Hypobiosis in mammals and birds living in the cold climate

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- In extremely severe conditions of cold climate in Yakutia, the one of the most effective adaptation is economization of energy resources for decreasing of metabolism (hypobiosis) level in winter. Shift to hypobiotic state during winter frosts is reported not only in winter-hibernating mammals but also in well-adapted ungulates (elk, reindeer, musk-ox, Yakutian horse and other indigenous animals of the region) and in some birds.

- Hypobiosis as well as it's the most deep form, wintering hibernation, is known from Aristotel time who learned that not only hibernating mammals but birds: swallows, thrushes, starlings, doves, storks, owls may reduce their activities and fall to hypobiosis.

- Starting from the 80-es of the last century, we study features of hibernation and hypobiosis states of no-hibernating mammals and birds.
- Hibernation of bats, Siberian chipmunk, Siberian Souslik, Arctic Souslik, Black-capped Marmot. These works became especially successful from 1982 when we started actively collaborate with specialists of physiology, biochemistry and biophysics from Biophysical Institute of Academy of the Science in USSR (Puschino town). These works were conducted on phemenology of winter hibernation of species mentioned above and with physiologic –biochemistry and biophysical mechanism of hibernation. By these results, several publications in Russian and foreign editions were published.

- Below, we will discuss our data on winter hibernation and hypobiosis of mammals and on hypobiosis of birds.
- 5 bat species of Vespertilionidae family are registered in Yakutia. These are Myotis brandti, Myotis daubentoni, Myotis ikonnikovi, Plecotus auritus and Eptesicus nilssoni.
- All bat species in Yakutia were met on wintering in cavities of gypsum mines near Olekminsk town. Experimental study of wintering hibernation of Eptesicus nilssoni, Plecotus auritus and Myotis daubentoni is shown that frost foodless period in bats is provided for long (97-98% of time budget) periods of hypothermia and short (1-2%) being in hormothermia (Fig.1)

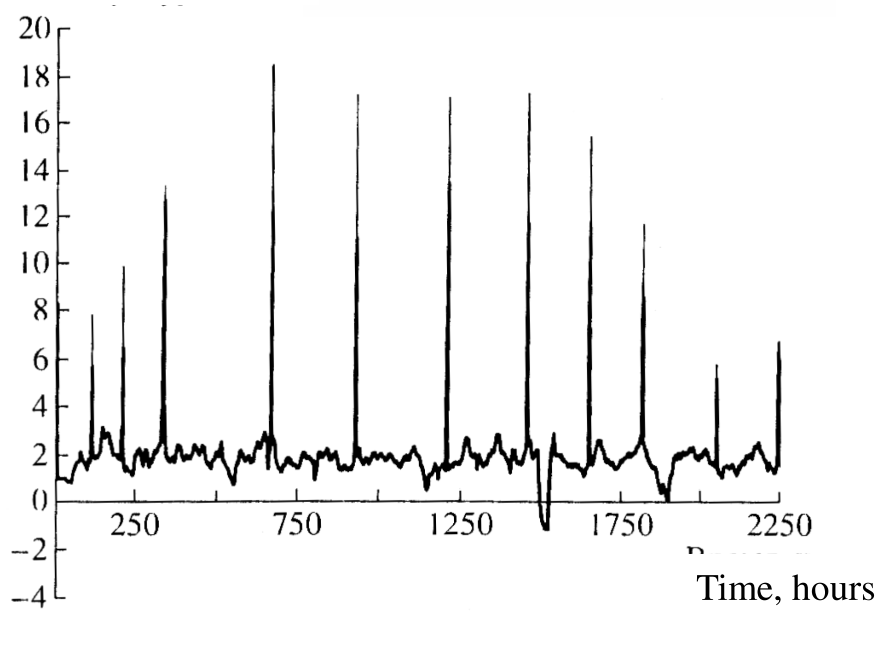


Fig. 1. Wintering hybernation in Northern Bat on changes of the body surface

- Length of hypobiosis periods was averagely 201.77 ± 22.9 lim = 92 - 329 hours, in Brown Long-eared Bats - 189.7 ± 17.29, lim = 137-260 hours. In Northern bats, active state lasts averagely 2.2 ± 0.67, lim = 0.5-6.0 hours, in Brown Long-eared Bats - 2.21 ± 0.24, lim = 1.5-3.0 ч

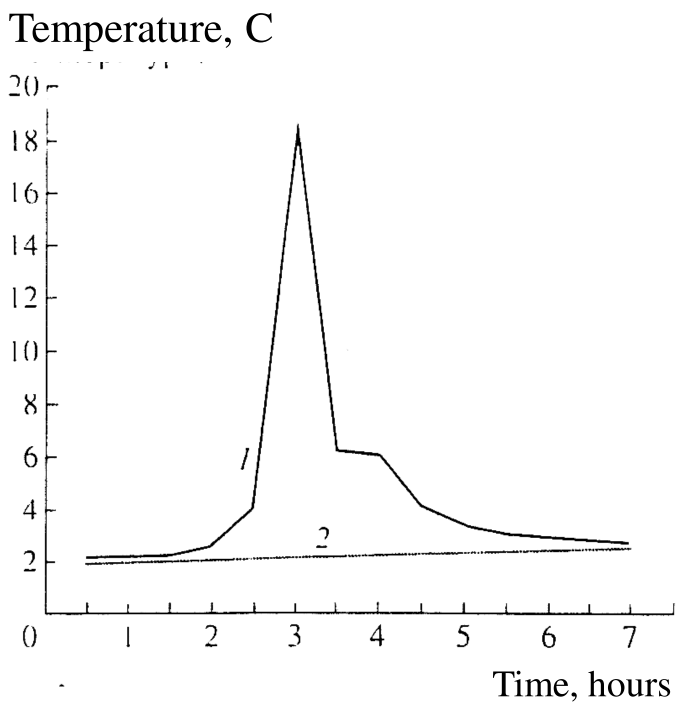
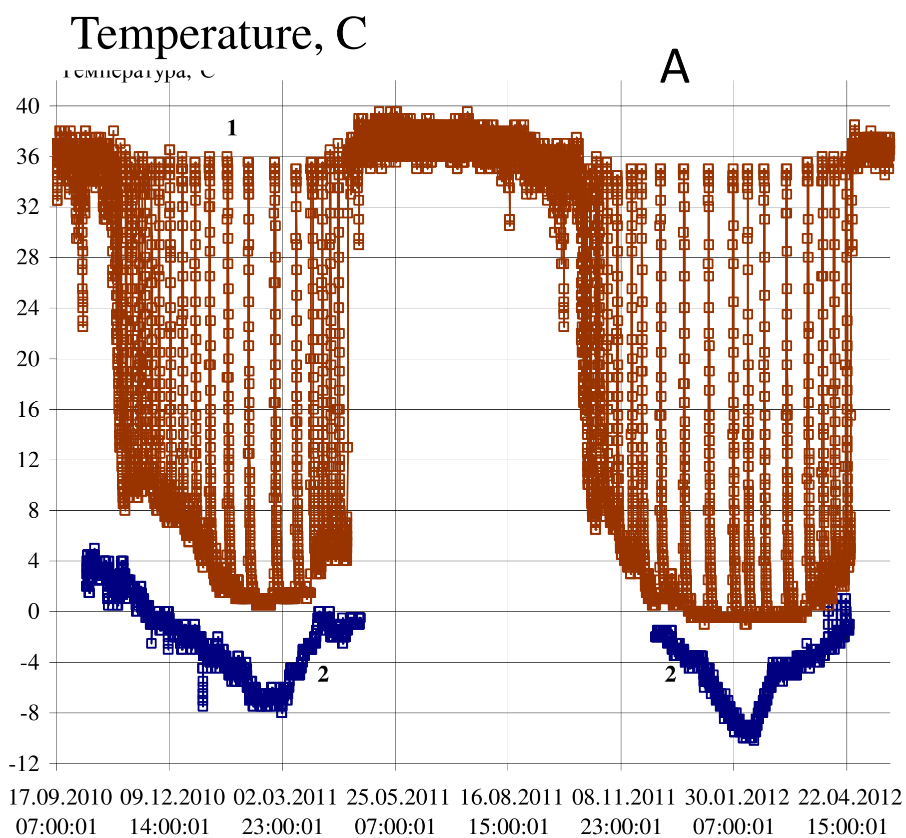


Fig.2. Temperature dynamics of bat during casual awaking 1 –body temperature 2 – ambient temperature

- Body temperature of hibernating bats almost does not differs from ambient temperature. Temperature of leather on animal’s belly just 0.5°C above ambient temperature. At animal’s periodical casual awaking, the body temperature for the short time (0.5-1.0 hours) increases and became active (fig. 2). In active state, bats moved in the cage, made excrements, not only liquid but also hard. Then, they again posed in hibernation usual for day-time and consequently fell to hypothermia.

- Experiment data we have got witnesses on principal similarity of bat winter hibernation phenomenon with well studied rodent hibernation. Firstly, it is alteration of periods for deep stupor when is significantly reducing of physio-biochemistry activeness (what reflects in metabolism and body temperature reducing), and short periods of awakening when animals almost do not eat but just release metabolism products. Such alteration is typical for the both animal groups. Particularities of winter hibernation in rodents of Yakutia we will discuss on example of Sciuridae family.

- Body temperature is an integral characteristic of mammalian metabolism. Measurement of body temperature of animals in practice, especially under near-natural conditions, is not sufficiently accurate owing to the characteristics of measurement instruments, on the one hand, and changes in animal bodies during forced measurement of their temperature, on the other hand. Implantation of a DS 1922 L-F5 temperature logger under the skin or into the body cavity makes it possible to partially overcome these disadvantages.



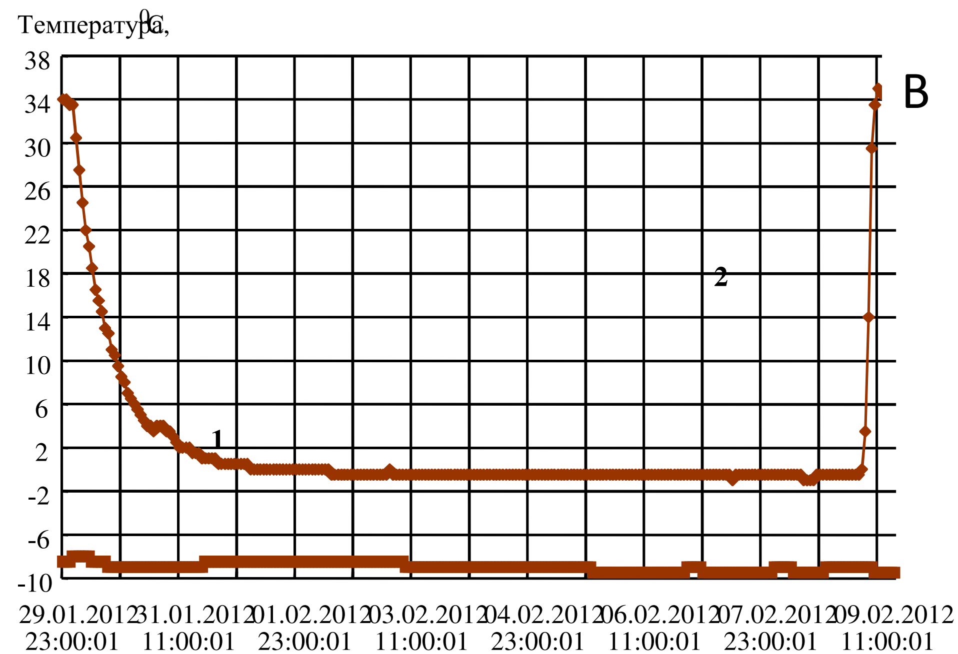


Fig. 3. Body temperature dynamics in hibernation period of Marmote camtchatica during 2 watching seasons (A), and during short cycle of hibernation (B):
1 - body temperature; 2 – ambient temperature

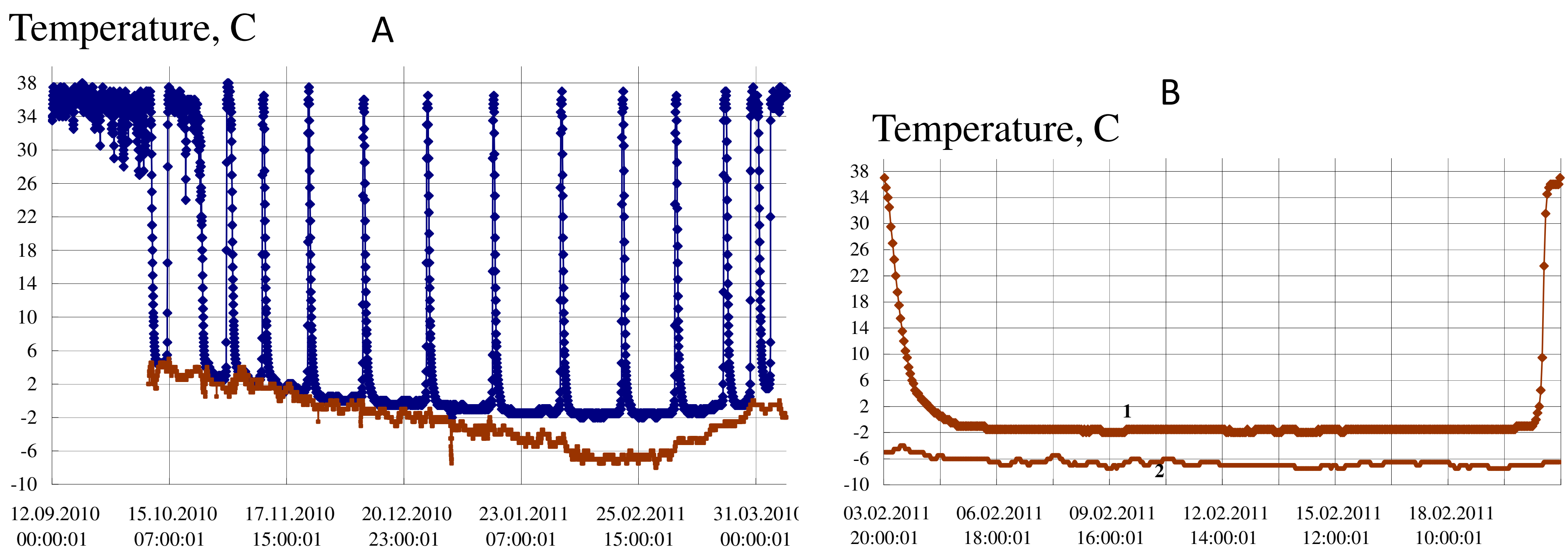
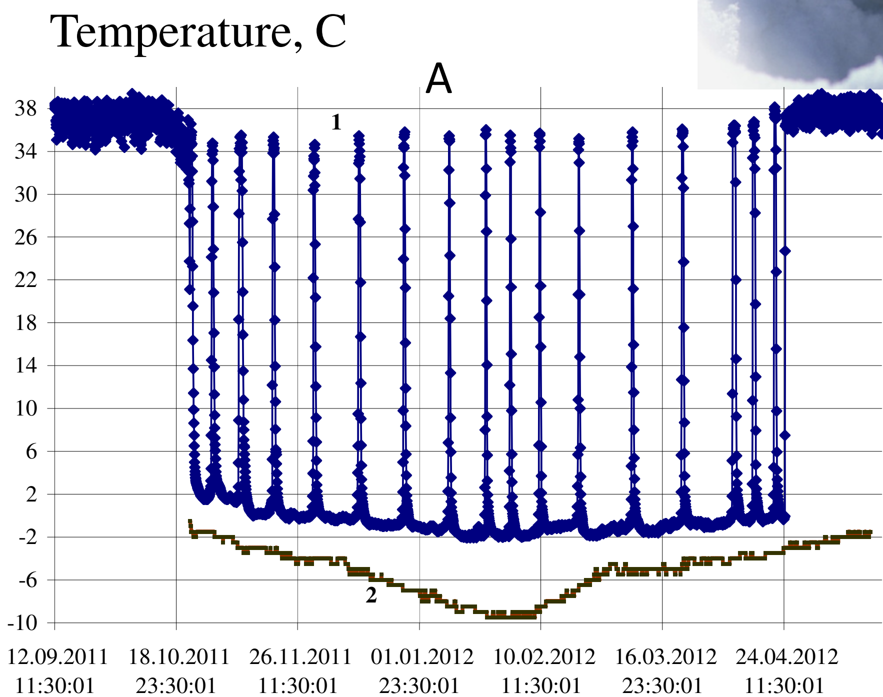


Fig.4. Body temperature dynamics in Spermophilus parryi in hibernation period (A) and during short cycle of hibernation (B): 1 – body temperature; 2 – ambient temperature



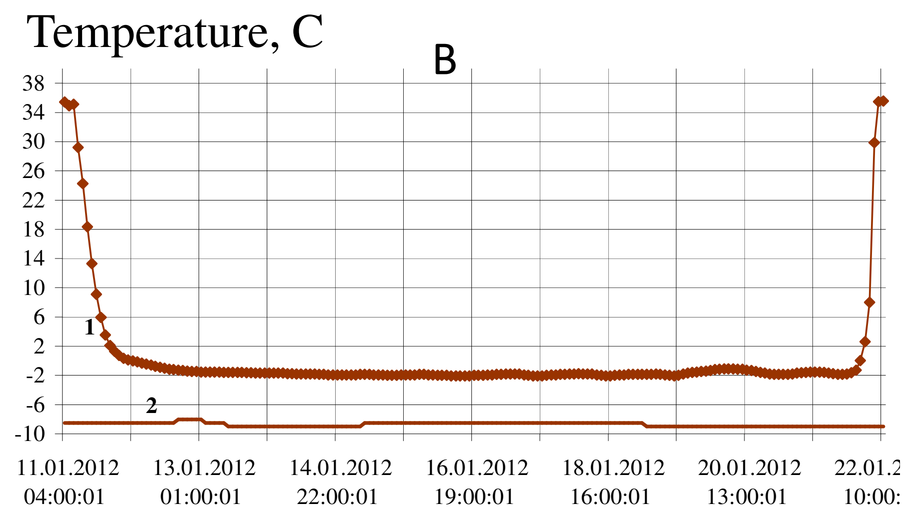


Fig. 5. Body temperature dynamics in Spermophilus undulatus in winter hibernation period (A) and during short hibernation cycle (B):

1 – body temperature; 2 – ambient temperature

From fig. 3, 4 and 5 you see that Black-capped Marmot, Arctic and Long-tailed Sousliks are able to reduce temperature till - 1-2°C during their hybernation

- Differently from above-mentioned species winter hibernation of which is very deep and long, Siberian Chipmunk awake more often. More than, at such awakening, it releases metabolic products as well as eats food from its stocks. Some North American chipmunks are facultative hibernants.

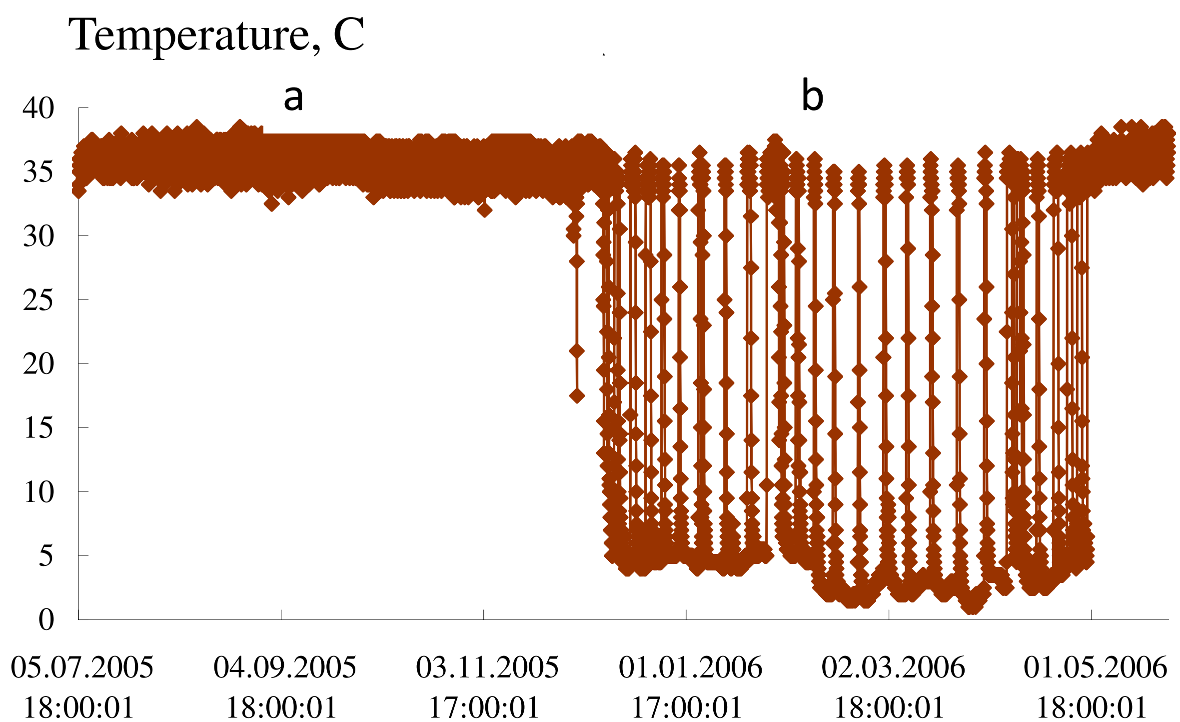


Fig.5. Time course of body temperature of the Siberian chipmunk (a) in the active period of life and (b) during hibernation.

- The special interest is the hypobiosis reactions of more large animals with all-year ground life and feeling direct influence of low temperatures, rains, snow and sharp winds.
- Mountain Hare living in Central Yakutia and Upper Yana District (North-East of Siberia), has a raw of specific ecologic, physiologic and morphologic features to environment in cold climate (Tavrovski and other; 1971; Solomonov, 1973). It has small body size. This species fall out of Bergman rule by its morphology characteristics. Its relatively small size and exclusively great number diapason we relate to ecology features, especially to feeding with low-energetic resources. Mountain Hare able to eat and treat great quantity of low-energetic food during 8 months of winter. Its relatively low activeness connected with food resource abundance and accessibility and low number of predators. Low mobility of Mountain Hare causes relatively low but stable metabolism level while metabolism growing is low till ambient temperature -35- 40°C.
- It reflects in Mountain Hare body temperature dynamics in winter time (Fig. 7).

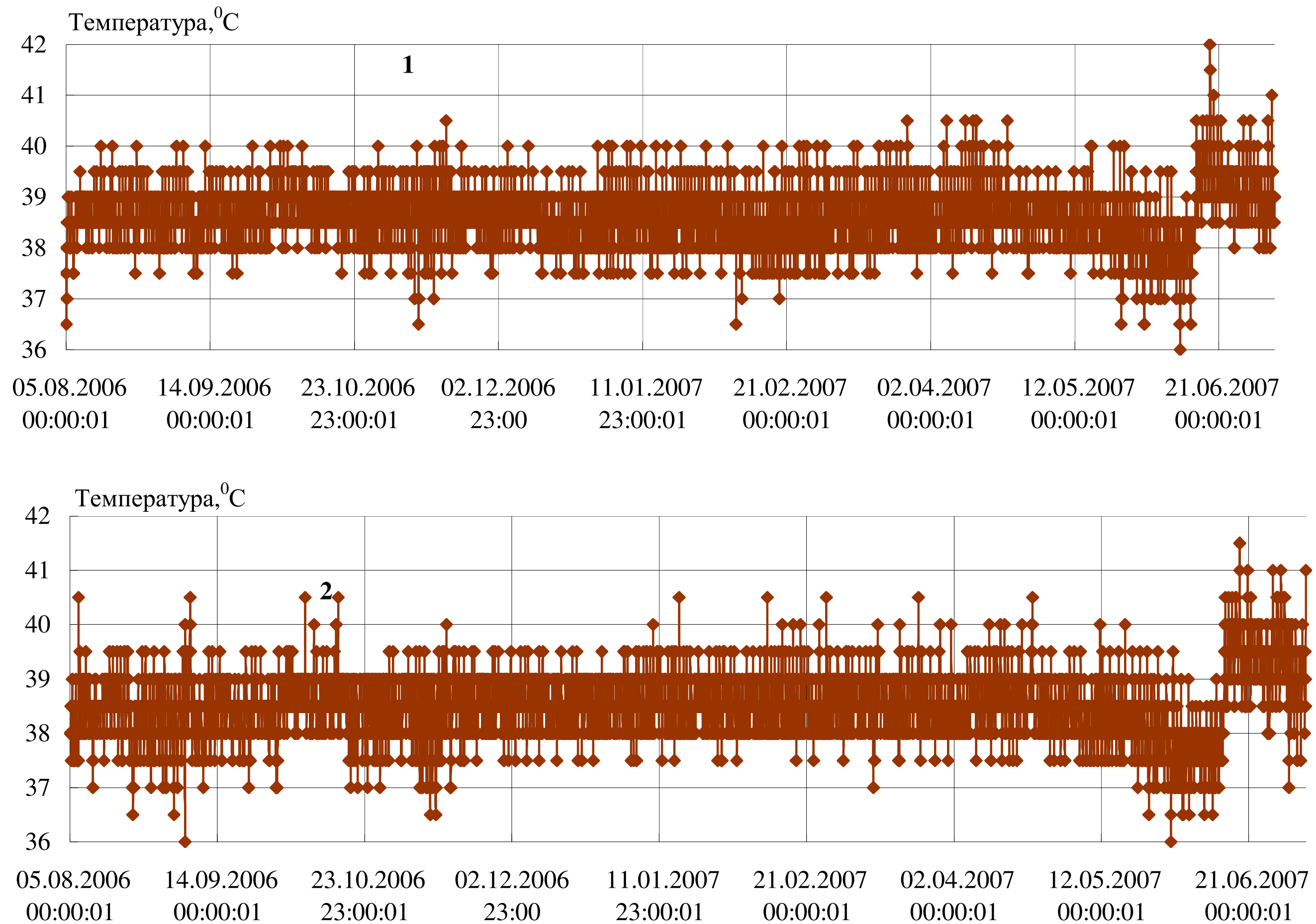


Fig.7. Mountain Hare body temperature change in a year cycle:

1 – male; 2 –female

- You see here the body temperature stability during all winter. The conspicuous changes from the base line can be seen just in periods between fall and winter (September-October) and between spring and summer (May-June).

- Even more interesting data on great ungulates hypobiosis. E.P. Knorre (1959) yet paid attention to elk activeness reducing in second half of the winter and considered that adaptation to existing in northern taiga. The most clear this shown in E.K. Timofeeva paper (1974) in Leningrad district. She wrote, in March-April, «mammals literally do not addition step without extremely necessity and try to feed themselves on the same place as long as it is possible».
- By data of our collaborator V.M. Safronov, reindeer conspicuously reduce their movement activeness in winter in Yakutia. They often rest. As usual, they will lay down on the snow in every 1.0 – 1.5 km of their way. Their feeding square just 0.009 ha.

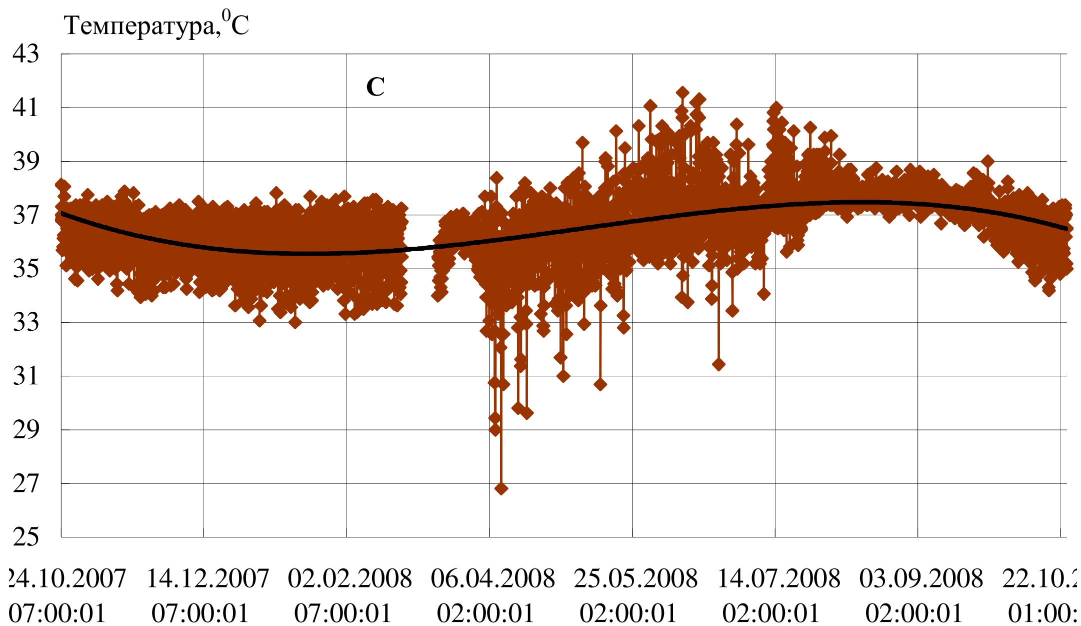
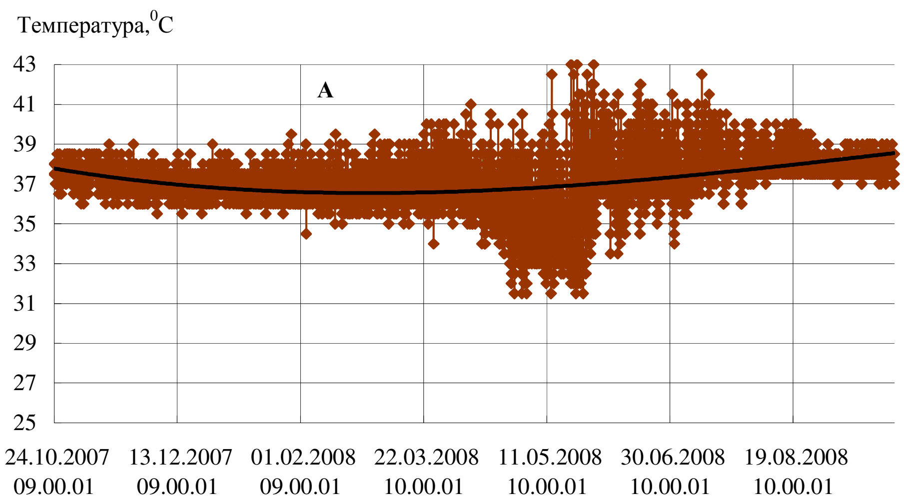
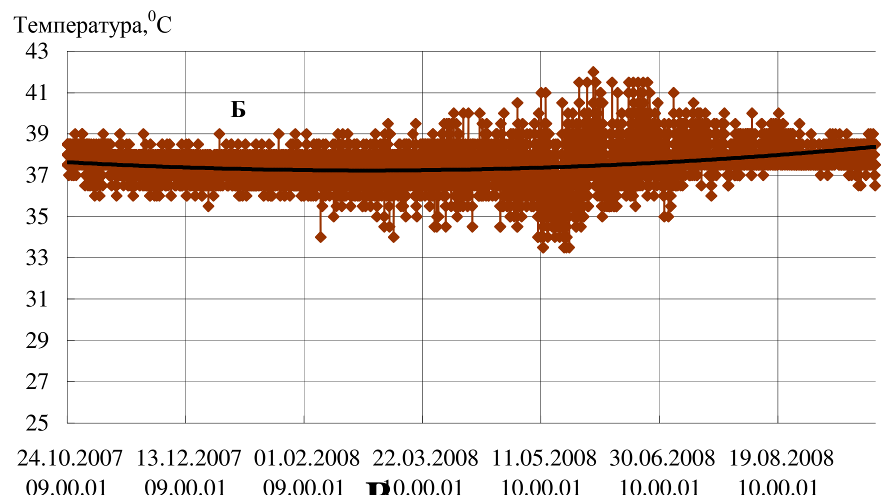


Fig.8. Reindeer body temperature dynamics. Reduce of Reindeer body temperature in December-February is apparently seen. It is 33.6-37.5℃ In December, 33.3-27.7℃ in January and 34.0-37.1℃ in February.

- The very interesting data we have got at studying of the year dynamics of musk-ox, Central Yakutian horse and Horse of Upper Yana district ecological type.

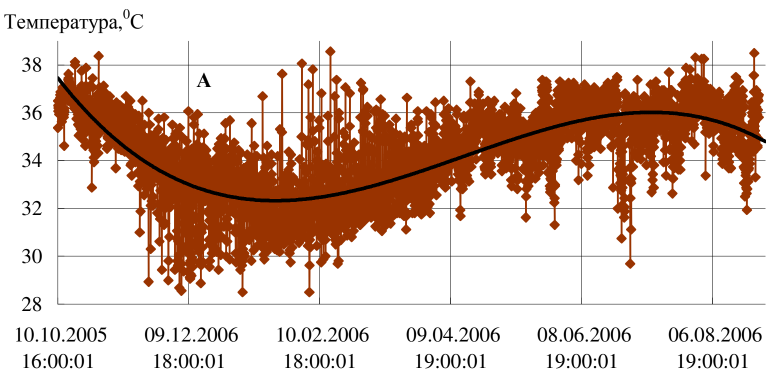


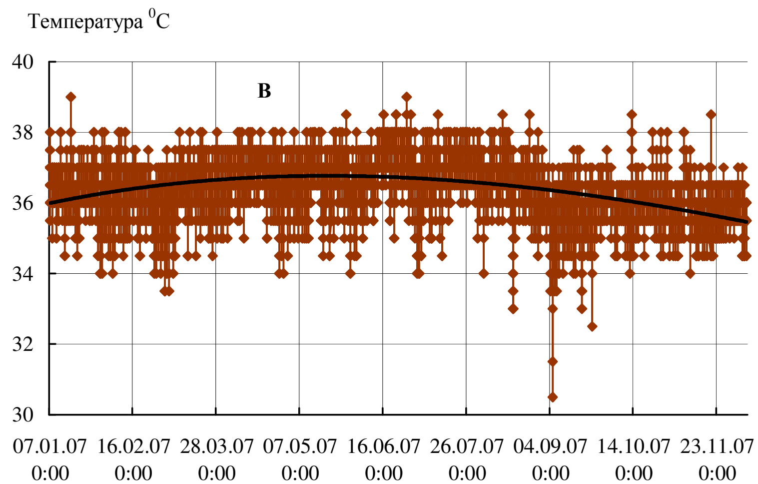
A



B

Fig.9. Musk-ox body temperature dynamics: female (A) and male (B).





A **B**

Fig.10. Dynamics of body temperature in Central-Yakutian (A) and Upper-Yana district Horse (B).

- It is seen that animals in Central population of Yakutian horse reduce their body temperature till 28-35°C, but more adaptive to Cold Pole condition Upper Yana district horse save the stable body temperature at -40-45°C.
- At study of Long-tailed Souslik in winter hybernation period it was learned that some chemical substances of protein nature presents in its brain tissues, in mucous membrane of thin intestines and in its blood. This substances cause metabolism level and body temperature reducing (Ivanitsky,1982; Кramarova et al., 1984; Akhremenko et al., 1994).
- We proposed that such substances may be formed at metabolism level reducing of large and cold-adapted animals – Yakutian horse, reindeer, elk and Yak brown bear. Because, extracts from these animals brains were got. Preliminary experiments on influence of these substances to metabolism level in homothermic animals were conducted with participation of scientists from Institute of Cell Biophysics under Russian Academy of the Science, Moscow University named after Lomonosov and Institute of Bioorganic Chemistry RAS (Sukhova, Ignatiev, Akhremenko et al, 1990).

It was learned that action of low-molecular peptide fractions in extracts of these animals is similar on power of effect from related peptide fractions which were extracted from organs of hibernating rodents (fig. 11).

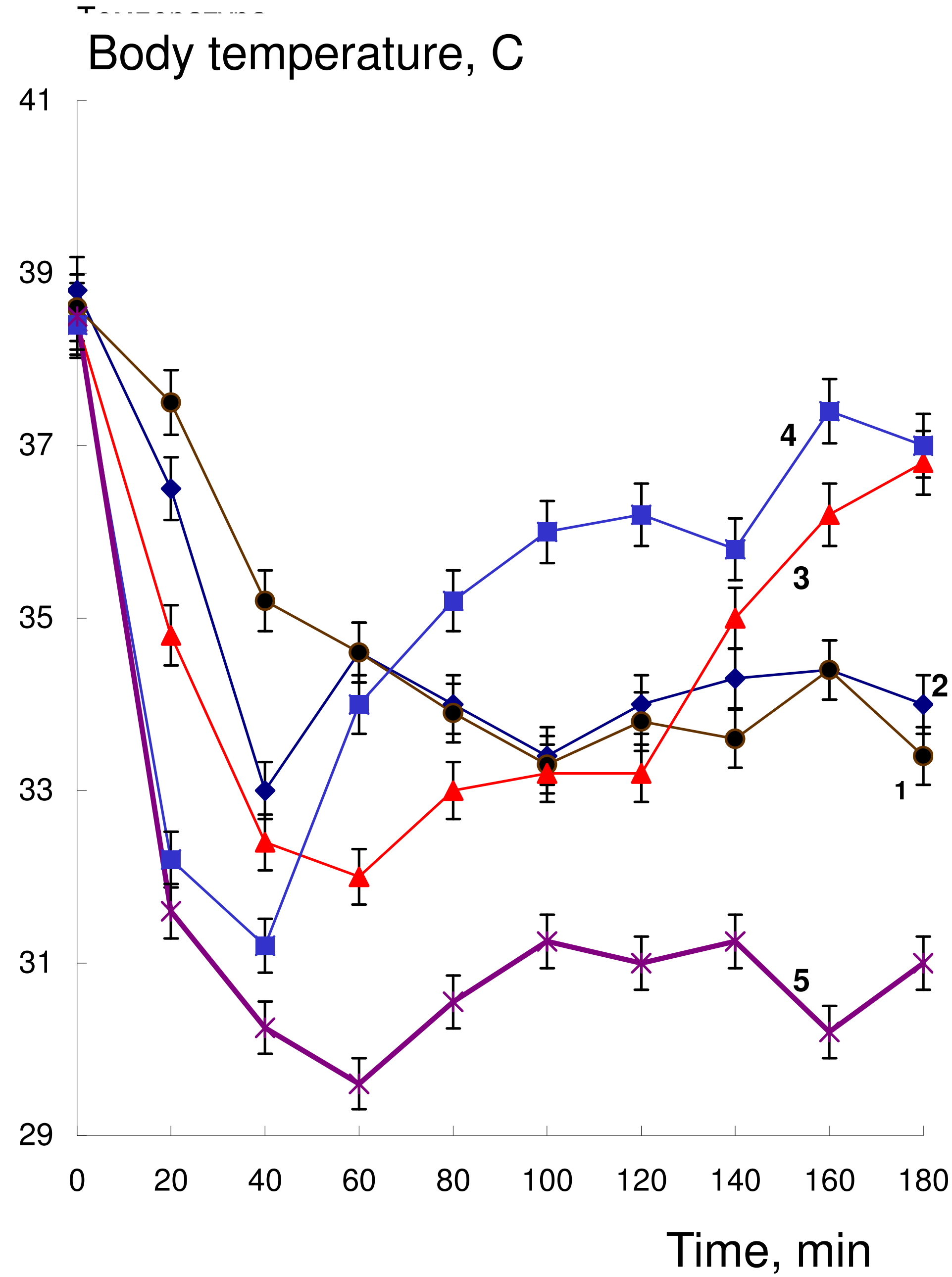


Fig.11. Change of body temperatures in white mice after adding of fraction 1-10 кilo Daltone (in 1 mg/g) from Elk brain (1), Reindeer (2), Snow Sheep (3), Yakutian horse (4), Brown bear (5).

- In one of our next report you will hear about very interesting data on energy resources economization and hypometabolic reactions of birds. It should be noticed here that night stupor among Yakutian forms of birds is reported among Passerine birds as well as in Large Grouses. In Grouses, all-year measurement of body shown its reducing in December-February for 3-5C. As result of mentioned above, we are noticing here that hypobiotic states in northern animal forms are the one of the most important ways of adaptation to cold climate.

THANK YOU FOR ATTENTION!