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Source: *Folia Zoologica*, 66(3) : 203-210

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: <https://doi.org/10.25225/fozo.v66.i3.a1.2017>

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# A histological study of tail width variation in the greater Japanese shrew-mole, *Urotrichus talpoides*

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Received 20 July 2017; Accepted 27 October 2017

**Abstract.** The greater Japanese shrew-mole, *Urotrichus talpoides*, has a wide and thick tail like a baseball bat with bristles like bottle brushes. It is known that not only length variations but also the width variations are observed in the tails of *U. talpoides*. To understand such width variations of the tail, we examined morphological and histological characteristics. The width variation was not related to the season when captured or aging, as indicated by the skull sizes. In addition, tail vertebra width was not correlated with tail width. On the other hand, according to histological observation of tail skin, the ratio of subcutaneous tissue/corium indicating the thickness of the subcutaneous tissue layer was positively correlated with the tail width ( $p < 0.05$ ). The thickness of the subcutaneous tissue layer means that the rich adipose tissue and cells observed were unilocular, then identified as white adipose cells. It is well known that one of the functions of white adipose cells is to store excess energy as neutral fat. Thus, it is suggested that *U. talpoides* stores an energy source as adipose cells in the skin of the tail, demonstrating that tail width variations are caused by the thickness of the subcutaneous tissue layer.

**Key words:** tail, skin, histological analysis, adipose cell

## Introduction

In the Japanese Islands, there are two species of shrew-moles, the lesser Japanese shrew-mole, *Dymecodon pilirostris* and the greater Japanese shrew-mole, *Urotrichus talpoides* (Soricomorpha, Talpidae, Ohdachi et al. 2015). The latter species is relatively common and inhabits forest areas from lowlands to highlands in Honshu, Shikoku, Kyushu and the peripheral islands, but not in Hokkaido (Ohdachi et al. 2015). Generally, *U. talpoides* prefers soft soil conditions, such as rich litter and humid layers as its habitat, and preys on invertebrates such as worms and spiders. One of the morphological characteristics of *U. talpoides* is the wide and thick tail like a baseball bat with bristles like bottle brushes (Imaizumi 1970, Ohdachi et al. 2015). Talpids have variable lifestyles, such as aquatic, terrestrial, fossorial, and semi-fossorial. Therefore, talpids have adapted to various environments and carry morphological features as adaptive characteristics (Shimer 1903). In the family Talpidae, talpine fossorial moles apparently have short tails as an advance for the lifestyle of using underground burrows (Shibanai 1967). Moreover, tails of the talpine species are quite short and narrow with scarce hairs. Thus, the baseball bat-like tail with bristles of *U. talpoides* is quite a unique characteristic,

and its function is interesting in talpids from an evolutionary standpoint (Imaizumi 1960, 1970).

According to Imaizumi & Obara (1966), it is known that not only length variation but also width variation is observed in the tail of *U. talpoides* as individual variations (Figs. 1a, b). As a similar example, it is known that the star-nosed mole, *Condylura cristata*, which is distributed in North America has width variations, such as swollen conditions, in the tail (Hamilton 1931, Eadie & Hamilton 1956, Imaizumi & Obara 1966, Petersen & Yates 1980). During breeding season from winter to early spring, the tails of both sexes of *C. cristata* are obviously enlarged more than that during non-breeding season (Hamilton 1931, Imaizumi & Obara 1966, Petersen & Yates 1980). Considering its ecological and physiological backgrounds, it is suggested that the tail may function as a temporary fat storage reservoir for energy usage during the winter season when its diet is insufficient in mating season when feeding behaviour becomes inactive (Eadie & Hamilton 1956, Imaizumi & Obara 1966, Petersen & Yates 1980). To date, such a mechanism for storing fats in a part of the body has not been seen in other species belonging to the family Talpidae (Yokohata 1998). Although *U. talpoides* and *C. cristata* are distributed in different environments, it

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is expected that the tail of *U. talpoides* may have the same function as that of *C. cristata*. In this study, we analyzed the tail of the shrew-mole samples morphologically and histologically to evaluate whether the tail of *U. talpoides* has the same function as that of *C. cristata* and to clarify that role.

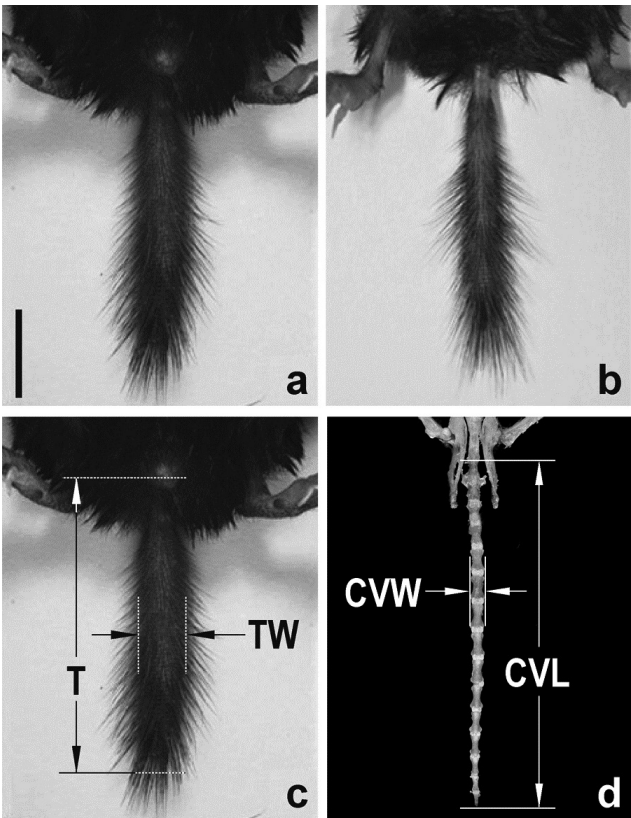
### Material and Methods

#### Shrew-mole samples

In total, 63 individuals of *U. talpoides* were collected at Saori, Fujinomiya, Shizuoka Prefecture (35°20' N, 138°32', alt. 700-800 m), using Sherman traps from May 2007 to November 2009, for use in this study (Table 1). These samples are preserved as specimens in the author's laboratory.

#### Morphological analysis

We measured the morphological characteristics of all shrew-moles in the sample: body weight, tail length and maximum tail width without hairs (here, called as "tail width") as an external measurement; and greatest length of skull, caudal vertebra length, and maximum

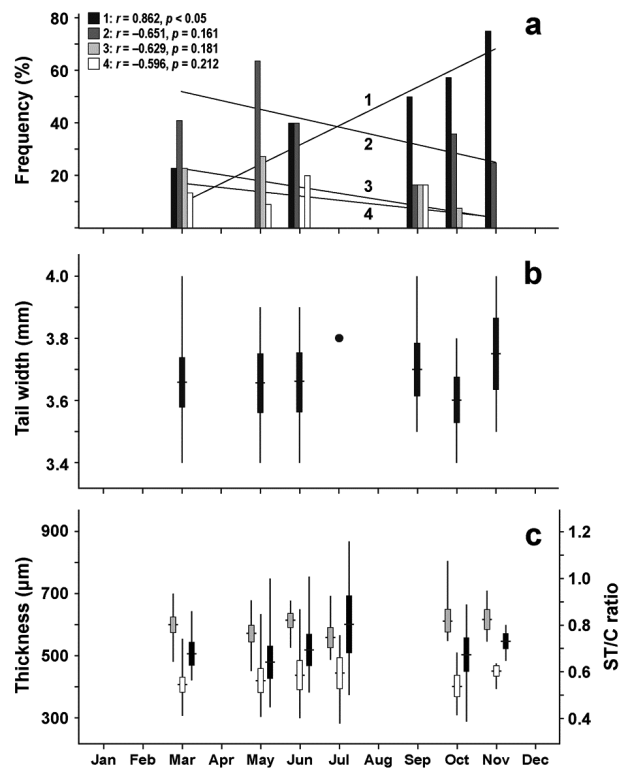


**Fig. 1.** Typical examples of wider (a, swollen) and narrower (b, slender) tails of dorsal views of *Urotrichus talpoides*. Morphological dimensions of some characteristics (c, ventral view of tail; d, ventral view of caudal vertebrae). T, TW, CVL and CVW mean tail length, maximum tail width without hairs, caudal vertebra length and maximum caudal vertebra width, respectively. Bar indicates 10 mm.

caudal vertebra width (here, called as "caudal vertebra width") as skeletal measurements (Table 1, Figs. 1c, d), using a digital caliper (Mitutoyo) at 0.01 mm level. The body weight and the greatest length of skull are considered to be age indicators based on growth patterns in small mammals. In addition, the present individuals were divided into four wear-classes (1-4) as also an age indicator by the wearing patterns and characteristics of the molars of the mandible, according to Usuki (1966).

#### Histological analysis

From fourteen specimens of *U. talpoides*, we picked a small piece of skin (approximately 10 mm square) from the right half of the anteroposterior middle point of the tail for histological analysis, and the skin pieces were fixed in Bouin's solution. After sufficient fixation, the tissues were subsequently transferred to 70 % ethanol and a dehydrated graded series of ethanol, infiltrated in xylene, and embedded in paraffin. The tissues were cut into 6 μm thick serial



**Fig. 2.** Monthly frequency of each wear-class with the linear regression of each wear-class (a) (a July sample was not included for statistical calculation because only one individual was obtained in July), monthly tendency of the tail width (b) and relationships between the month when shrew-moles were captured and the thickness of corium (gray rectangles), the thickness of subcutaneous tissue (white rectangles), and the ST/C ratio (black rectangles) (c). Vertical bars, horizontal bars and rectangles indicate ranges, means and SD, respectively, except for a July sample.

**Table 1.** Morphological data of *Urotrichus talpoides* samples examined in this study.

Specimen No.	Collecting date	Sex	BW (g)	HB (mm)	T (mm)	FFsu (mm)	HFsu (mm)	GLS (mm)	TW (mm)	CVL (mm)	CVW (mm)	Age <sup>#</sup>
MAI-530	26. May. 07	f	15.7	81.0	29.0	9.4	13.4	24.2	3.4	28.9	1.57	2
MAI-545	26. May. 07	m	14.2	73.0	34.8	8.9	14.2	25.7	3.6	32.4	1.72	3
MAI-595	23. Oct. 07	m	12.2	69.5	32.5	10.3	14.0	24.8	3.8	30.8	1.54	2
MAI-596	23. Oct. 07	m	12.8	85.0	37.0	8.8	14.3	24.4	3.5	32.1	1.65	2
MAI-622	28. Mar. 08	f	11.5	72.0	32.0	8.2	13.2	24.2	3.6	-	1.51	2
MAI-627	28. Mar. 08	f	12.8	77.0	33.0	9.7	13.4	24.0	3.5	30.3	1.74	3
MAI-628	28. Mar. 08	m	13.5	78.0	35.0	10.4	14.8	25.1	4.0	-	1.53	2
MAI-637	29. Mar. 08	m	12.9	78.0	30.0	10.5	14.3	24.6	4.0	29.7	1.63	2
MAI-650	17. May. 08	m	14.0	79.0	33.0	9.4	14.3	25.6	3.9	31.3	1.70	2
MAI-651	17. May. 08	f	15.4	83.0	34.0	9.6	15.5	24.7	3.5	32.7	1.63	2
MAI-655	18. May. 08	f	15.1	82.0	33.0	9.7	13.6	24.7	3.4	32.8	1.52	2
MAI-660	18. May. 08	m	15.1	92.0	33.0	10.3	13.7	25.1	3.5	31.6	1.47	3
MAI-672	20. Jun. 08	f	17.8	90.0	35.0	10.8	14.9	25.3	3.9	35.1	1.74	2
MAI-709	24. Jul. 08	m	15.2	90.0	31.0	9.6	14.5	25.3	3.8	32.9	1.56	1
MAI-734	29. Sep. 08	m	16.3	90.0	32.0	9.6	13.3	24.9	3.7	30.7	1.57	2
MAI-735	29. Sep. 08	m	16.7	91.0	34.0	9.8	14.4	24.9	3.6	31.9	1.56	4
MAI-773	23. Oct. 08	m	13.6	87.0	32.0	10.8	13.8	25.5	3.4	31.3	1.57	2
MAI-775	23. Oct. 08	m	13.7	84.0	30.0	9.9	14.1	24.9	3.7	31.6	1.57	1
MAI-776	23. Oct. 08	m	12.1	79.0	29.0	9.4	13.1	24.2	3.6	-	1.59	2
MAI-777	24. Oct. 08	m	15.1	82.0	34.0	10.5	14.6	25.2	3.6	33.2	1.63	1
MAI-823	20. Mar. 09	m	14.2	86.0	32.0	10.8	14.3	24.6	3.7	32.8	1.52	2
MAI-825	20. Mar. 09	m	14.9	87.0	32.0	10.3	14.1	24.7	3.7	29.9	1.51	4
MAI-827	20. Mar. ,09	f	11.8	84.0	30.0	10.3	13.5	24.5	4.0	28.6	1.52	1
MAI-831	20. Mar. ,09	m	14.0	82.0	33.0	10.8	13.9	25.6	3.5	31.9	1.37	2
MAI-832	20. Mar. ,09	m	14.1	87.5	32.5	10.5	14.5	25.0	3.7	32.4	1.46	3
MAI-833	20. Mar. 09	f	12.0	90.0	33.0	10.1	13.9	24.8	3.6	30.7	1.49	2
MAI-835	21. Mar. 09	m	13.8	87.0	34.0	10.7	14.4	24.6	3.5	32.4	1.56	3
MAI-836	21. Mar. 09	f	12.0	92.5	34.5	10.3	14.8	24.4	3.7	31.1	1.51	4
MAI-837	21. Mar. 09	m	13.4	90.0	35.0	11.5	14.9	24.3	3.6	32.1	1.46	2
MAI-839	21. Mar. 09	f	12.2	90.0	31.0	9.4	14.3	24.4	3.6	29.7	1.53	1
MAI-841	31. Mar. 09	m	13.6	85.0	32.0	9.5	14.4	24.1	3.4	29.7	1.5	1
MAI-843	31. Mar. 09	f	11.0	87.5	31.5	10.1	14.2	24.4	3.6	30.0	1.6	1
MAI-845	31. Mar. 09	m	10.9	88.0	32.0	9.7	14.3	25.5	3.6	32.2	1.5	3
MAI-846	31. Mar. 09	f	14.1	94.0	35.0	9.7	14.4	25.0	3.7	31.8	1.5	3
MAI-847	31. Mar. 09	f	11.6	87.0	32.0	10.1	13.9	24.2	3.5	-	1.4	1
MAI-848*	19. Mar. 09	m	12.1	89.5	33.5	9.8	14.6	25.3	3.6	31.8	1.6	2
MAI-850*	21. Mar. 09	m	13.2	86.0	33.0	10.4	14.9	24.7	3.7	32.6	1.5	2
MAI-854*	31. Mar. 09	f	11.1	89.0	32.0	9.4	14.6	24.8	3.8	30.4	1.6	4
MAI-857	22. May. 09	f	13.0	83.0	31.0	10.7	14.5	24.6	3.7	29.6	1.5	2
MAI-858*	23. May. 09	m	15.8	84.0	33.0	10.3	14.4	25.2	3.5	31.5	1.5	4
MAI-861*	23. May. 09	f	17.6	87.5	33.5	9.9	14.8	25.0	3.9	-	1.6	3
MAI-866*	24. May. 09	f	14.6	85.0	33.0	10.4	14.8	24.9	3.7	32.7	1.5	2
MAI-870*	23. May. 09	m	15.9	85.0	34.0	10.7	15.1	25.8	3.9	32.3	1.4	2
MAI-876	06. Jun. 09	f	13.0	84.0	31.0	9.9	14.6	24.2	3.4	30.0	1.5	1

MAI-877*	06. Jun. 09	f	15.1	88.5	31.5	9.8	14.3	24.8	3.7	31.4	1.5	2
MAI-878	06. Jun. 09	m	16.0	90.0	33.0	10.3	14.7	25.5	3.8	33.1	1.5	4
MAI-888*	05. Jun. 09	m	11.7	82.5	32.5	10.3	14.2	24.6	3.6	31.3	1.5	1
MAI-936	15. Sep. 09	f	13.6	81.0	31.0	9.9	14.3	24.6	3.6	30.9	1.4	1
MAI-938*	16. Sep. 09	m	15.0	87.0	33.0	10.3	14.4	25.3	4.0	32.1	1.6	1
MAI-942	16. Sep. 09	f	12.5	84.0	31.0	9.8	14.3	24.2	3.8	29.2	1.6	3
MAI-943*	16. Sep. 09	m	13.4	88.0	34.0	10.1	14.3	24.9	3.5	32.6	1.6	1
MAI-944*	14. Oct. 09	m	16.0	88.0	36.0	10.6	14.7	25.8	3.7	34.8	1.6	1
MAI-964*	14. Oct. 09	f	15.1	89.0	34.0	9.4	14.0	25.0	3.4	34.7	1.5	1
MAI-972	14. Oct. 09	f	12.5	85.0	31.0	9.6	14.2	24.4	3.4	30.4	1.4	3
MAI-973	15. Oct. 09	m	15.9	91.0	32.0	9.8	14.6	25.1	3.7	31.8	1.5	1
MAI-976	15. Oct. 09	f	14.3	89.0	30.0	9.5	14.1	24.6	3.8	30.6	1.5	1
MAI-977	15. Oct. 09	f	15.3	87.0	32.0	9.8	14.5	24.3	3.8	32.4	1.4	1
MAI-993	15. Oct. 09	f	14.8	90.0	32.0	9.4	14.3	24.9	3.6	30.9	1.5	2
MAI-998	15. Oct. 09	m	15.1	83.0	31.0	9.6	13.5	24.7	3.5	32.0	1.4	1
MAI-1013	11. Nov. 09	m	14.0	92.0	32.0	9.8	14.4	24.8	4.0	31.7	1.6	1
MAI-1036*	11. Nov. 09	m	14.6	86.0	33.0	10.5	14.6	25.3	3.5	33.5	1.5	1
MAI-1045	11. Nov. 09	m	13.0	85.0	32.0	10.6	14.3	24.6	3.6	32.1	1.5	1
MAI-1050	11. Nov. 09	f	13.7	86.0	32.0	10.1	14.8	25.0	3.9	30.2	1.6	2

BW, body weight; HB, head and body length; T, tail length; FFsu, fore foot length sine unguis; HFsu, hind foot length sine unguis; GLS, greatest length of skull; TW, maximum width of tail without hairs; CVL, caudal vertebra length; CVW, maximum caudal vertebra width. #1 means presence of deciduous teeth and 1 means absence of deciduous teeth. \*Used for tissue section analysis.

sections using a microtome and placed on glass slides. Sections deparaffinized with xylene were stained with hematoxylin and eosin and observed with a light microscope. Section specimens were observed from five to ten clear profiles in each individual. The profiles were measured linearly by pixels using Adobe Photoshop CS, and we calculated the relative ratio of tissue layers.

## Results

On the basis of the months when shrew-moles were collected and the wear-class which is considered to be an age indicator, the frequency of younger individuals with the wear-class 1 significantly increased from spring to autumn ( $r = 0.862$ ,  $p < 0.05$ ) but the other classes did not show any tendencies (Fig. 2a). In addition, the relationship between the wear-class and the tail width was also evaluated and its significant correlation was not confirmed ( $r = 0.025$ ,  $p = 0.845$ ). Moreover, the correlation between the body weight and the tail width was not recognized ( $r = 0.225$ ,  $p = 0.479$ ). On the other hand, we evaluated the relationship between the greatest length of skull and the tail width, then the tail width did not show a strong correlation with the greatest length of skull ( $r = 0.251$ ,  $p < 0.05$ ) in *U. talpoides*. Accordingly, we understood that the tail width did not vary due to aging in this species. Furthermore, we also evaluated

the relationship between the capturing season and the tail width. However, as shown in Table 1 and Fig. 2b, the tail width widely ranged in each month and the tail width was not related to the month of capture ( $p > 0.780$ ) by Tukey's multiple comparisons. Therefore, we were not able to find any regularities between the tail width variation and the aging, and between tail width variation and the season.

On the other hand, we tried to understand what factor in the internal tissue caused the tail width variation. The relationship between the tail length and the caudal vertebra length was investigated and both lengths were positively correlated ( $r = 0.648$ ,  $p < 0.01$ ) (Fig. 3). However, the relationship between the tail width and the caudal vertebra width did not show an obvious correlation ( $r = 0.224$ ,  $p = 0.078$ ) (Fig. 3). Thus, the present results indicated that the tail width of *U. talpoides* varied due to the soft tissue around the caudal vertebrae.

We recognized typical structures on the following skin tissue sections of the tail: epidermis, corium, subcutaneous tissue consisting of large amount of adipose cells, skin adnexa including hair follicle, medulla of hairs, and sebaceous gland (Fig. 4). In addition, adipose cells observed were typically unilocular and were identified as white adipose cells (Fig. 4). The present linear pixel measurements about the corium and the subcutaneous tissue layers indicated



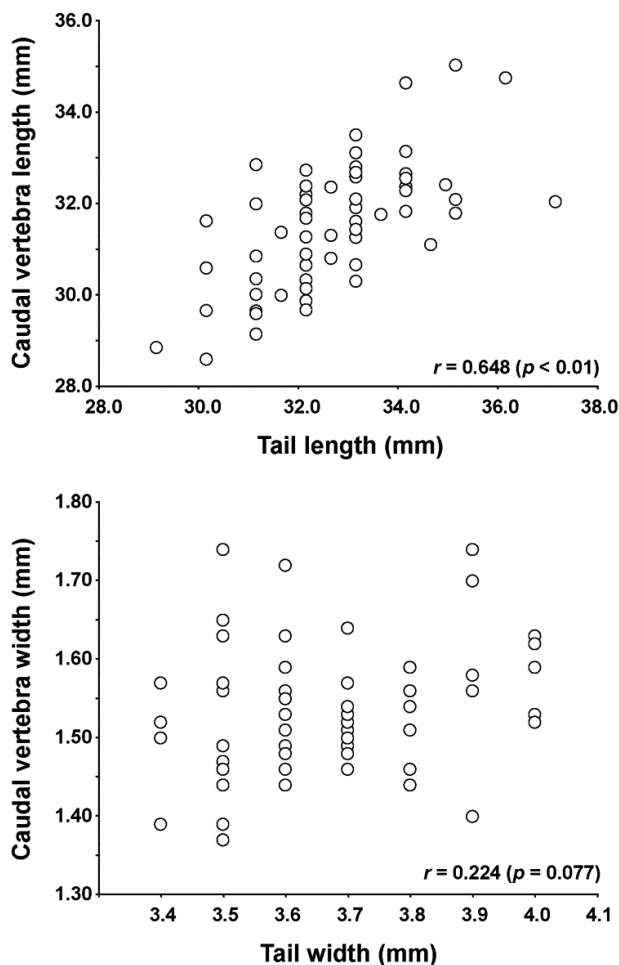


Fig. 3. Relationships between the tail length and the caudal vertebra length (upper), and the tail width and the caudal vertebra width (lower).

the thicknesses of corium and subcutaneous tissue and the ratio of subcutaneous tissue/corium (ST/C ratio, Table 2). We tried to statistically consider relationships between the month when shrew-moles were captured and these indices but significant differences were not obtained among the months for the thickness of corium ( $p > 0.203$ ), the thickness of subcutaneous tissue ( $p > 0.883$ ) and the ST/C ratio ( $p > 0.305$ ) by Tukey's multiple comparisons (Fig. 2c). Moreover, the body weight, the greatest length of skull and the wear-class were also evaluated with the ST/C ratio and these relationships were not correlated as  $r = 0.335$  with  $p = 0.283$ ,  $r = 0.232$  with  $p = 0.465$  and  $r = 0.003$  with  $p = 0.993$ , respectively. Thus, the ST/C ratio was not influenced due to aging in this species. However, the current measurements revealed that, based on the ST/C ratio values, *U. talpoides* with wide tails had relatively larger subcutaneous tissue layers than did *U. talpoides* with narrow tails (Table 2, Figs. 5, 6). Namely, the tail width was positively correlated with the ST/C ratio ( $r = 0.678$ ,  $p < 0.05$ ) in *U. talpoides* (Fig. 6).

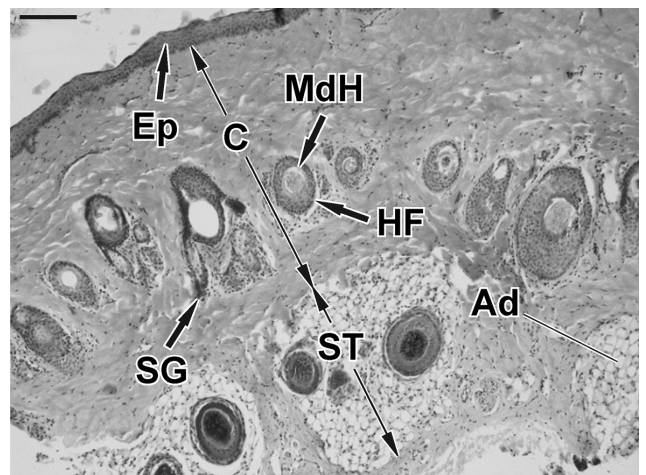


Fig. 4. A typical example of the tail skin tissue of the tail consisting of epidermis (Ep), corium (C) and subcutaneous tissue (ST). In addition, skin adnexa including hair follicle (HF), medulla of hairs (MdH) and sebaceous gland (SG) were also observed. An adipose cell (Ad) is indicated and subcutaneous tissues were consisted of large amount of unilocular adipose cells. Bar indicates 100  $\mu$ m.

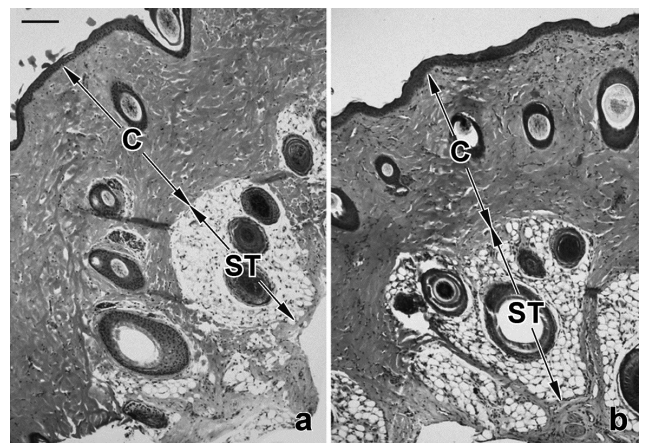
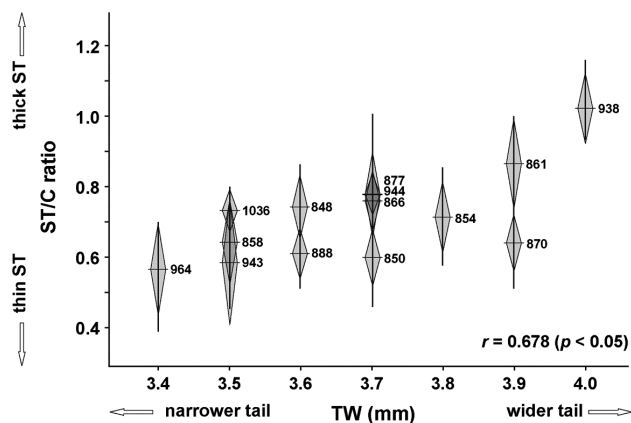


Fig. 5. Typical section profiles of the tail skin tissues of an individual of *Urotrichus talpoides* carrying narrower tail (a, MAI-1036) and that carrying wider tail (b, MAI-938). Abbreviations are identical to those in Fig. 4. Bar indicates 100  $\mu$ m.

## Discussion

On the basis of the current results in *U. talpoides*, it is concluded that the tail width variations were not caused by age or seasonal factors (Table 1, Fig. 3). On the other hand, according to the relationships between the tail width and the caudal vertebra width, the thickness of the tail variation was caused by the soft tissue around the caudal vertebrae (Figs. 2, 3). In *U. talpoides*, the present observation of the section profiles of the tail soft tissue revealed that the corium and the subcutaneous tissue layers were variables related to tail variation, especially in the tail width. The ST/C ratio indices indicated that the subcutaneous tissue layer is thinner in individuals with narrower (slender) tails and is thicker in those



**Fig. 6.** A relationship between TW and ST/C. Vertical bars, horizontal bars and rhombuses indicate ranges, means and SD, respectively. Numbers indicate specimen Nos. of MAI-series examined for the present section analysis.

with wider (swollen) tails (Table 2, Figs. 5, 6). The subcutaneous tissue layers usually consist of adipose and connective tissues (Hausman 1984). The present section profile showed that adipose tissue was mainly distributed around the hair follicles (Fig. 5), and the adipose tissue was not stratified but scattered in the subcutaneous tissue.

The soft tissue profiles of the tail skin observed were fundamentally similar to those of the skin of other mammals, e.g. rats, mice, dogs (Ito 1986, Hedrich & Bullock 2004) and humans (Shimizu 2005). Thus, the thickness of the subcutaneous tissue layer is increased along with tail thickening (Table 2, Figs.

5, 6). Furthermore, as adipose tissue was used as an indicator of the subcutaneous tissue, it is thought that the variation of the tail width is caused by the thickness of the adipose tissue. Generally, the adipose tissue is composed in large part of adipose cells and the adipose cells could be divided into white adipose cells and brown adipose cells that differ in the microscopic morphologies and functions (Saito 1997). In addition, it is well known that white adipose cells mainly consist of triglycerides, and one of the functions of white adipose cells is to store excess energy as neutral fat (Saito 1997). Consequently, in *U. talpoides*, it is expected that the soft tissues of the tail also have the above mechanisms. Furthermore, we suggest that the tissues potentially can function as nutritional support as well as those in *C. cristata* (Eadie & Hamilton 1956, Imaizumi & Obara 1966, Petersen & Yates 1980).

In hibernating mammals, it is reported that a lot of fats are stored in a part of the body before the winter season, e.g. the body weight of the Japanese pipistrelle, *Pipistrellus abramus*, increases by up to 30.6 % and 29.6 % in adult females and males, respectively, from summer to late autumn (Funakoshi & Uchida 1978b), and white adipose cells stored as visceral and subcutaneous fats are used for energy during hibernation (Funakoshi & Uchida 1978a). Takada (1993) also investigated mass variations of body fats in three rodents, *Apodemus speciosus*, *Mus musculus* and *Micromys minutus*. The intraspecific

**Table 2.** Tail width (TW), thicknesses of corium (C) and subcutaneous tissue (ST) and mean of the ST/C ratio by the measurements on the tail tissue section profiles in the current *Urotrichus talpoides* samples.

Specimen No.	TW (mm)	Range of thickness of C ( $\times 10^2 \mu\text{m}$ )	Range of thickness of ST ( $\times 10^2 \mu\text{m}$ )	Range of ST/C ratio	Mean ( $\pm$ SD) of ST/C ratio
MAI-0848	3.6	4.80-6.15	3.70-5.16	0.65-0.87	0.741 $\pm$ 0.0901
MAI-0850	3.7	5.37-6.99	3.20-4.30	0.46-0.70	0.601 $\pm$ 0.0840
MAI-0854	3.8	5.12-6.59	3.06-5.57	0.57-0.86	0.713 $\pm$ 0.1025
MAI-0858	3.5	4.52-6.80	3.05-4.16	0.45-0.78	0.646 $\pm$ 0.1292
MAI-0861	3.9	4.21-6.37	3.44-6.30	0.66-1.03	0.870 $\pm$ 0.1316
MAI-0866	3.7	5.13-6.28	3.87-4.91	0.62-0.84	0.768 $\pm$ 0.0897
MAI-0870	3.9	5.66-6.42	3.18-4.29	0.51-0.74	0.631 $\pm$ 0.0821
MAI-0877	3.7	6.21-6.75	4.23-6.49	0.65-1.05	0.777 $\pm$ 0.1389
MAI-0888	3.6	5.27-6.39	3.02-4.00	0.51-0.69	0.614 $\pm$ 0.0736
MAI-0938	4.0	4.85-8.69	4.56-9.40	0.93-1.16	1.021 $\pm$ 0.1095
MAI-0943	3.5	5.31-6.90	2.82-4.32	0.50-0.76	0.585 $\pm$ 0.1849
MAI-0944	3.7	5.53-6.07	4.27-5.13	0.72-0.89	0.777 $\pm$ 0.0686
MAI-0964	3.4	5.46-8.05	3.09-4.36	0.39-0.75	0.572 $\pm$ 0.1316
MAI-1036	3.5	5.46-7.11	3.93-4.77	0.65-0.80	0.732 $\pm$ 0.0665

variations of body fats in each species were extremely slight among individuals, and it is believed that body fats may not be important for non-hibernating rodents for the storage of energy. Although there are several hibernating insectivores (Lyman 1982, Kawamichi et al. 2000, Geiser 2013), talpid species generally need to feed frequently to avoid starvation throughout the year and have higher metabolic rates (Abe 1976). In addition, it is expected that the lack of food resources in the winter season is closely related to starvation for insectivores. Considering the above findings about hibernating mammals, it may be assumed that the amounts of fat stored in the tails of *U. talpoides* are not larger than those in hibernating mammals. On the other hand, fat storages have been also observed in mammals inhabiting deserts and those undergoing daily or seasonal torpor (Morton 1980, Hope 2000). In such mammals consisting of mainly marsupials, insectivores and rodents, fat is stored in an incrassated tail as an energy reserve, as well as the caudal fat of *U. talpoides*. In addition, as a physiological example of another species showing semi-fossorial lifestyle as *U. talpoides*, it is reported that the American shrew-

mole, *Neurotrichus gibbsii*, shows body temperature reduction and hypometabolism along with a reduction of ambient temperature (Campbell & Hochachka 2000). This fact means that the American shrew-mole may have a potential of torpor under a cold condition. Considering the similarity of the lifestyle and ecological traits between the American shrew-mole and the greater Japanese shrew-mole (Dalquest & Orcutt 1942, Carraway & Verts 1991, Yokohata 1998, Ohdachi et al. 2015), *U. talpoides* may have also a potential of a certain torpor system as well as *N. gibbsii*. If this estimation would be correct, the caudal fat of *U. talpoides* may be used as an energy reserve during certain torpor at a cold condition. However, in this study, we analyzed only tail tissues but other internal body fat storages were not investigated yet. To evaluate the fat storage mechanism of *U. talpoides*, the total fat storages in both body and tail, the metabolic traits and the occurrence of torpor should be analyzed in detail.

## Acknowledgements

We are grateful to Ms. Yuriko Watanabe for her kind help to our experimental works. Special thanks are also due to Keiki Matsuda for his kind help for sample collection.

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