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Why do small Japanese flying squirrels, *Pteromys momonga*, prefer Japanese cedar bark as a nest material ?
II. Study of heat–trapping capacity

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The Japanese flying squirrel, *Pteromys momonga*, is known to prefer the bark of Japanese cedar, *Crytomeria japonica,* as a nest material in their natural habitats. The present study was conducted to examine the heat-trapping capacity of wood fibers from the squirrels' nests made of the Japanese cedar bark and the bark of Japanese cypress, *Chamaecyparis obtusa,* and any morphological differences between the cedar nest and cypress nest fibers. The results suggest that cedar fibers have a greater heat trapping capacity than cypress fibers and that cedar nest fibers are longer and finer than cypress nest fibers.

Keywords
Japanese flying squirrels, nest material, bark of Japanese cedar, heat trapping capacity

1 Introduction

The Japanese flying squirrel, *Pteromys momonga*, is a species peculiar to Japan and is listed as an endangered species in the Red Data Book of many prefectures[1]. However, there is a little information on their natural history.

Previous studies have indicated the following.

(1) The squirrels prefer to inhabit Japanese cedar, *Cryptomeria japonica*, forests neighboring on natural forests rather than Japanese cedar forests not neighboring on natural forests or natural forests[2,3] .

(2) In their natural habitats, the squirrels typically use fibers of the Japanese cedar bark as a nest material[2-4].

(3) Their nests made of cedar bark have higher resistance to water penetration into the core of the nest where the squirrels rest than those made of the bark of Japanese cypress, *Chamaecyparis obtusa*[4].

(4) The squirrels prefer the nest boxes set up 6 m above ground level to those set up at lower levels[5].

(5) Communal nesting occurs more often in colder seasons[6].

(6) The squirrels mainly feed on leaves and buds of various plant species including cedars and other evergreen trees[7,8].

The squirrels spend winter days without hibernation[1, 8]. They can live through winter without hibernation partly because of the above (4) and (6), that is, using the nests 6 m above ground level, which are unlikely to be buried in the snow, and feeding on leaves of cedars and other evergreen trees, which are available even in winter.

Another factor enabling the squirrels to live thorough winter without hibernation is, presumably, that the cedar bark fibers the squirrels prefer to use as a nest material may have a great heat-trapping capacity in protection against low

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temperatures in winter. The above fact (3) suggests that the cedar bark fibers are morphologically characterized by inhibiting penetration of water and some other substances.

The present study was conducted to examine the heat-trapping capacity of fibers from the squirrels' nest made of the cedar bark and cypress bark to discuss the hypothesis that cedar fibers have a great heat-trapping capacity, and examine any morphological differences between the cedar nest and cypress nest fibers.

2 Methods

2・1 Study animals

Three squirrels (weight and sex; 125g ♀, 121g ♂, 118g ♂) were removed from the nest boxes set up on trees in the forest of Chizu, Tottori Prefecture, in July 2013. The area was composed of planted cedar trees and natural laurel and deciduous trees. The squirrels were captured under the official permission of capture and keeping (No.20140001527). They were reared separately in cages measuring 45×40×45 cm placed in a laboratory for 2 to 3 weeks.

Each cage contained a wooden box (18×18×23 cm) with a small hole, which was used as the nest. The squirrels were fed oaks (*Quercus serrata*, *Q. acutissima*, and *Q. mysinaefolia*) leaves and *Castanopsis cuspidata*, and dried vegetables (carrots, cabbage, and soybeans). They had free access to food and water.

2・2 Preparation of nests

Cedar and cypress barks were stripped, mostly by hand and occasionally with a knife, and cut into pieces of 2×20 cm (2 to 4mm thick). Cedar and cypress trees are relatively common in the

Fig.1 Method of measuring temperature of bark fibers in the vessel. Temperature sensor is inserted through the vessel cap hole to the center of bark fibers in the vessel.

natural habitat of the squirrel, and their barks resemble each other in appearance and material characteristics. Provided with four pieces of the bark of each of the two tree species in the cage, the squirrels made a nest in the box using its fibers. Each squirrel built the cedar and cypress nests in the same manner.

2・3 Estimation of heat−trapping effect

Wood fibers (15 g) from each nest were placed in a plastic vessel with a cap in which a small hole (∅ 7.1 mm) was created in the center.

The vessels containing 15 g of the cedar or cypress fibers obtained from the nests built by the same squirrel were warmed in a hot air oven (ISUZU soyokaze ASF-111s) to approximately 45 ℃ . Then, the vessels were removed from the oven and placed in a room at 21 to 22 ℃ . The temperatures of the barks in the vessels were monitored every minute using a digital thermometer (CUSTOM CT-1200) (Fig.1).

The above process was applied to the bark fibers from the nests built by the three squirrels.

2・4 Comparison between cedar and cypress nest fibers

Wood fibers (0.5 g) were obtained from the cedar bark nests and cypress bark nests created by the squirrels. The number of fibers was counted and themorphology (length and width) was examined.

The width of a fiber was defined as the width of the thickest part of the fiber.

3 Results and Discussion

3・1 Effect of heat−trapping

Fig. 2 shows the temperature change in the center of the nest fibers with time. The times for the cedar nest fibers and cypress nest fibers to reach the room temperature were 34 minutes and 41 minutes (squirrel A), 32 minutes and 38 minutes (squirrel B), and 35 minutes and 39 minutes (squirrel C). In all cases of the three squirrels (A, B, C), the temperatures monitored every minute till they reached the room temperature were higher in the cedar nest fibers than in the cypress nest fibers (($p < 0.01$ Student's t-test in all three cases). The average temperature difference (+ SD) (the cedar temperature – the cypress temperature) per minute was 2.2 (+ 0.6) (squirrel A), 2.4 (+ 0.7) (squirrel B), and 1.3 (+ 0.6) (squirrel C). The results suggest that cedar nest fibers have a greater heat-trapping capacity than cypress nest fibers.

3・2 Number and morphology of nest fiber

An amount of 0.5g each of fibers obtained from the cedar nests and cypress nests built by the squirrels comprised 185 and 98 fibers, respectively.

Figure 3 shows the comparison in shape between the cedar and cypress fibers obtained from the nests made by the same squirrel. The average lengths (+ SD) of cedar nest fibers and cypress nest fibers were 31.9 (+ 14.9) cm and 10.5 (+ 5.4) cm ($p < 0.01$ Student's t-test), respectively. The average widths (+ SD) of cedar nest fibers and cypress nest fibers were 0.8 (+ 0.3) cm and 1.3 (+ 0.5) cm ($p < 0.01$ Student's t-test), respectively. The results show that cedar fibers are longer and finer than cypress fibers.

The differences in fiber number and morphology observed in the study may reflect the difference in temperature loss between the cedar nest fibers and cypress nest fibers.

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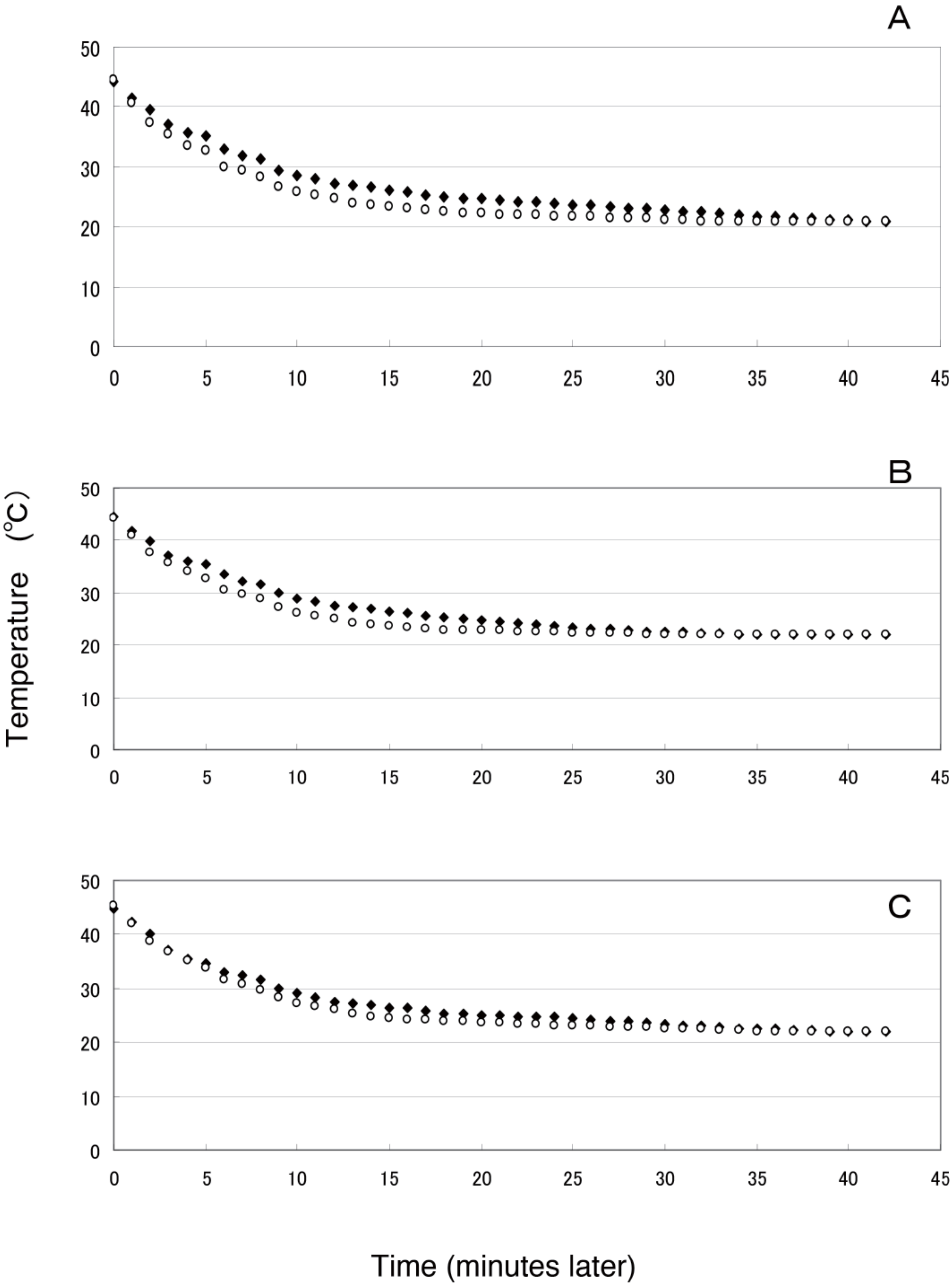

Fig.2 Temperature change with time in center of nest fibers in the vessel.
Three graphs show results from three squirrels (A, B and C). Black dots present the temperature in cedar fibers and white dots present the temperature in cypress fibers.

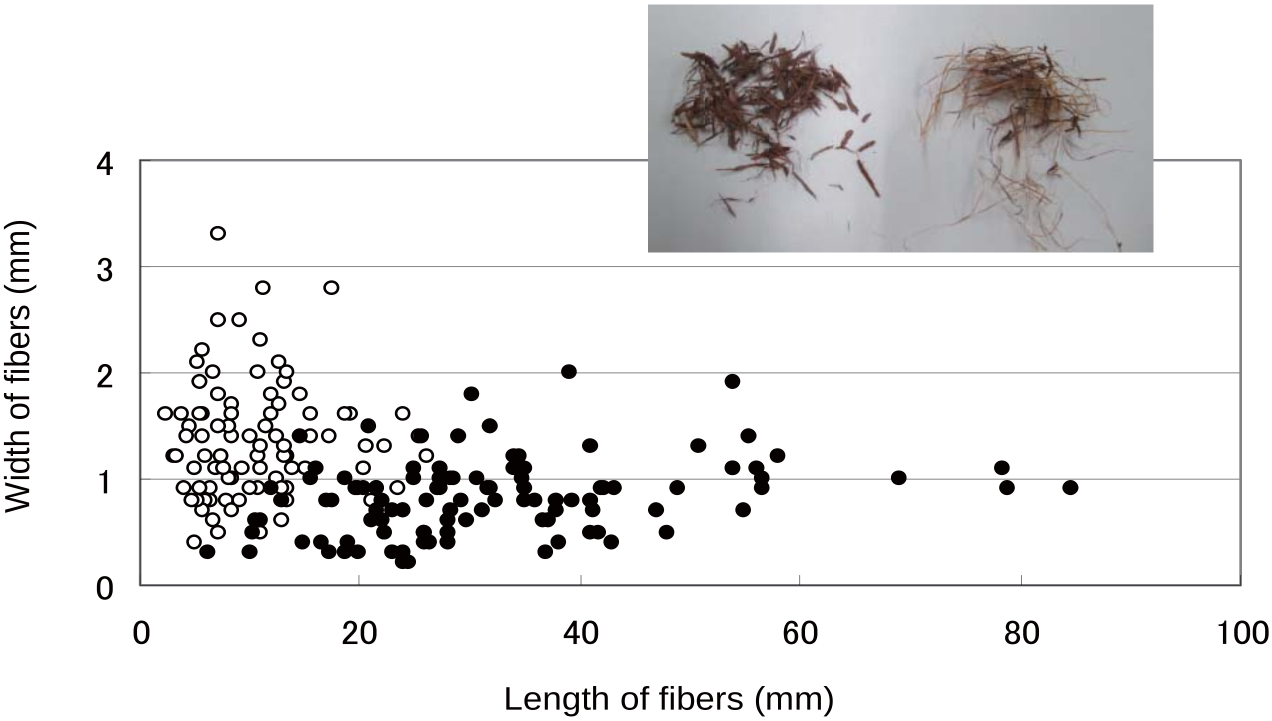

Fig.3 Comparison in shape between cedar fibers and cypress fibers.
Cedar fibers on the right and cypress fibers on the left of picture

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ニホンモモンガ *Pteromys momonga* はなぜ巣材としてスギの樹皮を好むのか Ⅱ．保温効果の検討

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ニホンモモンガ *Pteromys momonga* は，自然生息地において，巣材としてスギ *Crytomeria japonica* の樹皮を好んで用いることが知られている．本研究では，ニホンモモンガがスギとヒノキ *Chamaecyparis obtusa*，それぞれの樹皮でつくった巣の内部の保温効果，及び，それぞれの巣材の繊維の形状が調べられた．結果は，スギの樹皮でつくられた巣の内部はヒノキの樹皮でつくられた巣の内部より高い保温効果をもつことを示唆していた．また，スギ樹皮からつくられた巣材繊維は，ヒノキからつくられた巣材繊維より，長く，細いことが示された．

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