

Sexual differences in skull and femur size and body weight of raccoon dogs of Japan

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Abstract

Some studies on cranial lengths of the Japanese raccoon dogs showed that male skulls and mandibles were slightly longer than female ones, while other studies concluded that there was no difference. Studies on Finnish and Korean raccoon dogs also concluded that there was no difference. Measurements of other bones and body weight have not been reported. We studied the skull length, mandible length, and femur length of 118 raccoon dogs (61 males, 57 females) in Wakayama, western Japan, and found that male bones were slightly longer, but the difference was only within 2%. However, there was a significant difference in body weight, with males being 22.3% heavier than females in summer and autumn.

Key words: femur, mandible, *Nyctereutes procyonoides*, sexual dimorphism, skull.

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INTRODUCTION

The raccoon dog (*Nyctereutes procyonoides* Gray, 1834) is a medium-sized canid species that was originally distributed in eastern Asia. In the early 20th century, it was introduced into Europe for fur production and then naturalized in eastern and northern Europe (Helle and Kahuala, 1991; Kauhala and Kowalszyk, 2011). Compared with Japanese populations, Finnish raccoon dogs are larger (Kauhala et al., 1998b) and carnivorous (Kauhala et al., 1998a; Kauhala and Auniola, 2001; Drygala et al., 2013), whereas Japanese raccoon dogs are frugivorous (Hirasawa et al., 2006; Takatsuki et al., 2018, 2020a, 2020b; Takatsuki and Inaba, 2023; Takatsuki and Kobayashi, 2023). Finnish raccoon dogs also hibernate (Asikainen et al., 2004), whereas Japanese raccoon dogs are active throughout the year. In both Finland

and Japan, raccoon dogs have a monogamous mating system (Ikeda, 1983; Saeki, 2008; Drygala et al., 2022).

It is known that sexual dimorphism relates to mating system in mammals: sexual dimorphism is more pronounced in polygynous mammals and less pronounced in monogamous mammals (Clutton-Brock et al., 1977; Loison et al., 1999; Vanpé et al., 2007). A Finnish raccoon dog population was found to lack sexual size dimorphism (Kauhala, 1993); however, this phenomenon has not been well studied in Asian populations. Since sexual dimorphism can be affected by both the mating system and environment (McPherson and Chenoweth, 2012), it is worthy to study sexual dimorphism of Japanese raccoon dogs. There are some previous studies on skull size and morphology of the Japanese raccoon dogs (Hidaka et al., 1998; Kauhala et al., 1998b; Natori et al., 2001;

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Haba et al., 2008; Kim et al., 2015). Among them, only three studies compared male and female cranial measurements. Hidaka et al. (1998) showed that the male skulls were slightly (1.1%) longer than the female ones. Natori et al. (2001) compared three populations and showed that male skulls were longer than female ones by 1.0–3.7%, and mandible lengths of males were longer than females by 1.6–4.4%. Obara (2024) showed that skulls and mandibles of the male raccoon dogs in Okayama Prefecture were longer than those of females by 2.0% and 6.3%, respectively. However, Kim et al. (2012) studied Korean raccoon dogs and found that there was no sexual difference in skull and mandible lengths. Therefore, more case studies on sexual differences of this species are needed. All the former studies measured skulls and mandibles, but other bones showing body size have not been studied. We therefore measured femur length along with skull and mandible lengths and weighed the fresh body as indicators of body size using a population from Wakayama Prefecture in western Japan. We then investigated sexual size differences in these measurements and weight.

MATERIALS AND METHODS

We collected the carcasses of mature raccoon dogs killed through agricultural pest control, game hunting, and roadkill from 2002 to 2019. According to the objectives of this study, we compared only adult animals in order to avoid complex variations relating to growth. We therefore excluded juveniles from the analysis. We distinguished juveniles from adults according to the morphology of the canine teeth, as the canine tooth roots of juveniles are open (Obara, 1983; Kauhala and Helle, 1990). Subadults were included in the samples. Animals that showed signs of sarcoptic mange (Sugiura et al., 2018) were excluded, because they apparently lost body weight. A total of 118 carcasses of adult animals (61 males and 57 females) were included.

The carcasses were delivered to our institute and preserved in a freezer. We measured and weighed the samples after defrosting. They were weighed to the nearest 0.1 kg. Thereafter, skulls and femurs were cleaned. The maximal lengths of the skull (profile), mandible, and femur (Fig. 1) were measured to the

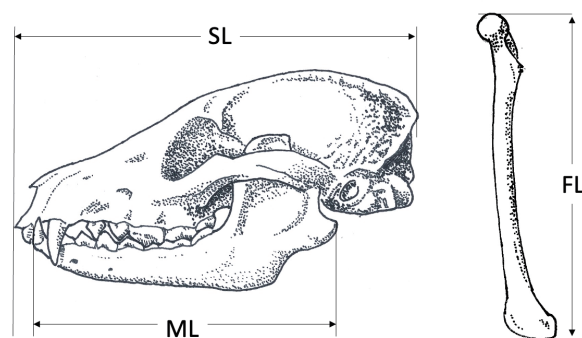


Fig. 1. Measurements taken from skull and femur of raccoon dog. SL: skull length, ML: mandible length, FL: femur length.

nearest 1 mm using a vernier caliper. The skull and femur specimens are preserved in the National Museum of Nature and Science, Tokyo.

Because a research reports that body weight changes seasonally in raccoon dogs, decreasing in summer and autumn and increasing in winter and spring (Takatsuki and Suzuki, 2022), body weight was compared between Period A (summer-autumn, July–November) and Period B (winter-spring, December–June) based on the timing of the sample collection. The weights and measurements of the males and females were compared by the Mann-Whitney *U* test, with a significance threshold of $P < 0.05$.

RESULTS

Differences in size measurements between males and females were generally slight, but sometimes significant. The mean skull lengths of male and female raccoon dogs were 110.4 ± 3.5 mm (mean \pm standard deviation) and 108.6 ± 2.9 mm, respectively, this difference of 1.8 mm (1.7% of the mean weight of the females) was significant (Mann–Whitney *U* test, $Z = 3.00$, $P = 0.003$). The mean mandible lengths of the males and females were 83.5 ± 2.8 mm and 82.0 ± 2.4 mm, respectively. The difference was 1.5 mm (1.8% of the mean length of the females), which was significant ($Z = 3.18$, $P = 0.001$). The mean femur lengths were 98.0 ± 4.1 mm in males and 96.7 ± 4.2 mm in females (non-significantly different, 1.3 mm; $Z = 1.66$, $P = 0.097$).

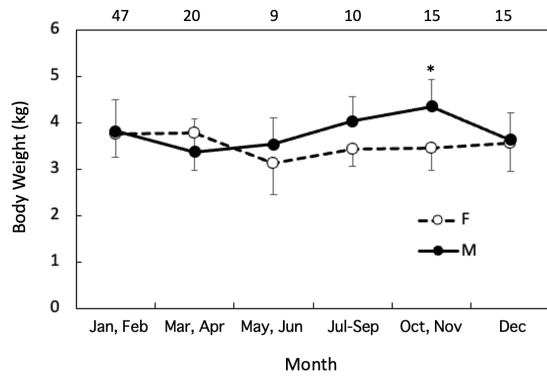


Fig. 2. Seasonal changes in body weights of male (M) and female (F) raccoon dogs. Error bar: standard deviation. *: $P < 0.05$. Sample sizes are shown above the graph.

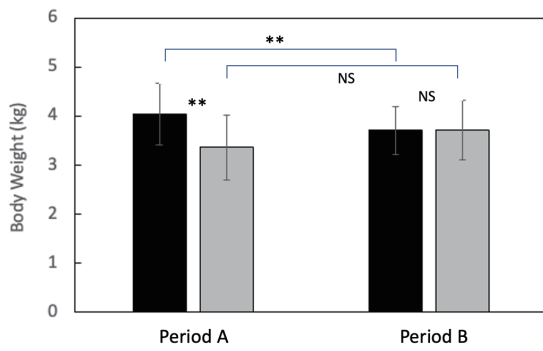


Fig. 3. Comparison of body weights of male (black) and female (gray) raccoon dogs in Period A (July–November) and Period B (December–June). **: $P < 0.01$, NS: non-significant.

Mean monthly or bimonthly body weight measurements in male and female raccoon dogs showed that males began to gain weight in May, peaking from October to November, whereas females maintained constant weight (Fig. 2). During Period A (July–November), the mean body weight of males was significantly heavier (4.2 ± 0.6 kg, $n = 14$) than females (3.5 ± 0.4 kg, $n = 11$, $Z = 2.97$, $P = 0.003$; Fig. 3). However, during Period B (December–June), the mean body weights of males and females were 3.7 ± 0.6 kg ($n = 47$) and 3.7 ± 0.6 kg ($n = 46$), which were not significantly different ($Z = 0.10$, $P = 0.923$). Additionally, body weight of males was significantly heavier during Period A (4.2 kg \pm 0.6 kg, $n = 14$) than Period B (3.7 kg \pm 0.6 kg, $n = 47$) ($Z = 2.63$, $P = 0.009$), whereas that of females did not differ significantly between Periods A (3.5 ± 0.4 kg, $n = 11$) and B (3.7 kg \pm 0.6 kg, $n = 46$) ($Z = 1.25$, $P = 0.210$).

DISCUSSION

Among the Japanese raccoon dogs sampled in this study, males had longer bones than females. However, these differences were very small, with female skull, mandible, and femur lengths being only 1.7%, 1.8%, and 1.4% shorter than the corresponding male values, although the sexual difference in femur length was not significant. Other studies on the raccoon dog skulls and mandibles showed similar results to ours. The skull and mandible lengths were almost same to our results: male skulls and mandibles were longer than female ones by 2–4% and 1–6%, respectively (Hidaka et al., 1998; Natori et al., 2001; Obara, 2024).

However, the body weight of males was significantly heavier (22.3%) than that of females during the period of July–November or summer and autumn. It is likely that males increased body weight in this season by feeding on abundant nutritious fruits. Japanese raccoon dogs are frugivorous; the large supply of fleshy fruits in late summer and autumn (Hirasawa et al., 2006; Takatsuki et al., 2018, 2020a, 2020b) allows Japanese raccoon dogs to gain more weight in autumn than in other seasons (Takatsuki and Suzuki, 2022). However, Takatsuki and Suzuki (2022) did not compare body weight between males and females. This study compared the weight males and females and found the difference during summer and autumn (Period A, Fig. 3), when fruit production is high. The reason for the slight decline in male body weight in December remains unclear. However, female body weight did not differ significantly between Periods A and B (Fig. 3; $P = 0.051$). It is likely because parturition and pup care occur from May to July, which impose a greater burden on females, thereby preventing them from matching the weight gain observed in males. Our results are different from those of a study on Finnish raccoon dog (Fig. 3 in Kauhala, 1993), where sexual difference in body weight was not found. The Finnish raccoon dogs are different from Japanese ones in that 1) they are larger (Kauhala et al., 1998b), 2) they are more carnivorous (Kauhala et al., 1998a; Kauhala and Auniola, 2001; Dryagala et al., 2013), while the Japanese raccoon dog is more frugivorous (Hirasawa et al., 2006; Takatsuki et al., 2020a; Takatsuki and Inaba, 2023; Takatsuki and Kobayashi, 2023), and 3) they “winter sleep” (Mustonen et al., 2007) while the Japanese ones do not.

We conclude that male raccoon dogs of a Japanese population have slightly longer bones than females and that males are heavier than females in autumn. Since the Japanese archipelago contains diverse ecosystems, it is expected that the body weights of the raccoon dogs may vary regionally, which may result variations of sexual dimorphism. This study was conducted in Wakayama Prefecture, which is a warm temperate zone; and therefore further studies in other environments are needed, particularly in the cool temperate zone of northern Japan, to confirm the generality of our results.

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Authors' contributions

Both the authors designed the study plan. S. Takatsuki measured the specimens, analyzed, and prepared the draft. K. Suzuki collected the specimens, weighted cleaned them, and read and completed the manuscript.

Competing of interests

Both the authors have no conflicts of interest.

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タヌキの頭骨、大腿骨と体重の性差

一夫多妻であるタヌキは日本産については頭骨に性差がわずかにあるという研究と性差はないとする研究があり、フィンランドと韓国ではないとされている。そのほかの骨と体重の性差については情報がない。そこで、和歌山県のタヌキ118個体(オス61, メス57)の頭骨長, 下顎骨長, 大腿骨長を調べたところ, いずれもオスがわずかに長かったが, その違いは2%以内に過ぎなかった。しかし体重は夏, 秋にオスがメスより22.3%重く, 有意差があった。

キーワード: 下顎骨, 性的二型, 大腿骨, タヌキ, 頭骨.