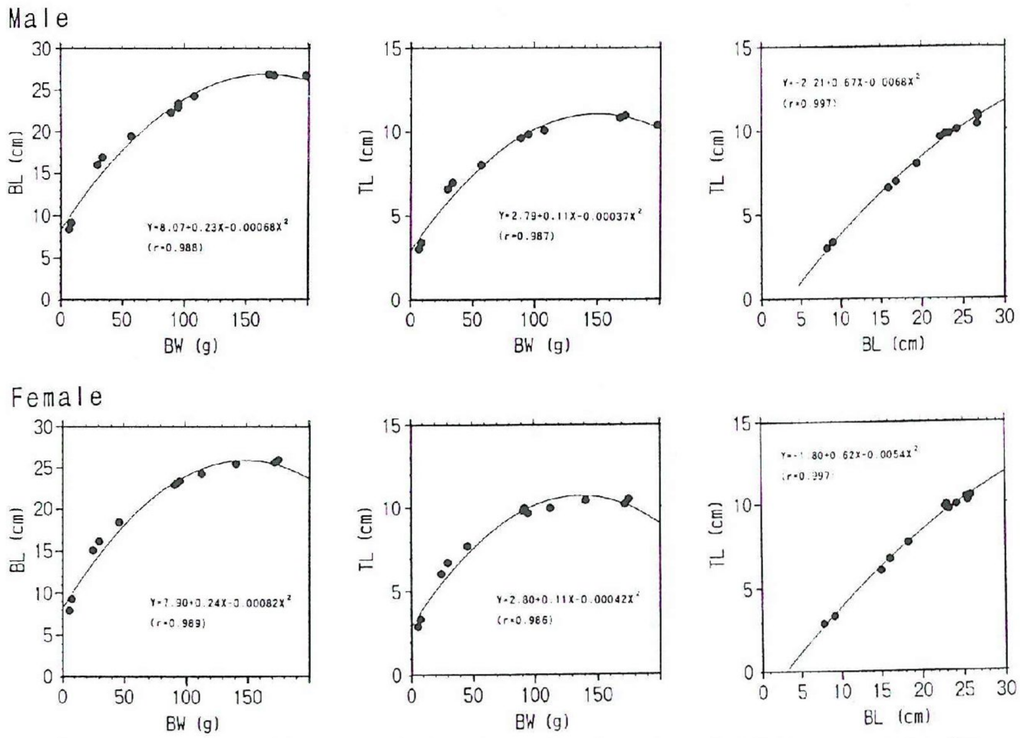

Fig. 4. Correlation relationships among the BW, BL and TL in cotton rats. The upper and lower figures are results of males and females.

numbers of young from 1,306 litters were 11. 1 and 6.1 in the cotton rats of our colony. The average BW of 8-week-old males and 10-week-old females were 107.5 g and 102.9 g in this study. In our colony of the cotton rat, both the rates of weaning and survival for the third months were over 80 percent (unpublished). The present results are fairly good in comparison with the earlier literature reported by Tanaka et al. (*Tanaka* 1965, *Tanaka & Arai* 1967). Generally, commercial feeds for laboratory animals have been well studied and improved. In addition, our cotton rats are maintained in clean condition. Therefore, it is thought that these factors had a good effect on the present results of growth curve.

Biological data of the cotton rat have also been reviewed previously by *Vaux-Peretz & Meignier* (1991). However, further studies are necessary, and the present study may be useful improving among other things, body weight norms, as it is used in the calculation of indices for energy metabolism, cardiac stroke and fluid therapy. The reference values must be established for quantitative use of the cotton rat in biomedical research. In addition, we have previously reported body surface area (*Ohwada & Katahira* 1993), hematological standard values (*Katahira & Ohwada* 1993) and reference values for blood chemistry (*Ohwada et al.* 1994).

Generally, tails of Sprague-Dawley and Wister rats constitute approximately 50 % of their body length, being somewhat longer in the female than in the male. In comparison, bodies and tails of both male and female cotton rats grow rapidly until about the 11th week, thereafter a steady length is maintained. *Tanaka & Arai* (1967) reported the tail ratio at the age of 10 weeks was 37.7 % in males and 39.8 % in females. In our study, the average BLs of both of 10-week-old males and females were identical both being 23.27 cm. The average TL of 10-week-old males and females were 9.77 and 9.64 cm. Thus, the TL/BL ratio at the age of 10 weeks were 42.0 % in males and 41.4 % in females.

As far as the authors know, there has been no investigation of the relationships among BW, BL and TL in the cotton rat. The present data reported involving correlation relationships can be used as useful reference values for the cotton rat.

Summary

The body weight (BW), body length (BL) and tail length (TL) of 202 cotton rats, 102 males and 100 females, were measured. Significant sex differences in the BW were observed 3 weeks after birth. The BLs in one-day-old males and females were 8.33 ± 0.36 cm and 7.82 ± 0.69 cm respectively, while the TLs were 2.98 ± 0.12 cm and 2.88 ± 0.28 cm. Growth of the BL and TL was rapid until about 8th week of age, when a steady length was reached. The equations in males were BL (cm) = 8.07 + 0.23 × BW (g) – 0.00068 × BW (g)^2, TL (cm) = 2.79 + 0.11 × BW (g) – 0.00037 × BW (g)^2 and TL (cm) = – 2.21 + 0.67 × BL (cm) – 0.0068 × BL (cm)^2. Correlations among the BW, BL and TL in male and female cotton rats were all highly significant (r = 0.98, P < 0.001).

This study was carried out under the control of Animal Research Committee in accordance with the Guidelines on Animal Experiments in Fukushima Medical College and Japanese Government Animal Protection and Management Law (No. 105).

References

Armstrong C: The experimental transmission of Polymyelitis to the eastern cotton rat, *Sigmodon hispidus*. Public Health Rep. 1939, *54*, 1719–1721.

Katahira K & K Ohwada: Hematological standard values in the cotton rat (*Sigmodon hispidus*). Exp. Anim. 1993, *42 (4)*, 653–656.

Müller-Kehrmann H: Antibody response against Litomosoides Carinii and the distribution of bound antibodies on microfirarie from the different internal organs of cotton rats. Acta. Trop. 1988, *45*, 361–372.

Ohwada K & K Katahira: Indirect measurement for body surface area of cotton rats. Exp. Anim. 1993, *42 (44)*, 635–637.

Ohwada K, T Ito & K Katahira: Reference values for blood chemistry in the cotton rat (*Sigmodon hispidus*). Scand. J. Lab. Anim. Sci. 1994, *21 (1)*, 29–31.

Tajima Y et al. (ed.): Biological reference data book on experimental animals. SOFT SCIENCE, INC., Tokyo 1989, pp. 464–467.

Tanaka H: Observation on the cotton rat as a laboratory animal for experimental filariasis studies. Exp. Anim. 1965, *14 (2)*, 80–86.

Tanaka H & K Arai: Breeding of cotton rat as the laboratory animal. Exp. Anim. 1967, *16 (4)*, 121–126.

Vaux-Peretz F & B Meignier: Le rat des cotonniers Sigmodon hispidus. Sci. Tech. Anim. Lab. 1991, *16*, 5–17.

The editors are indebted to the following external referees, who have been of invaluable help assisting with assessing manuscripts in 1994:

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