FRACTAL ANALYSIS OF POLAR BEAR HAIRS

by

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Hairs of a polar bear (Ursus maritimus) are of superior properties such as the excellent thermal protection. Why do polar bears can resist such cold environment? The paper concludes that its fractal porosity plays an important role, and its fractal dimensions are very close to the golden mean, 1.618, revealing the possible optimal structure of polar bear hair.

Key words: *fractal geometry, fractal porosity, polar bear, hollow hair*

Introduction

Some animals have hollow hairs, which are an adaptation of animals living in very cold climates. But only hollow structure is not enough for a polar bear to live in a harsh Arctic region, where the environmental temperature is extremely cold as low as –50 °C. A hollow hair with a labyrinth-like fractal porosity in polar bear hairs was found in [1], each labyrinth cavity is a good thermal insulator for keeping warm and the system of labyrinth cavities enable the animal to absorb energy from its environment [1, 2]. But there is an open problem unsolved, that is how to absorb more effectively energy from its environment. The fractal porosity of the hair might be the key for the answer.

Fractal dimensions of a polar bear hair

The inner morphology of a polar bear hair is illustrated in fig. 1, which is approximately considered as a fractal medium, and its fractal dimensions are calculated by the mathematic expression:

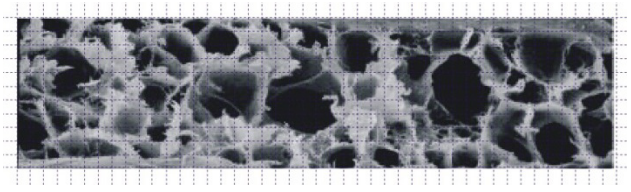

Figure 1. Inner morphology of a polar bear hair

$$D = \frac{\ln M}{\ln N} \qquad (1)$$

where M is the number of new units within the original unit with a new dimension, and N – the ratio of the original dimension to the new dimension.

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In order to calculate the fractal dimensions of a polar bear hair, we divide the sample given in fig. 1 into 11 rows and 44 columns, so the total area is 484 a^2, where a is the area of each block. The area of blank part is 152 a^2. According to eq. (1), the fractal dimensions of a polar bear hair are:

$$D = \frac{\ln \dfrac{152a^2}{a^2}}{\ln \dfrac{\sqrt{484a^2}}{a}} = \frac{\ln 152}{\ln 22} = 1.625 \tag{2}$$

The fractal dimensions are 1.625, which is very close to golden mean, 1.618, revealing the possible optimal structure of polar bear hair.

Conclusions

The polar bear hairs have hollow hairs with fractal porosity, and its fractional dimensions are closed to be the golden mean. Such structure is an adaptation of the animal to balance its two roles: thermal protection from its body and energy absorption from its environment. We considered two extremes: (1) its fractional dimensions were two, and (2) the fractional dimensions were zero. The first condition is that for hollow hairs like that in alpacas living in sub-zero, and that the hollow hairs enable animals to insulate and keep them warm. The second case would turn to be white and translucent hairs without hollow structure. The translucent hair can extremely easy absorb energy from its environment, but it is also extremely easy to transfer its body energy to its environment. The fractional dimensions of 1.618 must reveal the possible optimal structure of polar bear hairs, which enable the animal live in extremely cold climate as low as negative 50 °C.

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