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KATATHERMOMETRIC MEASUREMENTS OF INSULATING PROPERTIES OF THE FUR IN SMALL MAMMALS

KATATERMOMETRYCZNE POMIARY IZOLACYJNYCH WŁAŚCIWOŚCI FUTRA MAŁYCH SSAKÓW

Physical regulation of heat, as an adaptive character, plays an important role in the relations between an organism and its environment. The hairy covering, constituting a thermo-insulating layer, is its essential factor.

Various instruments have been used so far to examine the insulating properties of fur. Hammel (1955), for instance, adopted the apparatus used by the American Society for Testing Materials to examine thermal properties of fabrics for his studies on 15 mammals species. The degree of insulation for a thickness unit of a fur taken freshly off was determined by measuring the temperature gradient in this fur penetrated through by a known amount of heat coming from a heated metal disk. By means of such an instrument Lentz & Hart (1960) have measured the heat loss through the fur of new-born caribou.

Burton & Edholm (1957) have introduced a unit applied for determination of the insulating value of man's clothing *(clo)*:

$$1\ clo = 0.32 - 0.14 \frac{{}^{0}C}{Cal./sq.m. \times hrs}$$

The dependence of the cooling effect upon the insulating value is evident.

As regards the furs of small mammals, it is, however, practical to use Hill's katathermometer, which makes it possible to obtain the ready value of cooling immediately.

Hill's katathermometer is an instrument commonly used in biometeorology for measurements of cooling (Middleton & Spilhaus, 1953; Stružka, 1956). It is also of use in the fur industry to establish insulating properties of furs (Bradtke & Liese, 1958). And so Shilov (1961) applied Hill's katathermometer for measuring insulating properties of the furs of *Microtus arvalis* (Pallas, 1779) and *Microtus gregalis* (Pallas, 1779). He found differences between these two species, expressed relatively in percentages, assuming the fur value of one of them as 100%. Sinitchkina (1962) studied seasonal changes in the insulating properties of fur in *Rattus norvegicus* (Berkenhout, 1869). The heat conductivity of fur increased in these animals in summer and dropped in winter, being independent of the thickness of the fat layer of animals examined.

Using Hill's katathermometer for measurements we compared the heat conductivity of fur in several species of small mammals collected in the field and those bred in the laboratory (Table 1). The value of insulating properties was examined in the representative series of furs of the following species: *Sorex araneus* Linnaeus, 1758, white mouse, *Mus musculus* Linnaeus, 1758, *Clethrionomys glareolus*

(S c h r e b e r, 1780), *Pitymys subterraneus* (de S é l y s - L o n g c h a m p s, 1836), and *Microtus agrestis* (L i n n a e u s, 1761).

A fresh animal skin was put on the katathermometer receptor so that it covered the receptor utterly. The superfluous margins of the skin were cut off, the hair was smoothed. The whole was heated by a jet of hot air up to a temperature of about 40°C under standard conditions (air temperature — 19°C ± 1°, relative humidity of air — 70% ± 5%). At the same time measurements of cooling were taken with a dry katathermometer without a skin for control. The results were obtained in the comparable standard cooling unit (*H*):

$$H = \frac{\text{sq.cm.} \times \text{sec.}}{\text{mcal.}}$$

The cooling values for the skins of *S. araneus* and *P. subterraneus* living in the forest indicate an apparent thermal differentiation between their summer coats and the winter ones (Table 1). The cooling value depends undoubtedly on the density of coat and the thickness of skin, which both show seasonal variations. B o r o w s k i (1958) reports that the density of fur over the same areas in *S. araneus* is the greatest in

Table 1.

Mean insulating values of fur in some small mammals.
(S. — summer, W. — winter)

Species	S.araneus		M.musculus- /white mouse/	C.glareolus				P.subterraneus				M.agrestis	
	Field		Lab.	Field		Lab.		Field		Lab.		Lab.	
	S.	W.	W.	S.	W.	S.	W.	S.	W.	S.	W.	S.	W.
n	9	20	10	15	16	16	15	14	26	15	15	16	68
mcal. / sq.cm. × sec.	3.43	2.82	2.73	2.84	2.71	2.88	2.66	3.14	2.62	2.41	2.84	2.22	2.37

the winter (December—February) and the smallest in the summer months (May—June). In his opinion (B o r o w s k i, in litt.) the skin thickness is in *S. araneus* greater in summer than in winter. However, in spite of the nullifying action of these opposite changes, the insulating properties of the skin and hair cover as a whole are greater in winter than in summer. This fact plays an essential role in the processes of physical heat regulation in the seasonal cycle.

In the case of *M. agrestis* and *P. subterraneus* bred in captivity in the Mammals Research Institute of the Polish Academy of Sciences for 8—12 generations, the insulating values of winter and summer coats hardly differ from each other, and the winter coats have even somewhat higher values of heat conductivity than the summer coats. This phenomenon seems to be due to the disturbances of the moulting process caused by the stability of thermal conditions in the laboratory environment. The air temperature in the laboratory rooms keeps at a steady level of +18 to +20°C in the winter. In the summer the rooms are not heated and the temperature may occasionally drop below the winter level. This may cause an increase in the insulating value of the summer coats of *M. agrestis* and *P. subterraneus* in relation to that in winter. Sinitchkina (1962) also found that the differences in the insulating values of furs of *Rattus norvegicus* are not great, for the moult in the individuals examined by her and living under urban conditions continued all the year round (cf. also Becker, 1952; Stein, 1960).

In *M. agrestis* bred in the laboratory the insulating value of skin increases slightly with age (correlation coefficient $r = 0.50$).

Other studies carried out on *P. subterraneus* and *S. araneus* were aimed at the recognition of the changes in the insulating properties of coats with time. After taking proper measurements the skins were left on the katathermometers for several days, and their cooling was measured every day. The katathermometers with the skins on were kept in a vacuum dryer at a temperature of +20°C. As a result of this the skins dried and their heat conductivity decreased and brought about a drop in the cooling value. The greatest differences were observed between the first and the second day of experiment, then they began to decrease considerably and on the third of fourth day were almost undemonstrable.

The furs of animals living in the field have better insulating properties in summer than in winter. If the cooling values of summer skins are assumed to be 100%, the cooling of winter skins will be 82% for *S. araneus*, 83% for *P. subterraneus*, and 95% in *C. glareolus*. No such remarkable differences are observed in laboratory animals.

In summer *S. araneus* shows the lowest heat conductivity, whereas during the winter its cooling values do not differ so considerably from those in rodents. In general, *S. araneus* differs evidently from rodents, which also present some specific differentiation in respect of the insulating value of fur.

The insulating value of furs is higher in animals caught in the field than in the same species bred in the laboratory.

On the basis of the data from literature (Shilov, 1961; Sinitchkina, 1962) and the results of observations offered in this paper it may be stated that Hill's katathermometer is an instrument which can be used to good effect for studies on thermo-insulating properties of skins in small vertebrates.

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